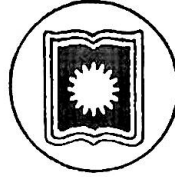


SOLID WASTE MANAGEMENT OF DHAKA CITY: ISSUES AND CHALLENGES



Ph.D. Dissertation

Researcher

Md. Mafizur Rahman

A Dissertation

Submitted to the Institute of Bangladesh Studies, Rajshahi University
in Partial Fulfilment of the Requirements for the Degree of

**Doctor of Philosophy
in
Environmental Studies**

**Institute of Bangladesh Studies
Rajshahi University
Rajshahi, Bangladesh**

November, 2005

SOLID WASTE MANAGEMENT OF DHAKA CITY: ISSUES AND CHALLENGES



Researcher

Md. Mafizur Rahman
Ph.D. Research Fellow
Institute of Bangladesh Studies
Rajshahi University
Rajshahi, Bangladesh

Supervisor

Dr. M. Zahidul Hassan
Professor
Dept. of Geography & Environmental Studies
Rajshahi University
Rajshahi, Bangladesh

Co-Supervisor

Dr. M. Mostafa Kamal
Assistant Professor
Institute of Bangladesh Studies
(IBS)
Rajshahi University
Rajshahi, Bangladesh

**Institute of Bangladesh Studies
Rajshahi University
Rajshahi, Bangladesh**

November, 2005

Rajshahi University Library
Document
Document No. D-...2540
Date... 27/5/06.....

DOC
628
RAS

Dedicated

to

My Deceased Elder Brother

Md. Abdur Rab Bhuyian

CERTIFICATE

This is our pleasure to certify that the dissertation entitled **“Solid Waste Management of Dhaka City: Issues and Challenges”** is the original work of Mr. Md. Mafizur Rahman that is completed under our direct guidance and supervision. So far we know, the dissertation is an individual achievement of the candidate's own efforts, and it is not a conjoint work.

We also certify that we have gone through the draft and final version of the dissertation and found it satisfactory for submission to the Institute of Bangladesh Studies (IBS), Rajshahi University in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Environmental Studies.

Md. Zahidul Hassan
21.11.2005

Dr. M. Zahidul Hassan

Professor
Dept. Geography & Environmental
Studies

Rajshahi University
Rajshahi, Bangladesh

&

Supervisor

Mostafa Kamal 21.11.2005

Dr. M. Mostafa Kamal

Assistant Professor
Institute of Bangladesh Studies
(IBS)

Rajshahi University
Rajshahi, Bangladesh

&

Co-Supervisor

DECLARATION

I do hereby declare that the dissertation entitled “**Solid Waste Management of Dhaka City: Issues and Challenges**” submitted to the Institute of Bangladesh Studies, Rajshahi University for the degree of Doctor of Philosophy in Environmental Studies is exclusively my own and original work. No part of it in any form has been submitted to any other University or Institute for any degree, diploma or for other similar purposes.

Rajshahi
November 2005



(Md. Mafizur Rahman)
Ph.D. Research Fellow
Session: 2002-2003
Institute of Bangladesh Studies
Rajshahi University
Rajshahi, Bangladesh

ACKNOWLEDGEMENTS

I owe to many individuals for their sincere cooperation for the completion of my dissertation. I like to mention the names of those people with deep gratitude and great pleasure.

First, I would pay my unbound indebtedness to Dr. M. Zahidul Hassan, Professor of Geography and Environmental Studies, and Dr. M. Mostafa Kamal, Assistant Professor, Institute of Bangladesh Studies (IBS), Rajshahi University for their supervision and constant guidance. Without their inspired cooperation, invaluable guidance and constant help, my work would not have seen the light of the day. So my indebtedness to them is beyond my expression. Their scholarly supervision, guidance and suggestion enrich the dissertation.

I express my indebtedness to Dr. Priti Kumar Mitra, Professor of History, and former Director of IBS, Rajshahi University for his informative lecture sessions on Research Methodology and History of Bangladesh during one year's coursework program. I also express my deep gratitude to him for his constant efforts for helping me in different ways. I remain grateful to all my teachers of this university who took classes in the coursework and helped me in different ways for enriching my knowledge and changing my attitude towards proper ways of doing research.

I express my thanks and gratitude to the authority of IBS for granting me a fellowship for conducting this research. It was really a unique opportunity for me to carry out my Ph. D. research in such an excellent institution.

This dissertation is a product of huge labour, brainstorming and intellectual capacity accompanied with extensive library work. I am grateful to the librarians and documentation officers of BIDS, BIBM, Rajshahi University library, Dhaka University library and IBS library for their help and assistance.

I also like thank to the IBS warden for cooperation to live in IBS dormitory. Thanks to my wife and two sons who encourage and support me to stay at Rajshahi for my research work. Also thanks to investigators of data collection in Dhaka city.

The inspirations of my mother and mother in law. always made me enthusiastic to do the work in due time. My brothers and sisters gave me suggestions and inspirations for completion of my dissertation.

It is not possible to express my gratitude and indebtedness to my wife Nasreen. Her continuous support for carrying on my study, and affectionate attitude inspired me to complete the study on time. In this connection

Finally, I pay my gratitude to them whose names have not been mentioned here due to lack of space, but I have received generous help from them in my day-to-day work.

Rajshahi
November 2005

Md. Mafizur Rahman

ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AIDS	Acute Immune Deficiency Syndrome
ARI	Acute Respiratory Infection
BANSDOC	Bangladesh Science Development Corporation
BAPA	Bangladesh Poribesh Andolon (Environment Protection Movement)
BC	Before Christ
BCC	Behavior Change Communication
BELA	Bangladesh Environmental Lawyers Association
BEN	Bangladesh Environment Network
BFIDC	Bangladesh Forest Industries Development Corporation
BFRI	Bangladesh Forest Research Institute
BLD	Bangladesh Legal Digest
BOD	Biological Oxygen Demand
BRTA	Bangladesh Road Transport Authority
btu	British thermal unit
BUET	Bangladesh University of Engineering and Technology
BUP	Bangladesh Unnayan Parisad
C/N	Chlorine Nitrogen ratio
CCO	Chief Executive Officer
Cd	Cadmium
CD	Computer Disk
CH ₄	Methane
CO ₂	Carbon Di Oxide
COD	Chemical Oxygen Demand
COT	Congressional Office of Technology
Cr	Chromium
Cu	Copper
DCC	Dhaka City Corporation
DG	Director General
DIT	Dhaka Improve Trust

DMCH	Dhaka Medical College Hospital
DMP	Dhaka Metropolitan Police
DMPA	Dhaka Metropolitan Police Area
DO	Dissolved Oxygen
DoE	Department of Environment
DoEPC	Department of Environment Pollution Control
DSMA	Dhaka Statistical Metropolitan Area
ECA	Environmental Clearance Assessment
ECC	Environmental Clearance Certificate
ECR	Environment Clearance Certificate
EIA	Environmental Impact Assessment
EKC	Environmental Kuznet's Curve
EPA	Environment Protection Agency (USA)
EPCB	Environment Protection Control Board
EQS	Environmental Quality Standard
ERR	Energy Resource Recovery
ESTs	Environmentally Sound Technologies
GO	Government Organization
GPO	General Post Office
HHV	Higher Heating Value
HSWA	Hazardous & Solid Waste Amendments
IBS	Institute of Bangladesh Studies
ICBN	International Conference of Bangladesh Environment
ICDDR	International Centre for Diarrhoeal Disease Research
IEC	Information, Education and Communication
IEE	Initial Environmental Examination
IUBAT	International University of Business, Agriculture and Technology
JICA	Japan International Cooperation Agency
k/j	Kilograms per Joule
LCA	Life Cycle Approach
LCC	Location Clearance Certificate
LDCs	Less Developed Countries
LEL	Lower Explosive Limit
LF	Landfill
LFG	Landfill Gas

MoEF	Ministry of Environment and Forest
MRR	Material Resource Recovery
MSWM	Municipal Soiled Waste Management
NCS	National Conservancy Strategy
NEMAP	National Environment Action Plan
NGO	Non-Government Organization
NRB	Non-Resident Bangladeshi
NRE	Non-Renewable Energy
OC	Officer in Charge (police)
PATC	Public Administration Training Centre
Ph	Phosphorous
PMC	Panajee Municipal Corporation (Philippine)
POCL ₃	Poisonous Phosgene
PVC	Polyvinyl Chloride
RAJUK	Rajdhani Unnayan Kartipakha (Capital Development Authority)
RDF	Refuse Driven Fuel
RE	Renewable Energy
SEMP	Sustainable Environmental Management program
SHED	Society for Environment and Human and Development
SLA	Sustainable Livelihood Approach
SoE	State of Environment
SSRC	Social Science Research Council
SWM	Solid Waste Management
t/d	ton per day
UBCs	Used Beverage Cans
UNCSD	United Nations Commission on Sustainable Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
WASA	Water and Sewerage Authority
WHO	World Health Organization
WTE	Waste to Energy

ABSTRACT

Waste production is obvious to human being. Either in consumption or in production process or commercial transaction some material will be discarded called urban waste. Waste may be gaseous, liquid, or solid. Whatever is the nature of waste that must be disposed in such a way that ensures the sound environment and clean city. It is easy to dispose the gaseous waste that is dispersed into atmosphere, liquid waste relegated to the water bodies, but solid waste management is too difficult. Volume of waste is increasing with economic development and changed consumption behavior. The sheer immensity of voluminous solid waste, the financial and infrastructure constraints including the lack of land for safe disposal, lack of awareness and apathy at all levels have come in the way of inefficient and unsafe solid waste management. Population boom and urbanization derives volume of solid waste and the city authority cannot cope with it. Solid waste management with other essential services cannot keep pace with increased population. The developed society manages their solid waste with modern technology and big investment. Most of the cities of developing countries are seriously suffering with huge volume of solid waste.

In most of the Afro-Asian cities, half of solid waste generated remains unattended. Officially on an average one-third of solid waste generated reaches in municipal dumpsite. The quantum of waste in this region is high, owing to higher level of population density in the cities. The tropical Asian climate with high levels of rainfall and huge humidity coupled with the organic character of waste aggravates the problem of solid waste disposal.

Dhaka is the capital city of Bangladesh with 8 million populations within 302 km² area. Dhaka City Corporation area is 131 km² with 5.7 million populations and produces about 3,700 tons of solid waste every day. Solid waste generation is 0.422 kg per person per day. Most of the solid waste is organic in nature. From food and vegetable, contribute for 53% the solid waste. DCC collect and transported for final disposal only 1200 ton amounting to 33% of total solid waste. The informal waste pickers collect 16% solid waste for recycling. Therefore, almost 50% of total solid waste is unattended and

uncollected in developing countries. This uncollected solid waste goes to drains, lakes, ditches and open spaces or elsewhere.

Solid waste management of Dhaka City is in deplorable condition. DCC could not show efficiency in the sector. Moreover, the air, water, and land pollution in and around Dhaka city is devastating. Solid waste management issue has got less important in the past. There was no thorough and comprehensive study held in this regard. The present study is an empirical as well as analytical or descriptive study based on both primary and secondary data. Therefore, it is a multidimensional research work. Questionnaire survey, key informant interview, observation, case study, and photographs used for primary data. The present study attempted to identify the various aspects of solid waste with a view to develop an integrated waste management policy guideline, which would be combating for sustainable environmental development of Dhaka city. The study provided lot of scope to visualize the present practice of waste management in the city. It has conducted aiming to find the current solid waste management practices of Dhaka city.

Solid waste is the valueless and unwanted matter in solid nature. The things, which has been discarded and have no economic value to the owner is treated as solid waste. With time span of urbanization and economic development, the amount and nature of solid waste has changed dramatically. For efficient solid waste management it is needed to know the constituents or properties of the waste. Integrated waste management is the combination of all waste handling with due importance. Waste management matrix provides the self-sustained role of the society. Solid waste management hierarchy follow the function one after another.

There are number of functions of solid waste management. Primary collection is carrying the waste from source of generation to transfer stations. Secondary collection is carrying solid waste from the primary collection points. 51% primary collection is done by CBOs and NGOs and rest 49% collected by the generators. Treatment is minimizing its environmental impact before final disposal. Historically, solid waste disposal consisted of open dumping. However, hog feeding, ocean dumping, simple dumping or general landfill, sanitary landfill, incineration are different solid waste disposal method. Particularly in developing countries are still using the open dumping method for waste disposal. Land reclamation is the ultimate goal of waste disposal. Only 33% solid waste is collected by DCC for final disposal, 16% of total is recycled by the informal sectors. 65% of collected solid waste is finally disposed at Matuail landfill sites, 30% is at Berri Band sites and only 5% is only at Uttara sites.

Sanitary land filling is an engineering option of waste disposal with having liner and cover material to protect the leachate contamination of soil and water. Leachate generation from landfill is very common and injurious to public health and environment. Strong control mechanism of leachate collection and treatment is essential. Incineration is another options of waste disposal. Through incineration the volume and weight of the solid waste could reduce maximum.

DCC is responsible for solid waste management, besides there are different organizations for maintaining environmental cohesiveness. There was a board working to protect water pollution before liberation of the country. In 1977, the board was changed into Environment Pollution Control Board (EPCB). In 1989 Ministry of Environment and Forest was established and the board was upgraded to Department of Environment. Environment Conservation Act, 1995 is the key environmental law. Dhaka City Corporation ordinance 1983 is another basic law for waste disposal. The legal provision is weak for solid waste management and enforcement is almost absence in this regard.

There was some civil society initiative is found to create public awareness for environment conservation. Only 23% of the respondents know the rules and regulation of the solid waste disposal, 37% of the lower level employees do not know the legal provision of ordinance regarding solid waste disposal. 96% households, 74% of business sector respondent replied that DCC officials did not inspect the household or business sector as part of the solid waste disposal. No rules and regulation for clinical and industrial waste handling.

Solid waste is treated as pollutant if otherwise not recycled or reused. The natural environment is being polluted throwing extraneous substances into environment by human being. Environment pollution is undesirable and unhealthy change in the general condition of environment caused by directly or indirect process of human living activities. Solid waste often called the third pollution after air or water pollution. There are three major categories of risks associated with waste, namely: aesthetic, environmental and health. Hazardous elements associated with solid waste are leachate, heavy metals, odors, and other particulate materials. Open dumps, scattered throwing, sanitary landfill, and incineration plant also poses threats to environment. Air pollution from open burning, incineration ash, particulate matters, odors etc. are very common. Landfill leachate is the major sources of to surface and ground water contamination. The polythene and other solid waste is liable for water clogging, lessen fertility of the land. The light blowing solid waste, odors are injurious to public health and unaesthetic. Solid waste heap is unsightly and unwanted view for tourism sector development. Flies, mosquitoes, rodents, and other diseases vectors are very common

in the city for inefficient solid waste. Industrial and clinical waste poses environment pollution and also causes serious public health concern. Uncontrolled infectious clinical waste recycling is identified as most dangerous to public health.

The developed societies manage their volume of waste as resource. Solid waste is one kind of biomass. It is renewable source of resource recovery. Both material resource and energy resource recovered from solid waste. Material resource recovery can be done through reuse and recycling. Energy resource can be achieved by recycling. Paper, plastics, rubber, metals and all other waste could be used for resource recovery. Heat combustion for heat energy, methane gas recovery, Charcoal, tar and char etc could be recovered from solid waste. Incineration ash can be used for road sub-base. Compost is the best resource recovery from organic waste. It is a good soil conditioner. In Dhaka city the recycling is done by the informal sector. Composting is not yet popularized. More than 50% of generated solid waste of Dhaka is organic in nature. It is possible to make the composting which will save the chemical fertilizer.

There are lot of problems identified in solid waste management of Dhaka city. DCC does not have sufficient resources need for efficient solid waste management. Incompetent workforce, lack of technology, insufficient financial capability, very poor people's awareness and perception about environment pollution, weak legal functionaries and very weak enforcement of law has identified as constraints for solid waste management.

In the present context, it requires an integrated approach to solid waste management of Dhaka city for sustainable environmental development. Policy guideline from the government, organizational capability of DCC and peoples participation is the key to efficient solid waste management. A competent workforce, sustainable technology for composting (treatment plant), cost recovery base well-built financial support, strong legal provision and enforcement, people's awareness and participation, public-private sharing, maximum waste recycling approach are the key factors for efficient solid waste management. The government through subsidies should patronize composting. More compost production will save the chemical fertilizer as well as keep the solid waste management cost minimum and decrease the environment pollution possibility. If all the stakeholders relating solid waste generation, collection, treatment and disposal extend their cooperation and participate in recycling program, then the unsightly, odorous solid waste would be a renewable resources rather than mere a waste. It will generate employment, resource recovery as well as ensure sustainable environmental development.

CONTENTS

Certificate	i
Declaration	ii
Acknowledgements	iii
Abbreviations	v
Abstract	viii
Contents	xii
List of Tables	xx
List of Figures	xxiii
 Chapter 1 : Introduction	 1
1.1 Backdrop	1
1.2 Statement of the topic	3
1.3 Review of literature	4
1.4 Justification/rationale of the Study	17
1.5 Research Gap	18
1.6 Significance of the Study	18
1.7 Thesis Questions	19
1.8 Objectives of the Research	19
1.9 Scope and Limitation of the Research	20
1.9.1 Scope	20
1.9.2 Limitations	20
1.10 Methodology followed the research	20
1.10.1 Types of Research	21
1.10.2 Methods of Research	21
1.10.3 Tools of Data Collection	21
1.10.4 Nature of Data for the Research	21
1.10.5 Sources of Data	22
1.10.5.1 Primary Data Source	22

CONTENTS

Certificate	i
Declaration	ii
Acknowledgements	iii
Abbreviations	v
Abstract	viii
Contents	xii
List of Tables	xx
List of Figures	xxiii
 Chapter 1 : Introduction	 1
1.1 Backdrop	1
1.2 Statement of the topic	3
1.3 Review of literature	4
1.4 Justification/rationale of the Study	17
1.5 Research Gap	18
1.6 Significance of the Study	18
1.7 Thesis Questions	19
1.8 Objectives of the Research	19
1.9 Scope and Limitation of the Research	20
1.9.1 Scope	20
1.9.2 Limitations	20
1.10 Methodology followed the research	20
1.10.1 Types of Research	21
1.10.2 Methods of Research	21
1.10.3 Tools of Data Collection	21
1.10.4 Nature of Data for the Research	21
1.10.5 Sources of Data	22
1.10.5.1 Primary Data Source	22

1.10.5.2 Secondary Data Source	22
1.10.6 Tools of Data Collection	23
1.10.6.1 Questionnaire Survey	23
1.10.6.2 Observation	23
1.10.6.3 Key Informant Interview	24
1.10.6.4 Photographs	24
1.10.6.5 Case Study	24
1.10.7 Selection of the Study Area	24
1.10.8 Sample Size of Estimation of the Study	25
1.10.9 Sample Size and Justification	25
1.10.10 Sample Size Estimation and Justification	26
1.10.11 Sampling Procedure	26
1.10.12 Data Collection Procedure	27
1.10.13 Scoring the Awareness and Level of Acceptance	27
1.10.14 Data Analysis	28
1.11 Chapter Summary	28
Chapter 2 : Conceptual Framework of Solid Waste Management	30
2.1 Introduction	30
2.2 History of Earliest Waste Disposal in Brief	31
2.3 Definition of Key Terms	33
2.4 Objectives of Solid Waste Management	36
2.5 Solid Waste Classification	37
2.6 Solid Waste Characterization	40
2.7 Factors Affecting Quantity and Quality of Solid Wastes	43
2.8 Effect of the Solid Waste	43
2.9 Solid Waste Management Matrix	43
2.10 Integrated Waste Management	45
2.11 Integrated Waste Management Tool	47
2.11.1 Solid Waste Management Hierarchy	47
2.11.2 End-of-Pipe or Life Cycle Approach	48
2.11.3 Community-Participation	48
2.11.4 Technology Requirement Options	49
2.12 Solid Waste Management Functions	50
2.13 Identifying the Source of Generation	50
2.14 Collection and Transfer of Solid Waste	51
2.15 Collection and Transfer Mechanism	51
2.16 Public and Private Arrangement	51

2.17 Types of Collection	52
2.17.1 Primary Collection	52
2.17.2 Secondary Collection	52
2.18 Method of Primary Collection	52
2.18.1 Door- to-door Collection	52
2.18.2 Curbside Collection Service	53
2.18.3 Backyard Collection	53
2.18.4 Block Collection	54
2.19 Transfer Operations	54
2.19.1 Transfer Station	55
2.20 Location of Disposal Areas	55
2.21 Collection and Transfer Operation Management	56
2.22 Collection Equipment	57
2.23 Waste Processing	58
2.23.1 Screening	59
2.23.2 Shredding	59
2.23.3 Classification by Separation	59
2.23.4 Magnetic Ferrous Separation	60
2.23.5 Baling	60
2.24 Reduction, Recovery, Reuse, and Recycling	60
2.25 Treatment and Disposal	60
2.25.1 Hog Feeding	61
2.25.2 Ocean Dumping	62
2.25.3 Onsite Disposal	62
2.25.4 Simple Land Filling or Open Dumping	62
2.25.5 Sanitary Landfill or Secure Landfill	63
2.25.6 Importance of Sanitary or Secure Landfill	64
2.25.7 Landfill Site	65
2.25.8 Types of Sanitary Landfill	65
2.25.9 The Advantage & Disadvantage of Sanitary Landfill	65
2.25.10 Preliminary Landfill Requirements	65
2.25.11 Landfill Operating Parameter	67
2.25.12 Landfill Guideline	68
2.25.13 Incineration	72
2.25.14 Suitability of Incineration	75
2.25.15 Types of Incinerators	75
2.26 Special Waste Handling	77
2.27 Chapter Summary	78

Chapter 3 : Institutional Development and Legal Framework	80
3.1 Introduction	80
3.2 Development of the Environmental Institutions in Bangladesh	81
3.2.1 Ministry of Environment and Forests	82
3.2.2 The Department of Environment (DoE)	83
3.2.3 Development of Social Organization	85
3.2.3.1 Bangladesh Environment Network (BEN)	85
3.2.3.2 Bangladesh Poribesh Andolan (Environment Movement)- BAPA	86
3.2.3.3 Bangladesh Environmental Lawyers Association (BELA)	86
3.2.4 Environmental Laws Regarding Pollution and Conservation	86
3.2.5 Environmental Conservation Act, Rules, Regulation, Policies	88
3.2.6 The Bangladesh Environment Conservation Act, 1995 (Act 1 of 1995)	88
3.2.7 The Environment Conservation Rules, 1997	92
3.2.8 Other Environment Related Laws, and Rules and their Implications in Brief	93
3.2.9 Environment Policy, 1992	99
3.2.10 The National Environment Management Action Plan (NEMAP), 1992	102
3.2.11 The Dhaka City Corporation Ordinance, 1983	105
3.2.12 Enforcement of Environment Laws in Solid Waste Management	107
3.2.13 Respondents Opinion about the Legal Options	108
3.2.14 Rules, and Regulations for Industrial and Clinical Waste	109
3.2.15 Chapter Summery	110
 Chapter 4 : Present Practices of Solid Waste Management in Dhaka	 111
4.1 Introduction	111
4.2 Dhaka City Background	111
4.3 Urbanization Pattern of Dhaka City	113
4.4 DCC: From a Tiny Municipality to Mega City	117
4.5 Historical Background of Conservancy Service of Dhaka City	118
4.6 Solid Waste Management Practice of Dhaka City	120
4.6.1 Trend of Solid Waste Generation	127
4.7 Characteristics and Composition of Solid Waste of Dhaka City	127
4.8 Solid Waste Management Function of Dhaka City	131
4.9 Collection and Transport Operation	132
4.9.1 Primary Collection	132
4.9.2 Community Based Initiatives in Primary Collection.	134
4.9.3 CBO and DCC	136
4.9.4 Secondary Collection or Transportation	139

4.9.5	Peoples Behavior of Garbage Disposal	142
4.9.6	Solid Waste Amount Transported to Disposal Site	143
4.9.7	Conservancy Operation Management of DCC	144
4.9.8	Human Resources in Solid Waste Management	145
4.9.9	Cleansing Staff Salary	146
4.9.10	Deployments of Cleaners by Zone	147
4.9.11	Collection and Transportation Vehicles	149
4.9.12	Number of Dustbin and Waste Container	151
4.9.13	Privatization of Secondary Collection	151
4.10	Peoples Awareness and Participation SWM	155
4.11	Treatment and Disposal of Waste	159
4.12	Incineration	164
4.13	Disposal of Special Waste in Dhaka City	165
4.14	Financial Position of Solid Waste Management	169
4.15	Chapter Summery	172
Chapter 5 :	Impact of Present Solid Waste Management	174
5.1	Introduction	174
5.2	Environment Pollution	176
5.3	Environmental Sustainability	176
5.4	Solid Waste : Environmental Hazard or Risk	177
5.5	Solid Waste & Environmental Pollution Source	180
5.6	Solid Waste and Environment Pollution	181
5.6.1	Air Pollution	181
5.6.1.1	Refuse Burning and Air Pollution	182
5.6.1.2	Incineration & Air Pollution	183
5.6.1.3	Impact of Air Pollution	183
5.6.1.4	Air Pollution in Dhaka	184
5.6.2	Water Pollution	184
5.6.2.1	Solid Waste and Water Pollution	185
5.6.2.2	Surface Water Contamination	185
5.6.2.3	Ground Water Contamination	186
5.6.2.4	Water Pollution and Its Impact	187
5.6.2.5	Water Pollution in Around Dhaka City	188
5.6.2.6	Wetland Pollution	189
5.6.3	Land / Soil pollution	189
5.7	Solid Waste and Health Hazards	191
5.7.1	Environment Pollution and Health Effects of Open Dumping	192
5.7.2	Hazardous Wastes and Pollution	194

5.7.2.1	Medical Waste Impact	195
5.7.2.2	Industrial Waste Pollution	195
5.7.2.3	Tanneries Waste Impact in Dhaka	196
5.8	Solid Waste Impact in and around Dhaka	197
5.9	Chapter Summery	199
Chapter 6 : Causes of Inefficient Solid Waste Management in Dhaka		200
6.1	Introduction	200
6.2	Causes of Inefficient SWM	200
6.3	The Operational Causes	201
6.3.1	Poor projection of generation and accommodation due to poor vision	201
6.3.2	Causes of Inefficiency in Primary Collection	201
6.3.3	Causes of Inefficiency in Secondary Collection	202
6.3.4	Causes of Inefficiency in Treatment and Disposal	203
6.3.5	Location of Dumping Site	204
6.3.6	Landfill Design	204
6.3.7	Waste picking / Recycling	205
6.3.8	Composting	205
6.3.9	Indiscriminate Mixture of Hazardous Waste	205
6.4	Basic Socio-Economic Causes	206
6.4.1	Technological Causes	206
6.4.2	Economic Causes	207
6.4.3	Financial Causes	208
6.4.4	Institutional Causes	209
6.4.5	Legal Causes	212
6.4.6	Social Causes	213
6.5	Some other general Causes	217
6.6	Chapter Summary	219
Chapter 7 : Solid Waste: Resource Recovery and Renewable Energy Source		221
7.1	Introduction	221
7.2	Importance of Resource Recovery	222
7.3	Resource Recovery Techniques from Solid Waste	224
7.4	Resource Recovery Factors	224
7.5	Types of Resources	226
7.6	Material Resource Recovery (MRR)	226

7.6.1	Resource Recovery through Waste Reduction / Minimization	226
7.6.2	Reuse	228
7.6.3	Recycling	229
7.7	Common Resource Recovery from Solid Waste materials	231
7.8	Composting: A Recovered Resource of MSW	238
7.8.1	Method of Composting	239
7.8.2	Composting procedure	241
7.8.3	Compost Marketing	245
7.8.4	Composting benefit	246
7.9	Energy Resource Recovery from Solid Waste	248
7.9.1	Importance Renewable Energy	248
7.9.2	Types of energy from Biomass	250
7.9.3	Factors Affecting the Energy Content	251
7.9.4	Types of Energy Recovery	251
7.10	The Use of 3 Rs	257
7.11	Impact of Resource Recovery	258
7.12	Recycling of solid Waste in Dhaka	259
7.12.1	Structure of Recycling Market	260
7.12.2	Main stakeholders in recycling sector in Dhaka	261
7.12.3	Major recyclable waste in Dhaka city	264
7.12.4	Legal options of recycling in Dhaka (Bangladesh)	265
7.12.5	Role of Waste Pickers	266
7.13	Prospects and Challenges of resource recovery in Bangladesh	267
7.14	Chapter Summery	268
Chapter 8 : Summary Findings, Recommendations, and Conclusion		270
8.1	Introduction	270
8.2	Summary Findings of the Study	270
8.2.1	Primary Collection	272
8.2.2	Secondary Collection and Transportation	272
8.2.3	Treatment and Disposal	274
8.2.4	Resource recovery	274
8.2.5	Use of 3Rs	275
8.2.6	Legal Aspects	275
8.2.7	People's Awareness	276
8.2.8	Solid Waste and Environment Pollution	276
8.3	Recommendations of the Study	278

8.3.1	Waste Generation	278
8.3.2	Primary Collection /Cleansing Operation	278
8.3.3	Secondary Collection/Transportation	279
8.3.4	Technology	279
8.3.5	Treatment and Disposal	280
8.3.6	Recycling operation & Use of 3Rs	280
8.3.7	Legal Options	281
8.3.8	People's Participation	281
8.3.9	People's Awareness	281
8.3.10	Health and Environment	282
8.3.11	Institutional Development	282
8.3.12	Policy Options	282
8.3.13	Miscellaneous	282
8.4	Summary Recommendation	283
8.5	Approaches for Implementation	284
8.6	Recommendation for Further Studies	285
8.7	Conclusion	286
	 Bibliography	 288
	Appendix A-C	299

LIST OF TABLES

Table 4.1	Population, Area and Density of Dhaka City 1864-2004	115
Table 4.2	Number of Conservancy Staff of Dhaka Municipality (1947-1964)	119
Table 4.3	Expenditure of conservancy services of Dhaka Municipality (1899-1900 to 1965-1966)	119
Table 4.4	Demographic Characteristics of the Respondent	121
Table 4.5	Profession and Education Level of Head of the respondent's Family	121
Table 4.6	Solid Waste Generation Per Family Per Day and Per Person Per Day in kg.	122
Table 4.7	Income Wise Solid Waste Generation per Family and Per Person Per Day	122
Table 4.8	Solid Waste Generated from Business Sector	124
Table 4.9	Total solid waste generated in DCC area	126
Table 4.10	Per capita solid waste generation of some Asian cities	127
Table 4.11	Solid waste composition of Dhaka city	128
Table 4.12	Total solid waste composition	130
Table 4.13	General information about primary collection	133
Table 4.14	Respondent's Response on Community Based Collection Information	134
Table 4.15	Respondent's Responses about the role of DCC in controlling CBOs	137
Table 4.16	Respondent's responses about CBOs based primary collection all over the city	137
Table 4.17	Respondent's responses about present time schedule for secondary collection (%)	139

Table 4.18	Respondent's responses about suitable time of secondary collection (%)	140
Table 4.19	Information (respondent's responses) on Secondary Collection (%)	140
Table 4.20	Respondents opinion (in percentage) about causes and remedies for improper cleanliness activities	141
Table 4.21	Respondents opinion (in %) about generators way of solid waste disposal	142
Table 4.22	Respondents responses (in %) about causes and remedies for throwing waste here and there	142
Table 4.23	Number of DCC's vehicles and amount of solid waste carried to different landfill sites in March 2004	144
Table 4.24	Total officer-staff in the head office and other related department of DCC	145
Table 4.25	Categories strength of DCC's Employee	147
Table 4.26	Distribution of Cleaners	148
Table 4.27	Comparative data of cleaners, waste generation and collection and population.	148
Table 4.28	Ideal situation of cleaners distribution	149
Table 4.29	DCC's Transportation Vehicles	150
Table 4.30	Number of dustbins and other containers	151
Table 4.31	General information about private contractors	152
Table 4.32	Respondents opinion about privatization of SWM activities	154
Table 4.33	Respondents opinion (in %) about secondary collection by the private firm	154
Table 4.34	Respondents response about household garbage disposal monitoring	155
Table 4.35	Respondents opinion about their role for SWM	155
Table 4.36	Respondents response to legal provision of SWM	156
Table 4.37	Respondent's opinion about the awareness building program and DCC's inspection activities	156

Table 4.38	Respondents opinion about effective awareness building program for SWM	157
Table 4.39	Perception level of household respondents	158
Table 4.40	Some information about landfill sites	160
Table 4.41	Facilities of Matuail landfill site	161
Table 4.42	Heavy equipment for landfill sites	164
Table 4.43	Types of hospital waste	167
Table 4.44	Number of hospitals and beds in Dhaka	167
Table 4.45	Financial balance of SWM for last 4 financial years. (in million taka)	171
Table 4.46	SWM expenditures by operation (in million taka)	171
Table 4.47	Department Wise SWM Cost (in million taka)	171
Table 5.1	Major industries and heavy metal pollution around Dhaka city	190
Table 6.1	Financial Balance of DCC for the year2002-2003	208
Table 7.1	Energy conversion process	254
Table 7.2	Heating value of solid waste	255
Table 7.3	Estimated recyclable material volume.	260
Table 7.4	Number of waste collectors in Dhaka city	261
Table 7.5	Major recyclable wastes and recycled products in Dhaka city	261

LIST OF FIGURES

Figure 2.1	Integrated Waste Management	46
Figure 4.1	Population of Dhaka City over the Time	114
Figure 4.2	Trend of population growth in Dhaka city (1961-2020)	115
Figure 4.3	Expansion of Dhaka city and Neighboring Area	117
Figure 4.4	Chronological Development of conservancy service in Dhaka	120
Figure 4.5	Solid waste generation from different sources (figure in metric ton)	126
Figure 4.6	Projected trend of solid waste generation in DCC for the next 20 years	127
Figure 4.7	Household Solid Waste Composition by Volume	129
Figure 4.8	Percentage of weighted average solid waste composition	129
Figure 4.9	Total composition of solid waste of Dhaka City	130
Figure 4.10	Primary and Secondary Collection	143
Figure 4.11	Organogram of DCC Conservancy Department	145
Figure 4.12	Revenue income of the DCC	170
Figure 4.13	Solid Waste Management Cost Flow	172
Figure 7.1	Flow diagram of recyclable marketing	260
Figure 8.1	Policy Guideline for efficient solid waste management.	283

Chapter 1

Introduction

1.1 Backdrop

Present world is facing different environmental problems creating from various causes. It is said that due to population growth, unwise and indiscriminate environmental resources utilization, unplanned urbanization and infrastructures development, industrialization, emission of huge CO₂ and other hazardous gaseous substance by industrial activities etc.; are creating various environmental problems such as urban and industrial waste management, pollutions, climate change and ozone layer depletion, biodiversity degradation, ecological imbalance, water scarcity, natural resource degradation and so on. Among those problems urban and industrial solid waste management is a severe problem in present world. In fact the present world is confronting with two major environmental problems, which are inter-related. These are how to use available resources in a sustainable manner in increasing demand of the resources and how to manage the waste generated by the increasing population to maintain the integrity of the environment. Waste generation is a natural phenomenon to the human society. It is augmented with the increasing of urbanization in different country in different era. The different governments of the countries have taken diverse policies and measures to manage urban and industrial waste. But at present it is observed that those policies and measures are not sufficient for urban and surrounding environment. For this reason urban and industrial waste has become major environmental problem in the developed as well as developing countries at the present time. And environmentalists are demanding an environment friendly and sustainable waste management measures from global bodies.

It is no secret that solid waste has been an issue for many hundreds, if not thousands of years. The term "out of sight", "out of mind", policy was adopted to dispose the waste even up to the first few decades of the twentieth century.¹ Earlier conceptions were compartmentalized: a closest living space and remote space for undesirable by-product (wastes). However, rapid population growth and more resource consumption and therefore a commensurate increase in waste generation have bound to change the idea of leaving waste isolate. It is not possible to throw the wastes over the fence, into the public pathway, vacant land, gutters, rivers wetlands, etc. However, the humanity cannot confine the waste in a clean living space; they have to live with their waste in the same place.²

¹ UNEP, *International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management* (UNEP & International Environmental Technology Center, Osaka/Siga: 1996), p. ii

² FTK Seife, "The Role of EIA in Waste Disposal and Management", *Pollution Control & Waste Management in Developing Countries*, Rogers W'u Okot-UMA, *et al*, eds. (London: The Commonwealth Secretariat, 2000), pp. 281-282.

Dhaka city is struggling like other cities and towns of the developing countries to provide an effective waste management service and this problem is exacerbating by rapid and unplanned urbanization. The world's population will be at least 8 to 12 billion in 2100. Though this number is not too concern in respect of number and to the impact on the planet's environment and its resources but much more concern on per capita level of resource consumption and the way they will manage the planets resources and environment. Today, for example, an individual human being uses several magnitudes of energy and mineral resources compared with an average individual one of hundred years ago.³ The sheer immensity of voluminous solid waste, the financial and infrastructure constraints including the lack of land for safe disposal of waste generated, lack of awareness and apathy at all levels have come in the way of inefficient and unsafe solid waste management. Over the years a progressive decline in the standard of services with respect to collection and disposal of municipal waste has occurred. About 35% of the urban population in Asian countries does not have any access to adequate sanitation.⁴ They lack drinking water and rudimentary sanitation facilities. A very high proportion of the people live in dilapidated and overcrowded houses. Garbage lies rotting outside their makeshift shelters, restricting access along narrow unpaved pathways and clogging surface drains.⁵

Solid waste management with other essential services cannot keep pace with increased population. Municipal or private hired sweepers, dumped into the back lanes or in stern drains, either collect the refuse. In middle to high-income areas, privately hired sweepers remove the trash to neighborhood pile; in low-income area, it is generally thrown into the back lanes. Periodically the refuse pile is transported by the grossly inadequate fleet of garbage vans to a municipal dumping site located away from city center. Officially one-third of solid waste generated in Karachi reaches in municipal dumpsite. Rotting garbage is most localities of the city are very common site⁶. The picture of Dhaka city is no more well enough than of Karachi. About 40% solid waste is dispersed and goes to drains, lakes, ditches and open spaces or elsewhere. Presently, solid waste is indiscriminately dumped on roads and into open drains, thus leading to serious health risk and degradation of living environment for millions of urban citizens. The quantum of waste in this region is high, owing to higher level of population density in the cities. The

³ Jon E. Gould, "Solid Waste Reuse and Recycling", *Pollution Control* p. 354.

⁴ An Unpublished "Concept Paper presented in SAARC Workshop on Solid Waste Management" (10-12 October, 2004, Dhaka), by Ministry of Environment and Forest, Government of Peoples Republic of Bangladesh, p.1.

⁵ Kwesi Darkoh, "Environmental Impacts of Urbanization", *Pollution Control*, p. 55.

⁶ An Unpublished "Concept Paper" presented in SAARC Workshop. p, 3.

tropical Asian climate with high level of rainfall and huge humidity coupled with the organic character of waste aggravates the problem of solid waste disposal. It is a complex task consuming 30% to 50% of municipal revenues and involves a variety of actors from city managers to small and large generators of waste. Its efficiency and effectiveness largely depends upon appropriate technical and managerial skill and support, transfer, recycling and dispose.

1.2 Statement of the topic

The people are producing more waste then ever before. With the development and spread of technology, industrialization, urbanization etc.; improve standard of living wich is resulting generation of waste. It is said that waste is an unwelcome effect of development. Due to industrial revolution and technological development, life has become easier, simple and comfortable but also responsible for generating a large amount of waste products in every day life.⁷ Waste refers to material leftover, rejected or thrown away, as well as the unwanted by-products of a manufacturing process. Waste management is a major challenge for governments around the world but it is not far-reaching task. Therefore, its disposal and management becomes a critical feature in urban planning in developing countries.⁸

Many cities generate more solid wastes than they collect or dispose it. The volume increases with the increase of income level and improve of living standard. In low and middle-income countries municipal waste management services often swallow between a fifth and a half city budgets, yet much solid wastes is not removed. About 30% to 50% wastes are not collected in most of the Afro-Asian countries whereas 95% wastes are collected in the developed countries. Poor neighborhoods generate lower wastes and typically receive low service because of congested road facility and or lack of other facilities for financial constraints.⁹

Solid waste management in Bangladesh is still primitive in nature and needs mobilization and innovative approach for its proper management. Dhaka including all other cities in Bangladesh simply collects, carry and dump around thirty percent of its solid wastes generated in urban areas into low lying lands aiming at land filling. This is the system of waste management. Improper and scattered storage, inadequate collection, and transfer, unhygienic way of recycling are causing urban environmental hazard such as pollutions, health hazard, dirtiness etc.

⁷Nasreen Alam, *Simple Facts about Environmental Pollution* (Dhaka: Luthfun Nesa Ahmed, 2002, p. 51.

⁸ UNEP, TUNZA; *Acting for a Better World* (UNEP, 2003), pp. 114-117.

⁹ World Bank, *Development and the Environment: World Development Report, 1992* (Washington: Oxford University Press, 2002), p. 53-55.

Crude and uncontrolled open dumping of wastes in low lands for landfill has resulted surface and ground water contamination largely dangerous for public health. Hazardous solid wastes are often indiscriminately mixed with municipal solid wastes, greatly compounding the threats posed to human health and environment. The growing demands for improved public services for efficient handling of solid waste are under no way of questioning.¹⁰ Dhaka City Corporation has not shown efficiency in handling solid waste management. Considering the environmental importance, it is ardent to have an integrated solid waste management policy guideline for efficient solid waste management. For this end, the researcher has undertaken the topic for conducting the research.

1.3 Review of literature

For any research work, review of literature is an important and essential part to find out the knowledge gap. However, in the research area, as far as the researcher knowledge goes, there was no thorough study held in Bangladesh. Some partial studies have done on solid waste management in Bangladesh. However, for the study purpose, the available relevant literature had reviewed and presented here.

Solid Waste Management Overall Issue, Trivedi (1992)¹¹

This is the 24th volume of environmental science encyclopedia. In this volume the basic idea of solid waste management is discussed. From definition, to final disposal of solid waste is given in short. Source of generation, characteristics, properties, health and injury hazardous, primary and secondary collection, disposal options etc. discussed in the volume. Composting is given more priorities in recycling options. Disposal of large waste also included in the discussion. However, the environmental pollution is not cover in the text.

Hamid and Huq (1998)¹²

This book is a compilation of papers presented at a seminar in Dhaka aiming at creating awareness of recent developments in public sector management at the local government level. The problems facing in Asian cities are rapid urbanization and migration, growing demand for improved service, and declining support from the government. Contemporary approaches to municipal management are the outcomes of these initiatives and presented in three volumes. Volume I deals with 'Leadership and Change in City Management', Volume II deals with 'Municipal Management Issues in South Asia' and Volume III deals with "Reforming Dhaka City Management". In the third

¹⁰ Noved Hamid and Saleemul Huq, eds., *Asian Cities in the 21st Century: Reforming Dhaka City Management*, Vol. 3. (Dhaka: Asian Development Bank, 1998), p. iii.

¹¹ P.R. Trivedi and Gourdeep Raj, *Encyclopedia of Environmental Science*, Vol. 24 (New Delhi: Akashdeep Publishing House, 1992).

¹² Hamid, and Huq, Eds., *Asian Cities in the 21st Century*, Vol. 3, p. iii

volume mainly discusses the institutional issues, financial management, and solid waste management of Dhaka city and provides recommendations on organizational reforms. Solid waste issue has discussed in a low profile. It was prepared based on secondary data from DCC, no detail study on this issue has been done.

Corbitt (1999)¹³

The book is written from engineering point of view. With all other environmental issue the solid waste management is discussed thoroughly from engineering perspective. The functional elements of solid waste management are elaborated and detailed discussion on engineering guideline. From primary collection, transportation, processing, treatment and disposal options are discussed in detail. Particularly, the sanitary landfill construction is given more priority with engineering design. Hazardous waste management is also included in a separate chapter. The book is very much helpful for designing a sanitary landfill. However, the environmental consequences are not discussed in the book.

Okot-Uma (2000)¹⁴

The book is a compilation of 15 articles. The book is a pioneer one with lot of issues of waste management. Solid waste management practice in African countries, their environmental concern, role of community based organization, possibility of recycling and composting, role of NGOs in waste handling, clinical and industrial waste handling etc topics covered in the book. Environmental concern and sustainable way of solid waste management in developing countries are is the main thirst of the book. The functional aspects of solid waste management are also covered in the text.

Solid Waste and Environment Pollution, Keller (1985)¹⁵

Keller in his book 'Environmental Geology' discussed the solid waste as well as the hazardous waste disposal system from the environmental viewpoint. The author analyzed how the pollutants come up from the waste and its impact. He also discussed the method of scientific waste management so that the pollution would be minimum. Solid waste is treated as renewable source of energy like other biomass. It is discussed the system of converting the solid waste into renewable energy and also described the sustainable disposal options.

¹³ Robert A. Corbitt, Eds., *Handbook of Environmental Engineering*, 2nd ed., (New York: McGraw-Hill, 1999).

¹⁴ Rogers W'u Okot-UMA, et all, eds., *Pollution Control & Waste Management in Developing Countries*, (London: The Commonwealth Secretariat, 2000).

¹⁵ Edward A. Keller, *Environmental Geography*, 4th ed., (Ohio, USA, Charles E. Merrill Publishing Co., 1985).

Rahman, Huq and Conway (1990)¹⁶

The book is a compilation of contributions from eminent experts from Bangladesh and abroad on water related issues from different disciplines including the natural, engineering, health and social sciences. The core discussion of this book is the review of the state of knowledge on all environmental aspects relating to surface water system of Bangladesh. Bangladesh is the world's largest delta and the land of many water bodies. Water dominates life, people and the economy of Bangladesh. But the water bodies of Bangladesh has become contaminated and polluted due to various reasons. The book's main thrust was given only on environmental aspects of surface water systems. How the industrial effluents contaminate the water bodies were discussed in detail among other issues.

Sadeque (1992)¹⁷

This is also the compilation of some papers presented in the national workshop arranged by Bangladesh Sociological Association in 1991. The articles published in this volume more or less related with the environmental issues. How the natural resources suffered and the environment is deteriorated in Bangladesh has been focused in this book. The rich but fragile natural resource base of Bangladesh, over time, has suffered from unsustainable and uncoordinated development activities, much of which has resulted in massive resource depletion and environment degradation. Environmental issues has discussed in comparison to natural resources base. On the other hand, the book did not include the urban environmental issue like air pollution, waste management, traffic jam etc. Specifically the waste management and its impact did not even touch in this book.

Gain (1998)¹⁸

It is discussed the state of environment Bangladesh, to a large extent, attempts to project some important signs of the times and what is coming in the 21st century. It is clearly depicted that World Bank, ADB, UNDP, USAID and lot of other Donor Agencies always suggest Bangladesh like other developing countries to do according to their advice or suggestion. In the name of globalization, developing countries are made dependent. The underdeveloped countries or LDC's are losing their identity; destroy its environment, made them dependent on developed world. It is tried in this book to understand that there is linkage between own resource (land, soil, water, agriculture, forestry, fishery etc) of a county and its environment.

¹⁶ A. Atiq Rahman, Saleemul Huq and Gordon R. Conway, *Environmental Aspects of Surface Water Systems of Bangladesh*, eds. (Dhaka: The University Press Ltd., 1990).

¹⁷ S. Zahir Sadeque, *Environment and Natural Resource Management in Bangladesh* (Dhaka: Bangladesh Sociological Association, 1992).

¹⁸ Philip Gain, ed., *Bangladesh Environment: Facing 21st Century* (Dhaka: Society for Human and Environment Development-SHED, 1998).

It is stated in the book that modern agriculture, industry and its affluent, wrong way of development approaches & activities, misuse & over extraction of natural resources, and lack of awareness causing degradation of the environment. It is nicely spelt out the present condition of land, soil, landscape, river, water, wetlands, agriculture, forests, fisheries, wild life, bio-diversity, and genetic and energy resources of Bangladesh. In this book it is also suggested how to address the environmental issues for sustainable development.

Rahman and Ali (2000)¹⁹

In the article, the authors describe the impact of human excreta, municipal solid waste, and industrial wastes on environment. The most serious concern is the crude open dumping of solid wastes in low-lying areas leading to potential surface and groundwater contamination. Disposal of untreated industrial wastes into rivers and streams is gradually destroying the aquatic environment. The paper mainly suggested for preparing a national waste management policy in order to protect the environment pollution.

Ahmed (2000)²⁰

This is an important book on environmental issues edited by M. Feroze Ahmed and published by Bangladesh Poribesh Andolon (Bangladesh Environment Movement). It is a compilation of technical papers of the 1st International Conference on Bangladesh Environment (ICBN-2000). There are 59 articles were compiled in this book. The broad themes are environment and civil society, Arsenic contamination in ground water, wetland, forest and biodiversity, agricultural and environment, water supply, waste management, water and soil pollution, water resource management and environmental health and development. The papers contain important data to describe the present environmental conditions and major threat to environmental degradation in Bangladesh. Under the waste management sub-title there are five articles are published.

United Nations Environment Program–UNEP (2001)²¹

The Bangladesh State of Environment (SoE) 2001 Report has been prepared as a response to the recommendation provided in Agenda 21 at the earth summit. The objective of the SoE is to identify the key environmental issues that act as barriers to attain sustainable development and provide guidelines for environmental planning, policy

¹⁹ Md. Mujibur Rahman and M. Ashraf Ali, "Waste Management and Environmental Pollution in Bangladesh", Firoze Ahmed, ed. Bangladesh Environment 2002, Vol. 2. pp. (Dhaka: Bangladesh Poribesh Andolen-Bapa, 2002), pp. 425-435.

²⁰ M. Feroze Ahmed, ed., *Bangladesh Environment 2000*, (Dhaka: Bangladesh Poribesh Andolen-Bapa, 2000).

²¹ United Nations Environment Program (UNEP), *Bangladesh: State of the Environment, 2001* (Klong Luang, Thailand: 2001).

setting, and options that can be undertaken to offset any negative environmental trends.

In these report five key environmental issues, viz, land degradation, water pollution and scarcity, air pollution, bio-diversity and natural disasters were identified as the environment deteriorating factors. Causes for degradation identified as rapid population growth, improper use of land, poor resource management, and uncontrolled discharge of pollutants from industries, vehicles etc. It is unfortunate that there is no implication of waste management issue in this report.

Bhatia (2002)²²

This is a handbook with two volume of through and detail analysis of pollution from different aspects. Pollution control measures have got more detail analysis in the book. Particularly pollution from solid waste and its control mechanism has discussed in detail. It is discussed how soil, water and air polluted from different stages of waste handling and how this can be controlled. All the discussion has been related with the Indian perspective based on American solid waste management system. However, in the volume 1, general aspects of solid waste is analysed in detail. Particularly the recycling of paper, plastics, rubber, metals and other recyclables and their processes discussed in the book. Incineration ash, sewage sludge disposal options are also articulated there.

Chowdhury, (2002)²³

The book 'Peoples voice' is almost like a discussion paper from different corner of the society. The local peoples from all walks of life-including the farmers, fishermen, factory workers, women as well as the professional from different vocational and trade organizations participate in the program. People's voice here thus means the grassroots level consultations identified the common people's opinion on a wide variety of topics related to environment and sustainable development. The core thrust of the book is the level of environmental degradation took place through the day-to-day work of the society and how is the people's perception of the matter. In this book, it is whole-heartedly tried to charting a future course of action for the nation on its path to sustainable development.

Ahmed, Tanveer & Badruzzaman (2002)²⁴

This is an important compilation of environmental issues edited by M. Feroze Ahmed and two others in two volume. This is the outcome of technical papers of the 2nd International Conference on Bangladesh Environment (ICBN-2002). There are 89 articles

²² S.C Bhatia, *Handbook of Industrial Pollution & Control*, Vol. 1 & 2 (New Delhi: CBS Publishers and Distributors, 2002).

²³ Quamrul Islam Chowdhury, ed., *Bangladesh Road to Sustainable Development: People's Voice*, (Dhaka: Forum of Environmental Journalists of Bangladesh [FEJB], Ministry of Environment & Forest and UNDP, 2002).

²⁴ M. Feroze Ahmed, Saleh A Tanveer, ABM Badruzzaman, eds., *Bangladesh Environment 2002*, Vol. 1 & 2. (Dhaka: Bangladesh Poribesh Andolen-Bapa, 2002).

were compiled in two volume. The broad themes are environment and civil society, Arsenic contamination in ground water, wetland, forest and biodiversity, agricultural and environment, water supply, waste management, water and soil pollution, water resource management and environmental health and development. The papers contain important data to describe the present environmental conditions and major threat to environmental degradation in Bangladesh. Under the waste management subtitle there are 16 articles are published. Solid waste management in Bangladesh, environmental consequences, industrial and clinical waste disposal system etc. are discussed.

Bhuiyan (2002)²⁵

This is a study report on unplanned waste disposal and possible impact on subsurface environment of Dhaka city. The study has conducted to show how the dumping site of Mirpur, Lalbag, and Matuail is contaminating the ground water. More than 80% of water supply in the city is dependent on ground water. The average thickness of impermeable layer of Dhaka city ranges from 5 to 10 meter. For this reason the leaching contamination of wastes seriously degrade this ground water. The study suggested that waste-dumping site should be in the area of Gagipur, Kaliakoir, Tongi, Joydebpur where the average thickness of impermeable layer ranges from 60 to 80 m. The study suggested making landfill in that area which has a natural barrier to protect ground water from leaching contamination.

Shamsuzzoha (2002)²⁶

This is an article titled "Dhaka City's Waste and Waste Management Scenario". The paper describes how environmental degradation is taking place in the capital city due to uncontrolled discharge of liquid and solid waste from domestic, commercial, and industrial sources. It identified the causes, such as lack of proper planning; insufficient finance and inadequate institutional capability are responsible for inefficient solid waste management.

Urban Governance and Solid Waste Management, Rahmam and Islam (2000)²⁷

The article articulates the growth pattern of Dhaka city and its impact. The authors describe that the rapid population growth and urbanization witnessed depletion of non-renewable energy and solid wastes, toxic waste affluent posing serious treats to the environment. The authors suggested for Implementation of planned town and decentralization, community participation and strengthening the local government for environmental sound city management.

²⁵ Md. Amir Hossain Bhuiyan, Nasser Ejazul Huq and Md. Moinul Hossain, "Unplanned Waste Disposal and its Possible Impact on Surface Environment of Dhaka City, Bangladesh", *Bangladesh Environment*, 2002, Vol. 2, pp. 723-731.

²⁶ M. Shamsuzzoha, "Dhaka City's Waste and Waste Management Scenario", *Bangladesh Environment* 2002, Vol. 2, pp., 818-829.

²⁷ Golam Rahman and Md. Monirul Islam, "Urban Growth Pattern in Dhaka City and its Problems of Urban Solid Waste Management", *Bangladesh Environment* 2000, pp. 436-443.

Islam (2000)²⁸

This is book of compilation of some articles entitled "Urban Governance in Asia" edited by Nazrul Islam. The book contained the governance system of some big Asian cities. There is an article written by Nazrul Islam and Nazrul Islam Khan titled 'Urban governance of Bangladesh and Pakistan' and another article by Nazrul Islam titled 'Reforming Governance in Dhaka, Bangladesh'. Both of the articles contained system of governance, their problems and some political reformation. Among the problems, solid waste management problem has not included.

Solid Waste Management Technology Issue, UNEP (1996)²⁹

International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management, focuses on just one factor that is contributing to the deterioration of the urban environment; the difficulty of managing Municipal Solid Waste (MSW). In this book, attempt has been made to find out the way of access to information about the solid waste and the Environmentally Sound Technologies (ESTs) that have the long- term consequences. Typically, it is not clear to an urban official that how well a particular technology or policy will work, in terms of dealing with the immediate problems face in collecting, transporting, and disposing of garbage.

The source book brings together experiences and ideas regarding solid waste management in the world dividing into 5 (five) separate areas. They are Asia and the Pacific, Africa, Europe, Latin America and the Caribbean and North America. Undoubtedly, Bangladesh is in backwardness in managing solid waste, but solid waste management position of Bangladesh did not assess and discussed under Asia and Pacific region. So it is not clear that how far the techniques available in the region will keep fit for Bangladesh.

Community Participation in Solid Waste Management, Cotton (1998)³⁰

This manual investigates the extent and nature of the involvement of low-income urban communities in the provision of their local infrastructure. It also provides guidance for policy makers and professional staff of urban government, development agencies, non-government organizations, and small to medium enterprises for promoting more involvement of communities in the procurement of neighborhood (tertiary level)

²⁸ Nazrul Islam, ed., *Urban Governance in Asia: Sub- regional & City Perspective*, (Dhaka: CUS & Pathak Samaj, 2000).

²⁹ United Nations Environment Programme (UNEP), *International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management*, Issue NO. 6 (Osaka/Shiga: International Environmental Technology Centre Publication Series, 1996).

³⁰ Andrew Cotton, M. Sohail and W.K. Tayler, *Community Initiatives in Urban Infrastructure* (Loughborough, UK: WEDC Publications, 1998)

infrastructure. In this book, case studies are examined. It is stated that infrastructure is the main component of effective solid waste management. Community participation is treated as part of the infrastructure. The motivation, awareness etc. are neglected in the study.

Sinha and Enayetullah (2000)³¹

This publication is a compilation of papers presented by the participants in the seminar from different Asian cities organized by Waste Concern, an NGO. In this book, solid waste is shown as a daunting problem for the South Asian cities, but there are also encouraging and successful stories of innovative approach in this region. The papers presented here demonstrate that Community Based solid waste management is a realistic approach to solve the solid waste disposal problem at local level. Moreover, municipal authorities in some Asian cities are showing interest in these initiatives by supporting communities or private sector to manage a portion of solid waste management services at local level. It is hoped that in more and more cities and towns, the concerned institutions and organizations would be inclined to promote community based solid waste management approach and will integrate with main stream solid waste management system for eventual improvement of the environment. But how far the community participation will be sustainable for collection, transfer and final disposal of waste that has been yet to be answered.

Alam (2002)³²

This is an article on solid waste management. It is a case study at Nirala residential area, Khulna, a very small study of solid waste management system on Nirala residential area of Khulna city. It is revealed from the study that the solid waste management system in the said area is neither satisfactory nor adequate. The study suggested for community based initiatives and collaboration with Khulna City Corporation for effective disposal. It seems that it emphasizes public-private sharing in solid waste management. It is an empirical study but with a volume of only 6 (six) page report covers a very little.

Huda (2002)³³

The author in his article "Municipal Solid waste management: Dhaka city perspective" opined that proper waste management is the responsibility of Dhaka City Corporation but it cannot manage its waste up to the satisfaction level. This is suggested

³¹ A.H.M. Maqsood Sinha and Iftekhar Enayetullah, *Community Based Solid Waste Management: The Asian Experience* (Dhaka: Waste Concern, 2000).

³² A.K.M Mazharul Alam, S.K. Saha and M.M.S Rahman, "Aspects of Solid Waste Management- A Case Study at Nirala Residential Area, Khulna," *Bangladesh Environment* 2002, Vol. 2. pp. 698-702.

³³ K.M Nurul Huda, "Municipal Solid Waste Management: Dhaka City Perspective", *Bangladesh Environment* 2002, Vol. 2. pp. 732-746.

in the report to come up the community-based organization for better waste management. It is also suggested to strengthen the DCC's capacity and efficiency through regulation, reform and training. It is also suggested to come up government for economic exploration so that the private sector can come up in the waste management process.

Sustainable Solid Waste Management, Liu & Liptak (1999)³⁴

This is an engineering handbook for environment management. Out of several other chapters' solid waste management is one of the important chapters in the book. The authors describe that solid waste management continues to progress from conventional disposal methods to an integrated approach focused on source reduction and recycling. As land becomes more limited and regulations strict, the environmental engineer also directs attention to development and application of advanced disposal techniques. In the book the solid waste management has subdivided into five subsections to understand the efficient solid waste management. The sources, quantities and effects, characteristics, reduction, separation and recycling etc are described. In material recovery, refuse driven fuel (RDF) and waste to energy (WTE) has given more priority. The engineering construction of incineration plant with pyrolysis mechanism and landfill detail plotted in discussion.

Ali (1999)³⁵

The books illustrated key options of solid waste management. Key options identified as municipal capacity, political commitment, finance and cost recovery, technical guideline, institutional roles and capacities and locations of disposal site. The study founds framework for selection of disposal options for Karachi, Pakistan and review of available guidelines for planning landfill, keeping in view of situation in low-income countries. The book aims to help improve the poor practices of municipal solid waste management that prevail in many low-income countries through a management framework.

Zulhash Uddin (2002)³⁶

This article describes the pattern of decomposition and its impact on the environment in Bangladesh. Existing wastes dumping practices in Bangladesh lead to an anaerobic decomposition wherein slow anaerobic microbes activate only hence it produces harmful gas and foul odor makes environment pollution. Sanitary land filling, incineration, gasification, and composting are environmental friendly system of waste management. It has suggested that composting might be the most sustainable and

³⁴ David Liu & Bela G. Liptak, *Environmental Engineering Handbook*. 2nd ed. (New York: McGraw-Hill, 1999).

³⁵ Mansoor Ali, Andrew Cotton and Ken Westlake, *Down to Earth* (Loughborough, UK: WEDC Publications, 1999).

³⁶ Md. Zulhash Uddin and Nakajo Keigo, "Technology Selection for Sustainable Solid Waste Management, Bangladesh Aspects", *Bangladesh Environment 2002*, Vol. 2. pp. 830-844.

affordable technology of waste management in Bangladesh because of organic nature of its wastes and tropical region

DCC and JICA (2004)³⁷

This is a study report of DCC and JICA under the clean Dhaka master plan. JICA dispatched a short-term specialist for the technology transfer of the waste disposal from March to August 2000. Further in response to the request from the Bangladesh government for formulating a master plan JICA dispatched study team to conduct in the month of December 2003. It is the progress report of the study. The objectives of the study are:

- To formulate master plan concerning solid waste management in Dhaka city with the target of 2015.
- To improve and strengthen the capabilities and management skills of the Bangladeshi counterpart organization and personnel in term of solid waste management through the technology transfer during the course of the study.

This progress report prepared on the basis of secondary data and the final study report will prepare on physical study through the survey. The study covers solid wastes generation and its sustainable management to have a clean Dhaka targeted 2015.

Sanitary Landfill, Mahmood (2002)³⁸

It is a study report on importance of sanitary land filling of municipal solid waste in Bangladesh. In this paper, it is stated that simple land filling through municipal wastes creates serious human health and environmental problems. The migration of gas and leachate from the landfill sites and release into the surrounding causes health hazards and environment pollution. It is also suggested to segregate the hazardous industrial and clinical wastes from solid wastes before land filling. However, the author could hardly clarify the possibility of segregation and the viability of sanitary land filling in Bangladesh in his study. Sanitary land filling is a very expensive and highly technical.

Incineration as Solid Waste Disposal, Rand (2000)³⁹

In this handbook, it is stated solid waste management is becoming a big challenge for city managers. Rather land filling now it is thinking on mass burn of solid waste. To minimize the environmental impacts, incineration is better to land fill. Though the capital and operating costs are very high for this program, World Bank has come up with advice

³⁷ DCC & JICA, *Progress Report on Clean Dhaka Master Plan: The Study on the Solid Waste Management in Dhaka City* (Dhaka: Pacific Consultants International & Yachiyo Engineering Co. Ltd., March, 2004).

³⁸ Hassan Mahmud, "Importance of Sanitary Land filling of Municipal Solid Waste in Bangladesh," *Bangladesh Environment* 2002, Vol. 2. pp. 785-799.

³⁹ T. Rand, J. Haukohl and U. Marxess, *Municipal Solid Waste Incineration: Requirements for a Successful Project* (Washington: World Bank, 2000).

and financial support for incineration. It is the technical guidelines for decision makers to incineration of municipal solid wastes.⁴⁰

In order to minimize the environmental hazardous and day to day operational problems of sanitary landfill, incineration is another good replacement of solid waste management. World bank has began a program of providing high-level advice on approaches that basically financially self-supporting, socially and environmentally responsible. This is the technical guidance report providing Decision Maker's Guide to Incineration of Municipal Solid Waste. The report focuses on large-scale incineration plants for large urban areas or inter-municipal cooperatives. Part I of the report provides information needed to assess the feasibility of MSSW incineration and part II covers technical aspects and the available technologies for incineration plant. However, the report does not cover the incineration plant design.

Special Waste Handling

Construction Waste, Kamal Uddin (2000)⁴¹

The article is written on management of construction debris. The debris creates serious problems in the city life. The paper is the out come of research for utilizing the debris as road sub-base as raw materials. Laboratory and field tests showed that this waste could be used as road sub-base materials complying the standards and design criteria.

Clinical Waste Management

Nasima Akther (2000)⁴²

The article describes the handling procedures of medical waste in different countries, the knowledge and awareness of individuals involved in medical waste generation, handling and disposal and potential impact on health and environment. It is found medical wastes are disposed in different ways like burning, burial entombing, selling, and common dumping with other municipal solid wastes. The peoples are seriously affected by this waste when they come to contact with it.

The technical guidance report provides decision makers and their advisers with more elaborate information on how to investigate and assess the degree to which the key criteria are fulfilled. The report comprises a comprehensive account of many aspects of waste incineration. Part I of the report provides information needed to assess the feasibility of MSW incineration and part II covers technical aspects and the available

⁴⁰ World Bank, *Decision Maker's Guide to Incineration of Municipal Solid Waste* (World Bank: Washington, n.d).

⁴¹ M. Kamal Uddin, "Management of Construction Waste: Utilization of Construction Debris as Road Sub-base Material in Bangladesh", *Bangladesh Environment 2000*, pp. 413-424.

⁴² Nasima Akther, "Medical Waste Management: A Review", *Bangladesh Environment 2000*, pp. 445-460.

technologies related to and MSW incineration plant.

Imtiaz (2002)⁴³

This is a study report published in the book titled "Health-care waste of Dhaka city: a socio-environmental assessment". The goal of the study was to understand the overall health care waste disposal and to evaluate the system from socio-environmental perspective. It was stated that almost all the health care establishments have similarity of having no documented waste management policy or guideline. All categories of solid wastes are disposed by being mixing in open dump stations without pretreatment. The study suggested for separation at source and special disposal method without mixing to the common municipal solid wastes.

Nasima (2002)⁴⁴

This is a study report published titled "Scenario of hospital waste management in Bangladesh" conducted among four government, two private hospitals, two private clinics and two diagnostic centers. The aim of the study was to identify the weaknesses, and provide suggestions for improvement of hospital waste management. It is shown in the article that a satisfactory hospital waste management system is severely lacking in the country. The hospital wastes are disposed together with other solid wastes and creates several problem for human health and environment. This is a very short report and no in-depth and systemic analysis of the data.

Solid Waste as Source of Renewable Energy, Hinrichs & Kleinbach (2002)⁴⁵

Robert Hinrichs and Marlin Kleinbach has discussed about the different sources of renewable resources. Solid waste is treated as the biomass energy sources. They tried to explain how solid waste could be used as resources. All kinds of solid wastes are biomass and it can be used as compost or energy sources for resource recovery.

Bari (2002)⁴⁶

This is an article on measuring solid waste compost maturity: A review and practice. In this study, the authors evaluated the compost maturity, which is very important for its successful utilization. If the compost is not sufficiently matured, it will cause subsequent problems in storage, transportation, and utilization as soil conditioner.

⁴³ N. Imtiaz and M. S. Alam, "Health-care Wastes of Dhaka City: A Socio-environmental Assessment", *Bangladesh Environment 2002*, Vol. 2. pp. 751-769.

⁴⁴ Nasima Akther, "Scenario of Hospital Waste Management in Bangladesh", eds. *Bangladesh Environment 2002*, Vol. 2. pp. 674-689.

⁴⁵ Robert A. Hinrichs & Merlin Kleinbach, *Energy and Its Use and the Environment*, 3rd ed., (USA: Thomson Learning Inc. 2002).

⁴⁶ Hamidul Bari and A. Koenig, "Measuring Solid Waste Compost Maturity: A Review and Practice", *Bangladesh Environment 2002*, Vol. 2. pp. 712-722.

It is tried to show that there are lot of techniques of measuring the degree of maturity of compost. There are number of physical, biological and chemical tests can be done to measure the compost maturity.

Waste Picking

Rouse and Ali (2001)⁴⁷

In this book, solid waste is uses as the sustainable livelihood approach. Waste pickers in Dhaka make their living by selling recyclable items collected from dumped waste. Most of children live on the streets or in slums where they have little access to infrastructure, a low status in society and an uncertain future. Waste picking in Dhaka explored as livelihoods using Sustainable Livelihood Approach (SLA). It presents much of the livelihood information gathered, and discusses the effectiveness of SLA in this urban context.

Summery of the Literature Review

It is revealed from the literature review that most of the developing countries including South-East Asian region waste management means simply collection and crude open dumping. Urban environment management in general and solid waste management in particular is the integrated approach of appropriate rules, regulations, technological advancement, skill workforce, awareness and participation. Not only the government or local authority is solely capable of being successful without community participation. Inefficient solid waste management is a serious threat for environment pollution. Its impact is manifold. It is unsightly and bad odour producing elements. The leachate (juice) from dumping place contaminates the surface and ground water. In the developed world solid waste is reused and recycled for valuable recovery of resources. It has become a source of earnings. On the other solid waste management is mainly through open dumping. Recycling and resource recovery is informal sectors in developing countries.

In the developed country solid waste is managed from environmental engineering point of view. From primary collection to final disposal is done through highly technical means. Processing, transportation, treatment, and final disposal are done through engineered design. There are lot of engineered literatures and text is available in context of America and Europe. The sustainable solid waste management, environment pollution and resource recovery etc issues are well written and consumed by the society.

Solid waste management in Bangladesh is at nascent stage. Waste management means merely the collection, transportation and just open dumping. The irregular collection, inefficient transportation and simple dumping causes serious health and environmental hazards. There are no waste management policy guidelines or strategy.

⁴⁷ Jonathan Rouse and Mansoor Ali, *Waste Pickers in Dhaka* (Loughborough, UK: WEDC Publications, 2001).

Research and development in solid waste management gets low priority. There had been no comprehensive study in this regard.

There is very little literature on solid waste management issues in Bangladesh. Bangladesh Poribesh Andolen (Environment Movement) has taken a little initiative to conduct some study and publication on environmental issue. It is manifested from the literature review that there should be comprehensive study on solid waste management for the sustainable environmental development.

1.4 Justification/rationale of the Study

Urban environment management in general and solid waste management in particular is a major concern in the capital city of Dhaka. Due to inefficient solid waste management, human health problems, eco-imbalance, air and water pollution, loss of wealth in the form of degradation etc are the major hazards of Dhaka city life. The economic loss of the environmental degradation for solid waste is innumerable. It is estimated that economic loss to Bangladesh from air pollution-related premature mortality falls in the range of \$65 to 68 million. The economic cost of sickness related to air pollution falls between \$120-240 million.⁴⁸

To improve the over all environmental condition, Bangladesh took some important initiative such as establishment of Ministry of Forest and Environment (MoEF), Department of Environment (DoE), and enacted Environment Protection Act 1995. Moreover, the Government and DCC implemented a few projects. Nevertheless, the situation is undermining.

The present standard of waste disposal in Dhaka city is no way could be treated as efficient. The condition of other cities and towns in terms of waste management is much more deteriorating. The reasons are not primarily technical. It is mainly managerial, infrastructure and financial. Efficient solid waste management needs well-equipped institutions with well-designed programs, efficient and honest work force, sufficient resource, proper law and regulations with strong enforcement. There are number of department related with waste management functions. The coordination among related departments, public-private initiative and overall people's awareness and participation are also very important for effective solid waste management. Research and development is one of the key factors to find the right way of solid waste management. For this end, the researcher did not find any through research material yet in Bangladesh. Therefore, it was needed a comprehensive and systematic study about solid waste management of Dhaka

⁴⁸ Staff Correspondent, "Firm Political Commitment Needed to Combat Environmental Degradation", *The Daily Star*, (Dhaka: August 23, 2001), p. 7.

city. This study attempted to identify the various aspects of solid waste management with a view to develop an integrated waste management policy guideline, which would be combating for sustainable environmental development of Dhaka city in Bangladesh.

1.5 Research Gap

There are no enough studies conducted on solid waste management in Bangladesh except some limited numbers. Most of the study conducted on solid waste management of Dhaka and other cities in Bangladesh based on environmental viewpoint. No study gone for detail and intensity of the management problems of the solid waste. None could sure about the actual volume of the waste generated in the city. The studies so far conducted by different researchers discussed mainly the environmental impact of inefficient solid waste management. Still there is a major gap in the functional areas of overall waste management yet to explore. The present research has tried to cover all the vital aspects of solid waste management for sustainable environmental development.

Moreover, the previous researchers did not put forward any specific policy guideline for the city or municipal authorities for better and efficient solid waste management. Solid waste could be a very good renewable resource, is still undermining. Sensitization of society members is a very important tool for effective solid waste management. For that reason it was felt necessary to have a detail study in this regard. It was again manifested that solid waste management demands the coordinated effort of the institution, community and GO and NGO initiatives. Thus, it needed to govern a comprehensive study on the existing solid waste management situation of Dhaka City with a view to evolve a sustainable policy guideline for solid waste management.

1.6 Significance of the Study

The literature review reveals that a very few study was held on the solid waste management of Dhaka city. The study conducted earlier has done in the form of articles in different journals and dailies. Some thesis or dissertation was written for acquiring B. Sc or Masters degree in BUET. Some institutional study had done scattered to determine the environmental affect aiming to environmental development. However, no thesis or research work was conducted to make a comprehensive study to have a policy guideline for better solid waste management.

Urban environmental management in general and solid waste management in particular is a major concern for Dhaka city. Due to inefficient handling of the solid waste, human health problems as well as the environment pollution is severe in the city. Dhaka city needs an integrated waste management policy to boosts up its environment and as well as to utilize the wastes as a resource. The present standard of waste disposal in Dhaka city is nothing but open dumping. It is expected that the present research work

would be a masterpiece for effective and efficient solid waste management for Dhaka and as well as for all other cities and towns of Bangladesh.

Furthermore, it is expected that the research findings would be of great use for policy makers, urban authorities, planners, researchers and students as well as for the environmentalists.

1.7 Thesis Questions

For any research work, there should be some set questions to identify the research objectives. Research questions further help the researcher to determine the methodology for the study. As well other researches, there are some research questions of the present study. The questions are:

What it is meaning of solid waste management? What are the volume/quantity, types and characteristics of solid waste generated in Dhaka City? What is the waste disposal method followed in Dhaka city? What are the causes/factors responsible for straitened (terrible) circumstances in solid waste disposal of Dhaka City? How and what role are playing the CBOs and NGOs in operating the door-to-door waste collection functions in the city? What are the environmental consequences of inefficient waste handling? What is the level of awareness of city dwellers in handling solid wastes? What is the position of solid waste recycling in Dhaka? What are the possible ways of resource recovery from solid waste in Dhaka city? What is the need of preparing a policy guideline for solid waste management? What are the ways of remediation of solid waste management problem?

1.8 Objectives of the Research

The general objective of the research is to present the existing solid waste management practices as well as to formulate a policy guideline for developing an efficient solid waste management strategy for Dhaka City.

Specific objectives of this research are to

- determine the volume, types, and characteristics of solid waste in Dhaka City as well as asses the environmental hazards;
- examine the present solid waste management systems of DCC;
- review the existing acts, rules, regulations, and their enforcement in the field of SWM;
- find-out the causes of inefficiency of SWM in Dhaka;
- determine the scope of resource recovery; and
- contribute to developing an environmentally sound solid waste management policy guideline.

1.9 Scope and Limitation of the Research

1.9.1 Scope

- The research provided the scope of theoretical understanding of solid waste management.
- The study provided the scope of determining the volume/quantity, types and characteristics of solid waste generated in Dhaka City with a view to develop a proper guideline for integrated solid waste management.
- The study granted the opportunity to go through the depth of the problems for identifying the bottlenecks of solid waste management functions of Dhaka city.
- The study also imparted the opportunity to review the existing laws, rules and regulations and their enforcement relating to waste management and suggested the necessary amendments.
- In the study, it is also offered the level of people's awareness towards the solid waste management, which is very important for efficient waste management as well as for economic utilization of solid wastes.
- The study has further provided the scope to develop an effective waste management system with a view to sustainable environmental development.
- The study has profound the researcher to understand that the solid waste that is thrown away, is a valuable renewable resource not merely a waste.

1.9.2 Limitations

The proposed research work has wide ranging scope but due to time and resource constraints, the research work did not consider so many aspects of solid waste. The technical aspects of solid wastes did not take into consideration. The environmental hazards of solid wastes are a vast one, which could be another research issue. Data collection was so difficult. The people were very much unwilling to talk or very reluctant to return the questionnaire. The research work needs lot of money but Institute of Bangladesh Studies (IBS) did not provide any financial support for field study. No other organizations except Social Science Research Council (SSRC) provided financial support for conducting the research work. SSRC provided fund at the end of the study period. If this fund could get earlier, the research work would be more effective. The secondary data source was very limited. There was no text curriculum on the issue of solid waste in the Bangladesh. The books and other materials containing solid waste issue are more or less written based on America and Europe. Most of the Internet findings are very short and presented by and for developed country context. Therefore, the secondary sources of data were very poor for the study.

1.10 Methodology followed the research

To carryout this research work smoothly, the researcher has designed and followed a research methodology, which helped the researcher to achieve research objectives by minimizing the constraints of time and resources. The focus of the study concentrated on

overall management procedure of solid waste in Dhaka and to develop a policy guideline for a better and sustainable environment development. Here is an elaborate picture of the methods followed to conduct the research work.

1.10.1 Types of Research

Research can be done either exploratory or evaluative/descriptive or both. Exploratory research implies the data collection from primary sources and it is empirical in nature. Evaluative or descriptive research indicates the data analysis from secondary sources. The present study complies both exploratory and evaluative method. The research conducted through data collection from field survey for primary data and as well as from official papers, books, records, rules and regulations for secondary data. Data relating to volume of waste generation, characterization, mode and collection time, transportation and disposal, awareness level etc. was collected through questionnaire survey, observation and key informant discussion. Side by side, the data collected from books, journals, official reports, and study findings for secondary information. As well as existing laws, rules and regulations, policy and programs, operation system has described and evaluated through content analysis relating to primary and secondary data as per availability and requirements. Therefore, it is clear that the present research work is the combination of empirical and descriptive research work.

1.10.2 Methods of Research

The present study is a cross sectional descriptive study; both qualitative and quantitative data were collected with the aim of exploring the state of Solid Waste Management in Dhaka City Corporation area. Data were collected through questionnaire survey, observation and in-depth interviews. Existing acts, laws, rules and regulations, policy and programs, operation system were reviewed and examined for finding out the legal aspects, relevancy, timeliness, enforcement procedure etc.

1.10.3 Tools of Data Collection

The proposed research is a cross sectional descriptive study, both quantitative and qualitative data collected with the aim of exploring the best sustainable solid waste management of Dhaka City. For the study, not a single method used rather a combination of different methods/tools used for data collection. Practically it is a combination of explorative and descriptive study. Information collected from the respondents by interview (questionnaire survey). Before finalization of questionnaire, it was pre-tested. Other tools are the in-depth interview, observation, case study and photographs.

1.10.4 Nature of Data for the Research

The research methodology applied in the study designed with a view to develop a sustainable solid waste management policy guideline. Data collected from primary

sources through extensive field survey. Questionnaire was pre-tested before final survey. Research methodology designed in such a way that is compatible with socio-economic condition of Dhaka city dwellers. To attain the predetermined objectives of the study, data or information were collected on the following issues:

- ◆ Nature and volume of solid waste generated in household, commercial and other institutions;
- ◆ Existing solid waste management systems followed by DCC;
- ◆ Urbanization pattern and environment management;
- ◆ Laws, rules and regulations relating to environment management in general and solid waste management in particular;
- ◆ Technical, financial and institutional capacity of conservancy services of DCC;
- ◆ Solid waste impact on health and environment pollution;
- ◆ Waste pickers and other informal sectors contribution on recycling and waste management;
- ◆ Peoples participation and awareness level;
- ◆ Role of community based organization in solid waste management process;
- ◆ GO and NGO partnership and its effectiveness in solid waste handling system; and
- ◆ Possibility of affording the high-tech approaches in Bangladesh in the field of solid waste management.

1.10.5 Sources of Data

1.10.5.1 Primary Data Source

The proposed research is an empirical ones, field based primary data collected in the research. Primary sources are directly associated with the particular area and the population/universe of the study. Sources of primary data are the households, markets, officials, and waste pickers. Officials of DCC, teachers, scholars and professionals, experts and policy makers, NGO representatives, community leaders, and imams constitute the source of primary data. Photographs are also considered as source of primary data. Therefore, the main stakeholders of solid waste generators and related officials are the primary data sources. Through the questionnaire, observation, interview, observation, case study method was adopted for the primary data collection.

1.10.5.2 Secondary Data Source

Various research reports and articles, official statistics, relevant books, unpublished study documents, reports, thesis/dissertations, journals, daily newspapers, laws, regulations etc are considered as secondary data. World Wide Web was also used as a secondary source of this study. The DCC library, the library of UNDP, World Bank, DoE, BANSDOC, BUET, PATC, etc were used for secondary data. The BUET library appeared to have been the best source of collecting published materials for the study.

1.10.6 Tools of Data Collection

The research considered both quantitative and qualitative data and thus a combination of different methods/tools was used for data collection. Practically it is a combination of explorative and descriptive study. Information was collected from the respondents by interview (questionnaire survey). Other tools were in-depth interview, observation, case study and photographs. Different tools used for data collection used in the study. These are as follows.

1.10.6.1 Questionnaire Survey

The main source of primary data was questionnaire survey among the respondents. There are five sets of questionnaire prepared for householders, marketers, (business community), city corporation officials (conservancy officials) waste pickers, and leaders of community-based organizations. Firstly, the respondents were interviewed by trained interviewers using questionnaires as scheduled and secondly, set questionnaires were handed over to the respondents and they were requested to respond to the questions by themselves. In case where voluntary filling up were sought, questionnaires were collected by the researcher or by the research associates afterwards. The rate of return of questionnaire delivered is 70% only.

1.10.6.2 Observation

Observation is one of the oldest methods of data collection and reporting. In the social sciences, it has played an important role, particularly in collecting qualitative information. The primary and secondary collection/transportation, waste picking and dumping practice were keenly observed.

Through observation, it is possible to get the real information. False and fabricated information may come in the questionnaire and interview but the chance of false information through observation remains low.⁴⁹ Observation method applied in the research for the following issues:

- ❑ Solid waste disposal time from households to the transfer stations or primary collection points;
- ❑ Solid wastes collection time by DCC vehicles from transfer stations;
- ❑ Behavior patterns of people who dispose or carry the waste from house or generating points to the transfer stations or bins;
- ❑ Waste picking materials and collections patterns;
- ❑ Working patterns and skills of the DCC employees;
- ❑ Overall, situations of the dumping sites and environmental impacts so far as possible observed.

⁴⁹ Cited in the Ph. D Dissertation, Karle E. Weber and Indra P. Tiwari, *Research and Survey Format Design: An Introduction* (AIT, Thailand: Division of Human Resource Development, 1992), pp. 47-48.

- ❑ Behavior patterns and skills of the employees of local community based organizations;
- ❑ Behavior patterns of the mass people whether they used to throw the remaining of the food, packages, banana peels, parts of the cigarette etc. in the street; and
- ❑ Level of awareness about environmental concern.

1.10.6.3 Key Informant Interview

It is argued that community people have good knowledge and experience on the topic under research. They are not in a position to have the questionnaire survey. The key-informant interview method is an important tool in this research method. Scheduled interviews conducted with officials, university teachers, scholars and present and ex high officials, professionals, experts and policy makers, NGO representatives, community leaders, imams, etc. They provide valuable ideas and suggestions regarding collection, transportation and disposal of the solid wastes. Some NGO personnel, who already gain expertise in this field, has interviewed in this method. A semi-structured interview schedule was used to collect data from the key informants.

1.10.6.4 Photographs

Photographs never tell lie and always picture the reality. Therefore, several photographs were taken for visualizing the real scenario concerning SWM. Waste collection, transportation, recycling, and dumping sites, scavengers activity were taken in the camera for real information for the study.

1.10.6.5 Case Study

In this research, case study method was also adopted to gather information in details from various perspectives of solid waste management within households in the study area. One household was studied as a case, where the composition of wastes, storing pattern, disposing time and procedure were followed. It was also observed by whom the waste carried from house to the dustbins. From generation to primary disposal were followed in detail. The case study result is discussed in a box in fourth chapter at the page number 138.

1.10.7 Selection of the Study Area

Though the study area was the Dhaka city but it covers only the jurisdiction of the DCC area, which totals around 145 km². For the collection of primary data from households, the whole Dhaka City Corporation are divided into five-regions such as old Dhaka; City Under Plan⁵⁰; mixed extended area⁵¹; Slums (basti), and Uttara-Gulshan

⁵⁰ Township Under Plan refers to the area where the township developed by the government or housing societies with a maximum facilities. Dhanmondi residential area was developed by the RAJUK (the then Dhaka Improvement Trust), Mirpur section-12, and Samoli Housing, Easkaton Garden Area were developed by either RAJUK or housing societies in a planned manner.

⁵¹ Mixed Extended Area refers to the area of Dhaka City, which is extended by the owners and became crowded area with having minimum facilities but with a heavy population. Virtually, these area

model town. From old Dhaka region, the area of Hazaribag, Moneshwar road, Urdu road, Islampur, Bangshal road and their lanes and by-lanes were covered. In the Township Under Plan region, the area of Dhanmondi, Mirpur section- 12, and Samoli Housing, and Eskaton Garden covered.

The maximum part of the Dhaka city is the mixed-extended area. In this region, the city expanded by the householders by their own. Under the mixed-extended region, the area of Mohammadpur, Mirpur, Kazipara, Jatrabari, Malibagh, Moghbazar, and shahjahanpur are covered. Under the slum region the Banglamotor, shabgibagan, and Agargoan Basti are covered. Uttara-Gulshan model town area is a planned city developed by the then Dhaka Improvement Trust (DIT) now Rajdhani Unnayan Kartipakha (RAJUK). Households from Uttara-Gulshan model town were selected due to the privatization of secondary collection of solid waste of the area. The areas covered were shown in the following figure (location map) of Dhaka City in page no. 116.

Figure no 1.1

Shopkeepers and salespersons from Karwan Bazar, New market, Mirpur No1 market were included for the survey. Conservancy officials of DCC were interviewed.

1.10.8 Sample Size of Estimation of the Study

The sample size calculation is very important for having good result of any study. The general rule of sampling is that the larger the sample size, the greater the accuracy of study estimates. But it is not always possible to take a larger sample because of budget, time constraints. To have a minimum sample size at 95% confident level there is a formula of calculating the sample size. The equation for computing sample size (n) is

$$n = \frac{z^2 p(1-p)}{d^2}$$

Here $z = 1.96$, the critical value for 95% level of significance, $p = 0.5$, trial value of the proportion

$d = 0.1/2 = 0.05$, half length of the interval,

$$\text{therefore, } n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2} = 384.16 = 385$$

1.10.9 Sample Size and Justification

According to the calculation, there should be the sample at least 385. Assuming 10% non-response, the estimated sample size became 424. To attain this number of household respondents, there were 500 household populations targeted and finally 397 respondents were interviewed. These 397 respondents are as follows:

Table No. 1.1 : Types of Respondents

Sample are/region	Mode of the data collection	Sample size
Old City region	Questionnaire Survey	68
Township Under Plan region	Questionnaire Survey	72
Mixed-Extended region	Questionnaire Survey	134
Slum (Basti) region	Questionnaire Survey	64
Uttara-Gulshan Model Town region	Questionnaire Survey	59
Total Household Sample size		397

Other than households 55 respondents from business community, 42 DCC conservancy officials, 30 waste pickers, and 21 community service providers were interviewed. In-depth interview was carried out among 10 scholars through purposive sampling. The total number of respondents became $(397+55+42+30+21+10)= 555$ which is as follows in the Table No. 1.2

Table 1.2 : Total Number of Respondents Surveyed

Sample are/region	Mode of the data collection	Sample size
The household respondents	Questionnaire Survey	397
Business community	Questionnaire Survey	55
DCC Officials and Employees	Questionnaire Survey	42
Waste Pickers	Questionnaire Survey	30
Community Service Providers	Questionnaire Survey	21
Scholars and Experts	Key Informant Discussion	10
Total Respondents		555

1.10.10 Sample Size Estimation and Justification

The sample size of the study is 555 among all groups of respondents. Considering the time and financial resource constraints the size of the sample kept at a reasonable level. Total households in DCC are 1,107,474. Although, 397 from total households seems to have been too small but according to the theory it is sufficient and well justified for a Ph. D. dissertation.

1.10.11 Sampling Procedure

As the main study population are the different cross sections of the city. The homogenous sampling method was followed. For survey, the household respondents were selected from five different regions of Dhaka city through disproportionate stratified sampling. In stratified random sampling the researcher attempts to stratify the population in such a way that the population within a stratum is homogeneous with respect to the characteristics chosen as the basis of stratification are clearly identifiable in the study population. There are two types of stratified sampling: proportionate and disproportionate stratified sampling. As the sample selected is in proportion to the size of each stratum in the population, this method is call proportionate stratified sampling. As this method does not take the size of the stratum in the selection of the sample, it is called disproportionate stratified sampling.⁵² According to this method, the five regions have been stratified in

⁵² Ranjit Kumar, *Research Methodology: A Step by Step Guide for Beginners* (London: SAGE Publications Ltd., 1999), p. 158.

such a way that the population of a particular stratum have the homogeneous character. Disproportionate sampling refers to the populations not equal to all strata. Dhaka city dwellers were selected through the disproportionate stratified sampling. Other respondents were selected based through non random purpose sampling. For key informant interviewers selection, the sampling was fully purposive. So, the sampling system was a combination of disproportionate stratified and purposive sampling.

1.10.12 Data Collection Procedure

A team of three interviewers was selected for two months and they were comprehensively trained. The researcher and the interviewers took face-to-face interview and the researcher supervised the total survey operation. On an average everyday, one interviewer interviewed seven respondents. After finishing the interview, the interviewers rechecked the questionnaires and the interview schedule for necessary correction. The researcher crosschecked twenty five percent of the interview sheet (questionnaire).

Secondary data were collected more or less in the form of paraphrase. Content analysis method was used for the interpretation of laws, regulations, policies etc. The researcher has attended a classroom training session, 2 workshops, observed family attitude concerning solid waste disposal as case study. The researcher also visited Matuail and Berri-Band dumpsites. A good number of photographs were used in the research for primary data. The researcher had accessed a lot of websites for collecting information.

1.10.13 Scoring the Awareness and Level of Acceptance

The level of awareness about solid waste management with some related aspects and attitudes of the city dwellers regarding activities of the DCC along with other agencies in case of SWM were explored with pre-selected statements using attitudinal scale with five responses. In the study the summated rating scale, also known as the Likert scale has been used. The attitudinal scales describes by Ranjit Kumar as⁵³

Attitudinal scales measure the intensity of respondents' attitudes towards the various aspects of a situation or issue and provide techniques to combine the attitudes towards different aspects into one overall indicator. This reduces the risk of an expression of opinion by respondents being influenced by their opinion on only one or two aspects of that situation or issue.

There are several statements mostly related to a single issue measured by using the Likert's scale. The issues are awareness respondents towards the solid waste management and their attitude towards the DCC's conservancy operation. In this method the responses measured by numerical scale. The responses were strongly agree, agree, uncertain or undecided, disagree and strongly disagree. For each positive statement, the scoring was 5 for strongly agree, 4 for agree, 3 for undecided, 2 for disagree, and 1

⁵³ Ibid. p. 128.

strongly disagree. For a negative statement the numerical value or the scoring was 1 for strongly agree, 2 for agree, 3 for undecided, 4 for disagree, and 5 for strongly disagree. In this study the peoples, awareness and attitude was classified into three levels based on mean and standard deviation as below:

High level of awareness/attitude $> \text{Mean} + \text{SD}$

Moderate level of awareness/attitude $\leq \text{Mean} \pm \text{SD}$

Low level of awareness/attitude $< \text{Mean} - \text{SD}$

1.10.14 Data Analysis

The data collected in the research were processed and analyzed mainly in the statistical process with help of computer program i.e. Statistical Package for the Social Scientist (SPSS). Other computer-aided method such as Microsoft Excel, MS word, power point etc., has been used. The descriptive and inferential techniques such as mean, median, frequency distribution, cross tabulation, variance, correlation-regression and different graphical presentation (Bar diagram, pie chart, tabulation form etc.) are used to process, analyze and interpret the data for research purpose.

Descriptive analysis of the findings used to explain the nature, characteristics of solid wastes. The level of peoples awareness or the perception about waste hazard, knowledge and attitudes towards modern waste treatment and disposal, social support i.e community participation is descriptive in nature. The qualitative data was also described with the scoring of Likert scale. The quantities data analysis was done through the simple statistical measurement like frequency distribution, mean, median and standard deviation etc.

1.11 Chapter Summary

The whole world is facing enormous problems. Out of them, one is resource constraint and another is the volume of solid waste generated. Solid waste generated in the cities of developing countries creates lot of environmental problems. Population boom and urbanization derives volume of solid waste and the city authority cannot cope with it. In most of the Asian cities, half of solid waste generated remains unattended. A World Bank study shows that by the year 2025 most of the SAARC countries will generate four to five times more waste that it was in 1995. On an average one-third generated solid waste collected by the municipality and dispose in the crude open dumping method. Dhaka City Corporation could not show efficiency in solid waste management. There was no comprehensive study conducted in this regard. The study proved justified and it is expected that the study results will benefit the policy makers, scholars, students, and further researchers. There were lot scopes in the study as well as time and money was the main limitations.

For any research, it is very important literature review. The available books, study reports, journals, daily newspapers articles, and Internet findings were reviewed for the research. The research work is an empirical as well as descriptive in nature. Data collected from primary sources through questionnaire survey, key-informant discussion, observation, case study and through photographs. Secondary data sources were the books, journals, study reports, newspaper articles, and Internet findings etc. through paraphrase and content analysis. Data analysis done through SPSS and other statistical and computer aided programs.

There is a few research work has done on solid waste management in Bangladesh. Some social organization such as BEN, BELA, and Bangladesh Poribesh Andolen (Environment Movement) has taken a little initiative to conduct some study and publication on environmental issue. It is manifested from the literature review that there should be comprehensive study on solid waste management for the sustainable environmental development.

Solid waste management issue has got less important in the past, it was needed a comprehensive and systematic study. The present study attempted to identify the various aspects of solid waste with a view to develop an integrated waste management policy guideline, which would be combating for sustainable environmental development of Dhaka city. The study provided lot of scope to visualize the present practice of waste management in the city. The research also faces lot problems and cannot cover different aspects due to time and financial constraints.

The present study is a cross sectional explorative and descriptive one. It has conducted aiming to find the current solid waste management practices of Dhaka city. Both primary and secondary data used in the research. The research has conducted through applying structured questionnaire for different respondents, key interview technique, and participant observation methods. Photograph also used as data source. Household respondents were selected using disproportionate stratified sampling system. Other respondents selected purposively. Data analyzed through SPSS and other statistical means. Likert Scale is used for analyzing the attitude and perception of the respondent.

Conceptual Framework of Solid Waste Management

2.1 Introduction

Solid waste production is as old as human civilization. It is to be said from the historical view point that waste production has been increasing with the development of technology, urbanization, industrialization, living standard and the modernization of human society. In the modern age, discarded materials are obvious by the process of day-to-day work, consumption, industrial production process, commercial and institutional operation etc. Thus type of wastes has changed in course of development processes and population increases. At present solid waste does not mean only the household waste, it is extended to the different types of waste such as household, industrial, clinical, chemical etc. Waste also may be solid, liquid or gaseous in nature in the modern industrialization era. Whatever the nature, the waste must be disposed in such a manner so that it does not create the adverse impact on environment. Solid waste is a major cause of urban environmental degradation and pollution. Disposal of solid waste is one of the most troublesome jobs facing urban society at this time. Rapid urbanization and unplanned expansion of the cities, industrial development in urban areas which draws huge number of rural people to these areas from other parts of the country, changes in life styles of the city dwellers etc.; resulted in significant increase of volumes of solid waste.¹ There are number of cities in the developing world are confronting seriously with huge pile of solid wastes make their life and environment hazardous. Dr. Yusuf J. Ahmed said that "The city is drowning in its own wastes".²

It is clear that Developing and Less Developed Countries (LDCs) are confronting with dilemmas between providing basic needs such as shelter and food supply. Where they are facing these problems acutely, an additional problem of solid wastes appeared as a third pollution" on them³. The pollution of land surface, which has been called the third pollution, is essentially the result of indiscriminate land disposal of solid waste

¹ Eugene A. Glysson, "Solid Waste", *Standard Handbook of Environmental Engineering*, 2nd ed, Robert A. Corbitt, eds. (New York: McGraw Hill, 1999), pp. 8, 142.

² John Elkington and Jonathon Shopley, *Cleaning up: US Waste Management Technology and Third World Development* (Washington: World Resource Institute, 1989), p. 17.

³ Dr. H.S. Bhatia, *A Text Book on Environmental Pollution & Control* (Delhi: Galgotal Publications Ltd., 1998), p. 93.

without any treatment. However, the developed world has managed this problem with technological improvement and as well as they have made it as resource through recycling. The waste generation is a must by almost every activity, and the amount varies by source, season, geography and time.⁴ Solid waste are those materials, other than liquids or gases, that are deemed by their owner to no longer possess value and are discarded. Solid waste management is the process of disposing the waste as a manner through which maximum resource recovery is possible and the pollution is minimum. Waste disposal comes as a final step in the processes of waste management; that is after attempts have been made to apply the "3Rs", namely, reduce, reuse and recycle. Solid wastes that have been generated may be sorted for resource recovery prior to disposal. Hazardous wastes on the other hand hardly ever require any sorting; they usually undergo treatment and disposal. Waste to be efficiently disposed of, it should have no negative or minimum impacts on the environment.⁵

Conventionally, solid waste disposal consisted of open dumping but today it has progressed to the integrated approach focused on source separation and recycling. Now it is disposed of in double-lined landfills with collection and controls for gases and/or leachate. Other disposal means include composting and incineration. Recovery and reuse are practiced widely. Source or central facility separation is used for variety of resource recovery and reuse. The disposal means typically require control for created pollutant, such as leachate and odour from land filling, compost operation and chemical and particulate emission from incinerator combustion.

2.2 History of Earliest Waste Disposal in Brief

During the flourishing of the Minoan civilization on Crete from 3000 to 1000 BC, solid wastes in the capital of Knossos were placed in larger pits with layers of earth at intervals. The Romans had no organized system of waste removal; disposal and wastes accumulated along the roadside. Some medieval German cities avoided the danger of being buried in their own wastes by requiring that departing wagons which had been used, perhaps, to bring farm produce into the city return with a load of wastes to be deposited in the country side.⁶ Remains from some of the earliest cities suggested that residents at first took a laissez-fair approach to waste disposal, simply raising the roofs of their houses as mounting garbage caused street levels to rise. In 19th century Charles

⁴ Glysson, Solid Waste, Corbitt, *Standard Handbook*, Chapter 8, p. 1.

⁵ Yvonne Gotlop Bogatsu, "Towards Effective Waste Disposal in Developing Countries", *Pollution Control*, Okot-UMA, ed., p. 271.

⁶ P. R Trivedi & Gourdeep Raj, *Encyclopedia of Environmental Science* (New Delhi: Akashdeep Publishing House, 1992), p. 6.

Dickens spoke to both water & waste problems of New York, he referred to it as a city of without baths or plumbing, lighted by gas scavenged by pigs.⁷

Before the industrial revolution the volume of waste produced was relatively small and the concept "dilute & disperse" was adequate. Most of the wastes are dispersed to the water bodies. With the industrial and urban expansion dilute and disperse became inadequate and new concept "concentrate and contains" became popular. But within short span of time this containment method proves ineffective. Containers, natural or artificial, may leak or break and allow waste to escape and thus, another concept developed that of converting the wastes to useful resources in which they are no longer wastes but resources. Some nations consider all wastes as essentially "resources out of place". This is possible through recycling process. Although it is probably never be able to recycle all wastes. Using modern technology most of the developed society recycled their wastes as much as possible. Other disposal system for remaining wastes is undertaken.⁸

The Americans are thrown-away society. They do not give up their disposable life style easily. Every year Americans toss 81 million tons (here after m/t) of paper, 44 m/t of food and yard waste, 15 m/t of metals, 1 billion m/t of glass, 19 m/t of plastics into landfills. Their MSW amount to 4 pound per day per person, twice that of European & Japanese generate. In New York State, with 18 million people, the trash generated per year could cover a football field to a height of 3 miles. Before 1960's a great deal of garbage was burned, either in open dumps or in highly polluting incinerators. However, strong environmental regulation of 1980's restricted for "secure landfill" to prevent leachate contamination. By 1987 more than 90% of US municipal solid wastes were being disposed of in landfill sites, most of which were not lined to prevent toxics from leaching into the ground water.⁹

Solid waste generation and management had received less attention in developing countries. The resulting health effects of methane emission from garbage dumps; disease vectors, underground water pollution etc. is equally acute as with other forms of pollution. The health impact could be particularly severe for scavengers who virtually live on garbage.¹⁰ Masonry bins are provided of capacity about 5 cubic meters for the temporary storage of solid waste in Sri Lanka. This is built on bricks and cemented floor.

⁷ Molly O'Meara, "Exploring a New Vision for Cities", *The Challenges of Urban Government: Policies and Practices*, Mila Freire & Richard Stren, eds. (Washington: The World Bank Institute, 2001), p. 343.

⁸ Edward A. Keller, *Environmental Geography*, 4th ed. (Ohio, USA, Charles E. Merrill Publishing Co., 1985), p. 25.

⁹ John Elkington and Jonathon Shopley, *Cleaning up: US Waste Management Technology and Third World Development* (Washington: World Resource Institute, 1989), p. 9.

¹⁰ Peter P. Roger et al, *Measuring Environmental Quality in Asia*, (USA: Harvard University and ADB, 1997), p. 205

Each bins serves about 25 families. The front end of the bins is open to facilitate the collection lorries. However, it was noticed that the dogs could enter through these opening and scatter the garbage. The community councils came out with the solution of construction wooden burrier which can be removed at time of collecting garbage.¹¹ Most developing countries do not separate special or hazardous wastes from municipal solid waste. The predominant practice is to collect these items along with the rest of the waste stream and co-dispose of them at the open dumps.¹² Like most of all other developing countries Bangladesh, disposal of its solid wastes in the form of crude open dumping in the low-lying lands.

2.3 Definition of Key Terms

The study has several key terms to be clarified for clear understanding. They are as follows:

Waste

Waste is defined as discarded material judged to be of no value for ordinary or normal use. When a material of no longer has an economic value for a certain purpose, it is discarded.¹³ The word "waste" refers to useless, unwanted or discarded materials, which are no longer, considered of sufficient value and are thrown away by the possessor. Wastes include solids, liquids and gases. The wastes in the solid or semisolid forms are called "solid wastes". Solid wastes comprise of all solid refuse or trash resulting from the normal activities of the community except excreta.¹⁴ Waste means any solid, liquid, gaseous, radioactive substance, the discharge, disposal and dumping of which may cause harmful change to the environment.¹⁵

Waste is defined in broadest sense, as all the discarded solid materials, either dry or wet or water-borne where the water itself was not of a discarding quality and discarded liquids, which result from municipal, industrial and agricultural activities.¹⁶ Any substance solid, liquid or gaseous, that remains as a residue or is an incidental by product of the processing of a substances and for which no use can be found by the organism or system that produce it.¹⁷

¹¹ M.S. Fardando, "Sanitary Aspects of Canal Projects" Johh Pickford, et all eds., *Affordable Water Supply and Sanitation*, (London: WEDC, 1994) p, 73.

¹² Brihton Kaonga, "Application of Appropriate Technologies", *Pollution Control*, p. 381.

¹³ <http://www.3.gov.ab.ca/env/waste/munisolid/index.html>.

¹⁴ Dr. H.S Bhatia, *Environmental Pollution & Control*, p. 93.

¹⁵ The Bangladesh Environment Conservation Act, 1995, (Clause I of Section 2).

¹⁶ FTK. Sefe, *The Role of EIA, Pollution Control*, p. 282.

¹⁷ Mechael Allaby, *Dictionary of the Environment*, 3rd ed. (Washington: University Press, 1989), p. 408.

Waste is defined by public advisory Panel of Chemical Manufacturing Association of USA (1992) as any gas, liquid or solid residual material at a factory, whether hazardous or non-hazardous, that is not used further in the production of commercial product or provision of a service and which itself is not a commercial product. Waste is wrong substance at a wrong place at wrong time in a wrong quality.¹⁸

There appears to be no standard textbook definition of waste. Some sources define it as: anything that has no value to anybody and only fit for discharging. It should however, be that something can be valueless (have no value) to someone yet invaluable to another. It is in this spirit of the Chinese sayings that waste is something. An ancient Chinese proverb defines waste as a resource which the people have simply not yet learnt how to use.¹⁹ Waste is the material, value of which, people have not yet assessed or appreciated. The waste is being used interchangeably with terms such as refuse, litter, garbage, trash, detritus, rubble, debris, dust, and valueless matter. Many of these are subsets of waste.²⁰ Waste is material, which is thrown away or aside as worthless.

Solid Waste

Solid waste as those waste that is neither wastewater discharged nor atmospheric emission. In Agenda 21 of Rio Earth Summit in 1992, solid waste has been defined as all domestic and non-hazardous waste such as commercial and institutional waste, street sweeping and constructional debris.²¹ Solid wastes are those materials other than liquid or gases that are deemed by their owner to no longer possess value and are discarded. They are generated by almost all activity and the amounts vary by source, season, geography and time.²²

The term solid waste means any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining and agricultural operations, and from community activities, but does not include solid or dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources

¹⁸ Bangladesh Center for Advanced Studies, *Guide to the Environmental Conservation Act 1995 and Rules 1997* (Dhaka: BCAS, 1999), p. 3.

¹⁹ Jon E. Gould, "SW Reuse", *Pollution Control*, p. 354.

²⁰ VTC Matsoga, "WM Services in Botswana: Evolution of Problems, Perspectives and Responses", *Pollution Control*, pp. 435-439.

²¹ Golam Rahman and Md. Monirul Islam, "Urban Growth Pattern in Dhaka City and its Problems of Urban Solid Waste Management", M. Firoze Ahmed ed. *Bangladesh Environment 2000* (Dhaka: Bangladesh Paribesh Andolon, 2000), p. 438.

²² Glysson, *Solid Waste, Standard Handbook*, p. 8.

subject to permits under section 1342 of the title 33, or source, special nuclear, or by product material as defined by the Atomic Energy Act 1954.²³

An apt definition of solid wastes is "matter in the wrong place", implying that a material becomes waste only when the owner ceases to have value for it. Yesterday's newspapers are wastes to the man who bought it, but it could be a useful matter for the paper mills.²⁴ Municipal solid waste is a waste from a community consisting of all the waste generated from residents, commercial and business establishments, institutional facilities, construction and demolition activities, municipal services and treatment plant sites.²⁵

Municipal solid waste generally viewed as a municipal responsibility, include: household garbage and rubbish, residential ashes, commercial refuse, institutional refuse, street sweepings, construction and demolition debris, dead animals, sanitation residue, industrial, clinical and hospitals wastes. Household waste is mainly composed of food, grass & plants, brick, dirt, paper and polythene, shredded skin, leather etc.

Management

Management is doing things in a proper way with minimum costs and efforts for attaining as predetermined objective. Management is a process of planning, organizing, directing, controlling, and coordinating for attaining a common goal.

Solid Waste Management

Waste management, as a whole and solid waste management in particular is a methodology of minimization of wastes, primarily through reduction at source, but also including recycling and re-use of materials and final disposal.²⁶ Solid waste management is the systemic administration of activities, which provides for the collection, source separation, storage, transportation, transfer, processing, treatment and disposal of solid wastes.²⁷

MSW is abundant, unsightly, and potentially odorous, contains numerous potential pollutants; and supports both disease-causing organisms, and disease-carrying organisms. Like MSW, bulky solid waste solid waste is abundant, unsightly and potential polluting. In addition, the dry, combustible nature of some bulky waste components can pose a fire hazard. Because of these characteristics of MSW and bulky waste, a prompt, effective, and reliable system is required to isolate solid waste from people and the environment.²⁸

²³ "Solid Waste Disposal Act of USA", *Selected Environmental Law Statutes*, Educational Edition (Minnesota: West Publishing Co.1991), pp. 567-568.

²⁴ Trivedi, *Encyclopedia*, p. 5.

²⁵ Glysson, *Solid Waste, Standard Handbook*, p. 8.

²⁶ [http://www. http://www.seamegypt.com/manuals/dakassolidwaste/content.html](http://www.seamegypt.com/manuals/dakassolidwaste/content.html).

²⁷ Alex Mallow, *Hazardous Waste Regulation* (New York: Van Nostrand Reinhold Co., 1981), p. 209.

²⁸ S. C Bhatia, *Handbook of Pollution*, p. 178.

Solid waste management means one sort of isolation (out of sight) of solid waste from the locality. This isolation does not mean hiding the waste into a deep well, throwing in water bodies or keep them in a barren land. Here the isolation meant a beneficial or efficient management. A beneficial use of solid waste is relatively difficult, because it contains many different types of materials in a range of different shape. It is needed sorting, processing before a valuable use. The only established use for unprocessed MSW is as fuel in mass burn incinerators. Even mass-burn incinerators cannot handle unprocessed waste. There was a time when the unprocessed MSW was used as fill materials. This practice has restricted in the developed countries. However, in the developing countries all the MSW are used as filling materials for land filling or land reclaiming. For effective and beneficial use of MSW needed processing to recover useful materials for reuse and recycle and for a better management.

Finally it can be summarized that solid waste management is a process of handling wastes (collection and transportation) through minimum cost targeting reduction at source, re-use and recycling and final disposal with least pollution for achieving a sustainable environmental development.

Environment

Environment means the inter-relationship existing between water, air, soil and physical property and their relationship with human beings, other animals, plants and microorganisms.²⁹ Environment is the condition of a surrounding of an organism including other living things, water, soil, climate and sounds.³⁰

2.4 Objectives of Solid Waste Management

The main objective of SWM is to remove the discarded materials from inhabited places in a timely manner to clean and to prevent the spread of disease, to minimize the likelihood of fires and to reduce aesthetic insults arising from putrefying organic matter. The second objective of SWM, which is equally important, is to dispose of the refuse in an environmentally sound manner; and third objective is to resource recovery for attaining the economic benefit from the discarded materials. These objectives can be simplified in a manner so that another number of objectives can be added in the list. Schubeler 1996 identifies four goals of MSW management.³¹

- a) Protection of environment health; b. Promotion of the quality of the urban environment

²⁹ The Bangladesh Environment Conservation Act, 1995, (clause d of section 2).

³⁰ Lawrence Pringle, *Lives at Stake* (New York: Macmillan Publishing Co., 1980), p. 142.

³¹ It is stated in *Down to Earth*, Mansoor Ali (Lofelbough, UK: WEDC), p. 71.

- b) Supporting the efficiency and productivity of the economy; and d. Generation of employment and income.

2.5 Solid Waste Classification

There are different types or categories of wastes produced in a society. Obviously all wastes are not same in all society and even in all season. Primarily wastes are solid, liquid and gaseous. Solid wastes can be classified from different point of view.

From the Point of Source

Solid wastes can be classified from the source of generation:

- ❑ Domestic or residential: The wastes generated in the households from day to day activity are the domestic wastes. Most of which comes from kitchen, dining table residues, cleaning dust, garden trimmings etc.
- ❑ Commercial: The solid waste of package materials, unused or obsolete things from commercial institutions.
- ❑ Industrial: Mainly raw materials, broken products, packaging materials, chemicals, etc.
- ❑ Institutional: there are so many items comes from different institutions like paper, plastics, food residues, packaging items, etc. and
- ❑ Miscellaneous (street sweepings, garden trimmings, sewage sludge etc.)

Classification from the point of combustibility: Combustible and Non-combustible

Combustible	Non-combustible
Newsprint paper	Ferrous
Other paper	Aluminium
Diapers	Nonferrous
Textiles and garments	Glass
Plastics, film	Bricks
Plastics, rigid	OBW (oversize bulky wastes) etc.
Dry food wastes	Sweepings (floor or sorting area) etc.
Wood	
Yard wastes (grass clippings) etc.	

Waste can be classified from the nature of biodegradability. This may be biodegradable or non biodegradable.

Biodegradable or Organic Wastes

There are some solid wastes, which organic in nature are easily biodegradable through the bacteria. Microorganisms can metabolise paper, yard waste, food waste, and wood etc. These wastes are classified as biodegradable waste. Some biodegradable waste materials are more readily metabolised than others. The most readily metabolised materials are those with high nitrogen and moisture content: food waste, grass clippings and other green, pulpy yard wastes. These wastes are putrescible and have high bioavailability. Leaf waste generally has intermediate bioavailability. Wood, cotton and wool although biodegradable, have relatively low bioavailability and are considered non-compostable within the context of solid waste management.³²

³² David Liu & Bela G. Liptak, *Environmental Engineering Handbook*, 2nd ed., p. 1146.

Non-degradable or inorganic

There are lot of wastes are non degradable in nature. It is not decomposable by the bacteria. Wood, iron, plastics, rubber, bricks, etc. are non-degradable waste. Moreover solid wastes can be classified into four categories from its characteristics. These are: inert, general, wet and hazardous³³

Inert (ash and dust contents) Wastes

This is the waste that have attribute of little, negligible or no chemical interaction with the environment. Inert wastes are also expected to have very little impact on the environment. Examples are builder's rubble (excluding plastic pipes and similar materials), excavation spoil, and material from the de-silting of drains.

General Wastes

A general waste is a generic term applied to all controlled wastes that is not inert, wet or hazardous. General wastes again are the simple domestic and institutional waste without having toxicity. It may be comprises domestic, commercial and general dry industrial wastes.

Wet Waste

Wet waste is characterised by a high moisture content and high leachate generation potential. Such wastes include semi-liquid wastes, sludge and abattoir wastes.

Hazardous Wastes

One inclusive definition is any substance that poses a potential threat to human health or the environment. The substances and wastes flows deemed to be hazardous, based on criteria such as ignitability, corrosivity, and toxicity. RICA of USA listed several hundred substances and waste flows deemed to be hazardous.³⁴

Hazardous waste comprises that has the potential, even in low concentrations, to have a significant adverse effect on public health and/or the environment. This categorization is based on the inherent chemical and physical characteristics such as toxic, ignitable, corrosive, carcinogenic or other properties. Some solid waste inevitably contains many of the toxic substances manufactured or extracted from the earth. Most toxic material in solid waste is in one of three categories: I) toxic metals, II) toxic organic compounds, many of which are also flammable; and III) asbestos.³⁵

³³ FTK. Seft, *Role of EIA, Pollution Control*, p. 283.

³⁴ Eban S. Goodstein, *Economics and the Environment*, 3rd ed. (New York: John Willy & Sons Incorporation, 2001), p. 249.

³⁵ S.C Bhatia, *Handbook*, Vol. 1, p. 176.

Miscellaneous wastes

There are some different categories of solid waste which can be treated as miscellaneous solid wastes.

- Batteries
- Medical sharp items
- Street sweepings
- Sewage sludge

OBW (Other Bulk Wastes, say broken sofa, freeze, Tv etc.)

There are some solid wastes in different nature, they are as follows:

Biomedical/Hospital Waste

In 1976, the US environment protection Agency (EPA) ruled that all wastes coming off the hospital floor could be classified as contaminated materials. As a result of the determination, all hospital wastes treated as infectious and were not accepted to landfill sites.³⁶

The medical establishments produce both biomedical and general garbage. Biomedical waste requires segregation in different categories and from general wastes. Biomedical waste must be segregated at the source of generation into red biohazard bags conspicuously labelled with "biohazards waste". Biomedical waste includes preparations made from living organisms and their products such as serums, vaccines, antigens and antitoxins. Medical wastes is generated or produced, as a result of the diagnosis, treatment, or immunisation of human beings and or animals. Biomedical wastes are three in nature³⁷.

Microbiological

Microbiological waste includes cultures and stocks of etiologic agents, which due to the species type, concentration are known to cause disease in humans;

Pathology waste

Pathology waste includes human tissues and organs, amputated limbs or other body parts, foetuses, placentas, and similar tissues from surgery, delivery or autopsy procedures. Animal carcasses, body parts, blood and bedding are also included.

Sharps waste

Sharps waste comprises many devices having acute rigid corners or edges, or projections capable of cutting or piercing, including hypodermic needles, syringes, blades, broken glass items, pipettes and vials that are contaminated with other medical wastes.³⁸

³⁶ Efraim Turaban, "Incineration of Solid Waste : A Case Study", *Cost Containment in Hospitals*, Efraim Turaban, ed. (London: An Aspen Publication, 1980), p. 315.

³⁷ M.F. Simpanya, "Biomedical Waste Management", *Pollution Control*, p. 305.

³⁸ Ibid., p. 304.

Sludge

Sludge is one kind of solid waste. Sludge is not only a by-product of wastewater treatment processes but even potable water treatment produces sludge. Effluents from the industries, institutions, domestic wastewater and public sewage etc produce sludge. Sludge is likely to contain high levels of industrial pollutants such as heavy metals, pathogens, persistent toxic agro-chemicals and other similar substances. Sludge is too harmful to the environment as well as it in fact provides the necessary nutrients and organic material for the soil and plants.

2.6 Solid Waste Characterization

Solid wastes is the term now used internationally to describe non-liquid waste materials arising from domestic, trade, commercial, industrial, agricultural, mining and from public activities. The characterization is very important for solid waste management. No rational decisions on solid wastes management systems, are possible until data of weight, density and constituents are available.³⁹ Characterisation of the MSW stream would first be necessary to establish the feasibility of incineration and waste to energy (WTE).⁴⁰

There are three primary purposes for waste characterisation. First, the data become the basis for planning economic analysis, designing, and subsequent management and operation of a disposal system or materials-energy resource recovery facilities. Second, waste characterisation for rehabilitation or retrofit it of a facility redefines the quantity and type of waste for disposal. Third, plant optimisation, emissions monitoring, or malfunction analysis of a waste-to-energy facility can be expedited by the characterization of the wastes being processed.⁴¹ The characterization is necessary to know the major constituents of the waste, their nature, moisture content, ash content, which have consequential impact on the energy value of the materials and also affect the combustion efficiency and gas emission.

Solid waste management largely depend on the characteristics of the waste generated in a prevailing society. The inherent flexibility of the waste must be understood to cope with processing system. Solid waste may be characterized from different angles.

Characterization Based on the Constituents

Municipal solid waste is typically made up of a broad spectrum of materials, some are abundant and some useless. It consists of both materials and products. Materials in MSW include more of less paper and paper board, yard trimmings, glass, metal, plastic,

³⁹ Trivedi & Raj, eds., *Environmental Science*, Vol. 25, p. 4.

⁴⁰ Brihton Kaonga, *Appropriate Technologies, Pollution Control*, p. 391.

⁴¹ Glysson, *Standard Handbook*, p. 8.

wood, and food wastes. With exception of food wastes and yard trimmings, each material category is made up of many products. Product means any sort of materials. Here the products indicate the finished products, which can be further use without any process. A portion of each material category was recycled, including being composted. Recovery rates for some products within a material category are higher than the overall recovery rate. Products in MSW are grouped into three main categories: a) durable goods such as appliances; b) non-durable goods, such as newspaper and c) containers or packaging items.

For planning and design projects, characterization of solid waste constituents must be tailored to the area or generator served. Two important reasons for sorting and sampling MSW are:

- To determine the constituents mix from the standpoint of recovered secondary materials for reuse or recycling;
- To determine the character of the waste for use as a fuel or incineration.

Characterization Based on Physical/Chemical Attributes

The assessment of physical and chemical characteristics is very essential to decide a suitable method of disposal. The physical analysis of refuse indicates the amount of combustible, non-combustible, fine earth or ash content. MSW may be characterizing on its physical-chemical parameters. These are:

Moisture content

There are some constituents in the waste heap are more wet in nature. Some are less wet. The high moisture value(s) of solid waste attributed principally to relatively high weighty wastes provide low calorific value.

Ash (inert) content

Ash content indicates the combustibleness of MSW. The more ash content of solid waste derives less combustibility. This is very important to know for Refuse Drive Fuel (RDF).

Calorific value

The chemical analysis of MSW indicates the pH, carbon, nitrogen, organic potash content and the calorific value (heating value). There are some combustible constituents in waste heap. Different waste has different heating value. Less moisture and ash free constituents have higher heating value.

Sulphur and chlorine

It is the potential acid gas formation parameter during combustion process.

Municipal solid waste can be characterized from different perspective. There are three main characteristics: weight generated, density and constituents. The weight is calculated as the waste generated per person/per day. The density calculated by weight per cubic meter and the constituents attributed through the percentage of different types wastes in total volume.⁴²

Solid Waste Composition or Properties

Solid waste composition is the ratio of mixture of different types of materials. Solid wastes properties means the amount of different components of wastes produced in a particular locality. Properties of wastes may be calculated through the densities of wastes components. The properties indicates the garbage, rubbish, refuse, sewage sludge and bulk waste.⁴³ The composition varied with socio-economic condition of a community. In some place food waste is much higher than the combustibles and somewhere organic waste is too less in relation to inorganic wastes. Properties of solid wastes are the amount of waste in different nature. For achieving a good management system the composition or properties of solid wastes is obvious to determine.

In order to design equipments and process to cope with the problem, however, detailed understanding of physical, chemical and biological properties of mixed waste stream are essential. Chemical properties is needed to know the reactivity of the waste, physical properties are essential for designing, operating and handling solid wastes. The low initial density and poor compaction characteristics of solid wastes has limit the carrying capacity and contribute to high cost for collection and bailing. Biological properties will help to find the way of resource recovery. Moreover, the combustion properties of solid wastes are very important for its heat content analysis.⁴⁴

Cities in low-income countries tend to generate fewer wastes than cities in high-income. Compostable materials accounts for most of the waste stream in low-income cities i.e. 96% for Karachi, 78% Calcutta, 60 % Manila, whereas Brooklyn, USA is 26%, London 43% and 59 % in Dhaka. In contrast, the more developed countries; non-food materials such as paper, glass and metals dominate the waste stream that is more recyclable. It is clear from statistics that income level is a significant factor in determining waste quantity and composition. Compared to municipal solid waste, industrial and commercial wastes are more heterogeneous accrues different economic systems.⁴⁵

⁴² S.C Bhatia, *Handbook*, Vol. 1, pp. 111-112.

⁴³ Trivedi, *Encyclopedia*, pp. 106-107.

⁴⁴ Trivedi, *Encyclopedia*, pp. 26-27.

⁴⁵ Peter P. Roger et al., *Measuring Environmental Quality in Asia* (USA: Harvard University and ADB, 1997), pp. 203-215.

2.7 Factors Affecting Quantity and Quality of Solid Wastes

Solid waste produced as a result of human activity. The amount of waste production and its quality are not equal to all people in all time. Certain societies consume more and create more waste than others. An American for example consumes, about 50 times more than an average Bangladeshi and generates at least 50 times more waste.⁴⁶ The waste quantity largely depends on the economic status of the society. Weakness in the economy generally reduces the quantity of solid waste generated. The generation of solid waste is greater in warm weather than in cold weather. There are some factors affecting the quality and also quantity of solid generation. The major factors are as follows:

- Geographic location
- Season of the year
- Income level or living standard
- Cultural factors
- Food behaviour of the citizens
- The extent of salvage and recycle operation
- Legislation
- Public awareness and attitude

2.8 Effect of the Solid Waste

In a very simple way solid waste seems to be no effect but due to its prevailing characteristics it set aside from the liquid and gaseous wastes. Liquid wastes are quickly relegated to the sewer or swept into ground and are out of sight. The gaseous waste disperses into the atmosphere. Solid waste, however, are sorted and transported in and through the societies living and have great potential for adversely affecting the quality of the environment. First of all it is very unsightly and very untoward to all for its odorous bad smell.

Most exposure to solid waste occurs when chemical leach out of dumps in rainwater or into the air in vaporous form. Common disposal method include surface impoundment, land filling, injection into deep underground wells, direct or indirect discharge into surface water, incineration and treatment.⁴⁷ Detail impact of solid waste titled environmental pollution discussed in the 6th chapter.

2.9 Solid Waste Management Matrix

It is critical to adopt a broad approach in developing a working framework for solid waste management. There are five strong forces/dimensions are active in the process of

⁴⁶ Rogers, *Pollution Control*, p. 354.

⁴⁷ Eban S. Goodstein, 'Economics and the Environment', 3rd ed. (New York: John Willy & Sons Incorporation, 2001), p. 249.

effective solid waste management. This covers the social, economic, technology, political and administrative dimensions. For example the social dimension of SWM involves waste minimization; the economic dimension of SWM involves waste recycling; the technology dimension of SWM involves waste disposal; and the political and administrative dimensions cuts across all the three issues of minimization, recycling and disposal. These dimensions are interrelated but their role is not equal in all respects.

Waste Minimization	Waste Recycling	Waste Disposal
“-- SOCIAL-- ”	“ --ECONOMIC--”	“ -- TECHNOLOGY-- ”
“ POLITICAL ”		
“ ADMINISTRATIVE ”		

SWM is not an isolated phenomena that can be easily compartmentalized and solved with innovative technology or engineering. It is particularly an urban issue that is closely related, directly or indirectly, to a number of issues such as urban lifestyles, resource consumption patterns, income levels, and other socio-economic and cultural issues. All these issues have to be brought together on a common platform in order to ensure a long-term solution to urban waste.

There is a whole culture of waste management that needs to be put in place - from the micro-level of household and neighborhood to the macro levels of city, state and nation. The general assumption is that SWM should be done at the city-level, and as a result, solutions tried out have been essentially end-of-pipe. 'End-of-pipe' refers to finding solutions to a problem at the final stage of its cycle of cause and effects. In the case of urban waste, it means focusing on waste disposal rather than waste recycling or waste minimization. But this approach essentially misses the forest for the trees, in attempting piece-meal and ad-hoc solutions to waste problems, instead of taking a long-term holistic approach.

The matrix that links the dimensions of decision-making (social, technology, economic, political and administrative) with the *levels* of decision-making (household, neighborhood, city, and nation) - helps in categorizing the decisions, action and related activities to be undertaken.

The Matrix is shown below:

Dimensions and Levels of decision-making	Household	Neighborhood	City	Nation
Social				
Technology				
Economic				
Political				
Administrative				

* Focal areas for action

The advantage of the SWM matrix of scales and themes is its essential simplicity - allowing for easy understanding and its adoption to various scales, and socio-political and cultural situations. Gaps in existing SWM programs and initiatives can also be identified. The matrix helps in understanding the interrelationships and interconnectivity of the various issues involved.

2.10 Integrated Waste Management

Integrated solid waste management refers to the complementary use of a variety of waste management practices to safely and effectively handle the MSW with minimal impact on human health and the environment. An integrated system contains some or all of the following components i) source reduction; ii) recycling of materials iii) landfill; and iv) incinerations. The EPA recommends a hierarchical approach to solid waste management problems. Using the four components of solid waste management, the hierarchy favours source reduction, which is aimed at reducing the volume and toxicity of waste. Recycling is the second favoured component. Recycling diverts waste from landfills and incinerators and recovers valuable resources. Landfill and incinerators are in the lower tier in the hierarchy, but are recognized as waste disposal method for ultimate disposal.⁴⁸

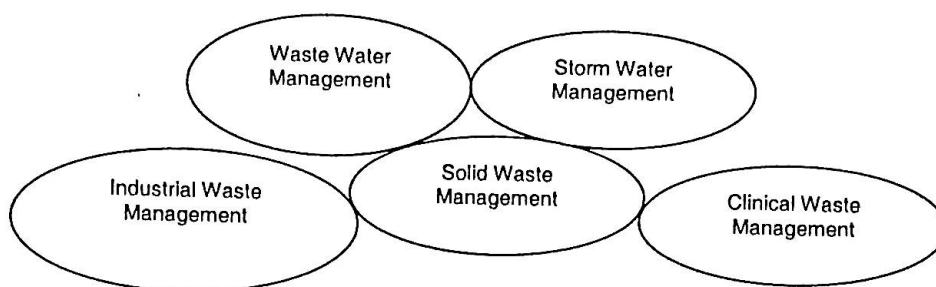
Simply the solving of problems of wastewater (effluent) and storm water (sewage water) without taking account of solid wastes will not achieve sufficient sanitation improvement to protect public health and environment. In discussing integrated waste management it is need also to consider solid wastes and wastewater produced by the industry. In many instances these may not differ in characteristics from domestic wastes, consisting primarily of biodegradable organic substance. Industries also produce lot of

⁴⁸ Liu & Liptak, *Engineering Handbook*, p. 230.

solid waste, which may be toxic to bacteria that are mixed with domestic waste and aggravated the situation worst. Toxic and hazardous wastes should be collected, recycled, reused or treat and disposed separately. Dumping SW in storm water drains will not only restrict the flow of storm water, they contaminate storm water. Simple industrial waste should be treated separately and industrial wastewater should be pre-treated if they are to be discharged to the sewer.⁴⁹ The following figure **** figure indicates that all wastes should be considered together to achieve environmental and public health improvement. Wastes should be separately collected and management.

Figure 2.1

Integrated Waste Management



Integrated solid waste management should have the components of legal and institutional framework; The vulnerability mapping; Establishment of a waste data bank; the research and development on specific waste streams and state of the art landfill operations; the qualification of technical staff and planners should be improved; public awareness with regard to proper waste handling and disposal as well as protection of environment; improved political understanding.⁵⁰

The integrated approach in waste management could save waste management cost by resource recovery, energy supply, composting, and creating income generating employment opportunity and environmental development. Resource recovery and different use of resources might reduce the loss of raw material, energy & nutrients. In Calcutta optimal use of waste resources showed the integrated WM. They use organic waste for animal fodder and vegetable production as long as they are sewage water to fishpond and effluent is used as irrigation water after some treatment. Co-composting of pig manure and garbage in Cairo is another example of integrated waste management. Solid waste near the source of generation and separation at source could be other elements of integrated approach and important means of shifting environmental problems to adjacent urban

⁴⁹ UNEP, *Environmental Sound Technology*, p. 8.

⁵⁰ Kodise A. Selotlegeng, "A Review of Waste Management in Developing Countries with Reference to Botswana", *Pollution Control*, p. 370.

areas. Composting at household as well as neighbourhood level could be a part of such strategy.⁵¹ Barrel type co-composting in the slum and government residential area of Dhaka is another example of integrated solid waste management.

2.11 Integrated Waste Management Tool

2.11.1 Solid Waste Management Hierarchy

A fruitful solid waste management has lot of sequential activities such as waste avoidance, utilization, cleaner, production, pollution prevention, waste minimization, treatment and disposal. Last step is striving to eliminate or remediation of impacts of waste discharged.⁵² A useful tool can help towards achieving integrated waste management is the waste management hierarchy. It has been used to direct SWM eventually sound practice following from one to six steps chronologically. When steps 1 to 5 have been fully considered and then go to step six. The waste management hierarchy is as follows:

- 1) Prevent or reduce waste generation;
- 2) Reduce the toxicity or negative impact of the waste;
- 3) Recycle waste in its current forms;
- 4) Reuse waste after further processing;
- 5) Treat waste before disposal;
- 6) Dispose in an environmentally sound manner

No society can prevent the production of human excreta or storm water, but they can prevent other material from being disposed with human excreta or solid waste with storm water. It is possible to avoid toxicity of wastewater by preventing toxic household or industrial wastes to be disposed with biodegradable organic wastes. The application of waste management hierarchy therefore, needs to consider the economics as well as other factors.⁵³ There is cost as well as benefits of any sort of waste management practice. It should be done cost-effective manner as well as sound management practice to sustainable environment. To get the sound environmental situation all waste should be separately collected and managed. Waste management should be integrated, with a view to health safety, environmental and economic aspects from "cradle to grave" or the Life Cycle Management approach. This approach is based on the principle that, products should be used properly and its residue must be disposed properly.⁵⁴

⁵¹ Lardinois, *Urban Waste Recovery*, Pickford, *Affordable Water*, p. 103.

⁵² World Bank Group, *Pollution, Prevention, Abatement Hand Book* (Washington: World Bank Group, 1998), pp. 29-32.

⁵³ UNEP, *Environmental Sound Technology*, p. 9.

⁵⁴ Dennis Bella Sr., "Environmental and Health Management", *Pollution Control*, p. 297.

2.11.2 End-of-Pipe or Life Cycle Approach

This life-cycle analysis is a gradual shift from 'end-of pipe' solutions that focus on waste disposal, to a source based approach. This places the responsibility not only on households, but also in manufacturers and retail businesses. Greater awareness at the local and community level has forced businesses and industries to take a more environmentally friendly approach to their activities, including better management of the wastes that they produce, using a more holistic life-cycle assessment. LCA is a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle.⁵⁵ Generally, there is no single 'correct' way to collect, handle and dispose of wastes, but a range of options. These must be tailored to local circumstances, such as the amount and climate, and economic conditions in integrated basis.⁵⁶

Solid waste management is a function, which starts from generation and ended at the final stage of disposal. In end-of-pipe approach, thrust is given to the final step of disposal. It has proved vague and ineffective. Definitely solid waste management have to consider from generation to final disposal as a whole, so a complete approach or LCA established. The matter should be clear through an example. Say, the secondary collection is good but it is open dumping and no leach ate of gas control. This situation will be exerbated. On the other hand, say the city has good treatment and disposal plant like Japan, but the primary and secondary collection is very bad. Therefore, the total solid waste management is very inefficient. Therefore, each element of solid waste has to click or activate together for a complete and efficient solid waste management program.

2.11.3 Community-Participation

As a consequence of the above two points is the realization that collection and processing of waste is not the exclusive domain of the local government - calling for a more comprehensive *partnership* between the community and local governments where each actor has a role to play towards waste minimization, waste recycling and waste disposal. As mentioned above, SWM is not an isolated, municipal problem that has to be 'done' by the local government. There is a need for a more comprehensive package of measures. Critical to this approach is to integrate SWM activities within the larger process of urban environmental management.

⁵⁵ www// Internet.

⁵⁶ Dennis Bella Sr., *Environmental Health Management, Pollution Control*, p. 296.

2.11.4 Technology Requirement Options

Technology is scientific knowledge applied in production or service process. Still technology is transferred from industrialized to developing countries, but they proved less effective. The types and composition of waste, the lack of technical know how and capital, the need for employment generation, the existence of large informal waste sector and socio-cultural attitudes should consider for developing a sustainable SWM or resource recovery system. One should consider the valuable technical know-how and existing feasibility of using high-tech capital-intensive processing system. Transfer of technology consists of more than just technical solution; a number of social and financial problems should be considered. Copying of technology will not bring expected results. But exchange of ideas and expertise opinion and suggestion may contribute more. The society and their habitual simplicity & commonness may be helpful for taking technical transfer initiation.⁵⁷

Technologies developed for use in the North are often hard to transfer successfully to developing countries due to wide differences in the climate, the pattern of urban settlement and prevailing wage rates. Most of the developing countries lie in the equatorial regions, where temperatures are generally high and rainfall, when it comes, is often intense. As a result MSW tend to be wetter and to putrefy faster than those generated by cities in the North. The moisture content of wastes is almost double in the region than that of USA. Incineration is almost impossible due to too wet to burn on a self-sustaining basis. So low-cost technologies are to be used for developing countries. On the other hand, the resource recovery is greater than the cost incurred for collection and disposal in Shanghai, China. Clearly, the viability of SWM recycling is related to the availability and cost of labour and the factor generally gives developing countries a lead over developed industrialized countries. Again, the Asian wastes consists mostly of organic mater, ash and dust, it generally breaks down to good rich compost.⁵⁸

Through recycling extraction of valuable materials from urban waste before it is burned for energy or LF. But the cost of separating the reusable materials often out weighed their commercial value. Among the new technologies and techniques of recycling are plasma techniques, polymeric membranes, and electrochemical reactions can extract valuable materials from waste water, slugs or factory dust. Technology is only one necessary ingredient among many to be successful recycling.⁵⁹ The depth of

⁵⁷ Lardinois, *Urban Waste, Pickford, Affordable Water*, pp. 103-104.

⁵⁸ John Elkington, *Waste Management Technology*, pp. 14-15, 21.

⁵⁹ *Ibid.*, p. 11.

commitment to recycling depends chiefly on the amount of LF space available, a nearby source of markets for secondary materials and community awareness of the local waste disposal problem.

2.12 Solid Waste Management Functions

Solid waste management is a combination of different functions. Identifying the source of generation to final disposal there are lot of programs has to achieve. The solid waste management functions are as follows:

- Identifying the source of generation;
- Collection and transportation;
- Waste processing;
- Recovery, Reuse and Recycling operation;
- Treatment and disposal;
- Special wastes handling with special manner

2.13 Identifying the Source of Generation

Solid waste may be generated from almost all-human activity. From home to office, market, institution, industry everywhere there is waste generated. Solid waste generation source can be divided from different perspective. The sources are as follows:

Residential

Residential wastes are generally considered to be household-type wastes. The wastes generated by the household activities are normally called residential wastes. This is more or less produced from food, packaging item, vegetable residues, garden trimmings, dust and cleaning residues, discarded utensils and other containers, useless materials etc. in the household level.

Non-residential

This is other than the residential source. It may the industry, commercial organization, public and private offices, educational and medical institutions etc. Non-residential waste can be divided into commercial, industrial, clinical and other institutional wastes.

The source of generation may be primary or secondary. The primary source of solid waste is the production of commodities and by-products from solid materials. Everything that is produced is eventually discarded and became wastes. A secondary source of solid waste is the natural cycle of plant growth and decay, which is responsible for the portion of the waste stream referred to as yard waste or vegetable waste.⁶⁰

⁶⁰ Ibid.

2.14 Collection and Transfer of Solid Waste

The most important and costly element of waste management is collection and transfer. Solid waste collection is a complex management program in urban communities. Urban solid wastes sources are divided into two principal categories: industrial and municipal. Municipal solid waste includes residential, commercial, institutional, and street sweepings, sewage sludge and demolition activates. All the solid wastes are to collect from different source of generation. About seventy to eighty percent of the solid waste budget is spent on collection and transfer functions. Collection is the part of solid waste management involving the collection route. Collection begins where the generators placed the refuse in transfer stations⁶¹ ends where the collection vehicle leaves the collection routes for off-route haul to final destination or disposal site. Collection means carrying the waste loads either from transfer stations or directly from the source of generation to the final disposal site. Collection is a key link in the chain of MSWM from the point of generation to ultimate disposal. In any initiative to upgrade waste management service, sustainable, contextually appropriate collection should be a major focus of attention. The lack of reliable collection service undoubtedly takes a toll on the public health and aesthetics of the African cities.⁶²

Collection and Transfer Mechanism

Solid waste collection and transfer can be undertaken through public, private or mixed public-private service.

2.15 Public and Private Arrangement

Public arrangements place control in the hand of government unit normally the municipal authority. Public arrangements take the form of either municipal collection or contract collection. Under municipal collection, waste is collected by public employees using publicly owned equipment. The operations are conducted under the direct supervision of a municipal department say Conservancy. Under contract collection, private firms collect waste. They use their won equipments furnishes employees and manages operations. The municipality retains responsibility for receiving complaints, billing customers, and controlling the activities of the private firm within the municipal jurisdiction. In case of private arrangements collection services are not provided by the government or local authority. Primary waste collection lies with one or more private firms. The distinguish feature of private collection is that collection firms are paid directly by the customers. The principal forms of private arrangement may be community based

⁶¹ A transfer station, i.e., a terminal where smaller collection vehicles empty their loads for continued haul by larger vehicle, may be part of the collection process.

⁶² Brihton Kaonga, *Appropriate Technologies, Pollution Control*, p. 386.

collection, franchise collection, and self service. Franchise collection consists of a governmental unit giving a private firm an exclusive license to serve a particular area. Self-service is the practice of letting the generator take waste directly to a transfer station or disposal area.⁶³

In most of the countries, the Community Based Organization (CBOs) are collecting the garbage from residence, institutions and other institutions. In Dhaka there are lot of CBOs are working collection function. In planning and implementing a solid waste collection system for any particular area, the design and operation parameters need to be carefully considered. Once implemented, a collection system must be continually monitored for assuring that maximum cost-effectiveness is being realized.

2.16 Types of Collection

2.16.1 Primary Collection

The primary collection starts from the generating point and haul to the transfer station by small vehicles. Any sort of MSW primarily collected either by the municipal authority, private firm or by the community-based organization (CBOs) or by the generator according to the institutional arrangement. Primary collection starts the picking up of MSW from source of generation and drops it into the transfer stations.

2.16.2 Secondary Collection

Secondary collection is nothing but collecting the refuse from transfer station to the treatment place or to the final destination. Generally, the local government authorities himself retain the secondary collection. This function of SWM is the most cost consuming. In some cases this may be leased out to the private operators but need close monitor.

2.17 Method of Primary Collection

2.17.1 Door- to-door Collection

This is the system where the householder does not do carry the waste to the nearest bins or transfer stations. The public or private service or the collector enters the house premises or courtyard with handcarts or small bins and empties it to the next secondary collection points. It is costly and labour intensive because of the high proportion of working time spent walking in and out of premises and from one dwelling to the next, but is the only really satisfactory system. A study in USA showed that this system costs about twice than that of kerbside collection, but this ratio would be greatly reduced in low-income countries.⁶⁴ In the DCC area 51% of solid waste is collected by

⁶³ Glysson, *Handbook*, pp. 36-37.

⁶⁴ Trivedi & Raj, *Encyclopedia*, Vol. 24, p. 112.

CBOs in the form of door-to-door collection. Small handcart or Rikshaw-van are used for door to door collection. It is neither curbside nor backyard systems of collection.

2.17.2 Curbside Collection Service

Normally residents store their residential refuse either in a container or small bin or bag. Curbside collection means the residents require placing waste containers at curbside or alley side (onto the foot way) on collection day before collection time. The collection crews collect the refuse from the containers and the residents to collect the empty containers from the curbside. This service is less expensive than backyard service, and about 60% of the collection systems in the United States had curb side service in the 1970s.⁶⁵ It is very important that bins or containers of standard type should be used as otherwise it is likely that wastes will inevitably scattered by animals and wind.

2.17.3 Backyard Collection

In this method, generators didn't place their container in the alley or kerbside rather they keep it within the premises of the house or backyard. The collection crews have to enter into the premises or backyard places or garages where the containers or bins are kept for collection. Naturally the residents are kept their refuse in a particular place in his/her backyard/premises and the collectors collect the trash from the backyard. Backyard collection service is usually in one of four forms:

Set out and set back

Collection crews carry containers to the curb/collection vehicles returned the empty containers to its original place where it was placed.

Set out

Collection crews only transport or carry the containers to the curb; residents return empty containers to its original place.

Tote barrel

In this method the crews neither carry the full containers nor the empty containers. The crews empty containers at the storage place into a tote barrel (small hand cart) and empty the tote barrel into the collection vehicle.

Satellite vehicle

A crewmember drives a small vehicle to the storage area, empties containers into the vehicle container, and then empties the smaller vehicle into the main collection truck. Particularly, where the big vehicles are not able to move due to narrow road space is suitable for satellite collection system.

⁶⁵ Glysson, *Solid Waste, Standard Handbook*, pp. 8- 42.

2.17.4 Block Collection

In this system, a collection vehicle travels a regular route at prescribed intervals, usually every two or three days, and it stops at every street intersection or suitable place, where a bell or flue is rung. At this signal the residents of all the streets leading from that intersection bring their wastes containers to the vehicle and handover them to the crew to be emptied. This system is operated in Mexico city and a study represents that the daily performance achieved by this system is about 3.5 tons/man and 7.0 tons/vehicle/day.⁶⁶

Frequency of collection

Residential collection service may vary with each municipality, depending on the citizen expectation, budgetary constraints, weather condition, nature of the waste etc. Once a week or twice a week or less interval collection schedule may be make for different societies. Once a week, twice a week collection may be appropriate where the cool weather prevails and the waste type is more or less non-degradable. But more frequent collection, even once in every day collection is necessary where warm climate creates nuisance with refuses stored for longer periods. The more frequently wastes are collected; the more costly is the collection service. Putrescible waste should collect more frequently than non-putrescible wastes.

Alternative	Potential advantage	Potential disadvantage	Collection that favour alternative
Once per week or less	Less expensive Requires less fuel	Improperly stored waste can create odour and vector problems	Adequate storage provisions Cold to moderate climate
Twice per Week	Reduces litter Reduces storage requirements	More expensive Requires more fuel	Quality for service provided more important criterion than economics
More than twice per week	Reduces litter Reduces storages requirements	More expensive Requires more fuel	Warm climate Seriously restricted storage space Dense population
Daily	Reduces litter Reduces storage Nil odour and clean premises	More expensive More fuel More supervision and equipment	Warm climate and easy degradation More moisture content in refuse Restricted storage capacity Densely population

2.18 Transfer Operations

Transfer operation is the physical transportation of solid wastes from source of generation to the disposal site. Transfer operation is the management of whole transporting activities of wastes with crew and equipment management. Collection vehicles collect garbage from source or from transfer station and off-load to the final destination. In some cases the disposal site may be far distance, resulting in too much off-route time for collection vehicle and crew. To increase productivity, in many places collection agencies have established terminals where the route vehicles can empty their

⁶⁶ Trivedi, *Encyclopedia*, Vol. 25, p. 110.

loads and return quickly to collecting refuse. From terminals a larger vehicle transports the loads of several collection vehicles to the disposal site. These terminals are also called transfer stations.

The situation differs in most developing countries where the collecting trucks transport wastes to the disposal area. Developing countries generally do not have separate formal transfer stations. So, all types of waste are collected from the road side, bins or demountable containers by the trucks and transported to the landfills.⁶⁷

2.18.1 Transfer Station

The principal reason for using a transfer station is to increase crew and truck productivity. A transfer station is justified when the cost of transport from route to the transfer station, and haul to disposal site using larger transfer vehicles is less than the cost of transport from route to disposal site by smaller vehicles. The purpose of a transfer station is to keep off-route time of collection vehicles to an acceptable minimum. Where the alleys/streets (lanes and by-lanes) are very narrow and collection vehicles can't move around the locality then a transfer station is a must. Small handcart or door-to-door collection by tiny vehicles needs transfer station for final transfer.⁶⁸

A transfer station should be near the centre of the collection area, convenient to good haul routes, and zoned industrially or if necessary, commercially. The site should not be near the residential area. A site can be at some distance from the centre of production without excessive economic disadvantage. Transfer stations should be attractive, convenient, and safe, with adequate storage facilities. The developing countries transfer station is the haul of refuse on to the roadside or bins or demountable containers placed for final disposal.

2.19 Location of Disposal Areas

The total collection and transfer operation design depends on the location of disposal site. Disposal areas are those parts of the collection area assigned to a specific disposal or processing site. Where a system has only one or two disposal options, matching routes to disposal sites is relatively easy. Where several disposal sites are available, the problem becomes highly complex. Many factors must be evaluated in choosing where to route vehicles. Among these are tipping fees⁶⁹, site reliability and

⁶⁷ Bogatsu, *Effective Waste Disposal, Pollution Control*, p. 273.

⁶⁸ Glysson, *Solid Waste, Standard Handbook*, pp. 8-63.

⁶⁹ Tipping fee refers to the fee or charge has to pay the transfer vehicles containing refuse to the disposal sites for entering into sites. For each trip, a particular amount of fee is to pay by the transporter to the site management. Where the private owners manage the landfill sites, tipping fees are common.

round-trip haul and disposal time, and vehicle wear and tear. In very complicated situations, a computer program might be used to identify the most effective use of many different facilities.

2.20 Collection and Transfer Operation Management

The whole collection and transfer operation is a managerial function need some administrative step includes record keeping, maintenance, standby equipment, and costs. Record keeping is vital part of management in any solid waste collection or transfer system. Without record, productivity measurements, evaluation, cost studies, and preventive maintenance is difficult to perform. Refuse collection is a very sensitive and also difficult task. There may be frequent equipment breakdown or out of order. The prudent collection manager will provide sufficient standby equipment to allow the daily collection to be completed as scheduled. The cost of solid waste collection varies considerably from system to system. Wage is to be the single largest component of cost factors of waste collection. Direct labour cost, spot density, distance of the haul station and disposal site, waste type and density, equipment size and type and crew productivity affects the cost factors of the collection and transfer.

Crew Productivity

Crew productivity is a measure of efficiency. Several factors influence crew productivity including route, service level, collection equipment, and personal characteristics and efficiency of crewmembers. Crew productivity may be measured in several ways. Among these are:

- Household collected per week per crew
- Weight per year per crew or crew member
- Volume per year per crew or crew member

Storage Containers

Whatever may be the type of waste it is required easy containers to carry/handle the solid waste from source of generation. The collection agency should regulate storage container size and shape, matching the container characteristics to the collection system. A suitable storage container must be easy to handle and to keep clean. Containers for mechanized collection efforts to increase productivity. Mechanized collection is a new application of technology requiring more experience before it can be generally adopted. Currently, large demountable containers used for primary station as well as secondary transport container. Collection vehicles are equipped to pick up the container and empty it into the vehicle or disposal site. The containers (in transfer station) may be such as bins, large drums, and cardboard boxes can be used.

Most of the developing countries use the open concrete or cement –block bins. The bins are unsanitary and inefficient, must be emptied by hand, attract insects and rodents, allow blowing papers and odours and if uncovered, can leach a foul liquid after rains. Steel drums and paper packing drums are also unacceptable. The drums usually do not have tight-fitting lids, allowing insects, birds, and animals access to the refuse. Cardboard boxes may be suitable for rain free area.

2.21 Collection Equipment

The collection equipment is very important aspect of solid waste management. The authority should choose equipment suited to the characteristics and local situation. The equipment selection depends on varying factors as anticipated service level, crew size and productivity, route of travelling, narrowness of alleys, restricted headroom, turning radius, time of collection, climate etc. Often more than one type or size of equipment will be needed in a particular service area. Naturally small vehicles are appropriate for narrow alley side residential area and big containers are more appropriate for wider area based commercial refuse collection.

Hazardous wastes including medical wastes require special equipment for transfer. More rigid plastic bags may be used for transporting swabs, human tissue, sharps and so forth. It should be pre-treated before disposal.⁷⁰ The transport vehicle or other equipment selection depends on several factors. Garbage nature, size, road space, distance, bridge and road weight limits, turns of the roads, crew productivity, cost factors etc are to be considered in case of vehicle selection

Maintenance

Transport vehicles are complicated mechanical devices requiring periodic maintenance. Vehicles or equipments may be out of order, dysfunction any time needs continuous maintenance. A mechanic capable of repairing mechanical and hydraulic systems together with the necessary tools and equipment should be a part of any solid waste collection system.

Routing

Routing means the path through which a vehicle will run for collection and transfer to the disposal sites. Route is the path through which the vehicles move around to make the collections within a particular area. The objective of routing is to direct the collection vehicle through the collection area so that the time is kept minimum. Route shows the direction of a collection vehicle will move from one point to another and finally

⁷⁰ Bogatsu, *Effective Waste Disposal, Pollution Control*, p. 273.

to the disposal site. Ideally, each collection vehicle should start the day empty and be packed out when the vehicle makes its final run to the disposal site. Most of the cases the route is selected on the basis of trial-and-error method. Computer program or heuristic methods also can be used for routing.⁷¹ The steps involved in establishing a collection route are -

- Define the collection area. For route identification a particular area of territory should be selected for a particular vehicle.
- Assign disposal sites. If disposal site is only one, no options but if more than one in that case, options should be clearly identified in the route to minimise the carrying cost.
- Establish daily zones. In some case collection zones may be establish. Zones may be on basis of area or even time base. Zoning system is fruitful where there is vast area covered by several vehicles.
- Balancing daily vehicle assignments. In case of rout selection the daily workload of a vehicle must be identified. This is depend on the crew productivity, on route time, area cover, distance, round trip haul time, rest time (coffee and lunch), condition of the vehicle, traffic jam etc.

From the above discussion it is clear that successful collection and transfer operation is the function of crew productivity, quality equipment and maintenance, effective routing and operation management.

2.22 Waste Processing

Solid waste management is considered as a number of material processing operations, like other production process. Fluctuations in waste generation must be entertained when waste processing is planned. Solid waste comes into different form and shape. For any sort of treatment, disposal and resource recovery need separation and screening.

Because objects in MSW do not readily stratify by size, screening of MSW generally requires a mixing action such as trommel screens. By processing refuse-derived fuel (RDF) containing refuse (with more heating value) can be isolated. This system is also called a supplemental fuel system because the combustible fraction is typically marketed as a fuel to outside users (utilities or industries) as a supplement to coal or other solid fuels in their existing boilers.⁷² Before final disposal or utilization solid wastes are to be processed in the form of screening, shredding, separating, classifying, and baling.

⁷¹ Glysson, *Solid Waste, Handbook*, p. 56.

⁷² S. C. Bhatia, *Environmental Pollution*, p. 132.

2.22.1 Screening

Screening is the process of separating some unwanted particles from others. A separation method based upon particle size uses the trammel screen, sometimes called a rotary screen or rotary tube. In a typically system, MSW is fed into a trammel or rotating screen to remove glass and dirt, and the remaining fraction is conveyed to a shredder for size reduction.⁷³ It is a method of separating the solid wastes into different size and shape by rotating the materials onto a screen or tube.

2.22.2 Shredding

Shredding is the size reduction to make a uniform size of all particles in a waste heap. There was a time when a waste treatment facility relied on hammer mills and hog pressure for reducing waste volume. Although those technologies still are utilized in communities, the trend is to replace them with shredders and grinders.⁷⁴ The composition of municipal solid waste is typically a mix of different articles. Among them there are also big and small particles. The purpose of shredding is to size reduction and make the material more uniform and, hence, more predictable. This is done by chopping up the items and mixing the fragments together.

Shredding is essential prior to introduction of any operation. Shredding not only breaks the material into smaller size, making it more uniform, but shredding also imparts a blending action to the material stream. Beside this shredding helps to volume reduction, minimise vector problem, reduced fire hazard, reduced odour potential and reduced litter problems.

2.22.3 Classification by Separation

Classification is one of the easy processes of waste separation. Shredded wastes may then pass through an air classifier to separate the "light fraction" (plastics, paper, wood, textiles, food wastes and smaller amounts of light metals) from the 'heavy fraction' (metals, glass, aluminium, ceramics etc.).⁷⁵ Solid wastes are passed through a strong current of air effects to separate them. The heavier materials are dropped down and the air presser takes the lighter ones away. If relative density is to be the criterion for separation, then the viscous drag on each particle must be uniform regardless of the material. The effectiveness of the air classification depends on the particle size. The higher the particle size, the lower the possibility of separation. The flow of air velocity is also important for fluidisation of the material to be separated.⁷⁶

⁷³ Glysson, *Solid Waste, Handbook*, p. 70.

⁷⁴ Internet, (Internet-0403 net).

⁷⁵ S. C Bhatia, *Environmental Pollution*, p. 132.

⁷⁶ Glysson, *Solid Waste, Handbook*, p. 82.

2.22.4 Magnetic Ferrous Separation

The separation can be done through the other process. The lighter fraction after being routed through air classification can be separated through a magnetic system to remove the ferrous metals. The heavier fraction also separated by another magnetic process for recovering the ferrous metal. It is the magnetic separation of ferrous scarp from other refuse. It is a relatively easy and inexpensive operation to separate the ferrous and non-ferrous items.

Baling

Baling means compact solid waste materials into small size and shape. Baling is a relatively simple process that does not alter the physical or chemical nature of the solid waste. Rather it is a compression process for the significant reduction of volume occupied by the solid waste. In addition, baling produces a predictable product, the bale that is both much easier to handle and takes smaller places at the disposal site. Baled solid waste is less prone to methane generation; generally will not support combustion; and produces a leachate of a less concentrated character and it is more economical.⁷⁷

2.23 Reduction, Recovery, Reuse, and Recycling

Reduction, Recovery and reuse are the three important aspects of integrated solid waste management. Some scholars articulate that recycling is another component of reintegrated waste management. In fact recovery is contemporary to the recycling. However, all these aspects of solid waste management are discussed in chapter seven.

2.24 Treatment and Disposal

Treatment is preparing or processing the wastes through separation, volume reduction, including by-product recovery, and reducing its physical impact on environment to a minimum before final disposal. Treatment is one kind of stabilization. In general, waste must be treated to prepare it for disposal. Treatment reduces waste's toxicity and volume, change its physical form, or make it safer to dispose in compliance with environmental regulations. Selection of treatment methods depends on the quantity and form of the waste material. There is no identical method of solid waste treatment. Source separation, screening, shredding, classifying, baling etc and finally recycling are the part of treatment.

The final step in the waste management process is waste disposal, the safe and secures isolation of waste. Disposal is the final stage of solid waste management, which disappears solid wastes from the scenery through different methods. Disposal method depends on the type of wastes and with available technology.⁷⁸ Now a day it is tried to

⁷⁷ Glysson, *Solid Waste, Handbook*, p. 86, Liu & Liptak, *Environmental Handbook*, pp. 1174-75.

⁷⁸ Internet.

recover materials as much as possible before disposal. Current waste disposal philosophy is to endeavour to treat all wastes as resource materials: some for recycling; some for conversion to fertilizer or as a source of energy; and the balance for land reclamation.⁷⁹

Waste disposal means the deposition of a stream of waste at a site, which has the facility to handle the type of waste, and is bio-geophysical-conducive to receiving that types of waste. There are, normally, three objectives in selecting a waste disposal site. These are: a) the economic objective. The site should be within an economic haulage distance of the waste generation points. b) Environmental acceptability. The site selected should be environmentally acceptable for the particular type of waste envisaged. c). Socially acceptable. The site should be socially acceptable to the majority of the community.⁸⁰

The importance of socio-economic considerations in the identification of sustainable waste management disposal options is very important. The system must be appropriate to the particular circumstances and problems of the city and the locality, employing and developing the capacities of all stakeholders, including the households and communities requiring service, private sector enterprises and workers (both formal and informal) and government agencies at the local, regional and national levels.⁸¹

The most common method of disposal is by use of a landfill. Other methods of interest are land reclamation, composting, incineration, pyrolysis, and wet oxidation. All methods are not appropriate for all community and even for all types of solid wastes.⁸² The environmental impact of wastes disposal must be considered before selecting the disposal methods. There are different types of wastes disposal methods. These are as follows:

2.24.1 Hog Feeding

At one time, hogs (pig) were extensively used for garbage disposal. The hogs ate the raw garbage. In colonial times hogs wandering in the streets served as scavengers of the wastes in the gutters. But once it was know that the feeding of raw garbage to hogs led to high incidence of trichinosis in humans for pork, the practice decreasing. During the years 1950 to 1955 the rapid spread of a virus disease of hogs, vesicular exanthema, largely through raw garbage, led many countries to institute regulations forbidding the feeding garbage to hogs. Around 1960s the hog feeding became so restricted and presently almost insignificant.⁸³

⁷⁹ Trivedi, *Encyclopedia*, Vol. 25, p. 5.

⁸⁰ Ibid, pp. 284-285.

⁸¹ Ali, *Down to Earth*, p. 71.

⁸² Glysson, *Handbook*, p. 110.

⁸³ Trivedi., *Encyclopedia*, Vol. 25, pp. 116-117.

2.24.2 Ocean Dumping

Once upon a time when the garbage are dumped into the nearest ocean, ultimately it was proved that due to ocean dumping the eco-balance of the ocean hampered seriously and the voice raised against the ocean dumping of waste. Ultimately it was banned or restricted by law in most of the countries. This is largely a consequence of restrictions on ocean dumping initially related to hazardous waste under the Rome IV and Bamako Conventions, as well as the London Duping Convention of 1972. Even though the practice is largely prohibited across Africa, it still occurs to a significant extent in larger coastal cities of Africa.⁸⁴

2.24.3 Onsite Disposal

There is a common on-site⁸⁵ disposal method in urban areas. In some cases peoples throw the garbage to the open space, drains, ditches, near the railway lines etc. Even there is a system of mechanical grinding of kitchen/food waste. Garbage disposal devices are installed in the waste water pipe system from kitchen sink and the garbage is grind and flushed into the sewage system.⁸⁶ The system effectively reduces the amount of handling and quickly removes food wastes but final disposal transferred to the sewage treatment plant where solids such as sewage sludge still must be disposed. Another means of onsite disposal is incineration. Simple burning is one kind of onsite disposal commonly used by the low-income people for cooking food and other use.

2.24.4 Simple Land Filling or Open Dumping

Open dumping is oldest and most common and simple method of disposing of solid wastes. It is the process of just making a heap of wastes either in a pre-selected place after formal collection and transportation or random throwing in a place. This method is cheaper then other disposal methods and has the advantage of avoiding the acute pollution problems associated with discharging wastes into waterways or polluting the air from incineration. In many cases, they are located wherever land is available, without regard to safety, health hazard & aesthetic degradation. The waste is piled as high as equipment allows. In some instances, the refuse is ignited and allowed to burn; in others, the refuse is periodically levelled and compacted.⁸⁷ The open dumping may happen at local level through the process of digging pits in back yards only temporary solve the waste problems, but in areas where topography and hydrological conditions are unfavourable, pollutions may result.

⁸⁴ Kaonga, *Appropriate Technologies, Pollution Control*, p. 389.

⁸⁵ Keller, *Environmental Geography*, p. 253.

⁸⁶ Ibid.

⁸⁷ Keller, *Environmental Geography*, pp. 253-254.

Like other Asian countries, India too disposed solid waste in land filling. Simple dumping in the low-lying areas, are prone to flooding. This is a very shortcut approach of waste disposal also knowing the hazard. The daily cover techniques are poor leading to vector problems. The birds foraging on garbage dumps have resulted in a great deal of loss of avian sector.⁸⁸ In Botswana, waste was dumped indiscriminately in the field as long as it was “far away”; this idea was not taking care of the fact that far away is next to someone’s home, cattle post, farm lands, or development designated areas. This brought a chaotic situation in surrounding areas.⁸⁹

As it is easy and less cost consuming, open dumping is easiest disposal. As the population increases now it is being realized that almost any open piece of land eventually will be used for another purpose. On the other hand burning of wastes become unwise and even ban by the law for environmental protection. To complement this, open dumping is no longer aesthetically desirable nor it is sanitary.⁹⁰ As a general rule, open dumps tend to create a nuisance by being unsightly, breeding pests, creating a health hazard, polluting the air, and both ground water and surface water. The most potential of open dumps are water pollution. It was found that chloride concentration at the dumpsite of Surrey County, England, were 800 mg per litre, which is over three times the maximum concentration of 250 mg per litre considered safe for a public water supply.⁹¹

2.24.5 Sanitary Landfill or Secure Landfill

The sanitary landfill defined by the American Society of Civil Engineering as “an engineered method of disposing of solid waste on land in a manner that protects the environment, by spreading the waste in thin layers, compacting it to the smallest practical volume, and covering it with compacted soil by the end of each working day or at more frequent intervals if necessary”. Sanitary landfills are and will continue to be the principal method of solid waste disposal.⁹² Sanitary landfill is the deposit of waste onto and into land in such a way that the environmental risk is controlled at an appropriate and acceptable level and where, subsequent to disposal, the land can be made available for other uses.⁹³

According to the sanitary engineers, sanitary land filling is ‘a method of disposing of refuse on land without creating nuisances or hazards to public health or safety, but

⁸⁸ Jain, & Pant, *Waste Management in India*, Pickford, *Affordable Water Supply*, p. 94.

⁸⁹ VTC Matsoga, *Waste Management, Pollution Control*, p. 438.

⁹⁰ Alter & Dunn, *Solid Waste Conversion*, pp. 44-45.

⁹¹ Keller, *Environmental Geography*, p. 254.

⁹² Glysson, *Solid Waste, Handbook*, p. 110.

⁹³ Ali, *Down to Earth*, p. 73.

utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each days operation, or at such more frequent intervals as may be necessary'.⁹⁴ Sanitary landfill is nothing but land filling with trash or garbage with a covering of 6-8 inch of soil and allowing nature to do the rest. Low swampy areas are good for sanitary landfill.⁹⁵

Covering the waste with compacted soils makes the landfill 'sanitary'. The compacted layer effectively denies continued access to the wastes by insects, rodents, and other animals. It also isolates the refuse from the air, thus minimizing the amount of surface water entering into and gas escaping from the waste heap.⁹⁶ Some LFs are double liner system: plastic, clay and again plastic, clay liner for more protection. The collected leachate should be treated separate.⁹⁷

2.24.6 Importance of Sanitary or Secure Landfill

Though the landfill places are running out but everything cannot be recycled or incinerated and landfill will continue to be needed. It avoid the harmful effects of uncontrolled dumping by spreading, compacting and covering the waste on land that has been carefully engineered before use. Through careful site selection, preparation and management, operators can minimize risks from leachate and gas production both in the present and the future.⁹⁸

Sanitary land filling is a recommended disposal option for developing countries when suitable land is available at an affordable price. This option must be considered after an assurance that pollution could be controlled and human and technical resources are available to operate and manage the site.⁹⁹

Sanitary landfill operation is environmental friendly as well as it is resource-generating program. **Firstly** it is not just expediency for disposing large amount of trash ut it will eventually reclaiming lowland for valuable use. **Secondly**, organic nature solid waste would become eventually topsoil.¹⁰⁰

⁹⁴ Trivedi, *Encyclopedia of Environmental Science*, p. 119.

⁹⁵ Alter & Dunn, *Solid Waste Conversion*, p. 44.

⁹⁶ Keller, *Environmental Geography*, p. 254.

⁹⁷ Hinrichs & Kleinbach, *Energy*, 3rd ed., p. 547.

⁹⁸ Ali, *Down to Earth*, p. 8.

⁹⁹ Ibid.

¹⁰⁰ Alter & Dunn, *Solid Waste Conversion*, p. 45.

2.24.7 Landfill Site

The effective sanitary landfill project must be sited in a suitable place. The most desirable site is in a high humidity. Wastes are buried above the water table in relatively impermeable clay silt soils. Any leachate produced will remain in the vicinity of the site and be degraded by natural filtering action and based exchange of some ions between the clay and the leachate. The sanitary landfill should be lined with impermeable clay soil or plastic sheets beneath the garbage, and then widespread groundwater pollution possibility is less. On the other hand if landfill site is not lined with clay soil or other materials, due to permeable sand and gravel soils, considerable contamination of the ground water might happen. This is because the leachate quickly moves through the permeable soil and enters the water table or aquifers.¹⁰¹

2.24.8 Types of Sanitary Landfill

There are two types of sanitary landfill. Excavated or trench method and area method. At excavated or trench method, soil is excavated from the area where waste is to be deposited and saved for use as daily, intermediate or final cover. Excavated landfills are constructed on sites where excavation is economical and the water table is sufficiently below the ground water. Area landfills do not involve soil excavation and are built where excavation is difficult or the water table is near the surface. Both type of landfills are lined; the excavated landfill on the bottom of the excavation, the area landfill on the ground surface. In the excavated method the earth is excavated like a ditch and made a liner onto the bottom and sideline to protect the leachate movement. In area method of land filling an artificial ditch is made over the plain land like a dam with liner over the land and in the side wall. The size of the landfill depends on the rate at which waste is deposited in the landfill, local precipitation rates, site topography etc.

2.24.9 The Advantage & Disadvantage of Sanitary Landfill

The advantage of a sanitary landfill, as opposed to an open, uncontrolled dump, has been i. The public health problems are minimized because flies, rats and other pests or vermin are unable to breed in the covered refuse; ii. There is no air pollution from burning and none from dust or odours; and iii. The fire hazards are very small. There is a danger of ground and surface water pollution, if the landfill site is improperly chosen or if it is dug too deep. Landfill gas emission could create greenhouse effect if methane concentration is more than 5% in volume.

2.24.10 Preliminary Landfill Requirements

Every proposed sanitary landfill has some basic requirements that must be determined prior to commencing any design activity.

¹⁰¹ Keller, *Environmental Geography*, p. 257.

- ❑ **Estimate of solid waste quantity:** An accurate record of solid waste amount is very essential for a proposed sanitary landfill.
- ❑ **Type of waste delivered to site:** There should be clear attention that non-typical waste is not disposed in the site. Hazardous waste should not be disposed in the landfill site without treatment.
- ❑ **Requirements of state regulation:** Landfill construction is now more expensive and complex than past because of requirements concerning daily cover, liners, leachate collection, gas collection, monitoring, hazardous waste exclusion, closure and post closure requirements etc.
- ❑ **Location restrictions:** Location should be choose free of floodplains, fault areas, seismic impact zones, and unstable area restrictions should apply. LF is well enough to impermeable soil condition. The airports, floodplains, wetlands protection, social restrictions etc. are the major concerns for landfill site and also the natural environmental consequences should be studied in landfill site.
- ❑ **Wildlife protection:**¹⁰² It must be take into consideration that land filling creates no hamper of wildlife and natural resources. No society can destroy natural resources (i.e. swamp and low lands, abandoned quarries, which act as sanctuaries) for wildlife in the name of landfill.
- ❑ **Hazardous waste exclusion:** A program should be developed and implemented to detect and prevent disposal of regulated hazardous wastes at the sanitary landfill.

Landfill Site Selection

Selection of a sanitary landfill site is often more a social-political process than an engineering process.¹⁰³ First of al the site selection process should have the available data on landscape position, topographic maps, water well logs, soil test report, highway maps, and bridge loading information etc. Prior to finalization of the landfill site it is required a detail hydrogeology and soil investigation report. The soil report will indicate the nature of on-site soils and the need for any liners or leachate collection system. It is important to know the nature of soil. It is necessary to know the type of soil, whether clay or saturated porous soil. Clay soil that will serve as an in situ impermeable barrier or it is used to construct a clay liner. Generally, porous soils {permeability greater than 0.00028 ft/day (1×10^{-7} cm/s)} will require a liner system and leachate collection mechanism. The hydrogeologic report will provide the designer with information as to how deep the site may go below ground surface. Water well position is essential before site selection. The water well logs will provide some indication of the location, depth, capacity, and water quality of the aquifer.¹⁰⁴

¹⁰² Alter & Dunn, *Solid Waste Conversion*, p. 45.

¹⁰³ Glysson, *Standard Handbook*, p. 111.

¹⁰⁴ Ibid., p. 114.

Landfill Size¹⁰⁵

The size of a landfill site should be a sufficient one for long time disposal. The fixed cost of engineering, land, roads, buildings, and environmental controls for a site with a 25-year life are not much different than for a site for only 10 years. Landfills should be designed for a minimum depth of 20 ft (6m) and a minimum life of 25 years.

Generally the earth is removed or scooped out by means of dredges or bulldozers and refuse trucks dump their trash into the void (empty space). The bulldozer then distributes the trash and compact it and covers it with 6-8 inch of soil. More refuse can be added and covered in the same manner until to a suitable level.¹⁰⁶ The depth of landfills is varying from about 2 to 13 meters. Normally, refuse is deposited, compacted and covered by a minimum of 15cm of compacted soil at the end of each day. There is 1: 4 cover ratio is common, i.e. 30cms of soil for every 120cms of compacted wastes.¹⁰⁷

In Holland, new waste tips gave to be sealed at the bottom to prevent pollution of the ground water. By doing this, the highly polluted leachate can easily be collected by means of a drainage system. Before discharging this leachate it can be treated for purification. In Zoetermeer landfill, Holland, a double re-infiltration system is recommended. In this way, the tip itself is used as a bioreactor. It consists of an anaerobic re-infiltration of the leachate as pre-treatment and an aerobic re-infiltration of the methanogenic stabilized leachate as a post-treatment.¹⁰⁸

2.24.11 Landfill Operating Parameter

Daily Covers

In a Landfill, solid waste must be covered with a minimum of 6 inch of earthen material at the end of each operating day, or at more frequent intervals if necessary. Soil is the best cover material. However, alternative materials of an alternative thickness may be acceptable if demonstrated that the alternative material satisfies the daily cover objectives. Indigenous materials are appropriate alternative cover for landfill. Examples of indigenous materials include: ash from municipal incinerators; compost-based material; sludge treated with lime; construction and demolition debris; shredded automobiles tyres etc. The daily cover is essential to control disease vectors, fires, odours, blowing litter, and scavenging. Covering also reduces exposure of combustible materials to ignition sources and may reduce the spread of fire if the disposed waste

¹⁰⁵ Glysson, *Standard Handbook*, 114; Alter & Dunn, *Solid Waste Conversion*, p, 45; Edward Keller, *Environmental Geography*, p. 256.

¹⁰⁶ Alter & Dunn, *Solid Waste Conversion*, p. 46.

¹⁰⁷ Edward Keller, *Environmental Geography*, p. 256.

¹⁰⁸ PA de Bocks, *Re-infiltration of Waste Tip Leachate: An inexpensive Alternative*, JKA Dewal ed., *Environmental Technology* (Holland, 1987), pp. 587-592.

burns. Odours and blowing litter are reduced by elimination the direct contact of wind and disposed waste.

Liner Requirements

It is already stated that porous soils permeability greater than 0.00028 ft/day needs a liner system in landfill site. The prevailing theory of sanitary landfill design is to prevent water from entering the refuse mass and also to prevent leachate from entering ground or surface waters. A landfill can be thought of as a bathtub. Liners make the bottom and sides of the landfill less permeable to the movement of leachate and water.¹⁰⁹ Downward percolation of the leachate can be retarded if the in situ soils of the landfills are clay soil with a thickness and permeability is sufficient. If the in situ soils do not satisfy the requirements, a different liner must be designed. Liners may be constructed or either clay, synthetic fabrics (geomembranes) or soil-additive mixtures. Synthetic fabrics are made of one or more polymers along with a variety of other ingredients. But clay liners are more appropriate and less expensive if the clay is within a reasonable haul distance. The clay liner provides excellent protection against leachate migration. Because of their inherent impermeableness, the use of geomembranes in landfill liner construction has increased.¹¹⁰

Final Landfill Cover

As well as daily cover at the end of the landfill life, there must be a final cover. The finishing cover is at least 50cms of compacted soil designed to minimize infiltration of surface water. When the LFs are filled and ready for final closure, a plastic liner is placed over the top and then covered with soil. However, there is a debate between the EPA and others on such closure method. The EPA wants dry storage to minimize water contamination. Others want to keep the waste wet to speed up decomposition. One benefit is the production of methane gas from the LF by bacterial breakdown of complex organics in the garbage.¹¹¹

2.24.12 Landfill Guideline¹¹²

The following guideline should be followed in site selection of a landfill.

- ♦ **First:** The soil condition of the LF should be appropriate. Limestone or highly fractured rock quarries and most sand and gravel pits make poor landfill sites

¹⁰⁹ S.C Bhatia, *Handbook*, p. 224.

¹¹⁰ Glysson, *Solid Waste, Standard Handbook*, pp. 117-118.

¹¹¹ Hinrichs & Kleinbach, *Energy and Environment*, p. 547.

¹¹² Edward Keller, *Environmental Geography*, pp. 256-257; Glysson, *Solid Waste, Standard Handbook*, pp. 111-125, PA Bocks, *Re-infiltration of Waste, Environmental Technology*, pp. 587-592.

because these earth materials are good aquifers. It is easy percolation of rain water as well as leachate movement around the water table;

- ♦ **Second:** Swampy areas, unless properly drained to prevent disposal into standing water, make poor sites;
- ♦ **Third:** Clay soil is good for landfill site. It is impermeable which is barrier of water moving and leachate percolation. Clay pits, if kept dry, may provide satisfactory sites;
- ♦ **Fourth:** Flat upland areas are favourable sites if an adequate layer of impermeable material such as clay is present above any aquifer;
- ♦ **Fifth:** Floodplains that are likely to be periodically inundated by surface water should not be considered acceptable sites for refuse disposal;
- ♦ **Sixth:** Any permeable material with a water table is probably an unfavourable site;
- ♦ **Last:** In rough topography, the best sites are near the heads of gullies where surface water is a minimum. While these general criteria are useful they do not prelude a hydrological investigation including drilling to obtain samples, permeability testing and other tests to predict the movement of leachate from the buried of refuse.

Landfill Operation Control¹¹³

Landfill site may be the potential source of pollution. Therefore, it is very essential to monitor the LF sites for long period. Once site is chosen for sanitary landfill, monitoring of the movement of the ground water should begin before filling commences. After the operation starts, continued monitoring of the movement of leachate and gases should continue as long as there is any possibility of pollution. This is particularly important after the site is completely filled and permanent cover material is placed, because a certain amount of settlement always occurs after a landfill is completed. Any moment the surface water may collect, infiltrate and produce more leachate. Monitoring and proper maintenance of an abandoned landfill reduces its pollution potentials.

Landfill Leachate Control

Leachate is any liquid, including any suspended components in the liquid that has percolated through or derived from hazardous wastes.¹¹⁴ Leachate is liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.¹¹⁵ Leachate, especially from new landfills, can have high concentrations of COD, BOD, nutrients, heavy metals, and trace organics. Leachate that contracts drinking water supplies can result in contamination. For this

¹¹³ Keller, *Environmental Geography*, p. 257; Glysson, *Solid Waste, Handbook*, pp. 132-133.

¹¹⁴ Mallow, *Hazardous Waste Regulation*, p. 207.

¹¹⁵ Glysson, *Solid Waste, Handbook*, p. 119.

reason, liners and collection systems are used to minimize the leachate that escape from landfill.¹¹⁶ Leachate is the outcome of degradation of organic mater. COD is the measure of organic mater.¹¹⁷

The factors affecting the leachate generation are climate, site topography, the final cover materials, the vegetative cover, site phasing and operating procedure, type of waste in the fill, rainfall rate in the area etc. Topography of the area and rainfall infiltration is the possible causes of more leachate production. One measure used to prevent the movement of water pollutants from the landfill site is a liner system integrated with a leachate collection system. Unless exemptions are made, this requirement means that the final cover must be done with geosynthetic layer. A drainage layer in final cover will reduce the amount of water infiltrating the fill. Vegetative cover on final cover reduces infiltration by intercepting precipitation and encouraging transpiration.

Whatever is the amount the production of leachate in the fill is a must. The amount of leachate production may be changed under different situation. Through the controlled mechanism the volume may be retain into a reasonable level. Good design dictates that as much off-site storm water as possible be diverted around the landfill. It is important that the refuse mass be kept as dry as possible. The placement of refuse in trapped storm water must be avoided.

Leachate controls are the final cover, the surface water controls that keep water from running onto the landfill, the liner, the leachate collection system, the leak detection system, and the leachate disposal system. Leachate is generally collected from the landfill through sand drainage layers, synthetic drainage nets, or granular drainage layers with perforated plastic collection pipes and is then removed through sumps or gravity drain carrier pipes.¹¹⁸ The collected leatchate may be treated by recycling, onsite treatment, or discharge to a municipal waste-water treatment plant (lagoon) for stabilization.

Disease Vector Control

Disease vectors such as rodents, bird, flies, and mosquitoes typically are attracted by putrescent waste and standing water, which act as a food source and breeding ground. Normally, application of a daily cover is sufficient to control disease vectors; however other vectors control alternatives may require. These alternatives could

¹¹⁶ S.C Bhatia, *Handbook of Pollution*, Vol. 1, p. 223.

¹¹⁷ Katarina Kylefors, Holger Eche and Akdras Lager Kvist, "Accuracy of COD Test for Landfill Leachates", *Water, Air and Soil Pollution: An International Journal of Environment*, Vol. 146, No. 1-4, June 2003 (Kuler Academic Publishers,) pp. 153-169.

¹¹⁸ Glysson, *Solid Waste, Handbook*, p. 20; Kylefors, "Accuracy of COD", *Water, Air and Soil Pollution Journal*, pp. 153-169; S. C Bhatia, *Environmental Pollution*, p. 137.

include reducing the size of the working face; increasing daily cover thickness, changing cover type, density, placement frequency, grading, use of insecticides or rodenticides; composting or processing of organic wastes prior to disposal; and predatory or reproductive control of insect, bird and animal populations.

Landfill Gas Control

There are lot of gases are generated due to microbial activity within the landfill. But carbon dioxide and methane are among them more significant. Methane production rates will vary with the time spending in a landfill. The two principal gases generated in a landfill are carbon dioxide (CO_2) and methane (CH_4) during decomposition process. During the first stage of decomposition, aerobic bacteria are dominant and lot of CO_2 is generated, but as the available oxygen declines and its work taken over by anaerobic bacteria, and lot of CH_4 is generated at later stages of landfill life.¹¹⁹

The explosive CH_4 is the most worrisome for landfill designers. The lighter-than-air, CH_4 will rise until it meets an impermeable barrier. It is then deflected laterally until an escape is found. There should be the provision of venting the landfill gas. The best vents are probably the leachate collection manholes. Monitoring is necessary to establish if the concentration of methane gas generated by the facility exceeds 25% of the lower explosive limit (LEL).¹²⁰

As landfill gas is generated within the landfill, it attempts to migrate in all directions, escaping through the bottom, sides and top surfaces. Landfill operators may comply with the gas monitoring requirements by any combination of a number of monitoring methods.¹²¹ A variety of technologies are available for controlling landfill gas accumulation and migration. Landfill gas management is designed for two purposes: extracting gas from the landfill and controlling gas migration. Two basic types of gas collection systems, passive and active, are used depending upon the gas management purpose and rate of gas accumulation and migration. Passive gas control system collects and release LFG at individual points that are not connected. Each gas collector is extended at a safe distance above the surface to allow LFG to be vented to the atmosphere. Passive control systems rely upon the natural forces of convection and diffusion to control landfill gas migration.

Active extraction systems link together a group of gas collectors with piping. An active system consists of deep extraction wells connected by a header pipe to a blower

¹¹⁹ S.C Bhatia, *Environmental Pollution*, p. 137.

¹²⁰ Glysson, *Solid Waste, Handbook*, p. 115.

¹²¹ www.urbanwaste.org.

that either delivers the gas for energy reuse purposes, or to an on-site burner or simply releases it to the atmosphere.¹²²

Facility Access Control

The development landfill facilities should include means to control public access to prevent illegal dumping, public exposures to hazards at the site, and unauthorized vehicular traffic. Generally, unauthorized persons are unfamiliar with the hazards associated with landfill facilities. Access to facilities should be controlled through gates that can be locked when the site is unsupervised.

End use LFs

Landfills are actually act as the land reclamation. This developed land can be used for different purpose. But the landfill areas are better for green areas, playing fields, parks, arboretums, and the like, not used for building dwellings. Landfills should be used after a long period of settlement.

2.24.13 Incineration

Incineration is the second oldest method of waste disposal after land disposal. By definition, incineration is the conversion of waste material to gas products and solid residues by the process of combustion.¹²³ Incinerator is an enclosed device using controlled flame combustion, the primary purpose of which is to thermally break down the wastes.¹²⁴ Incineration can be defined as a controlled combustion process for burning solid, liquid and combustible wastes and reduces them primarily to carbon dioxide and other gases, water vapour and non-combustible in offensive solid residue.¹²⁵ Incineration is the controlled burning of waste in a purpose built facility. The process sterilises and stabilises the waste and for most waste, will reduce its volume to less than quarter of the original. Most of the combustibles materials is converted into carbon dioxide.¹²⁶ Incineration is the combustion or controlled burning of volatile matter such as sludge or solid waste, which reduce the volume of a material while producing heat, inorganic ash, and gaseous emissions.¹²⁷ It has been generally described as a device or installation for the burring and destruction of solid waste. Now heat recovery incinerator is used to mean a unit for burring unprocessed SW to generate steam or heatt

¹²² www.urbanwaste.org.

¹²³ S.C Bhatia, *Handbook*, p. 192.

¹²⁴ Mallow, *Hazardous Waste Regulation*, p. 206.

¹²⁵ S. C Bhatia, *Environmental Pollution*, p. 143.

¹²⁶ Ali, *Down to Earth*, p. 13.

¹²⁷ Glysson, *Solid Waste, Standard Handbook*, p. 8.

content.¹²⁸ Many waste-energy plants are breaking even, with the income from the sale of process steam and electricity and the tipping fee at the facility.¹²⁹

Incineration is one of the most efficient method of reducing weight and volume of waste. Moreover it is one of the most hygienic and sanitary methods of waste disposal, if performed in a controlled manner. Hospital refuse, which is particularly dangerous, is best disposed of by this method. This method is quite effective in killing pathogens but the other hand gives rises to smoke and gases resulting in air pollution.

Disposal of 92% of municipal refuse in USA is in landfills. But due to decreasing of landfill sites, alternatively incinerators has come up because it reduces waste mass by 75% in weight and volume 90%. However, environmental concern about organic pollutants (particularly dioxins) in stack emissions and heavy metals in incinerator ash has slowed incinerator development in USA.¹³⁰

Solids incineration is not a true disposal method, because most solid materials contain non-combustibles and have residual ash. Incineration has the objective of reducing the volume of refuse to the maximum through complete combustion. It satisfies the basic needs for bulk reduction than other methods. But due to the complications of wide variety of materials, complete combustion cannot possible. There are some things in the garbage pile with a heating value of approximately 2000 btu/lb and some the items such as plastics and as polystyrene, which have a heating value approximately 19000 btu/lb. So it is difficult to achieve a standard result from the mixture of solid wastes.¹³¹ The usual measure of fuel value (energy potential) is the heat of combustion, also called calorific value or the heat released during under specified laboratory condition. The heat of combustion is an inherent property of a substance and is related to its molecular structure. It is expressed in units such as Btu/lb or cal/g preferably international unit is Jules/kg (j/k).

Advantages of Incineration

The use of 'energy from waste' incineration is practiced globally though is not necessarily perceived as an environmental friendly technique. The benefits to energy from waste incineration are: energy generation from waste material destined for storage in landfill; elimination of organic material to be land filled and hence elimination of the methane and volatile organic carbon vapours produced in a landfill; increased landfill lifetime due to reduced waste volume and finally more easily stabilized landfill structure

¹²⁸ Alter & Dunn, *Solid Waste Conversion*, p. 60.

¹²⁹ Hinrichs & Kleinbach, *Energy and Environment*, p. 546.

¹³⁰ Stanly E. Manhan, *Environmental Chemistry*, 6th ed. (Columbia: USA, Lew's Publishers, 1994), pp. 534-535.

¹³¹ Herbert F. Lund, *Industrial Pollution Control Handbook* (New York: McGraw-Hill Book Co., 1971), p. 37.

for closure at end of life. These benefits must be considered against the risks associated with management of combustion by-products.¹³²

It is the reduction of combustible wastes to inert residue by burning at temperature (900 to 1000 degree. These temperatures are sufficient to consume all combustible materials, leaving only ash & non-combustibles. Advantages of incineration at the municipal level are two fold.¹³³ **First;** Combustion under optimum conditions can cut MSW 90% by volume and 75% by weight. Volume reduction also reduces the potential for groundwater pollution from organic and hazardous constituents; **Second;** combustible wastes can be used to supplement other fuels in generating electrical power and **third;** further, the potential use of remaining material from the residue as a fill or road base, and beneficial use of the energy generated in the combustion process.

Disadvantages of Incineration

Garbage incineration as an alternative to landfill is less than ideal because it converts land pollution into air pollution. Disadvantages are high capital outlay, high maintenance cost, additional handling to remove materials that do not burn, and air pollution. Air pollution from the products of fuel combustion must be taken into account, but the principal air pollutant is fly ash. Several methods are used to reduce the emission of fly ash. One such method entails the use of water with devices called scrubbers; but the large amount of water needed is another water pollution problem. If industrial waste mixed with other MSW, may have high heat content and also more air emission and it is also problematic in the standpoint of operator safety and public health.¹³⁴

Where the landfill cost is minimum and coal-based power generation of easier, power generation from waste incinerator doesn't suitable. However, from the environmental point of view it is comparatively viable. Essentially, the higher cost of the fuel is more than offset by the avoided cost of landfilling. But environmental disadvantage relates to emissions of CO₂, sulphur oxides, particulates, heavy metals and other pollutants. Emissions can be reduced in terms of controlling inputs to incinerators by prior recycling and source separation.¹³⁵ Incineration is a popular and useful method of refuse disposal in large urban areas where LF is remote and expansive. But the major

¹³² Eugenius Mokrzychi, Alicja Uliasz and Mieczyslaw Sarnz, "Waste as Alternative Fuels in Cement Industry", Peter Chatania, ed., *Energy 2000 : The Beginning of a New Millennium* (Italy: Technomic Publishing Co. Inc. and Bala Ban Publishers, 2000), pp. 1017-1022.

¹³³ Keller, *Environmental Geography*, pp. 252-253.

¹³⁴ Peter P. Roger et al., *Measuring Environmental Quality in Asia* (USA: Harvard University and ADB, 1997), pp. 203-215; Keller, *Environmental Geography*, pp. 252-253, Trivedi, *Encyclopedia*, Vol. 25, p. 110.

¹³⁵ Corazon M. Siddayno, ed., *Energy Investments and the Environment : Selected Topics* (Washington: World Bank, 1993), pp. 18-19.

disadvantage is economic: incineration costs approximately three times as LF and attempts to recovery thermal energy have not generally provided economically viable.¹³⁶

2.24.14 Suitability of Incineration

Incineration largely depends on the nature of the solid waste. Residential and commercial refuse is composed of combustible and non-combustible material. The moisture content in the solid waste largely affects the incineration process. If the moisture content is very high that it may be difficult to sustain combustion. Unsuitable waste composition is often a major drawback for incineration. In the developed or high-income countries the refuse contain higher proportion of paper and plastics, which are more combustible and had more calorific value. On the other hand in Bangladesh and like other low-income countries most of the waste volume has a high content of inert material in the form of silt, dust and also high organic content with a low calorific value does not suitable for combustion. An extensive waste sampling programme in India, for example found that most of the waste had calorific value of just 3350 joules/g compared to 9200 joules/g in high-income countries.¹³⁷

Most of the combustible fraction of MSW is cellulose. The remainder of the combustible content is composed of various fats, oils, waxes, rubbers and plastics. The heat released by burning cellulose is approximately 8000 Btu/lb. With a very less moisture and ash free combustibles of MSW have 9400 Btu/lb.¹³⁸ Incineration plant is the source of energy production. Only to destruction of the solid waste into incineration should not be the motto, Waste to Energy (WTE) should be the ultimate goal. WTE is a new dimension for incineration as resource recovery.

2.24.15 Types of Incinerators

Simple Burner

This is the simple burner where the waste is eliminated by open burning. Open burning proves to be quite ineffective for certain types of hazardous wastes, as the temperature cannot be controlled. These types of incinerators exist in developing countries. These may be constructed using bricks or metal. This is also a low technology manufactured incinerator. This sort of incinerators is used in hospitals and certain cities for burning medicinal wastes. These types of incinerators reach up to 900 degree Celsius. The gas or heat content does not use as fuel. The simple burning creates serious air pollution.

¹³⁶ A.V. Bridgwater and C.J. Manford, *Waste Recycling and Pollution Control Handbook* (London: George Godwin Ltd, 1979), p. 501.

¹³⁷ Ali, *Down to Earth*, p. 13.

¹³⁸ Glysson, *Solid Waste, Standard Handbook*, p. 144.

Pyrolysis and Gasification

Both in pyrolysis and gasification processes high temperature used to alter the physical and chemical character of MSW. Pyrolysis is the process of heating an organic material in the absence of oxygen.¹³⁹ In the said process MSW are converted to a variety of alternative fuels that can be substituted for fossil fuel. Pyrolysis is an old process. Prebiblical Egyptians prepared embalming fluid by pyrolysis. Pyrolysis of wood to produce chemicals (acetic acid, acetone, methanol) was widely practiced through World War II. It is the thermal degradation of carbonaceous material to gaseous, liquid and solid fractions by heat in the absence of oxygen. This occurs at temperatures between 200 and 900°C. The product of pyrolysis is gas of the relatively high calorific value of 20,000 joules/g with oils and tars and solid burned residues.¹⁴⁰

A large portion of MSW is composed of long-chain hydro carbonaceous material such as cellulose, rubber and plastic. Pyrolysis is a process that is less regressive than incineration and recovers much more chemical energy. Long-chain organic material disintegrates when exposed to a high-temperature thermal flux according to the following equation:

Polymeric material +heat flux ---> gas+ liquid+ solid

Pure pyrolysis involves only the reaction in the above equation, the destructive distillation in an oxygen free atmosphere.¹⁴¹

Gasification is the partial oxidation of carbonaceous material through combustion at high temperature (roughly 1000°C) to single carbon molecules, forming gas, which are mainly carbon dioxide, carbon monoxide, hydrogen, water and methane.¹⁴² Under this processes introduce reacting gases into the reactor to encourage the formation of gaseous products and or release within the reactor. The reactive gases most often used are oxygen, steam, and sometimes hydrogen. Gasification reactions usually take place at higher temperature than required for pyrolysis.

In many discussions, the terms pyrolysis and gasification are use interchangeably. There is no universally accepted definition for these terms in modern literature, which has led to confusion. When additional gas is added to the reactor of a pyrolysis process it becomes gasification.¹⁴³ The gas is used as fuel. To achieve high

¹³⁹ Ibid., p. 167.

¹⁴⁰ Ali, *Down to Earth*, p. 15.

¹⁴¹ S.C Bhatia, *Handbook of Industrial Pollution*, Vol. 1, p. 212.

¹⁴² Ali, *Down to Earth*, p. 15.

¹⁴³ S.C Bhatia, *Handbook of Industrial Pollution*, Vol. 1, p. 218; Glysson, *Solid Waste, Standard Handbook*, pp. 169-170; Liu & Liptak, *Engineering Handbook*, pp. 1228-1230.

gas conversion rates, high temperatures are required in gasification system. Even when there are no reactive gases added to the system, the pyrolysis gases produced would react with char and tar to produce additional gas if the temperature is high.¹⁴⁴ The end products from pyrolysis include pyrolytic oil (tar), and char, residues and gases.¹⁴⁵

Incineration Plant Location

The incineration plants should generally be located in barren area or sparsely populated areas of the city, so that any negligent operation or accident from the plant may not cause smell or fire nuisance. An isolated site is preferred for any such plant to avoid, as much as possible, objections of neighbours. However, well-designed and well-operated incinerators that do not present a nuisance may also be installed in light industrial and commercial areas, thereby avoiding the economic burden of extended collection truck routes or extensive refuse transfer operations.

Incineration Residue Handling

The residue from a well-designed, well-equipped mass-fired incinerator burning as received refuse will include the non-combustible material in the MSW plus somewhat less than 5% of the combustibles. The nature of this material will vary from relatively fine, light ash, burned tin cans, and partly melted glass etc. This residue from incinerator may be disposed in the landfill. The volume of the residue will range from 5 to 15% of that received at the plant for combustion.

Comparison of Landfill and Incineration

Several assessments of the various disposal and recovery alternatives confirm the view that LF is the cheapest method of solid waste disposal and also straight incineration and recovery of RDF share second place. Recovery of energy as steam or electricity from incineration or fuel from pyrolysis, is generally expensive. The added value of stored or derived products does not justify the cost of gaining it.¹⁴⁶

2.25 Special Waste Handling

Sludge Disposal¹⁴⁷

Unless it is treated and reused, it goes to the surroundings and pollutes the environment. Techniques for handling sludge including drying it up then discharging it, reusing it or incinerating it. Before final disposal of sludge, it is in need of treatment. Ideal

¹⁴⁴ Glysson, *Solid Waste, Standard Handbook*, pp. 169-170.

¹⁴⁵ Liu & Liptak, *Engineering Handbook*, p. 1241.

¹⁴⁶ Bridgwater & Manford, *Waste Recycling & Pollution Control*, p. 396.

¹⁴⁷ UNEP, *Sound Technology*, p. 59, Bogatsu, *Waste Disposal, Pollution Control*, p. 276; Darkoh, *Management of Effluent, Pollution Control*, p. 460.

methods of dealing with sludge include thickening and stabilization. The stabilization will reduce odours and pathogens. The most common procedure for dealing with the sludge is to treat it in drying beds. Dried sludge can be used with incineration ash for road sub-badger instead of brick rubbles. Incineration of sludge can be done by a multiple hearth furnace or fluidised bed furnace. Energy input is required to dry the sludge before combustion is self-sustaining. Sludge incineration project investment and operating cost is very high.

2.26 Chapter Summary

From the days of primitive society man has used the natural resources of the earth to support life and to dispose waste. Historically, solid waste disposal consisted of open dumping. In that time the disposing of open dumping didn't pose a problem as the population was small and the amount of land available. But today, neither the population is small nor is plenty of land available. Therefore the disposal of solid waste has posed a serious environmental problem, particularly for the big cities.

Waste is the discarded material of solid, liquid and gaseous emissions. Solid waste is the valueless and unwanted matter in solid nature. Solid waste can be classified from different perspective. With time span of urbanization and economic development, the amount and nature of solid waste has changed dramatically. For efficient solid waste management it is needed to know the constituents of the waste. Integrated waste management is the combination of all waste handling with due importance. Waste management matrix provides the self-sustained role of the society. Solid waste management hierarchy follow the function one after another.

Primary collection is carrying the waste from source of generation to transfer stations, generally, the generators or the private arrangement for primary collection. Secondary collection is transporting the garbage from transfer stations to final disposal site. Processing includes screening, shredding, classification and bailing etc. Treatment is minimizing its environmental impact before final disposal. Source separation, recycling, composting and processing etc are example of treatment.

There are different options of final disposal. Hog feeding, ocean dumping, simple dumping or general landfill, sanitary landfill, incineration are different solid waste disposal method. However, hog feeding and ocean dumping are now almost obsolete. Simple or crude open dumping was almost regular disposal method. Particularly in developing countries are still using the open dumping method for waste disposal. Land reclamation is the ultimate goal of waste disposal. But due to environmental concern sanitary land filling became one of the most effective and popular disposal options.

Sanitary land filling is an engineering option of waste disposal with having liner and cover material to protect the leachate contamination of soil and water. Leachate generation from landfill is very common and injurious to public health and environment. Strong control mechanism of leachate collection and treatment is essential. Methane gas produced in the landfill could be collected and used as energy.

Incineration is another option of waste disposal. If land filling is too costly and the nature of waste is highly combustible, incineration is more suitable. Through incineration the volume and weight of the solid waste could reduce maximum. The heat generated from incineration can be used as energy. The products from pyrolysis and gasification include tar, liquid, and char fraction along with gas are also resource recovery. Potential gaseous emissions, incomplete burned products (primarily hydrocarbon) from the combustion process, and trace emissions etc. are matter of concern for both environment and public health problem.

Institutional Development and Legal Framework

3.1 Introduction

All the citizens of Bangladesh have right to protect his life and personal liberty as a fundamental right ensured by the Bangladesh Constitution (Article 31 and 32). However, the Constitution did not explicitly recognize the right to have a good environment as the fundamental right. Though the constitution doesn't ensure the right to have a peaceful environment, in two recent cases {XLVIII DLR, 1996 p.438 and XVII Bangladesh Legal Digest (BLD), 1996 (AD), p.1} the Supreme Court of Bangladesh has resolved that the "right to life" has enriched as a fundamental right includes the "right to a healthy environment".¹ Nevertheless, each sectors of life, the people of Bangladesh does not have peaceful environment. Particularly, in the city area the life of the citizens are full of hazardous and foul environment. The environmental laws of Bangladesh and other local government laws do not have implications with environmental issues of cities and towns.

✓Solid waste management for growing cities and towns all over the world is considered as a serious problem for both developed and developing countries. In developing countries, the most pressing need is finding out the way of waste management. For efficient waste management it is needed the institutional development. Most of the cases of third world countries there are a few institutional developments as well as very low legal implications for solid waste management. Developing countries used open dumps as the accepted way of disposing of all types of wastes, hazardous material included. These countries have no or little legislation governing the generation, handling, and disposal to toxic wastes. Industrial & chemical wastes are treated like MSW and dumped indiscriminately in landfills or discharged into rivers, canals, and ditches or into the sea.² For efficient handling of solid waste, it is very essential to have institutional arrangement and legal base for waste handling and recycling. In some cases, it is need to be fresh legislation or updating.

In 1988, a new law passed in New Jersey requires both household and business firms to segregate their refuse. Late 1987, New Jersey also began giving tax credits for

¹ Farooque, *Environmental Laws*, p. 261.

² Elkington and Shopley, *Waste Management Technology*, p. 12.

business that by equipment uses recycled materials. Nonetheless, the ever increasing costs of LF disposal together with public resistance to incineration seem likely to force a more pronounced swing toward recycling to reduce MSW volume.³ It is so important to have legal baseline for resource recovery through recycling and institutional development for efficient management and for resource recovery.

3.2 Development of the Environmental Institutions in Bangladesh

About 80 percent of the population of Bangladesh depends on its natural resources for their economic activities. This put a pressure on the limited resource base and at times degrades the environment. High population growth and massive poverty are also important factors of environmental degradation. These factors accompanied by resource degradation are posing danger to the sustainability of the country's water environment. To protect the water pollution there was a board named Water Pollution Control Board under the then East Pakistan Water Pollution Control Ordinance, 1970. The board was functioning under the Department of Basic Democracies and Local Government.

After independence of Bangladesh, the board was also functioning as usual under the Ministry of Local Government renamed as Bangladesh Water Pollution Control Board. It is mention worthy that the board was only for protecting the water pollution. Hence, to protect the over all environmental pollution the government enacted the Environment Pollution Control Ordinance, 1977 repealing The Water Pollution Control Ordinance, 1970. The Environment Pollution Control Board (EPCB) was established under the new ordinance. The creation of EPCB is an important step in environmental development. In 1983, the Environment Pollution Control Board (EPCB) was upgraded into the Department of Environment and pollution Control (DoEPC). It was under the Ministry of Local Government, Rural Development, and Cooperative until 1989. It was further upgraded as Department of Environment (DoE) when a separate ministry was formed in 1989.

Independent Ministry

There was a time when the per capita income Bangladesh people was very low but the air of Bangladesh was clean, water was fresh and uncontaminated, the river was very navigable, the country was full of greenery, there were thousands of birds, and other animals and fishes etc. Now Bangladesh is trying to increase the income level but due to variety of causes, it is loosing its environmental integrity. According to the Environmental Kuznte's Curve (EKC), Bangladesh is lowering its environmental situation for economic growth. However, the EKC notion proved to be void in different part of the

³ Ibid.

world. Costa Rica's experience clearly testifies that the goals of economic growth and environmental protection can be complementary rather than being contradictory. Virtually, environmental degradation can even stifle economic growth.⁴

Strong concern for environmental degradation led Bangladesh to take some important step. Creation of a separate ministry for environmental control is a milestone in this regard. The separate Ministry in the name of Ministry of Environment and Forest was established in 1989, and DoEPC was placed under the MoEF and renamed it as Department of Environment (DoE).

The other development was the declaration of 1990 as the year of Environment and the 1990s as the Decade of Environment. The Fourth and Fifth Five Year Plan identified the major environmental problems faced by the country. The issue of environmental and ecological sustainability was also emphasized during the preparation of the Participatory Perspective Plan for Bangladesh (1990-2010). In accordance with the Rio Earth Summit in 1992, the GOB has adopted broader perspective which includes: Formulation of National Conservation Strategy (NCS) which provides guidelines for conservation and sustainable use of resources; preparation of an Environment Policy (1992); preparation of National Environmental Management Action Plan (NEMAP) through a participatory process; enacting of the Environmental Protection Act, 1995.⁵ Under the NEMAP, the government is implementing lot of programs for sustainable environmental development.

3.2.1 Ministry of Environment and Forests

The key government ministry to deal with environmental activities of Bangladesh is the Ministry of Environment and Forest (MoEF). The ministry was created in 1989 with the stated goal to play a key role in planning, reviewing, monitoring environmental initiatives, and ensuring environmental concerns properly to integrate the national development process.⁶ The MoEF has four agencies to perform specific environmental activities, viz, 1) Department of Environment (DoE); 2) Department of Forest; 3) Bangladesh Forest Industries Development Corporation (BFIDC); and 4) Bangladesh Forest Research Institute (BFRI). Out of them, only the DoE is entitled to monitor and ensure the environmental coherence. In fact, all of the ministries, departments, and subsidiary organizations of Bangladesh are more or less related with the environmental

⁴ BEN, *Bangladesh Environment*, pp. 8-10.

⁵ MoEF, *TAPP of Sustainable Environment Management Program*, p. 4.

⁶ Dr. Md. Nasir Uddin, "Air Pollution Control in Urban Areas of Bangladesh: Quest for Sustainable Improvement of Air Quality of Dhaka City" (A Ph.D. Dissertation, Institute of Bangladesh Studies, Rajshahi University, June 2004), p. 46.

activities. But all of them are not directly related with environmental protection. Waste management is the function of DCC under the Ministry of Local Government, Rural Development, and Cooperatives. Improvement of waste management and ensuring the environment protection is the key function of both the DoE and DCC.

The Ministry of Environment and Forest is charged with other responsibilities like wildlife conservation, land, air and or water resources environment management. These responsibilities generally carry a higher national priority than MWSM, since they often directly generate income. However, environment conservation is the main duty of the ministry, but MSW might not receive due attention because it is not their purview. But the environmental concern should realize by DoE for inefficient solid waste management extend its cooperation for sustainable environment.

3.2.2 The Department of Environment (DoE)

The DoE, technical agency of the MoEF, looks after environmental planning, management, monitoring, and enforcement of the environmental laws and regulations. The DoE is empowered with the law to ensure the over all environment, protect the habitats, eco-system with special concentration to air, water and natural resources conservation from all sorts of pollution and destruction.⁷

Organization of the DoE

The Department of Environment (DoE) is an important organ of the government of Bangladesh to ensure the environment management. The scope of activities of the DoE transcends into every sector of the socio-economic system and spreads throughout the length and breadth of the country.⁸ The DoE has four regional offices in Dhaka, Chittagong, Rajshahi, Khulna and headquarter in Dhaka. Another two regional offices in Barisal and Sylhet is in underway. The DoE is headed by the Director General supported by Director (technical) and director (administration) at the head quarter and two directors, one at Chittagong and another at Khulna office and two Deputy Directors at Dhaka and Rajshahi office. Besides, there are eight deputy directors, one program coordinator, ten assistant directors, one accounts officer, seven research officers, three analysts, one librarian, one inspector, one senior technician and one draftsman at he headquarters and at the regional offices, two DD (one at Chittagong and one at Khulna), ten Assistant Directors, one assistant Biochemist at Dhaka and four senior technicians are operating in the regions.⁹

⁷ Mohiuddin Farooque and Rezwana Hasan, "Environmental Laws in Bangladesh", in Philip Gain, ed., *Environment Facing 21st Century* (Dhaka: Society for Environment and Human and Development-SHED, 1998), p. 261.

⁸ Nasir, Ph.D Thesis, p. 48.

⁹ DoE, *Introducing Department of Environment* (Dhaka: Government of Peoples Republic of Bangladesh, 1997), p. 1.

The Principal Functions of the DoE¹⁰

Department of Environment is one of the key organs of the government for ensuring environmental integrity. Under the provisions of the Environmental Conservation Act 1995, Environmental Policy, 1992 the principal functions of the DoE's are as following:

Monitoring Activities

- Analysis of surface water quality;
- Analysis of ground water quality;
- Surveillance of drinking water quality;
- Analysis of water at the specified monitoring stations for the Global Environmental Monitoring System;
- Analysis of water quality on request from persons/organizations;
- Analysis of ambient air quality;
- Analysis of industrial waste affluent.

Survey and Inspection of Industries/Projects

- Identification of polluting industries and encourage them to take necessary measures in pollution minimization/control through motivational and instructional process.

Environmental Clearance Certificate

- Department of Environment issue environmental clearance certificate to new industries/development projects through inspections of sites as well as examine and assess the impacts of new industries / development projects.

Automobile Pollution Survey

- Undertake automobile pollution survey with the assistance of BRTA, police, and magistrate.

Review of Environmental Impact Assessment (EIA) Reports

- Provide comments based on review of EIA reports of various industries/projects.

Survey of Pollution Caused by Fertilizers and Pesticides

- Conduct the survey to determine pesticide residues as well as quantities of heavy metals present in the surface water, such as wetlands, rivers, streams, etc. of the country.

Clearance for Ship-Breaking

- Department of environment issues the clearance of ship breaking, investigates and disposed various environmental related complaints.

Publicity, Publication and Creation of Awareness

- DoE is playing a vital role regarding creation of awareness among the people by publicizing various environmental related slogans in the mass media. Make statements on various environment related topics, distribution of posters bearing slogans or environmental conservation. It also organizes seminars, conference, workshops and training programs on various environmental occasions. It has also observes the World Environment Day with a befitting and colorful manner.

¹⁰ DoE, *Department of Environment*, pp. 2-5.

Contact with International and Regional Programs

This department also maintains regular contact and coordination with various international and regional forum related to environmental issues. It provides environmental data and information to the United Nations Commission on Sustainable Development (UNCSD), Montreal Protocol on Substances that deplete the Ozone Layer, Basel Convention on Control of Trans-boundary Movement of Toxic and Hazardous Wastes, and their disposal, United Nations Convention on Combating Desertification and United Nations Convention on Biological Diversity, etc.

3.2.3 Development of Social Organization

3.2.3.1 Bangladesh Environment Network (BEN)¹¹

It is very much true that to overcome the economic gap and technology gap, Bangladesh increase her environmental gap. Air pollution, Arsenic contamination, drying river, loss of wetlands, chemical runoff to water bodies, noise pollution, deforestation, loss of biodiversity, medical and industrial and solid waste mismanagement etc. has gone up to aggravate the overall environmental degradation. The environmental degradation has created concerns among the non-residents of Bangladesh (NRB) living abroad. NRBs are trying to play role for the development of Bangladesh environment. However, it was not possible to do it alone and they got the rationale of being united through organizing a forum. Accordingly 13 NRBs constituted "Bangladesh Environment Network" (BEN) in July, 1998 in USA. The aim of BEN is to unite and mobilize the support of non-resident Bangladeshis and member of the Bangladeshi community for protection of environment in Bangladesh. NRBs, Residents Bangladeshis, and international communities could be the member of BEN.

BEN is playing an important role in building a broad-based environmental movement in Bangladesh. In persuading this, BEN already arranged International Conference on Bangladesh Environment (ICBEN) 2000, and ICBEN 2002 with collaboration Bangladesh Poribesh Andolan {Environment Movement} (BAPA). Besides these, BEN is working in the field of information dissemination regarding environment movement. BEN played an important role formulating BAPA. BEN played important role in different environmental movement. It is also activating the "Buriganga Bacho Andolon" (save the Buriganga river) with BAPA. It is also implementing the action project "Barrel composting of household waste' in Bhashanteck slum in Dhaka.

¹¹ BEN, *An Introduction to Bangladesh Environment Network* (Atlanta: Prof. Nazrul Islam, 2001), pp. 1-2, 9, 19, 39, 40, 43.

3.2.3.2 Bangladesh Poribesh Andolan (Environment Movement)- BAPA¹²

The first International Conference on Bangladesh Environment (ICBEN) 2000 held in Dhaka to unite pro-environment forces of Bangladesh, so that they can become an effective voice in the countries social arena. Accordingly, in July 2000 BAPA constituted. The objectives of BAPA are to save the environment of Bangladesh raising social voice. By this time the BAPA has played in important role in developing the air pollution of Dhaka by phasing out the Two Stroke Engine Vehicle (TSEV), measures against encroachment in the Buriganga river by raising voice "Buriganga Bachao Andolon", banning polythene bag from the country etc. By arranging ICBEN 2002 BAPA played an important role raising voice to halt and reverse the alarming environmental degradation in Bangladesh.

3.2.3.3 Bangladesh Environmental Lawyers Association (BELA)

Some lawyers formed the organization in 1992 with a goal to policy advocates for sustainable environment development. Mr. Mohiuddin Farooque was the key person started the organization. Now it is working for policy advocates on local and national issues of environment. BELA is fighting through providing the legal support for ensuring the sustainable environment. Generally BELA, at first try to create awareness for the protection of environmental issues and if not success it usually goes to the court for legal verdict through which environment could be protected. Particularly, where there the government agency or any person who contravene the environmental priority, BELA usually fight against them. BELA source informed that it has won in 5 cases and about 30 cases are pending in different court regarding environmental protection. BELA is working for the protection of the Buriganga, and the Turag river from encroachment, protection of wetlands around Dhaka from waste dumping, saving Gulshan Lake, Sorwardhy Uddan (city park) etc. from environmental pollution.

3.2.4 Environmental Laws Regarding Pollution and Conservation

History of Environment laws in Bangladesh

There are about 185 statutory laws, which have bearing on environmental issues directly or indirectly. Most of these laws are almost obsolete in nature but they do officially exist, not for repealing. Some of the laws have relevancy either to protect against environmental offences, to conserve the environment, to prohibit or to ensure to do some activities. Some laws have clear direction for citizens to do some things for the peaceful environment and some laws have stated the right and duties of the people. There are a

¹² BEN, *Bangladesh Environment Network*, p. 43; BAPA 2-002, pp. xiv-xvi.

number of laws are amended and new laws have promulgated in place of old British based laws. Bangladesh Environment Conservation Act 1995 is one of the important developments in conserving environment. A great bulk of these environmental laws were existent in the country right from 19th century, although they remained either un-enforced largely due to change situation for long time or vaguely known to the public agencies.¹³

Source of Environmental Law

Bangladesh's legal system is based on common law system inherited from British colonial rulers, which was introduced in the 18th, 19th and 20th centuries. The foundation of Bangladesh's environmental law can be traced back to that British laid legal system. It was observe that the statutory laws prevailing in Bangladesh have about 185 laws deal with or have relevance to environmental issue. The statutory laws (laws enacted by the parliament) and by-laws (rules, regulations etc.) promulgated by the concerned authorities under the provision of the statutory laws are the main source of environmental legislation.¹⁴

It is observed that there are 23 laws, which contain provisions regarding conservation of environment and control of environmental pollution from various sources. Of these, the Bangladesh Environment Conservation Act, 1995 is the principal act for environment conservation.

Types of Environmental Laws

The government legislation in the sub-continent; especially the substantive and administrative rules are made in different sectors. The procedural rules for the courts to administer these laws derive mostly from the Code of Civil Procedure 1908, the Code of Criminal Procedure 1898, and the Evidence Act 1872 etc. These procedural laws are assisting to implement the principal laws, acts and ordinance, rules and regulations.

In general, environmental legislation can be categorized to cover sector and issues like pollution and conservation; displacement, relief and rehabilitation; land use and administration; agriculture and agrochemical; water resources, fisheries; forestry; wildlife and domestic animals; energy and mineral resources; local government; rural and urban planning; transportation and safety; food and quality control; cultural and natural heritage etc. Taking into consideration the dignity of human resources laws relating to health; food and consumer protection; occupation right and safety; public safety and dangerous cargo; may be also included in the list of environment legislation.¹⁵

¹³ Nasir, Ph.D. p. 63.

¹⁴ Ibid, pp. 62-63.

¹⁵ Farooque, *Laws Relating*, p. 262.

3.2.5 Environmental Conservation Act, Rules, Regulation, Policies

There are many laws; rules and regulations have the environment implications. Out of them some of the laws, rules-regulations have direct implications, and some of them have indirect relations. The more concern laws and rules, policies are mentioned here.

3.2.6 The Bangladesh Environment Conservation Act, 1995 (Act 1 of 1995)

The Bangladesh Environment Conservation Act, 1995 (here after mentioned as ECA for further discussion) is a remarkable law for conservation and development of environment in Bangladesh. It is enacted for conservation and development of biodiversity and ecological balance, improvement of environmental standards and control and mitigation of environmental pollutions. ECA is the principal law for the conservation of environment and considered as fundamental law directly related to pollution control.¹⁶ There are some other laws were enacted earlier to deal with control and mitigation of pollution and conservation of environment those are still in execution in respective area.

Salient Features of ECA

Preamble

An act passed for providing conservation and development of environmental standard, control and mitigation of environmental pollutions etc.

Creation of the Department of Environment

Under the provision of the section 3 of the act, the government creates the Department of Environment headed by a Director General. In fact, there was a board in the name of Environment Pollution Control Board, which is renamed as DoE after the enactment of ECA.

Power and Functions of the Director General

Under the power conferred by section 4, Director General may take necessary measures, as he considers necessary and expedient for the conservation of the environment, and improvement of environmental standards and for the control and mitigation of environmental pollution. He may issue necessary directions in writing to any person (s) or organization (s) for the discharge of his duties under this act. In particular and without prejudice to the generality of the foregoing power, he may take the following measures.

- Co-ordination with the activities of any authority or agency having relevance to the objectives of this act;
- Prevention of probable incidents, which may cause environmental degradation and pollution, undertaking safety, measures for the remedial;

¹⁶ Farooque, *Laws Regulating*, pp. 1709-716.

- Giving advice or, issuing directions to the concerned person regarding the environmentally sound use, storage, transportation, import and export of a hazardous substance or its components;
- Conducting inquiries and undertaking research on conservation, improvement and pollution of the environment and rendering assistance to any other authority or organization regarding those matters;
- Searching and investigating any place, examining any equipment, ingredients or substances for the purpose of improvement of the environment conservation.
- Collection and publication of information about environmental pollution;
- Advising the government to avoid such manufacturing processes, commodities and substances as are likely to cause environment pollution;
- Observing the water quality standard, making report and rendering advice or direction to follow the standard of drinking water.

The direction made by the DG for closure, prohibition, or regulation of any industry, processes and the person shall be bound to comply with such direction.

Assistance from Law Enforcing Agencies and Other Authorities

The Director General or a person authorized by him may, for the purpose of exercising any power or performing any function under the act, request any law enforcing agency, or any other government or statutory authority to render necessary assistance, and upon such request that agency or authority shall render the assistance. (Section 4A)

Declaration of Ecologically Critical Area

The government may, by notification in the official Gazette, may declare an area as ecologically or environmentally critical or is under threat of being critical as a result of environmental degradation. (Section 5)

Restrictions Regarding Smoke Emitting Vehicles

The vehicles which is emitting such amount of smoke more than the standard and injurious to the environment shall not be operated unless other wise testing. (Section 6)

Prohibition of Polythene Manufacturing

Under the provision of the act, the government has restricted manufacturing all kinds or any kind of polythene shopping bag, any other article made of polyethylene or polypropylene, or any other article is injurious to the environment. By a notification in the official Gazette, the government, imposing absolute ban on the manufacture, import, marketing, sale, demonstration for sale, stock, distribution, commercial carriage or commercial use of polyethylene bag except export or beyond polythene shopping bag. (Section 6A)

Remedial Measures for Injury to Ecosystem

The Director General, making a proper assessment of the harm caused to ecology by certain activity, may direct the concern person (s)/agencies/organizations to take corrective measures and make such persons(s)/agencies/organizations comply with such directives. (Section 7)

Complain and Hearing by the DG

If any person complains to the DG that he/she is affected or likely to affect because of pollution or degradation of the environment, the Director General may hold public hearing and take other measures. (Section 8)

Discharge of Excessive Environmental Pollution

In the case where emission or effluent cause by an accident or any other unforeseen activity or event exceeds the amount specified by rules, the persons or agencies responsible for such an accident or unforeseen activity or event. The person or agencies responsible or the person in charge of the place at which such discharge occurs shall be bound to render assistance and cooperate to control or mitigate such emission or effluent as required by the DG. (Section 9)

Power of Entrance, Search or Seize etc

Subject to the provision of the act any person empowered by the DG, have the right to entrance any building, office, factory, plants etc and search, seize, test or verify etc of any documents, record, register or any specific materials for the reason to believe of any offence or contravention of the act or rule there under. (Section 10)

Power to Collect Samples

Under the provision of this Act any authorized person can collect from any factory, premises or other place any sample of air, water and soil or other substances for analysis. (Section 11)

Environmental Clearance Certificate

No industrial unit or project shall be established or undertaken without obtaining, in the manner prescribed by rules, an environmental clearance certificate from the DG. (Section 12)

Formulation of Environmental Guidelines

The government may, by notification in the official Gazette from time to time, formulate and publish environmental guidelines relation to the control and mitigation of environmental pollution, conservation and improvement of the environment. (Section 13)

Appeal

Any person aggrieved by a notice, order, or direction, can appeal within 30 days. The appellate authority can give another 30 days in the case of justification. (Section 14)

Penalties

For violation of a provision or for non-compliance of a direction, or for the activities specified in the table under section 15 the penalty mentioned there will be imposed. Different penalties (imprisonment or fine or both) are scheduled for violation or non-compliance of the order of the authority in the act. The table is as follows:

Description of Offences	Penalties that may be imposed
Non compliance of a direction issued under subsection (2) or (3) of section 4	Imprisonment not exceeding 10 years or fine not exceeding 10 lac (one hundred thousand) taka or both.
Violation of sub-section (2) by continuing activities or processes or by initiating activities or processes, prohibited under sub-section (1) of section 5 in an area declared as an ecologically critical area	Imprisonment not exceeding 10 years or fine not exceeding 10 lac taka or both.
Violation of sub-section (1) of section 6	In case of first offence, a fine not exceeding 5,000; in case of second offence not exceeding 10,000 and in case of each subsequent offence, an imprisonment not exceeding 1 year or fine not exceeding 10,000 taka or both.
If, in violation of a direction issued under section, 6A, any article specified in the direction is a) Manufactured, imported, marketed b) Sold, exhibited for sale, stocked, distributed, commercially transported or commercially use..	a) Imprisonment not exceeding 10 years or fine not exceeding 10 lac taka or both. b) Imprisonment not exceeding six months or fine not exceeding 10 thousand taka or both.
Non-compliance of a direction issued under sub-section (1) of section 7	Imprisonment not exceeding 10 years or fine not exceeding 10 lac (one hundred thousand) taka or both.
Violation of sub-sec. (1) or (2), or failure to take remedial measures in accordance with sub-sec. (3) of section 9	Imprisonment not exceeding 10 years or fine not exceeding 10 lac taka or both. Provided that where a lower penalty is fixed by rules for violation of section 9 (1), that penalty shall be applicable.
Failure to render, without reasonable excuse, assistance or cooperation to the DG or a person authorized by him as required by sub-sec (2) of sec. 10	Imprisonment not exceeding 3 years or fine not exceeding 3 lac taka or both.
Violation of section 12	Imprisonment not exceeding 3 years or fine not exceeding 3 lac taka or both.
Violation of any other provision of the act or a direction issued under the rules or obstructing the DG or a person authorized by him in discharging his duties or intentionally delaying the discharge of such duty.	Imprisonment not exceeding 3 years or fine not exceeding 3 lac taka or both.

Confiscation of Materials and Equipments

Where a person is found guilty and sentenced under section 15, all equipments or parts thereof, transport, substance or any other thing used in the commission of the offence may be confiscated under the order of the court. (Section 15A)

Claim for Compensation

Where a person or a group of persons or the public suffers a loss due to violation of a provision of the act or the rules made there under or a direction issued under section 7, the DG may file a suit for compensation on behalf of that person, group or the public. (Section 15A)

Cognizance of Offence and Claim for Compensation

No court shall take cognizance of an offence or receive any suit for compensation under this act except written permission from the DG or authorized person. (Section 17)

Delegation of Power

The government or the DG may delegate to any other officer of the department of his power under this act. (Section 19)

3.2.7 The Environment Conservation Rules, 1997

The Environment Conservation Rules, 1997 (here after ECR) was made by the government under the power conferred by the section 20 of Environment Conservation Act 1995. For making the rule the conservation act is now fully operative.

Key features of the ECR

In the rule, the factors are determined for declaring ecological areas, different types of form, amount of fee, and Environmental Quality Standard (EQS) has been set up for air, water, sound, and odor, emission from vehicle, factory, and effluent from industry. All standards are specified in the schedules 2 to 8 of the rule. For controlling the smoke emission of vehicles catalytic converter or oxidation catalyst or diesel particulate filter or such other devices approved in the rule. The Location Clearance Certificate (LCC) and Environment Clearance Certificate are compulsory for all industrial and other projects. Total industries or projects have been classified into four categories based on its location and impact on environment. These are

- Green
- Orange-A
- Orange-B and
- Red

Land filling by industrial, household and commercial wastes is classified as "Red Category," which includes most harmful or dangerous industrial units and projects (Rule 7 and schedule of the rules). The period of validity of an environment clearance certificate shall be in case of green category three years from the date of its issuance and in other case only one year. Each certificate shall be renewed at least thirty days before of its expiry of its validity period. To obtain the ECC for industrial units or projects

of the red category, report on the feasibility of the industrial unit or project, report on the Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) along with Layout plan (showing location of Effluent Treatment Plant) process flow diagram, and design and time schedule of the Effluent Treatment Plant

Information of Special Incident:

If, at any place, discharge or emission of environment pollutants occurs in excess of the prescribed standards and poses threat must immediately inform the DG of the occurrence or the threat.

3.2.8 Other Environment Related Laws, and Rules and their Implications in Brief

The Motor Vehicle Ordinance, 1983 (Ordinance No LV of 1983)

The motor vehicles are one of the media of environment pollution. Particularly the emission from the vehicles polluted the air directly, restriction of poor quality motor vehicle movement, using horn near school, college etc, obstruction in public street/ public places etc by unauthorized parking are the main issue of this act.

The Smoke Nuisance Act 1905 (Bengal Act III of 1905)

This law is relating to the abatement of nuisance arising from the smoking of furnaces or fireplace in certain areas in Bangladesh. If smoke be emitted from any furnace in greater density, or at a lower altitude, or for a longer time than is permitted by rules made under the law, the owner of the furnace shall be liable to fine. This is the law to control the air pollution from over emission from a fireplace or furnace. There is a relation between the incinerator and smoke emission, but nothing is stipulated in this regard. This is one of the old laws of Bangladesh. Possibly there was no waste incinerator functioning in that time. So there is no implication of this law with the solid waste management.

The Penal Code 1860 (Act XIV of 1860)

Section 268 and 278 contains penalty provision for making public nuisance and atmosphere noxious to health.

Public Nuisance

A person is guilty of a public nuisance who does any act or is guilty of an illegal omission which cause any common injury, danger or annoyance to the public or to the people in general who dwell or occupy property in the vicinity, or which must necessarily cause injury, obstruction, danger or annoyance to persons who may have occasion to use any public right. (Section. 268)

Making Atmosphere Noxious to Health

Whoever voluntarily vitiates the atmosphere in any place so as to make it noxious to the health or persons in general dwelling or carrying on business in the neighborhood or passing along a public way, shall be punished with fine which may extend to five hundred taka. (Section. 278):

Analysis of the Penal Section of Public Nuisance

Under the penal code 1860, a person will be guilty for doing any act or omission, which creates the public nuisance. In particular, throwing the garbage here and there is a public nuisance and the citizens and even the DCC itself is creating the public nuisance by carrying the garbage in daytime, and dumping the refuse without treatment. The industries, medical institutions, and markets and hat-bazars are creating atmosphere noxious to health by indiscriminate mixture of infectious and hazardous wastes to common MSW. But none of them are charging under this section and in fact the penal code sections are not implementing for this purpose.

The Criminal Procedure Code 1860 (Act V of 1860)

Sections 133 to 143 empower the magistrate to issue an order for removal of public nuisance and to prohibit repetition of public nuisance. However, these sections shall not apply to a Metropolitan Area. In Dhaka city, Dhaka metropolitan Police Ordinance will be effective.

The Dhaka Metropolitan Police Ordinance, 1976

Law and order situation is maintained under the Dhaka Metropolitan Police Ordinance 1976. The police commissioner of Dhaka is responsible for maintaining the discipline, peace and tranquility in the city. For this purpose, there are many directives; prohibition, restriction etc. are awarded in the ordinance. In case of public nuisance, there are several sections are inserted in the act. However, in section 80 of the ordinance related to the waste is as follows:

Penalty for Committing Nuisance in or Near Street, etc

Whoever in or near any street or any public place commits a nuisance by easing himself or suffers any child in his care or custody under seven years of age to commit such nuisance or spits or throws any litter, refuse or rubbish so as to cause annoyance to any passer-by shall be punishable with fine which may extend to one month.

The police commissioner may make regulation with the prior approval of the government prohibiting or controlling the placing of building materials or other articles or the fastening or detention of any animal in any street or public place according to the (j)

of section 25. According to (m) of section 25, the police commissioner make the regulation guarding against injury to person and property in the construction, repair and demolition of buildings, platforms and other structures from which danger may arise to the passengers, neighbor or public.

Analysis of the DMP Ordinance

There is a provision of taking legal action against those who will make nuisance by placing or throwing refuse or rubbish onto the roads and streets. Placing building materials over the roadside is prohibited in the law and it nuisance creation also barred in the law by placing refuse. The police commissioner would take action under this law against the lawbreakers. But in Dhaka city it is very unsightly and unaesthetic that people is easing onto the footpath and littering silly matters everywhere. However, none has been given punishment for violation of the provision of the law. Over telephone talking with Officer in Charge (OC), Ramna police station informed that police do not take any legal action under the provision of the DMP ordinance because the garbage disposal is the duty of DCC.

The Territorial Water and Maritime Zones Act 1974 (Act XXVI of 1974)

Section 6 and 8 contains the elements of Conservation Zone and Control of Pollution respectively. Under the provision of section 6, the government may declare certain marine areas as conservation zones for maintaining the productivity of the living resources. According to the section 8, government may take measures, as it may deem appropriate for the purpose of preventing and controlling marine pollution and preserving the quality of ecological balance in the marine environment. This law is applicable for ensuring an ecological balanced maritime environment. It is not the case of environmental pollution in the city.

The Brick Burning (Control) Ordinance 1989 (Ordinance No 8 of 1989)

Under the provision of section 5 of this Act, no person shall use the fuel wood for brick burning. The ordinance is totally related to the environmental issues of wood burning for brick kilns. Wood burning has a devastating environmental effect on the environment but is not related to the current study.

The Protection and Conservation of Fish Act, 1950 (Act XVIII of 1950)

Section 3 contains provision to prohibit the destruction of or any attempt to destroy fishes by explosive, gun, bow and arrow in inland water or within coastal territorial waters and also have the provision to prohibit the destruction of, or any attempt to destroy, fishes by poisoning of water or the depletion of fisheries by pollution, or by trade effluent or otherwise.

The law has direct implications on the issue of water pollution by effluent and otherwise in Dhaka city. The water bodies say the Buriganga River, the Shitalakma River, Dhanmondi and Gulshan Lake etc are seriously contaminated by the waste and effluent from the industries, sewerage and open dumping. Under this act, the authority can save the said rivers and lakes from indiscriminate dumping of wastes and effluents. But the fact is that the said law is not applying in this regard.

The Factories Act 1965 (Act IV of 1965)

Under the factory act, general cleanliness and refuse collection is particularly mentioned in the law. According to the section 12 (1) every factory shall be kept clean and free from effluvia arising from any drain privy or other nuisance, and in particular:

- a) Accumulation of dirt and refuse shall be removed daily by sweeping or by any other effective method from the floors and benches of workrooms and from staircases and passages and disposed of in a suitable manner;
- b) The floor of every workroom shall be cleaned at least once in every week by washing, using disinfectant where necessary or by some other effective method;

It is mentioned in section 13(1) that effective arrangements shall be made in every factory for the disposal of waste and effluent due to the manufacturing process carried on therein. The government may make rule or requiring arrangement describing the methods of disposing wastes and effluent. According to Factory Rule 1979, the arrangement of waste and effluent disposal must be authorized by the chief inspector of factories, who will consult for this with Directorate of health.

It is clear from the factory act and rule that the factory must have arrangement for refuse disposal system and cleanliness. But they are only dispose their waste to the municipal bins and drained out the effluent into the water bodies. The act did not classify the toxic waste different from others and separate disposal system. So, the factories are very much reluctant of their wastes just keeping it to bins or open space as other municipal solid waste.

Shops and Establishment Act 1965

The law is concern with working hour of workers and weekly closure of shops and other establishments. According to the provision of this law every worker will of any establishment shall have one and a half day consecutive holiday in each week. The shops, commercial and industrial establishments will remain entirely closed one and a half day in each week. The chief inspector will fix the same day and time for each town or area. However, the shops deals with food, vegetable, meat, fish, dairy, cigarette, medicinal store, public conservancy, water, light or other public suppliers etc will out of this provision.

No worker will work more than 9 hour in a day and 48 hours a week. It will be 7 hours in a day and 42 hours in a week for young workers. Provided that a worker may require to work more than 9 hours have to pay overtime. But total number of hours of work including overtime in a week shall not exceed sixty in the case of adult and fifty-two in case of young person. Young person is in the age of more than 12 to 18 years. No women or young person shall be employed in any establishment otherwise than between the hours of 7 a.m. and 8 p.m. except with the permission of the chief inspector. The working place will have to maintain cleanliness and sufficient light and air. The law is completely dealt with the working hour, weekly holidays of the workers and other working condition in any shops and establishment.

The Building Construction Act 1952 (East Bengal Act II of 1953)

It is an act to provide for the prevention of haphazard construction of building and excavation of tanks, which are likely to interfere with the planning of certain areas in Bangladesh. Under the provision of section 3, of the Building Construction Act 1952, it is restricted on construction of building and excavation of tank without the prior permission of the authorized officer. It is further restricted the improper use of lands and building under section 3A. It is further directed to remove the construction being made, or fill the tank excavated without the sanction or any other causes under section 3B. Under section 3C and 3D it is restricted and directed for cutting and stopping of cutting and razing of hill without the prior sanction of the government. Under section 7, of the law if the owner is directed to remove the construction or fill the tank excavated according to 3B and the authority will remove or fill and the cost incurred for it will be recovered as fine under section 386 of the code of criminal procedure 1898.

This is also an important environmental law but does not directly relate with solid waste management. It will be mention worthy here that it is seen that the there are lot of construction materials or building dismantling rubbles (building waste) are kept on the road. This creates public nuisance. This is a weak point of the law it should be included that the rubble or building dismantling waste should be removed by the owner.

The Town Improvement Act, 1953 (E.B Act No. XIII of 1953)

This is act to provide for the establishment, development, and expansion Dhaka City under Dhaka Improvement Trust (DIT) now changed Rajdhani Unnayan Kartripakka (RAJUK) or Capital Development Authority. Under this act RAJUK is authorized for expansion and improvement Dhaka City. RAJUK is mainly authorized to expand the city by making new area as town. In this processes sometimes RAJUK, violate the natural environment by destroying natural landscape in and around Dhaka. It has no direct implication on solid waste management.

Factories Act 1965 (Act No IV of 1965)

Under the factory act, general cleanliness and refuse collection is particularly mentioned in the law. According to the section 12 (1) every factory shall be kept clean and free from effluvia arising from any drain privy or other nuisance, and in particular:

- a) Accumulation of dirt and refuse shall be removed daily by sweeping or by any other effective method from the floors and benches of workrooms and from staircases and passages and disposed of in a suitable manner;
- b) The floor of every workroom shall be cleaned at least once in every week by washing, using disinfectant where necessary or by some other effective method;

It is mentioned in section 13(1) that effective arrangements shall be made in every factory for the disposal of waste and effluent due to the manufacturing process carried on therein. The government may make rule or requiring arrangement describing the methods of disposing wastes and effluent. According to Factory Rule 1979, the arrangement of waste and effluent disposal must be authorized by the chief inspector of factories, who will consult for this with the Directorate of health.

It is clear from the factory act and rule that the factory must have arrangement for refuse disposal and cleanliness. But they are only dispose their waste to the municipal bins and drained out the effluent into the water bodies. The act did not classify the toxic waste different from others and separate disposal system. So, the factories are very much reluctant of their wastes just keeping it to bins or open space as other municipal solid wastes.

The playground, open space, park, and natural water bodies of the Municipal Area Preservation Act, 2000

Under section 5 of the act, otherwise the provision of this act the playing field, open space, park and natural wetlands of the municipal area cannot be changed its classification. It is further restricted otherwise use of the area mention in the act and for that purpose it cannot be leased, rented or transfer. Under this Act, the removal of trees from a park will be treated as changing its classification. Under this act, nobody should be allowed to encroachment the rivers, lakes for environmental safety and for a balanced ecosystem.

According to preservation act of 2000, requires consent of the government before to change the structure, i.e., causes any change from the original Master Plan or Government Gazette, of open place, playing field or natural reservoir of water identified by the Master Plan or declared in the Gazette by filling land, building construction. DCC did not take clearance was taken from RAJUK, for landfill operation, which is required for structural change of open space and/or reservoirs according to the Preservation Act of

2000. The river Buriganga, Lakes of Dhaka city encroached time and again but the law is not enforcing by the competent authority.

The Environment Court Act, 2000

The Government of Bangladesh has enacted a law for the trial of offences relating to environmental pollution and matters incidental thereto in the name of 'The Environment Court Act, 2000' (Act No. 11 of 2000). Some important features of Environment Court Act, 2000 are as follows:

Establishment of Environment Courts

For carrying out the purposes of the act, the government can appoint one or more environment court in each division of the country. Joint district judge of the judicial officer will constitute the environment court. Where there the environmental law provides of an imprisonment not exceeding 2 years or a fine not exceeding ten thousand taka or both or confiscation of anything, for commission of an offence, a Special Magistrate of the first class or Metropolitan Magistrate will constituted a special court.

No court will take cognizance of an offence or receive any suit for compensation except on the written report of an inspector or any authorized person by the director general of the DoE. However, if the court is satisfied after a proper hearing of the concern authority, may directly take cognizance. The environment court will follow the Criminal Procedure Code for investigation and trial and Civil Procedure Code for disposal of the matter.

Environment Appeal Court

The government can establish one or more environment appeal court by official gazette notification by the rank of District Judge. Appeal should be made within 30 days of passing order of the environment court.

It has been reported from the DoE source that no case was filed under the ECA, 1995 for contravening the improper disposal of solid or liquid waste in Dhaka city. The inspectors of DoE informed that generally they do not file a suit for solid waste related matter because it is the duty of the DCC.

3.2.9 Environment Policy, 1992

Preambles and Perspective

The existence and progress of life on earth depend on nature and environment. In recent times, gradual degradation of the natural environment has posed a serious threat to the existence of all living beings and to the progress of human civilization. In view of the various adverse impacts on environment, the government of Bangladesh has

attached special importance to its protection and improvement. A number of environmental problems, which inter-alia include natural disasters like recurrent floods, droughts, cyclones, tidal bores etc., primary signs of desertification in the northern districts, intrusion of salinity in the rivers, land erosion, fast depletion of forest resources, instability of the weather and climate etc. are prevalent in the country. Against this backdrop, the Government has established the Ministry of Environment and Forest (MoEF) and upgraded the Department of Environment (DoE) in order to coordinate and supervise the activities concerning protection and improvement of the environment. To implement government's commitment to environment and mitigation of other environment related problems are possible only through a well-defined national policy. In the context of the environment, the Government prepared an environment policy in 1992.

Objectives

The objectives of environment policy are:

- to maintain ecological balance and overall development through protection and improvement of the environment;
- to protect the country against natural disasters;
- to identify and regulate activities which pollute and degrade the environment;
- to ensure environmentally sound development in all sectors;
- to ensure sustainable, long term and environmentally sound use of all national resources; and
- to actively remain associate with all international environmental initiatives to the maximum possible extent.

Sector Wise Interventions of Environment Policy 1992

Environmental activities encompass all geographical regions and development sectors of the country. As such, policies towards realization of the overall objectives of this Environment Policy are described in 17 sectors. The environmental options regarding waste management and related issues of the Environment Policy are mentioned here in brief.

- **Industries sector-** Adoption corrective measures by polluting industries will be taken in phases.
- **Health & Sanitation-** Prevent activities, which are harmful to public health in all spheres, including development activities in the country.
- **Housing & Urbanization-** Integrate environmental considerations into all housing and urban planning activities and research. Extend environmentally sound amenities to all the existing urban and rural housing areas in phases. Control housing and urban development schemes, which have possibility of

adverse impact on the local and overall environment. Focus greater importance on the role of water bodies in enhancing beautification of the cities.

- **Energy & Fuel-** Reduce and discourage the use of those fuels, which pollute the environment and increase the use of environmentally sound and less harmful fuels. Reduce the use of fuel wood, agricultural residues etc. to meet energy need and increase the use of alternative energy sources. Conserve country's fossil fuel reserves and use renewable sources of energy. Conduct Environmental Impact Assessment before implementing the projects for extraction of fuel and mineral resources.
- **Water Development, Flood Control and Irrigation-** Ensure environmentally sound utilization of all water resources. Keep the rivers, canals, ponds, lakes, haors¹⁷, baors¹⁸ and all other water bodies and water resources free from pollution. Ensure sustainable, long term, environmentally sound and scientific exploitation and management of the underground and surface water resources.
- **Land-** Formulate a balanced and environmentally sound national land use policy and prevent spread of salinity and alkalinity on land.
- **Forest, Wildlife and Bio-diversity-** Conserve wildlife and bio-diversity, strengthen related research and disseminate or exchange of knowledge in the concerned area.
- **Fisheries and Livestock-** Prevent activities, which diminish the wetlands/natural habitats of fish and encourage rehabilitative measures in this area.
- **Food-** Dispose rotten or harmful foodstuff and food crops in an environmentally acceptable manner.
- **Education and Public Awareness-** Create widespread mass awareness regarding environmental conservation and improvement, sustainable, long term and environmentally sound utilization of all resources. Incorporate environmental issues in all government and non-governmental training programs and for industrial and commercial workers.
- **Science, Technology, and Research-** Encourage necessary research and evolve technology to ensure long term, sustainable and environmentally sound utilization of all resources for conservation and improvement of environment.

¹⁷ Haor is the low-lying area, which goes under water for the whole time of rainy season particularly in the area of greater Sylhet and Kishorgonj and Netrokona district of Bangladesh. Haor is one of the big sources of fish resources of Bangladesh. It is very beautiful to look at. In winter there are lots of guest birds come to this haor from abroad. The biggest haor in Bangladesh "the Tanguar Haor" is declared as one of the world heritage by UNICEF.

¹⁸ Baor is the small size Haor. The haor which is less than 3 acre in area is termed as baor in the low-lying area in the greater Sylhet, Kishoregonj, Netrokona district of Bangladesh. In fact it is the small size ditches or low-lying areas which go under water for long time in the rainy season.

- **Legal Framework-** Amend all laws and regulations related to protection of environment, conservation of natural resources, and control of environmental pollution and degradation with a view to meet present day's need. Frame new laws in all sectors necessary to control activities concerning environmental pollution and degradation. Ensure proper implementation of all relevant laws/regulations and create wide spread public awareness in this regard. Ratify all concerned international laws, conventions, and protocols for sustainable environmental development.

Environment Policy and Solid Waste Management ✓

It is revealed from the environment policy 1992 that a lot of issues are covered in the environment policy. However, the need of efficient solid waste management did not come categorically. Solid waste is one of the important factors of urban environment management. Indiscriminate disposal of solid waste makes the air, water and land pollution as well as affect the public health. The use of renewable resources has been priorities in the policy. However, solid waste is one kind of biomass energy and it could be mentioned in the policy. It seems that this issue has not given proper attention in environment policy. The policy makers could not produce an effective and sustainable waste management policy guideline for efficient solid waste management. In housing and urbanization sub-sector, the solid waste management issue could come more elaborately and policy options could more clearly for sustainable urban environment development.

3.2.10 The National Environment Management Action Plan (NEMAP), 1992

Under the Environment Policy 1992, it was necessary to draw a specific action plan to achieve the objectives of the policy. To implement the recommendations of the National Environment Policy the National Environment Management Action Plan (NEMAP) was under taken. There were many actions planned for implementation sectorwise. Among these, the related ones with solid waste management are mentioned here.

Industry Sector Action Plan

- Approval of new industries for production of environmentally hazardous and non-biodegradable wastes as goods will be prohibited gradually.
- New industries proposing to use hazardous and or poisonous wastes prohibited.
- "Waste permit/consent order" system will be established in the industrial sector, so that waste disposal and waste refinement will be facilitated.
- Recycling will be encouraged to reduce waste.

Health & Sanitation Sector Action Plan

- Waste discharge in rivers, canals and all other water bodies from industries, municipalities and agricultural or other sources will stringently regulated through enactment and implementation of appropriate laws.
- Open trucks will not be allowed to collect transport or dump garbage during the daytime in urban areas.
- Necessary steps will be taken to protect the environment and public health from the adverse impact of all sorts of waste materials.

Fuel and Energy Sector Action Plan

- Appropriate measures will be taken to find out the alternative source of energy to conserve the coal, oil and natural gas.

Water Development, Flood Control and Irrigation Sector Action Plan

- Treatment of domestic and industrial waste before discharging in rivers, wetlands or other water bodies will be strictly enforced.

Housing and Urban Development Sector Action Plan

- Steps will be taken for zoning of residential, commercial and industrial areas.

Education and Mass Awareness Sector Action Plan

- To create awareness participation of imams¹⁹, social and voluntary organizations will be ensured.

Organizational Structure Sector Action Plan

- The MoEF will coordinate implementation of environmental programs & it will update the environment policy and action plan as and when necessary.

Sustainable Environmental Management Program (SEMP)

Under the NEMAP follow up, the "Sustainable Environmental Management Program" (SEMP) has been conceptualized which consists of five major components namely:

- Policy and institutions;
- Participatory eco-system management;
- Community based environment sanitation
- Awareness and advocacy; and
- Training and education.

¹⁹ Imam is the leader Muslims who led the prayer in the Mosque or in a big Eid Congregation. Imam holds a very prestigious position in the society and he has a dominant role for awareness building.

SEMP had close links with other NEMAP follow-up projects supported by other development partners. Under the third components of community based environment sanitation, one of the sub components is "Community Based Urban Solid Waste Management" and the implementing agency is "Waste Concern" funded by UNDP. The objective of the component is to develop community based solid waste management model with emphasis on recycling and resource recovery in Dhaka; encourage and promote public-private-community partnerships in solid waste management and recycling for improved urban environmental sanitation; create job opportunities for the marginal poor (especially women) by involving them in waste recycling activities. Mainly low-income people of Dhaka city and farmers would targeted by piloting 'community Based Approach' for converting organic waste into compost; and promoting use of Compost/enriched compost in agricultural farming. The initial TAPP budget was \$ 162,750.00 but it was revised to \$ 450,000.00 (in taka 2,51,45,000). The project is still going on.

Achievement of the Project

- Awareness of the beneficiaries at different project areas regarding proper waste management and resource recovery has been increased;
- Physical environment at neighborhood level improved significantly through introduction of house-to-house waste collection and composting;
- The concept of public-private community partnerships in solid waste management has been successfully implemented;
- Good demonstration effect of the project on the communities as well as the city level;
- Increase in yield of crops between 30-50% has been found by using enriched compost;
- A new medium of employment generation especially for neglected urban poor women has been created through recycling of organic waste;
- Private sector is marketing compost to rural areas of Bangladesh produced in different community based composting plant, thus creating an urban-rural symbiosis;

Two factors contributing to the success of the project are that its cost is recovered from sale proceeds of compost and income from house to house waste collection charge and it is based on renewable resource, and thus facilitate its sustainability.

3.2.11 The Dhaka City Corporation Ordinance, 1983

The Dhaka City Corporation Ordinance is the principal law for solid waste management of Dhaka city. This is the key element of city (municipal) administration. Along with lot of other act and ordinance, rules, regulations are functioning for maintaining the administration, law and order and other social service. Among them, the City Corporation Ordinance is the driving position for city administration. Particularly the solid waste management directly linked with this law. The salient features regarding waste management of the ordinance are as follows:

Definition: Most related definitions are given here for clear understanding.

Conservancy: Conservancy means the removal and disposal of refuse; (sub section 10 of section 1)

Nuisance: Nuisance includes any act, omission, place of thing which causes or is likely to cause injury, danger, annoyance or offence to the sense of sight, smell or hearing or which is or may be dangerous to life or injuries to health or property; (Sub section 28 of section 1)

Refuse: Refuse includes rubbish, offal, night soil, carcasses of animals, deposits of sewage, waste and any other offensive matter; (Sub section 28 of section 1)

Responsibility for Sanitation

The corporation shall be responsible for the sanitation of the City, and for this purpose, it may cause such measures to be taken as are required by or under this Ordinance. (Section 76)

Removal, Collection and Disposal of Refuse (section 78)

1. The Corporation shall make adequate arrangements for the removal of refuse from all public streets, public latrines, urinals, drains, and all buildings and land vested in the Corporation, and for the collection and proper disposal of such refuse.
2. The occupiers of all other buildings and lands within the Corporation shall be responsible for the removal of refuses from such buildings and lands subjects to the general control and supervision of the Corporation.
3. The Corporation may cause public dust-bins or other suitable receptacles to be provided at suitable places and where such dust-bins or receptacles are provided, the Corporation may, by public notice, require that all refuse accumulating in any premises or land shall be deposited by the owner or occupier of such premises or land in such dust-bins or receptacles.

4. All refuse removed and collected by the staff of the Corporation or under their control and supervision and all refuse deposited in the dust-bins and other receptacles provided by the Corporation shall be the property of the Corporation.

Latrines and Urinals (section 79)

The DCC may, if so required by the government shall provide sufficient number and in proper situation of latrine and urinal separate for each sex in the city. The city corporation will ensure the cleanliness of public privy and urinals and ensure the private ones are cleaned and operate in order. If necessary, DCC can order for closure, shift or properly maintained by the owner or possessor.

Offences (Section 147)

Every act or omission specified in the Third Schedule shall be an offence under this Ordinance.

Offences under the Ordinance (The Third Schedule)

There are 63 offences are listed in the third schedule. Only the offences are directly or indirectly linked with the waste management and public health issues mentioned here. According to the serial number of the third scheduled, the offences are as follows:

- 13 Throwing or placing any refuses on any street, or in any place not provided or appointed for the purpose by the Corporation;
- 15 Doing any act by which water for drinking is rendered unfit for such use;
- 19 Dyeing or tanning skins within such distance of the residential area as may be specified by the Corporation;
- 25 Disposing of carcasses of animals without the sanctions of the corporation.
- 26 Failure to provide, close, remove, alter, repair, clean, disinfect or put in proper order any latrine, urinal, drain, cess-pool or other receptacle for filth, sullage, water or refuse when so required by the Corporation.
- 38 Slaughtering animals for the purpose of sale of meat at a place other than the place set apart for the purpose.

Punishment (Section 148)

An offence under this Ordinance for which no penalty is expressly provided shall be punished with fine which may extend to two thousand taka, and if the offence is a continuing one, with a further fine which may extend to one hundred taka for every day after the date of the first commission during which period the offender has persisted in the offence.

Compounding of Offence (Section 149)

The Chief Executive Officer or any person generally or specially authorized by the Corporation in this behalf may compound any offence under this Ordinance.

Cognizance of Offences (Section. 150)

No court shall take cognizance of any offence under this Ordinance except on a complaint in writing received from the Chief Executive Officer or a person generally or specially authorized by the Corporation in this behalf.

The application of the provisions of City Corporation Ordinance, 1983, DCC is very much reluctant in the area of indiscriminate waste handling. Dumping refuses in public street or open spaces, should be controlled by enforcing 150-153 (offence and punishment) of the ordinance. Though the punishment would be the last resort to prevent the offences, the enforcement of the provisions may contribute to enhancement of public awareness and subsequent change of the behavior of the people.²⁰

3.2.12 Enforcement of Environment Laws in Solid Waste Management

The content of the ECA revealed that there are no direct implications of solid waste management issue. Only there is a definition of waste in sub-section (I) of section 2. But the Director General of DoE, can assess the harm caused directly or indirectly to ecology by certain activity (here it may be scattered throwing of waste or indiscriminate solid waste disposal). DG has the power to direct the concern person (s), agencies and organizations (here it may be DCC) to take corrective measures. If any direction comes from the DG to take corrective measures, the person(s) or organization is bound to comply it. However, if the party concern do not comply it DG can make civil suit for compensation and or criminal case for non-compliance. But no action was taken in this regard.²¹ Therefore, it is clear that ECA has no direct implications on the solid waste management.

Land filling by industrial, household and commercial wastes classified as "Red Category", which includes most harmful or dangerous industrial units projects. So, it is a must to obtain the ECC from the DoE for any kind of land filling sites. However, DCC has not obtained the Environmental Clearance Certificate (ECC) for Matuail landfill site, although use of the site for final disposal was started before the enforcement of Environmental Conservation Act (ECA) of 1995. Berri Bandh and Uttara landfill sites was started after the enforcement of the ECA and Environmental Rules of 1997. Though

²⁰ JICA Draft Final Report, p, 15.

²¹ It was verbally informed by the DCC officials and DoE office source that from the commencement of ECA, there was no direction from the DG issued for making the indiscriminate disposal of solid waste or polluting the environment through scattered throwing waste in water bodies, housing areas etc.

these two sites are not official, DCC did not feel for ECC requirements. It is interesting that DoE did not take any legal action against DCC for not having ECC for Matuail and even no step was taken to stop the unauthorised other two landfill sites.

Uncontrolled discharged of waste effluents into surface water cannot be stopped by DoE. The DoE is fully equipped with necessary legislation but they don't have the legal implementing tool for application of the law.²² Furthermore, neither of the sites got approvals from RAJUK, which is required for structural change of open space and/or reservoirs according to the Preservation Act of 2000.²³ The study found that DCC does not comply the ECA, ECR and Preservation Act for Matuail sites and other two non-official sites.

3.2.13 Respondents Opinion about the Legal Options

Dhaka City Corporation Ordinance 1983 and Environment Conservation Act 1995 are the two major laws relating to solid waste management and as well as environment conservation. According to the section 78 of DCC ordinance, primary collection lies with the waste generators and secondary collection goes to the city corporation. ECA is dealt with overall environment protection procedure. In reply to the question whether the people know the rules and regulation of waste disposal procedure only 23% replied that they know, 64% said that they do not know and rest 13% gave no comments. It indicates that 77% of the population do not know the rules and regulation of the waste disposal and environment protection rules. It is interesting that 37% of the lower level employees do not know the legal provision of the ordinance and ECA. There was a question among the household respondent that whether DCC inform the rules and regulation regarding waste disposal. In reply to that question only 9% said yes the DCC has informed and 91% of the respondent said no DCC did not informed rules and regulation.

Another question was that whether the DCC officials inspected the household as part of the solid waste disposal, only 4% said yes and 96% said no. Among the business sector 26% of said yes and rest 74% said that no DCC official inspected the business place as part of the solid waste management. But 65% of business sector respondent replied that waste collection and transportation operation from dustbins are monitored and inspected by the higher officials.

Another question was that whether the respondents follow the common cleanliness of his surroundings stated in the ECA. In reply that question, 12% the respondents replied that they follow the rules, 19% said that one's do what he/she fell necessary, 16% said that ones do what he/she seems to be good, 24% said one's try his/her level best, 25% said they do not know what is in the law, and 4% replied other

²² M. Shamsuzzoha, "Dhaka City's Waste", p. 818.

²³ JICA Draft Final Report, Vol. 2, Chapter 2, p. 29.

answers. Another interesting thing is that DCC took, no legal action was taken against the people who throw or place garbage into the public place. DoE did not take any legal action against DCC or other organization for non-compliance of the provision of law.

It is worthwhile to mention that most of the population actually do not follow the rules and regulations regarding the cleanliness of his surroundings. Most of the population do not know the rules and regulations of solid waste disposal. DCC and DoE, none of the two organization has any awareness program of informing the people and for efficient solid waste management.

3.2.14 Rules, and Regulations for Industrial and Clinical Waste

Nothing is identically spelt out in the ECA, DCC ordinance about the handling of toxic and infectious industrial and hospital waste categorically. There are no provisions in the law to dispose these wastes separately. There is no indication about the status of the hospital wastes. Government has not enact legislation for the health care waste management or workers safety or even environment pollution due to mishandling of hospital waste, but there exist only a manual compiled by Director general of Health Services, Ministry of Health and Family Welfare in 2001.²⁴ This manual is not well known to the staffs handling waste in the hospitals and cleaners of DCC engaged waste handling. This manual was supposed to give directions to hospitals about how to handle and manage medical waste to protect hospital staffs from incidents caused by hazardous and toxic components contained in the hospital waste. ECA, 1995 is the principal legislation in context of environment conservation. But no legal provision for handling, transportation and disposal of industrial and clinical waste is articulated in this act.

Solid waste management is the function of cross-related stakeholders. The waste generators are the householders, commercial enterprises, different kind of institutions, industries etc. The responsibility of waste management lies on the Dhaka City Corporation. Solid waste is one of the main factors for environment pollution. The Ministry of Environment and Forest is embodied with the responsibility to protect the environment is not capable enough to prevent environment pollution. The ministry performs the duty through the Department of Environment. The health and family welfare ministry, industry ministry and ministry of local government and rural development have also the important role for handling industrial and clinical waste. These ministries can monitor and provide executive instruction for efficient handling of solid waste and keep the environment clean and safe.

²⁴ A.K.M. Saiedur Rahman, *Manual for Hospital Waste Management* (Dhaka: Ministry of Health and Family Welfare, 2001), p. 14.

3.2.15 Chapter Summery

Bangladesh Constitution has ensured the right to protect the life and personal liberty as a fundamental right of the citizen. However, the Constitution did not explicitly recognize the right to have a good environment as the fundamental right. The Supreme Court of Bangladesh has resolved the right to have a healthy environment by the verdict of the case.

Solid waste is one of the major causes of environment pollution in the city area. The responsibility of waste management lies with the city corporation. DCC collect only 33% of the waste and rest goes to elsewhere to create environment pollution. There were institutions for solid waste management and as well as to protect the environment. There was East Pakistan Water Pollution Control Board to protect water pollution, and 1977 it was changed accordingly to Environment pollution Control Board. In 1989 Ministry of Environment and Forest was established and EPCB was upgraded to Department of Environment. DoE is the principal organ of the country to protect the environment. DoE is theoretically capable of environment pollution by law, but it has no strong enforcement power.

There is lot of environmental laws in Bangladesh. Environment Conservation Act, 1995 is key one. According to the Act and Conservation Rules 1997, Environment Clearance Certificate is necessary for landfill site. DCC did not collect ECC still today. Therefore, the environmental law enforcement is very weak. Dhaka City Corporation ordinance, 1983 is another law basic law for waste disposal. There is provision of punishment for throwing or placing garbage onto the public place. It is also prohibited in the DMP ordinance 1976 not to create public nuisance. There was no instance of enforcing of these two laws against lawbreakers. Therefore, environment pollution becomes inevitable. There was some civil society initiative is found to create public awareness for environment conservation. The BEN, BELA, BAPA etc are the civil society who is playing important role for environment conservation.

Only 23% of the respondents know the rules and regulation of the solid waste disposal, 37% of the lower level employees do not know the legal provision of ordinance regarding solid waste disposal. 96% households and 74% of business sector respondent replied that DCC officials did not inspect the household or business sector as part of the solid waste disposal. No rules and regulation for clinical and industrial waste handling. Therefore, unscrupulous traders recycled the infectious clinical items leads to serious public concern.

Chapter 4

Dhaka City and Practices of Solid Waste Management

4.1 Introduction

Dhaka, as the capital city of Bangladesh has a prolonged and historical background. A major factor that led to Dhaka's being what it had been through the ages is perhaps the city's peculiar position. The city Dhaka lies in 24°40'N to 24°54'N Latitude and in 90°20'E to 90°30'E Longitude, stands on the northern bank of the river Buriganga about eight miles above its confluence with the river Dhaleswari.¹

Dhaka has a number of area connotations. Dhaka City Corporation (DCC), for instance, has a clear administrative boundary and its area is now 145 km². The second connotation is Dhaka Metropolitan Area (DMPA), the function of police administration. DMPA is larger than DCC and consists of 14 sub-units known as Thanas (lower tier of police administration). The total area of DMPA is 360 km². The third connotation is Dhaka Statistical Metropolitan Area (DSMA), which in 1991 had an area of 1353 km². DSMA is known as Dhaka Mega City. The fourth concept is the capital development authority named as Rajdhani Unnayan Kartipakkha (RAJUK) area covers 1530 km². It is, in fact, planning area of DSMA plus Narayanganj, Tongi, Savar, and Gazipur municipal areas and adjacent areas.²

4.2 Historical Background of Dhaka City

Dhaka was under the Buddhist Kingdom of Kamrup in the seventh and eighth centuries. Then, the ninth century, it came under the rule of the Sena kings of Vikrampur. Dhaka came under the Muslim domination in 1338, when Sultan Fakhruddin Mubarak Shah founded the first independent Muslim Kingdom in Bengal. When Sher Shah Suri established the Pathan rule with his capital at Delhi, a strong fort was built in Dhaka. After the Suri dynasty about the middle of the sixteen-century, Dhaka passed under the rule of the Sultans of Sonargoan. Dhaka was the camp of Mughal forces operating against the confederacy of the Baro-Bhuiyans.³

¹ DCC, "Profile of Dhaka City Corporation", *A Pamphlet of DCC* (Dhaka: DCC, 2004), p. 1.

² Nazrul Islam and Nazrul Islam Khan, "Urban Governance in Bangladesh and Pakistan", *Urban Governance in Asia: Sub-regional & City Perspective*, in Nazrul Islam, ed. (Dhaka: CUS & Pathak Samaj, 2000), p. 159.

³ Azimussan Haider, "Dacca (Dhaka) through the Ages", *A City and its Civic Body*, in Azimussan Haider, ed. (Dhaka: Dhaka Municipality, 1966), pp. 1-3.

Dhaka was founded in 1608 A.D, as the capital of the Bengal Province, by Islam Khan Chisti during the regime of Mughal Emperor Zahangir and it was renamed Jahangirnagar.⁴ With the establishment of Mughal control over the region, Dhaka continued functioning as the capital of Bengal, Bihar and Orrisa. Dhaka's Geographical location and topographical advantage and above all its commanding position on the water-routes of the country, motivated Islam Khan Chisti, the Mughal Subahdar, to transfer his capital from Rajmahal to Dhaka in 1610.⁵ In the early part of 18th century, the glory of Dhaka ended with shifting the provincial capital from Dhaka to Murshidabad in 1717. Due to its commercial importance, Dhaka attracted the European traders. All came and established their factories in Dhaka in 17th century.⁶ Dhaka was a very small township in that period. At this time in Dhaka, there was only one road, Islampur, and one mosque, now known as Islam Khan Ki Masjid.⁷

Due to lessening Mughal control over, the trading of the Europeans has increased. The European traders (ultimately the East India Co) took over the administration after the battle of Palashi. After the acquisition of Dewani in 1765 by the East India company, the fate of Dhaka fade out and it suffered physical shrinkage and got less priority.⁸

In the early twentieth century, a spotlight fall over the fortune of Dhaka when Dhaka was made the capital of newly formed province of Eastern Bengal and Asam in 1905 with an area of 6 km.⁹ Again, the impetus of growth, which was started in 1905 with the partition of Bengal, was seriously jolted by the annulment of the partition in 1911. The establishment of University of Dhaka in 1921 was the only renounced institution in Dhaka.¹⁰

In 1947, Dhaka got the status of provincial capital city and virtually started its physical development through establishment of different administrative offices, residential areas.¹¹ The creation of the independent state of Bangladesh in 1971 bestowed the glory on Dhaka and prestige of the capital of a sovereign country.

⁴ A. M. Chowdhury and Ms. Shabnam Faruqui, "*Physical Growth of Dhaka City*", Dhaka: Past Present Future, in Sharif Uddin Ahmed ed. (Dhaka: The Asiatic society of Bangladesh, 1991), p. 43.

⁵ Ibid., p. 43.

⁶ Ibid, p. 50.

⁷ Abdul Karim, "Origin and Development of Mughal Dhaka", *Dhaka: Past Present Future*, Sharif Uddin Ahmed ed. (Dhaka: The Asiatic society of Bangladesh, 1991), pp. 28-30.

⁸ Chowdhury, "Physical Growth", p. 50.

⁹ JICA, Clean Dhaka Master Plan, Progress Report, March 2004, Chapter 2, p. 1.

¹⁰ Khwja Shahabuddin, "Foreword of the Book", *A City and its Civic Body*, in Azimussan Haider, ed. (Dhaka: Dhaka Municipality, 1966), pp. 95-96.

¹¹ Chowdhury, "Physical Growth", pp. 54-60.

4.3 Urbanization and Growth Pattern of Dhaka City

With the independence and the burgeoning national governments ardent interest in promoting industrialization and the favorable climate provided by new international division of labor, the industrialization in the developing countries highly expedite the urbanization.¹² Urbanization is the increase in number of people living in town and cities compared to those living in rural areas. The project share of urban population for the world as a whole will be 60% in the next 25 years and out of which 90% will be living in developing countries.¹³ It is caused by the migration of the rural population to cities and the natural growth of the urban population. Though the economic importance of urban centers is improving but unfortunately the living environmental condition is decreasing.

In the British regime (1757-1947), large-scale urbanization did not take place in Dhaka due to absence of industrialization.¹⁴ There had also been significantly large scale rural to urban migration in Dhaka in the newly independent country. In 1971, the proportion of the Bangladesh population living in the towns and cities was only 8 percent and it was 20% in 2001. The rapid growth of Dhaka occurred due to increase native increase of population and rural urban migration.¹⁵ The main factors responsible for this migration are: slow progress in the agriculture sector, low crop yields, lack of alternate employment opportunities and environmental degradation due to river erosion, water logging/salinity, deforestation and desertification. The industrialization (garments) in the eighty's of last century made a huge trend of urbanization in Dhaka.¹⁶

The urbanization rate of Bangladesh is the highest in the world and the annual increase is about 1.5 million people in urban areas generate some 300,000 new households.¹⁷ Nearly 25% of total urban populations in Bangladesh live in Dhaka. Dhaka City Corporation is holding over 5.7 million people.¹⁸ Dhaka, already the most densely

¹² Kwesi Darkoh, "Environmental Impacts of Urbanization", Pollution Control, p. 56.

¹³ Qazi Kholiquzzaman and Ahsan Uddin Ahmed, eds., *Bangladesh Citizens Perspective on Sustainable Development* (Dhaka: BUP, 2002), pp. 152-155.

¹⁴ Nazrul Islam, "Urbanization and the Urban Environment in Bangladesh", A Atik Rahman, et al. eds. *Environment and Development in Bangladesh* (Dhaka: UPL, 1994), pp. 333-334.

¹⁵ GOB, *Peoples Report on Bangladesh Environment*, Vol. 1 (Dhaka: MoEF, 2001), p. 195.

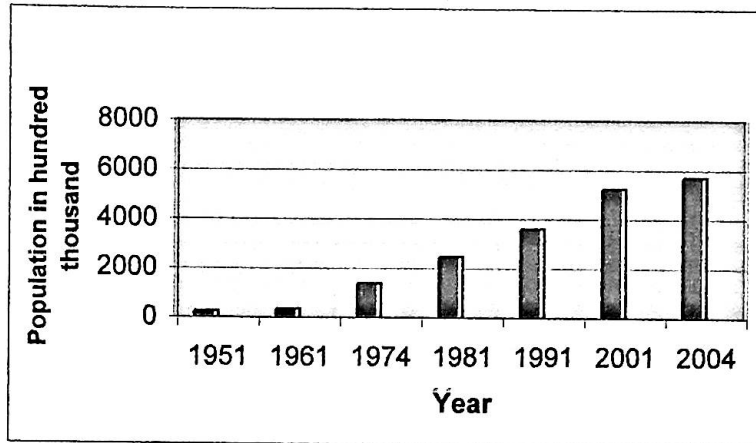
¹⁶ Nazrul Islam, "Urbanization and the Urban Environment in Bangladesh", pp. 333-334.

¹⁷ UN, *The Common Country Assessment: Bangladesh* (Dhaka: UPL, 2000), pp. 58-59.

¹⁸ JICA *Progress Report*, Chapter 2, p. 1.

populated city after the city-states like Singapore will become a mega-city by the year 2020.¹⁹ The growth of urban areas has been consistently faster than the growth of infrastructure provision to serve the urban population.²⁰ The population of Dhaka city is shown in the figure 4.1

Figure 4.1
Population of Dhaka City over the Time



Source : DCC published pamphlet

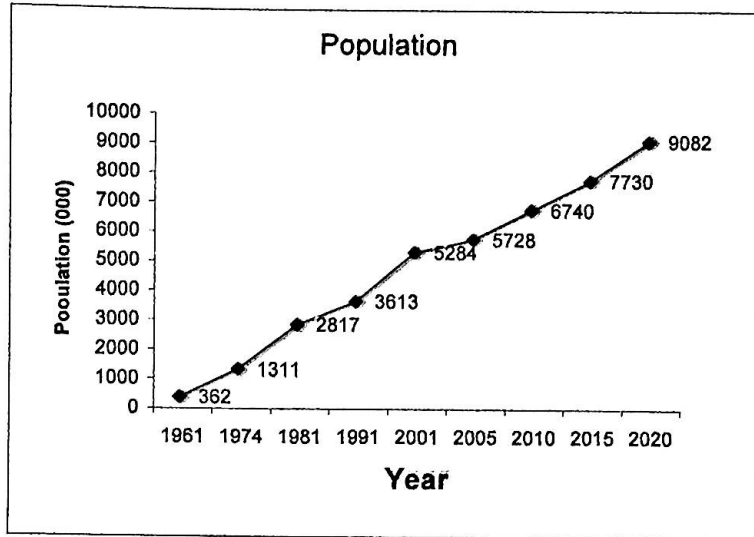
The population increase rate is 3.1% during 1991 to 2001 in Dhaka and on that basis the population in 2005 would be 5,773,347. Population growth in the period 1974-1981 was drastic (almost 11%) with the annual increasing number of population more than 210,000 persons. In the following decade (1991-2000), the annual growth rate dropped to 3.17% to 3.2%. The average population density in Dhaka city reached 40,300 person/km² in 2001. At present the population of Dhaka is increasing at rate 3.1% much higher than the overall population growth rate of Bangladesh i.e. 1.54%. In 2015, the total population would be 7.7 million and the density of population will be 66,000 person/km² in 90 Wards of DCC area, while that of Dhaka Mega City area to 16 million.²¹ By the year 2020, the total population of Dhaka City Corporation area will be 9.08 million. The trend of population in Dhaka is projected in figure no. 4.2.

¹⁹ Philip Gain, ed., *Bangladesh Environment: Facing 21st Century* (Dhaka: SHED, 1998), p. 278.

²⁰ UN, *The Common Country Assessment: Bangladesh*, pp. 58-59.

²¹ JICA, *Clean Dhaka Master Plan, Draft Final Report*, Chapter 4, pp. 6-8.

Figure 4.2
Trend of population growth in Dhaka city (1961-2020)



In the year 1864, initial stage of its foundation, the Dhaka town was with an area of only 3.0 sq. miles. There was a revision of boundaries in 1906 following the partition of Bengal and the area of the town came to 6.15 sq. miles.²² Only within a hundred years the Dhaka became a big mega-city. The area increase over the time is shown in table no. 4.1.

Table 4.1
Population, Area and Density of Dhaka City 1864-2004

Year	Area (sq.km)	Population (000)	Density (per sq.km)	Population growth	Household (000)	Dwelling size
1864	3.00					
1906	6.15					
1951	8.1	276	7763	39.8%	62	6.9
1961	36	369	9180	37.2%	197	5.9
1974	100	1403	---	7.97%	367	7.1
1981	208	2476	1354	4.15%	755	6.1
1991	276	4232	15333		1107	5.5
2001	290	5282	---		---	4.5
2004	302	8000				

There is a huge difference between different study about the area and population of Dhaka city. In most cases the area of Dhaka is mentioned 360 km² in 2004. However, the DCC itself claims it area is 302 km² 2004. The JICA study report stated that the area under Dhaka City Corporation is only 131.2 km² and the population according to BBS is 5.2 million.²³

²² Shahabuddin, "Foreword of the Book", pp. 95-96.

²³ JICA Draft Final Report, Chapter 4, p. 5.

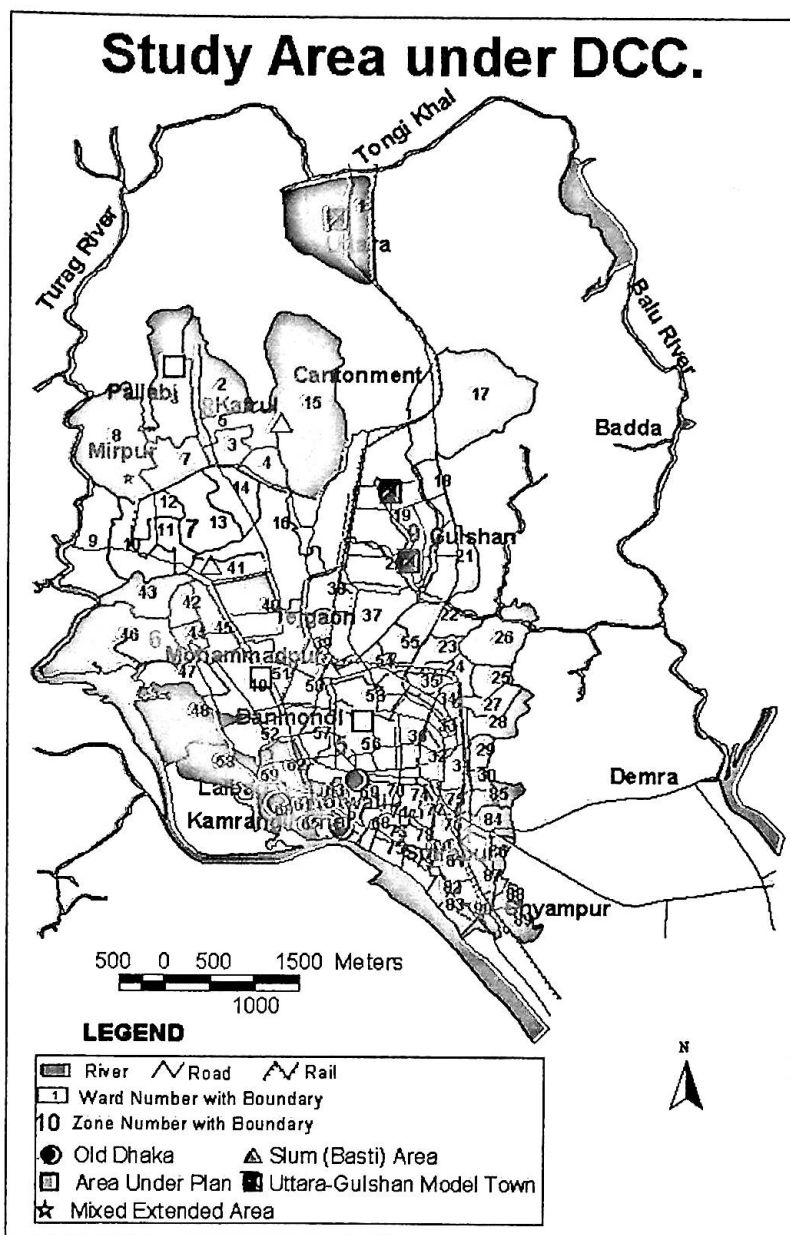
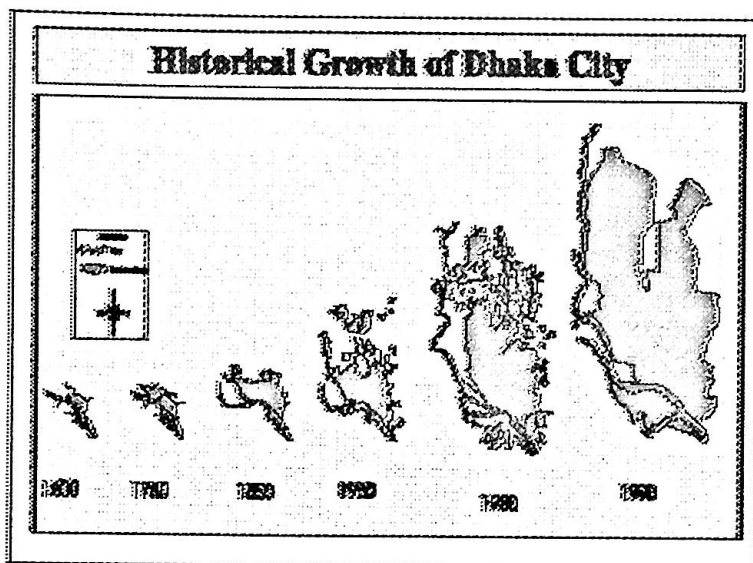


Figure 4.3
Expansion of Dhaka city and Neighboring Area



Source : DCC

The figure 4.3 shows the spatial development of Dhaka city over the time and it revealed that Dhaka city is expanded towards North to Northeast.

4.4 DCC: From a Tiny Municipality to Mega City

The Dhaka Municipality was created under the District Municipal Improvement Act of 1864. The first changes as came to the city area in 1882 since its establishment. In that time, seven mahallas were added to the municipal area. A proposal to extend the municipal area towards the north was sent to the government in 1939-40 but not executed. With the establishment of Pakistan, the volume and tempo of activities multiplied in the city. By a gazette notification, dated September 30, 1961, forty-two local areas were included in the municipal jurisdiction. The expansion added 14.20 sq. miles and 2.50 lakh persons to the Municipality's existing 7.8 sq. miles and 3.26 lakh citizens.²⁴

Municipal limits were defined on March 3, 1962, when three areas (Goran, Ramchanderpur, Enayetganj) were added by notification. By 1962, the municipal area extended to 25.9 sq. miles and the population of Dhaka has been estimated about eight lacs (0.8 millions). After liberation of Bangladesh, Dhaka became the capital city of Bangladesh but the position of Dhaka municipality did not changed.

²⁴ Shahabuddin, "Foreword of the Book", pp. 95-96.

The city administration became a Corporation in 1978. In 1982 the adjoining municipalities Mirpur and Gulshan were absorbed in Dhaka Municipal Corporation. The Dhaka Municipal Ordinance 1983 provided the legal framework for the corporation. In 1990, it was renamed the Dhaka City Corporation.²⁵ Now it has 90 wards. One Mayor and 90-ward commissioners (one Commissioner for each ward) and 30 Female Word Commissioners (one for each three wards) are elected.

Mr. Skinner, District Magistrate, was the first ex-officio Chairman and Mr. George Billert, a teacher of Dhaka College, the first Vice-Chairman of Dhaka Municipality. Mr. Ananda Chandra Roy was the first elected chairperson in 1885. Mohammad Hanif is the first elected Mayor of DCC. The present Mayor Mr. Sadeque Hossain Khoka is the second elected Mayor of DCC will continue his office until 2007.

4.5 Historical Background of Conservancy Service of Dhaka City

The conservancy Act, 1842 (Act of X 1842) was the first legislation in Bengal for the creation of modern municipality.²⁶ The present Dhaka City Corporation was first established in the name of "Dhaka Municipal Committee" in 1st August, 1864. In 1870 the Dhaka Conservancy Act (Act of VII of 1870) was applicable to the town of Dhaka only for improving the sanitary condition of this town.²⁷ Before that, the function of conservancy service was limited to night soil collection. In 1874-75, conservancy budget was at Rs. 23,742 (the actual expenditure was Rs.13,378). A government notification of 1878, declared that the Commissioners of Dhaka Municipality would maintain a conservancy establishment for cleansing their areas. In fact, that is the starting point of conservancy establishment after nine years from the act of 1870.²⁸

In 1909, the tramways were established with a capital expenditure of Rs. 2 lakhs (0.2 million) with a view to dispose the night soil five miles away from the town. The railways then charged Rs. 24,000 annually and trenching charge of more than Rs. 6,080, thus making a total of Rs. 30,080. By 1924, a reverse arrangement was made to dispose the night soil at several points of the city. At that time, a vast tract of land near the Ramna Race Course was reserved as the trenching ground. However, doing so, an efficient

²⁵ Nazrul Islam and Nazrul Islam Khan, "Urban Governance in Bangladesh and Pakistan", Nazrul Islam, ed., *Urban Governance in Asia: Sub-regional & City Perspective* (Dhaka: CUS & Pathak Samaj, 2000), p. 137.

²⁶ Azimushshan Haider, "A Concise History of Dacca Municipality", Haider, ed., *City and Civic Body*, p. 97.

²⁷ DCC, *Profile of Dhaka City Corporation* (Dhaka: Urban Planning Department, DCC, April 2004), p. 28.

²⁸ Haider, "A Concise History of Dacca Municipality", pp. 115-116.

conservancy could not be established due to shortage of conservancy staff.²⁹ The strength of sweepers available and expenditure for conservancy shown in tables 4.2 and 4.3.

Table 4.2
Number of Conservancy Staff of Dhaka Municipality (1947-1964)

Year	Population	Total strength of sweepers	No. of sweepers per 1000 of population
1947	2,58,038	750	2.3
1951	3,38,762	936	2.74
1961	5,66,712	1,323	2.33
1964	8,50,000	2,200	2.32

Table 4.3
Expenditure of conservancy services of Dhaka Municipality (1899-1900 to 1965-1966)³⁰

Year	Expenditure	Year	Expenditure
1899-1900	83,000	1948-49	5,50,000
1920-1921	1,36,000	1962-63	18,85,000
1939-1940	2,06,000	1964-65	21,07,000
1947-1948	4,21,000	1965-66	27,21,000

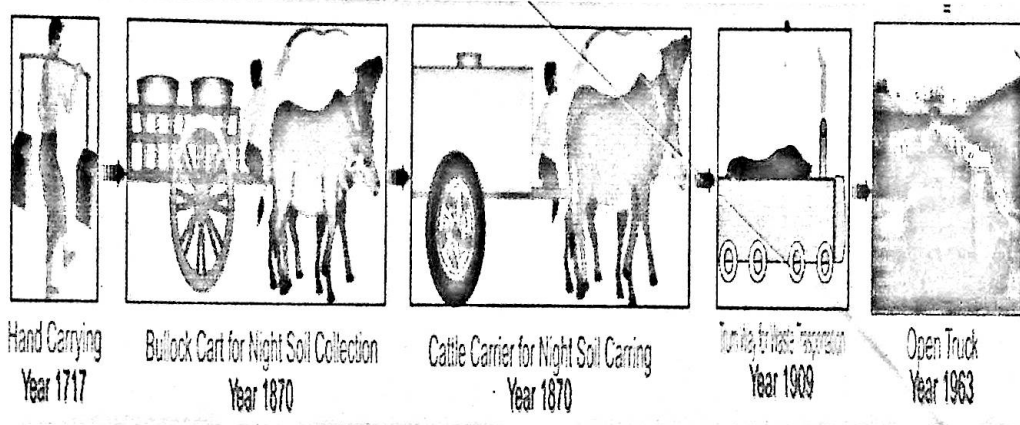
During 1830, Mr. Walter, the then collector of Dhaka formed a committee for waste management of Dhaka. For long period, night soil was collected by bullock cart or cattle carrier. From when the municipality was collecting garbage other than night soil, is out of record. In 1963, open truck was used for refuse collection. In the year 1982 there was a major change in garbage collection. One is abolition of bullock cart and switch over to refuse collection vehicle (RCV) in year 1982 and the other is the night-time collection in the city in 1989.³¹ In the 90's of the last century, there was a massive improvement in waste management. Different types of vehicles are used for garbage carrying. Open truck, covered truck, container carrier and trailer truck used for carrying. Different equipments are used for loading, unloading and spread over garbage land. These are bulldozer, tire, dozer, pay loader, excavator, wheel excavator, and hydraulic crane etc used for solid waste management. Demountable containers are used for primary transfer stations for secondary collection. The development of conservancy service is shown in the following figure.

²⁹ Ibid.

³⁰ Ibid.

³¹ M. Shamsuzzoha, "Dhaka City's Waste and Waste Management Scenario", *Bangladesh Environment 2002* (Dhaka : Bapa, 2002), p. 823.

Figure 4.4
Chronological Development of conservancy service in Dhaka



Source : DCC Pamphlet

4.6 Solid Waste Management Practice of Dhaka City

There are several stakeholders of solid waste management. DCC is playing key role. From generation to final disposal there are lots of functions. Solid waste management of Dhaka city is conducted by the Dhaka City Corporation. DCC did not conduct the primary collection. It is now making arrangement of primary collection. The present position and practice of source of generation, characteristics, primary and secondary collection, treatment and disposal options are described here on the basis of primary and secondary data collected in the study.

Domestic or Household Waste

The field survey of the research conducted during the month of June and July in the year 2004. The amount of solid waste generated in households has determined on the basis of primary data and other secondary sources.

Among total solid waste generated in Dhaka City Corporation area, the household or domestic source is big one. The domestic waste calculated through primary survey. There are 397 household were surveyed from different part of Dhaka city. The respondents are selected from five major regions of Dhaka city. Basic demographic characteristics of the household respondents is mentioned in the table no. 4.4 and 4.5

Table 4.4
Demographic Characteristics of the Respondent

Sl no	Location of the respondent	Total Respon.	%	Leaving in Dhaka (years)	Religious status			Gender	
					Muslim	Hindu	Others	Male	Female
1	Old Dhaka	68	17.13	16.7	46	19	3	57	11
2	Planned area	72	18.13	12.2	56	14	2	58	14
3	Mixed ext. area	134	33.75	9.4	115	15	4	98	36
4	Slum (Basti)	64	16.12	4.3	51	13	0	41	23
5	Model town	59	14.87	13.5	48	9	2	42	17
Total/average		397	100						

Source : Field Survey, 2004

Table 4.5
Profession and Education Level of Head of the respondent's Family

Profession	N	%	Education	N	%
Government service	52	13.20	Illiterate	41	10.30
Private service	66	15.75	Primary level	49	12.40
Business	76	19.60	SSC	53	13.35
Teachers	55	14.20	HSC	68	17.05
Physician	15	3.70	Graduation	61	15.20
House wives	63	15.70	Post graduation	46	11.70
Hawker, ferriwalla, van driver, rickshaw puller, day laborer	45	11.5	Post doctoral	26	6.75
Others	25	6.35	Others	53	13.25
Total	397			397	

Source : Field Survey, 2004

As of 2004, the total solid waste amounted from domestic source is estimated at 2,417 ton per day (here after t/d). The total population is 5.7 million in the DCC area with average generation rate of 0.422 kg/person/day. Solid waste generation per family per day and per person per day are stated in table No 4.6

Table 4.6
Solid Waste Generation Per Family Per Day and Per Person Per Day in kg.

Sl. No.	Location of the respondent	No. Respondent	Average income Tk.	Mean family size	Total Waste (kg)	Waste per family per/day (kg)	Waste per person/perdayay (kg)
1	Old Dhaka	68	7,755	4.68	121.72	1.79	.381
2	Planned area	72	15,565	5.49	179.28	2.49	.458
3	Mixed ext. area	134	13,461	4.93	341.7	2.63	.549
4	Slum (Basti)	64	1,610	4.15	55.68	0.86	.210
5	Model town	59	19,135	5.95	132.75	2.25	.371
	Total/average	397	11,798	5.020	842.79	2.122	0.422

Source : Field Survey

For study purpose the Dhaka city has been divided into five region and data collected accordingly. According to the study result, per family solid waste generation is 2.63 kg per day, highest in the mixed extended area and lowest is 0.86 kg per day in the slum (basti) area.

The study also finds the volume of waste on the basis of income. The respondents are grouped into five categories according to their income. The low-income group produce 0.184 kg/person/day and the high-income group produce 0.406 kg/person/day. Income wise solid waste generation is presented in the table no. 4.7

Table 4.7
Income Wise Solid Waste Generation per Family and Per Person Per Day

Income group	Income in Taka	No of family	Percentage of total family	Family size	Total waste generation in kg	waste per family per/day (kg)	Waste per person/day (kg)
Low	Less than 3000	64	16.12	4.062	55.10	0.860	0.184
Lower middle	3000- to 7000	63	15.86	5.158	118.50	1.880	0.364
Middle	7000 to 15000	171	43.07	4.736	412.49	2.412	0.509
Upper middle	15000 to 25000	88	22.15	5.613	230.70	2.621	0.467
High	More than 25000	11	2.770	5.818	26.0	2.363	0.406
	Total/average	397	100	5.020	842.79	2.122	0.422

Source : Field Survey.

The solid waste generation on the basis of income indicates that low income group produce 0.86 kg, medium income group (7,000-15,000) produce 2.412 kg, and high income (more than Tk. 25,000) group produce 2.363 kg solid waste per family per day. The highest solid waste generator is the upper middle-income group (15,000-25,000) is 2.621 kg per family per day.

Some other study found that domestic waste generation rate from medium-income residential area (0.32–0.37 kg/capita/day) is higher than slum area (0.23-0.25). The average generation rate is 0.39 kg/capita/day.³² World Bank estimated from the recent study that in Dhaka city approximately 3500 tons of SW produced a day, city dwellers are expected to generate as much as 4000-5000 tons of SW daily in the year 2020.³³ Accurate estimate or figure of solid waste generation from different sources is so important to develop a waste management policy.³⁴ According to the JICA study team under Clean Dhaka Master Plan, the total domestic solid waste generation of Dhaka City Corporation area is 1,945 t/d with average generation rate is 0.34 kg/person/day.³⁵

Commercial or Business waste

As of 2004, the total solid waste amount from business sources is estimated at 1,034 t/day based on the JICA survey. The waste generated by those non-resident people coming to Dhaka is considered being contained in this category of waste and stated in the table no. 4.8

³² Rita Sutradhar, "A Case Study on SWM System of Dhaka Metropolitan City", M.Sc. Thesis, Department of Civil Engineering, BUET, 2002, p. 5.

³³ WB & Bangladesh Center for Advance Studies, *Bangladesh 2020* (Dhaka: UPL, 1999), pp. 42-44.

³⁴ Md. Mujibur Rahman & M. Ashraf Ali, "Waste Management and Environmental Pollution in Bangladesh", *Bangladesh Environment 2000* (Dhaka : Bapa, 2000), pp. 425-434.

³⁵ *JICA, *Draft Final Report*, Volume 2, Chapter 2, p. 2.

Table 4.8
Solid Waste Generated from Business Sector

Business category	Number	Area (m ²)	Kg/place/day			Waste volume (t/d)
			Dry	Wet	Average	
Restaurant	2,283	--	24.0	23.6	23.8	54
Shop	56,967	--	0.9	0.8	0.9	51
Hotel	642	--	11.0	19.6	15.3	10
Office	52,831	--	2.4	5.6	4.0	211
Market*	26,550	457,367	0.907	1.313	1.110	509
Tannery	277					150
Other Industry	--	--				35
Medical Waste						15
Total Business/Commercial waste						1035

* (kg/ m²/day)

Source : JICA study report and other sources

As mentioned in the table 3.5 the amount of business waste is estimated 1,034 t/d in the study area. About 834 t/d out of 1,034 t/d is comes from business sectors such as markets, offices, hotels, commercial establishments and public units. Hence, the remaining 200 t/d is roughly considered to be from the industries. Out of them tannery waste is 150 ton per day,³⁶ the amount of other industries and clinical sources of solid waste accounts for 50 t/d in the study.

There are 277 tanneries in Bangladesh. Out of them 90% located in Hazaribagh, Dhaka. The tanneries produce 8.47 million liter of liquid waste and 98 t/d solid wastes everyday. The solid wastes of tanneries are tinny peaces of leather, excess fat, flesh and hair. Shaving and buffing dust come out when leather is shaved and buffed for smoothing. This solid waste piled up at the roadsides, in front of the tanneries. Later a portion is carried by DCC and a major part goes to low land and to the river Buriganga.³⁷ On the other hand, JICA study report stated that the total amount of tannery waste is 150 t/d. The amount mentioned by JICA seems to be more appropriate and take into account for this study.

³⁶ UNDP, HABITAT, "Approximate amount for industrial Waste" *Dhaka Metropolitan Development Planning: Waste Management Report*, (Dhaka: 1992), p. 18.

³⁷ Philip Gain & Shishir Moral eds., *Leather Industry: Environment Pollution & Mitigation Measures* (Dhaka: SHED, n.d.), pp. 11-26.

Out of 50 t/d the general clinical waste would be 15 t/d. This is based on generation rate of hospital wastes would be 7.2-22.8 t/d by multiplying total bed number (12,000) with common solid waste generation rate 1.2 kg/bed/day. So average clinical waste production $(7.2 + 22.8)/2 = 15$ t/d. Out of this medical waste 1.5 t/d is hazardous waste.³⁸ However, another report stated that around 200 m/t of hospital waste are generated in the Dhaka city. About 20% of this garbage is infectious and hazardous. According to WHO approximately 85% of hospital wastes are non-hazardous, 10% are infectious, and 5% are non-infectious but hazardous. In USA 15%, Pakistan 20%, India 15 to 35% and Bangladesh it is 20% of the medical wastes is infectious and hazardous.³⁹ There is a big difference found among the clinical waste generation from different study results. The latest JICA study stated 15 t/d and Nasima Akter stated that according to Rahman and Ali (2000) a total of 255 tons of medical waste generated every day in Dhaka city.⁴⁰ The JICA study report seems to be more correct because it is based on the calculation per bed per day.

Street Waste⁴¹

In the Dhaka city there are almost 5,000 cleaners sweep the city roads and streets. During the survey, JICA study team found that on an average one sweeper sweeps 110 m of road length. Average volume of street waste is assumed at 365 kg/km of road length as the following table. Hence, the road length, which is swept by the 5000 cleaners in a day, is estimated to be 550 km and the amount of waste is estimated at 200 t/day (0.365 t/d $\times$ 550 km = 200.75 t/day).

Therefore, the total amount of solid waste produced in DCC area from different sources is 3,667 t/day. It is displayed in the following table.

³⁸ JICA, *Draft Final Report*, Vol. 1, Chapter 1, pp. 21-22.

³⁹ Nasima Akter, "Medical Waste Management : A Review", *Bangladesh Environment*, 2000, * p. 447

⁴⁰ Nasima Akter, *Scenario of Hospital Waste*, p. 675.

⁴¹ JICA, *Draft Final Report*, Vol. 2, chapter-2, p. 2.

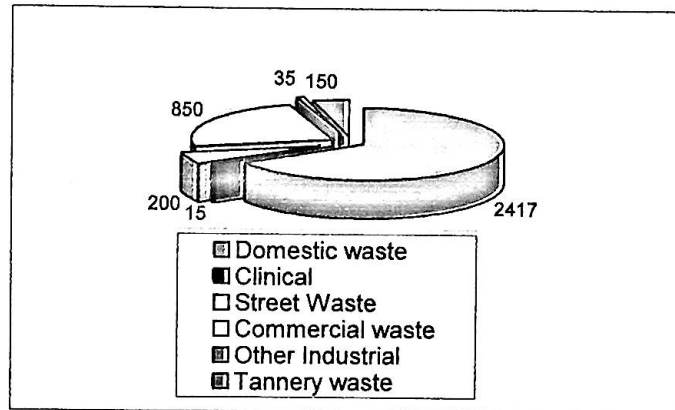
Table 4.9
Total solid waste generated in DCC area

Source	Amount (ton/day)	%
Domestic waste	2,417	65.92
Commercial waste (market, shops, restaurant, office & other institutions)	850	23.18
Tannery	150	4.10
Other Industrial	35	0.94
Clinical	15	0.41
Street waste	200	5.45
Total solid waste	3,667 t/d	100%

Source : Field Survey and JICA Study

To visualize the total solid waste generation of DCC area from different sources are shown the pie chart.

Figure 4.5
Solid waste generation from different sources (figure in metric ton)



According to the JICA study the total solid waste production is 3,200 t/d in DCC area⁴². The author calculate the domestic solid waste on the basis of field survey but the other sources of solid wastes is taken from the JICA study report. JICA study reports stated that the domestic waste is 1950 t/d, business waste 1050 and street wastes is 200 t/d and totaled 3200 t/d.

House hold solid waste generation in Dhaka and some other Asian cities are presented in the table 4.10

⁴² Ibid.

Table 4.10
Per capita solid waste generation of some Asian cities

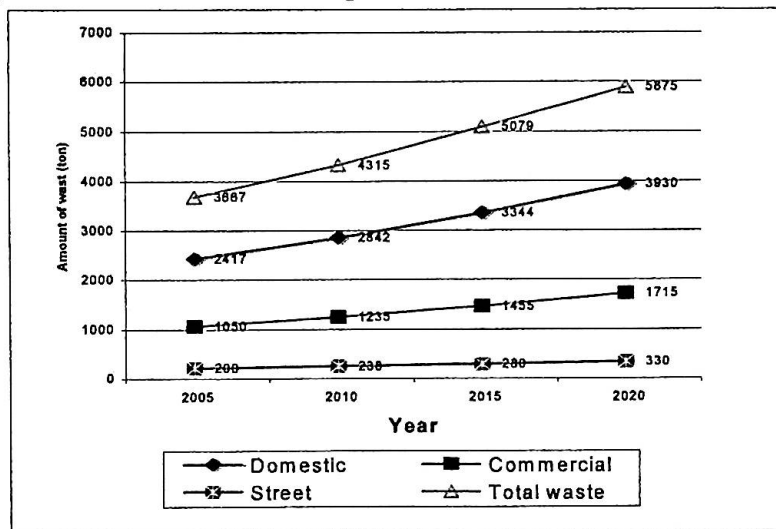
Status of the city	Waste generation rate (kg/cap/day)
Low income cities- Calcutta, Karachi	0.400-0.700
Middle income cities- Manila, Bangkok	0.500-1.00 "
High income cities- Tokyo, Singapore	0.800-1.50 "
Waste generation in Dhaka city	0.350-0.600 "

Source :

4.6.1 Trend of Solid Waste Generation

The study conducted by United Nations in 1995 shows that the per capita solid waste generation is 0.49 kg/c/day. JICA study team found that the per capita solid waste generation is 0.558 kg in 2004. The population of Dhaka city increase at a rate of 3.1% per year. The present study found that the solid waste generation is 0.422 kg/c/day. Therefore, the solid waste generation would be at least 3.1% more every year. With a 3.1% yearly increase of solid waste in the DCC area for the next 20 years trend is presented in the figure no. 4.6

Figure 4.6
Projected trend of solid waste generation in DCC for the next 20 years



Source : Author's computation

4.7 Characteristics and Composition of Solid Waste of Dhaka City

The solid waste generated in the Dhaka city is mostly composed of domestic waste. Almost 66 percent covers the domestic waste, 23 percent commercial and other waste cover only 11 percent.

Household Solid Waste Composition

Major compositions of solid waste are paper, vegetable, food items, wood, glass & metal, plastics, dust-sand and others. The highest quantity is vegetable residues (more than 29%) followed by food items (more than 23%) and paper and plastics (about 21%). The food and vegetable together covers almost 53% of total waste. The physical characteristics and composition of solid waste in Dhaka is elucidated in the table 4.11. From the table 4.11 it is also found that the total composition is different after mixing the domestic waste with other wastes.

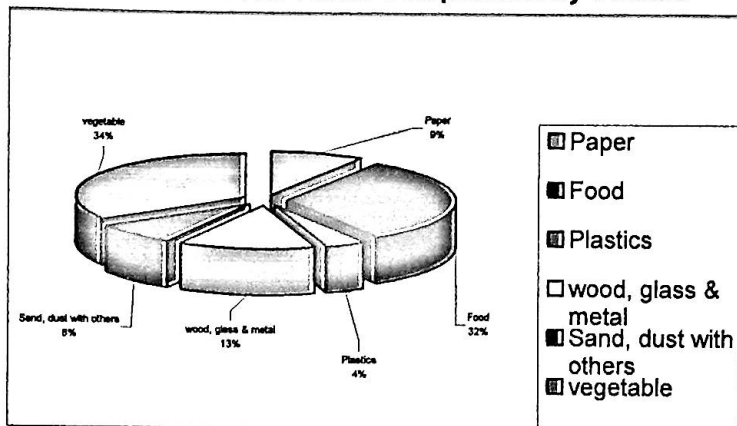
Table 4.11
Solid waste composition of Dhaka city

Source	Category	Composition (%) by volume					
	Monthly income (Tk.)	Paper	Vegetable	Food items	Wood, glass metal	Plastics	Dust, sand & others
House hold waste by income	Income up to 3000	5	39	24	18	5	11
	3,000 to 7,000	5	43	25	14	6	7
	7,000 to 15,000	9	36	27	10	8	10
	15,000 to 25,000	11	28	41	7	2	11
	More than 25,000	13	22	46	6	1	12
	Average	9	34	32	13	4	8
Business waste	Restaurant	2	47	45	3	2	1
	Shop, hotel	26	28	24	5	12	5
	Market	10	40	15	21	6	8
	Public facility	35	13	17	25	3	7
Street waste		6	13	9	14	8	51
Weighted average composition		14.67	29.17	23.5	13.5	5.83	13.33

Source : Field survey, 2004

To visualize the composition of household solid waste of Dhaka city is presented in the figure 4.7.

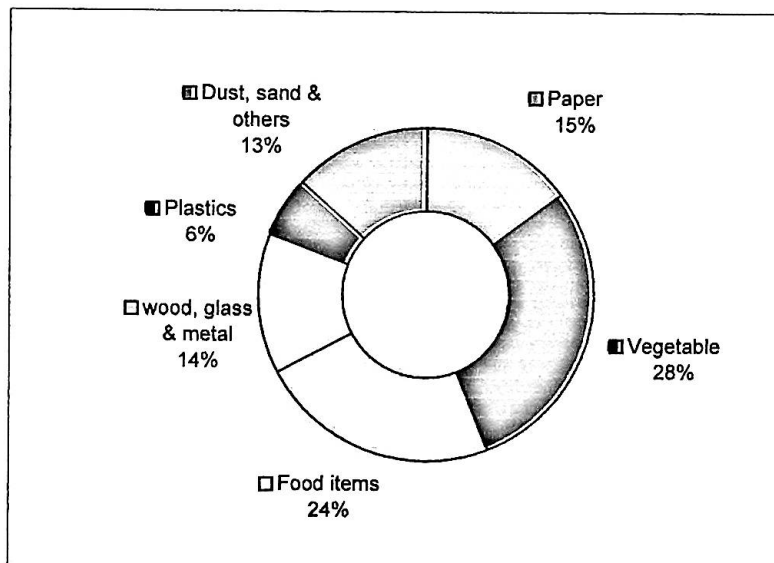
Figure 4.7
Household Solid Waste Composition by Volume



Source : Field Survey

The composition of total waste is little bit different from the household waste. The household, commercial and street waste together changed the composition of the solid waste.

Figure 4.8
Percentage of weighted average solid waste composition



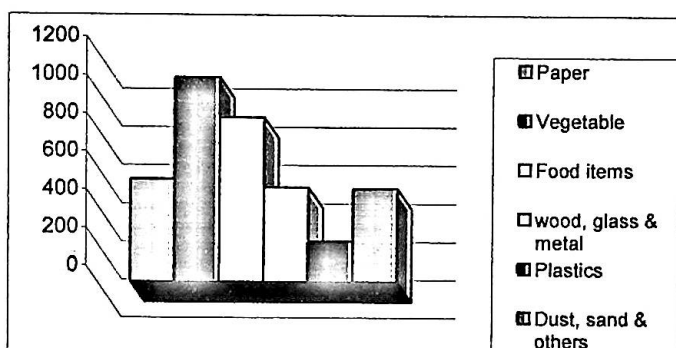
The total solid waste composition, in respect of volume is shown in table No 4.12.

Table 4.12
Total solid waste composition

Types of wastes	Total amount (in ton)	Percentage
Paper	538	15
Vegetable	1070	28
Food items	861	24
Wood, glass & metal	495	14
Plastics	214	6
Dust, sand & others	489	13
Total (t/d)	3667	100

The figure 4.9 shows the component wise total amount of solid wasted generated in DCC area. It is clear from the figure that vegetable waste and food waste are two major sources of total solid waste. Both of the items are organic in nature and easy compostable. Another source is garden trimmings and leaves of trees etc at least will come to organic group. Therefore, total organic waste would be at least 57% of total solid waste.

Figure 4.9
Total composition of solid waste of Dhaka City



Density of Solid Waste

Density is the compactness of things or solid mass of certain materials. Generally density is calculated by weight per cubic meter. Density is two types: low initial or bulk density and ultimate density. The low initial or bulk density is the initial condition of solid waste as it comes to the dumpsite. It is the poor compaction characteristics of solid wastes have been found to limit carrying capacity and thus have been contributing to the high cost of collection and hauling. The bulk density of the solid waste has been appreciably lower than the ultimate density of its components.⁴³ Solid waste density

⁴³ Tribedi, Encyclopedia, p. 26.

calculation is important for selecting collection vehicles and disposal system. Compaction increases the density primarily by reducing irregularity of solid waste. In most cases, shredding and other size reduction measures also increase density by reducing haphazardness.⁴⁴

Ultimate density is the final density after having some processing operation say shredding or bailing. Heavy compaction increases ultimate density of solid waste. In some instance, there is a light difference between bulk and ultimate density. Density depends on nature of the items.

The apparent bulk density of Dhaka City's solid waste⁴⁵ ranges from 0.1 to 0.2 t/m³ for domestic waste and 0.1 to 0.6 t/m³ for business with other waste throughout the year. The average apparent bulk density is 0.24 t/m³.

Moisture Content and Calorific Value⁴⁶

The moisture content of the solid waste of Dhaka city ranges from 65% to 80% for the mixture of waste on average. More moisture content tends to low combustion possibility. The most fundamental combustion property has been probably the heat content or heating value. Solid waste with low moisture content naturally has higher heating value (HHV) expressed in Btu/lb. The HHV may be defined as the heat released from the complete combustion of the material in question starting at 20°C and ending with all products at 20°C. Based on the value of the moisture contents, the calorific value is calculated at 550 to 850 kcl/kg. This value indicates that the average waste in Dhaka does not sustain combustion without support of auxiliary fuel. The self-combustion requires minimum 1,200 kcl/kg of Hu. For power generation the applicable technology is combustion and it requires at least 1,500 kcl/kg of Hu.

4.8 Solid Waste Management Function of Dhaka City

Solid waste management is the combination of some functions or activities. From source of generation to final disposal, several processes have to complete. Solid waste management functions are primary collection, secondary collection or transportation, processing, treatment and disposal.

⁴⁴ S.C Bhatia, Handbook of Pollution, p. 175.

⁴⁵ JICA, *Draft Final Report*, Vol. 2, chapter2, p. 5.

⁴⁶ JICA, *Draft*, Vol. 2, chapter-2, p. 6; Tribedi, Encyclopedia, p. 33.

4.9 Collection and Transport Operation

According to the DCC publication it has only 145 km² and JICA stated that DCC has its jurisdiction is only 131 sq. km⁴⁷. The whole city area is under 90 Wards divided into 10 Zones for administrative purpose. DCC provides the solid waste collection and transportation services all over the city. DCC's overall cleansing operation is carried out by conservancy department with the help of other three departments. These are:

- Conservancy department;
- Transport department;
- Mechanical division of Engineering department; and
- Urban planning department.

Conservancy department plays the primarily role for this cleansing operation through 10 zonal office deploying approximately 7,160 employees (including sweepers) with one conservancy inspector in each ward. The cleansing functions include street sweeping, cleaning drains, cleaning around the solid waste discharge stations, and instruments etc.

4.9.1 Primary Collection

It is the responsibilities of the waste generators to carry the waste to the dustbins or receptacles. Household waste can be carried by the householder's him/herself from house to the dustbins or some body else. According to the section 78 of the ordinance, DCC is allowed to provide the dustbins or receptacles to suitable place and it is the responsibilities of the waste generators to carry their waste to the dustbins or receptacles. DCC will dispose the waste from this dustbins or receptacles (transfer stations) for final disposal.

Dhaka City Corporation does not do primary collection. The primary collection services are provided by private sectors including the waste generators, NGOs, CBOs and or private companies. Where there are no private collection service peoples themselves carry the garbage to the dustbin or waste container. In some cases DCC cleansing workers carry garbage from house to the waste depot on payment by the waste generator. The area of Uttara-Gulshan, Zone 9 and 10 of DCC, has been privatized and collected by the contractors.

General information about primary collection

Primary Collection is carrying the garbage from household, offices, commercial organizations, industries or any other source of generation to the transfer stations i.e

⁴⁷ JICA, *Draft Final Report*, Vol. 1, chapter-2, p. 2.

dustbins, receptacles, roadsides or any other places from where the secondary collection started. Before primary collection, garbage is used to store in a particular place and somebody has to carry to secondary collection point. The study found that in Friday household garbage production is almost two times than other days of the week. Some general information about the primary collection stated in the table no 4.13

Table 4.13
General information about primary collection

Subject							
Garbage deposit place	Kitchen	Barandah	Store room	NPP*	No deposit	Others	
Percentage	56.8	10.7	5.9	15.4	6.5	4.7	
Container used at household	Jhury**	Bucket	Poly bag	Closed drum	Particular spot	NPC***	Others
Percentage	31.4	33.7	13.8	7.3	5.8	6.6	2.4
At what time waste send out for disposal	At dawn	Morning (8-11)	At noon	After-noon	Evening	At night	NPT*
Percentage	1.3	4.1	13.5	12.2	16.2	5.4	47.3
Who dispose from home	Male servant	Maid servant	Guard	Driver	Gardener	Respondent	Others
Percentage	18.8	29.7	5.7	3.6	9.5	13.5	19.2
Place of disposal	Particular Bins	Road side spot	Demount Container	Ditch, drain etc	Throwing away	Others	
Percentage	26.2	21.91	19.50	18.60	8.70	5.09	
Distance of dis. Place	Adjacent home	Near the home	Little bit away	Not known	No place in the area	Others	
Percentage	57.3	23.7	9.4	2.0	6.5	1.1	

* NPP= No particular place

** Jhury refers to the plastic made local container usually used for containing any sorts of articles/refuse/products etc.

*** No particular container

Source : Field survey

The study revealed that almost 57 % of the household respondent deposit their household trash in kitchen and 7% do not store their garbage in a particular place. It means that they used to throw the garbage here and there. The study finds that 31%

household respondents deposit their garbage in Jhury, 34% in bucket, 14 % poly bag. It is clear that the use of poly bag has not stopped in Dhaka city and this poly bag goes to waste dumps that creates environmental problem. 14% respondents send the trash at noon, 12% at afternoon, 16% at evening 5% at night and 47% do not have any particular time. 19% male servant, 30% female servant and 14% respondent himself carry the garbage from house to the dustbins. 26% disposed at the bins, 22% roadside, 20% demountable container, 19 ditch and drains and 9% throw away.

4.9.2 Community Based Initiatives in Primary Collection

Initially door-to-door primary waste collection was introduced in Kalabagan in 1987. Afterwards there are lots of Community Based organizations, NGOs, and private initiatives started this program. Almost 150 organizations collecting the garbage from households, commercial institutions and they are taking some charge for this service. As up to January 2005, there are 82 private sector groups (**List of the Groups are in Annexure A**) provides primary collection services in different parts of Dhaka but they covers 51% of total area. In some cases, even getting permission from DCC, the private groups could not start primary collection due to conflict among existing groups and some other financial reasons. Recently DCC introduced letter of permission for community services for primary collection. They use rickshaw van, handcart for collecting the garbage from door to door and dispose in the nearest bins, containers or roadside. Bangladesh Integrated Environmental Development Forum, an NGO coordinating the 35 NGOs door- to-door collection, in the area of Uttara and Gulshan Model town. The following table shows the general information such as area covered, collection fee etc; of primary collection by CBOs.

Table 4.14
Respondent's Response on Community Based Collection Information

Community Based /NGOs or local initiatives	Area covered (%)	Collection fee of CBO (Tk)	Fee justified		What should be justifiable amount (Tk)	CBO should cover all over the area (%)		
			Yes	No		Yes	No	No comments
Old Dhaka	62	10-25	60	40	20	86	11	3
Area under plan	49	20-50	75	25	25	91	4	5
Mixed ext. area	44	15-30	80	20	25	84	12	4
Slum (basti)	4	0	0	0	0	12	80	8
Model town	97	75-200	55	45	50-100	96	3	1
Total	51%							

Source : Field Survey

It is revealed from the study that 62% of old Dhaka, 49% of area under plan region and 44% of mixed extended area is covered by CBO based primary collection. There are no local initiatives of primary collection in the slum area. The Uttara and Gulshan area is almost entirely covered by CBO. The table indicates that the collection fee in other than Model town is reasonable. The average charge or fee for door-to-door collection is Tk. 10-25 for old Dhaka, Tk. 20-50 for area under plan and Tk. 75-200 for Model town. Majority respondents of old Dhaka, Planed area and mixed-extended area replied that the charge is justifiable. However, around half of respondents of Model town opined that the charge should be limited to Tk. 50–100 according to income. The respondents were asked that who fixed the rate of the fee or charge for door-to-door collection. In reply to that question, only 24 percent replied that the charge fixed with discussing the locality, but 76 percent told that the charge fixed the CBOs alone. On the other hand, 52% of CBOs employees answered that it was fixed by the CBO, 28% said local commissioner and others replied not known.

Door-to-Door Collection Time

A total of 3% household respondent said that door to door garbage collection by CBOs/NGOs at dawn, 10% at morning, 71% at noon 4% afternoon and 11% said there is no particular time. In reply to the question of proper time of door-to- collection 8% said at dawn, 34% at noon, 52% at afternoon and 6% said at evening. The figure D.1 of Appendix D (a photograph) is showing the community basis primary collection.

Entrepreneur of CBOs

33% of the CBO representative respondents said that the principal entrepreneur is local commissioner, 14% said local political leaders, 23% said social worker, 24% said coordinated initiatives. Therefore, it is clearly revealed that solid waste collection does not directly operated by the local community. The people's participation is very weak in community organization. Virtually it is only community-based organization in the name.

Revenue Collection and Expenditure of CBO

Only 2% of the CBO representative respondents said that they collect hundred percent fees, 70% CBO collect 90% revenue, 15% collect 80% revenue and 13% said that they collect revenue only 70% from household. 57% CBOs respondent said their revenues collected from households is deposited to the CBOs fund, 24% said their

collected revenue is taken by owner, 10% said they do not know and 9% CBOs said that a portion of revenue is to give DCC staff. The expenditure bear from CBOs own fund said 43%, owners pay said 33%, 10% respondent said that owners pay first and now it is maintained by the earned revenue.

Social Cooperation and Attitude

15% of the household respondents are highly satisfied with the community based (CB) door-to-door collection, 30% are satisfied, 36% opinion is average, 17% are not satisfied and 12% are fully dissatisfied. 5% of the household respondents mentioned that the cleanliness of the locality is very nice for Community Based garbage collection, 42% said nice, 42% replied average, 7% said not good and 2% said extremely bad. There was a question that CBO service has benefited the city dwellers and in reply to that question 7% said it has benefited the people, 59% said that it is a good initiative, 28% said that DCC could do this function and 7% said that CBO operation has made the people in trouble.

21% of the CBO representative respondents replied that people's cooperation is extraordinary, 33% said very nice, 18% said nice and 15% said average and 13% said that the peoples are non-cooperative. In reply to a question that CBOs are charging high and they are collecting by force, 19% CBO representative respondents said that they collect fixed charges, 52% said no pressure or force, 10% said somebody don't want to pay, 19% said that rate is very reasonable and peoples are very cooperative to pay fee. Another question was asked the CBO representative respondents that CBOs service is good business or not. 23% replied that it is a good business, 10% said business and social welfare, 43% only social welfare and 14% said that it is the need of age.

4.9.3 CBO and DCC

It is already stated that CBO service is increasing in door-to-door primary collection in Dhaka city and DCC is issuing letter of permission. There was a common question to all respondent groups that what should be the role of DCC if CBOs are charging high for primary collection. The answer is presented in the table no 4.15

Table 4.15
Respondent's Responses about the role of DCC in controlling CBOs

Respondent groups	DCC should fixed the rate	Cancelled permission	Provide punishment	CBO selection on competition	Others
Household Respondent	28	16	19	29	8
DCC employees	7	17	46	24	6
Business sector	23	11	23	38	5
CBO representative	2	13	21	37	27
Waste pickers	20	32	25	21	2
Scholars & experts	9	13	15	58	5
Weighted average					

Source : Field Survey

From the above table it is clear that if the rate is high then there should be some alternative arrangement suggested by the respondent. In most cases, the respondents opined that CBO should be select on the basis of competition.

CBO Operation all Over Dhaka City

There was a common question to all respondents that whether community based primary collection should be all over Dhaka.

Table 4.16
Respondent's responses about CBOs based primary collection all over the city

Respondent groups	Yes	No	No comments
Household Respondents	71%	14	15
DCC employees	33	61	6
Business sector	74	24	2
CBO representative	89	7	4
Waste pickers	27	61	12
Scholars & experts	86	14	0

Source : Field Survey

From the above table it is clear that all the respondents other than the DCC employees opined that CBO based primary collection should be introduce all over the

city. In reply to a question of why the DCC employees do not support the privatization of conservancy service, 16% said in fear of jobless, 17% said no confidence on private sector, 27% said DCC activity will lessen, 27% said that DCC's image will hamper, 9% said corruption opportunity will stop and only 4% said different answer.

Case Study Results

In the month of August, 2004, the case study has completed by the author himself. It was studied through observation that how the solid waste disposed in household level. The author observed the daily solid waste disposal process of one household for seven days in Eskaton Garden area. The household is a business person with average monthly income about Tk. 25,000 equivalent to \$ 400. The family member is 6.

Amount and nature of waste: It was found that the amount of garbage disposed were 2.9kg, 3.9kg, 3.6 kg, 4.1kg, 3.8kg, 2.2kg and 5.2kg. The total amount of waste generated in the family in a week was 25.7 kg. The daily average waste generation was 3.671 kg in the family and per person per day waste generation was 0.62 kg. It was found that at Friday it was highest and at Thursday it was the lowest. Most of the wastes are vegetables and food items. Vegetable, food residue, paper, can or paper packet, cardboard etc were main items. At Friday, about 1.5 kg of fish and meat residue found into the waste amount. Almost 70% of the total wastes were organic and wet in nature.

Time and manner of disposal: It was observed that waste disposed from home take place in different time. It was 3.00 pm at Saturday, 3.50 pm at Sunday, 5.30 at Monday, 3.00 pm at Wednesday, 6.30 pm at Thursday and 2.30 pm at Friday. Almost everyday it was disposed by the maid servant expect Monday. At Monday it was disposed by the driver of the car because at that time the maid servant was absent. It is observed that the maid servant dispose the refuse into the demountable container nicely 5 days but one day she through it from little distance. On the other hand the driver through the bucket from long distance and maximum refuse scattered around the bins. The bucket was very unclean.

Container used and Place of disposal: For carrying the waste from the house hold they used the Plastic bucket. The place of disposal is a demountable container placed near the house. The maid servant placed the garbage into the container it was observed that she was habituated of garbage disposal. But the bucket was dirty and unclean. The overall situation in and around the container was so unclean and dirty.

Results: It was found that the average waste generation per person per day in Dhaka is about 0.422 kg but in the case study family it is 0.611. According to the income it is almost equal to the high income group of the city dwellers. It is also found that all the garbage came to the bins together. No waste is segregated before disposal. It was asked the maid servant that the household guardians never monitor the garbage disposal. Every body is very much reluctant the garbage disposal.

4.9.4 Secondary Collection or Transportation

Primary collection ends and secondary collection starts from the transfer stations. According to article 78 of the DCC ordinance, it is the duty of DCC to secondary collection and cleansing operation of roads and drains. Collection from concrete made dustbins, steel made demountable containers, and temporary discharging places at road sides and open places in the city to the final disposal site is the secondary collection. Virtually it is the transportation function. Secondary collection or transportation operation is carried out by DCC for Zone 1 to Zone 8. Zone 9 and a part of Zone 10 (Ward 1, Ward 17 to 21, Ward 37 & 38 a total of 8 Wards) were privatized for both of the service of cleansing and transportation of waste from waste depots to the disposal site through the annual contract with the total payment of 37.4 million Taka by DCC.⁴⁸

Secondary Collection/Transportation Time

Collection and transportation operation is carried out everyday for one shift. Day shift is carried out in most of the city area and night shift is carried out in the busy traffic area of Old Dhaka. People can discharge the garbage at any time to the dustbins, waste depots and other places. The present time and suggested suitable time for secondary collection replied by the respondents are shown in table 4.17 and 4.18.

Table 4.17
Respondent's responses about present time schedule for secondary collection (%)

Respondent groups	Early morning	Morning (7-11am)	At noon	Afternoon	Evening	At night	NPP	Not known
Household Respon.	12	53	9	4	0	1	6	5
DCC employees	15	36	11	2	2	16	16	2
Business sector	12	37	24	11	0	11	5	10
CBO representative	11	22	43	14	5	2	3	0
Waste pickers	8	41	14	9	5	7	14	6
Scholars & experts	6	39	12	0	0	21	8	14
Weighted average								

Source : Field Survey

From the above table it is clear that DCC collects the garbage mainly at morning (in between 7 to 11 am). While it is found that most of the respondents desire that secondary collection should be done either early in the morning or only at night.

⁴⁸ JICA, Progress Report, March 2004, chapter 1, pp. 4 -5.

Table 4.18
Respondent's responses about suitable time of secondary collection (%)

Respondent groups	Very Early morning	Morning (7-11am)	At noon	Afternoon	Evening	Only at night	No comments
Household Respon.	38	13	4	2	7	32	4
DCC employees	48	20	0	0	5	23	4
Business sector	23	19	11		0	35	12
CBO representative	23	11	4	6	13	41	2
Waste pickers	8	21	32	15	3	18	3
Scholars & experts	47	12	0	0	0	31	10
Weighted average							

Source : Field Survey

Common Information of Secondary Collection

There was some common information (respondent's responses) about the secondary collection and presented in table no 4.19

Table 4.19
Information (respondent's responses) on Secondary Collection (%)

Subject						
Vehicle used for SC	Animal Cart	Open Truck	Covered Van/ Truck	Container Trailer	Demountable container	Others
Percentage	12	41	11	17	16	3
Labor force expertise	Very efficient	Efficient	Average	Inefficient	Extreme inefficient	
Percentage	3	27	30	35	5	
Attitude of cons. employees	Very positive	Positive	Average	Below Average	Negative attitude	
Percentage	11	20	28	34	7	
Technological capacity	Very good	Good	Average	Not good	Below quality	No comments
Percentage	11	23	32	14	12	8
Infrastructure facility	Very good	Good	Average	Poor condition	Very poor condition	
Percentage	6	10	42	36	6	
Evaluation of DCC's SC	Very good	Good	Average	Bad	Very bad	
Percentage	8	25	36	23	6	12

Source : Field Survey

From the above table it is clear that DCC still transport 41% of garbage with open truck. The respondent replied that the 30% conservancy staffs are efficient and 65% replied that they are inefficient. 31% replied that the attitude of the conservancy staffs are positive and 28% said average and more than 40% has below average attitude. 34% respondent said that the technological facility of DCC is good, 32 said average and rest opined that it is below standard or bad quality. The infrastructure (say bins, demountable container, excavator, compotator etc) facility is very good/good, said only 16%, 42% said it is average and rest of the respondent replied that it is poor condition. The total evaluation of the DCC's secondary collection is very good/good said 33%, 36% said average and 31% respondents opined that secondary collection is not satisfactory or very bad. Figure D. 2 of Appendix (a photograph of secondary collection) is showing the efficiency of secondary collection.

Cleanliness Operation by DCC Staff

The City Corporation cleaners and other conservancy workers do not clean or collect the garbage very neatly. The reasons are identified and remedies suggested by the respondents are presented in table 4.20 as follows.

Table 4.20
Respondents opinion (in percentage) about causes and remedies for improper cleanliness activities

Causes identified	%	Remedy suggested	%
No accountability	36.7	St. monitoring/ supervision	31.5
No supervision	20.7	Ensuring accountability	13.3
No risk of loosing job	16.6	Departmental action	13.5
Less salary	2.4	Dismissal from the service	10.4
Nature is like that	7.7	More salary	13.5
No motivation	6.5	Training	12.4
Collect very nicely	6.5	Others	5.4
Others	2.9		

Source : Field Survey

On the other hand, the DCC employees mentioned that secondary collection could not effectively done because of improper handling of the refuse by the generators. Primary collection should be in proper manner for successful secondary collection. Efficient SWM need timely disposal of refuse into the bins. The opinion of the different respondent groups about the way of disposal followed by the generators is shown in table 4.21.

Table 4.21
Respondents opinion (in %) about generators way of solid waste disposal

Timely & right disposal	Household	Employees	Business	CBO representative	Waste pickers	Average
Drop into the bins rightly	21	8	19	13	24	
Drop near the bins	26	35	25	33	19	
Thrown away from distant	14	30	17	19	28	
Don't follow any rule	17	18	23	27	17	
Not known	22	8	16	8	12	

Source : Field Survey

4.9.5 Peoples Behavior of Garbage Disposal

The study found that most of the respondents opined that 20 to 35 % generators drop the garbage near the bins and 15% to 25% throw the garbage from away. The people throw the waste here and there. The reasons identified and remedies suggested by the respondents mentioned in table no 4.22

Table 4.22
Respondents responses (in %) about causes and remedies for throwing waste here and there

Causes of throwing here & there	%	Action/remedy suggested	%
Unconscious about environment	32.6	Drastic law enforcement	34.9
Lack of education	11.2	Publicity for awareness	22.5
Lack of monitoring by authority	16.0	Model training program	32.5
No punishment for wrong doing	21.3	Mobile court operation	8.3
Inherent nature of the people	14.2	Others	1.2
Others	4.7		

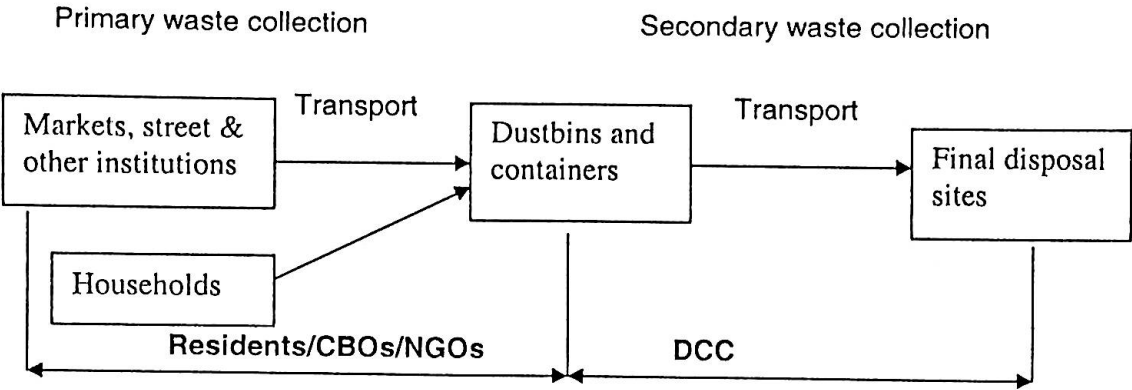
Source : Field Survey

About 33% of the respondent replied that people throw garbage here and there for unconsciousness about environment, 11% said lack of education, and 21% said that no punishment of wrongdoing, 14% said it is the bad habit or practice of the people. About 35% opined that drastic law enforcement is necessary to stop throwing here and there, 23% said publicity for awareness, and 33% said model-training program should be introduced.

DCC's secondary collection includes garbage transportation from transfer points, roads and drains cleansing operation. DCC collects Zone 1 to 4, all of garbage is transported to Matuail landfill site while Zone 5 to 9 use both Matuail and Berri Band

landfill site. Waste from Zone 10 is transported to Uttara site. The primary and secondary collection of waste is shown in figure 4.10

Figure 4.10
Primary and Secondary Collection



4.9.6 Solid Waste Amount Transported to Disposal Site

DCC's secondary transportation virtually limits collection garbage from different points to the final disposal site. Officially one and unofficially 2 dumpsite is used for dumping. The amount of garbage is transported to these sites ranges 970 t/d in dry season and 1420 t/d in wet seasons. The maximum capacity of secondary collection by DCC and private sector (for Zone 9 & 10) are assumed at 1,400 t/d as surveyed by JICA study team. The amount assumed on the basis of weight carrying by the vehicles with full of garbage coming to the landfill. The capacity reflects the amount and quality of human and material resources as well as traffic condition to the dumpsites across the city.

In the rainy season, the amount and weight of the garbage's usually increases. For easy handling, the number and trip of sold wastes transporting vehicles are to be increased. It is found from the study that collection and transport vehicles increases from 350 to 525 trips in wet season. The increase ratio of numbers of trips in wet season is exactly 150%. The number of vehicles transported solid waste to different disposal sites are shown in table no 4.23.

Table 4.23
Number of DCC's vehicles and amount of solid waste carried to different landfill sites in March 2004

Survey time	Matuail site		Berri bandh site		Uttara site		Total	
Dry / wet season	Waste amount carried (t/d)	No of incoming vehicle (unit/d)	Waste amount carried (t/d)	No of incoming vehicle (unit/d)	Waste amount carried (t/d)	No of incoming vehicle (unit/d)	Waste amount carried (t/d)	No of incoming vehicle (unit/d)
Dry	649	226	313	122	6	2	969	350
Wet	913	338	399	153	104	33	1,416	525
Average	781	282	356	138	55	18	1,193	437
Percentage	65%	65%	30%	31%	5%	4%	100%	100%

Source : JICA study draft final report

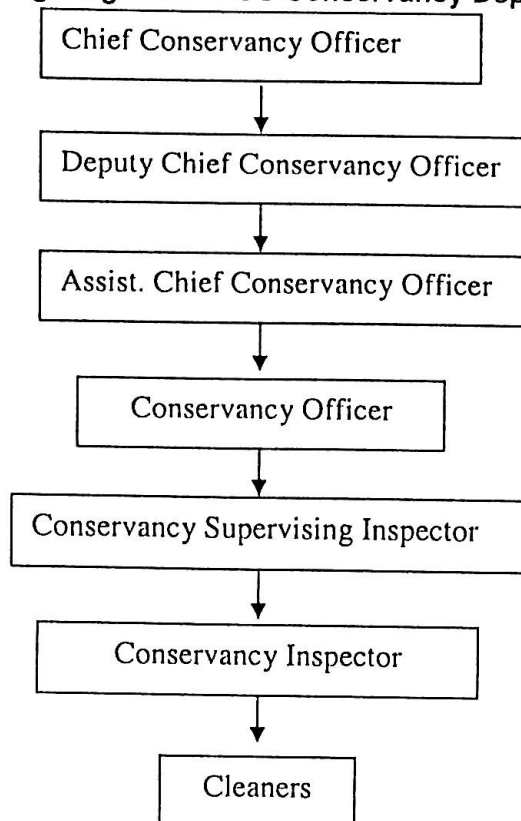
The above table shows that incoming waste to disposal site varies from 970 to 1420 t/d as the maximum level of capacity. On an average 1200 t/d solid waste is coming into the landfill sites. Matuail accounts for 65%, Berri band site for 30% and Uttara site for 5% collected waste disposed.⁴⁹ Therefore, it is clear that DCC is disposing only about 32 % of total generated solid waste in Dhaka City.

4.9.7 Conservancy Operation Management of DCC

The Dhaka City Corporation conservancy operation is managed by the conservancy department headed by Chief Conservancy Officer (CCO). It is dominated by the field workers. The conservancy pool of transport department is in charge of transportation of waste from dustbins/containers to disposal site. To coordinate the conservancy function, recently the manager of conservancy pool has been temporarily placed under the CCO, the head of the conservancy department. Engineering department is involved for repair of transport vehicles and heavy equipments. Major repair works done through the private operators on contract. Store and purchase department procures the conservancy appliances such as cleaner's brooms, handcarts, baskets, aprons etc., and spare parts for vehicles. The organizational structure of conservancy department is shown in figure 4.11

⁴⁹ JICA Study Draft Final Report, Vol. 2, chapter-2, p. 22.

Figure 4.11
Organogram of DCC Conservancy Department



4.9.8 Human Resources in Solid Waste Management

Solid waste management is the integrated function of some departments. Conservancy department, transport department and mechanical division are jointly related to the solid waste management. Among them most of the personnel are the field staff. An important number of officer and staffs are working in the head office, zones, workshop and local office.

Table 4.24
Total officer-staff in the head office and other related department of DCC

Name of the office	Officer and staff	Remarks
Conservancy office	84	Field worker 7276 + officer and staff 374) = 7650
Transport department	250	
Mechanical division	44	
Total	374	
All officer, staff and workers of the conservancy, transport and mechanical division.		7,650

Source : DCC Conservancy Department

A critical factor in the evaluation of alternative systems of solid waste management and the establishment of efficient organization is the quality management. It is necessary to deploy a complete set of technical skills, which derive from several professional disciplines. These include civil, mechanical and chemical engineers, transport organizers, land use planners and economists. Thus, solid waste management is a teamwork, and whatever the original discipline of the top managers, is prime qualification should be his specialized background in this field. A second requirement, no less important, is skilled "man-management", the purpose of which is to obtain high productivity from a contented staff at all levels. It is usual for a city to employ between two to five workers for each 1000 population. Transport is required on a scale of about 1 heavy vehicle for 15,000 population. Efficiency of systems and high labor productivity, therefore, are of vital importance.⁵⁰ In Dhaka city there is one cleaners per 760 populations is working.

Hence, unskilled labour force is used to sweep streets and collect garbage. Though labour is cheap, with a low productivity, the costs are high. It is estimated that India spends four times as much on sweeping as on refuse collection. Poor motivation of workers, inadequacy of supervising and management skills at local levels are other leading causes of low productivity. The cost of collection in India tends to be a very large part of overall solid waste budget.⁵¹

4.9.9 Cleansing Staff Salary

There are two types of cleaners in conservancy department. One is temporary and another is permanent job. Permanent cleaners are hired ranges from Tk. 2,500 –3,000 per month with other allowances. Most of the cleaners have second job. After finishing jobs as DCC cleaners, they work as rickshaw pullers or street hawkers to sell cigarette, candy, tea stall etc. Income of DCC cleaners is around Tk. 5,000- 7000 if they have second jobs. These categories of DCC cleaners are finally better off than other workers, particularly private cleaners.⁵²

DCC has employed lot of cleaners and sweepers temporary basis on 'no work no pay basis'. Because of status problems many cleaners prefer to working in the office as bearer instead of cleaning roads. These people put pressure on the conservancy budget with no contribution in cleaning the city. The supervision system is very weak in DCC's

⁵⁰ Trivedi, Encyclopedia of Environmental, Vol. 25, p. 738.

⁵¹ Jain, Waste Management in India, Plckford, Affordable Water Supply, p. 93.

⁵² JICA, *Draft Final Report*, Vol. 2, chapter-2, p. 26.

conservancy system. The ratio of supervisory official and field level workers is 3:100 and it is not practicable.⁵³

The cleansing staff deserves 40% health hazards wage enhancement, which sanitary engineers and staffs (waste water projects) receive in the governorate of Dahleya, Egypt. The operators/workers accept the cleansing job only because of job security and pension. Only those with no other option in life has come this profession in a physically taxing job i.e. accepting like a health hazardous life.⁵⁴ Therefore, it is desiring that cleansing staff should get more salary/wage for risky job.

The total strength of DCC's employees i.e. waste cleaner, collection and transportation workers are shown in table 4.25

Table 4.25
Categories strength of DCC's Employee

Workers Category	Assignment	Number	Total
DCC worker			
Road cleaner	Ward	5,003	6,992 (6,880 cleaners are deployed to Zones and Wards and the rest are reserved for emergency deployment for special requirement)
Deep drain cleaner	Zone	284	
Storm sewage cleaner	Zone	119	
VIP road cleaner	Zone	178	
Market cleaner	Zone	425	
Other cleaner	Zone	19	
Truck cleaner	Ward	663	232
Special truck cleaner	Zone	189	
Container cleaner	Central	112	
Truck driver	Ward		
Container driver	Zone 9 & 10	232	578
Road cleaner		359	
Deep drain cleaner		86	
Truck cleaner		106	
Truck driver		27	

Source : JICA study draft final Report

4.9.10 Deployments of Cleaners by Zone

There is no specific guideline for deployment of cleaners to different area of DCC. Conservancy department provide deployment of the cleaners on the basis of importance of the locality and requirements of the Ward Commissioner. Therefore, deployments of cleaners are not proportionately distributed and hence more cost incurred in conservancy service. The deployment of cleaners of conservancy department is shown in the following table No. 4.26

⁵³ K. M Nurul Huda, Bangladesh Environment 2002, p. 738.

⁵⁴ <http://www.solidwaste.com>

Table 4.26
Distribution of Cleaners

Zone no	Road cleaner	Truck cleaner	Drain cleaner	Storm sewer cleaner	VIP road cleaner	Market cleaner	Special truck cleaner	Other cleaner	Total
1	781	70	30	13	8	32	58	0	992
2	681	65	25	25	0	78	8	0	882
3	565	71	32	12	4	15	8	0	707
4	832	129	44	17	40	49	18	0	1,129
5	633	121	48	13	50	97	40	10	1,012
6	586	141	25	39	36	132	18	0	977
7	460	33	40	0	20	7	19	9	588
8	465	33	40	0	20	15	20	0	593
9	294	79	62	0	0	0	0	0	445
10	65	27	24	0	0	0	0	0	116
Total DCC	5,003	663	284	119	178	425	189	19	6,880
Private sector in the Zone 9 and 10 has total 578									
Private	359	106	86	Total cleaners of private sectors in Zone 9 and 10					561
Grand Total	5,362	769	370	119	178	425	189	19	7,441

Source : JICA study draft final report

Due to privatization of secondary collection, the cleaners of Zone 9 and 10 (116+445)= 561 cleaners are not working in Zone 9 & 10 rather they are redistributed among other 8 zones or reserved. These 561 cleaners have not been sacked from the service.⁵⁵ The Zone wise distribution of cleaners, generation of wastes and amount collected shown in table no 4.27 to find out the productivity of the workforce.

Table 4.27
Comparative data of cleaners, waste generation and collection and population.

Symbol	A	B	C	D	E	F	G	H
Zone no	Cleaner assigned /d	Estimated waste /d	Total Waste collected	No of cleaners working	Excess/ shortage (A-D)	Population in the Zone	Population / cleaner (F/D)	Population/Cleaner 1=Average
1	992	346	103	667	325	622,986	628	0.88
2	882	356	156	1,011	-129	428,868	486	0.68
3	707	229	75	486	221	463,437	655	0.92
4	1,129	402	126	816	313	783,422	694	0.98
5	1,012	278	197	1,276	-264	480,803	475	0.67
6	977	325	175	1,134	-157	469,329	480	0.68
7	588	401	141	913	-325	681,478	1,159	1.63
8	593	457	89	577	16	739,749	1,247	1.76
9	445	363	0	0	0	546,476	1,228	1.73
10	116	43	0	0	0	65,537	565	0.80
Cleaner (1-8)	6,880	2,793	1,062	6,880	0	4,670,072	679	0.96
Grand total	6880					5,282,085	710	1.00

Source : JICA study team

⁵⁵ The Chief Conservancy Officer of DCC informed in verbal discussion with him that some of the cleaners, and other equipments are redistributed and some are kept reserved for emergency.

DCC cleaners as a whole collect 1,062 t/d solid waste by $(6,880 - 561) = 6,319$ cleaners that means they collect on average 168 kg solid waste per person per day. In Zone 9 & 10 a total of 138 t/d waste is transported to the disposal site. Therefore, each cleaner collects about 246 kg solid waste per day.⁵⁶ In Mansura city of Egypt, the total population 400,000 and cleansing staff is 511 full time and part time. Waste production is 336.5 t/d. The per capita collection is 658 kg per day. In Talkha district of Egypt total population 110,000 and SW 79 t/d and worker 138 with 572 kg solid waste per day.⁵⁷

From the data stated above, it is clear that conservancy cleaners are not distributed equally. The cleaners should be distributed either on the basis of population or total waste production in the Zone. Somewhere more workers are working and somewhere a shortage of workers. It indicates that cleaner's productivity is not efficiently utilized. Surplus cleaners of zone 1, 3, 4, & 8 should be further adjusted to other zones where the cleaners are less than the standard number. Of course, the landfill site and other situation of infrastructure in each zone in Dhaka city should also be considered. The ideal situation of cleaners deployment is shown in table 4.28

Table 4.28
Ideal situation of cleaners distribution

Zone	Estimated waste (t/d)	Ideal number of cleaners *	Actual working	Overused or underused
1	103	667	992	Surplus 326
2	156	1009	882	Shortage 127
3	75	486	707	Surplus 221
4	126	816	1129	Surplus 313
5	197	1276	1012	Shortage 264
6	175	1134	977	Shortage 127
7	141	915	588	Shortage 327
8	89	577	593	Surplus 16
Total		6880	6880	

Source : Computation by author

4.9.11 Collection and Transportation Vehicles

The transport department operates 358 units of conservancy (collection and transportation) vehicle including open trucks, container carriers and trailer trucks etc. Compactor is not used in DCC service. These vehicles are pooled at Saidabad Garage about 200 units, at Mirpur Garage about 60 units and the rest is pooled at Workshop-1 of Mechanical Division and about 110 units for repair and maintenance purpose. DCC owns 358 collection vehicles belong to the Transport department. The details of the vehicles are shown in table no 4.29

⁵⁶ 6,319 cleaners of DCC collects 10,62,000 kg solid waste per day and hence each cleaners collects 168 kg. As well as the 561 private cleaners collect 138000 kg solid waste per day and hence each cleaner collect 246 kg solid waste per day.

⁵⁷ <http://www.solidwaste.com>

Table 4.29
DCC's Transportation Vehicles

Type of collection vehicles	Belongs to	Number of units
Open truck	Transportation department	
Open truck 1.5 ton	Do	95
Open truck 3 ton	Do	99
Open truck 5 ton	Do	34
Total truck		228
Container Carrier	-	-
Container Carrier 3 ton (Volume 6m ³)	Do	93
Container Carrier 5 ton (Volume 12m ³)		34
Total Container Carrier		127
Trailer Truck 30 ton	Mechanical Div.-Eng. Dept	3
Total Collection and Transportation Vehicle		358

Source : DCC Mechanical division

At present seventy two percent of the total units are in service. In addition to the aforementioned numbers of unit, open dump trucks are provided by the Workshop-2 as required to cope with the increase of waste quantity. As of March 2004, five (5) units of open dump trucks are allocated for collection and transportation services. In addition to DCC vehicles, the four service providers operate 19 to 27 units of 5 ton trucks in eight wards of Zone 9 & 10.

Conservancy department allocates the collection vehicles for all over the 90 Wards in between 10 Zones. But due to privatization of Zone 9 and 10. There is no scientific analysis of allocating the vehicles. It is allocated on the past records and population on an average. In case of breakdown or disorder of the vehicles, the vehicles of neighboring Wards/Zones make backup. To avoid the second or third tip, the cleansing staff/ truck drivers filled the truck/container as so high than the sides of the truck/container, this results in much of the waste littering onto the streets while traveling to the disposal site.⁵⁸

Maintenance of the collection vehicle

Workshop-1 under Mechanical Division is responsible for repair and maintenance. Workshop-2 is responsible for operation and maintenance of heavy machine such as backhoe, bulldozer, etc. mostly used for road repair and construction work. There are 1 engineer, 2 assistant engineer, 7 sub-assistant engineer, 4 head mechanics and 23 mechanics in Workshop-1 for repair and maintenance work of vehicles. The transport department carries out light maintenance. At present about 120 units of vehicles are under maintenance as reported by the workshop engineer on March 2005.

⁵⁸ JICA Draft Final Report, vol. 2, Chapter-2, p. 17.

4.9.12 Number of Dustbin and Waste Container

There are neither regulations, by-laws/guidelines for installations of dustbins or other infrastructure facilities. Generally it is made on the requirements of the local commissioners. The total number of dustbin and waste container using for waste disposal have collected from different Zonal offices. Total number of storage facilities is 1,071 units, which include 688 units of dustbins, 260 units of 6m³ containers and 123 units of 12m³ containers as summarized in table 4.30. The total capacity of storage was estimated at approximately 1,720 tons.

Table 4.30
Number of dustbins and other containers

Zone	No of dustbins (units)	Total capacity of dustbins	No of containers in field (units)		Capacity of dustbins & containers	Conversion to weight of waste
	Unit	M ³	3 ton: 6 M ³	5 ton: 12 M ³	M ³	Ton
1	106	242	17	10	464	116
2	159	377	60	14	905	226
3	124	383	17	3	521	130
4	61	165	49	26	771	193
5	56	532	52	26	1,156	289
6	77	606	7	22	912	228
7	28	204	17	14	474	119
8	36	160	41	8	502	126
9	29	1,060	0	0	1,060	265
10	12	108	0	0	108	27
	688	3,837	260	123	6,873	1,718

Source : JICA Study draft Report

The above table indicates that in DCC area there is 688 dustbins with a capacity of 3,837 m³. A total of 260+123 = 383 containers covers area of 6,873 m³. All of the dustbins and containers can hold 1,718 ton solid waste. Whereas daily generation of solid waste is 3,667 ton. Therefore it is identical that almost 2000 tons of solid wastes are primarily stored in the open space near road side or placed elsewhere.

At the city of Sohag, Egypt collection bins or collection/transportation points are commonly drums (similar to oil drums) which are placed every few meters on the main street. Residents bring their waste to the drums, which are emptied twice a day on a two-shift basis.⁵⁹

4.9.13 Privatization of Secondary Collection

Solid waste management privatization was at first started in 2003. It was a special initiative of present Mayor of DCC. Ward-Wise Waste Management Project (private

⁵⁹ <http://www.colorstoneconcrete.com>

initiative) in 8 Wards of Zone 9 and 10 initiated through competitive bidding. DCC's officials did not show the bidding papers in this connection. Four organizations were selected and awarded to operate the project. The project started on 15 th May 2003 and administered entirely by conservancy department.

Terms of Reference (TOR)

Terms of Reference (TOR) for the privatization project are stated in the following statement;

Sl No	Items	Contents
1	Name	Ward-Wise Waste Management Project of City Corporation (private initiative)
2	Objectives	To provide superior quality of service to the residents
3	Project area	In Zone 9: Ward 17-21 and 37-38 in Zone 10: Ward No 1= Total Ward 8
4	Project Duration	1 (one) year
5	Working Areas	a. All roads, market, park, footpaths, etc. b. All open and closed drains c. The surrounding areas of dustbin and container d. Dumping the waste at landfill site (Matuail) e. Road signs and traffic sings
6	Other Descriptions	Requirements for methodology and quality of service, cleaning frequency, working time, grading the service etc.

Source : Urban Planning department, DCC

Basic Information of Privatization

There are four organization was initially got the permission for collecting and transporting garbage from 8 Wards of Zone 9 and 10. The total yearly contact amount was Tk. 37,000,000 (37 million). At starting time, the private contractors employed the slum dwellers as cleaners. The total number of field staffs employed by the private firm was smaller than the number deployed by DCC. The demountable containers were removed because they do not have container carrier. Some general information about private contractors is given in table no 4.31

Table 4.31
General information about private contractors

Name of the organization	Number of Ward	No of Spot or dustbins	No of Field Staff	No of Trucks	Population covered	Area (km ²) covered
BIDF**	5	24	358	14.*22	344,000	18.27
Mrs Rythem	1	4	55	2	85,000	6.77
LN Corporation	1	8	46	2	117,000	2.99
MIRUD***	1	41	130	3	66,000	3.92

* BIDF hired 14 trucks for dry season and 22 to for rainy season.

** BIDF for Bangladesh Integrated Environment Development Forum

*** MIRUD for Mission for Rural Urban Development

Source : JICA study report

Evaluation of Privatization Work

At the end of the first year, the performance of private parties calculated on the basis of TOR. As the result of grading 3 contractors got the renewal for another one year for the same amount but the LN Corporation failed to renew the contract. At present, the BIDF has given the responsibility of collection of Ward 37 until further competitive tender finalization.⁶⁰

Dhaka City Corporation has introduced privatization for the first time in its history of solid waste management. Only one and a half year has passed. From technical point of view private firm showed efficiency than the DCC. Private trucks (3 ton and 5 ton truck) gave 1.1 to 1.5 times more trips than the DCC truck. Private trucks spend more time in each trip than the DCC truck. There may be two-way explanation that DCC staffs are expert or they do not clean the site very clearly. On the other hand, private trucks may take more time for their inefficient workers or they clean the site very neatly. Private contractor loads 1.5 times more garbage per trip than DCC vehicles.

Another important factor demands consideration for privatization. For the last year, total cost would be Tk. 53.1 million for 8 Wards. This cost of privatization is Tk. 37.0 million. That indicates that DCC saved 16.1 million taka for 8 Wards. Consequently, the conclusion from the financial point of view is that the privatization project may be forwarded.⁶¹ But, things is like that through privatization, DCC has to incurred fixed cost and some variable cost for the pays and allowances, maintenance cost which is very natural though the workers and equipments not working in privatized area. From that point, privatization is burden for DCC.

Respondents Opinion about Privatization

Some inhabitants of privatized area have favorable and many of them gave adverse opinion. The opinions of the respondents of Uttara-Gulshan Model Town about the privatization are given in table from 4.32

⁶⁰ JICA *Draft Final Report*, Vol. 2, Chap.-2, pp. 68-69; Oral discussion with Zonal Executive Officer of Zone 9.

⁶¹ JICA, *Draft Final Report*, Vol. 2, Chapter 3, pp. 20-22.

Table 4.32
Respondents opinion about privatization of SWM activities

Opinions	Remarks		
	Yes	No	No Comments
Know that SWM of Uttara-Gulshan has privatized	52	42	8
Find any change of cleanliness in the locality due to private operation	31	50	19
Know private contractors worker clean the drain, roads and premises	29	54	17
See private workers clean the dustbin clearly than DCC cleaner	27	52	21
Find a positive changed of overall environment in and around the dustbins	37	47	16
Think privates employees are very much efficient and trained	23	65	22
Think private Companies has sufficient technological facilities than DCC	14	79	17
Comparatively private contractors has done well in SWM	36	58	6
Find qualitative change has come in SWM of Model town after privatization	27	63	10
Believe privatization process was transparent and follow all rules and regulation	18	75	7
Think no need of privatization, DCC is capable of doing SWM efficiently	57	28	15

It is seen from the above table that 52% respondent know that the area is privatized for solid waste management, and cleansing of roads and drains. About 50% respondent did not find any change of total cleanliness in the locality due to private operation. More than 52% respondent mentioned that the private cleaners do not clean the roads, drains, and around dustbins better than before. The respondents do not think that private operators are more expert and skilled than DCC employees. Quality of service is also not good relating to DCC's service. Majority (75%) respondents think that privatization process was not transparent. About 57% respondent thinks that there is no need of privatization because DCC is capable of doing this. Some other information (respondent's opinion) about secondary collection by the private firm is shown in table no 4.33

Table 4.33
Respondents opinion (in %) about secondary collection by the private firm

When private firm collect garbage from transfer stations to final site		Suitable time of collection recommended by the respondents	
Collection time	%	Collection time	%
Early morning	7	Very early morning (before 7a.m)	37
Morning (8-11)	63	Early morning (8-11 a.m.)	4
At noon	3	At noon	3
Afternoon	-	Afternoon	-
Evening	-	Evening	-
Not known	27	Only at night	47
		Not known	9

The above table shows that private contractors also collect garbage in the morning in between 8 -11 am. Most of the respondent (47%) prefers that garbage should be collected only at night or very early in the morning (37%).

The formal discussion with the BIDF president informs that they are working far better than the DCC authority. However, the respondent's opinion went against in most of the cases.

4.10 Peoples Awareness and Participation in SWM

Peoples' awareness is very important for efficient solid waste management. The study reveals the level of the people's awareness is poor in respect of SWM.

Garbage Disposal Monitoring

Only 29% respondent replied that they monitor the garbage disposal process and 63% of the respondent does not monitor the garbage disposal process in his/her own home. While only 10% respondent monitor and 78% do not monitor the garbage disposal method of his neighbor (table 4.34).

Table 4.34
Respondents response about household garbage disposal monitoring

Monitor the garbage disposal of your own home		Monitor the garbage disposal by the neighbor	
Monitoring position	%	Monitoring position	%
Yes, monitor	29	Yes, monitor	10
No monitoring	63	No monitoring	78
No comments	8	No comments	12

Source : Field survey

Table 4.35
Respondents opinion about their role for SWM

Suggestion to the neighbor for right way of garbage disposal		Disposal of banana peel, fruit shell etc in the outside	
Suggestion to neighbor	%	Method of disposal follow	%
Yes, suggestion given	14	Path disposal	47
No, suggestion	45	Fell in nearest dustbin	32
Never seem to be told	13	Carry at home	10
Quarreled for telling	15	Others	11
No comments	13		

Source : Field survey

There was a question whether the respondent suggested or discussed about the way of garbage disposal with his/her neighbor. In reply to question 14% said they suggest or discussed, 45% replied no, 13% said that they did not find reason to suggest and 15% said there has been negative relation for suggesting. About 47% of the population left the banana peel, packaging materials, and other silly matters into the

roads and pavements, 32% disposes into nearest dustbins, 10% carry at home and 11% gave different answers. Therefore, it is very much clear that, the city dwellers are not very much cautious or sincere regarding cleanliness and waste disposal.

Awareness about Legal Provision

DCC ordinance is the key law to solid waste disposal and Environmental Conservation Act is vital law of environment conservation. In reply to a question 15% replied that they know the DCC ordinance, 56% said no, 21% said they don't know the law but they feel that garbage should not throw elsewhere. To reply to another question 12% said they follow the ECA '95, 18% said they follow as possible, 16% said they do what they feel good, and 25% said that they try as their level best and 24% said they don't know the legal provision (table 4.36).

Table 4.36
Respondents response to legal provision of SWM

Knowledge about DCC ordinance not to throw or place any garbage other than schedule place		ECA has directions for cleanliness the surroundings, how follow	
Know the law or not	%	EPA regulations follow	%
Know the legal provision	15	Yes follow	12
Do not know	56	Follow as possible	18
Do not know the law, but feel that refuse should not throw anywhere	21	Do what they feel good	16
No comments	8	Try level best	25
		Don't know what in law	24
		Others	5

Source : Field Survey.

Awareness Building Program

Respondent's opinion about the awareness building program and DCC's inspection activities (table 4.37)

Table 4.37
Respondent's opinion about the awareness building program and DCC's inspection activities

Awareness building activities for solid waste management in the area. (%)			Inspection by DCC officials for awareness building or as part of the solid waste management (%)		
Awareness buildup activities	Yes	No	DCC officials inspect	Yes	No
Household respondent	11	89	Household respondent	4	96
Businessperson	18	82	Businessperson	33	67
DCC Official	43	67	DCC Official	55	45
CBO representative	27	73	CBO representative	21	79
Waste pickers	31	69	Waste pickers	42	68
Experts, Scholars	15	85	Experts, Scholars	20	80
Weighted average	24.3	75.7	Weighted average	29.2	70.8

Source : Field survey, 2004

In reply to the question, whether any awareness buildup program of DCC, more than 75% replied that there is no awareness-building program. Whether the DCC officials inspect the household, business center for awareness building or as part of the management, on an average 29% replied positive and 71 % replied negative. It is clear from the above table that City Corporation is not very much sincere about awareness building among the citizens. In reply to another question of how the awareness level could be increase, the respondents replies are shown in table 4.38.

Table 4.38
Respondents opinion about effective awareness building program for SWM

Awareness program taken	Household	Business person	DCC officials	CBO representative	Waste pickers	Experts & scholar	Weighted average
More publicity Radio/TV/News paper	40	50	32	38	26	27	36
Work seminar participation	3	5	25	7	10	22	12
Like on the job training	21	12	21	18	21	15	18
SWM, like national movement (tree plantation)	28	26	18	25	40	31	28
Others	8	7	4	12	3	5	6

Source : Field survey, 2004

The above table shows that to create the awareness among the citizen the publicity through radio, TV and newspaper got top priority (36%). On an average 28% replied that SWM program should be thrown as a crash program like tree plantation, EPI (Extensive Program of Immunization) for child health, which has been found successful in Bangladesh. On the job training, indicate that the conservancy staffs will conduct demonstration program showing solid waste handle mechanism among the citizens time and again.

Sense of Participation

Participation does not mean the peoples are directly participating in solid waste management program. In terms of solid waste management, there are so many CBOs or NGOs are using the term of 'participation'. Most of the people of Dhaka do not participate in community organization because they do not hold the idea of belongings because more than half of populations have no land ownership. The term 'participation' could mean the people stop to throw their waste in vacant lands or roads and properly handover the garbage to the collectors or dispose into the bins in right time in right

manner.⁶² Participation is limited only into primary collection i.e CBO's representative is going to collect garbage and the dwellers participate in the program by paying some money either willingly or with unwillingness.

The participation may include regarding willingness to participate in segregation, recycling and composting. However, most of the households indicated negative answers to the question regarding willingness to participate in recycling, segregation, and composting. Only 9% respondents replied that they store the organic garbage separate from other garbage. About 35% thought that garbage could be resource, 12% said no and 53% did not have any comments. 56% of the respondents replied that they are ready to separate storing of organic waste if the DCC or anybody else take initiative in this regard. On the other hand, JICA study team found that 77% of all respondents mentioned that they are willing to participate in activities on solid waste management in their community.⁶³

Respondents Awareness and Attitude/Perception Level

There were 12 questions to find out the perception level of household respondents about solid waste management. According to Likert Scale the responses were strongly agreed, agree, uncertain or undecided, disagree, and strongly disagree. For each positive statement, the scoring was 5 for strongly agree, 4 for agree, 3 for undecided, 2 for disagree, and 1 strongly disagree. For a negative statement the numerical value or the scoring was 1 for strongly agree, 2 for agree, 3 for undecided, 4 for disagree, and 5 for strongly disagree. In this study the peoples, awareness and attitude was classified into three levels based on mean score and standard deviation as below:

Scoring Level 1= (Low level of awareness/attitude) < Mean -SD

Scoring Level 2= (Moderate level of awareness/attitude) $\leq$ Mean $\pm$ SD

Scoring Level 3= (High level of awareness/attitude) > Mean +SD

The table no 4.39 shows the results.

Table 4.39
Perception level of household respondents

Scoring Level	Frequency	Percent	Cumulative Percent
1	37	10.9	10.9
2	246	72.8	83.7
3	55	16.3	100.0
Total	338	100.0	

Source : Field Survey, 2004

⁶² JICA, *Draft Final Report*, volume 3, Chapter-2, pp.47-48.

⁶³ Ibid, p. 47.

According to Likert Scale, out 338 household respondents 37 (10.9%) has low level of perception. A total 55 or 16.3% respondents has high level perception and the 246 (72.8%) respondents of Dhaka city has average or moderate level of perception. The results clearly indicate that the citizens of Dhaka do not hold very good perception about the solid waste management. Therefore, it is very essential to have strong awareness building program for creating awareness and positive attitude for efficient solid waste management.

Attitudes Towards Conservancy Staff

The social status of solid waste management workers is generally low in both developed and developing countries, but too low in developing countries than developed countries. This owes much to a negative perception of people regarding the work, which involves the handling of waste or unwanted material. Such people's perception leads to the disrespect for the work and in turn produces low working ethics of laborers and tends to low productivity.⁶⁴ The situation is worse in Dhaka city where more than 65% respondents show their disrespect to the conservancy staff.

4.10.1 Treatment and Disposal of Waste

Solid waste is collected from dustbins and or hauled container by the generators, street cleaners, and or primary collectors from houses, offices or other institutions. It is loaded to collection vehicles and transported to landfill sites for dumping and filling. The facility is located at the perimeter of urban centres in open lots, wetland areas, or next to surface water sources. Though the corporation has statutory requirements for the construction and maintenance of landfills but not yet enforced. Like other developing countries, the landfills are owned and operated by the public agency (DCC) that is charged with enforcing the standards. Often a lack of financial and human resources, coupled with absent of enabling policies, limit the extent to which landfills can be built, operated, and maintained at minimum standards for sanitary practice.

There is no treatment facility operated by DCC and a portion of solid waste collected and transported to dispose at landfill sites excluding some reusable materials picked up by waste pickers and some cleansing staffs. The waste disposal is crude open dumping in one official and two unofficial dumpsite in Dhaka. Besides these there are lot of private and public place where the generators dump their garbage as open dumping. Some photograph attached in Annexure B. There are no comprehensive inventories of organic loads into the Buriganga River from Dhaka urban complex. But, it is estimated that total solid waste is discharged into this river will be around 250 m/t per day.⁶⁵

⁶⁴ <http://www.nutriject.com>

⁶⁵ JICA, Drart Final Report, Chapter-1, p.14.

The overwhelming majority of landfills in Africa are open dumps. Landfills are generally sited based on considerations of access to collection vehicles rather than hydrological or public health considerations. The environmental and health consequences for water sources at risk are more where more rainfall accompanied.⁶⁶ As like as Afro-Asian cities, DCC dispose the waste simply transporting and makes a pile of waste heap into the landfill site. The current disposal method is approximately a) uncontrolled dumping 84% and b) recycling 16%.

There are no treatment facilities or mechanism of DCC in its waste management. But the private sector recycles some portion of solid wastes. Scavenging of reusable materials is carried out at every stage of waste flow such as waste discharge, primary collection, discharging to dustbins and or container, loading to collection vehicle and final disposal. Reusable material scavenged by waste pickers is sold to dealers. These materials are sorted further and recycled.⁶⁷ So treatment means a little bit composting and recycling and disposal includes simple open dumping or land filling excluding reusable material picked out by waste pickers.

Disposal Site

Presently there are three disposal sites are operating in Dhaka. In Dhaka city 586 t/d of solid waste is collected for recycling. The rest 3081 t/d solid waste are disposed either by DCC or otherwise. Out of these only 970 to 1400 or on an average only 1200 t/d solid wastes are disposed into three-landfill site. The rest of the wastes go to either different public/private ditch, near road or railway line side, drains etc. The three landfill site are Matuail, Berri bandh and Uttara dumping station for final disposal. The following table 4.40 details the landfill sites.

Table 4.40
Some information about landfill sites

Name of the site	Area in hector	Start operation	Daily incoming trucks in number	Remarks
Matuail	20	1993	282	Owned DCC & open dumping
Berri bandh	4	Not known	138	Private land & open dumping
Uttara	1	2003	18	Private land & open dumping

Source : JICA study team

⁶⁶ Kaonga, Appropriate Technologies, Pollution Control, p.388.

⁶⁷ JICA, Study Report, Chapter 5, p. 2.

Matuail landfill Site

Matuail is the only one official landfill site owned by DCC. The site is located to South-East side adjacent to Dhaka Demra Road. The site is distant 7 km from the city centre (GPO/Zero point of Dhaka). It is a simple open dumping site without soil cover. The site has surrounding embankments and solid waste filled inside surrounding embankment. According to the transportation department, solid waste collected from Zone 1-6 is transported to Matuail landfill site. The facilities provided in the site are shown in table 4.41

Table 4.41
Facilities of Matuail landfill site

Facilities	Description
Fence	Not installed
Surrounding embankments	Constructed
Access road	Constructed
Weighing bridge	Not installed
Control room	Not available (only one is abandoned)
Liner facility	
Leachate collection facility	Not installed
Leachate pond	Not installed
Gas removal facility	Not installed
Storm water drainage	Not installed
Operation road	Constructed
Dumping platform	Constructed

In Matuail landfill site there are 649 t/d in dry season 913 t/d in wet season, and average is 781 t/d disposed, which is 65% of total DCC's disposal. The photograph of Matuail sites are in Annexure B is showing the physical condition of Matuail Landfill site. The proposed Sanitary Landfill site in Matuail is presented in Annexure C 1-2.

Berri Bandh Site

It is an unofficial dumping site and located at the West side of Gabtole-Babubazar Berri Bandh of Dhaka city. There is a flood protection embankment at the West side of Dhaka city. Garbage is disposed of in between the brickfields and the Berri Band. One bulldozer and one wheel dozer is working in this dumping site but no other facilities is installed. This site is also filling open dumping without soil covering. The garbage of Zone 7 and 8 is transported to Berri Bandh dumping site. The site is a private land. In the dry season there is no discharge of leachate. As the site is located outside the flood protection embankment, the site may be flooded in rainy season. In Berri Bandh landfill site there are 313 t/d in dry season, 399 t/d in wet season, and average is 356 t/d disposed, which is 30% of total DCC's disposal. The photograph of Beri Bandh sites are in Annexure B is presenting the present position of the Beri Bandh landfill site.

Uttara Site

Uttara dumping site is located north side of Dhaka city and a low land along the Tongi River. It is also an unofficial dumpsite owned by the International University of Business, Agriculture and Technology (IUBAT) and requested DCC to reclaim by solid waste. But site is out side of the flood protection embankment and flooded in the rainy season. Solid waste collected from Zone 9 and 10 (transportation of solid waste contracted out to the private company for this 2 Zones) is transported to Uttara dumping site. The Uttara side also follow an open dumping without soil cover. In Uttara landfill site there are 6 t/d in dry season, 104 t/d in wet season, and average is 55 t/d disposed, which is 5% of total DCC's disposal. The photograph of Uttara are in Annexure B presenting the present position of the Uttara site.

Berri Bandh and Uttara dumping sites are private land. It is reported by the DCC officials orally that the concerned landowners of these two landfill sites requested DCC to fill their land by solid wastes.⁶⁸

The only official dump site Matuail is not a sanitary landfill. There is no lining or cover material for the site. The disposal is simply a crude open dumping. The site has not obtained the Environmental Clearance Certificate (ECC) from DoE. Although use of the site for final disposal was started before the enforcement of Environmental Conservation Act (ECA) of 1995. Use of Berri Bandh and Uttara sites for final disposal of solid waste was started after the enforcement of the ECA and Environmental Rules of 1997. Under these regulations it is required ECC for earth filling by industrial, domestic and commercial waste. Furthermore, neither of the sites got approvals from RAJUK, which is required for structural change of open space and/or reservoirs according to the Preservation Act of 2000.⁶⁹

Closed landfill Sites

There are six dumping sites were abandoned after filling their capacities are- Kulshi, Chalkbazar- Mirpur, Gabtali- Mirpur, Lalbagh Sawshan Ghat, Mugdapara and Jatrabari. These sites are now using for development of urban infrastructure like stadium, market, filling station and housing in a few years after the finishing the land

⁶⁸ Ibid, p. 3

⁶⁹ JICA Draft Final Report, Vol.2, Chapter-2, p. 29.

filling by wastes. The immediate use of the closed landfill might have some problems such as ground subsidence and methane gas emission. Due to the high demand of land in the city, landfill has high demand. Prior to the development scheme, covering soil put on the site. It is also risky for development work.

Operation and Management of Landfill Site

The landfill management operations are very minimal. In all cases waste disposal is the simple open dumping without control of incoming waste and no covering soil. All of the sites are unlined and unfenced. Operating practice generally does not include compaction or the application of daily cover. Surrounding embankment, access road and dumping platform are provided at Matuail site, but no leachate collection and gas removal facilities are installed. The solid waste is dumped without surrounding bank at either Berri Bandh or Uttara. Additionally, large number of waste pickers may scour the landfills for materials of economic or personal value. The returns from the sale of these materials go to the waste pickers, and not to the agency operating the facility.

The landfill sites of Dhaka city are almost same as the landfills in most of the Afro-Asian cities. Afro-Asian landfill sites are primarily open dumps without leachate or gas recovery systems. Several are located in ecologically or hydrological sensitive areas. The landfills are generally operated below the standards of sanitary practice. The result is substandard and unsafe facilities, which pose public health risks and aesthetic burdens to citizens.⁷⁰ The management of the landfill operation is very much reluctant in Dhaka. In the Matuail and Berri Bandh landfill site, conservancy department deployed 4 staff and Mechanical Division-2 provides heavy equipment and operators to the sites. However, none of them assigned specific duty, job description, and operation plan in the site. It can be said that landfill operation is left to the heavy equipment operators without instruction or control.⁷¹

The Heavy Equipment for Landfill Sites

Heavy equipment used for final disposal is shown in table 4.42 DCC has considerable number of heavy equipment but only a few are working. The photograph of Matuail sites are in Annexure B is showing the heavy equipments used for Matuail landfill site.

⁷⁰ Brihton Kaonga, *Appropriate Technologies*, Rogers, Pollution Control, p. 389.

⁷¹ JICA Final Draft Report, Vol.2, Chapter 2. p. 30.

Table 4.42
Heavy equipment for landfill sites

Equipment	Total	Not working	Working
Bulldozer	15		11
Tire dozer	8	9	4
Pay loader	9	3	6
Excavator	6	4	2
Hydraulic crane	2	1	1
Hydraulic excavator	2	1	1
Total	42	17	25

Source : Engineering department, DCC

It is clear that 17 heavy equipments out of 42 are not working. It indicates that almost 40% of the heavy equipments are out of order.

4.11 Incineration

Incineration and Waste to Energy (WTE) remain little used options for MSWM in Dhaka. As a disposal options, incineration is not applied by DCC. There are some small-scale incinerators is basically a furnace designed to destroy metallic and other medical refuse for safe disposal. The main objective of this incinerator as a means to destroy the waste material (mostly toxic medical waste) to aid in their safe disposal. But that is insignificant in terms of solid waste disposal options in Dhaka city.

Incineration is high tech and heavy capital intensive project. Local capacity to sustain safe and efficient operations of such projects is a key consideration in weighing the appropriateness of this technology. These considerations include local technical capacity to maintain and service the facility, the availability of basic spare parts, the scheduled replacement of pollution control equipment, and the effective implementation of monitoring program to protect public health from plant emissions. High capital and operating costs make incineration and WTE inaccessible technologies for developing countries. Another limiting factor is the lack of infrastructure to support this technology. This included human and mechanical resources as well as institutional capacity. Furthermore, incineration in Asia and Africa would be infeasible if the waste stream is indeed 70% (wet basis) putrescible organic content. Under these conditions, incineration is likely to be an energy-consuming rather than energy-producing option.⁷²

High costs relative to other waste management options, a limited infrastructure of human, mechanical and institutional resources, and the composition of the waste stream itself, suggest that incineration is not inappropriate technology for Bangladesh. The

⁷² Brihton Kaonga, *Appropriate Technologies, Pollution Control*, op-cit., p. 391.

nature of waste stream, the moisture content, and organic character of solid waste of Dhaka and other cities of Bangladesh is not appropriate for incineration.

4.12 Disposal of Special Waste in Dhaka City

It is already stated that there are different types of waste produced in a society. Among municipal solid waste, there are common non-hazardous household wastes as well as hazardous and toxic industrial waste, infectious and hazardous medical waste. Dhaka city is not exception and about 200 t/d industrial and medical solid waste produced.

Industrial Waste Disposal

Industrial solid wastes may dispose of by the traditional landfill. In that case, landfill site should be located far from areas where people work or live though the waste may have to transport many miles that is too costly. The alternative disposal may be chemical or biological treatment, recycling or incineration. Essentially, chemical process seek to change the structure of substances to make it less toxic, while biological processes use bacteria to help decompose organic wastes into natural nontoxic substances.

Major industrial wastes generators

There are many industries and factories in Dhaka. The size of industries counted by the amount of products or the number of employees. The industries that potentially generates wastes are mostly located in Mohammadpur, Hazaribag, Lalbagh, Shyampur, Demra, Tejgaon, and Badda. According to the statistical data published in January 1993 number of industries with employee number of 10 or more is 6,919 in Dhaka.

Amount of Industrial Wastes in Dhaka

Information on industrial waste generation in Dhaka is nil. No survey was conducted except some hazardous or toxic substances produced by some special industry. Typical waste of such case is tannery waste generated from tannery industry that is mainly located in Hazaribagh area. The amount of tannery waste generated in the area is estimated to be 150 ton/day, while other industrial wastes as 25 ton/day.⁷³ According to the JICA study team analysis other than tannery waste there should be other industrial waste is 35 ton/day. The amount of tannery wastes varies according to seasons, festivals when animals are slaughtered and market demand. Most of the solid wastes from paper-related industry, textile, plastics, rubber, metal and machinery, wood-related etc are seem to recycled in Dhaka and that is why amount of industrial wastes other than tannery wastes are seem to be very low (only 35 ton/day).

⁷³ UNDP, HABITAT, "Approximate Amount of Industrial Waste", p. 7.

Industrial Waste Disposal System in Dhaka

Most of the industrial wastes, which cannot be reused or recycled, are discharged to the public dustbins or containers of DCC from which wastes are hauled to the three dumpsite. Some are dumped illegally at open spaces in the factories on site or out of the factories. All tanning liquid waste mixed with the natural water bodies without treatment. All industrial wastes, either hazardous or non-hazardous, are disposed at the dumpsites together with ordinary municipal waste.

Anyone who produces a hazardous wastes has a moral obligation as well as a legal duty to make sure it is disposed of safely. Therefore a comprehensive waste management service to the waste generation industry coexists of following activity. a) Consultancy and analytical service. b) Collection and transport equipments. c) Cleaning & decontamination equipments; d) Pre-treatment plants for hazardous waste disposal; e) 24-hours emergency service response.⁷⁴ In an interview with a manager of tannery industry, it was found that they do not bother about the consequences after discharging the tannery waste to the public dustbins. They think that it is the duty of DCC to transporting and disposing waste.⁷⁵

Medical Waste Management

There is neither a universal definition nor a name of medical wastes that pose hazard and thus require a special care for handling and treatment. Infectious waste, health care waste, health care risk waste, and bio-medical waste are among those often used as medical waste. Very broadly medical waste is defined as any solid or liquid waste that is generated in the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biological test or medical treatment. Medical waste may be solid or liquid in nature. The waste produced in hospitals, clinics, pathological laboratories, diagnostic centers, doctors offices and other medical and research institutions in the process of treatment either human or animals.⁷⁶

Eigneheer and Zanon⁷⁷ classified hospitals waste into liquid and solid form. This is shown in table 4.43

⁷⁴ P.H. Mayer & Zu Schlochtern, "Waste Management: A comprehensive Service to Industry", *Environmental Technology*, KJA Dewal, WJ Van Sen Brink, eds. (Dordrecht, Holland: Martinus Nijhoff Publishers, 1978), pp. 638-640.

⁷⁵ JICA, *Draft Final Report*, Vol. 1, Chapter-2, p. 19.

⁷⁶ Nasima Akter, "Medical Waste Management: A Review", *Bangladesh Environment 2000*, (Dhaka, Bapa), P. 444.

⁷⁷ Nasima Akter, *Medical Waste Management*, p. 447.

Table 4.43
Types of hospital waste

Type	Typical examples
1. Liquid Wastes	
1.1 Biological waste	Blood, excrement, body fluid etc.
1.2 Chemical waste	Solutions, inorganic salts etc.
1.3 Over-dated medicines	Unused drugs, over-date drugs
1.4 Radioactive waste	Wastes from radiology (iodine 125, iodine 131 etc.)
2. Solid Wastes	
2.1 Perforating and cutting wastes	Needles, syringes, scalpels, blades, broken glass, vials etc.
2.2 Non-perforating and non-cutting wastes	Wastes from treatment (dressings, stools napkins, plaster cast etc.) Part of the body, organs, placentas, tissue etc. Over date medicines (expired drugs) House hold type wastes: dry or wet.

Medical wastes mainly generated from hospitals, clinics, and diagnostics/pathological centres, research centre, blood bank, nursing homes, mortuaries, autopsy centre etc in Dhaka. Although number of diagnostic centres are more than that of hospitals. Hospitals are likely major generator of medical waste. Medical waste in DCC area about 200 tons produced every day. Out of them 20% i.e. 40 MTs of are infectious and hazardous.⁷⁸ According to the JICA study and other studies this figure seems to be too much high and it is not acceptable.

There are 288 hospitals/clinic of different sizes having more than 12,000 beds and 450 diagnostic centres in Dhaka, of which 260 hospitals/clinics have beds less than 100.⁷⁹ The number of hospitals and beds are shown in the following table no 4.44

Table 4.44
Number of hospitals and beds in Dhaka

Size of hospitals (No. of beds)	Type	No. of hospitals	No of beds
Large (No of beds 500 or above)	Government	6	5,000
	Private	1	1,570
Medium (100< No of beds <500)	Government	8	1,325
	Private	11	1,274
Small (No of beds 100 or less)	Government	0	0
	Private	260	2,924
Total		288	12,093

Source : JICA study reports

⁷⁸ J. Hasan, "Managing the Hospital Waste", *Bangladesh State of Environment* (Dhaka: Ministry of Environment & Forest, 2001,), pp. 241-246.

⁷⁹ Matiur Rahman, "Study on the solid Waste Management in Dhaka City", Report prepared for JICA, October, 2003. p. 9. (an unpublished document)

Internationally hospital waste generation rate is ranged from 1.0 to 1.5 kg/bed/day, of which 5-10% are really medical/clinical waste. Total bed 12000 and total solid waste generation is $(12000 \times 1.2 = 14.4)$ ton that is may be 15 t/d. Out of this 15 ton there is 1.5 ton is infectious and hazardous waste.⁸⁰

Medical Waste Treatment & Disposal

The medical or clinical wastes are not segregated at sources more or less, those wastes are normally discharged to a public dustbin in which wastes are mixed with general municipal waste. The wastes discharged and stored in the dustbin are eventually scavenged by waste pickers to recover recyclables. Rest of the wastes are collected by DCC's waste collection fleet for a final disposal, mostly land disposed at official or unofficial dumpsites.

A survey conducted by Dr. Salim Rashid (1996) found that government hospitals placed all wastes in open dustbins. There is no specific legislation pertaining directly to the handling, transportation or disposal of medical waste in Bangladesh's Environment Conservation Act 1995. "Prevent activities which are harmful to public health in all spheres" is not assured by dumping medical wastes in common dustbins according to the Bangladesh Governments Environment Policy 1992.⁸¹ There are very few medical establishments dispose their waste by burning, and burying. In most cases the wastes are simply dispose in the municipality bins. In some cases human wastes like fetus, placenta is buried nearer within boundaries and even in some cases human body parts are also found in the bins.⁸²

Facilities of Clinical Waste Management in Dhaka

A few hospitals segregate infectious waste from other medical waste and store and discharge separately. Most of the hospitals discharge their waste to the common public bins. Only the technology applied for clinical waste management in Dhaka is incineration in a very limited space. Incineration is the most promising technology to treat medical waste if operated properly in terms of volume reduction, detoxification and microbiological inactivation. Except ICDDR, no hospital or clinics in Dhaka has the arrangement of any sort of scientific disposal method. DMCH has a small electric furnace

⁸⁰ JICA, *Draft Final Report*, Vol.2, Chapter -2, pp. 41-43.

⁸¹ Nasima Akter, *Managing Hospital Waste*, vironment 2000, pp. 49.

⁸² J. Hasan, *Managing Hospital Waste*, pp. 242.

for destruction of syringes and presumable needles, but do not use it. Holy Family Hospital with 375 beds has a crusher for infectious waste and hazardous waste to bury in a pit at hospital compound.⁸³

It is already stated that the waste pickers collect medical waste and ultimately a big portion of that items are coming back to the users by unscrupulous traders. The leftover is mixed with other common solid waste simply discharged at public dustbin, either hazardous or non-hazardous are hauled and dumped at different dumpsite.

Industrial, medical and construction waste and other large quantities of waste discharged from the waste generation sources other than domestic sources. It is a burden to the collection and transportation services of DCC. Although the DCC is collecting and transporting these wastes but no charging system has not yet practiced. There is a strong opinion is under consideration for charging these special waste handling on principal 'Polluters Pay Policy'.

In some hospitals, clinical waste disposal system has introduced but most of the cases it is inoperative or out of order. In the Khulna city an NGO 'Prodipan' has started that medical waste treatment and disposal pilot project and if it is expected that it will be successful and will be introduced all over in Bangladesh.

4.13 Financial Position of Solid Waste Management

Income and Expenditure of Solid Waste Management

The conservancy department has an income of conservancy tax. It is only 2% of the total revenue income of DCC. The total revenue income of DCC is the 12% of the taxes of rental value of the city dwellers out of which only 2% come from conservancy sector. The total tax revenue earned is as follows:

- DCC Charges 12% taxes on the rental value of the house hold in the heading of Taxes and Rates (Holding, Conservancy & Lighting). Rental value means households receive the rents for buildings.
- Break down of the 12% taxes charge:

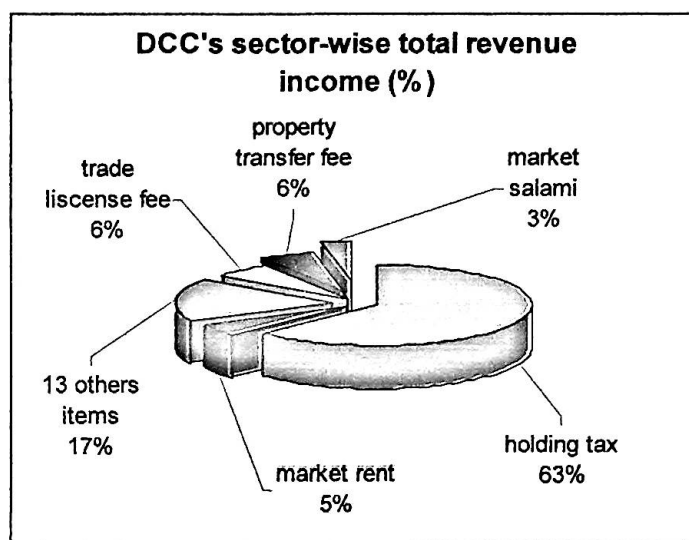
House hold taxes	= 7%
Conservancy taxes	= 2%
Street light taxes	= 3%
Total	= 12%

⁸³ Matiur Rahman, Study on Solid Waste Management in Dhaka City, p. 10.

Income and Expenditures for Solid Waste Management of DCC

DCC has many almost 19 items of revenue earnings and among them the five contribute about 83% of total earnings. 13 other items contribute only 17% of total earnings. The five sectors are a) holding tax b) market rent c) market salami d) trade license and e) property transfer fee. Out of them only holding tax contribute 63% of the total earnings. The figure 4.12 shown the sector wise revenue income of DCC.

Figure 4.12
Revenue income of the DCC



Income and Expenditure of conservancy department

Among the holding tax, only 16.66% has come to the conservancy head as income. It is the only income of conservancy department. On the other hand conservancy department's cost shares is the highest portion of the department wise SWM expenditure. The conservancy department cost is 64% and among it cleaning of roads & drains shares the largest (57%) in operation wise SWM cost. The revenue expenditures for Solid Wastes Management are made in the conservancy, Transport, Mechanical Engineering Division 1 and 2 of Engineering department of DCC. Revenue expenditures of these departments includes the salaries/wages, fuels, store supplies (such as spare parts, tire-tubes, material for container box & hand wheel barrows), repair & maintenance expenditures for conservancy trucks, equipments, container boxes, hand wheelbarrows etc. DCC prepares only 'total actual expenditures' after closing of financial year.

Year wise conservancy tax collection (income) and expenditure for 4 financial years are shown in table no. 4.45

Table 4.45
Financial balance of SWM for last 4 financial years. (In million taka)

Items	1999-00	2000-01	2001-02	2002-03	Rate in own DCC
Overall SWM income	126	141	150	176	6%
Overall SWM expenditure	367	383	402	476	18%
Balance	-241	-242	-252	-300	

Source : JICA Study Report

DCC do not maintain the 'department-wise expenditures' nor 'operation-wise expenditures' but by studying the expenditures the JICA study team, estimated the operation expenditures of last four years (table 4.46). The table clearly indicates that the highest cost involved in cleaning the road and drain (58%) and a very little amount (1.4%) was spent for landfill.

Table 4.46
SWM expenditures by operation (in million taka)

SWM operations	1999-00	2000-01	2001-02	2002-03	Average % (99-03)
Cleaning road and drain	201	227	249	273	58%
Collection & transport	87	98	116	139	27%
Dumping & landfill	5	5	6	7	1.4%
Repair works	74	53	31	57	13%
Total	367	383	402	476	100%
A) DCC total own expenditures	2,162	2,328	1,881	2,670	
Rate of SWM total expense to A	17%	16%	21%	18%	
B) DCC revenue expenditures	-	-	-	1,138	
Rate of SWM total expense to B	-	-	-	42%	

Source : JICA Study draft final report

From the above table it is clear that the DCC in general and conservancy in particular has to depend on the additional budget for conservancy expenditure. The total department wise costs are shown in table No. 4.47

Table 4.47
Department Wise SWM Cost (in million taka)

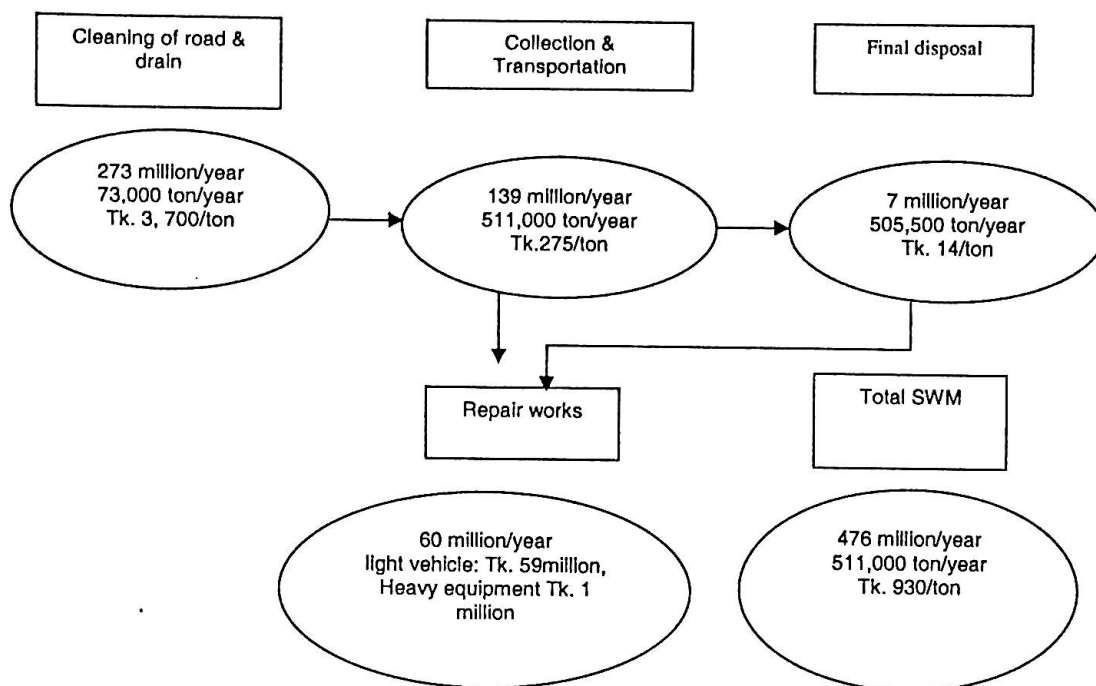
Items	1999-00	2000-01	2001-02	2002-03	Ratio
1. Department –wise actual SWM cost					
a) Conservancy department cost	212	243	279	305	64%
b) Transport department cost	66	73	84	106	22%
c) Engineering dept. cost	89	67	39	65	14%
Total cost	367	383	402	476	100%

Source : JICA study report

Flow diagram of SWM operational cost (financial year 2002-2003) shown in figure 4.13. In the last financial year 2002-03, the total SWM expenditures reached approximately Tk. 476 million, which accounted for 18% of DCC's total won expenditures

and 42% of revenue expenditures of the year. Total SWM cost of DCC in the financial year 2002-03 is estimated at Tk. 930/ton (US \$ 16/ton.)⁸⁴

Figure 4.13
Solis Waste Management Cost Flow



4.14 Chapter Summery

Dhaka is the capital city of Bangladesh. It has the prolong history of ups and down. Islam Khan Chisti established Dhaka in 1610 as the capital city. Dhaka is now one of the largest cities in the world. About 8 million people live in Dhaka city and in the DCC area it is 5.7 million. Population density and urbanization in Dhaka city is so high but DCC cannot cope with this rapid growth providing municipal service. With other problems solid waste management is a serious concern of Dhaka City Corporation.

Daily solid waste production in DCC area is about 3667 tons. Of the daily total Solid waste generation household source is the principal source produced 2417 tons (66%) followed by commercial sources (834 tons) , street waste (200 tons), tannery (150 tons) and other sources (50 tons). Primary collection is done by the generators and as well as by the community based organization or private sectors. 51% of solid waste

⁸⁴ JICA Draft Final Report, Chapter-2, p. 28.

collected by CBOs and NGOs and rest 49% is collected by the generators. Secondary collection is done mainly DCC and private sector as only in the Zone 9 and 10 under the contract with DCC.

Most of the solid waste is organic in nature. Food and vegetables, contribute for 53% the solid waste, paper 14%, plastics 6% and other 27%. DCC can collect only 1,200 t/d into the three landfill sites.

There is no treatment system in the DCC area. Only 16% of the total solid waste is recycled by the informal sectors. DCC itself could not recycle and even associate the recycling sectors. The final disposal of solid waste is meant by DCC is crude open dumping in the three-landfill site. Matuail is only one official landfill sites and other two is private land. 65% of transported or collected solid waste is finally disposed in Matuail landfill sites, 30% is in Berri Bandh sites and only 5% is only in Uttara sites.

There are some special nature waste in all over the cities and towns in the world. Industrial and clinical wastes are hazardous as well as infectious in nature. All these wastes are mixed with common municipal solid wastes and transported to the land filling facilities which for simple disposal.

Chapter 5

Impact of Present Solid Waste Management

5.1 Introduction

Global environmental degradation is continuing at an alarming rate, fuelled by social & economic problems. This environmental degradation is mostly killing the children. Air and water pollution are at a crisis point in many major cities with one billion urban people who breath and drink unhealthy air and water.¹ Human being is responsible for pollution by extraneous substances in his environment.² Solid wastes is one the substances that caused human health and overall environmental degradation. Every kind of unusable and undesirable or discarded materials produced in the course of daily human activities and not soft enough to be regarded as liquid wastes falls into the category of solid wastes. Solid waste often called the third pollution after air or water pollution, is that material which arises from various human activities.³ As a result of population pressure, pollution level gradually increasing in the urban centers; compounded by unplanned growth and inadequate civic and physical facilities. The mismanagement of solid waste is contributing to water pollution, obnoxious odors at the dumping sites and increasing flies and mosquitoes associated health hazardous.⁴ The biggest threat to health from waste is when it is left uncollected, or improperly stored or disposed.⁵ Meeting waste disposal needs of the world's exploding population is nonetheless likely to remain one of the most critical and difficult tasks of the present time.⁶

21st century is the century of urbanization. Since 1950, the number of people living in cities has almost tripled in developing countries. This process of urbanization

¹ UNEP, UNCEF & WHO, *Children in the New Millennium*, (Malta: UNEP, UNCEF & WHO, 2002), p. 15.

² Rahman & Ali, *Waste Management and Environmental, Bangladesh Environment 2000*, p. 426.

³ S.C Bhatia, *Handbook of Industrial Pollution & Its Control*, Vol. 1 (New Delhi: CBS Publishers and Distributors, 2002), p. 170.

⁴ QK Ahmed, Nilupher Ahmed & KB Sajjadur Rasheed, eds., *Resources, Environment and Development in Bangladesh*, (Dhaka: BUP & Academic Publishers, 1994), p. 107.

⁵ Dennis Bella Sr., "Environmental and Health Management", *Pollution Control & Waste Management in Developing Countries*, Rogers W'u Okot-UMA, et al., eds. (London: The Commonwealth Secretariat, 2000), p. 295.

⁶ Elkington John and Shopley, Jonathon, *Cleaning up: US Waste Management Technology and Third World Development* (Washington: World Resource Institute, 1989), p. 9.

has generated a resource crunch, energy crisis, housing problem, environmental problems such as air, water, housing, noise pollution, municipal and industrial wastes effluents and sewage problems which have enormous impacts on ecosystems of both developed and third world countries.⁷ Solid waste constitute a veritable source of air, water and land pollution in many urban areas of developing countries because of their poor management and disposal. Some of these wastes are blown by wind while others are washed by runoff after rainstorms into urban river channels. Indiscriminate dumping in the river or water channels create water clog leading to flooding situation.⁸

Today, garbage is most voluminous in rich countries but most visible in cities of developing countries. Like water, waste profoundly affects human health.⁹ The waste problems are typically associated with non-degradable or bio-accumulative substances such as waste pesticides, solvents, heavy metals and chemical sludge. The development and widespread use of plastic products improved standard of living but they have introduced a lot of threats to the environment.¹⁰

In addition, even the most expensive methods of waste disposal-high-tech sanitary LF_s and incinerators not completely free of health risks. Toxins from LF_s can leach into ground water and heavy metals, chlorine compounds and dioxins are among the hazards in incinerators ash.¹¹ Current trends in environmental degradation must be reversed in order to sustain the health and productivity of the world's ecosystems.¹² In chapter 18 of Agenda 21 of Rio Earth Summit states, water resources have to be protected taking into account the functioning of the aquatic ecosystems and perennially of the sources, in order to satisfy and reconcile needs for water in human activities.¹³

⁷ S.N. Dhyani, *Management of Environmental Hazards* (New Delhi: Vikash Publishing House Pvt. Ltd., 1993), p. 132.

⁸ Prof. J.O. Ayoade, "Climate Factors Affecting Pollutants in Waste Disposal Sites in Developing Countries", *Pollution Control & Waste Management in Developing Countries*, p. 253.

⁹ Yvonne Gotlop Bogatsu, "Towards Effective Waste Disposal in Developing Countries", *Pollution Control*, p. 275.

¹⁰ World Bank Group, *Pollution, Prevention, Abatement Hand Book*, (Washington, World Bank, 1998), pp. 29-32.

¹¹ Molly O'Meara, "Exploring a New Vision for Cities", *The Challenges of Urban government: Policies and Practices*, Mila Freire & Richard Stren, eds. (Washington: The World Bank Institute, 2001), p. 343.

¹² DFID, EC, UNDP & WB, *Linking Poverty Reduction and Environmental Management: Policy Challenges and Opportunities* (Washington: WB, 2002), p. 9.

¹³ Shahnaz and Karim, "Out Goes Polybag in Comes Jute Bag", *State of Environment Report 2001*, Chowdhury, ed., p. 54.

5.2 Environment Pollution

Environment is the physical, chemical, and biotic condition of surrounding living organism.¹⁴ Environment refers to the living (biodiversity) and non-living components of the natural world, and to the interaction between them, that together support life on earth. The environment provides goods (natural resources) and services (ecosystem functions) used for food production, the harvesting of wild products, energy and raw-materials. The environment is also a recipient and partial recycler of waste products from the economy and an important source of recreation, beauty, spiritual values, and other animals.¹⁵

Scientifically, pollution can be defined as anomalous distribution and accumulation of elements and other undesirable compounds in air, land and water, which affect the survival of living organisms and degrade the environment.¹⁶ Traditionally, the term pollution has been connotative with waste and has referred mainly to reduction in purity of the atmosphere and to a lesser extent of water. Now, however, pollution encompasses any change in natural environment, including any contamination of air, water, and land and excessive noise, whereas implies a lost material/resources potentially available for recovery.¹⁷ Environment pollution may be generally define as an undesirable and unhealthy change in the general environment caused directly or indirectly by human beings, either in the process of living or through industrial processes. Pollution may thus be of the air, water and land; there is also the increasing menace of noise pollution in the town and cities.¹⁸

5.3 Environmental Sustainability

The character of economics and activities determines the 'metabolic' rate of extractions from and returns to the nature and thereby, the number of human beings that can survive comfortably for the long time within the carrying capacity of the planet. Sustainability can be defined either broadly or narrowly. Broadly, environmental sustainability is the capacity to continuously produce the necessities of a quality human existence within the bounds of natural world of undiminished quality. Environmental

¹⁴ Mechael Allaby, *Dictionary of the Environment*, 3rd ed. (Washington: University Press, 1989), p. 408.

¹⁵ DFID, *Linking Poverty*, p. 9.

¹⁶ K. Shivkenar, A.K. Pande, & G. Bikshan, "Toxic Trace Element Pollution in Ground Water Around Patancheru and Boloram Industrial Areas, Andhra Pradesh, India: A graphical Approach", G.B Wiersma, ed. *Environmental Monitoring*, Vol. 45, No. 1 March 1997, pp. 57-80.

¹⁷ A. V. Bridgwater, and C.J. Manford, *Waste Recycling and Pollution Control Handbook* (London: George Godwin Ltd, 1979), p. 3.

¹⁸ A. K. Banargee, "Pollution: A Natural Process", R. N. Trivedi, ed., *Environmental Pollution and its Impact on the Organisms* (Patna: Bharati Bhawan, n.d.), p. 289.

sustainability encompasses high performance levels within 3 measurable sets of environmental values; 1) human life; 2) ecosystem health (the protection of habitat, wildness and bio-diversity); and 3) resource sustainability. The narrower sense of sustainability is achieved through the effective management of society's total materials and energy requirements. In other words, resource sustainability seeks to minimize extraction & maximize material reuse and recycling; and limit the use of renewable resources to amounts well within nature's capacity to supply them perpetually.

5.4 Solid Waste : Environmental Hazard or Risk

Solid waste is associated with direct nuisance, lack of value and cost of disposal. Waste is treated as a pollutant if otherwise not recycled and reused. A pollutant may be simply qualitatively defined as unnatural and/or obnoxious substance that is released to the environment.¹⁹ Inefficient solid waste management resulted lot of environmental hazards. Environmental hazard is defined here as material risk of death, injury or impairment of health to persons or animals or any deposit probable to threaten the pollution or contamination of water, air or land. There are three major categories of risks associated with waste, namely; aesthetic, environmental and health. The most is that of health as the majority of deaths in developing countries are caused by diseases transmitted through human waste (infections and parasitic diseases,) i.e.; Malaria, Cholera, Dysentery, Salmonellas, Helminthes diseases, etc. and airborne wastes (respiratory diseases), i.e. aggravation of asthma, bronchitis, Acute Respiratory Infections, etc. Rotten uncollected garbage also poses as pollution both as smell nuisance and as centers of origin of diseases through flies and scavenging crows and dogs.²⁰

Environmental risk associated with air, water and land pollution. Air pollution causes for dust, effluvia, smoke and fume, water pollution causes for deposited material or percolate escape either through surface runoff or by underground movement threatening streams, rivers, aquifers or even the sea; direct poisoning or eutrophication and land pollution for gross amenity damage, undermining of site stability; sterilization of surrounding land due to heavy metals, Ph changes.²¹

¹⁹ Bridgwater & Manford, *Waste Recycling Handbook*, p. 3.

²⁰ Nazrul Islam, "The State of Urban Environment in Bangladesh", Nazrul Islam and Rosie Majid Ahsan, eds., *Urban Bangladesh: Geographical Studies* (Dhaka: Geography Department, DU, 1996) p. 27.

²¹ Bridgwater & Manford, *Waste Recycling Handbook*, p. 93.

Hazardous Elements in Solid Waste

Every product has a life cycle. From plastic bag to ships, eventually they reach the end of their useful life. Then unless, recycled into other products, become waste. Many of these wastes produce by human being are hazardous to human health and environment. Municipal solid wastes, old batteries, obsolete computers and mobile phones, medical and industrial wastes all pose a threat to the environment. Computers, which have a low rate of obsolescence, also contain hazardous materials such as cadmium, lead and mercury. Another area of concern is plastic waste. Many developing countries lack either facilities or laws to cope with the dramatic growth in these types of wastes. Often they are disposed of by burning, producing toxic fumes, or they dumped in landfill where there is enormous untapped potential for recycling, that too poses its own waste problems. The common hazardous elements in solid wastes are:

Leachate

Leachate is called garbage 'juice'. It is liquid that results when water percolates through the landfill.²² The generated leachate contains high levels of BOD, COD, nitrate, chloride, alkalinity trace elements, and even toxic constituents, that all degrade water sources.²³ Leachate is a common outcome of landfill. In any waste tips 'young parts' of the waste tip (up to 2- 3 years) highly polluted leachate accumulates. This formed due to the microbial degradation to the organic parts of the waste. In this stage, the BOD value of the leachate is almost as high as the COD value because of the easily degradable character of the organic wastes.²⁴ The amount of leachate produced from sanitary LF depends on the moisture content of SW, chemical, biological and hydrodynamic processes.²⁵ Leachate from the LFs is recognized as one of the important ground water pollutants.

Heavy Metals

Lead is the most widely used metal after iron. Three-quarters of world lead is used in lead-acid batteries. Exposure to lead can cause acute and chronic poisoning to

²² Roger A. Hinrichs and Merlin Kleinbach, *Energy: Its Use and the Environment*, 3rd ed. (USA: Thomson Learning Inc., 2002), p. 542.

²³ Yong S. Chae and Ahmed Hamidi, "Ground Water and Surface Water Pollution", David HF Liu, ed., *Environmental Engineers Handbook*, 2nd ed. (New York: Lewis Publishers, 1997), p. 1007.

²⁴ P. A de Bocks, "Re-infiltration of Waste Tip Leachate: An inexpensive Alternative", JKA Dewal ed., *Environmental Technology* (Holland, 1987), pp. 587-592.

²⁵ P. Shivkumar, Thandaveswa and KD. Chandarsekeran, "Solid Waste Leachate Quality and its Effects on Soil Properties", *Pollution Research*, Dr. R.K Trivedi, ed. Vol. 23(1), 2004 (Kerad, India), pp. 69-81.

children and urban babies.²⁶ Lead, a heavy metal used in cars batteries is a toxin that causes symptoms including anemia, nausea, coma, and blindness.²⁷

Trace metal

In the industrial areas, trace metals are entering with effluents to the ground water. The contaminants, toxic metals, and other suspended solids contaminate entire aquifer. It is affecting the surface, sub-surface and ground water being polluted.²⁸

Mercury

Mercury is extremely toxic, especially to the developing nervous systems. It is therefore particularly harmful to children and urban babies. Despite the risks, mercury is used in a very wide variety of products and applications worldwide, including in mining, thermometers, batteries, dental fillings, paper, paints, and pharmaceuticals industries.²⁹

Green House Gas

Green house gas is responsible for atmospheric pollution. It is warming the air of the atmosphere. Green house gas is the combination of CO₂, chlorofluorocarbons (CFCs), NO and methane gas. The developed countries are mainly responsible for green house gas emission. The green house gas emitted by USA 22%, Russia 17%, Australia 4% in the atmosphere. It is hopeful that 16th February, 2005 The Quito agreement has been effected into 141 countries. 55% green house gas emitted countries were agreed to decrease the green house gas emission by 5.2% or as it was into 1990.³⁰ Methane is an odourless gas but it is very efficient as a greenhouse gas. It is also a combustible gas that becomes explosive when its concentration in the atmosphere exceeds 5% by volume.³¹

Odors

Odors mean the bad smell, which has a nuisance effect. The common chemical sources of odors have been organic compounds that are having nitrogen or sulfur in their

²⁶ UNEP, TUNZA, *Acting for Better World* (New York, UNEP: 2003), pp. 114-117.

²⁷ World Almanac Library, *21st Century Science*, p. 55.

²⁸ P. Shivkumar, Thandaveswa and KD. Chandarsekeran, "Solid Waste Leachate Quality and its Effects on Soil Properties", Dr. R. K Trevedi, ed., *Pollution Research*, Vol. 45, 2004 (Kerad, India) p. 59.

²⁹ UNEP, TUNZA, *Better World*, pp. 114-117.

³⁰ Dr. Mushkifur Rahman, "Quito Chukiti Amader Sujog Dave", (The Quito Agreement will give us opportunity), *The Daily Prothom Alo*, 3rd March, 2005, p. 11.

³¹ Prof. J.O. Ayoade, "Climate Factors Affecting Pollutants in Waste Disposal Sites in Developing Countries", Rogers, *Pollution Control*, p. 254.

molecular configuration. Amines, mercaptans and complex decomposition product of proteins (containing both nitrogenous and sulfuric compounds) have been typically representatives of the odor. Among odor producing compounds that are having no nitrogen or sulfur are phenols, cresols, and some folic acids.³²

Blowing light dump waste is another nuisance. Sand, dust, ash, and small particulate matter is blowing in the air and create serious public health hazards.

5.5 Solid Waste & Environmental Pollution Source

Solid waste is at first come to transfer station from source of generation. Secondary collection starts from the transfer stations. Waste is deposited sometimes even whole day or more in that place and pollutions begins from here. Unsightly scenario, obnoxious odour, flies, vectors, rodents are pollutants of collection points. Scavenging is another waste hazard.

Open or Simple Landfill

One of the disposal methods of solid waste is open or simple landfill. Most of the developing countries dispose their solid wastes into open or simple landfill. It is the major sources of environment pollution. Landfill leachate is main elements of pollution. Obnoxious odour, possibility fire hazard, methane gas emission, blowing particles in the air etc. are other sources of pollution. Open dumping station is the breeding centre of rodents, vectors, mosquitoes, flies and other diseases containing variables. Scavenging in the landfill is another public health concern.

Sanitary Landfill

It is the scientific method of solid waste disposal. Though is lined and cover soil is put over the landfill, it is also produce leachate and less amount of odour. It is also another source of environment pollution if not controlled leachate. Landfills generate emission over long periods, even after longer than a human lifetime. The longest lasting and most polluting emission is leachate.³³ Waste buried in a landfill comes into contact with water percolating down from the surface water or ground water moving laterally through the refuse, obnoxious, mineralised liquid capable of transporting bacterial

³² GR, Chhatwal, *et al.* eds. *Encyclopedia of Environmental Pollution and Its Control* (New Delhi: Anmal Publication, 1989), pp. 286-287.

³³ Katarina Kylefors, Holger Eche and Akdras Lager Kvist, "Accuracy of COD Test for Landfill Leachates", *Water, Air and Soil Pollution: An International Journal of Environment*, Vol. 146, No. 1-4, June 2003 (Kuler Academic Publishers), pp. 153-169.

pollutants. In a humid environment, leachate production is higher than in arid regions.³⁴ It is perceived that as various chemical or biological processes proceed inside the landfill waste layer, they can lead to the formation of diverse types of mercury (H_g) including both inorganic (elemental H_g) and organic forms of mono methyl or dimethyl (DMH_g) at their excessive level.³⁵

Incineration

Waste incineration is a recognized man made waste disposal process which release dioxins, creates air pollution and serious health problems. There are air pollutants emitted during combustion. Heavy metals and dioxins form during combustion (from chlorine compounds that formed combustion process). Dioxins are considered one of the most potent carcinogens sources.³⁶

Hazardous or Infectious Wastes

What ever is the disposal method there some special waste, which is by nature hazardous and infectious to human health. Hazardous and infectious wastes are clinical and industrial toxic waste. Both of the solid wastes contribute to human health concern and environment pollution.

5.6 Solid Waste and Environment Pollution

It is already stated that solid waste is one of the major source of environment pollution. Air, water and land pollution with public health concern of solid waste pollution is discussed here in brief.

5.6.1 Air Pollution

Air pollution can be defined as the presence of one or more contaminants (pollutants) in the out door atmosphere as such quantities and of such duration as may be (or may tend to be) injuries to human, plant or animal life or property, materials or which may unreasonably interfere with the comfortable enjoyment of life or property or the conduct of business. Air pollution may be from natural and man-made source. However, the main cause of air pollution is the burning of fossil

³⁴ Keller, *Environmental Geography*, pp. 252-253.

³⁵ K.H. Kim and M. Kim, "Mercury Emissions as Landfill Gas from a Large Scale Landfill Site in Seoul", *Atmospheric Environmental International*, Vol. 36, No. 3 (Pergamon), January 2002.

³⁶ Moo Been Cheng, Jung-Jeng Lin, & Shu-Hao Chang, "Characterization of Dioxin Emission from Two Municipal Solid Waste Incinerators in Taiwan", *Atmospheric Environmental International*, Vol. 36, No. 2, January 2002 (Pergamon), pp. 283-286.

fuels. Gasoline, coal and natural gas are fossil fuels. When fossil fuels are burned, waste products are emitted from chimneys and the exhaust of factories, and pass directly into the air. Besides human activities, pollutants from dust storms, a volcanic eruption of natural sources causes air pollution.³⁷ Waste dumping and its odour is man made source of air pollution.³⁸ Air pollutants are air borne substances (either solids, liquid or gaseous) that occur in concentration high enough to threaten the health of the people and animals, to harm vegetation and structures or to toxify a given environment.³⁹ There are lot of causes of air pollution. Smoke, fumes, obnoxious gases, dust, small particulate matters etc. are the main sources of air pollution. Air pollution only for solid waste is discussed here.

5.6.1.1 Refuse Burning and Air Pollution

There are lot of human activities, among them refuse burning is one of the major causes of air pollution. Some people may dispose their trash by burning it outdoors in open space. CO₂ and particular mater is result of refuse burning. The term particulate mater represents a group of solid particles and liquid droplets that's are small enough to remain suspended in the air collectively known as aerosols. Items such as paper, cardboard, plastic and food waste as well as tin can and glass go into fire. This practice may release more dioxin in the air, and if not be regulated by local authority, is more harmful than mechanized incinerators.⁴⁰ There are some other particulate matter come out from burning includes iron, copper, nickel, and lead.⁴¹ Air pollution from burning, gaseous emissions and even explosion occur around improperly managed disposal sites.⁴²

Indoor and outdoor air pollution of open burning of urban wastes with components of plastic like polyvinyl chloride (PVC) is also a source of dioxins, furans, and heavy metals in urban societies. Plastics do not rot, like most other materials, although they can be burned. PVC (polyvinyl chloride) has been especially objectionable

³⁷ Nasrin Alam, *Simple Facts about Environment Pollution* (Dhaka: Lutfun Nesa Ahmed, 2000), pp. 12-13.

³⁸ Larry W. Ganter, *Environmental Impact Assessment*, 2nd ed. (New York: McGraw Hill Inc. 1996), pp. 145-146.

³⁹ C. Donald Ahrens, *Metrology Today: An Introduction to Weather, Climate and the Environment*, (USA: Thomson Book, 2003), pp. 46-63.

⁴⁰ Hinrichs & Kleinbach, *Energy: Its Use*, p. 547.

⁴¹ Donal C. Ahrens, *Metrology Today: An Introduction to Weather, Climate and the Environment* (USA: Thomson Book, 2003), pp. 46-63.

⁴² World Bank, *Development and the Environment: World Development Report, 1992* (Washington: Oxford University Press, 2002), p. 54.

because it forms highly corrosive hydrochloric acid when burned, which is an extreme nuisance in the operation of refuse incinerations. If it is burned with a high temperature, even it will produce highly poisonous phosgene (POCl_3).⁴³

5.6.1.2 Incineration & Air Pollution

Incineration is also burning in a scientific way into incineration plants. Solid wastes are burned in a regulated way. Generally, solid wastes are segregated into to make good refuse driven fuel and incinerated into plants to produce heat combustion. Like simple open burning, incineration plants also produce dioxin and other particulates that create air pollution. Dioxin played a significant role in the contamination of Love Canal, New York, and exposure of soldiers in Vietnam. Dioxin is formed either in the combustion chamber or after combustion when the gases cool in the exhaust stack. Also of concern is the residual ash, which has high metal concentration calcium, cadmium, lead, aluminum etc are available in the bottom as well as fly ash.⁴⁴

To effectively reduce dioxins emissions from incinerating process four methods have been commonly used as engineering practice to either inhibit the dioxins formation or to remove dioxins gases streams. They include: a. addition of chemicals to inhibit dioxins formation; b. high temperature decomposition; c. low temperature decomposition with selective catalytic reduction; d. applying activated carbon injection. Due to easy retrofitting, applying activated carbon injection (ACI) to absorb gaseous dioxin has become a common practice. In Taiwan, it has been proved that ACI technology can effectively decrease the flue gas dioxins concentrations from waste incinerators.⁴⁵

5.6.1.3 Impact of Air Pollution

Air pollution causes many problems into environment and public health. The most common problems of air pollution in the planet are depletion of the ozone layer, acid rain and warming of the atmosphere. The sun gives light energy to the earth. With light it also emits ultra violet rays (UVR). However, a layer of ozone is present in the stratosphere tends to filter out most of these UVRs. The ozone layer protects the world form the ultra violet rays. But due to chlorofluorocarbons damage the ozone layer and UVRs are coming easily to the atmosphere of the planet. Ultra violet rays can damage the immune system and cause skin cancer.⁴⁶

⁴³ Kim and M. Kim, "Mercury Emissions", Vol. 36, No. 3.

⁴⁴ Hinrichs & Kleinbach, *Energy: Its Use*, p. 547.

⁴⁵ Cheng, Lin, & Chang, "Dioxin Emission", pp. 283-286.

⁴⁶ Nasrin Alam, *Environment Pollution*, pp. 14-18.

Due to air pollution health problems as well as damage to property or materials or cause decrease in atmospheric aesthetic features. Examples of effects on human health include eye irritation, headaches, and aggravation of respiratory difficulties. Plants and crops have been affected including abnormal growth patterns, leaf discoloration or spotting and death. Animals such as cattle have been subjected to undesirable consequences of atmospheric fluorides. Property and materials damage include devaluation because of odours, discoloration of painted materials. The aesthetic effects include reductions in visibility, discoloration of air, photo-chemical smog-related traffic disruption at airports and the general nuisance aspects of odours and dusts.⁴⁷ Dioxin played a significant role to cause cancer in animals and as linked with a variety of other health problems, including genetic effects.⁴⁸ Dioxins and other particulate matters of pollutants can immediately influence the human respiratory system. Once inside the lungs, it can make breathing difficulties, particularly for those suffering from chronic respiratory disorders.⁴⁹

5.6.1.4 Air Pollution in Dhaka

However, the overall air pollution in Bangladesh is not so dangerous, but the urban air pollution has reached alarming level. Air pollution in Dhaka is mainly for vehicular air pollution. Simple open burning and incineration may be responsible for air pollution. The lead content of Dhaka city's air is at places reported to be more than one hundred times of the UN recommended safe level. Dhaka has become a gas chamber for slow poisoning.⁵⁰ This poisonous air is destroying the body and brain of Bangladesh's citizens, particularly of the children, the future generation. Dust, sand, ash and blowing particulate matters are liable for air pollution of Dhaka city.

5.6.2 Water Pollution

Water is very important for mankind. Another name of water is life. Without water, man cannot survive. However, the water must be pure water. Polluted water is rather dangerous for human health and environment. Natural water is clean and pure. Water purity affected by the level of pollutants in the water bodies. There are two types of tolerance; a) Non-threshold pollutants such as mercury, lead, cadmiums etc which are dangerous even in small amount. b) Threshold pollutants such as pesticides, sulphates,

⁴⁷ Larry W. Ganter, *Environmental Impact Assessment*, 2nd ed. (New York: Mcgrall Hill Inc. 1996), p. 146.

⁴⁸ Cheng, Lin & Chang, "Dioxin Emission", p. 286.

⁴⁹ Ahrens, *Metrology Today*, p. 60.

⁵⁰ BEN, *Bangladesh Environment Network*, pp. 1-2.

organic wastes, phosphorus, carbon and that pollute and dangerous when remain above the certain level.⁵¹

Due to human activity, water becomes polluted. Water exists in various forms in various places. Water can exist in vapor, liquid or solid form. It exists as vapor in the atmosphere, above the ground as surface water and below the ground as sub-surface water or aquifer. Not all-subsurface water is ground water. Ground water is that portions of subsurface water, which occupies the part of the ground that is fully saturated, and flows into a hole under pressure greater than atmospheric pressure.⁵² Aquifer is a geologic group of formations or part of a formation capable of yielding a significant amount of ground water to wells or springs.⁵³ The potential sources of contaminants flow with runoff. Runoff is any rainwater, leachate or other liquid that drains over the land from any part of a facility. The contaminants such as leachate, pathogens, human excreta, digested organics etc. mixed with runoff and join surface water and subsequently goes to aquifers below thereby posing danger to the ground water.⁵⁴

5.6.2.1 Solid Waste and Water Pollution

Solid waste is one of the detrimental sources of water pollution. Solid waste can pollute the watercourses directly if thrown into water bodies or landfill leachate. Open dumping in watercourses, ocean dumping, or sanitary landfill will produce leachate. Leachate is one of the complicated liquids containing various pollutants such as mercury, lead, cadmiums, pesticides, sulphates, and other organics etc. Because of highly organic nature of the material, a large BOD is placed on the receiving water and sediment becomes coated with highly organic ooze.⁵⁵ Solid waste can contaminate the surface as well as ground water.

5.6.2.2 Surface Water Contamination

Simple landfill and even sanitary landfill have implications for surface water pollution. Surface water pollution can be defined in a number of ways: however, most common definition addresses excessive concentrations of particular substances for sufficient periods to cause identifiable effects. Surface water pollution may occur from two sources of water pollutants: non-point or point sources. Non-point source refer to as

⁵¹ Bangladesh Center for Advanced Studies, Guide to the Environmental Act & Rules, p. 3.

⁵² Chae and Hamidi, "Ground Water and Surface Water Pollution", David HF Liu, ed., *Environmental Engineers Handbook*, 2nd ed. (New York: Lewis Publishers, 1997), p. 1007.

⁵³ Alex Mallow, *Hazardous Waste Regulation* (New York: Van Nostrand Reinhold Co. 1981), p. 204.

⁵⁴ Ibid, p. 209

⁵⁵ Trivedi & Raj, *Encyclopedia of Environmental Science*, Vol. 25, pp. 106-107.

'area' or 'diffuse' sources. This is the runoff from agricultural, commercial, and industrial pollutants. Point source is related to specific discharges from municipalities, commercial or industrial complexes or landfill sites.⁵⁶

There are lot of causes of surface or ground water contamination but most serious one is the threat to ground water from waste chemicals from dumps and landfills.⁵⁷ In the landfill, material decomposes, dissolve in or become suspended in the rainwater and mixed with runoff and ultimately mixed with surface water and pollute it.⁵⁸

5.6.2.3 Ground Water Contamination

Ground water is water below the land surface in a zone of saturation.⁵⁹ Ground water accounts for a small portion of the world's total water (only 0.6%) but it accounts for a major portion world's freshwater resources. The polluted runoff mixed with the surface water and percolate into the ground water and thus into aquifers. Thus polluted tend to contaminate not only ground water but also surface water, since the two systems are ultimately inter-connected.⁶⁰

However, except for glaciers and ice caps, the aquifers represent the largest source of fresh water supply in the world's hydrological cycle. This ground water may be contaminated by nature or human activity: such as waste disposal, mining and agricultural operation. Contamination from natural causes is very small but waste disposal is one of the highest contaminating sources of water. Among all disposal practices of waste, contribute the most wastewater to the ground or surface water.⁶¹ Leaking pollutants into the ground water table located nearby can also cause contamination to soil and freshwater courses and aquifers.⁶² Waste effluents and Solid waste leachate result in offensive contamination of water with odor and cause clogging of ground water filters.

The land disposal of municipal or industrial solid waste is another potential cause of ground water contamination. Continuous heavy rains dissolve chemicals impounded in

⁵⁶ Ganter, *Environmental Impact Assessment*, pp. 189-196.

⁵⁷ S.C Bhatia, *Handbook of Industrial Pollution*, Vol. 1, p. 111.

⁵⁸ Trivedi & Raj, *Encyclopedia Science*, Vol. 25, p. 107.

⁵⁹ Mallow, *Hazardous Waste Regulation*, p. 206.

⁶⁰ Trivedi & Raj, *Encyclopedia Science*, Vol. 25, p. 107.

⁶¹ Chae & Hamidi, Ground Water, David Liu, *Environmental Handbook*, p. 1007.

⁶² UN, *Environmental Management in the Transnational Corporation: Report on the Benchmark Corporate Environmental Survey*, Environmental Series No. 4, (New York: UN, 1993), p. 126.

a waste heap and flush poisons leachate into an aquifer. Burial waste is subject to leaching by percolating rain and surface runoff and contact to ground water fill. The hazard from leachate of a landfill would depend on factors such as the persistence of the waste, site hydrology, depth of groundwater, the attenuation of the constituent in the underground environment and location of the drinking the water.⁶³

5.6.2.4 Water Pollution and Its Impact

Through the history, the quality of drinking water has been a factor in determining human welfare. Waste may pollute aquifers that feed shallow wells on which many low-income families depend. Fecal pollution of drinking water has frequently caused water borne diseases that have decimated the pollution of whole cities.⁶⁴

Soluble organics as represented by high BOD, cause depletion of O₂ in the surface water. This can result in fish kills, undesirable aquatic life, and undesirable odors. Suspended solids decrease water clarity and hinder photosynthetic processes.⁶⁵ Untreated wastes pollute watercourses; destroy fresh water or marine life that may be an economic resource.⁶⁶ The Minatama Bay incident in Japan is one of the most famous cases of poisoning by mercury emitted by a factory, which found its way up the marine food chain into the fish which was eaten by the local people, who suffered severe consequences.⁶⁷

The environmental risk associated with landfill leachate is largely attributable to the presence of high ammonium (NH₄⁺) nitrogen levels that threaten surrounding water. Since it is a potential source of ammonia (NH₃), which poses a significant threat to fish and marine environment. The contaminants are released from LFs to water through physical, chemical, and microbial process and percolate through the unsaturated soil, polluting ground water with organic and inorganic matters.⁶⁸

⁶³ R. Swarup, SN. Misra & VP. Jauhare, eds., *Dimensions of Environmental Pollution, Encyclopedia of Ecology, Environment & Pollution Control* (New Delhi: Mittal Publication, 1992), p. 86.

⁶⁴ S.C Bhatia, *Handbook & Control*, Vol. 1, p. 111.

⁶⁵ Ganter, *Environmental Assessment*, p. 195.

⁶⁶ Sandra J. Contreau, *Environmental Management of Urban Solid Wastes in Developing Countries: A Project Guide* (Washington: WB, 1982), p. 159.

⁶⁷ UN, *Environmental Survey*, Series No. 4, p. 126.

⁶⁸ Mark S. Brown, Timothy S. Clune, Bruce G. Sutton, "Sustainable Management of LF Leachate by Irrigation", *Water, Air and Soil Pollution: An International Journal of Environment*, Vol. 134, No. 1-4, February 2002 (Kuler Academic Publishers), pp. 81-96.

5.6.2.5 Water Pollution in Around Dhaka City

Bangladesh is a riverine country. It has lot of water around everywhere; unfortunately, access to water is not sufficient. The newly adopted international Water Poverty Index (WPI) finds Bangladesh position not among the 10 water-rich nations in the world. The WPI assigns a value of 20 points as the best score for each of its five categories. The categories are capacity, resources, access, use and environment. In Bangladesh, while access and use are relatively moderate scores, the per capita resource and the environment are low, with capacity being no more than average.⁶⁹

Organic pollutants, nutrients, toxic, organic compounds, chemicals, drugs and pathogens (from medical wastes) etc. are the major pollutants, which dissolved oxygen, leading ultimately to eutrophication.⁷⁰ Different types of wastes make the situation worse around Dhaka city water bodies and ground water as well. The industrial discharge from tanneries, pulp and paper mills, textile, dying, and other chemical industries aggravated the water quality of Dhaka and surrounding area. The river Buriganga, Shitalakkha and Turag are indiscriminately used as the dumping place of garbage. One has only to look at the river Buriganga, which is choked with industrial effluent.⁷¹ The organic waste which goes to water bodies need more oxygen for decomposition. So, level of oxygen in water decrease and for this reason fish and other aquatic livings are extinct.⁷²

The minimum dissolved oxygen (DO) at certain sections of Buriganga river was found less than the minimum level required for survival of fish and other aquatic life. The discharge of biodegradable organic wastes in Buriganga causes a decrease in DO and an increase in bacterial production and a change in photosynthetic activities in the aquatic system. The computed and measured DO was found to be lower than the desired level in the Buriganga river.⁷³ River water around Dhaka was tested by DWASA and BCSIR on April 1997 and the heavy metals aluminum, cadmium, chromium, lead, mercury, selenium, and zinc are found. Except selenium and zinc, all other five heavy metals were higher than the recommended standard.

⁶⁹ Enayetullah Khan, "Reflection on Water", *State of World Water*, Qumrul Islam Chowdhury, ed., (Dhaka: WWFJ, MoEF& UNEP, 2003), p. 107.

⁷⁰ Ibid., pp. 86-87.

⁷¹ Ibid., p. 107.

⁷² Dr. Abdul Hamid, "Underground Water Resource: Bane Bashe Boon (Waste goes to water)", *Development Review*, Vol. 11, No. 1 & 2, (Dhaka: January and Jun, 1999), p. 79.

⁷³ M. Firoz Ahmed, "The Effect of Bio-degradable Organic Pollutants on Aquatic Ecosystem of the River Buriganga", Max A Tilzer and Moniruzzaman Khondaker, eds., *Hyper-tropic & Polluted Freshwater Ecosystems: Ecological Basis for Water Reserves Management* (Dhaka: Department of Botany, DU, 1993), p. 78.

5.6.2.6 Wetland Pollution

For the purpose of Ramsar Convention, as adopted in Ramsar, Iran, 1971, wetlands are defined as areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed six meters.

Due to throwing or dumping solid waste into the rivers, lakes and other water bodies seriously pollute the wetlands and furthermore, is creating new problems of water logging and filth, giving rise to additional problems of health, sanitation and environment. Loss of wetlands is causing temperature imbalance and general ecological deterioration. It is also aggravating flood. Indiscriminate waste dumping is resulting in chemical and toxic runoff to surface water bodies. This is causing serious damage to country's fresh water fish stock.

Bangladesh possesses enormous wetlands other than rivers, streams and freshwater lakes. Wetlands are most fertile and productive ecosystems and important breeding grounds for fisheries and other aquatic lives. It is the dynamic interaction of the terrestrial and aquatic system. Wetland also provide habitat for a rich variety of resident. But these wetlands lost their natural beauty and ecosystem due to open dumping and its effect.⁷⁴ The wetlands near and around Dhaka city are seriously polluted due to industrial effluents and solid waste dumps. The river in and around Dhaka city and the Gulshan and Dhanmondi lakes are almost abundant for fishery only because of waste pollution.

5.6.3 Land / Soil pollution

Of all gift of nature, none is more indispensable to men than soil. Soil pollution is usually a consequence of unsanitary habit and inefficient handling of solid and liquid waste.⁷⁵ Each year, human being releases million of tons of industrial and household trash, fertilizer, and pesticides, to the natural environment. If thrown into water the pollutants ultimately set on land as sediment. Therefore, if not properly treated all kinds of effluents and solid wastes finally polluted the land.

Organic materials which contains carbon, are biodegradable, decomposed by microorganisms and disappear relatively rapidly in land. But inorganic products which are increasingly numerous and varied, infiltrate the ground, where they form toxic residues. Discarded automobiles, polythene, plastics are major source of soil pollution.

⁷⁴ M. Salar Khan *et al.*, Eds., *Wetlands of Bangladesh* (Dhaka: BCAS & Nature Conservation Movements, 1994), pp. 2-4.

⁷⁵ S.C Bhatia, *Handbook & Control*, Vol. 2, p. 369.

The automobile batteries contain lead and acid, their oil infiltrates the water table and the plastics and rubber tubes decomposes very slowly. The household trash like plastics, detergents, solvents and heavy metals decomposes very slowly, if ever.⁷⁶ Partly decomposed organic materials specially food and vegetable remaining, toxic hydrocarbons and pathogenic microbes are also liable for pollution.⁷⁷

Effect of Soil Pollution

The use of polluted water containing human excreta, sewage sludge, leachate from waste dumps and chess pool, detergents and trace metals for irrigating the agricultural fields damage the crops and decrease production, together with soil fertility by killing bacteria and soil micro-organisms. The organic contents of wastes are usually beneficial to soil productivity, but its excess is extremely dangerous.

Scenario of Land Pollution in and Around Dhaka

Soil pollution in and around Dhaka city is mainly due to toxic chemical and heavy metals of industrial waste discharge. There is lot of industries in Tejgaon, Hazaribagh and Tongi, Narayanganj. However, Tongi and Narayanganj is out of Dhaka, they also contribute to soil pollution in the region. Heavy metals from different industries seriously contaminated the soil. Major industries and heavy metals liable for soil pollution is shown in table 5.1

Table 5.1
Major industries and heavy metal pollution around Dhaka city

Location of industry	Major industry	Heavy metals (mg/kg soil)
Hazaribagh	Tannery	Cr: 25014, Zn: 330
Tejgaon	Food, Chemicals, Textile	Ni: 84-146, Cd; 163
Tongi	Battery	Zn: 2,026
Narayanganj	Power, Metal, Steel	Pb: 171-158, Ni: 84-116

Source : JICA Draft Final report as stated from S.M. Ullah, Heavy Metals and Industrial Pollution in Bangladesh, in 1st National Conference on Environmental Health, 19-20 February, 2002.

Tannery industry of Hazaribagh contaminate the soil by Cr and Cu, in Tejgaon area fabricated metal product, machinery and equipment, textile wearing, leather chemicals, rubber and plastics etc contaminate the soil by mainly Ni and Cd. Allopathic

⁷⁶ World Almanac Library, *21st Century Science*, pp. 52-54.

⁷⁷ S.C Bhatia, *Handbook & Control*, Vol. 2, p. 369.

and pharmaceutical, pesticides and fungicide, metallic and non-metallic industries also produce heavy metals in Dhaka. Dust discharged from smelter or furnace of those industries is also responsible for soil pollution.⁷⁸

5.7 Solid Waste and Health Hazards

From generation to disposal solid wastes has to pass through lot of events and can cause the public health hazards. During these general sequences of events, non-toxic wastes could become poisonous; sterile wastes may become capable of transmitting disease; non-explosive wastes may cause explosions; and wastes, which apparently have no injury-causing potential, may in fact produce injury and even death. Within a matter of hours in a warm temperature, sterile organic matter, like cooked meat, become a potentially lethal source of toxic or disease-producing organisms. Moreover, there is some disease transmittal elements that transmit the disease from waste dumps to food chain. The blame for disease transmittal must placed especially, on the flies, mosquitoes and rodents. It is estimated that 90% of the urban flies population breeds in the contents of open trash barrels or dumping place. Rats also rely on readily available scraps of food such as those, which are kept in open place.⁷⁹

The putrefying food and animal waste in open containers on street is both environmentally objectionable and hazard to health. The problems are exacerbated when health care (particularly clinical waste that can include human body parts) dead animals, and hazardous industrial waste accumulates with MSW. To make a matter worse, scavengers and animals access the accumulating waste, they seriously risk their own health as well as spread the risk by dispersing components they identify as being of value.⁸⁰ The figure D.10 and D.11 of Appendix D (two photographs) presents the overall public health condition of the solid waste management position of Dhaka city.

Chemical from LF sites may travel through soil and reach rivers, lakes, wells and ground water. Some of the chemicals last a long time and may eventually escape, decades from its disposal. It was proved that wastes might become health hazards long after burial. The mixture of chemicals may badly effect due to the law of synergism. The action of two or more factors, which has an effect that is greater than the simple addition of their separate effects. For example, two substances acting together may cause cancer but acting along can do nothing.⁸¹

⁷⁸ JICA, *Draft Final Report*, Vol. 2, Chapter 2, pp. 37-38.

⁷⁹ Trivedi & Raj, eds., *Encyclopedia of Environmental Science*, Vol. 25, pp. 67-69.

⁸⁰ <http://www.nutriject.com>

⁸¹ Lawrance Pringle, *Lives at Stake* (New York: Macmillan Publishing Co., 1980), pp. 40-43.

The unsustainable management of different types of waste is exacting a heavy toll on human health. The health effects of contamination of air, water, and soil with hazardous wastes may cause carcinogenic consequences, which may be evident after many years.⁸² It was found that toxic wastes that were buried with clay in the area of Love Canal in Niagara Falls in 1953 but were harming local residents that was built in 1970s. During late 1970s, chemicals began oozing to the surface and seeping into basements. People noticed foul odors, some had trouble breathing, unusual number of women suffered miscarriage of children with birth defects, of adults with liver and genetic damage. Eventually about a thousand families were to be relocated from Love Canal area by the government. expense.⁸³

The small particles in polluted air enter deep into lungs and respiratory organs, causing viral and bacterial Acute Respiratory Infection (ARI), the most severe being pneumonia and other diseases like asthma, chronic obstructive pulmonary disease, lung cancer, still births and low birth weight.⁸⁴

5.7.1 Environment Pollution and Health Effects of Open Dumping

The practice of open dumping often creates adverse environmental impacts by not only threatening the health of the people nearest but also their immediate surroundings, which in turn affects their economic and social life. In a survey, medical center located at the On-Nooch disposal site of Thailand reported that 35.1% of the local residents suffer from disease such as asphyxiate, dengue, hay fever, jaundice, tetanus, etc. as compared to any other population, a higher percentage of potential suffering from skin diseases were also reported in the area. A sample of leachate and stream water alongside the landfill at On-Nooch sites was tested. Physical parameters (temperature, suspended solid, color) chemical parameters (P_H , alkalinity, DO, COD, total phosphorus, total nitrogen chloride and biological parameters (BOD, Coliform) were analyzed to determine the existing water quality for both leachate and stream water. Heavy metals found in water are very dangerous.

People in some occupation for example, scavenging in dump sites in many poor cities are particularly vulnerable.⁸⁵ The effect of open dumping are discussed as follows:

⁸² World Bank, *Development and the Environment*, p. 55.

⁸³ Pringle, *Lives at Stake*, pp. 40-43.

⁸⁴ UNEP, UNCEF & WHO, *Children in the New Millennium* (Malta: UNEP, UNCEF & WHO, 2002), pp. 15-20.

⁸⁵ World Bank, *Development and the Environment*, p. 55.

- a) **On physical resources.** The surrounding areas water quality and aquatic environment would be poor. Soil of surrounding area is contaminated as the result of direct discharge of leachate to the surrounding area creating accumulation of toxic substances in the soil. Leachate drainage will carry various kinds of pollutants including BOD, COD, $\text{NH}_3\text{-N}$ and toxic heavy metals, most of which may be harmful to the vegetation growth.⁸⁶
- b) **On ecological resources.** It was found that there is a high concentration of contaminates which can be readily released to the ecosystems receptors -biota, soil and water. Hence, adverse environmental impacts could be expected on ecological resources, including valuable fish or other aquatic lives.
- c) **Quality of life values.** The quality of life are discussed from socio-economic and health aspects. Socio-economic value is the thought of having a dumping site near the house is not appealing to most people. Frequent opposition by the localities and complaints is regular phenomena. The objection is usually associated with bad odors, flies, water pollution, traffic congestion etc.⁸⁷ Open dumping causes public health problems by encouraging the growth population of flies, rats and cockroaches, and mosquito.⁸⁸
- d) **Aesthetic values.** Toxic gases like CO_2 , NH_4 , and hydrogen-sulfide are produced as a result of decomposition of organic waste. These gases produce an extremely offensive odor and certain concentration may cause detrimental effects on aesthetic values.
- e) **Solid Waste and Biodiversity.** Biodiversity has three main dimensions: the genetic variation within species and population, the number of species, and habitat preservation. Biodiversity is a sort of immune systems husbanded by previous generations. To pass it on undiminished is each generation's change.
- f) **Green House Gas Pollution.** Another possible hazard of landfills is uncontrolled production and escape of methane gas, generated as organic wastes decompose. If the methane concentration is more than 5% in the air, there is a possibility of explosion. For example, gas generated in Ohio Landfill migrated several hundred meters through a sandy soil to a housing area, where one home exploded and several others had to evacuate.

⁸⁶ S. Muttamara and Shing Tet Leong, "Environmental Monitoring and Impact Assessment of a SW Disposal Site", *Environmental Monitoring and Assessment*, Vol. 48, 1997), p. 17.

⁸⁷ Ibid., p. 21.

⁸⁸ Trivedi & Raj, *Encyclopedia Science*, Vol. 25, p. 117.

Pollution Cycle and Path

Whether solid wastes are released into water, the air, or the ground, pollutants disperse quickly into an ecosystem. Eventually, they enter a food chain and are transmitted from species to species, up to human beings. Pollutants released by human into the environment contaminate the water, air and land and ultimately enter human bodies by different paths, including the atmosphere from where all the living being take breathe, the plants and animals they eat and the water they drink.

Hazardous wastes pollutants from a solid waste disposal site can enter the environment by as many as six paths: a) components volatilised in the soil and fill after placement, such as methane, ammonia, hydrogen-sulphide and nitrogen gases may enter the atmosphere; b) heavy metals such as lead, chromium, and iron are retained in soil; c) soluble material such as chloride, nitrate and sulphate readily pass through the fill and soil to the ground water system; d) overland runoff may also pick up leachate and transport it into surface water network; e) some crops and cover plants growing in the disposal area may selectively take-up heavy metals and other toxic materials to be passed up the food chain as people and animals eat them; f) plant residue containing toxic substances, will return these materials to the environment through soil-farming and run-off processes.⁸⁹

5.7.2 Hazardous Wastes and Pollution

The RCRA defines toxic wastes that pose a substantial present or potential hazard to human health or the environment by significantly contribution to serious irreversible or incapacitating reversible illness.⁹⁰ Hazardous wastes are any waste that is ignitable, corrosive, reactive, or toxic. The danger is that these wastes may pollute ground water used for drinking and soil used for grazing and firming.⁹¹

All toxic wastes are hazardous but not all hazardous wastes are toxic. A wastes is hazardous if it poses a direct and immediate peril, the environmental equivalent of a 'clear and present danger.' For example, acid or alkaline wastes are hazardous but not toxic: they eat through clothing and burn flesh. Such corrosive wastes seldom threaten pollution downstream or downwind. By contrast, dioxins are toxic. The peril they pose is not confined to persons nearby. They may eventually poison water supplies and so human beings. Toxic wastes evoke terror precisely because their effects can be insidious and remote.⁹²

⁸⁹ Keller, *Environmental Geography*, pp. 256-257.

⁹⁰ Swarup, Misra & Jauhare, *Dimensions of Environmental Pollution*, p. 88.

⁹¹ James A. Lee, *The Environment, Public Health and Human Ecology* (Baltimore and London: The John Hopkins University Press, 1985), pp. 43-47.

⁹² Swarup, Misra & Jauhare, eds., *Dimensions of Environmental Pollution*, p. 86.

5.7.2.1 Medical Waste Impact

Hospitals and clinics are often disposing indiscriminately their harmful clinical waste into the municipal bins causing serious health and environmental hazards. Infectious and hazardous clinical waste comes back to the users as new one in recycled form by unscrupulous traders leads to serious human health hazards. About 2-4% of the total SW from hospitals may be regarded as potentially hazardous due to infectious nature. It contains highly infectious pathogens and dangerous chemicals. An infectious agent is any organism (such as a virus or bacteria) that is capable of being communicated by invasion and is able to multiply in a body tissues resulting in disease or adverse health effects in humans and or animals.⁹³

The improper handling of this waste poses a threat on not only the environment but also the public health. This waste affects the people at every stages of its life cycle either physically or biologically. Waste handling workers in both hospitals and in conservancy crews may be most amenable group that can be affected by clinical waste.⁹⁴

Rag picking children and waste pickers collect contaminated needle, syringes, blood bags, IV bags and other medical items.⁹⁵ These often come back to customers after washed and repacked by dishonest dealers with treatment that may leads to deadly diseases like hepatitis or even AIDS.⁹⁶

5.7.2.2 Industrial Waste Pollution

As long as man produces goods, so long waste will be produced as an unwanted by product with negative value. Industrial effluent is perhaps the biggest menace of industrialization leads to serious pollution. Even the solid waste produced there contains chemical and toxic elements poses environmental hazards.⁹⁷ Most non-biodegradable pollutants in the soil come from industry, which release more than 700 substances. Mercury used on batteries and paints causes serious sensory and motor problems in human beings.

These effluents contain ammonia, chromium, and other heavy metals, from fertilizer, tanneries, mercury from cholera alkali units, and phenols from pulp and paper

⁹³ M.F. Simpanya, "Biomedical Medical Waste Management in Developing Countries", *Pollution Control*, p. 304.

⁹⁴ JICA, *Draft Final Report*, Vol. 2, Chapter 2, pp. 8-11.

⁹⁵ J. Hasan, "Managing the Hospital Waste", *Bangladesh State of Environment* (Dhaka: Ministry of Environment & Forest, 2001), pp. 241-246.

⁹⁶ *Asia Pacific Technology Monitor*, Vol. 21, No. 3 (May-June 2004), New Delhi, India. p. 28.

⁹⁷ Banargee, "Pollution: Natural Process", *Environmental Pollution*, p. 255.

refinery, plastic, pharmaceuticals and paint industry.⁹⁸ Industrial waste contains more or less chemicals. Chemicals can be released in solid, liquid or gaseous form into air, water and land. All chemicals are toxic to some degree. The health risk from any particular chemical is a function of toxicity and exposure.⁹⁹ Cadmium (heavy metal) come from industrial waste effluent discharged into the surface water and finally reaching into irrigation and underground water tables. Continuous discharge of industrial wastes also results in dissolved oxygen depletion thus, destroying aquatic lives. Ultimately it goes to food chain and causing bone cancer.¹⁰⁰ Poisonous residues from the industry carelessly deal today can produce calamities miles away and decades later. Dioxins are lethal, capable of killing people in concentration as diluted as one part in a million.¹⁰¹

5.7.2.3 Tanneries Waste Impact in Dhaka

The 277 units of tannery industry located in the western part of Dhaka, has in fact, turned the areas into a 'waste land' or dumping ground.¹⁰² Tannery industry is ranked as the highest polluter of soil for both hazardous chemicals and heavy metals. The main chemicals used in this industry are sulfuric acid, chromium, ammonium sulfate, ammonium chloride, and calcium oxide. In the pre-tanning stage hides are soaked to remove blood, dung, curing salt, water soluble and saline soluble proteins.¹⁰³

Only 2 tanneries of Bangladesh have the treatment facilities of liquid wastes. As a result, the entire liquid tannery wastes carried by the DCC drains deposited in the low land and ultimately goes to the Burigangda river and rainwater. Flies carry germs from the rotten flesh to the foodstuff particularly in the adjacent hotels. The shaving and buffing dust mixed with air and entered into lungs may cause bronchitis and cancer. Poor people in the areas used dried shaving dust as fuel for cooking. After sweating and slaving in the deadly tanneries all day long, they have to spend the nights in the same unhygienic condition.¹⁰⁴

Heated the chromium trivalent of the shaving dust transform into chromium hexavalent. Both the trivalent and hexavalent forms of chromium are extremely harmful

⁹⁸ O.K. Ahmad, Nilufar Ahmad and K.B. Sassadur Rashid, eds., *Resources, Environment and Development in Bangladesh* (Dhaka: BUP & Academic Publishing, 1994), pp. 105-107.

⁹⁹ Jon E. Gould, "Solid Waste Reuse and Recycling and Reuse", *Pollution Control*, p. 358.

¹⁰⁰ Shamsuzzoha, *Dhaka City's Waste*, p. 818.

¹⁰¹ Swarup, Misra & Jauhare, *Dimensions of Environmental Pollution*, pp. 84-85.

¹⁰² Philip. Gain, ed., *Bangladesh Environment: Facing 21st Century* (Dhaka: SHED, 1998), p. 278.

¹⁰³ JJCA, *Draft Final Report*, Chapter 7, p. 10.

¹⁰⁴ Gain, *Bangladesh Environment*, p. 278.

for the human physique.¹⁰⁵ Among other pollutants, chromium adversely affects the fish and other aquatic vertebrates.¹⁰⁶

5.8 Solid Waste Impact In and around Dhaka

The South East Asian region faces enormous environmental problems, including resource depletion and ecological degradation, indoor and urban air pollution; lack of access to clean water supplies and sanitation, toxic and hazardous industrial/clinical waste generation and disposal and vulnerability of natural disasters. Bangladesh is becoming industrialized in a very slow pace. With industrialization process and with some other social reasons the environmental degradation is undergone alarming position. (BEN) Air pollution causes approximately 130,000 premature death annually in Bangladesh.¹⁰⁷

Loss of biodiversity

Due to waste and waste related compounds are responsible for extinct process of bio-diversity. A diversity of biological species is essential to maintain the planets life-sustaining balance.¹⁰⁸ Loss of wetlands is also leading to loss of its flora and fauna. Many species of freshwater fish and other aquatic animals and vegetation have now become either extinct or rare. Many land-based animal species and plants are also become extinct. Geographically, Bangladesh is becoming an uninterested part of the world. The biological as well as plant species could be extinct through the process of mishandling solid wastes.¹⁰⁹

Imbalance of Eco-system

Microorganisms are always present in the environment and given the right conditions of food availability, temperature and other environmental factors, they grow & multiply. In a natural water body i.e. river, lake the number and type of microorganisms depend the degree of pollution. The general effects of pollution appear to be a reduction in species numbers. For example a badly polluted lake, there are fewer species but in larger numbers, while a healthy lake there can be many species but in lower numbers or in balance manner.

¹⁰⁵ Gain, Philip & Moral, *Leather Industry: Environment Pollution & Mitigation Measures* (Dhaka: SHED, 2002), pp. 11-26.

¹⁰⁶ M. Salar Khan *et al.*, eds., *Wetlands of Bangladesh* (Dhaka: University Press Ltd, 1994), pp. 50-51.

¹⁰⁷ WB, *Environmental Matters, World Bank Magazine* (Washington: WB, 2001), p. 44.

¹⁰⁸ UN, *Environmental Management*, Environmental Series No. 4, p. 126.

¹⁰⁹ *Ibid.*

From January 2002, the use of polythene (20 micron thick) was banned in Dhaka city and from July on from the country. But the poly bag is now again started in the different form. The polythene bags is seriously polluting the soil and water and adversely affecting the environment and the bio-diversity. The poly bags are not biodegradable; they remain intact in the ground forever and destroy soil fertility. In the existing polythene, recycling process emits poisonous smoke and causes serious public health hazards. It is injurious to human health and is a major factor responsible for cancer and other skin diseases.¹¹⁰ The recent discovery of mercury in fish intended for human consumption is an example. In view of the known effects of mercury in enzyme system is harmful to human body.¹¹¹

Squatter settlement Impact in Dhaka

The absence of provision for the collection of household wastes within low-income settlement also contributes to the likelihood of facial contamination and the large disease burden things bring. Most informal settlements have no service to collect solid waste. The uncollected garbage along with excreta is often disposed of in drainage, ditches, which can become quickly clogged. These wastes create the blockage in drainage system and organically polluted water becomes a breeding place for certain disease vectors, i.e. the flies, mosquito etc. Where the inadequate provision of waste collection as much of the uncollected waste generally finds it way into water bodies adding to the pollution.¹¹²

Sewage Sludge Impact in Dhaka

Recent findings at the university of Toronto indicate "alarming amounts of cadmium and lead occur in sewage sludge which is used as fertilizer for food crops. These metals could be assimilated by crops in amounts harmful to human and animal health. Medical evidence reveals a correlation between cadmium and hypertensive, cardiovascular, and respiratory problems. Lead can bring about brain damage or death. Vireo cholera found in sewage sludge causes for cholera."¹¹³

¹¹⁰ Kazi Shahnaz and Reazaul Karim, "Out Goes Polybag in Comes Jute Bag", *Bangladesh State of Environment Report 2001*, Quamrul Islam Chowdhury, ed. (Dhaka: WWF, MoEF, and UNDP, 2001), pp. 27-32.

¹¹¹ Banargee, *Pollution: A Natural Process*, p. 255.

¹¹² Quamrul Islam Chowdhury, ed., *Air Pollution in Asian Cities* (Dhaka: FEJB, MoEF & UNDP, 2000), pp. 173-174.

¹¹³ Trivedi P. R & Raj, Gourdeep. eds., *Encyclopedia of Environmental Science*, Vol. 25 (New Delhi: Akashdeep Publishing House, 1992), p. 80.

5.9 Chapter Summery

The natural environment is being polluted throwing extraneous substances into environment by human being. Solid wastes are one of the major substances that caused human health and overall environmental degradation. Environment is the physical, chemical, and biotic condition of any given surrounding living organism. Environment pollution is undesirable and unhealthy change in the general condition of environment caused by directly or indirect process of human living activities. Solid waste often called the third pollution after air or water pollution.

Solid waste is treated as pollutant if otherwise not recycled or reused. There are three major categories of risks associated with waste, namely: aesthetic, environmental ad health. Hazardous elements associated with solid waste are leachate, heavy metals, odors, and other particulate materials. Open dumps, scattered throwing, simple landfill, incineration plant, and all poses threats to environment.

Air pollution from open burning, incineration ash, particulate matters, odors for waste decomposition are very common. Both fly ash, and bottom ash of incineration plant is responsible for air pollution. Greenhouse effect from methane gas if concentrated more than 5% is another pollution. Landfill leachate is the major sources of water pollution. Whatever the amount leachate generation is obvious in waste heap or landfill. Rainwater or surface water percolation always increases leachate generation. BOD, COD, nitrate, chloride, alkalinity, trace elements, and toxic constituents are the ingredients of leachate. Leachate is dangerous contaminants of water and land pollution. Both surface and ground water may be polluted by leachate. Leachate containing water can also pollute the land if irrigated. The polythene and other solid waste is liable for water clogging and lessen fertility of the land.

The aquatic life and bio-diversity is being lost for un-controlled open dumps. The contaminants released from open dumps hamper the eco-system particularly extinct the valuable fish and aquatic lives. The light blowing solid waste, odors are injurious to public health and unaesthetic. Solid waste heap is unsightly and unwanted view for tourism sector development. Mal-odors, flies, rodents, other diseases vectors are very common in the open dumps and causes public health concern.

Solid waste is one of the major environment pollution sources of Dhaka city. Uncontrolled open dumps contaminate air, water and land pollution of the surrounding areas. Flies, mosquitoes, rodents, and other diseases vectors are very common in the city for inefficient solid waste. Water congestion in the drain is very common. The surrounding rivers and lakes are mostly contaminated and became unfit for fish and other aquatic lives. Industrial and clinical waste poses environment pollution and also causes serious public health concern. Uncontrolled infectious clinical waste recycling is identified as most dangerous to public health.

Chapter 6

Causes of Inefficient Solid Waste Management in Dhaka

6.1 Introduction

Typical solid waste management systems in developing country displays plethora of problems including low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control mechanisms. Every sorts of waste are problematic for handling and disposal but solid waste problem is double folds. In case of gaseous wastes the problem is the volume of waste to handle; for liquid waste, the problem is the variety of constituents; but in case of solid waste, the problem is both.¹ Solid waste disposal, due to of its nature, allows doing three things. The first one is to burn it; the second is to burry it in a hole with a cover and third one is to treat it using biological methods to make it a reasonable product. Only incineration and landfill or burial methods are final disposal consideration but the third, composting is mentioned here may offer a valuable answer to desperate the problem. Composting is not appropriate everywhere due to nature of solid waste, moisture content, marketability etc.

The developed country has been able to manage their solid waste with the support of technological advancement and huge financial investment. The developing countries are confronting with this problem because they cannot introduce high tech facility as well as budgetary constrain. So they have little options to introduce modern solid waste management systems instead of the option of simple collection and make a heap of garbage in a crude open dump as disposal means. The public health issue and environmental pollution are the two major challenges of solid waste management. From generation to final disposal there are many problems or challenges are to face in solid waste management.

6.2 Causes of Inefficient SWM

Solid waste management in Dhaka City is the responsibility of DCC. DCC is facing enormous problems or challenges in this regard. It is facing some operational problems and some basic socio-economic barriers. The broad constraints are **firstly**, solid waste is low perceived matter and given less important by the policy makers as well as by the generators. **Secondly**, the City Corporation has the lapses of technical, financial, and

¹ Herbert F. Lund, *Industrial Pollution Control Handbook* (New York: McGraw-Hill Book Co.,1971), Chapter 7, p.7.

managerial capability. **Third and final** one is the peoples perception and participation is not well enough for a sound and environment friendly solid waste management. These three broad challenges are closely related with waste generation to final disposal and will discuss in phase. Generally waste management operational problems are related with primary and secondary collection, processing, treatment, and disposal options. The operational problems and basic SWM problems are discussed here systematically.

6.3 The Operational Causes

Dhaka City Corporation has to manage 3,667-t/d solid wastes daily. All of these wastes are not placed into the bins or containers or primary disposal places fixed by the DCC. A large volume of waste is scattered around the bins, roads and here and there. Litters are diluted and thrown away by scavengers, birds, and cattle. The situation is exerbated by the behavior of residents who dump waste next to the bins or containers instead of into them and some people through plastic bags containing waste from balconies. DCC has to cover all the occurred to manage solid waste. In its daily operation, it is facing lot of operational barriers. These are as follows:

6.3.1 Poor projection of generation and accommodation due to lack of vision

The volume of total generated waste in Dhaka city is ambiguous. For the last 5 years it is said that around 5000 tons of solid waste generated in Dhaka city. There was no survey about it. According to JICA study, it is 3200 tons in the Dhaka City Corporation area. The present study reveals that total volume of solid waste generation is 3,667 t/d in DCC area. Though the vision about the volume of generation was very poor, planning and accommodation was also poor.

The waste includes non-hazardous common solid waste, infectious and hazardous waste. There is no provision of source separation. The present study found that more than 95% of the respondents do not separate the kitchen residues from others. If it is not separated in source of generation, it is difficult to segregate in primary or secondary collection. As a result, the infectious hospital wastes or toxic and chemical wastes are not separate from other MSW. Every kinds of solid waste are indiscriminately dumped into the landfill sites, which create serious health hazards and environmental degradation.

6.3.2 Causes of Inefficiency in Primary Collection

There is no uniform time of garbage disposal from household or other source of generation. The present study found that the generators covers 49% of the primary

collection and CBOs and NGOs based community primary waste collectors cover 51%. Whenever, in the day or night, the generators could dispose their garbage to the dustbins or disposal places. The present study reveals that almost half of the households do not have specific time of waste dispose. The households dispose their waste with Jhury (bamboo or plastic made) or something like that, which litters the garbage into the street. 35% of the respondents replied that those who dispose refuse, do not keep the garbage into the bins rather 31% throw the garbage from distance of dustbins or near the bins. CBOs also do not maintain the time schedule of door-to-door collection. Furthermore, some households often dispose their waste without any bags or containers which makes waste more scattered and slowdown collection.

There are no guidelines or rules for primary collection. Structures and roles of the various actors are not clearly identified and informed to the public. There is no platform of discussion and coordination about development of the program and the program is not transparent to the stakeholders. Different actors are making efforts following their own concerns and interests. Therefore, there are some conflicts between service providers and stakeholders. DCC is monitoring and coordinating the CBOs and NGOs engaged in primary collection services. Conservancy inspectors and Ward Commissioners do not always grasp all primary collection by service providers. Primary service is not synchronized by DCC and it causes waste scattering around dustbins and containers.²

6.3.3 Causes of Inefficiency in Secondary Collection

Inappropriate waste container designs and resultant time consuming and unhygienic loading procedures as well as scavenging operations also hamper collection efficiencies. Containers are not well distributed, old and ill maintained. Vehicles are often incompatible for containers and rarely suitable for collection in the narrow streets. Most of the waste collection vehicles are imported, which means they are costly to replace, and require spare parts that are costly and difficult to obtain. Vehicle procurement does not take into account of waste characteristics. Poorly equipped workshops and inadequate maintenance increase downtime and reduce the working life of the vehicles fleet. Also lack of street sweeping equipments and proper supervision, sweeping does not cover all street, particularly in small lane and by lane.

² JICA, Draft Final Report, Vol.2 Chapter-3, p. 1.

The growing urbanization increased the generation of urban solid waste; so it needs more infrastructure, equipments, technology and efficient management systems. Relatively poor management of urban wastes is reflected in degradation of living environment in urban areas. Weak infrastructure and poor financial status lead the city authority reluctant in secondary collection. All the dustbins and containers can hold only 1718 ton solid waste. Therefore, around 2000 tons solid waste is usually lying down in the open space at roadsides or elsewhere on the roads. Most of the urban solid wastes in Bangladesh largely comprises of biodegradable substances. High moisture and organic content coupled with high prevailing temperatures needs necessarily frequent removals. The collection of refuse presents peculiar problems as household wastes are thrown out indiscriminately. In addition, due to narrow road, lane, and by-lane, collection vehicles can reach only selected accessible points.³ Though, the condition of Dhaka city is not different from other cities of developing countries. The secondary collection does not follow stipulated timing, obstruction made by construction materials in roadside and people are not cooperate regarding secondary collection are identified as working barriers.⁴

In the key-informant discussion, some of the conservancy inspector opined that after clearing the transfer station (dustbin site) the householders, commercial operators etc., are placed waste again on the same dustbins or places and this garbage lies in the dustbins for long 24 hours for next day collection. Therefore, the Dhaka city cannot keep clean due to this reason. 45% of the respondents responded on another problem that they disposed the silly matters like banana peel, nutshells, packets, cigarette parts etc. on the street. Therefore, the secondary collection cannot keep the city clean all along.

6.3.4 Causes of Inefficiency in Treatment and Disposal

There is no solid waste treatment facility in the city. DCC is simply collect the garbage, transported to the disposal site, and finally disposed in the form of open dumping. Disposal of waste is problematic in Dhaka city due to limited availability of land and improper controls on dumping procedures. It causes odor, litter, and smoke nuisance as well as posing health risks to nearby communities. Flies and rodents are very common in the site, which further aggravates the environmental problem.

³ A.P Jain, G.B. Pant, "Solid Waste Management in India", Johh Pickford, et al eds. *Affordable Water Supply and Sanitation* (London: WEDC, 1994), pp.92-93

⁴ JICA Draft Final Report, Vol. 2, Chapter-3, p. 7.

6.3.5 Location of Dumping Site

Only one or two disposal sites in Dhaka are more costly and time consuming due to distant corner of city. The south-eastern and south-western part of Dhaka city is mainly composed of fluvial sediments and the thickness of clay layer is lesser. The stratigraphy of Dhaka city reveals that the thickness of impermeable clay layer, underneath the city, generally ranges between 5 to 10 meters. This is not suitable for landfill site.⁵ Water level in this region rises during monsoon period. The major portion of groundwater of Dhaka city is recharged from rivers. If the landfill site is situated in this area, it could contaminant from open dump mix with urban runoff and fall into the surrounding rivers. Thus, the surface water in the rivers and adjacent lowlands are contaminated. The thinner impermeable clay layer, which cannot significantly, prohibits the leaching contaminants to move around. So the contaminated surface water and the leachate itself go down and contaminate the groundwater.⁶

It is noted that there are several place filled and/or dumped by solid waste along the flood protection bandh. It is necessary to stop illegal dumping along in different places. Matuail is the only one official site and all the garbage transported to Matuail is too costly.

6.3.6 Landfill Design

The main environmental threat creates from land filling is water pollution. A landfill should be sited where the geological and hydrological characteristics are least likely to allow impacts on groundwater or surface water.⁷ The site has no liner and no cover mater. There is no compaction and slope in garbage heap. The rainwater percolate into the garbage and leachate is very common to create serious surface and ground water contamination. There is no leachate collection system and do not have gas removal mechanism in the landfill site. From the geomorphologic and geological observations⁸, it could be said that dumping site without liner or leachate treatment facility is not suitable in around Dhaka city. Foul odour from open landfill, methane gas, flies; rodents and vectors are very common which create devastating environmental pollution of the city.

⁵ K. M Nurul Huda, "Municipal Solid Waste Management-Dhaka City Perspective", *Bangladesh Environment* 2002, p. 742.

⁶ M. A. H. Bhuiyan, N.E. Huq and M. M Hossain, "Unplanned Waste Disposal and Its Possible Impact on Subsurface Environment of Dhaka City", *Bangladesh Environment*, pp. 723-731.

⁷ The World Bank Group, *Pollution Prevention and Abatement Handbook 1998: Toward Cleaner Production*, (Washington: the World Bank, 1999), pp. 146.

⁸ Bhuiyan, "Unplanned Waste Disposal and Its Possible Impact on Subsurface Environment of Dhaka City", p. 729.

6.3.7 Waste picking / Recycling

Recycling is widely practiced throughout the city predominantly through the informal sector, which recovers paper, cartons, plastics, metals, glass, and textiles. The waste is frequently scavenged in unsanitary conditions. Among the places of recyclable waste collection, those conducted around dustbins or containers cause negative impacts to keep the street clean and to remove waste efficiently because they scatter the waste around there for their convenience.⁹ The scavengers do not return the waste to the bins and create collection problem for secondary collection. It produce unsightly and odorous scenario around the dustbins or roadside.

The government of DCC has no control over the recycling. In this reluctant situation, infectious and hazardous wastes are washed, clean and repacked into new package and came back to the market through unscrupulous traders. The heterogeneous clinical waste is recycled and creates the probability of human health concern.

6.3.8 Composting

Management of composting is considered a worthwhile option for waste treatment. DCC do not have any composting plant. One small composting firm "Waste Concern" a NGO is making compost with the financial help of SEMP project. Existing composting plant sometimes suffer from lack of marketing skills and technical experience. Financial sustainability of composting operations has not been proven yet. There is a doubt that without the financial help Waste Concern can not be able to survive.

There is only one composting plant in Dhaka city uses 9-10 t/d organic waste. They are operating in lower level in respect with weekly demand of compost product. Compost is a good soil conditioner but due to its bulkiness, odors, and public consciousness it could not be proven very good. Waste composting contributes very little to the waste reduction though the compostable waste shares the largest portion of generated wastes.

6.3.9 Indiscriminate Mixture of Hazardous Waste

Generation of clinical waste is estimated to be 15 ton per day in Dhaka. Some major hospitals in the city have no incineration facilities for safe disposal. However,

⁹ JICA Draft Final Report, Vol. 2, Chapter-3, p. 9.

clinical waste are found at most disposal sites, as does hazardous waste from other sources like industries, slaughterhouses, households and agriculture. The quantities of hazardous waste are unknown and are not being routinely separated from the waste stream. It poses health risks to the collectors; scavengers and eventually the community are high. The industrial toxic and hazardous waste like tannery waste is mixed with MSW and indiscriminately dumped to the sites creates serious health and environmental concern. Moreover, lot of toxic and detrimental chemical waste is mixed and disposed into the river and other water bodies to contaminate the surface water. The river Buriganga, Sitalakkhma, Balu etc around the city is seriously polluted for solid waste and industrial effluent. The Dhanmondi and Gulshan Lakes and canals of Dhaka city are under serious threat of indiscriminate waste disposal.

6.4 Basic Socio-Economic Causes

Other than operational constraints, there is lot of barriers hindering the solid waste management. The basic socio-economic causes of solid waste management challenges can be classified into six groups such as technical, financial, institutional, economic, and social constraints.

6.4.1 Technological Causes

Most of the developing country is typically lacking technological advancement. Usually they hire technology from developed countries as technology transfer. Technology transfer is the exchange of technical knowledge, data, designs, inventions, or trade secrets from one organization to another or from one application to another application.¹⁰ In the developing countries, there is shortage of human resources at both the national and local levels with technical expertise necessary for solid waste management. There is no categorization of source of generation and no mechanism of source segregation. If solid wastes are stored in separate container it would be helpful for transportation and final disposal. Moreover, the segregated wastes caused minimum environment pollution. There is no matching design between primary collection vehicle and secondary collection vehicles.

Many officers in charge of solid waste management, particularly at the local level, have little or no technical background or training in engineering or management. The

¹⁰ S.C Bhatia, *Handbook of Industrial Pollution & Its Control*, Vol. 1, (New Delhi: CBS Publishers and Distributors, 2002) p. 28.

disposal facilities are in deplorable conditions because there is no initial environmental concern and sensitive planning due to lack of technical expertise. In the DCC, the Chief Conservancy Officer (CCO) is a Naval Officer working on deputation having no conservancy experience. Without adequately trained personnel, a project initiated by external consultants could not be continued.

In DCC, conservancy function is run by collaboration with transport department and mechanical division. There is big problem of coordination among these three departments. There is a lacking in the coordination between transport, mechanical and conservancy department. Transport department monitors and control the activity of fleet of vehicles. Procurement, maintenance and management lie with mechanical department. Conservancy cannot command and control over the man & mechanics of the transport and technical department though the full responsibility to keep the Dhaka clean and waste disposal, rest with conservancy department.

There is a limitation of using heavy equipment in the final disposal site. There are 42 heavy equipments for landfill but 17 are out of order. Tire dozer is effective to remove solid waste at dumping platform though it is not commonly used at landfill site.¹¹ The roads and drains are cleaned by manual labors with hand broom and spade. No sophisticated equipment like road vacuum cleaners is used for cleansing operation.

6.4.2 Economic Causes

The total economy of a country has a key role of waste generation and management. Economic and industrial development plays key roles in solid waste management. Obviously, an enhanced economy enables more funds to be allocated for solid waste management, providing a more sustainable financial basis. However, by definition, developing countries have weak economic bases and, hence, insufficient funds for sustainable development of solid waste management systems.

Bangladesh is one of the developing countries with a US\$ 440 per capita income. The annual progress for the last five years is 5.5%. Most of the development budget is to prepare on the basis of foreign aid and donation. The economic base is very weak. Accordingly, DCC is not economically a viable organization as poor country budget. Income and expenditure of 2002-03 will give the actual position of the DCC (table 6.1).

¹¹ JICA Draft Final Report, Vol. 2, Chapter 2, p. 30.

Table 6.1
Table no 6.1 Financial Balance of DCC for the year2002-2003

Income (in million Tk.)		Expenditure (in million Tk.)	
Opening balance	286	Rev. exp. Salary/wage	634
Revenue income	1,828	Other revenue expenditure	504
Government grant	463	Development expenditure	1,241
Special government grant	285	Local	291
	2,575	Total expenditure	2,670
Total		Closing balance	216
Opening balance + income	2,886	Expenditure + closing balance	2,886

Source : JICA Study Team

From the above table, it is clear that the economic condition of the DCC is not well enough. It is confronting with economic problems, because it is not self sustained but dependent to government grant for its development work.

Economic incentives to reduce waste generation or to recycle waste are also lacking. DCC or government does not have any incentive program for the factories or recyclers who are contributing through recycling or using the recycled raw materials. Community-based initiatives exist in solid waste management in Dhaka and they have problems with fee collection and lacks support of the government.

6.4.3 Financial Causes

In general, solid waste management is given a very low priority in developing countries, except perhaps in capital and large cities. As a result, very limited funds are provided to the solid waste management sector by the governments, and the level of services required for protection of public health and the environment are not attained.

In African countries, the central government generally finances MSWM and other municipal activities. The municipality also collect household refuse taxes. This amount is insufficient for municipal waste handling. It has to subsidies by the municipal budget. The municipality is funded by the concern ministry for capital projects and other special projects. It does not accommodate the actual budget required for the MSWM program, projects, and operations. User fees are based on a flat rate for collection service to households and commercial establishments. Where this service is provided by the private sector it is likely that the fees yield full cost recovery plus a profit for the service provider. In Dakar of Senegal the municipal tax is imposed by the government and collected by the treasury. In Bamako a cleansing tax based on property value is levied

and direct user fees are also employed. Financing options includes government allocation, taxes, user fees, bank financing (for private service providers) and international aid.¹²

The conservancy department has an income of conservancy tax. It is only 16.66% of the total revenue income of DCC. The total revenue income of DCC is the 12% of the taxes of rental value of the city dwellers out of which only 2% for conservancy sector. The conservancy income was Tk.176 million and expenditure was Tk.476 million in the year 2002-03 and there was a deficit of Tk.300 million. Almost every year the deficit is increasing due to more waste handling. DCC in general and conservancy in particular has to depend on the additional budget for conservancy expenditure.

The conservancy service is not cost effective. The service is dependent on financial allocation. Pursuing the cost recovery, it is necessary to revise the conservancy tax. The law says that the ceiling is 7% on property value. Currently, DCC imposes only 16.66% of rental value. The taxation ground of 16.66% of rental value supposedly comes from a notification made in 1962, according to revenue department. It is easy to understand that the main SWM at that time was to clean exclusively roads, which could allow that percentage as compensation toward services rendered. Now that the public recognizes SWM has changed and diversified dramatically, this taxation rate should be revised realistically. At present only 70% of the tax is collected.¹³ Reassessment of tax and collection level should be increase at least required to cost recovery of solid waste management expenditure.

6.4.4 Institutional Causes

The normal urban services is lacking behind than the standard in Dhaka. To cover the backlog, the urban infrastructure needs to be doubled and in some case tripled within next decade. It is an overwhelming development challenge for a resource constraints country like Bangladesh.¹⁴ Several agencies at the national level are usually involved in solid waste management. However, there are often no clear roles/functions of

¹² Brihton Kaonga, "The Application of Appropriate Technologies in Waste Management in Developing Countries", *Pollution Control*, pp. 381-399.

¹³ JICA, Draft Final Report, Vol. 2, Chapter 3, p. 19.

¹⁴ Qazi Kholiquzzaman and Ahsan Uddin Ahmed, eds., *Bangladesh Citizens Perspective on Sustainable Development* (Dhaka: BUP, 2002), p. 152.

the various national agencies defined in relation to solid waste management and also no single agency or committee designated to coordinate their projects and activities. In Bangladesh the City Corporation or Municipality, Water and Sewerage Authority (WASA), Ministry of Local Government, DoE etc. are direct or indirectly involved with cleanliness and waste management. For Dhaka city, DCC is directly linked with the solid waste management.

There are three departments of DCC mandated for solid waste management. They are conservancy, transport and mechanical division of engineering department. However, there is no clear identification of roles/functions of these departments. So there is gap among them and it hampers the solid waste management. Disordered of vehicles, inadequate and faulty design of bins, irregular and partial clearing by conservancy workers made the situation worse.

DCC has lot of limitation in solid waste management. These are:

- ❑ **DCC's capacity of collection vehicles:** There are 358 unit vehicles of different capacity for collection and transportation. out of them 65 units are under repair. The number of drivers in the conservancy pool is less than the number of open trucks and container trailer. Therefore, on an average 300 units of transport vehicles transport 1200 t/d garbage daily which is very low average.
- ❑ **Inadequate and broken dustbins:** Some of the dustbins are placed without any facilities. These dustbins are unhygienic and eyesore. Some dustbins are broken or one side open, allowing waste to scatter, odor to escape, flies to multiply, and rainwater to enter. Most of the dustbins are broken in Dhaka by superannuated facilities and careless operation.¹⁵ Broken dustbins cannot hold waste well, resulting in scattered waste around with littering problems.
- ❑ **Dirty Demountable Containers:** Most of the demountable containers are not clean by the cleaners. These are mostly dirty and placed such a way that caused traffic problems.
- ❑ **Unusual or uneven deployment of human and material resources:** It is revealed from the study that DCC could not utilize their human and material resources rationally. Cleaners, drivers, waste containers, and transportation vehicles are distributed irrationally among different zones. Therefore, the man-hour is lost or under utilized and the total productivity hampered.

¹⁵ JICA, Draft Final Report, Vol. 2, Chapter3, p. 3.

- **Unnecessary overhead cost:** Recently DCC has privatized the secondary collection of 8 wards of Zone 9 and 10. All of the conservancy staff deployed in the area were redistributed or idle. The cost of them is going on and increases overhead solid waste management expenditure.
- **Mishandled fuel and overtime cost:** The number of trips and job area and distance of the transport vehicles are not recorded. The fuel is one of the major cost items of SWM and depends on the trip, route, and distance. The distance record is an essential data for rational valuation of fuel consumption. The record of the fuel cost measured by the meter cabin but most of the vehicles mile meter is out of order. Therefore, fuel allotment is given on average, a lot of fuel is wasted, and more cost incurred than the actual. Moreover, almost the all driver is taking overtime bill even carrying one trip in day spending only 2-3 hours. The trade union of the drivers is so strong that the authority is bound to provide overtime bill replied by the DCC officials. Therefore, huge amount of cost incurred for overtime and false fuel cost record.
- **Absence of proper monitoring:** The conservancy operation is many fold works. Working records of cleaners, collection, trips, repair works are prepared in conventional record and kept in on-sites managers office and hardly accessible for higher official who need to know the everyday situation for proper planning and sustainable operation. Only one inspector is working in each Ward. For a small Ward it is possible for one inspector but in a big ward it just impossible for one inspector to monitor the whole solid waste situation.
- **Low level institutional and organizational capacity:** Institutional strengthening is considered essential for long lasting improvements in solid waste management. DCC have tried to establish a central solid waste management department in 2004. An integrated waste management approach is crucial, while implementing new waste management systems and optimizing existing systems, which means addressing technical, social, economic and environmental aspects of waste management. A number of institutional problems hamper effective and efficient solid waste management. Governmental officials and decision-makers usually have a limited understanding and awareness of solid waste issues. Law enforcement is in need of improvement. Salaries and incentives for waste management workers are low and there is too much reliance on seasonal workers. The private sector and NGOs are little involved in solid waste management and lack incentives to do so. Lack of communication between

municipalities and citizens does not motivate residents to handle waste properly and to keep to rules and regulations.

- **Low productivity of conservancy worker:** It has found that the one cleansing worker only collects 154 kg solid waste in Dhaka is too less than other part of the world. This is due to low salary and other benefits. The workers have very low incentives. The cleansing staff deserves 40% health hazards wage enhancement which sanitary engineers and staffs (waste water projects) receive in the governorate of Dahaleya, Egypt.¹⁶ There is no mechanism of providing extra benefits for cleansing staffs or cleaners. They are working in deplorable condition in and around waste heaps. Bounce to that the productivity and output is very less in solid waste management.

6.4.5 Legal Causes

The lack of effective legislations is a barrier to efficient SWM, which is a norm in most developing countries. In the DCC ordinance, there is no specific time schedule of primary collection, transportation, and no standard settings for landfill. Only 12% of the respondents follow the ECA '95, and rest others either do not know the law or they act what they would like to do. 35% respondents drop their garbage near bins and 31% throw their garbage from distant place.

Law enforcement about solid waste management is almost nil. DCC itself does not comply with the legal provision collecting ECC of landfill. Even the owners or DCC do not taking ECC from DoE for Uttara and Berri Band landfill site which is mandatory according to Environment Conservation Act. Nor DCC or DoE or even DMP cannot take legal action against throwing garbage onto the footpath, pavements and public places. These figure clearly indicate that the legal drawbacks of solid waste management.

The enforcement of law regarding solid waste management is very weak in Dhaka city. The study reveals that under DCC ordinance no case was filed against the lawbreakers for legal action. Only few cases have been filed to Magistrates by DCC against offenses of No 19 of the third schedule of the ordinance. No 19 offences is dyeing or tanning skins within such distance of the residential area as may be specified by the Corporation. It is very surprising that DCC did not file any suits against placing or throwing garbage in a place other than particular place provided by DCC under offence

¹⁶ <http://www.seamegypt.com/manuals/dakassolidsaste/content>

13 of the said schedule. It is proved that enforcement of law is very weak and virtually no existence of law regarding solid waste management.

6.4.6 Social Causes

There is a negative attitude of the people on solid waste issue. They perceive waste as a useless matter and only fit for disposal at distant places. SWM in one hand never got proper attention and on the other sufficient resources was not poured in the sector. However, such perception leads to generating disrespect for the work and in turn produces low working morale of cleaners, laborers and other conservancy staffs and ultimately the result is poor performance. Solid waste management is very difficult work. Peoples throw the garbage here and there. Litters are diluted and thrown away by scavengers and cattle, the situation is exacerbated by the behavior of residents who dump waste next to the bins, pavements or containers instead of putting into bins and throw plastic bags containing wastes from balconies and windows.

People's Awareness

People's awareness is very important in efficient solid waste management. Although the people do not dispose the garbage rightly but they want their surrounding environment clean. The awareness, perception, attitude and behavior, etc are the catalyst in solid waste management. In the 1980s, in Botswana there was mounting pressure from members of the community and the press. There were articles in the press that called for action from the authorities. Politicians, especially councillors in selected local authorities started to sensitise the public and the council management imperative to do something on the control of wastes.¹⁷

The study reveals the poor quality of the people's awareness. Almost 63% of the respondents do not monitor the garbage disposal in their own home. About 47% of the population left the banana peel, packaging materials, and other silly matters onto the roads and pavements, 32% disposes into nearest dustbins, 10% carry at home and 11% gave different answers. 15% respondents know the DCC ordinance, 56% do not know and 21% do not know the law but they feel that garbage should not throw elsewhere. 71 % replied that DCC officials do not inspect the household, business center for awareness building or as part of the management. It is clear from the above discussion that City Corporation is not very much sincere about awareness building among the citizens.

¹⁷ Kaonga, "Appropriate Technologies", *Pollution Control*, p. 438.

Attitudes towards conservancy staff

The social status of solid waste management workers is generally low in both developed and developing countries, but too low in developing countries than developed countries. This owes much to a negative perception of people regarding the work, which involves the handling of waste or unwanted material. Such people's perception leads to the disrespect for the work and in turn produces low working ethics of laborers and tends to low productivity.¹⁸ The situation is worse in Dhaka city where more than 65% respondents show their disrespect to the conservancy staff.

Sense of participation

Participation does not mean the peoples are directly participating in solid waste management programs. In terms of solid waste management, there are so many CBOs or NGOs are using the term of participation. The term participation could mean the people stop to throw their waste in vacant lands or roads and properly handover the garbage to the collectors or dispose into the bins in right time in right manner. The participation may include willingness to participate in segregation, recycling and composting. However, most of the households indicated negative answers to the question regarding willingness to participate in recycling, separation of organic waste, and composting.

Awareness Program

It is already stated that solid waste management is a neglected sector. It is revealed from the study that DCC does not have any awareness-building program. More than 75% respondent replied that there is no awareness-building program. DCC never gave proper attention on this issue. In DCC there is a public relation department and their main function is to publish announcements of daily activity and opinions of the mayor and administrative matters. Therefore, there is little awareness campaign regarding solid waste management and environment conservation. Only conservancy department distributed 10,000 stickers to ward commissioner offices, mosques and many other public places in 2004. Occasionally DCC play little roles for creating peoples awareness. For example, DCC observed a 15 days "Cleanliness Drive" from 10th to 25th April 2005 for cleanliness of the city. It is reported that DCC is trying to show that the city would remain if the dwellers dispose their garbage at DCC designated spots. Some of the citizen said that this sort of drive will create awareness among the people.¹⁹

¹⁸ <http://www.gov.ab.ca/env.index>

¹⁹ Sabrina Karim Murshed, "Cleanliness Drive", *Daily Star*, 24th April, 2005, p.17.

Only in the 2nd Islamic Eid Festible (Ed-ul-Azha) DCC announces for clearing the cattle carcasses in television and newspaper. However, some of the NGOs and social environmental organizations do some awareness program like seminar, workshop, demonstration etc. Sometimes newspaper publishes some news and pictures for awareness. DCC's awareness program regarding solid waste handling is disappointing. DCC could done aware the people through outreach programme, demonstration program in TV and radio, caucus meetings, councillors meetings, workshops and seminars for parliamentarians, commissioners, officers-staffs, community members etc.

Inefficient Clinical Waste Management

A large part of hospitals waste usually consists of clinical and non-clinical waste. Such pollutants can therefore, be divided into solid and liquid waste (waste water). Both are important source of natural environmental degradation and constitute a health hazard. The soil associated or under the disposed wastes is one of the main reservoirs of microbial life, and contaminated water contains pathogenic microorganisms, which are causative agents of different types of disease.

Doctors, nurses, lab technicians, sweepers and aya's (maids), however, had no training on handling of medical wastes. There is no safety measure observed in dealing with waste disposal or laboratory analysis of infectious or hazardous diseases. Potential risks of handling medical waste –

- a) Injuries and accidents
- b) infectious medical waste risk
- c) hazardous medical waste risk
- d) environmental hazard for clinical waste

The waste is generally collected by untrained word attendants, no arrangement of proper separation process; many hospital sell the empty saline bags, bottles, syringes and other materials for recycling process; no central facility for medical waste treatment; no curriculum in the medical education for waste treatment in hygienic way; no awareness program about medical waste and its dangerous effects; many of the institutions has no incinerators.²⁰

Problem Facing Recycling Sector

The recycling sector is facing lot of problems in Bangladesh:

²⁰ J. Hasan, "Managing the Hospital Waste", *Bangladesh State of Environment* ,(Dhaka: Ministry of Environment & Forest, 2001), p. 243.

No government policy to encourage recycling

There is no specific policy, which includes laws and regulations for promoting recycling activities in Bangladesh. The recycling activities are mainly conducting by informal sectors. The competitiveness of the recycling business and sanitary management capacities are very weak and vulnerable.

Low quality recyclable materials and unstable market

The recycling market does not automatically become static because of its raw materials. In general, the demands of recyclable materials will increase due to the increase of industrial product price. However, the present qualities of the recyclable materials are still low, which are subject to good quality and stable supply of recyclable materials. Recyclables should be given various opportunities to compete the imported products. An example if the newspaper from foreign countries is given favour the recycling local newspaper will never survive. Also, the prices for recyclable materials are subject to large fluctuations and are unpredictable mainly due to lack of the stable supply and governmental supports. The recycling sector is treated with disregard in Bangladesh.

Conflict between material recovery and efficiency of secondary collection

Waste pickers at dustbin / or container sort recyclable waste by spreading waste as thin as enable them to easily find target objects. After finishing material recovery, the heap of waste is left as they spread in wider space than waste generator initially placed the wastes. The spatial expansion of waste pile forces secondary collection workers to spent more time for loading waste and cleaning the dustbin or container. This gives a negative effect on efficiency of secondary collection and discourages waste picking. There needs a certain rules for coexistence of secondary collection and material recovery.

Insufficient Recovery of Compostable Wastes

There are abundant contents of organic wastes like kitchen and market vegetable waste which are more suitable compost production. The dry wastes like paper, plastic, glass and metal are mostly recovered by huge number of collectors. It is observed that small portion of dry wastes are contained at landfill site and waste pickers continuously collect recyclable materials of dry wastes. Recovery of compostable waste has a great potential of waste reduction and resource recovery, however, it is not realized yet to the lack of market in adjacent area of Dhaka city.

6.5 Some other general Causes

In Dhaka, the garbage collection and disposal management is unsatisfactory; heaps of rotten garbage is normal sights along city streets or neighborhood lanes. People are forced to coexist with refuse in the city. There is very little evidence of garbage collection by city authority from urban poor settlement. However, the poor also help the city authorities by scavenging into garbage dumps and bins collecting wastes from the street and by sorting out garbage. However, in doing so, they expose themselves to health hazardous.²¹

Environmental Causes

Absent of Environmental Impact Analysis (EIA) in Landfill

Environmental Impact Assessment is a relatively new planning and decision-making tool first enshrined in the United States in the National Environmental Policy Act of 1969.²² It is a formal study process used to predict the environmental consequences of any development project. EIA thus ensures that the potential problems are foreseen and addressed at an early stage in project planning and design. Environmental Assessment enables in carrying out Environmental Cost-Benefit Analysis of projects at an initial stage. In view of the fact that development is an ever growing process, its impact on the environment is also ever increasing, leading to rapid deterioration in environmental conditions. As such Environmental Assessment provides a rational approach to sustainable development.

Some measures are required to be taken in the future to reduce the anticipated environmental degradation. Before starting a major project, it is essential to assess the present environment without the project, and the likely impact of the project on the environment, when it is completed. The Environmental Impact Assessment should have the following objectives:

- Predict environmental impact of projects
- Find ways and means to reduce adverse impacts
- Shape project to suit local environment
- Present the predictions and options to the decision-makers

²¹ Nazrul Islam, "The State of Urban Environment in Bangladesh", Nazrul Islam and Rosie Majid Ahsan, eds., *Urban Bangladesh: Geographical Studies* (Dhaka: Geography Department, DU, 1996), pp. 26-27.

Islam, Urban Environment, Islam and Ahsan, pp. 26-27.

²² <http://www.colorstoneconcrete.com>

However, in case of DCC landfill site no EIA plan was done for existing sites and no ECC obtained from the DoE. But for Matuail extension project, EIA has been prepared and now under process of obtaining ECC from DoE.

Community Sensitisation Vs Profit motive

Until 1987 there was no community participation in solid waste management. In that time at Kalabagan area door-to-door collection started and that was the community sensitisation era in Dhaka. Community mobilisation is one of the important modes of awakening stage of waste management. But it was not appreciated from government or DCC. After a long struggle it became successful and now it is expanding everywhere. Kalabagan Model was totally social work. But afterwards lot of Community Based Organization raised and they are collecting money for door-to-door collection. It is all right to have some money for cost recovery of the social work. But now it turned into profit motive and charged heavy amount for collection. The study revealed that in Uttara and Gulshan area from Tk.75 to 250 is charged for collection. The respondent seems that it should be Tk.50 to 100 on an average. It is a barrier to extensive development of community participation.

Low priorities for political and administrative support

Solid waste management was always given low priority. It was given low ranking in priorities due to lack of political and higher administrative support. Where there was any beautification program of Dhaka city, the roads, drainage and pavements maintenance, lighting, tree plantation, artificial waterfall etc was given high priority. Solid waste management was in the dark because neither the political nor administration gave high priority. However, recently the government has taken an initiative to have a clean Dhaka Master Plan under direct auspicious of Japan International Cooperation Agency (JICA). JICA is preparing a Master plan for solid waste management for Dhaka city targeting year 2015.

Absence of Sustainability in SWM

Municipal solid waste is abundant, unsightly and potentially odorous, contains numerous potential pollutants; and supports both disease causing organisms and disease carrying organisms. Because of these characteristics of MSW, a prompt, effective and reliable system is required to isolate SW from people and the environment. A beneficial use of SW is relatively difficult, because it contains many different types of materials in a range of particular size.²³ But DCC cannot solve the solid waste problem

²³ S.C Bhatia, *Handbook of Industrial Pollution*, p. 172.

promptly, even some times putrisible solid waste lying daylong together. Panaji Municipal Corporation (PMC), Philippine developed sustainable SWM program. Five major elements of sustainable SWM program i) Quantity and quality of solid waste, ii) community need and participation iii) collection, transportation & disposal iv) institutional needs v) financial management and cost recovery.²⁴ None these factors had effectively encountered in solid waste management of Dhaka city.

There are four or five non-exclusive options for solving the MSW crisis: reduce the amount of trash generated; institute vigorous recycling programs; incinerate garbage in "waste to energy plants"; construct more "secure landfills"; and anaerobic digestion (compost plants). The first option is obvious but difficult to achieve. Reducing garbage at the source would do much to alternate the burden on recycling program, incinerations and landfills.²⁵ Unfortunately, none of the options utilized in Dhaka city effectively to ensure sustainable waste management. Neither DCC nor the government has any program for reduction solid waste and recycling initiative. Rather unscrupulous recycling is going on without any restriction. No scientific incineration plant and sanitary landfill system in Bangladesh. Only the crude open dumping is the disposal method leads to serious human health and environmental degradation.

6.6 Chapter Summary

Solid waste management system in a developing country displays plethora of problems, including low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control mechanism. The developed countries managed their solid waste with technological advancement and huge financial investment. The developing countries are confronting with this problem because of modern technology and financial constraints. There are lots of causes of inefficient solid waste management. The causes of inefficient solid waste management of Dhaka city are enormous. Out of them, some are operational problems and some other socio-economic problems.

Poor projection of volume generation, inappropriate primary collection time and mode of transport, insufficient and unhygienic dustbins, containers, littering when traveling the garbage are very common. Unskilled cleaners are responsible for inefficient secondary collection. Indiscriminate waste picking aggravate the situation. There is no treatment facility of solid waste in the city. Only the crude uncontrolled open dumping is

²⁴ Paneer Selvan, "Community Based SWM Project Preparation", *Water Supply and Sanitation*, p. 108.

²⁵ Hinrichs & Kleinbach, *Energy and its use*, p. 543.

the method of disposal. No leachate control, gas control mechanism of the landfill. Recycling is only informal sector. Only 16% of solid waste is recycled. Among them the infectious and hazardous waste is recycled by unscrupulous traders.

The socio-economic causes of inefficiency are technical, financial, institutional, economical, legal etc. DCC is lacking of technical facility. It has no modern equipments for carrying and handling solid waste. Like other developing countries, DCC has suffered for financial weakness. It has only about 17% conservancy tax for solid waste management. It has to depend for governmental allocation for solid waste management. The weak condition of the national economy hampers more allocation in this sector. Due to weak economic baseline, government cannot implement development project without the help of foreign aids and donation.

The attitude and perception of city dwellers is very low. Peoples throw wastes everywhere. There is no awareness-building program of City Corporation. The political and administrative support is also very weak. Like all other environmental issues, solid waste management issue does not entertain properly. The government, City Corporation, and the peoples take the solid waste issue very reluctantly. There is no sustainability in solid waste management program leads to serious environmental problem in the city.

Chapter 7

Resource Recovery and Renewable Energy from Solid Waste

7.1 Introduction

The natural resources are static in the earth. The population is growing very fast. The world has to survive within this limited resource. For this end, resource should be used carefully and wastage of resource must be eliminated as much as possible. The people who are living now must leftover more resource to the next generation what they got from their ancestors and predecessors. Ultimately, "spaceship" the earth has limited resources, and a growing number of passengers are facing the resource scrunch. If the human societies would like to successfully complete their journey into the future without running out of resources or polluting and contaminating the planet, they must better start doing what every astronaut has to do, reduce consumption levels and recycle as much as possible of the waste materials.¹

Industrialization and urbanization has prompted the use of more resources and increase the volume of waste generation. Resource crunch relating to demand has bound the human being to be cautious and they tried to find out the alternative resources. At the 1970s when the price of energy cost was rapidly escalating more attention endured alternative fuel. The researchers tried to convert solid waste into usable energy by evaluating the waste heating value and competing recovery technologies. There are varieties of difficulty in resource recovery, still then the effort is continuing for alternative resource recovery from solid waste as renewable sources.²

Energy is considered as a prime agent in the generation of wealth and also significant factor in economic development. Energy is required in every step of development. But this energy source in the earth is not unlimited. The ever increasing population and appetite for energy is staggering. The three major sources of energy likely to be used are fossil fuels such as coal, oil shale, and tar sands/natural gas; nuclear energy (fission today and perhaps fusion sometimes in the future); and

¹ Jon E. Gould, Jon E. Gould, "Solid Waste Reuse and Recycling", *Pollution Control & Waste Management in Developing Countries*, Rogers Wu Okot-UMA, *et al*, eds. (London: The Commonwealth Secretariat, 2000), pp. 353-359.

² A.V. Bridgwater and C.J Manford, *Waste Recycling and Pollution Control Handbook* (London: George Godwin Ltd, 1979), p. 396.

renewable energy (RE).³ Except renewable energy, all sources are limited. Renewable resources are inexhaustible and offer many environmental benefits over conventional energy sources. Almost none of them release gaseous or liquid pollutants, during operation. Among RE sources biomass is important because its share of total energy consumption is still high.⁴ The promise of RE is that it offers a solution to many environmental and social problems associated with fossil fuel.

The fossil fuel is expected to running out, the human society should find out the alternatives that will provide usefulness, flexibility, cleanliness and economy of resources. One of the alternatives is biomass fuel. Biomass energy is that energy derived from living matters such as field crops (corns, wheat), trees and water plants. It is also agricultural & forestry wastes including crop residues and manure and MSW. The biomass: a source of energy is both as old as human kind as new as the morning paper.⁵

Solid waste is one of the important sources of biomass fuel. It is renewable and could be material resource as well as energy resource. Waste reduction, reuse, and recovery through recycling are the possible way of getting rid of the waste hazard as well as renewable resources. Producing fuel from wastes accomplishes two essential tasks; it reduces the existence of environmental hazardous situation and it increases the supply of energy.⁶

7.2 Importance of Resource Recovery

There are two types of resources into the earth; one is Non-Renewable Resources (NRR) and another is Renewable Resources (RR). Every society should conserve its natural capital by maintaining the per capita value. This could be done through efficient use of Renewable Resources (RR). Each generation should inherit at least a similar natural environment with regard to NRR. The aim is to preserve options by making compensating investments so that no future generation will be worse-off than any that precedes it. NRRs are non-living resources that cannot be replaced in immediate future.⁷

³ Keller A. Edward, *Environmental Geography*, 4th ed. (Ohio, USA, Charles E. Merrill Publishing Co., 1985), pp. 252-253.

⁴ Kamil Kayguruz, Abdullah Kaygusuz, "Renewable Energy and Sustainable Development & Turkey", *Renewable Energy: An International Journal*, AAM Sayigh, ed., Vol. 25, No. 3, March 2002 (UK: Pergamon), pp. 431-454.

⁵ Robert A. Hinrichs & Merlin Kleinbach, *Energy and its use and the Environment*, 3rd ed., (USA: Thomson Learning Inc. 2002) pp. 540-541.

⁶ David A Tillman, "Energy from Waste: An Overview of Present Technologies & Programs", Larry L. Anderson & Tillman, eds., *Fuels from Wastes* (New York: Academic Press Inc., 1977), p.17.

⁷ M.D Yong, "Sustainable Investment & Resource Use", *Equity Environment, Integrity & Economic Efficiency, Man & the Biosphere Series*, Volume 9, (Paris: UNESCO & the Parthenon Publishing Group, 1992), pp.75-78.

Many environmental problems are caused by consumption of NRRs like coal, petroleum and heavy metals. These problems can be offset by increasing use of RRs. Solid waste is unutilised material. Utilizing the unwanted solid waste as renewable resources will decrease pressure on the other fuel energy.

The sound environmental waste management starts with the reduction i.e. source reduction. By this time solid waste has proved as one of the important renewable resources. Agenda 21 of Rio Earth Summit agreed upon that reducing wastes and maximizing environmentally sound waste reuse and recycling should be the first step in waste management. Even those societies in which resources are scarce have not yet been recognized the potential for reuse and resource recovery through recycling wastes.⁸ A large portion of urban wastes is organic in nature, which therefore, forms an interesting source of resource recovery. Organic material could be used in three ways: to improve the bio-manure in the soil (compost), to feed animals (fodder) and to produce energy (briquettes, biogas). Inorganic materials such as Glass bottles and jars can be remelted to produce new containers, while plastic containers find other uses; for example as fibrefill stuffing for pillows, sleeping bags and automobile seats.⁹ Recovered material from waste heap save the disposal cost as well as generates resources and increases employment.

Biomass in its various forms appear to have a bright future as a renewable energy source. As the fossil fuels, particularly oil and gas depleting continues to rise the price, the RE sources certainly becoming more and more attractive.¹⁰ The energy production from MSW is an indigenous resource. Every society should conserve the natural resources and environment by treating waste as resources and returning them either to use or, in a harmless condition, to the ecosystem.¹¹ The quickly the man will conserve it will sustain a compatible environment.¹²

There are many low and middle-income countries, the municipal refuse collection, disposal services are woefully inadequate, and thus wastes accumulate in the roadside and transfer stations. Today about 30% US wastes stream is recovered and returned to use; some countries achieved 50%.¹³ Resources either as material source or energy source could be achieved in the form of reduction, reuse and recycling. The extent of

⁸ Sandra J. Contreau, *Environmental Management of Urban Solid Wastes in Developing Countries: A Project Guide* (Washington: WB, 1982), p.159.

⁹ Hinrichs & Kleinbach, *Energy and Its Use*, pp. 543-544.

¹⁰ Keller, *Environmental Geography*, p. 835.

¹¹ Tillman, "Energy from Waste" *Fuels from Wastes*, p. 18.

¹² Keller, *Environmental Geography*, p. 835.

¹³ Hinrichs & Kleinbach, *Energy and Its Use*, p. 543.

commercial recycling of paper, metals, glass, and plastic depends on the presence of industrial or other uses for these materials.¹⁴

7.3 Resource Recovery Techniques from Solid Waste

The term recovery is very much contemporary with reuse and recycling. Recovery might be done for two folds, one in the direct form of reuse and another is the recovery through recycling. The plastic bags and containers, glass, paper, cardboard, and other materials are most often separated for domestic use, sold, and recycled. The rate of reuse in this instance is high, and these materials enter the waste stream only when they are of no longer fit for use. Wastes can be sorted at the source of generation, transfer stations or landfill sites. For instance, the Gaborne landfill has sorting centres for tyres, metal scrap, construction wastes (or rubble). Construction waste is crushed and reused as cover material for landfill. A separate area is routine demarcated nearer to the domestic and other food waste disposal site, for sorting and storage of beverage cans to be recycled.¹⁵

Resource recovery technique cannot be same in every society. The reasons behind those solid wastes are not same nature all over the world. It is depend on the nature of resource consumption, characteristics of the wastes, temperature, societal, environment, technology availability etc. High-energy content materials are fit for incineration for producing heat energy. The abundance of low-energy content materials undermines the feasibility of adopting garbage incineration. In contrast, high-organic contents in the waste streams make composting more appealing for developing countries.¹⁶ Virtually, the situation will fit the technique to be used for resource recovery.

7.4 Resource Recovery Factors

Choice between recovery of valuable materials from waste and disposal of waste depends, mainly of 3 factors: technology, economics and attitude. Generalizations are difficult because so much depends on the detailed circumstances of individual cases. However, technology is not usually a problem as there are adequate chemical and physical methods available to treat, dispose of or recover values from most wastes.¹⁷ Waste utilization technology is continually modernized. First of all to prevent wastes over creation, next it is to use them rationally and in extreme, to render them harmless safety.

¹⁴ Brihton Kaonga, "The Application of Appropriate Technologies in Waste Management in Developing Countries," *Pollution Control*, p. 385.

¹⁵ Yvonne Gotlop Bogatsu, "Towards Effective Waste Disposal in Developing Countries", *Pollution Control*, p. 274.

¹⁶ Peter P. Roger et al, *Measuring Environmental Quality in Asia* (USA: Harvard University and ADB, 1997), pp. 203-215.

¹⁷ Bridgwater & Manford, *Waste Recycling*, p. 7.

It is to remember that according to the ranking of ecological preferences, wastes neutralizing is always placed below recycling or utilization.¹⁸

Economics is perhaps the most important factor and the most difficult to analyse. For disposal, the cheapest alternative is not always chosen; convenience and attitude often influence the producer in choosing the disposal method. From the viewpoint of profitability, resource conservation, environmental damage etc. are not the consideration for recovery. It is only commercial attitude of profit margin. Often what is missed, however, is the opportunity to use the recycling itself as a means of disposal: a non-profitability recovery proposal may appear attractive when viewed as a disposal method.¹⁹ Resource recovery by means of incineration or pyrolysis of household refuse may thus be regarded as an increasingly attractive method of disposal in view of the rapidly increasing cost of landfill, transport and fuel.

Finally, **attitude** is impossible to quantify. Attitude is the function of belief, ethics, prejudice, stigma, politics, apathy etc. Even where recovery is technically, economically, and commercially viable, is some times ignored for attitude including, self-interest and conscience. There is change in forthcoming in case of attitude because of education and leanings. Though, considerable research effort and political encouragement have directed towards resource conservation.²⁰ The resource recovery is directly affected by the attitude of the community. Say the uses of cow dung for domestic cooking in some Muslims families are disliked due to the religious beliefs. But most of the developing countries use the cow-dung as fuel for heat energy is very common.

There are some other common factors affect in resource recovery:

- The socio-economic conditions directly affect the reduction and recovery program;
- The standard of living increase, voluntary source separation tends to decline, unless a) it is encourage through an incentive program or b) the opportunities for waste generators to sell recyclables remain very convenient;
- A wide range of recyclable markets;
- Incentives and opportunities for recyclable industries; (imported high quality recyclables can undercut the local market resulting decline in waste recovery operation);
- Municipal sponsored recovery and legislation may encourage reduction and recovery.

¹⁸ Eugenius Mokrzychi, Alicja Uliasz and Mieczyslaw Sarnz, "Waste as Alternative Fuels in Cement Industry" Peter Chatania, ed., *Energy 2000* (Italy: Technomic Publishing Co. Inc. and Bala Ban Publishers, 2000), pp. 1011-1015.

¹⁹ Bridgwater & Manford, *Waste Recycling*, p. 7.

²⁰ Ibid.

7.5 Types of Resources

There are two types of resource that may be recovered from refuse: material resource and energy resource. Though energy is one kind of resource it is differentiated from material resources. Material resources can be achieved from solid waste through reduction, reuse and recycling process. On the other hand energy resource only can be achieved through recycling. There are some matters that can be reused, either directly or recycled. Compost is an important recycling material resource used as soil conditioner. Energy from solid waste can be achieved through recycling. Resource recovery from solid waste is discussed here in two folds as Material Resource Recovery (MRR) and Energy Resource Recovery (ERR).

7.6 Material Resource Recovery (MRR)

Recovery is an essential element of an integrated solid waste management program. Energy and other resources may be recovered from the solid waste stream. Recovery is the extraction of resources from a waste heap that has some value in other use.²¹ Resource recovery and production offer a direct economic benefit and lessen demands on processing and disposal requirements. Recovery is obtaining materials or organics (by source separation or sorting out from mixed wastes) that can be reused or recycled.²² Material recovery is the mechanical processing of waste or its fraction to materials in a form suitable for sale. Material recovery is stressed because the revenue from material recovery can be a substantial portion of total revenue of resource recovery plant.²³

7.7 Resource Recovery through Waste Reduction / Minimization

Waste reduction means of reducing the amount of waste that must be collected and disposed of by municipal authorities. It is separation and prevention of the recyclables and compostable organics from entering final waste stream. It could be happen at the source of generation. Source separation is keeping different categories of recyclables and organics 'at source' i.e., at the point of generation, to facilitate reuse, recycling. Source reduction is sorting out the recyclables before mixing them with other refuse to be collected. Waste reduction is the avoidance of producing more waste. Avoidance refers to actions by the producer to avoid generating the waste. Utilization

²¹ World Bank Group, *Pollution, Prevention, Abatement Hand Book*, 1998 (Washington: World Bank Group, 1998), p. 29.

²² UNEP and IETC, *International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management*, (Osaka, IETC, 1996), p. 20.

²³ Harver Alter & J. J Dunn Jr, *Solid Waste Conversion to Energy* (New York: Marcell Dekker Inc, 1980), p. 95.

includes the range of action that makes the waste a useful input to other processes, eliminating the need for disposal. Waste minimization thus comprised both avoidance and utilization.²⁴

It is already stated that reduction is lessening the volume and toxicity of solid wastes. Under the Hazardous & SW Amendments (HSWA) of 1994 the waste minimization is any action taken to reduce the volume or toxicity of waste. Congressional Office of Technology (COT) define waste reduction 'in plant practice' that reduce, avoid, or eliminate the generation of waste so as to reduce risks to health and the environment whereas USEPA's waste minimization includes source reduction, treatment and recycling onsite and offsite. COT considers offsite recycling and treatment as waste management.²⁵

Reduction can be achieved by reuse, recovery and recycling. Reuse declines the volume of total wastes to be accumulated for waste heap, again the amount of recovered materials also reduce the total volume of waste to be disposed. In the last spell, recycling converts/makes a lot of waste materials as useable and thus it is also reduce volume of waste materials.

Importance of Reduction

The disposal of MSW has become a critical problem from both the economic and environmental point of view. The continued use of the traditional means of disposal (including open dumping, discharge into rivers, lakes, oceans, conventional incinerators and even sanitary landfill) is now being sharply questioned. Not only do these disposal methods have inherent environment pollution problems, they are wasteful of potentially valuable & recoverable resources.²⁶ The high cost and scarcity of landfill, environmental degradation waste reduction and recovery and reuse is inevitable. Widespread litter disposal discourage the development of a growing tourist sector and also the municipality had to spend millions of dollars on potentially unnecessary litter picking and waste management activities.²⁷ Through reduction and recovery, a huge amount of waste management cost can be reduced, lessening the landfill areas, source of income

²⁴ World Bank Group, *Pollution, Prevention, Abatement Hand Book*, 1998 (Washington: World Bank Group), pp. 29-32.

²⁵ G.R.E.M.U Roosmalen et al, "The Effect of Processing on the Heavy Metal Content in Compost", JKA Dewal ed., *Environmental Technology* (Holland, 1987), pp. 77-86.

²⁶ Tillman, "Energy from Waste" *Fuels from Wastes*, p. 41.

²⁷ Dr. H.S Bhatia, *A Text Book on Environmental Pollution & Control* (Delhi: Galgotia Publications Private Ltd, 1998), p. 353.

and potential environmental development possible. People should perceive the waste as in fact valuable resources and can be reused or recycled.²⁸

Source Reduction

Waste reduction in fact starts with source separation. The yields of source separation can be reused, sold, gifted to others, and recycled for resource recovery. Source separation took place at first in the household, office or other institutions. In the second phase separation took place at the bin or transfer stations and the third phase took place at the disposal site or dumping stations. In the United States two types of source separation programs are in common use. One type uses centralized recycling centres to which materials are brought by generators. The other type provides curbside collection of materials to be recycled.²⁹

Generally, in the low-income areas, waste generators carryover the separation operation. But in the high-income areas the domestic servants and/or wardens carry out recovery. Rather than reusing the materials directly, they sell recovered materials to middlemen or commercial centres that pay for these materials. Glass bottles are largely returned to their point of sale for direct reuse by the beverage industry. In majority of the cities, the broken glass content of the MSW stream would not be sufficient to support a glass recycling industry goes to the landfill. Source separation is one of the important techniques of waste reduction and also resource recovery.

Priorities for Maximum Reduction

The **first** priority is the diversion of organics from the waste stream has the highest potential for waste reduction. The reason is that organics are the largest category of MSW and the greatest reduction in waste for disposal can be achieved by diverting organics; and Second priority is the supporting maximum reduction/recovery of synthetic materials.

7.7.1 Reuse

Reuse refers to the products used for the same purpose or different purpose without recycling. Reuse refers to the separate use of a 'waste' material in a process (often after some treatment or makeup).³⁰ The used household appliances, container bottles, plastics, cardboard, and paper products, clothing, utensils and other durable goods can be reused. The use of a product more than once in its same form for the same purpose, i.e. a soft drink bottle is reused when it is returned to the bottling

²⁸ MoEF & GOV. UNEP, *Peoples Report on Bangladesh Environment*, Vol. 1, (Dhaka: MoEF, UNEP 2001).

²⁹ Eugene A. Glysson, "Solid Waste", *Standard Handbook of Environmental Engineering*, 2nd ed, Robert A Corbitt, eds. (New York: Lewis Publishers, 1999), Chapter 8, p. 60.

³⁰ World Bank Group, *Pollution, Prevention, Abatement Hand Book*, (Washington: World Bank, 1998), p. 29.

company for refilling. The consumers have to pay an extra burden of importing or manufacturing the non-returnable beverage containers.³¹ The waste reduction effect of a reusable product depends on the number of the items it is used and thus the number of single-use products that are displaced.³²

7.8 Recycling

Recycle means to produce a useful article from the original item. Recycling is the process of transforming materials into secondary resources for manufacturing new products. Recycling refers to the use by one producer of a waste generated by another.³³ Reusable products are used more than once and compete with disposable, or single use products. In South Africa a deposit system is used to encourage the return of bottles and tin and aluminium cans.³⁴ To encourage the recycling, waste-consuming industries should locate near waste producing areas.

They continuously recycled their waste for further use. As William McDonough dreams of a world without waste, a world without poisons, a world in which all materials are continuously recycled. The ultimately goal is to create a sustainable world, enabling humans to "love the children of all species-not just our own- for all time."³⁵

Importance of Recycling

Recycling leads to major savings of raw materials. It also saves lot of energy. Recycling leads to material savings of avoiding the use of virgin materials and reduced pollutions. For example, aluminium is an extremely energy intensive material, however, recycling aluminium requires just 5% as much energy as producing it from bauxite. There is also a greater energy savings in recycling rather than incineration of the material. The energy derived from incineration is usually less than the energy saved by not production that product from raw materials. Composting is another method of recycling. Japan serves as an example of a premier recycling country. Half of its wastes stream is recycled.³⁶

Recycling can certainly reduce quantities of solid waste, perhaps as 50%, but it is not panacea claimed by its most avid advocates. To overall solution to the solid waste problem most involve several kinds of measures, particularly (a) reduction waste at

³¹ MoEF & GOV. UNEP, *Peoples Report on Bangladesh Environment*, Vol. 1. p. 353.

³² Bhatia, *Handbook of Pollution*, p. 183

³³ World Bank Group, *Hand Book*, 31.

³⁴ Brihton Kaong, *Waste Management in Developing Countries*, *Pollution*

³⁵ Special Report, *Environment*, Vol. 2, 2002, p. 38.

³⁶ Hinrichs

company for refilling. The consumers have to pay an extra burden of importing or manufacturing the non-returnable beverage containers.³¹ The waste reduction effect of a reusable product depends on the number of the items it is used and thus the number of single-use products that are displaced.³²

7.8 Recycling

Recycle means to produce a useful article from the original item. Recycling is the process of transforming materials into secondary resources for manufacturing new products. Recycling refers to the use by one producer of a waste generated by another.³³ Reusable products are used more than once and compete with disposable, or single use products. In South Africa a deposit system is used to encourage the return of bottles and tin and aluminium cans.³⁴ To encourage the recycling, waste-consuming industries should locate near waste producing areas.

They continuously recycled their waste for further use. As William McDonough dreams of a world without waste, a world without poisons, a world in which all materials are continuously recycled. The ultimately goal is to create a sustainable world, enabling humans to "love the children of all species-not just our own- for all time."³⁵

Importance of Recycling

Recycling leads to major savings of raw materials. It also saves lot of energy. Recycling leads to material savings of avoiding the use of virgin materials and reduced pollutions. For example, aluminium is an extremely energy intensive material, however, recycling aluminium requires just 5% as much energy as producing it from bauxite. There is also a greater energy savings in recycling rather than incineration of the material. The energy derived from incineration is usually less than the energy saved by not production that product from raw materials. Composting is another method of recycling. Japan serves as an example of a premier recycling country. Half of its wastes stream is recycled.³⁶

Recycling can certainly reduce quantities of solid waste, perhaps as 50%, but it is not panacea claimed by its most avid advocates. To overall solution to the solid waste problem most involve several kinds of measures, particularly (a) reduction waste at

³¹ MoEF & GOV. UNEP, *Peoples Report on Bangladesh Environment*, Vol. 1. p. 353.

³² Bhatia, *Handbook of Pollution*, p. 183.

³³ World Bank Group, *Pollution, Prevention, Abetment Hand Book*, p. 31.

³⁴ Brihton Kaonga, "The Application of Appropriate Technologies in Waste Management in Developing Countries", *Pollution Control*, p. 384.

³⁵ Special Report, "Portrait of Beleaguered Planet", *Newsweek*, September 2, 2002, p. 38.

³⁶ Hinrichs and Kleinbach, *Energy*, pp. 543-544.

source (b) recycling wastes as much as practical and (c) reducing the volume at remaining wastes by means of incinerations (d) treating residual materials as much possible to render it non leachable and innocuous and (e) placing the residual materials in landfill, properly protected from leaching or release by other pathways.³⁷

It is cheaper to recycle than to put garbage in landfills, because the landfill options require transportation and tipping fees.³⁸ This saves raw materials. To make new things, it is need a lot of natural resources and energy. By recycling, it can save lot of natural resources and energy.³⁹ Recycling in the home seems to have the biggest impact on the waste steam. For recycling program to succeed, there must be a market for the materials that are reclaimed. Recycling had great impact on resource utilization.

Material Recovery Practices in Industrialized Countries⁴⁰

Worldwide commercial 'waste' recycling industries emerged in a high speed but still it is a small fraction relating to total waste volume. The most common reason is 'un-economic' to do so. The economic or un-economic is relative term in case of waste recycling. What is un-economic today may be economic tomorrow. But cost of cleaning or environmental cost have to pay by the next generation must be added to this perspective. Most of the Western Europe, North America and developed Asian countries adopted reduction and recovery mechanism through subsidisation and sponsorship. The components are as follows:

- ❑ Source separation of different categories of waste form household, offices, shop, and institutions, collection at the curbside by government or private industries.
- ❑ Collection of organics (kitchen and garden wastes) for large-scale;
- ❑ Promotion of backyard composting through education and sometimes the provision of a small compost bin;
- ❑ Public subsidisation of extensive and varied educational campaigns to sustain participation in all aspects of waste reduction;
- ❑ The separation of post consumer materials by waste generators has been mandatory; and
- ❑ Subsidisation for initiatives in changing manufacturing design and packaging towards reduction of wastes.

³⁷ Stanly E. Manhan, "Environmental Chemistry" 6th ed, (Columbia: USA, Lew's Publishers, 1994), pp. 534-535.

³⁸ Hinrichs and Kleinbach, *Energy and Its Use*, p. 544.

³⁹ Nasreen Alam, *Simple Facts about Environmental Pollution* (Dhaka: Luthfun Nesa Ahmed, 2002), p. 54.

⁴⁰ MoEF & GOV. UNEP, *Peoples Report on Bangladesh Environment*, Vol.1, p. 353; *World Bank Group*, p. 31; Brihton Kaonga, "Appropriate Technologies", *Pollution Control*, p. 384 ; Hinrichs and Kleinbach, *Energy and Its Use*, pp. 543-544 and Manhan, *Environmental Chemistry*, pp. 534-535.

Material Recovery Practices in Developing countries

In the developing countries reduction and recovery are taking place mainly in informal sectors. Due to technological backwardness and financial constraints developing countries cannot recycle garbage as a maximum. Most of the garbage recycled there is in indigenous form. Recycling components in developing countries are as follows:

- In most developing countries, materials recovery is widespread and occurs efficiently through traditional practices. It is in the process of repair and reuse, sale, barter or gift of used or surplus goods.
- Reduction takes place as gift (a large portion of usable materials goes to the relatives, charities, servants as gift)
- Informal collection by the scavengers and selling to the recyclables markets;
- A big portion of organic nature garbage goes to agricultural field in the natural process of composting and some small scale backyard and community based initiatives for composting;
- Waste reduction through legislation and protocols are still yet to be feasible in the developing countries.

7.9 Common Resource Recovery from Solid Waste materials

Most of the wastes can be recycled using a process specific to the material. Recycling depends on the nature of the product, available technology, sufficient financial resources and socio-economic condition of the society. Some materials including extremely useful such as glass and aluminium-can be recycled and used many times over without noticeable changes occurring in the quality of the finished product.

Nothing is valueless now. Taiwan, the largest manufacturer of computer discs (CD) in the world, started processing unused CDs. About 60 million CDs weighing 990 ton are discarded every year in the country. CD comprises plastic materials as well as metal, including aluminium, gold, silver and titanium. At present, one environmental service company systematically recycles CDs and produces 4 ton plastics per month from discarded CDs.⁴¹

The following are the common products in the waste piles can be reduced by reuse, recovery or recycling processes:

Paper

Lot of different types of paper is used in every society. Paper is almost one time useable item and goes to waste heap. On an average paper comprises about 35% waste stream in USA, 15% in Dhaka. These waste papers could be recycled and a huge amount of energy and resources can be saved. As example, recovery of the paper used

⁴¹ Vatis Update: *Waste Management*, Vol-5, No 60 (New Delhi: Jan-Feb 2004), p. 7.

to produce only the Sunday edition of New York Times would preserve 75000, trees per year.⁴² Recycling of waste paper not only save the trees but also saves, 4,100 kWh of energy per ton (the equivalent of a few months of electricity use by the average home), 7000 gallons of water, 60 pounds of air-polluting emissions, and three cubic yards of landfill space and associated tipping fees. It also needs fewer chemicals and bleaching.⁴³

In the process of recycling paper is soaked in water, stirred and heated until it is transformed into pulp; the pulp is screened and then placed in a centrifuge, which extracts the ink and impurities such as staples. When the surplus moisture is drained off and the pulp is pressed, it becomes paper once again.⁴⁴ The most effective way to create waste paper market is to establish a pulp and paper mill and there should be government patronize for its success.

Cardboard

There are a big amount of cardboard (corrugated paper) has gone through into waste pile. The cardboards consume a lot of volume rather than their weight. Cardboard is mainly comes from household, commercial places and they are separated by the generator or scavengers from waste heap. Almost all cardboards are recycled. Like papers the cardboard is submerged in a soaking basin. It is then stirred and heated until it is transformed into pulp. The pulp is then screened and placed directly into a press, where it solidifies into new sheets of cardboard.⁴⁵

Plastic

There are different types of plastics (polyolefin including polypropylenes) with styrene polymers and polyvinyl chlorides (PVCs) are used in packaging and other appliances instead of wood, paper, glass and metallic products. Plastics are strong, waterproof, durable, and microwave-able than others. Due to its durability it is reused but plastic recycling has been limited by both technical and economical reason. Recycling of plastics from mixed municipal waste is complicated by lower concentrations.⁴⁶ The metallic impurities in flakes of plastic are eliminated using ferromagnetic processing.⁴⁷ The potential for reuse of mixed plastics is primarily with the thermoplastics fraction that can be re-melted. Thermoplastics comprise 80% of the plastics in the waste, while the

⁴² Hinrichs and Kleinbach, *Energy and Its Use*, p. 544.

⁴³ Bhatia, *Handbook of Pollution*, p. 187.

⁴⁴ World Alamnic Library, *21st Century Science, Climate: the Environment*, (USA: Milwauka, WI, 2002), pp. 60-61.

⁴⁵ Alamnic Library, *21st Century Science*, pp. 60-61.

⁴⁶ Glysson, *Engineering Handbook*, pp. 08-109.

⁴⁷ Alamnic Library, *21st Century Science*, pp. 60-61.

remaining 20% are thermosetting plastics 'set' after forming. The evolution thermoplastic recycling technologies are still under research stage.⁴⁸

The Japan Steel Works Ltd., Japan, offers a waste plastic dechlorination solid fuel facility. In this process, waste plastics classified, impurities are removed through washing and dewatering of feedstock for residue disposal. In the next plasticizing stage, plastic is melted by raising its bulk density and temperature in order to remove moisture and afterwards the molten material enters the dechlorination stage. Dechlorination refers to decomposition of molten plastics under elevated temperature by adding and compounding force of extruder twin-screws to separate and direct hydrogen chloride gas produced from the plastic through vent boxes on the extruder. The gas is treated with dechlorinating equipment and dechlorinated plastic is forced to go through die nozzles, cut and water-cooled into solid products. These products can be used as a substitute fuel for coal in boilers, power stations, blast and furnaces, as well as in cement manufacturing.⁴⁹

Glass

Glass is one of other most recyclable products. Most of the raw materials of glass production come from broken glass (cullet). However, there are incentives for recycling glass in the reduction in energy and water consumption in the melt reaction.⁵⁰ After impurities are eliminated through opt electronic sorting, cullet, or broken glass suitable for re-melting, is mixed with sand, lime, and sodium carbonate⁵¹. This mixture then melted in an oven/furnace at temperature 2600 to 2800⁰ F. The melted glass is dropped into a forming machine where it is given shape. It is then cooled to make finished products. Manufacturers use from 20% to as much as 80% of salvaged glass in their glass-making process.⁵² The use of recycled crushed glass reduces both the energy cost and the pollutant emissions associate with glass making. Crushed or salvage glass is easily saleable, with a market almost as good as that for aluminium. Nothing is valueless of glass products either as a new or broken/used or salvage.

Ferrous Metals

There are several sources of scrap ferrous metals: from iron and steel product (home scrap), from conversion (industrial or processing scrap), and from discarded goods from end users. Most of the ferrous metals are obsolete automobiles, bicycles,

⁴⁸ Glysson, *Engineering Handbook*, p. 110.

⁴⁹ Vatis Update: *Waste Management*, Vol. 5, No 60 (New Delhi: Jan-Feb 2004), p. 7.

⁵⁰ Glysson, *Engineering Handbook*, p. 104.

⁵¹ Alamnic Library, *21st Century Science*, pp. 60-61.

⁵² Bhatia, *Handbook of Pollution*, pp. 187-188 & 191.

steel cans, and discarded home scrap. An estimated 10 million tons of ferrous scrap made up largely of steel cans was discarded in the municipal solid waste stream in the USA in 1981. Magnetic separation of ferrous metals from waste is one of the most developed and simplest material separation processes. After shredding, re-shredding of ferrous item is ready for marketing. The potential markets of ferrous metals recovered from municipal waste would be reached through brokers, detinners, or scrap dealers and include iron and steel mills and foundries, the detinning industry, the copper industry (for use in precipitation processes) and production of ferroalloy.⁵³

Ferrous metal parts (small pieces) from cans, to scraps, to automobile bodies can be recycled in a wide variety. They are first shredded in a pulverize (grinding machine). The particles obtained are sorting with a magnetic device and sometimes enriched with raw materials. The metal, with or without additives, is melted in a blast furnace and then moulded into ingots. These ingots are transformed into sheets of metal that are used in the manufacturing of many types of products.⁵⁴

Non-ferrous metal

Non-ferrous items are easy to recycling and more revenue-earning source. Non-ferrous scrap is classified into three types: home scrap, industrial scrap (new scrap) and old scrap (obsolete or post user scrap). The major nonferrous metals recovered are aluminium, zinc, copper, brass and stainless steel.⁵⁵ Out of them aluminium is about two-third.

Aluminium recycling is profitable and well established because it requires only 5% of the electric power to re-melt it to extract bauxite ore. Manufacturing new aluminium cans from Used Beverage Cans (UBCs) uses 95% less energy than producing them from virgin materials. Steel food cans, which make up more than 90% of all food containers, are often called tin cans are also recyclable by steel industry. At a reclamation plant, shredded aluminium cans and other aluminium materials are first heated in a reacquiring process to remove coatings and moisture. Then they are charged into a re-melting furnace. Molten metal is formed into ingots that are transferred to another mill and rolled into sheets. These sheets are sent to container manufacturing plants for making new cans or other products.⁵⁶

Rubber

There are lot of rubber materials are scraped and added to MSW. In the past, tires were piled; land filled, burned or ground up and mixed with asphalt for road

⁵³ Glysson, *Engineering Handbook*, pp. 98-99.

⁵⁴ Alamnic Library, *21st Century Science*, pp. 60-61.

⁵⁵ Glysson, *Engineering Handbook*, p. 100.

⁵⁶ Bhatia, *Handbook of Pollution*, p. 191.

surfacing. These 'solutions' were expensive and often caused environmental problems because of the air pollution resulting from massive tire burning. Some new rubber recycling processes have tried to eliminate these limitations. The new option does not pollute the air and water because nothing is burned and no water is used.⁵⁷ Old tires are shredded in a pulverizer, which then transforms into powder. The powder goes through a magnetic sorting process that eliminates metallic impurities. This powder is mixed with the chemical agent /synthetic materials such as polyurethane are added, and the resulting mixture is then moulded to produce flooring, soundproof panels, and solid tiers and other competitive economic products.⁵⁸

Incineration Ash

It is already stated that incineration is not the final disposal of solid waste. Managing waste ash generated from incinerators is a major challenge for modern society. Ash disposed through landfill is expensive and is being discouraged by significant regulations and public opposition. There are two types of ash produced in an incinerator, one is fly ash collected in electrostatic precipitators, scrubbers or bag filters; and another is bottom ash. The former is about 10% and the later is about 90%. This residue is a soaking-wet complex of metals, glass, slag, char and unburned mineral oxide etc. Bureau of Mines tested and found that 1000 pounds of incinerator residue yielded 166 pounds of larger-size ferrous metals, such as wire, iron items, shredded cans etc. After ferrous metals recovering by magnetic separation ash could be used as landfill cover, landfill road base, aggregate in cement and road building applications. The ash also may be melted as fusion for having a glazed, nonabrasive, lightweight black aggregate. The fusion of combined incinerator ash and sewage sludge is currently used in Japan.⁵⁹

Application of waste ash to agricultural land presents an opportunity for the recovery essential plant nutrients. Ash reduces the need for commercial fertilizer, counteracts the ongoing acidification and is a solution to the potential problem of ash disposal. Waste ash typically has a high Ph value, content elements, and micro-nutrients, which are considered essential for plant growth. The feasibility of ash utilization depends on the soil environment and crops. It has been reported that wood ash can be used as a neutralizer of soil acidity and as a supplier of nutrients for tropical acid soil. On the other hand, heavy metals contents of ashes may restrict the use of ashes in agriculture. From the aspect of liming effect and plant nutrients, the waste ashes can be used as liming agent on acid soil and may bring agronomic benefits. But the most

⁵⁷ Ibid, p. 188.

⁵⁸ Alamnic Library, *21st Century Science*, pp. 60-61.

⁵⁹ Bhatia, *Handbook of Pollution*, pp. 188-189.

desirable method of utilization of the ashes is to reduce the heavy metals to safe levels before they are applied to agricultural land.⁶⁰

Valuable elements such as chromium, molybdenum and lead can be recovered from the residue with relative ease. The ultimate residue has, of course, very little value, consisting mainly of compounds of silicon and aluminum, of which the earth's crust has superabundance. A proportion of the ultimate residue can employ as an aggregate in building construction and a ballast in road or motorway construction.⁶¹

Removal of the metal contaminants from fly ash to be used as a silica source for cement production, characterisation of fly ash samples has shown a high surface area silica rich material i.e. high strength concrete. For most fly ash by products, the enrichment is not large enough to be of commercial interest for metal recovery; however, the concentration is sufficient for environmental concern.⁶²

Sewage Sludge

Sludge is a by-product of wastewater treatment plant. Sludge is the sediment deposited in waste water plant, sewerage and drainage. Effluents from the industries, institutions, domestic wastewater and public sewage etc. produce sludge. Before final disposal of sludge, it is in need of treatment. Sludge is a compatible item. Sludge can be composted and composted sludge act as a soil conditioner in agriculture and horticulture. Biogas is collected from the digester.⁶³ Composted sludge returns carbon, nitrogen, phosphorous and elements essential for plants growth back to the soil. The organic carbon helps to improve soil structure for soil aeration, water percolation and root growth. The nitrogen and phosphorous are also released gradually for plant uptake. However, pathogens and heavy metals can limit the reuse of sludge. Sludge contains heavy metals or toxic chemicals. Heavy metals and toxic chemicals are difficult to remove from sludge. Reuse may still be possible for alternative purposes such as mining site rehabilitation, highway landscaping or for land fill cover. Sludge, which has been conditioned for reuse, is also called 'bio-solids'. Through the pyrolysis conversion process, oil production from sludge is feasible. Such a plant is operating in Perth, Australia Through this process, heating dried sludge to a high temperature in the

⁶⁰ Fu Shen Zhang, S.Yanasaki, M. Nanzyo, "Wastes Ashes for Use in Agricultural production, Liming Effect, Content of Plant Nutrients and Chemical Characteristics of Some Metals", *The Science of Total Environment*, Vol. 284, Nos. 1-3, February, 2002, pp. 215-225.

⁶¹ Trivedi, *Encyclopedia of Environment*, p. 14.

⁶² Eugenius Mokrzychi, Alicja Uliasz and Mieczyslaw Sarnz, "Waste as Alternative Fuels in Cement Industry" Peter Chatania, ed., *Energy 2000: the Beginging of a New Millennium* (Italy: Technomic Publishing Co. Inc. and Bala Ban Publishersl 2000), pp.1011-1015.

⁶³ UNEP, *Environmental Sound Technology for Wastewater and Strom Water Management: An International Source Book* (Osaka/Siga: IWA Publishing, 2002), p. 9.

absence of oxygen or with a controlled amount of oxygen. Capital and running costs of an oil plant from sludge is very high.⁶⁴

Mixture of Incineration Ash and Sewage Sludge

The mixture of incinerators bottom ash and reservoir sludge could be used as raw material of construction brick. The moisture content in the sludge will decrease after mixing with incinerators bottom ash. The high porosity of bottom ash is considered as the water absorbent in the mixture. This mixture is suitable for the construction brick. The mixture will be 70% of sludge and 30% bottom ash. The new process has to install a mixture, two quantities feeders and a magnetic separator for preparing the ash and sludge. The power cost will be higher about 30% than the conventional brick making plant. Due to severe wear of incineration ash particles, the maintaining cost will increase a half, but still the mixture of sludge and ash to be an effective raw material of brick manufacturing had examined technically feasible in Taiwan.⁶⁵

Construction Wastes Utilization

The increased demolition activities of old structures for rebuilding purpose produces bulk volume of debris which has been identified as an environmental problems associated with unwanted space occupation and disposal. The construction debris consists of mainly crushed concrete pieces, plaster, concrete hollow blocks, waste bricks etc along with other construction wastes. This construction debris can be mixed with stones/pebbles for making road sub-base material. It was found that the material comprising of construction wastes is perfectly suitable to use as road sub-base satisfying AASHOTO criteria. With all test it was proved that construction debris is good raw material for road sub-base.⁶⁶

Pig-raising Fodder

In Manila and Cairo small scale, enterprises raise pig farming and they collect organic wastes from restaurants daily basis for animal's food. Pig raising is a popular backyard operation. This fodder is chief, about 50% of commercial feed. The 'Zabbaleen', a marginalized group of Christian survives through waste recovery. They collect relatively high value waste from high and middle-income area of the city. They also raise pigs on organic materials. They made composting with organic waste and pig manure. They earned more than average wage.⁶⁷

⁶⁴ Ibid., p. 59.

⁶⁵ Yung-Hui & Shaw-Bing, "Preparation of Construction Brick from Mixture of Incineration Ash and Reservoir Sludge", *Energy* 2000, p. 993.

⁶⁶ M. Kamal Uddin, "Management of Construction Waste: Utilization of Construction Debris as Road Sub-base Material in Bangladesh", *Bangladesh Environment* 2000, pp. 413-424.

⁶⁷ Anselm Rosario, "Decentralized SWM Approach", John Pickford, et al. eds. *Affordable Water Supply and Sanitation* (London: WEDC, 1994), p. 106.

Tipping fees

The charge imposed on trucks entering the landfill and does not provide any revenues from selling material reclaimed.⁶⁸ Tipping fees are generally charged where the landfill is operated by the private organization on the basis of cost recovery. In Bangladesh, there is no landfill which is operated by private organization. DCC is disposing the solid waste to their own landfill. Therefore, no provision of tipping fees to be charged for the truck coming with loads of garbage.

7.10 Composting: A Recovered Resource of MSW

Composting is the biodegradation of the organic constituents in wastes materials. Through the microbial activity taking place during composting, organic matter is decomposed into a stable, humus-like substance. At the same time the heat produced can result in pathogen destruction. Compost is a recycled product. It is the result of natural decaying of organic compounds. Waste materials when thrown away into the environment, the nature takes care of it. Living things recycle these wastes. Bacteria, fungi and other organisms digest and break down dead plants and animal materials into the food for other living things. This process is called decomposition.⁶⁹

Composting from solid waste for use as a soil amendment or fertilizer in many countries is very well known. Composting is an ancient practice whereby farmers have converted organic matters into soil amendments. These amendments were used to stabilize soils from erosion, provide nutrients, and replenish depleted organic matter that was lost through intensive cultivation. Asian countries in particular have a long tradition of making and using compost. In Western Europe, a range of modern technologies is used to produce compost.

With the development of the chemical fertilizers, organic recycling was abandoned and chemical fertilizer used to enrich soil in growing urbanizing societies. But fertilizer is now a major source of water and soil pollution. So USA and Europe have sharp increase in composting of solid waste. US composting facilities grew more fourfold from 1989 to 1996; even then composting rates in industrialized nations averaged only 11% in the early 1990's.⁷⁰

In peri-urban areas throughout Africa, NGOs, community based organizations and economic interest enterprises also promote composting of MSW.⁷¹ In Bamako, Mali,

⁶⁸ Hinrichs and Merlin Kleinbach, *Energy: Its Use*, pp. 543-544.

⁶⁹ Nasreen Alam, *Simple Facts*, p. 52.

⁷⁰ Gary Gardner, "Organic Waste Reuse Surging: Vital Signs," Linda Starke, ed., *The Environmental Trend that are Shaping our Future*, (New York: World watch Institute, 1988), pp.130-131.

⁷¹ Kaonga, *Appropriate Technologies*, Pollution Control, p. 390.

MSW is decomposing via natural process by many micro-enterprises. The garbage that dumps in the site without treatment for natural decomposition, the small –enterprise exploits this free source of raw material. Using relatively simple tools, (sieves, spades, brooms, & pushcarts) the enterprises manage to produce fine compost by sieving out the impurities and non-organic materials. They earn three times the minimum wage. The regular supply, the low cost and the proven quality of this soil conditioner have created a high demand, particularly from vegetable farmers in the peri-urban areas. These projects are generally highly labour-intensive with a low capital investment.⁷²

7.11 Method of Composting

Composting of organic wastes and residues remained more of an art than a science until about 50 years ago. Until this period, there were several development of mechanical or intensive systems, in Europe, such as the Itano process in 1928, Beccari in 1931, and VAM in 1932. The Europeans continued to develop and install composting systems in Europe, South America and Asia. In 1974, the U.S department of Agriculture at Beltsville, Maryland, developed the "static pile" method. Over 200 municipalities throughout the United States are currently using this method.⁷³

Recently there are three methods for composting solid waste and sewage sludge. These are windrow, static pile and in-vessel. Besides these some other forms of composting systems are developed.

Windrow or Active Pile Methods

The simplest method of composting is to place the waste in a long pile. In this process the compostables are deposited in a pile, called 'windrows' form the basic environment for compost bacteria and other organisms to perform decomposition. Regular turning of the windrows assists with mixing of the materials and more importantly supply the oxygen to the bacteria. Temperatures can reach 55°C, because compost has a good heat insulating property. The active pile systems require manual or mechanical turning of the windrows, with crews using shovels or rakes, or with equipment such as a bulldozer, tractor, or windrow turning machine. Turning aerates the piles, blends the materials, brings about additional size reduction, and prevents excessive build-up of temperature to the point of spontaneous combustion. Material in the warmer centre of the windrow matures faster and turning the waste eventually matures all part in a same manner. Important considerations for planning windrow system include:

⁷² Lardinois, "Small Scale Urban Waste Recovery," *Affordable Water Supply*, pp.101-102.

⁷³ Corbitt, *Standard Handbook*, pp. 8-135.

- ❑ Sufficient space for making a pile and turning facility;
- ❑ Need relatively high land for windrows;
- ❑ For a large amount, there need to be composting plant;
- ❑ Windrows are open or covered, depends on the climate and the moisture content of the waste;
- ❑ A large buffer zone between the composting plant and neighbouring residences may be needed for odour release, especially if the windrows are infrequently turned.

Static Pile Systems

It is another option for composting and it is more capital intensive method. Under this static pile system, the windrows are not turned. Instead, they are aerated continuously or periodically using blown air systems. In this systems typically require a site with aeration channels built into the pad on which the piles sit. Piles are built over this channel, and a network of perforated piping is introduced during placement into piles of the materials to be composted. During composting, air is blown or drawn by pipe systems driven by electric or gas motors through the static piles to provide aeration. The machinery includes pipes and blowers or vacuum pumps to blow or draw air through the windrows.⁷⁴ This may be on large rotating cylinders, or tower digesters, in which the waste is aerated and turned as it progressively falls down.⁷⁵

In-vessel Systems

This is higher technology basis composting. In an in-vessel system, much of the composting process is carried out indoors or inside a vessel- a large, enclosed chamber in which mechanical mixing and or forced aeration are performed- where moisture, air, and temperature can be controlled to create the optimal conditions for composting. At most all in-vessel systems require a residence time (physically in the vessel) 3-30 days, followed by a period of 21 to 180 days of active composting in an active static pile.⁷⁶ In-vessel system offer protection from weather conditions, better odour control, and shorter periods of active processing, but they are expensive to built and operate corresponding to windrow or static pile.

Drum or “Dano-type” Composting

In the drum barrel system compostables are introduced into a rotating horizontal drum for a relatively short residence time, followed by a long period of active-pile

⁷⁴ UNEP, *International Source Book*, p. 71

⁷⁵ Mansoor Ali, *Down to Earth*, (UK: WEDC, 1999), p. 12

⁷⁶ UNEP, *International Source Book*, p.71.

composting. These systems are called "Dano-type" systems after the original Danish design, now no longer protected by patent. The large metal drums are up to 30 meters long and may be divided into separate chambers. In the first chamber may be used for trommel screen for ousting the non-compostable materials. This system of composting requires a large amount of land for the active pile composting and it is also cost consuming.

Tower/Barrel Type Composting

In the tower system composting items are introduced into a vertical tower and composted under forced aeration. Some tower systems also mechanically turn or agitate the materials during its residence. Residence time is normally 2-5 weeks. Tower systems offer more odour control during composting and require much less land, since the period of active composting takes place in the vessel. This system is very much applicable for sludge composting or co-composting of sludge and organic waste. Small barrels are also used for this type of composting in a small scale. In Dhaka, 'Waste Concern' an NGO introduced a barrel composting in the residential and slum areas.

Vermey Composting Process

It is one kind of aerobic composting in which certain varieties of red worms and earthworms are used. These worms mechanically break down the organic components and partially decomposed materials by eating them. The biochemical decomposition occurs via bacteria and chemicals in the worm's digestive systems.⁷⁷ The composting also called vermiculture or worm composing. The worms eat waste and produce a caste (natural waste produced) with a content of nitrogen, phosphorus, and magnesium several times that of soil making it a good soil conditioner. For vermiculture, source separation is obvious. Vermiculture does not necessarily kill all pathogens. In particular, some viruses and parasites can survive the process. Therefore, vermiculture compost contains the pathogens. The vermiculture composting is still in the phase of pilot project. This system has been introduced at first in Manila in 1970 but could not survive.⁷⁸

7.11.1 Composting Procedure

Composting is the biological decomposition of complex animal and vegetable materials into their constituent's components. It is a natural process of bacteria and other organisms eating what they like in a favourable environment.⁷⁹ Microorganisms, such as bacteria play an important role in the natural cycling of materials in the decomposition of organic wastes. They form what is termed a 'food chain' for example, organic substances

⁷⁷ Ibid, p. 73.

⁷⁸ Mansoor Ali, *Down to Earth*, p.12.

⁷⁹ UNEP, *International Source Book*, p. 62.

in wastes are consumed by bacteria, fungi and algae. These are in turn consumed by protozoa and nematodes (some fungi however trap nematodes) and the later by rotifers. The most common composting process take place is aerobic, anaerobic and photosynthetic process. Under aerobic condition aerobic bacteria require a mix of approximately one part nitrogen to at least 30% and no more than 70% carbon in their food supply. Aerobic bacteria also require at least 40% but not more than 60% water in their environment, and a plentiful supply of oxygen. In aerobic situation microorganisms utilize O_2 to oxidise organic substances to obtain energy for maintenance, mobility and the synthesis of cellular material. Anaerobic digestion can also occur at higher levels of moisture. The microorganisms utilize nitrates, sulphates and other hydrogen acceptors to obtain energy for the syntheses of cellular material form organic substances. The products of anaerobic digestion are methane gas and decomposed organic material.⁸⁰

Factors Affecting in Composting Procedures

The efficient composting is the biodegradation of the organic fraction depends mainly on the optimal interaction of the temperature, oxygen, moisture, and carbon/nitrogen ratio.

Temperature

Temperature is very important for decomposition. Optimal temperature for composting is 55°C. The high temperatures above 55°C will effectively destroy the pathogens.

Oxygen

Composting can be done with oxygen or without oxygen. With oxygen is aerobic composting which faster the composting process and also does not produce malodours. Oxygen levels between 5-5% are optimum. Below 5% may results in anaerobic conditions, which may slow the decomposition process and produce undesirable odours. Oxygen level above 15% may result in loss of heat with slower decomposition and poor pathogens destruction.

Moisture

Bio-logical degradation is usually slow in cool weather and rapid in warm weather. Moisture is also an important ingredient of composting since it helps in the degradation of the material. The optimum moisture levels for composting are between 50 to 60% by weight. Below 40%, decomposition is reduced, and above 60% the pore space necessary for aerobic composting is blocked by water and anaerobic conditions can occur.

⁸⁰ Ibid, pp. 22-24, & 62.

Carbon/Nitrogen Ratio

The carbon nitrogen (C/N) ratio is one of the important parameters affecting the decomposition process of organic matters. Carbon is an energy source for the microorganism; whereas nitrogen is necessary for protein synthesis. The ideal C/N ratio is from 25 to 30. Sewage sludge has a low C/N ratio (10 to 15), whereas solid waste has high ration (35 to 80). The agitated of bulking materials with sewage sludge enhance the C/N ratio and the use of sewage sludge in combination with solid waste improves the latter's ratio.

Guidelines for Sound Composting Practice

The waste stream must be compostable

The material to be composted must be compostable in order to produce a marketable product. The carbon-nitrogen ratio of waste must be optimal for compost. Yard waste is very good for composting for optimal C/N ratio. The vegetable and animal wastes from kitchens need more careful management process. If not separated it may be too high nitrogen ratio (protein, from meats, dairy products, and certain green vegetables. To high protein content can complicate the composting activity and lead to unpleasant odours.⁸¹ Source separation of inorganic materials from waste stream is one of the important practices having valuable composting.

Compost plant site

Compost facilities must be reasonably close to the input stream and the potential users, but must be sited in a way that is compatible with the desires of the nearby community.

Pre-processing

The finer the particle size, the faster and more efficient is the composting process. Pre-processing means source separation for composting. Separation before composting is more effective than screening after composting. It is probably economically advantageous only when organic material is collected separately from other wastes.⁸²

Selection of appropriate technology

The technology chosen must be adequate for the input stream and for the level of economic development of the country. Composting should be suited with the local condition. In the 1960s many mechanized composting plants were constructed often promoted by foreign firms in Africa, Asia and other developing countries. Almost all of the plants are now not operating or operating at a 20-30% capacity because they were

⁸¹ Ibid, p. 66.

⁸² Keller, *Environmental Geography*, p. 253.

unsuitable for the local wastes, parts and skilled operators were not available, and/or the product was too expensive or not good enough to secure markets.

Scale

The production level of composting should be on the basis of marketability and locality based technical support. Smaller scale facilities often facilitate careful composting and the formation of a good product. A large scale facility does not work well other than the enormous support from the local users. Large scale composting should only be undertaken if adequate skilled manpower, equipment and demand for compost are available.⁸³

The market development/economic viability

Waste, that is technically suitable for compost does not automatically becomes a valuable economic product if there is no market for it, or its use is not commercially viable and hence they should be disposed of.⁸⁴ The development of markets is a crucial step in promoting compost as an increasingly important part of an integrated MSWM system. Market development does not mean only the profit making from composting. 'Marketing' may include any type of beneficial use, ranging from use in roads, parks⁸⁵ and cover materials for sanitary landfill etc.

Compost quality control

The compost quality control is very important from within the composting itself and solid waste management. The first element in quality control is controlling the inputs to the composting process. In the industrialized countries quality control rests upon clear and enforceable source separation protocols, combined with sound collection practice and pre-processing.⁸⁶ In the developing countries where source separation is unlikely, manual pre-processing and post-processing is required to ensure the quality of the compost.

Users' confidence

Composting could be more successful when it could grow users confidence. Training of farmers to use compost is a key to success of compost.⁸⁷ The potential users

⁸³ Ali, *Down to Earth*, p.12.

⁸⁴ Irena Twardowska and Jadwiga Szczepanska, "Solid Waste: Terminological and long-term Environmental Risk Assessment Problems Exemplified in a Power Plant Fly Ash Study", *The Science of Total Environment*, Vol. 285, No. 1-3, Feb, 2002 (ELSEVIER), pp. 29-53.

⁸⁵ UNEP, *International Source Book*, p. 74.

⁸⁶ Ibid, p. 75.

⁸⁷ Gary Gardner, "Organic Waste Reuse Surging: Vital Sings", Linda Starke, ed., *The Environmental Trend that are Sharpening our Future*, (New York: World Watch Institute, 1988), pp.130-131.

confidence is very important for survival of the composting plants. Confidence will increase when the compost using yields will be more than chemical fertilizer. It is the duty of the government to apply compost in government projects and show the impact to the farmers and potential compost users.

7.12 Compost Marketing

Effective marketing of the compost is very important to sound practice of waste management. In the industrialized countries compost is ordinarily considered as soil conditioner rather fertilizer. To date Europe is only area of the world with clear and enforceable compost quality standards, and with a history of government intervention to stimulate and support compost markets. The European community emphasised on source separated bio-waste composting rather mixed waste for ensuring a quality compost. Like the Europe, no other part of the world could attain such policy. There are some critical points for compost market development.

Government stimulation

The government can play an important role on compost market development. It is possible through using the compost in public works department for demonstration. The government contractors using compost in government funded projects. Providing technical assistance, supporting or subsidise in compost plants so that it can compete with chemical fertilizer. Providing free or low cost testing of compost fertilizer for its nutrient value is not feasible.

Compost and land application standards

It is very essential of establishment of compost and land specification standard. It will help the users to be comfort for using compost. The Europe Union has identifies the three grade of compost ranging from acceptable to very high quality-based on levels of heavy metals. Land application standard ensure the use limit of compost especially for different crops. It is essential to give farmer's confidence that compost is safe for use, and they will not be penalized at a later date.⁸⁸

Compost use in public sector

The successful compost market development primarily depends on the heavy participation of using compost in the public sector projects. This is a win-win strategy, as it tends to reduce costs and increase effectiveness of the project.⁸⁹ It has also demonstration effect of the composting benefit. The common people will be interested in this regard and the market will enhance.

⁸⁸ UNEP, *International Source Book*, p.75.

⁸⁹ Ibid.

Compost as daily or final landfill cover

Compost market may be increase through using as daily landfill cover. Landfill cover is an excellent use of lower quality compost or compost with large particles in it. Compost is useful as landfill cover where the soil cover have to be excavated, purchased and transported.

Distribution channel

Distribution of compost is an essential phase of the marketing program. Identification of distribution alternatives can assure the municipality that the compost will be removed from the site in a timely manner without interfering with treatment plant or composting operations. The distribution system also helps to assure users of obtaining materials when needed.⁹⁰

7.13 Composting Benefit

There is a conflict between the financial constraints and ecological advantage of resource recovery. Large-scale composting in developed country proved environmental benefits is more realistic target than economic feasibility. But in developing country resource recovery should seen as to secure profits rather as a contribution to social and ecological improvements. The composting benefits are as follows:

Soil benefit

Composting provides multiple benefits to soils. It is an excellent organic soil conditioner. Organic composting if carried out effectively, the final product is stable, odour-free, does not attract flies. It is used to increase organic content, water retention and improve soil structure. The addition of the compost to soil can make it easier to till.⁹¹ Compost itself decomposes slowly and thus remains effective over a longer period of time. Moreover, the compost will improve the physical properties, as evidenced by increase water content, increase water retention, enhance aggregation, increase soil aeration, increase permeability, increase water infiltration, and decrease surface crusting. It shelters nutrients that would otherwise be leached or eroded away. It helps soil to retain water, which can secure crops through periods of low rainfall. And it suppresses plant diseases: compost has been shown to limit the spread of root rot, for example, as effectively as many fungicides.⁹²

Reduction of SWM Cost

Organic waste recovery reduces the overall volume of solid wastes that needs to be disposed in landfills or otherwise, thus reducing transportation and disposal costs.

⁹⁰ Twardowska & Szczepanska, "Solid Waste", *The Science of Total Environment*, pp. 29-53.

⁹¹ Mansoor Ali, *Down to Earth*, p.11.

⁹² Gardner, "Organic Waste Reuse" *The Environmental Trend*, pp.130-131.

These so-called opportunity savings could be used to subsidize recovery initiatives to a certain extent.⁹³ Composting can cut land filling cost and place in a remarkable portion.

Environmental benefit

Composting decreases the leachate production through reducing waste dump. In addition to returning nutrients to the soil increases the soil fertility and, thus permits the reduction of artificial fertilizer.

Composting problem

High cost

Due to low skill/managerial inputs, the operating efficiencies may be low resulting in high cost of production. The problems may further compounded due to large distances between compost production centers and the compost utilizing farmlands. The resulting cost of transportation make the compost marketing uneconomical. Farmers also reported problem with broken glass pieces in the compost. Careful segregation of source can remove this issue.⁹⁴

Heavy metals

Negative image on urban waste is also a barrier of resource recovery. Another example of possible negative side-effect constitutes the quality of the compost is heavy metals in compost. In 1991, a chemical analysis of the compost product at Cairo plant resulted well below European Standards; it contained high levels of zinc and lead and even dangerous levels of cadmium. It was assumed organic waste being contaminated by mixing with non-organic, sometimes hazardous wastes (such as house hold batteries) during storage and collection.⁹⁵

Market demand

A major drawback of composting is that there may be no market demand. From the viewpoint of transportation cost compost is a less demanding item. Due to high cost of transportation to the users, there is the possibility of less demand of the compost. So, there is a drawback of compost marketing.

Green house gas effect

Gases released from improperly maintained compost plies are negative effect associated with the composting process. When piles are not properly aerated, much more anaerobic bacteria flourish and produce methane gas. The decomposition

⁹³ A.P Jain, G.B. Pant, "Solid Waste Management in India", *Affordable Water Supply*, p. 93.

⁹⁴ Ibid, p. 94

⁹⁵ Lardinois, "Small Scale Waste", *Affordable Water Supply*, p. 103

process also releases carbon dioxide, volatile organic compounds, bacteria, and fungi. The release of methane and carbon dioxide contributes to the problem of greenhouse gases in the atmosphere. Poorly operated composting facilities also cause unpleasant odours.

7.14 Energy Resource Recovery from Solid Waste

The total amount of energy in the universe is constant. Energy is not created or destroyed but just converted or redistributed from one form to another. None can 'see' energy, only its effects; it cannot be made; only use it; none can destroy it; only waste i.e. someone can use it inefficiently.⁹⁶

Solar energy is the root of all energy. Solar Energy includes a number of different sources, as wind, hydropower, steam, biomass, oceanic thermal energy etc. These all energy sources are renewable. The necessity of RE emphasised by examining its environmental impact. The advantages of these sources are that they are inexhaustible and are generally associated with minimal environmental degradation. With the exception of burning biomass or urban waste, they don't pose the threat of adding CO₂ to the atmosphere and causing potential climate modification. The lead-time of adopting the technology is also shorter.⁹⁷

From the human history, biomass energy was long used for cooking, heating and still is more used in poorer part of the world. The momentum of the industrial revolution first linked to cheap, readily accessible fossil fuel (coal, and later oil and natural gas) became the most important energy source. This fossil fuel is non-renewable and causing concern about what will happen when it will run-out.⁹⁸

7.15 Importance Renewable Energy

Survival of the humanities always depends on his ability to derive adequate energy in the form of food calories and other energy from the natural environment. But the fuel energies are depleting day by day. More and more extraction of fossil fuel leads environmental catastrophe.⁹⁹ There is a limitation of oil, natural gas and coal. There is a

⁹⁶ Hinrichs & Kleinbach, *Energy and Its Use*, pp.1-3.

⁹⁷ Dr. Engineer K. Islam, "Application of Potential of Renewable Energy Technologies with special reference to solar PV Electrification of Remote Rural Areas of Bangladesh", Md. Mahtab Uddin, ed. (Dhaka: AI Publication Ltd.), pp.365-366; Keller, *Environmental Geography*, pp. 377-378.

⁹⁸ Richard Mayer, *Connection in Environmental Science: A Case Study Approach* (Boston: McGraw-Hill Higher Education, 2001), pp. 128-129.

⁹⁹ Robert L. Loftnes, *Energy Handbook*, (New York: Van Nostrand Reinhold Co. Inc, 1984) p. 3; K. Islam, *Potential of Renewable Energy*, pp. 365-366.

little doubt that once upon a time there will be an energy crunch and that for some energy usages a partial or complete transition must be made from non-renewable energy sources; as solar, water, biomass and wind.¹⁰⁰

After II world war in the period of energy crisis, the society understood that by developing new technique the fossil fuel must be conserved. It was expected that nuclear power would replace fossil fuel but due to unforeseen hazardous accidental possibility, it is not dependable. In fact the oil embargo imposed by OPEC in 1973 triggered a series of 'shock waves' across the globe, which literally jolted the 'petroholic' human society back to their senses to become careful in use of fossil fuel resources and look for solution through use of alternative sources of energy.¹⁰¹

Global warming caused by the greenhouse gases is a serious concern for the humanity. The human society, all over the world, in its efforts to attain and sustain ever higher standard of living, keep on burning of tons of fossil fuel like oil and coal thereby pumping more than 22 billion of tonnes of CO₂ and other green house gases each year to the atmosphere. The gases are already started their journey towards the South Pole to melt the Icecap which lead to submerge the land beneath the seawater. The country like Bangladesh is under serious threat to be submerging of its coastal area.

Nuclear energy, while imposing no threat to climate modification, is associated with serious problems such waste disposal, accidents as weapon proliferations (Chernobyl accidents in Russia). Finally, it must be emphasised that all fossil fuels and nuclear energy from fission are ultimately exhaustive, and to be eventual transition to the R/E.¹⁰² Unlike fossil or nuclear fuels, renewable sources of energy are also depleted as they are used. But they are renewable. The term 'renewable' and sustainable used to mean the same thing that is an energy source that is renewable to be understood as sustainable.¹⁰³ So it is needed to walk for renewable energy sources. It was tried to recover the resources from municipal solid waste. Combustible portion of wastes used for alternative fuel.¹⁰⁴

Use of Solid Waste as Energy Resource

Waste has long been use as fuel. The American India used buffalo chips (& presumably other wastes) for heating & cooking before European settlers arrived in

¹⁰⁰ Dennis L. Little, Robert E. Dils & John Gary eds., *Renewable Natural Resources: A Management Handbook for the 1980'* (USA: West View Press, 1982), pp.1 & 189.

¹⁰¹ Alter & Dunn, *Waste Conversion to Energy*, p. 1; K. Islam, Potential of Renewable Energy, pp. 377-378;

¹⁰² Keller, *Environmental Geography*, pp. 377-378.

¹⁰³ Mayer, *Environmental Science*, pp. 128-129.

¹⁰⁴ Alter & Dunn, *Waste Conversion to Energy*, p. 1.

North America. The practice was probably followed by various early societies. Heat recovery from incinerators was first practiced in turn of 19th century. This method of generating steam & electricity began in Hamburg in 1896 and New York City 1903. But when land filling became less expensive, the generation of steam plus electricity by incinerator became less importance. By contrast, due to raise oil price and crisis and landfill cost, they used refuse-derived fuel for coal supplement.¹⁰⁵

Scope of Renewable Energy from Biomass

In response to the dramatic increase of oil price in 1970's and as well as the environmental concerns for over use and over extraction of natural resumes, the term renewable energy come forward. Liquid and gaseous fuels can be produced from virtually all form of biomass by a number of processes. The most common liquid fuels are alcohol-based products ethanol and methanol, while the most important gaseous fuel is biogas. The type of fuel ultimately produced depends on the type of conversion process. The biochemical process of anaerobic digestion produces biogas. Biogas is a medium British thermal unit (medium BTU) mixture of methane and carbon dioxide, which can be purified to yield high BTU methane, the principal component of natural gas. Small anaerobic digesters have been relatively successful in developing countries. For example, in china over seven million small digestion systems have been installed to partially meet the cooking, space heating, and lighting demands of a number of rural communities.¹⁰⁶

7.16 Types of energy from Biomass¹⁰⁷

Biomass can be used as fuel in three forms. These are solid, liquid and gaseous form. Solid biomass means the plants, firewood, grains, and solid wastes etc. for fuelling by direct combustion. All types of wood and other feedstock are used as firewood for heat generation. MSW is burned and the heat energy is used to make steam for a variety of purpose ranging from space heating to generation of electricity. The Western European countries are using one third to one half of their MSW for energy production. With the end of chief available fossil fuels, more and more energy recovery will be forthcoming.¹⁰⁸

¹⁰⁵ Ibid, 58.

¹⁰⁶ Corazon M. Siddayno, ed., *Energy Investments and the Environment: Selected Topics* (Washington: World Bank, 1993), pp.18-19.

¹⁰⁷ Keller, *Environmental Geography*, pp. 385; K. Islam, *Potential of Renewable Energy*, pp. 189; Little, Robert & Gary, *Renewable Natural Resources*, p.189; Tillman, *Energy from Waste*, pp. 74-75 and; Hinrichs & Kleinbach, *Energy and Its Use*, p. 540.

¹⁰⁸ Keller, *Environmental Geography*, pp. 385.

Liquid fuel produced from solid biomass through chemical or biological action and or conversion of plant sugars to ethanol or methanol. The production of liquid fuels from wastes is desirable for several reasons. Because the liquid fuel can be store, transport and used for commercial purpose. Thus the energy product does not have to use at or near the recycling plant site. This flexibility, plus the ability to sell the fuel on a calorific content basis, provides powerful use incentives for humanity. Gaseous fuels produced by high temperature and high pressure processing. As the waste decomposes, it produces methane gas that can be recovered through shallow wells.

7.17 Factors Affecting the Energy Content

The heat energy cannot be the same in all types of waste materials. Even due to seasonal variation and income level, social practice etc differentiate the nature of waste. The thermal output of a recovery system is the product of waste input quantity, waste energy content, and boiler efficiency. Boiler efficiency is greatly influenced by the moisture content of the fuel. Typical boiler efficiencies are 60 to 70% for mass burning and 70 to 75% for RDF combustion.¹⁰⁹ The removal of inert materials has the added advantage of producing more easily handled fuel, since the glass, stone, and metals can contribute to the deterioration of materials handling equipment. The quantity of energy that can be recovered from MSW depends on four factors:

- Waste input quantity
- Waste energy content
- Boiler efficiency
- System availability

7.18 Types of Energy Recovery

Landfill Gas (LFG) Recovery

The rapid rise of cost of energy has prompted increased interest in recovery and utilization of landfill gas. LFG is composed of mainly methane and some other gases.¹¹⁰ Landfills that are considered a place of nuisance are now viewed as a potentially valuable resource. An analysis of average urban waste shows that 30-40% of its total volume, is an agricultural product. The largest constitute of canteens and hotels use putrescible agricultural product. The percentage of weight is about 80%. This waste can be used to produce biogas fuel by the process of anaerobic digestion. Typically, biogas

¹⁰⁹ Glysson, Enginerring Handbook, Chapter 8, p. 59.

¹¹⁰ Robert P. Stearns and Thomas D.Wright, "Landfill Gas Recovery at the Ascon Disposal Site- A Case Stuey," *Fuels from Biomass and Wastes*, Donald L. Klass and George H. Emert, eds., (Mihcigan: Ann Arbur Science, 1981), pp.199.

contains about 60% methane, 35% CO₂ and 5% other gases. Sanitary land filling involves the covering of refuse with soil, thereby creating condition conducive to anaerobiosis and formation of a variety of gases. Of these gases, methane is main constituent. This methane gas has not got great attention for its negative effects, but with a controlled mechanism other elements remove and methane can be used as natural gas. Through active gas control system, methane gas can be used for energy purpose. About 1/5 of annual natural gas can be replaced by methane produced from sanitary landfill.¹¹¹

Methane Gas Evolution Process

The evolution of methane gas from sanitary LFs follows a general pattern. When wastes are placed into a landfill, there is a mixture of biodegradable materials, moisture and air (in the void spaces). In this environment, decomposition of the waste and gas generation is inevitable. The organic garbage naturally biodegrades and produces methane and other gas. Biodegradation takes place in three main phases: (a) the hydrolysis process (b) an acid phase & c) the methane phase. In the first phase, bacteria use the oxygen from the void spaces as an ingredient during the waste decomposition process (this is called aerobic decomposition).¹¹² The large molecules break into small one but enzyme in the hydrolysis process and produce simple molecules that are able to pass through the bacteria membrane. The primary gaseous product of aerobic decomposition is carbon dioxide.¹¹³

The second phase is anaerobic, non-methanogenic acid phase. In acid phase, complicated molecules such as protein, fats and carbohydrates are brake down by acid forming bacteria into organic acids, CO₂, H, ammonia, etc. In this stage decomposition process begins which does not require the presence of oxygen that is called anaerobic decomposition. During this period, hydrogen production increased and gaseous nitrogen rapidly depleted.¹¹⁴ The decomposition of organic wastes in an oxygen deficient atmosphere produce methane gas or controlled fermentation for production of alcohols ethanol or methanol.¹¹⁵ In the presence of moisture and absence of oxygen, most organic materials will undergo natural fermentation in which 60-80 % of the carbon in the

¹¹¹ L. Van den Berg, "Bioconversion of Biomass into Methane", *Food Feed & fuel from Biomass*, D.S. Chatal ed., (New Delhi: Oxford IBH Publishing Co., 1991), pp. 248-249.

¹¹² Glysson, *Engineering Handbook*, Chapter 8, p. 57.

¹¹³ Mokrzychi, "Waste as Alternative Fuels", *Energy 2000*, pp. 1023-1027.

¹¹⁴ L. Van den Berg, "Bioconversion of Biomass into Methane", *Food Feed & fuel from Biomass*, D.S. Chatal ed., (New Delhi: Oxford IBH Publishing Co., 1991), p. 248-249.

¹¹⁵ Hinrichs & Kleinbach, *Energy & Its Use*, p. 548-550.

organic materials is converted into a mixture of CO₂, methane, traces of hydrogen sulphide and nitrogen.¹¹⁶

In the final phase, fermentation of acid & alcohol produce methane, H and CO₂. This phase is characterized by the initiation of methanogenic activity. This phase begin 180 to 500 days after landfilling. The conversion takes place at temperature of 15-50°C and near atmospheric pressure. All three phases are occurring simultaneously and in the case of the domination of any phase, methane production seriously affected. The effect of temperature is critical for the performance of digesters. The cow-dung is to be used in digesters as a catalyst to initiate digestion process.¹¹⁷ One pound of cow dung will yield about 1 ft³ of gas; while one cow's annual output is equivalent to the energy is about 50 gallons of gasoline.¹¹⁸

Once steady condition is reached, gas production comprising about two-third methane and one-third carbon-di-oxide and a minor other gases produce.¹¹⁹ The actual amount of gas evolved from a LF site (standard is 0.56 m³ per kg of dry solid waste) depend on landfill age, method of construction and microenvironment.¹²⁰ The rate of gas generation generally higher during first few years of waste burial and tend to decrease with time. If not collected and utilized the potential resources just melting in the atmosphere.¹²¹ Landfill sites are now designed such a way that increases methane production and biotechnologists are working on ways of 'seeding' LFs with appropriate bacteria to accelerate the biodegradation process for more methane production.¹²²

Methane gas production could be possible from mixture of sewage sludge, animal dung, farm waste and industrial waste. If the sludge is mixed with solid waste it enhance the possibility of producing more methane gas.¹²³ The methane rich gas can be

¹¹⁶ Hinrichs & Kleinbach, *Energy & Its Use*, pp. 548-550; Loftnes, *Energy Handbook*, p. 2; Islam K. *Renewable Energy Technologies*, pp. 356-366.

¹¹⁷ Eugenius Mokrzychi, Alicja Uliasz and Mieczyslaw Sarnz, "Waste as Alternative Fuels in Cement Industry", *Energy 2000*, pp. 1023-1027.

¹¹⁸ Hinrichs & Kleinbach, *Energy & Its Use*, p. 548-550.

¹¹⁹ Siddayno, ed., *Energy Investments*, p. 70.

¹²⁰ Van Berg, "Biomass Methane", *Food, Feed & fuel*, pp. 248-249.

¹²¹ Corazon M. Siddayno, ed., *Energy Investments and the Environment: Selected Topics* (Washington: World Bank, 1993), p. 70; Van Berg, "Biomass Methane", *Food Feed & fuel*, pp. 248-249; Robert P. Stearns and Wright, "Landfill Gas Recovery at the Ascon Disposal Site- A Case Study," *Fuels from Biomass*, p.199.

¹²² Mokrzychi, "Waste as Alternative Fuels", *Energy 2000*, pp. 1023-1027; Elkington & Shopley, *Cleaning up*, p. 9.

¹²³ Jill Gale de Villa ed, *Energy End Use: An Environmentally Sound Development Pathway* (Manilla: ADB, n. d.), p.139. Van Berg, "Biomass Methane", *Food, Feed and Fuel*, pp. 248-249.

upgraded as a supplement to natural gas by removing the CO₂ and trace gases.¹²⁴ The volatile gas produced has a heating value of 500-700 Btu/ft³. Removing CO₂ and HS will provide a gas that is essentially pure methane and which has a heating value of 1000 Btu/ft³ corresponding to natural gas. One-pound dry organic materials will produce 4.5 to 6.5 ft³ methane.¹²⁵

Heat Energy/Refuse to Energy (RTE)

Solid waste is one kind of biomass and it is renewable energy source. The refuse which is applicable to convert energy is termed as refuse to energy (RTE). A refuse to energy system is the mechanical, chemical and biological processing of MSW or its processed fraction, to produce a gaseous fuel, heat, steam or electrical energy in a forms that fulfils a customer's specification.¹²⁶ There are numerous forms of biomass conversion into energy. The fundamental conversion process is green plants in photosynthesis, which is the combination of CO₂ from the atmosphere with water plus light energy to produce oxygen and carbohydrates (sugar + starches): CO₂ + H₂O + light energy = O₂ + carbohydrates. The reversal of this process is called respiration in which CO₂, H₂O and heat are produced in the combustion of carbohydrates and O₂. Solid biomass can be converted into energy resources through different process. These energy conversion processes¹²⁷ are mentioned in table 7.1

Table 7.1
Energy conversion process

Type of energy	Conversion Process	Remarks
Heat energy	Direct combustion, RDF & Pyrolysis	
Oil energy	Chemical reduction & Pyrolysis	
Gas energy	Bio-digestion or fermentation, & Pyrolysis	
Electrical energy	Mechanical conversion of heat energy into electrical energy through turbine	Electric energy can't be produce from waste direct

Direct Combustion for Heat Energy

This is very simple procedure of heat generation from refuse. The direct use of organic waste as fuel for cooking in the home is quite common. Woody residues such as coconut shells, dry vegetable residues are frequently used for conventional fuels and other combustibles. Compressing combustible material is useful like other solid fuel that can be burned like wood or charcoal.¹²⁸ The burning of solid waste (biomass) is very

¹²⁴ P.D. Chase and J.H. Singletary, "Biodegradable Potential of Pretreated Municipal Solid Waste", *Fuels from Biomass and Wastes*, Donald L. Klass and George H. Emert, eds., (Michigan: Ann Arbor Science, 1981), pp. 185 & 196.

¹²⁵ Loftnes, *Energy Handbook*, p. 2 & 361.

¹²⁶ Alter & Dunn, *Waste to Energy*, p. 95.

¹²⁷ Glysson, *Environmental Handbook*, pp. Chapter 8, pp. 136.

¹²⁸ Lardinois, "Urban Waste Recovery", *Affordable Water Supply*, pp.101-102.

common to produce heat for cooking, space heating, or for the production of electricity through a steam turbines. Anything from solid wastes to crop residuals to wood can serve as feedstock for this process. So, urban and industrial waste can be used in industry as a conventional fuel substitutes: separately or mixed, fluid as well as solid. Almost 14% of total energy burnt for clinker in Poland from this alternative fuel, which proved economically, and ecologically justified.¹²⁹

Heat Content of the Solid Waste¹³⁰

The heating value (or energy content) of most solid wastes is roughly one-third to one-half of the heating value of coal. The quantity of heat generated by complete combustion of a fuel is known as the heating value, heat of combustion, or caloric value. Heating values are usually expressed in units of Btu (British thermal unit) per cubic foot (kilocalories per cubic meter) for gaseous fuels, Btu per gallon (kilocalories per litre) for liquid fuels, and Btu per pound (kilocalories per kilogram) for solid fuels. The heating value of all solid waste fuels is a function of carbon content. Material containing as much as 75% moisture free and ash free can be burned without auxiliary fuels.

Typical heating values of MSW as received at resource recovery facility or disposal site range from approximately 3000 to 6000 Btu/lb (1700 to 3300 kcal/kg). However, the average value is typically 4500 to 5000 Btu/lb (2500 to 2800 kcal/kg) as received. The heating value of MSW depends upon its composition. The RDF component of solid waste by removing glass, ceramics and metals typically has a HHV (higher heating value) of 4500 to 8000 Btu/lb (2500 to 4500 kcal/kg). RDF typically burns more efficiently than unprocessed MSW due to lower ash content, lower moisture content, and higher degree of homogeneity. Because of these qualities, RDF requires less excess combustion air than mass burning process. Table 7.2 shows the heating value¹³¹ of some common MSW.

Table 7.2
Heating value of solid waste

Typical waste stream	Heating value	
	Btu/lb	Kcal/kg
Paper, 35%	$7,750 \times 0.35=2712$	$4300 \times 0.35=1505$
Plastic, 10%	$18,000 \times 0.10=1800$	$10,000 \times 0.10=1000$
Other organics, 10%	$2,000 \times 0.10= 200$	$1,100 \times 0.10=110$
Total	$= 4,712$	$= 2,615$

¹²⁹ Mokrzychi, "Waste as Alternative Fuels", *Energy 2000*, pp. 1011-1022.

¹³⁰ Glysson, *Environmental Handbook*, Chapter 8, pp. 67-168; Elkington & Shopley, *Cleaning up*, .p 9; Alter & Dunn, *Waste Conversion*, p. 61.

¹³¹ Glysson, *Environmental Handbook*, pp. Chapter 8, pp. 139.

Refuse Driven Fuel (RDF) ¹³²

The basic technology for producing energy from MSW, incineration and steam turbine electrical generation, was developed during the early twentieth century. New technologies have been developed to recover materials from MSW and also an improved fuel product, generically described as refuse-derived fuel (RDF). It is variety of technologies that produce solid fuel by processing MSW into combustible and non-combustible fractions. The resulting fuel can be co-fired with fossil fuels or burned alone in a "dedicated boiler". RDF facilities consume prepared materials usually made by removing toxic and un-burnable units, and drying & shredding the reminder.¹³³ RDF refers to the product derived from the mechanical processing of MSW. RDF can be obtained by several means. Out of them separating and shredding is important. The liquid or gaseous fuels from chemical or biological treatment of wastes are also another form of RDF.¹³⁴

Pyrolysis Product¹³⁵

Different technologies process the MSW in oxygen deficient environment to producing gaseous, liquid, and solid fuels. Organic materials can be converted into gases, liquids and solids through pyrolysis at temperature of 500 to 900^o C by heating in a close vessel in the absence of oxygen. The pyrolytic destructive distillation of wood has long been used to recover methanol, acetic acid, turpentine, and charcoal. This process can handle all forms of organic materials. The gases produced are the mixture of nitrogen, methane, carbon monoxide, CO₂ and other hydrocarbons. The liquids produced are oil-like materials and the solids are similar to charcoal. Synthetic fuel can be produced from solid waste through pyrolysis. Cellulose base materials (RDF) are suitable for pyrolysis. This cellulose polymeric material subject to thermal stress (elevated temperature), it breaks down. With the level of temperature in pyrolysis process destruction happen in cellulose. When cellulose is heated very slowly, the polymer is slowly broken down and the outputs are non-combustible gases, non-reactive char etc. when cellulose is heated rapidly to high temperature, the cellulose molecule is shattered into small molecules having a small tar, liquid, and char yield but produce more combustible volatiles. The plastic materials in RDF provide little char and a gas with a higher heating value.¹³⁶

¹³² Elkington & Shopley, *Cleaning up*, p.9; Alter & Dunn, *Waste Conversion*, p. 61.

¹³³ Ibid, p. 62.

¹³⁴ Alter & Dunn, *Waste Conversion*, p. 61.

¹³⁵ Glysson, *Environmental Handbook*, pp. Chapter 8, pp. 67-168; Elkington & Shopley, *Cleaning up*, p. 9; Alter & Dunn, *Waste Conversion*, op-cit., p.61

¹³⁶ Ibid, p. 167-168

Chemical Reduction for Oil production ¹³⁷

The conversion of organic waste material into oil can be accomplished by treatment of the waste at temperatures of 300-350°C and pressures of 2000-4000 pounds per square inch in the presence of water, carbon monoxide and catalysts. The process is continuous with the organic materials remaining in the reaction vessel for 1 to 2 hours. About 40% of organic material is converted to oil. The product yield is about 2 barrel of oil per ton dry waste materials. The oil has a heating value of about 15000 Btu/pound.¹³⁸

The Use of 3 Rs

In developing countries, where regulation is not the driving force, the most pressing need is reduction for municipal waste management.¹³⁹ The use of 3 Rs in solid waste management is a technique for resource recovery from solid waste. The 3R represents for reuse, reduce; and recycle. Most of cases the 3 Rs cannot be separated from one another. One example of reuse some refuse materials also contribute to reduction and recovery. Recycling refers to recovery after some process. There is a possibility of working on solid waste problem from both ends. One, of course, is the disposal and the other is the reduction of certain types of wastes by changing the living habits. There are several things which can be pre-treat before burn it or bury it but do not eliminate the next step. Reduction through reuse and also in the form of processing can reduce loading space and transportation cost. By compressing garbage and waste paper under high pressure, the volume can be reduced by 75%.¹⁴⁰ Application 3Rs in solid waste management has proved scientific and contribute in resource generation as well as environmental development. Americans dispose of almost 4 pounds of garbage per person per day that about 3 tons per family per year. There were 14,000 landfills in 1970' but only 3000 now for more people. This is possible not only by incinerating, but recycling, reusing and by means of other uses.¹⁴¹

The 3R's of waste management namely reuse, reduce; and recycle are oft-repeated phases in Indian solid waste management policy. There is a thriving informal sector of recycling. This recycling is achieved through 'kabaris', the waste handlers, who go from door to door and collect used bottles, broken plastics, metals, waste paper etc. Then it is traded to manufacturer of secondary products for which market exists. The scavengers as the 2nd fitter after 'kabaris' have taken away of first batch of useful

¹³⁷ Loftnes, *Energy Handbook*, op-cit., p.-2; Islam, *Renewable Energy Technologies*, op-cit., pp. 293- 306

¹³⁸ Loftnes, *Energy Handbook*, p. 2 & 361.

¹³⁹ Elkington & Shopley, *Cleaning up*, p.14 .

¹⁴⁰ Lund, *Pollution Control Handbook*, Chapter 7 p. 38.

¹⁴¹ Hinrichs & Kleinbach, *Energy 2000*, pp. 1-3.

materials for secondary market. Scavengers are foraging through wastes in an unhygienic practice. The income from foraging provides much needed subsistence to poorest of the urban poor. A ban on scavenging on health grounds may seem like a solution but will only aggravate the problem of basic sustenance. The market driven mechanism of segregation at source is a positive urban waste scenario. The specifications quality and hygienic status is often sacrificed. These being cheap but can be harmful for human health. There is a definite need to examine secondary products and to regulate effectively to safeguard human health and environment.¹⁴²

7.19 Impact of Resource Recovery

Economical Aspects

Direct benefits may include job creation and reduced demands on foreign exchange reserves for importing raw-materials. Indirect benefits may include a decline in waste disposal costs resulting from reduction in total size and volume. A negative economic impact is that the price fluctuations which can affect the price of both the waste being recycled and the recycled end-product and so that the recycling industries are short-lived.

Social Aspects

Recycling definitely improve the aesthetic condition of the society. It will create a neat and clean health environment in the city. It has also an indirect benefit of tourism progress.

Public health Aspects

There is lot of solid wastes if not recycled causes public concerns. Cans and tires trap rainwater and become ideal breeding sites for mosquitoes and other disease carrying vectors. Dengue fever is the most common in the cities where cans, tires and other containers holds clean water which is good for dengue mosquito breeding. Rodents and vectors attributed the diseases in the dumpsite.

Marketing Aspects

Little is to be gained from building a recovery facility if the recovered material or energy (i.e. fuel) cannot be sold or used. Before investing, the municipality or its agent should have, reasonable assurance that markets for recovered products exists.¹⁴³

Sustainable Energy

Apply to energy, sustainable means tapping a renewable source of power in way that creates a few environmental problems. In other words, sustainable source of energy are both renewable and environmental friendly: they do not pollute the atmosphere,

¹⁴² Lardinois, "Small Scale Urban Waste Recovery" *Affordable Water Supply*, p.93.

¹⁴³ Alter & Dunn, *Waste Conversion*, p. 111.

contaminate surface or ground water, degrade fish and wild life habitats, or diminish the quality of human life and culture.¹⁴⁴

Environmental Aspects

The Planet "World" is becoming unsafe and dangerous for human being and unfortunately; the human being is responsible for this massacre.¹⁴⁵ The breathing, the food, the shelter, the medicine, amusement and all other necessities are coming from the nature. But the great tragedy is that the human being should have looked at the areas of environmental degradation from their activities that really kill the hundred and thousands of people. The abundant supply of wastes into the planet is destroying eco-system and biodiversity. Only recycling and further use of the waste can reduce the environmental pollution. The environmental benefits of reusing and recycling waste are obvious. More reuse and recycling reduce the negative impacts of pollution and visual untidiness. It reduces the demand for virgin products, so fewer trees to cut or fewer minerals are mined. Less pollution, less scarring of the landscape, fewer greenhouse gas emissions and so on are the benefits.¹⁴⁶

7.20 Recycling of solid Waste in Dhaka

Recycling is the conversion of materials to recover resources or energy from solid waste. The amount of solid waste heap is increasing due to small amount of recycling in Bangladesh. In Dhaka city, recycling of paper, plastic, glass, metals and others amounted to 500-600 ton daily.¹⁴⁷ However, recycling in Dhaka city is not yet properly organized. Currently scrap metals, paper products, plastic and rubber, glass, and clothes are recycled a limited scale.¹⁴⁸

Dhaka City Corporation does not recycle or treat any solid waste before final disposal. A handsome portion of solid wastes is recycled by the private sector. Recycling is going on in the informal sectors. According to the JICA study team 435 to 450 ton/day of recyclable material is recovered which corresponds to 12 to 13% of total daily generation (3,200 ton).¹⁴⁹ The household and other respondents opined that waste picking is about 15-20%. Waste pickers stated that they collect about one-fourth to one-fifth. From waste pickers, households, business men and DCC official sources statement and physical verification by weighting the waste pickers daily collection it is assumed in

¹⁴⁴ Mayer, *Connection in Environmental Science*, pp. 128-29.

¹⁴⁵ Eric Roston, "New War on Waste", *Time*, September 2, 2002, p. 56.

¹⁴⁶ MoEF, *Peoples Report on Bangladesh Environment*, p. 355.

¹⁴⁷ Sakhina Akhter & Mostafa Kamal Farooque, "State of Environment", Mohiuddin Ahmed, ed., *Bangladesh Towards 21st Century*, (Dhaka: Community Development Library, 1999), p.138.

¹⁴⁸ *Ibid*, p. 138.

¹⁴⁹ JICA, *Draft Final Report*, Chapter 2, p. 34.

the present study that 586 ton solid waste is recycled in Dhaka city everyday. Therefore, that total amount of solid waste recycled is 586 t/d (16% of 3,667 t/d) shown in table 7.3.

Table 7.3
Estimated recyclable material volume.¹⁵⁰

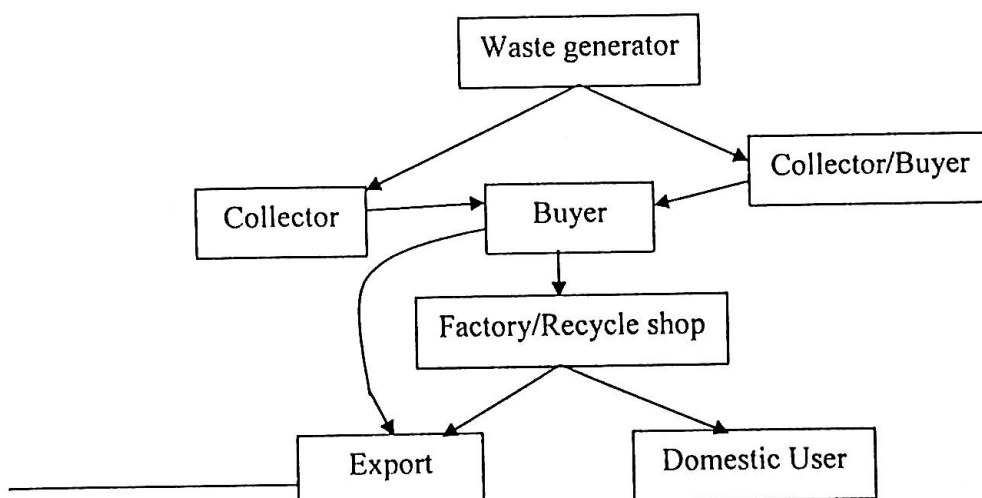
Material	a) Estimated generation of recyclable wastes (t/d)	b) Estimated recycled wastes (t/d)	c) Recycle rate	d) Contribution to waste reduction (volume /3667*)
Plastic	214	132	61.7	
Paper	538	324	60	
Glass, metal and wood	495	108	15	
Compostable	1931	10	0.52	
Others	489	12	9.4	
Total	3,667	586	16%	

Source: field survey

7.21 Structure of Recycling Market

Recycling market of municipal solid waste is composed of three principal groups namely collector, buyer, and factory/shops for recycled industry. There works a special group functioning as collector and buyer. They are called as street hawker or feriwalla and collect waste from source of generation, by paying cash or giving recycled products in exchange for recyclable materials. Feriwalla also buys materials from other collectors at the places collectors are working. Hawkers and feriwallas are used to sell the materials to the wholesalers or Vangari Dokans (recyclable waste buyer and seller). The price of materials in general goes higher as each level of buyers refines it. Most of recovered materials are put into production of commodities destined to domestic market. Recycling market is composed of three principal groups¹⁵¹ (figure 7.1) namely collector, buyer and factory/shop for recycling:

Figure 7.1
Flow diagram of recyclable marketing



¹⁵⁰ Statement made by the DCC Officials, Waste Pickers, Recycling Traders.

¹⁵¹ JICA, *Draft Progress Report*, Chapter 6, p. 2.

Number of collectors of recyclables in Dhaka city according to place¹⁵²

The number of solid waste collectors (individual buyer, hawker, ferriwala etc.) and major recyclable waste and recycled products of municipal solid wastes in Dhaka city are placed in table 7.4 and 7.5.

Table 7.4
Number of waste collectors in Dhaka city

Place of recovery	Share	Approximate number of workers	Status
Generation source	85%	1,800	Private sector employee for primary collection
		1,500	CBO employee for primary collection
		40,000	Hawker, Ferriwalla, individual buyer from generation sources
Container/dustbin	11%	1,000	Individual or organized
Dumpsite	4%	400	Individual
Total	100%	44,700	

Source : JICA draft final report

Table 7.5
Major recyclable wastes and recycled products in Dhaka city

Types of wastes	Recyclable wastes	Recycled products
Plastic	Mug, pipe, old sandal, doll, plastic bucket etc.	Shoes, sandal, boots, bucket, mug bottle, lunch box, etc more than 150 items
Paper	News paper, cardboard, duplex board, etc.	Media paper, simplex board, cement packing bag, etc.
Glass	Any kind of broken glass	Glass sheet, bottle, lamp shade, etc.
Metal	Iron tin, iron pieces	Steel rods, nuts, bolts, pumps etc.

Source: JICA draft final report

7.22 Main stakeholders in recycling sector in Dhaka

There are different stakeholders in the recycling market. The collectors are classified into four categories and operating individually or as business unit. There are different categories of stakeholders in waste recycling sector. The role of stakeholders is discussed here:

Recyclable materials collectors-

Street buyer (Hawker)

The peoples collect high quality recyclable waste form households. They are called as "street hawker" and collect the recycling materials from household and other

¹⁵² JICA, *Draft Final Report*, Chapter 6, p. 3.

institutions. The hawkers usually collect paper, plastic, cans, cosmetics bottles, lean cloths, utensils etc. and sell them to retail shop, or wholesalers.

Waste pickers (Tokai)¹⁵³

The poor people of slums and squatters are engaged in waste picking. They are usually called "tokai" and collect low quality recyclables from the streets, dustbins, transfer stations and finally from the dumpsite. Usually they collect paper, polyethylene, plastics, bottles, cans, rubber etc. and sell them to the nearest retail shoppers or floating buyers. The figure P.8 and P.9 of Appendix D is stated the waste picking operation in the road side and landfill site.

Private company's employee

Some NGOs formed a forum and employed in waste collection and transportation in the area of Uttara and Gulshan-Banani of Dhaka under the contract with DCC. The employees of the forum are functioning as waste pickers besides doing their normal operation.

Waste picker of community people

Community people are also organizing waste recycling activity as part of community waste collection. Their worker also collects recyclables from the waste piles they collect and transported to the transfer stations.

Recyclable Material Buyers/Sellers-

Floating buyers (Ferriwalla)¹⁵⁴

Floating buyers are also playing very important role as small trader in recycling activities in Dhaka. They are called as "feriwalla" and buy separated recyclable waste as well as store the primary recyclables. They usually sell them to the wholesalers.

Retail shopper (Vangari Dokans)

There is some retail shops in Dhaka city, which are involved in recyclable trading. These retail shoppers are called "Vangari Dokans". They buy recyclable materials such as old papers, cardboard, plastics, iron and silver items etc. from hawkers and ferriwallas. They also buy low quality recyclables from waste pickers (tokai), DCC

¹⁵³ The term "Tokai" is used in Bangladesh as a tin age poor children usually moving back and forth of the city and do odd jobs. They are often engaged them for doing odd jobs or to go on errands for somebody. This children from slums, squatters or homeless boys and girls who naturally don't have certainty of food and shelter are usually do something for their livelihood either by odd jobs or collect recycling materials from different places. In some cases, they are also doing hawking like a feriwalla. There are lots of tokai scavenging recyclables from the waste heap.

¹⁵⁴ In the JICA study report "Clean Dhaka Master Plan" the term hawker and feriwalla used as separate. In fact, there is no different between these two terms. Both hawker and feriwalla are same in nature of their work. However, hawker indicates who collects/purchase things or recyclables from the households or other places and feriwallas are used to sell something from house to house. In some cases hawkers and feriwallas, both collect and sell the recyclables and even very useful day-to-day essential commodities.

cleaners and other collectors. These retail shoppers sell all these recyclables to the wholesaler or recycling factories through brokers.

Wholesaler

Wholesalers are playing an important role in recycling sector. The wholesalers sell their recyclables directly to the factories of recyclable products. Sorting and cleaning of purchased recyclable materials into different quality level is one of the main wholesaler's duty for recycling activities.

Brokers

Recyclable material brokers in Dhaka city are playing as intersectoral activities or intermediate traders between retail shoppers, wholesalers, raw materials suppliers, and recycle products factories. They gain some money just as commission of brokery.

Raw material suppliers

There are other stakeholders of recycling activities are raw materials suppliers. They do not sell the recyclables as they purchase the items. In fact they used to make the items as particular raw materials by cutting, washing, drying and sorting of the recyclables before selling to the factories.

Compost Stakeholders

Organic Waste Producer

"Waste Concern", a NGO producing organic fertilizers from organic waste at Mirpur-2 in Dhaka. Some of the collectors are engaged by Waste Concern for organic waste collection from door-to-door. The collected waste is sending to a compost factory, which is located at close to the Mirpur, section 2. Some workers in the factory produce compost. Around 9 to 10 tons organic waste used daily for compost production.

Compost Product Dealer

At present, few dealers/companies such as "ALFA Agro" and "MAP Agro" in Dhaka city purchase the compost from the factory produced by Waste Concern and they are marketing the compost in adjacent area of Dhaka city. They are also making the product acquainted to the nearest farmers as an advertisement.

Compost Users (Farmers)

Most of the plant nursery shop in the city and garden are using the compost as fertilizer. Nearest agro farmers around Dhaka city are using lion share of compost. It is reported that farmers are getting more benefits by using the compost fertilizer instead of chemical fertilizer. Compost has proved very effective for vegetable farming and gardening rather chemical fertilizer. The use of compost is increasing day by day.

7.23 Major Recyclable Waste in Dhaka City

Major recyclable wastes are plastics and paper, and these two items share is 78% and rest other items share is 22% of total recyclable in Dhaka city. There are lot of recyclables are in the waste heap. But all of them are not collected.

Paper

Paper is the mostly recycled item of solid waste. Old newspaper, cardboard, clean paper, old books and official used paper etc are used for recycling. There is 538 ton paper and paperboard materials are left as refuse in the waste heap in Dhaka City. It is corresponding to 15% of total solid waste. Out of 538 almost 324 ton (60%) is recovered. Proportionately paper is the highest recycling item in Bangladesh. In most cases, the recovered papers are using as pulp of respective type of papers in the factories. The recyclable paper market area in Dhaka city is Moulabi Bazar, Choto Katra, Naya Bazar, Chalk Bazar, Nimtoli and Bangla Bazar etc. The market condition of recycled paper is relatively stable.

Plastics

Plastic is another important recycling item. Total plastic waste is 214 ton and 32 ton (about 62%) is recycled. Plastic recycling trade generates one of the local small-scale industries in Dhaka city. It is reported that approximately 300 plastic recycling factories and 30,000 peoples are directly engaged in recyclable plastic materials trade in Dhaka¹⁵⁵. It is found almost all waste collectors are collecting plastic material and it yields comparatively good profit margin than other waste item. The main plastic material markets are located in Islambag, and Lalbag. Main recycled products are bucket, different shaped container, jar and other daily home use products. All kinds of plastics with polyethylene and soft plastics are also recycled in Dhaka.

Glass and Metal

The total glass, metal and wood waste is about 494 ton. Out of this glass and metal is recycled about 74 ton. In comparison it is very low in amount but glass and metal is recycled as maximum. Glass is another typical recyclable items in Dhaka city. It reported that approximately 20,00 peoples are directly involved in glass recycling industry. The broken glass and different bottles are used for recycling. The main glass recycling market areas in Dhaka are Kanchpur, Katasur at Mohammadpur and Narayngonj. Main glass recycled products are lampshade, drinking water glass, jar and many kinds of bottles etc. The selling price of recyclable glasses depends on the type of

¹⁵⁵ JICA, *Progress Report*, Chapter 6, p. 8.

glass, shape, quality, selling places.¹⁵⁶ Many brokers and dealers handles large amount of metal such as iron, steel and can. The corrugated iron, lead and hardware are used for recycling. The recovered metals are going to different factories depending on the type of metals. The main recycled products are rod, steel sheet, and others metal box etc. The largest metal recycling areas in Dhaka are Tajgoan, Kanchpur, Fotulla, and Narayangonj.

Others Recyclables

There some other items in waste heap also recycled but very poor amount. Lean clothes, bones, leather, rubber etc are the items also recycled. The total amount would be recycled 12 ton daily.

Organic Waste Recycling

Organic waste recycling is underway in the city in a very limited pace. Only Waste Concern has a composting plant in Mirpur, section-2. Organic compost is the only out put of the organic waste recycling. At present, organic wastes has very little market in Dhaka city due to low demands for composting. Organic wastes occupy 65% of the total municipal waste in Dhaka. It means the organic waste have huge volume /potentials for supply side for composting. But composting didn't increase due to lack of publicity and high transportation cost.

7.24 Legal options of recycling in Dhaka (Bangladesh)

In Bangladesh, Environment Conservation Act 1995, City corporations and Pourashava (municipality) Ordinance and other laws and regulations exist to dealt with environmental issues. However, there is no specific or independent laws and regulations in terms of solid waste management, which includes recycling activities. The Dhaka city Corporation Ordinance 1983, which stipulates the responsibility of removing solid waste management and disposing of solid waste, lies with DCC. However, the DCC ordinance did not contain any recycling issues. Even the term recycling didn't include in the Ordinance. Therefore, there is no specific regulation to promote recycling activities as well as no control or monitoring over recycling business/ industry in Dhaka city. However, National Policy for Safety Water Supply and Sanitation 1998 has only one clause "Use of organic waste material for compost and bio-gas will be promoted and." This policy only addresses organic waste material and not mentioned any specific measures.¹⁵⁷

¹⁵⁶ Ibid, Chapter 6, pp. 8-9.

¹⁵⁷ JICA, *Draft Final Report*, Vol. 2, Chapter 6, p. 5.

However, none of the law or regulation bars recycling of infectious and hazardous waste, which may be dangerous to the human health and environment. These items should not be recycled rather disposed or destroyed and legal action should be taken against the un-scrupulous trading or recycling.

7.25 Role of Waste Pickers

Despite spending almost 18% of municipal budget for waste management, still then inadequate collection of waste attracts large number of waste pickers who retrieve recyclable waste. There is a close relationship between indiscriminate throwing of refuse and waste picking services. Waste picking tends to strew the waste around the bins and exposes the waste pickers to direct contact with decaying materials. They do not return the remaining waste to dustbin or container after they finish picking materials. There should be some adjustment of activity between waste pickers and DCC to pursue both side interest to keep efficient operation and waste picking.¹⁵⁸ It was argued decentralization instead of competing or replacing the formal system of handling waste operated by municipal bodies, would complement the process. West Wise, a social organization of Bangalore, India, evolved recognition for waste pickers to render their working condition less hazardous and to gain public recognition for their role in recycling and protecting environment. West Wise utilize them for door-to-door collection and segregate organic and inorganic matters. City authority of Bangalore, provide a piece of land for treatment of garbage.¹⁵⁹ Accordingly DCC should come up to make a liaison for waste picking and cooperate recycling for effective solid waste management.

Economic Aspects

The recycling sector of Dhaka city is completely informal and run by private initiatives. Approximately 10% of total labor forces in Dhaka city are engaged in recycling sector. More than 31,000 persons are directly hired by recycling factories. Most of the recycling industry in Dhaka is low capital investment and low cost except paper recycling factories.¹⁶⁰ For example, glass recycling factories in Dhaka city are facing the severe competition with foreign as well as local glass manufacturing factories, which do not use recyclables materials. Kitchen waste compost has the enormous success probability but due to low marketability, it is not expanding. The opportunity of wider use in agriculture will generate lot of employment as well as will save lot of money for chemical fertilizers.

¹⁵⁸ Ibid, Chapter 3, p. 3.

¹⁵⁹ Rosario, "Decentralized SWM Approach", *Affordable Water Supply*, p. 106.

¹⁶⁰ JICA, *Draft Final Report*, Vol. 2, Chapter 3, p. 9.

Social Aspects

Waste pickers or material collectors are self employed or privately employed. They are mostly working on individual basis and earn Tk. 3,000 to 5,000 per month, which is little bit more than garments workers. They are raising almost same money as the workers of leading industry of Bangladesh. Therefore, material collectors at upstream are higher income than those at downstream.¹⁶¹ However, the waste pickers or material collectors are working in unhealthy condition, but economically they are in good position than other distressed vocational group.

7.26 Prospects and Challenges of resource recovery in Bangladesh

Bangladesh is one of the lowest energy consuming country. With an amount of per capita energy consumption is only 100 kg per year. About 55% of the countries energy comes from traditional biomass (fire wood, crop residues and animal waste etc.), another 24% is met from its own reserves of natural gas, 2% from hydro-electric power plant and the rest is from importing coal and petroleum oil. Although low consumption rate and a good domestic energy supplies (natural gas), biomass fuel is consumed beyond the regenerating rate. So reliance on biomass fuel (fire wood) is not decreasing. The high demand for biomass (fire wood) has both environmental as well as health costs; it fosters soil degradation, lowers agricultural yields, degrades forests, contributes to loss of vegetative and animal biodiversity and leads to high levels of indoor air pollution with health impacts that are yet to be measured on a national scale.¹⁶² Therefore, energy resource generation from solid waste is so important for Bangladesh to reduce the pressure on natural gas and firewood. If the solid waste could be used for power generation, the electricity and gas requirement would be lessen in Dhaka city. It is too much essential to increase recycling of solid waste for resource generation.

It is estimated that approximately 126,000 people are dependent on and involved in the recycling activities or trade in Dhaka. Out of them 74,000 are engaged in MSW recycling and rest are considered on industrial waste recycling. This figure is estimated based on secondary data and people's statement of this sector. According to "Bangladesh Statistical Yearbook" and "Profile of Dhaka City", about 6% of the total labor force in Dhaka city gathers around recycling sector.¹⁶³ There is a huge possibility of resource recovery from solid waste recycling. A huge amount of compost could be produce from organic waste and if utilized it will save lot of chemical fertilizers. The more

¹⁶¹ Ibid.

¹⁶² UN, *Country Assessment: Bangladesh*, pp. 28-29.

¹⁶³ JICA, *Draft Final Report*, Vol. 2, Chapter 2, p. 31.

solid waste will recycle, the less will be the management cost and decrease the environment pollution.

The need for increased recycling and reuse in Bangladesh is obvious. Indiscriminate dumping of waste and widespread littering have become serious environmental problems in recent years. In Dhaka city and other towns and cities of the country thousands of cans, broken bottles, plastic bags, old tyres, papers, building grabbles, sewage sludge etc. are despoiling cities and town.

There is lot of risks to public health for uncontrolled recycling of clinical and industrial waste. Some of the hospital wastes such as syringe, plastic tube, and plastic packaging materials, saline bags, X-ray water container, vials, slides empty packets and bottles are recycled in a similar manner as other municipal wastes. However, serious public health threat associated with hospital waste reuse and recycling is pointed out.¹⁶⁴ This is the case when the scavengers collect syringe including needles and plastic materials, are sold to scrap buyers who sell them to specific traders. The used clinical items stated above are not destroyed or breakdown and leftover to the bins. Waste pickers collect these item sell to the buyer or traders. These syringes, needles, and other medical items come back to the hospitals and clinics or into the market in the name of new one with new cover and packet for further use by the unscrupulous traders.¹⁶⁵ This is very risky to the public health. The highly contaminated clinical items and toxic industrial waste may spread over the serious even death bearing diseases to the users. Therefore, clinical, industrial waste should not be recycled with other municipal solid waste.

7.27 Chapter Summery

Natural resource is static in the earth. Population increase and more consumption for luxurious lifestyle has created the natural resource crunch in the world. Natural resource is depleting for extraneous extraction. Material resource and energy resource both are so important for development. Industrialization and urbanization prompted the use of more resources and increase the volume of waste. There are two types of resource: one is non-renewable and another is renewable resource. Solid waste is on kind of biomass fuel, which is renewable.

Resource recovery from different sources is contemporary with reuse and recycling. There are lot of things to be reused otherwise keeping them to waste box. Through recycling solid waste, material as well as energy resource can be generate.

¹⁶⁴ WHO, "Managing Medical Wastes in Developing Countries, Report of a Consultation of Medical Waste Management in Developing Countries" (Geneva: WHO, 1992), p. 1.

¹⁶⁵ JICA, *Draft Final Report*, Vol. 2, Chapter 2, p. 11.

Paper, plastics, glass, ferrous metal, organic part, incineration ash, sewage sludge etc. all of the waste can be recycled and resource could be recovered. Composting has long been important and successful in some parts of the world, yet others have had little or no success. The technology, economics and attitudes directly associated with the resource recovery from the solid waste. The uses of 3Rs namely reuse, reduction, and recycling are the technique of resource recovery.

Energy is conserved quantity in the universe, it cannot be create or destroy, only can convert or redistribute from one form to another. More natural energy consumption made the environmental catastrophe. For that reason human society has bound to turn from non-renewable energy source to renewable source like solar, water, biomass and wind source of energy. Solid waste is one kind of biomass and energy could be recovered from it. The energy can be finding in solid, liquid or gaseous form. In solid form it could be used as direct combustion as firewood for heat generation. Liquid form is that methanol or ethanol production through chemical or biological conversion. Gaseous form includes methane gas production from waste heap or landfill site through biological decomposition. The energy production from solid waste depends on waste input quantity, energy content, technology available and process efficiency.

Landfill gas recovery, heat energy or Refuse to Energy (RTE), RDF, pyrolysis, chemical reduction, anaerobic fermentation etc are the way of energy recovery from solid waste. Recycling of solid waste in Dhaka city is not sufficient. Only 500-600 ton/day is recycled. Recycling is an informal sector. No government initiative or City Cooperation or Municipality participate or patronize recycling sector. About 44,700 workers are employed and 74,000 peoples are living on recycling sectors in Dhaka city. Paper and plastics account for 78% recyclables in Dhaka. Only 9-10 ton/day organic waste is recycled for compost production. Due to marketing cost and transporting problems composting cannot be flourished. However, there is enormous possibility of compost recycling from huge organic waste that will save lot of chemical fertilizer in Bangladesh.

Chapter 8

Summary, Recommendations and Conclusion

8.1 Introduction

Dhaka is the eighth largest city in the world in respect of population density amounts around 8 millions in 302 km² area. Total area of Dhaka city is not under the purview and control of Dhaka City Corporation. Present area of Dhaka City Corporation is 131 km² and population is around 5.7 millions and population is increasing in every year. Population density exceeds 40,000 per km². Moreover, due to unplanned urbanization, lack of infrastructure development, centralized administration systems,, natural waterbodies degradation etc., Dhaka city is confronting with environmental and other lot of issues such as pollution, solid waste creating pollution and environmental hazards, over population, traffic jam, shortage of water and sanitation, failure of electricity, short supply of gas in the pick hour, clogging drainage and sewerage etc. Among them solid waste management has appeared as a major challenge of DCC because it is creating different environmental pollution and health hazards in DCC area. DCC is mandated the task of solid waste management. Solid waste generation in Dhaka City increases proportionately with the growth of it's population that is 3.1 percent per annum, but solid waste management capacity of DCC fails to match with the increasing demand and the gap is widening over the time. The present study tried to find out the real solid waste management scenario of Dhaka city.

The present study is empirical in nature; field based primary data were collected through questionnaire, face to face in-depth interview, key informant interview, observation, to address the objectives of the research. The households, commercial places, waste pickers, officials of DCC, teachers, scholars and professionals, experts and policy makers, NGO representatives, community leaders, imams, etc. are constituted the source of primary data. Photographs are also considered as source of primary data. Secondary data source were the books, journals, study reports, and other printed materials. The study result is hereby present in the name of summary findings in brief.

8.2 Summary Findings of the Study

Solid Waste Generation

Sources of solid waste generation are the household, business organization, shopping malls, industries, hospital and clinics, other institutions engaged in commercial

activities, street sweepings etc. The solid waste generation in the DCC area is 3,667 ton per day.

Household Waste

The present study found in the study area that the total solid waste generated from household source is 2,417 ton/day. Per capita generation of household solid waste is 0.422 kg/day. Total population of DCC is 5.728 million and total amount of solid waste is $(5.728 \times 0.422) = 2,417$ ton/day. Low income group (monthly income less than Tk. 3000) generate 0.184 kg/day, lower middle income group (income in between Tk. 3000-7000) generate 0.364 kg/day, middle income group (income in between Tk. 7000-15,000) generate 0.509 kg/day, upper middle income group (income in between Tk. 15,000- 25,000) generate 0.467 kg/day, and the high-income group (income more than Tk. 25,000) produce 0.406 kg/day per person. According to monthly income level, middle income group generate the highest per capita solid waste. According to the area solid waste generation in old Dhaka is 0.381 kg, area under Plan (AUP) is 0.458 kg, mixed extended area is 0.549 kg, slum is 0.210 and Uttara-Gulshan is 0.371 kg/person/day respectively. According to the location of the city, mixed extended area generates the highest per capita solid waste.

Commercial Waste

Volume of solid waste from all business sources is estimated around 1,034 t/d. Business waste includes all business and commercial organizations, industries, and clinical institutions. Out of the total amount, 834 tons come from commercial sources, 200 tons comes from industrial and clinical sources. Out of 200 tons, the tannery industries share 150 tons; other industries share 35 and hospitals and clinics 15 tons/day.

Street Waste

Street wastes include sand, dust, leaves, sewage sludge and other components. Average volume of street waste is 365 kg/km/day. The total road length is 550 km in DCC area and the volume of waste is estimated approximately 200 t/d ($0.365 \times 550 \text{ km} = 200.75 \text{ tons/day}$).

Total solid waste generation

The total solid waste generated in Dhaka City Corporation area (131 km²) is 3,667 t/d (domestic 2,417 + business 1,050 + street 200).

Composition and Characteristics of the Solid Waste

Solid wastes of Dhaka city are mainly consisted of paper, plastics, kitchen (vegetable, waste of other food items) waste, timber, glass and metal residues, sand, dust, garden trimmings etc. Among them vegetable are 29%; different food items 24%, paper 15%, plastics 6% and others 27%. Moisture content range of waste is from 65% to 80%. Calorific value of the solid waste is only from 550 to 850 kcal/kg. The average apparent bulk density is 0.24 t/m^3 .

8.2.1 Primary collection

Responsibility of primary collection of waste generated lies on waste generators. Generally generators carried their waste to the bins or dispose places by themselves until just introducing community based waste collection. In recent years, various types of community based organization (CBOs), and NGOs emerged for waste management. They are giving service of door-to-door primary collection in lieu of service charge. So, there are two types of primary collection systems prevailing in Dhaka city:

- Generators own collection
- Door-to door collection by community based organizations, NGOs and others

In case of primary collection the study found that there is no uniform time of primary collection by the generator himself in the study area. Only about 14% collect at noon, 12% at afternoon, 16% in evening and 47% do not follow any particular time of primary collection of the household waste. It is found that 71% primary collection is done by CBOs at noon. Most of the respondents desire that CBOs collection should be at dawn (34%) and at afternoon (52%).

The present research found that the generators own collection covers 49% and CBOs or NGOs based primary collection covers 51% in the study area. As of March 2005, 91 CBO and NGO organizations are collecting waste from households, business and commercial institutions by charging some monthly fees instead of their services. Recently, DCC issued letter of permission to the CBOs or NGOs for primary collection. Primary collection is labor-intensive work uses the rickshaw van usually operated by one van driver and one or two helpers. Generators handover the wastes to the vans or they emptied the refuse into nearest bins for secondary collection.

8.2.2 Secondary Collection and Transportation

According to the Dhaka City Corporation Ordinance 1983, DCC is responsible for secondary collection. Conservancy department is the core organization for solid waste

management and cleaning roads and drains. With the support of transport, mechanical and engineering department, the conservancy department disposes the solid waste of the city and maintains the cleanliness. Out of 3,667 t/d, DCC carries only 970 t/d to 1420 t/d into the dumpsite everyday. On an average 1200 t/d solid waste is carried to three-landfill sites. Therefore, DCC collects only around 33 % of total generated solid waste in the city. DCC managed its secondary collection and cleansing operation with 7,000 workers and 300 plus trucks. The secondary collection and cleansing operation of 8 Wards (seven Wards in Zone 9 and one Ward in Zone 10) of Uttara and Gulshan Model Town has been leased out to the CBOs and NGOs since 2003.

Collection Time

There is no particular time of secondary collection/transportation. 59% respondents replied that DCC mostly collect the waste in between 8 a.m. to 11 a.m. and this is not suitable time for secondary collection. It is observed that office bound people and waste containing trucks and trailers are moving at the same time on the roads and streets, which is untoward and eyesore. Most of the respondents desire that the waste should be collect either very early in the morning or only at night.

Dustbins/demountable Containers

DCC supposed to bound set up dustbins or supply demountable containers for primary disposing. But there is shortage of dustbins or containers. Therefore, in many places primary waste disposes is happening in open places or in roadsides. Moreover, the lots of dustbins are broken and garbage are easily scattered by scavengers and cattle. The total dustbin capacity is about 1700 tons per day. Therefore, about 2000 tons solid waste is lying here and there near the roadsides, drains, ditches and elsewhere.

Cleansing Operation

The cleansing operation carried out by almost 7000 cleaners. The cleaners are distributed unevenly. The City Corporation cleaners and other conservancy workers do not clean or collect the garbage very neatly. The reasons identified in the present study that they do not have accountability, there is weak supervision, no incentives etc. On the other hand, DCC employees mentioned that secondary collection does not carry out effectively due to improper handling of refuse by primary disposers and scattered around the bins by waste pickers. Efficient SWM needs timely disposal of refuse into the bins or in proper disposal places and need modern instruments.

8.2.3 Treatment and Disposal

The responsibility of solid waste management lies with DCC. Other than secondary collection, (transportation from primary disposal and transfer stations to dumpsite) DCC does not do any treatment. A very few amount (about 586 t/d) of solid waste recycled by the informal sector and around 9-10 t/d is used for composting by an NGO named "Waste Concern" in Mirpur Section-2. On an average 1200 t/d solid waste is disposed into three landfill sites and virtually it is the disposal options of DCC. Out of 3,667 tons generated solid waste, on an average only 1,200 t/d are transported to the landfill sites. Around 40% of the waste is self-disposed and or illegally dumped in different places. All of these solid wastes goes to several unofficial public/private lands, waterbodies, ditches, drains, and hither and thither around the whole city. The only official site 'Matuail' accounts for 65%, Berri-bandh site 30% and Uttara site 5% of collected waste disposal. Matuail site is only one official site for land filling. It is a simple crude open landfill site and it does not have liner and does not cover wastes every day by soil. It does not have leachate and gas control mechanism. There is no access control system.

There is no responsible organization and personnel to manage and control landfill sites. Final disposal has little attention in context of money and manpower allocation. The cost incurred for landfill sites is only 1.4%, cleaning of roads and drains covers 58%, collection and transportation covers about 27% and repair works cover 13% of total solid waste management cost.

8.2.4 Resource recovery

Resource recovery through recycling of solid waste is an informal sector of Bangladesh. Paper, plastic, rubber, ferrous metal, glass etc., are the main recyclables in DCC area. Composting is too small to mention. "Waste Concern", an NGO is operating a composting plant consuming 9-10 t/d organic waste under the financial help of SEMP project of the Government of Bangladesh.

Volume of Recycle Waste

According to the draft report of the JICA study team, 435 to 450 t/d recyclable materials is recovered corresponding to 12% to 13% of total waste (assuming 3200 t/d generation). The present study found that waste pickers collect 20% of total waste discharged in the dustbins. Household and other respondents opined that waste picking is about 15-20%. Summarizing these observations, it would be drawn to a conclusion that total volume recycled in DCC is 586 t/d (16% of 3667 t/d). Around 15,000 waste pickers are involved in waste picking, 31,000 persons are directly hired by recycling industry, and 74,000 people live on recycling sectors.

Socio Economic Condition of Waste pickers

About 10% of the total labor force in Dhaka city is engaged in waste picking and recycling industry. Their average monthly income is Tk. 3000 to 5000 a bit higher than garments worker that earn about Tk. 3000-3500 per month.

8.2.5 Use of 3Rs

Efficient and effective solid waste management mostly depends on the use of 3Rs. These are reduction; reuse; and recycling. Reduction could be achieved by separation in sources. Source separation culture is not developed in Dhaka city because of unawareness and absence of systems must be introduced by the DCC. 95% of the respondents do not separate their kitchen waste from others. Reusable materials are less kept separate in household level. There is some practice of reusing among households and other organization. Say the glass bottles of beverage, plastic jar, and good quality containers are reused. It is difficult to find how much solid waste is reused other than recycling. It is revealed from the study that around 586 t/d solid waste is recycled for resource recovery. Composting is one of the main resource recoveries through recycling biodegradable kitchen waste which could also meet up the increasing demand of bio manure in agriculture. Only 9 to 10 t/d organic waste is used for production of bio-fertilizer, which is very much insignificant.

8.2.6 Legal Aspects

Dhaka City Corporation Ordinance, 1983 (ordinance no XL of 1983) and Environment Conservation Act 1995 are the two laws have direct implication with solid waste management. According to the DCC ordinance, removal and transportation of refuse waste is the duty of Corporation. There is no provision about primary collection in this law. There are 63 offences listed in the 3rd schedule of the ordinance which are punishable. Placing or depositing refuse in the public places is an offence. The maximum punishment is a fine of Taka two thousand only.

However, the enforcement of this law is very poor. Only 5% of the respondents replied that DCC has issued some notices for improper primary disposal. DCC officials informed that no suit had been lodged but only 31 notices had been issued for caution since 2002 for non-compliance of the provisions of the law. On the other hand, DCC itself does not comply with the instruction of the Environmental Conservation Act (ECA) 1995 for landfill site. Landfill is categorized as red group of industry sector and there is a provision of taking Environmental Clearance Certificate (ECC) from DoE. DCC did not obtain the ECC for landfill sites. No clearance certificate has been taken from RAJUK, which is required for structural change of open space and/or reservoirs in accordance

with the Play Ground, Open Space, Park and Natural Waterbodies of the Municipal Area Preservation Act, 2000. Uncontrolled disposal of waste or waste effluent into surface water cannot be stopped by Department of Environment (DoE). The DoE is fully equipped with necessary legislation but they do not have the legal implementing tool for the application of law.

8.2.7 People's Awareness

The present study reveals that the individual awareness level of Dhaka city dwellers is not highly appreciable. In case of primary collection, only 9 percent respondents are found to have put their household wastes into the selected bins or places in right time and manner. 32% put their garbage near the bins and 31% throw their garbage from distance of bins. 37% respondents dispose the silly matters (like banana peel, fruit shell, cigarette residues etc.) into the roadsides and drains, 32% carry the things into nearest bins or disposal places. 63% of respondents do not monitor the garbage disposal of his/her family. Only 15% of the study respondents know the provisions of the DCC ordinance and ECA act regarding the waste disposal and environment conservation. On the other hand, DCC and DoE do not have sufficient awareness promotion programs. Only 25% respondent said that DCC took some awareness programs once a year during the Eid Festival (Eidul-Azha, Muslim's second largest religious festival) for clearance of animal carcasses. On the other hand, the overall awareness level of the city dwellers about the solid waste management is moderate or average. According to the Likert Scale, out of 338 respondents, 37 (10.9%) has low level perception. Total 55 or 16.3% respondents has high level perception and the rest 246 (72.8%) respondents of Dhaka city has average or moderate level of perception. This study results clearly indicate that the citizens of Dhaka do not hold very good perception about the efficient solid waste management and overall urban environment conservation.

8.2.8 Solid Waste and Environment Pollution

Environment Pollution

Inefficient solid waste disposal leads to air, water, and soil pollution. Leachate is a common outcome of landfill. It is formed due to the microbial degradation of the organic parts of the waste and the leaching process of percolating rainwater. Solid waste disposal in Dhaka is crude open dumping. Nuisance creation is the first outcome of health hazards from solid waste because of waste heap here and there in the roadsides in Dhaka. Loaded truck or container with garbage frequently moving in daytime into the main roads and streets is another social nuisance. Scattered scavenging is very

common in and around the dustbins, waste hips, and landfill sites. All these activities lead to a very bad and undesirable scenario of Dhaka city.

Flies, rodents, and other disease vectors, produced in the waste heap, carry the viruses that enter the human body through food chain. Diarrhea, jaundice, headache, bellyache are very common phenomenon among the waste pickers, cleansing staffs and neighbors of the dumping site of the city. The children engaged in waste picking are in most vulnerable condition.

Air Pollution

Air is mainly polluted by vehicular emission but solid waste is also responsible for air pollution due to bad odor from waste hips. Dust, light waste and floating particulate matters also responsible for air pollution. Another pollution source of solid waste is air. Air becomes bad smell, which has a nuisance effect. The common chemical sources of odors have been organic compounds containing nitrogen or sulfur in their molecular configuration which pollutes the surrounding air. Dhaka city dwellers are to coexist with bad odors like neighbors. The health effects of contaminated air may cause carcinogenic consequences, which may be evident after many years.

Water Pollution

The water sources in and around Dhaka city is dangerously polluted. Leachate and biodegraded solid waste produce BOD, COD, and heavy metals in the water bodies and limit the dissolved oxygen. The water of the river Buriganga and other waterbodies of the city are so polluted that natural living being cannot survive. The leachate percolation also polluted the ground water seriously.

Soil Pollution

Land pollution in and around Dhaka city is also matter of concern for leachate, polyethylene, and other heavy metals.

Solid Waste and Public Health

The immediate effects of health and environment for inefficient and ineffective solid waste management could be seen as the followings:

- Health problems by affecting human health and other livings
- Economic problems through affecting the value of human property and materials;
- Ecological and biodiversity degradation due pollutions of air, water and soild
- Absence of aesthetic in urban areas

Health Risk from Special Waste

The infectious clinical waste is another source of health hazards, which come to the users after repacking by some unscrupulous traders in the name of recycling. Blowing light dumped waste is another nuisance. Open dumping also damages the farmland nearby. Vireo cholera is found in sewage sludge dangerous for public health.

8.3 Recommendations of the Study

To ensure an effective and efficient solid waste management, it requires formulating a comprehensive policy guideline, raising people's awareness, and participation. The institutional development with technological support and skilled workforce is very ardent for efficient and effective solid waste management. The study recommended the following actions for environment friendly solid waste management:

8.3.1 Waste Generation

- To take measures for creating awareness to reduce volume of solid waste. Initiatives must be taken for changing behavior and living pattern so that less volume of solid waste is generated.
- To guarantee reliable data on volume of wastes for the design of optimal collection, transportation and disposal options;
- To give due importance on public health, urban environment

8.3.2 Primary Collection /Cleansing Operation

- To ensure primary disposal by the households in a particular time, so that the garbage will not left over in the bins or transfer stations for long time;
- To expand the community service coverage for primary disposal for the whole city, phase by phase through NGOs, CBOs on the basis of their efficiency.
- To promote partnership among the community service providers and DCC at the Ward level and extend cooperation;
- Collect the restaurants wastes door-to-door basis at least twice a day on a full cost recovery system.
- Closed body vehicles should be used for garbage collection to stop littering;
- Collect infectious wastes separately from hospital and clinics on a full cost recovery basis;
- Sustain the waste pickers contribution to resource recovery by organizing them into a formal group with help of local NGOs, providing them with tools to sort out wastes, raising their status to that of waste collectors and providing facilities;

- Introduction of separate color container in the households and other sources of generation for organic waste and other wastes and collect them different container so that organic waste cannot be mixed with other wastes.

8.3.3 Secondary Collection/Transportation

- Reliable data on volume on wastes are important for the design of optimal collection, and disposal options;
- Secondary collection exclusively at night (10 pm to till complete) or very early in the morning (so that transportation ended before 7 a.m.) with closed body vehicles to stop littering of waste.
- Expand secondary collection capacity by full utilization of the work force and transport vehicle through standardizing the route and trips based on distance;
- Ensure the schedule of operation and keep some vehicle reserve for emergency operation;
- Provide the sweepers with more efficient tools such as a long handle brooms and handcarts, caps, boots, luminescent armband, gloves, pitchforks, first-aid kits, to facilitate and increase productivity;
- Provide more salary and other health benefits to protect them from health risk;
- Increase number of containers and ensure frequent collection from markets, restaurants and other places where waste generation is high and nature of wastes are organic to reduce unpleasant odors and the growth of diseases vectors;
- Ensure the collectors and cleaners maintain their bins, trucks and other vehicles clean state;
- Ensure hundred percent supervision of the secondary collection from primary transfer station. Appoint more conservancy inspectors in each Ward to attain cent percent checking.
- Make an objective evaluation of private sector secondary collection system in Uttara-Gulshan and extend the practice on the basis of people's satisfaction.

8.3.4 Technology

- Support technology transfer which is compatible with local situation;
- Research and development efforts that have the potential to significantly increase waste recovery rates, as well as work to reduce the barriers to their implementation;

- The composting is the best options of resource recovery from organic waste. Therefore, composting technology should entertain and initiative should be taken for technology transfer with financial support. The technology transfer should be adopted by built and transfer (BoT) basis.

8.3.5 Treatment and Disposal

- Prepare a Master Plan with a vision of at least 50 years ahead for a sustainable solid waste management for environment protection;
- Stop open dumping immediately and replaced by least control dumping if not possible sanitary landfill;
- Establish sanitary landfill system of disposal either transforming the present Matuail dumpsite or new landfill;
- Create at least 4 landfill sites in the outskirts of 4 sides of the city for easy transportation and cost minimization;
- Construct engineered leachate treatment plant at the landfill;
- Arrangement of deep well for water quality measurement near landfill to check water pollution;
- Arrangement for separate collection and disposal of clinical and industrial waste.

8.3.6 Recycling operation & Use of 3Rs

- Introduce and appreciate using of recycled goods and provide tax holiday;
- Arrangements for ensuring segregation of organic waste from solid waste at household level;
- Recognize waste pickers' contribution to resource recovery by organizing them into a formal group and providing tools, to sort out wastes, like caps, boots, luminescent armband, gloves, pitchforks, first-aid kits and personal safety instruments;
- Introduce incentive system for organization, individuals, and others to carry out projects for efficient solid waste management like recycling industry, composting plant etc;
- Program of financial assistance for investors in recycling and compost producers and marketing;
- Waste management authorities must encourage the minimization of both the quantity and toxicity of wastes as a matter of expediency

8.3.7 Legal Options

- Amend the DCC ordinance for clear understanding of the stakeholders role;
- Enforcement of DCC ordinance, ECA and DMP ordinance and other acts and laws regarding cleanliness and better disposal;
- Legal provision for specific time schedule of primary collection;
- Introduction of mobile court operation for throwing garbage in the public place for demonstration effect;
- Make provision of burning, isolated treatment and disposal of infectious and hazardous clinical and industrial waste by generators own;
- Implement Environment Management Plan (EMP);
- The police commissioner should take legal action against who easing onto the footpath and throw refuse to and fro and create nuisance by lettering garbage other than particular place.

8.3.8 People's Participation

- Establish partnership among common people, civil society, community service providers, social workers, public representatives, and DCC;
- Introduction of SWM monitoring committee in each Ward with cross sectional representatives of the society, (a sub-committee with a good number of female members should be established for house to house monitoring)

8.3.9 People's Awareness

- Extensive or far-reaching people's awareness promotion programs about solid waste management and its effect on human health and environment;
- SWM program should entertain as some other national program like tree plantation, Extensive Program of Immunization (EPI), so that peoples response would be spontaneous;
- Demonstration program for segregation of organic and inorganic waste and separate collection;
- Introduce seminar, workshop, discussion by DCC once a month (in each Ward by rotation) involving civil society, community leaders, and common people for open discussion and arrangement of extensive publicity;
- Start media campaign on Radio and Television for waste segregation, storing, carrying and disposal system on a regular basis;
- Introduce waste management learning sharing activism among young generation to promote their commitment;
- Widespread curriculum of waste effect and public sharing in education system.

8.3.10 Health and Environment

- ❑ Conduct continuous research to find out the impact of inefficient solid waste management on human health and environment;
- ❑ Establish surface water monitoring system where the surface run-off is frequent in the dumpsite;
- ❑ Introduce periodic chemical analysis of soil and plants around the dumpsite for environment protection;
- ❑ Odor is one of the serious health and aesthetic problem. Arrangement for quick disposal to keep the facility clean.

8.3.11 Institutional Development

- ❑ Increase capacity and expertise of officials to enhance sensitisation of the importance of efficient solid waste management;
- ❑ Identify solid waste management is an important service sector and sufficient resources need to be channelled into the sector;
- ❑ High ranking in priorities of political and administrative support for sustainable environment management;
- ❑ Appoint environmental engineers and experts in the conservancy service of DCC;
- ❑ Introduce regular training of staffs for increasing efficiency in solid waste management.

8.3.12 Policy Options

- ❑ Government of Bangladesh has to prepare a policy guideline for solid waste management immediately denoting time of primary and secondary collection, processing, treatment and disposal for Dhaka city and all over the country;
- ❑ Medical and industrial waste disposal should be specially mentioned in the policy so that it cannot be mixed with other general waste.

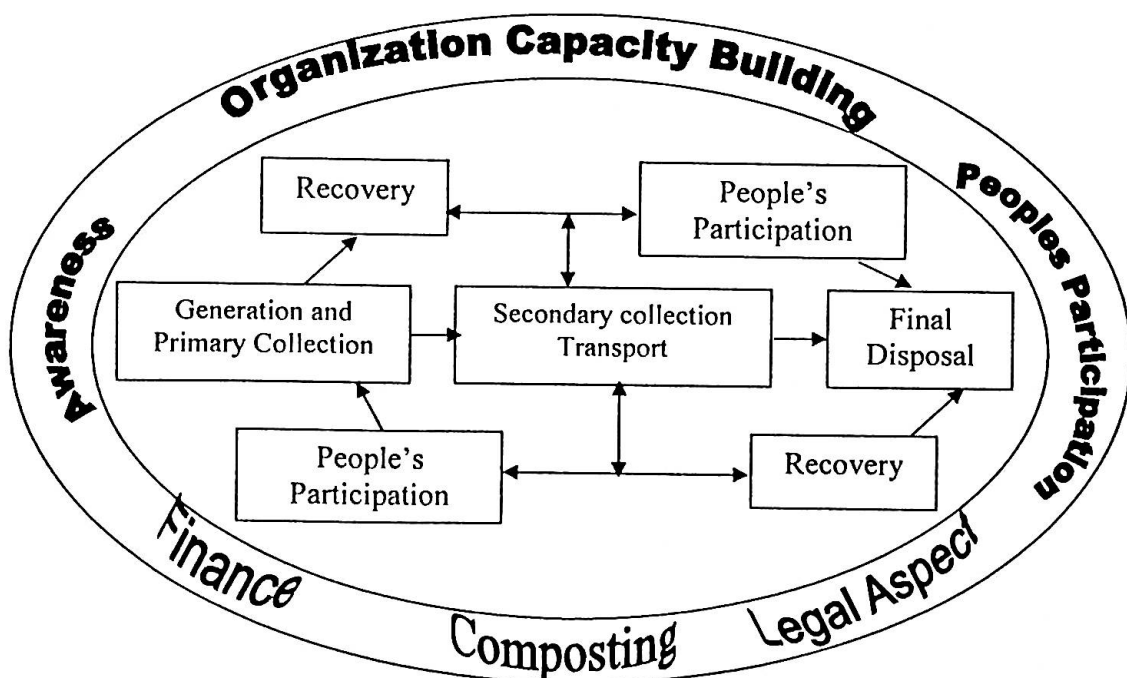
8.3.13 Miscellaneous

- ❑ Introduction of 'polluters pay policy' in solid waste management;
- ❑ Incentive or tax holiday for the producers, who inspire to reuse the recyclable materials. Producers can improved their performance through both management changes and technological improvements.

8.4 Summary of Recommendation

Assessing the waste quantity, quality, and composition is an important first step before deciding on a waste management strategy, and will provide an opportunity to evaluate the implications for health and the environment. In the present context, it requires an integrated approach to solid waste management of Dhaka city. The study reveals that it is essential to formulate a comprehensive policy guideline for integrated approach, which implicates strengthening city corporation, buildup people's awareness and participation, technological support, skilled workforce, and public-private partnership, strong legal base and financial capability with a view to ensuring resource recovery and a sustainable environment development. The organization structure of DCC should be strengthen through establishment of fully equipped Waste Management Department, trained workforce, strong financial support. The strong and clear legal base and its enforcement, building public awareness and participation are most important for efficient solid waste management. All these activities will interact towards the source of generation, primary collection, secondary collection/transportation, treatment (resource recovery) and final disposal of municipal solid waste. The total policy guideline is shown in the figure 8.1.

Figure 8.1
Policy Guideline for efficient solid waste management.



8.5 Approaches for Implementation

The recommendations mention in the thesis is not difficult to implement. For attaining the efficient solid waste management, it is no need of heavy investment. Nevertheless, the most important is the people's awareness and positive attitude from people as well as the implementing authority. The government, City Corporation, and the peoples are the main stakeholders of the process. Among them, the role of the government and DCC is extending or throwing the program and role of the people is cooperation and participation in solid waste management program.

To implement the recommendation Government and DCC can come up with special program phase by phase. The first one is investment in the sector to build up the infrastructure and facilities. Infrastructure include establish new sanitary landfill or convert Matuail Landfill into sanitary one. Collect modern road vacuum cleaner, covered van for secondary collection, (like the van of P- of Appendix D), establish solid waste treatment plant (like as the plant in Japan in the P- of Appendix D), facilitate establishing compost plant, and compost marketing. Government can provide subsidy to the private organization, which will establish composting plant.

The second important factor is awareness build up program. In fact, awareness buildup among the people is more important than other program for efficient solid waste management. If the people could make aware about the harm of inefficient solid waste handling and the benefit of solid waste as renewable resources, definitely they will cooperate in this regard. People' awareness could be made by applying two approaches.

Information, Education and Communication (IEC)

The IEC technique is providing right information, giving proper education and communication between service provider and receiver. Information definitely indicate the actual volume of solid waste, method of storing, mode of primary collection, bad impact of solid waste. Education indicates formal-informal education and training. Extensive curriculum should include in the primary, secondary, and tertiary level. Training is another mode of education. Both the DCC counterpart and people should be trained. Formal training for conservancy staff and informal or demonstrational training program for public should introduce. Communication is the mode transmitting the information and education to the people. There are many ways for communication such as interpersonal talking, official correspondence by letter, notice, advertisement, booklet, pamphlet, workshop, seminar, symposium, rally etc. TV and radio program is the best way of communication. Demonstration program in the locality is also another mode of communication. People should introduce with solid waste environmental impact; resource recovery for creating awareness. All these strategy will increase people's awareness and increase the people's participation for better solid waste management.

Behavior Change Communication (BCC)

This is another model successfully used for people's awareness in the field of health sector. For population control, BCC played an important role. The thrust of this approach is changing the habit or behavior pattern what the people following for long time. It is too difficult to alter the behavior of human being instant. However, it is possible through education, training, exchange of ideas and throwing extensive modular program. An example of changing behavior, a demonstration program of bad effects of throwing the banana peel or nut shells, or packaging materials in the street will motivate people not to throw elsewhere. Through the modular program, people's behavior can change. Thorough and in-depth awareness building program should be launched to change behavior regarding solid waste management.

Strengthening DCC

Solid waste management is more than something to other city service. It is one of the important services than other service sector. In one hand, it is a citizen service and another it provide relief the people from environmental pollution. It is revealed from the study people's want that solid waste management should be kept under the hands of DCC. Peoples opined that primary collection may render by the private organization but the secondary collection and final disposal must be in the hand of DCC. There should be a solid waste management department in City Corporation fully equipped with transport and other equipments for waste management. Trained and skilled workforce, modern technological support, sufficient financial base and peoples participation will make the Dhaka City Corporation capable of being providing efficient solid waste management.

8.6 Recommendation for Further Studies

Solid waste management is a big issue. Municipal solid waste includes household waste, other institutional waste, and commercial waste. A portion of hospital, industrial waste, and sewage sludge also include municipal solid waste. The present study mainly conducted with household waste. Primary data collected for domestic waste. Secondary data used for commercial, industrial and clinical, street waste. Therefore, lot of issues are yet to explore by field studies. The study recommends the following issues for further studies.

- Commercial solid waste management of Dhaka city;
- Industrial waste management practice of Dhaka city;
- Clinical waste disposal;
- The role-playing by the community organization for primary collection;
- Compost manufacturing prospects from organic waste;
- The effectiveness of solid waste management privatization etc.

8.7 Conclusion

The study on solid waste management is a cross sectional explorative and descriptive one. The research has aimed at finding the current solid waste management practices of Dhaka city. The research has conducted through applying structured questionnaire for different respondents, key interview technique, and participant observation methods. Photograph used for primary data. Both primary and secondary data used in the research. The overall objective of the research is to formulate a policy guideline for developing an efficient solid waste management for sustainable environment development.

About 3,700 ton solid waste produced in Dhaka city every day. Out of them 57 % is organic waste. The waste generators share in primary collection is 49% and 51% primary collection done by community based organization. Out of total generation, only about 34% is collected by Dhaka City Corporation. Rest of the waste disposed into roads, drains, near railways lines, uncontrolled open dumps etc.

DCC collected 65% solid waste dumps at Matuail site, 30% in Berri Bandh and 5% in Uttara site. No sanitary landfill and there is no provision of leachate control or gas control mechanism. About 16% of total solid waste is collected for recycling. Recycling is going on as informal sector. A lion share of infectious and hazardous medical waste are recycled and come back to the users by unscrupulous traders. No authority is concern about untoward recycling and its consequences on public health.

Solid waste management of Dhaka City is in deplorable condition. About 50% waste is not collected properly. Therefore, the unsightly, odorous, and unaesthetic scenario is very common in the city. Moreover, the air, water, and land pollution in and around Dhaka city is devastating. Incompetent workforce, lack of technology, insufficient financial capability, very poor people's awareness and perception about environment pollution, weak legal functionaries has identified as constraints regarding inefficient solid waste management.

Therefore, an integrated solid waste management is essential for sustainable environmental development. Policy guideline from the government, organizational capability of DCC and peoples participation is the key to efficient solid waste management. A competent workforce, sustainable technology for composting plant, cost recovery base well-built financial support, strong legal provision and enforcement, people's awareness and participation, public-private sharing are the key factors for efficient solid waste management for sustainable environmental development. The

government of Bangladesh and City Corporation might take necessary initiative for implementing the recommendation of the study. The city dwellers have to play an important role through participating in the program.

Solid waste generated in Bangladesh is mainly organic in nature. This waste is a good source of organic compost. Composting technology will minimize the volume solid waste to be disposed into the landfills as well as it will generate employment. Composting is an important source of resource recovery. It will decrease the requirement of chemical fertilizer. Therefore, composting is the cost effective method of solid waste disposal in Bangladesh due to tropical weather and organic nature of solid waste.

Each and every human being has a responsibility to keep the natural environment sustainable for the coming generation. The resource should be utilized carefully so that volume of waste would be minimum level and the environment will remain unpolluted. If all the stakeholders relating solid waste generation, collection, treatment and disposal extend their cooperation and participate in recycling program, then the unsightly, odorous solid waste would be a renewable resources rather than mere a waste. It will generate employment, resource recovery as well as ensure sustainable environmental development. The present citizens could play an important role keeping fossil fuel reserve to the next generation using more renewable biomass fuel through recycling untoward solid waste.

Bibliography

Websites

<http://www.solidwaste.com>
<http://www.safelystorage.com>
<http://www.wm.canada.com>
<http://www.colorstoneconcrete.com>
<http://www.nutriject.com>
<http://www.em.gov/epaswer/non-hw/muep>
<http://www.solidwastemag.com>
<http://www.nswma.org>
<http://www.adeq.state.ar.us/swmb>
<http://www.us.swmb>
<http://www.paalgroup.com>
<http://www.si-schaefer.com>
<http://www.capitupub.com>
<http://www.epa.gov/epaoswer/osw>

Unpublished Documents

DCC, "Profile of Dhaka City Corporation", *A Pamphlet of DCC*. Dhaka: DCC, 2004.

Iman, M. Shami, "Citizen Survey". Dhaka City Management Reform Workshop. (A Paper Presented in a Workshop, Organized by Bangladesh Center for Advanced Studies (BCAS) and BRAC. 15-17 March, 1998.)

Islam, A.K.Maminul. "Solid Waste Management System of Chittagong City Corporation". A Master's Thesis in Industrial & Production Engineering, in Bangladesh University of Engineering & Technology. 1994.

Islam, Professor Nazrul. "Public Private Partnership in Solid Waste Management : A Case Study in Dhaka City". Dhaka City Corporation. Dhaka. 2000.

Sutradhar, Rita. "A Case Study on Solid Waste Management System of Dhaka Metropolitan City". A Master's Thesis in Dept of Civil Engineering, in Bangladesh University of Engineering & Technology. 2002.

"An unpublished Concept Paper presented in SAARC Workshop on Solid Waste Management"(10-12 October, 2004, Dhaka), by Ministry of Environment and Forest, Government of Peoples Republic of Bangladesh.

Karle E. Weber and Indra P. Tiwari, Cited in the Ph. D Dissertation, "Research and Survey Format Design: An Introduction". AIT, Thailand: Division of Human Resource Development, 1992. pp. 47-48.

Reports and Documents

- "Assessment of a Solid Waste Disposal Site". *Environmental Monitoring and Assessment*. Vol. 48, 1997.
- Asia Pacific Technology Monitor*, Vol. 21 NO. 3. May-June 2004. New Delhi, India. p. 28.
- JICA. *Clean Dhaka Master Plan, Draft Final Report*. 2005. Dhaka: DCC, Pacific Consultant International, 2005.
- JICA. *Clean Dhaka Master Plan, Draft Progress Report*. 2004. Dhaka: DCC, Pacific Consultant International, 2004.
- JICA. *Greater Dhaka Protection Project*. Japan: Pacific Consultant International, 1994.
- Kingsley, G. T. et al. eds. *Managing Urban Environment Quality in Asia: World Bank Technical Paper No. 220*. Washington: The World Bank, 1994.
- Rahman, A.K.M. Saiedur. *Manual for Hospital Waste Management*. Dhaka: Ministry of Health and Family Welfare, 2001.
- Sinha, A. H. M. Maqsood and Enayetullah, Iftekhar. "Organic Waste Recycling Potentials in Dhaka City". Vol. 5. *Earth*. Dhaka: 1995.
- UNEP. *Manual for Urban Environmental Management: Thailand, Bangkok*. Urban Environment Project, Centre of Urban Development, 1990.
- World Bank, *Development and the Environment: World Development Report, 1992*, Washington: Oxford University Press, 2002. pp. 53-55

Acts and Policies

- The Brick Burning (Control) Ordinance 1989 (Ordinance No 8 of 1989)
- The Building Construction Act 1952 (East Bengal Act II of 1953)
- The Criminal Procedure Code 1860 (Act V of 1860)
- The Dhaka City Corporation Ordinance, 1983
- The Dhaka Metropolitan Police Ordinance, 1976
- The Environment Court Act, 2000
- The Factories Act 1965 (Act IV of 1965)
- The Motor Vehicle Ordinance, 1983 (Ordinance No LV of 1983)
- The National Environment Management Action Plan (NEMAP), 1992
- The Penal Code 1860 (Act XIV of 1860)
- The playground, open space, park, and natural water bodies of the Municipal Area Preservation Act, 2000
- The Protection and Conservation of Fish Act, 1950 (Act XVIII of 1950)
- The Shops and Establishment Act 1965
- The Smoke Nuisance Act 1905 (Bengal Act III of 1905)
- The Territorial Water and Maritime Zones Act 1974 (Act XXVI of 1974)
- The Town Improvement Act, 1953 (E.B Act No. XIII of 1953)
- The Bangladesh Environment Conservation Act, 1995.
- Bangladesh Environment Conservation Rules, 1997.

News Paper, Journals and Magazines

- Brown, Mark S. Clune, Timothy S. and Sutton, Bruce G. "Sustainable Management of Landfill Leachate by Irrigation". *Water, Air and Soil Pollution: An International Journal of Environment*, Vol. 134. No. 1-4. February 2002. Kuler Academic Publishers. pp. 81-96
- Cheng, Moo Been, Lin, Jung-Jeng & Chang, Shu-Hao. "Characterization of Dioxin Emission from Two Municipal Solid Waste Incinerators in Taiwan". *Atmospheric Environmental International*. Vol. 36. No 2. January 2002. Pergamon. pp. 283-286.
- Hamid, Dr. Abdul "Underground Water Resource: Bane Bashe Boon (Waste goes to water)", *Development Review*, Vol. 11, No. 1 & 2. Dhaka: January and Jun, 1999.
- Islam, Nazrul & Mahjabeen, Zeenat. "The Role of Civil Society Organization in Urban Development in Dhaka City". *Oriental Geographer*, Vol. 47. No 2. Dhaka: BGS, July 2003.
- Karin, Sabrina Murshed. "Cleanliness Drive". *Daily Star*, 24 April, 2005. p. 17
- Kayguruz, Kamil and Kaygusuz, Abdullah "Renewable Energy and Sustainable Development & Turkey". *Renewable Energy: An International Journal*, AAM Sayigh. ed. Vol 25. No 3. March 2002. UK: Pergamon. pp. 431-454
- Kayguruz, Kamil. Kaygusuz, Abdullah. "Renewable Energy and Sustainable Development & Turkey", *Renewable Energy: An International Journal*, AAM Sayigh, ed., Vol. 25, No. 3, March 2002. UK: Pergamon.
- Kim, K.H. and Kim, M. "Mercury emissions as Landfill gas from a large Scale Landfill site in Seul". *Atmospheric Environmental International*. Vol. 36. No 31. January 2002. UK: Pergamon.
- Kylefors, Katarina, Eche, Holger and Kvist, Akdras Lager. "Accuracy of COD Test for Landfill Leachates".
- Muttamara, S and Leoong. Shing Tet. "Environmental Monitoring and Impact". *Environmental Monitoring and Assessment*. Vol. 48, 1997. pp. 1-23.
- Rahman, Dr. Mushfiqur. "Kyoto chukti Amader natun sujog dabe (Kyoto Protocol will giver us Opportunity)". *Prothom Alo*, 3rd March 2005.
- Roston, Eric. "New War on Waste". *Time*. September 2, 2002. p. 56
- Shivkenar, K, Pande, A. K. & Bikshan, G. "Toxic Trace Element Pollution in Ground water around Patancheru and Boloram Industrial Areas, Andhra Prodesh, India: A graphical Approach". G.B Wiersma, ed. *Environmental Monitoring*. Vol. 45. No 1. March 1997.
- Sinha, A. H. M. Maqsood and Enayetullah, Iftekhar. "Solid Waste Management & Recycling in Dhaka City". *Earth*. Dhaka: Vol. 4. 1995.
- Special Reporter. Portrait of a Beleaguered Planet". *Newsweek*. September 2, 2002. p. 38.
- Staff Correspondent. "Firm Political Commitment Needed to Combat Environmental Degradation", *The Daily Star*. Dhaka: August 23, 2001.
- Twardowska, Irena and Szczepanska. Jadwiga. "Solid Waste: Terminological and long-term Environmental Risk Assessment Problems Exemplified in a Power Plant Fly Ash Study". *The Science of Total Environment*, Vol. 285. No. 1-3. Feb, 2002.
- Vatis Update: *Waste Management*, Vol-5, No 60. New Delhi: Jan-Feb 2004.

Water, Air and Soil Pollution: An International Journal of Environment, Vol. 146. No 1-4. June 2003. Kuler Academic Publishers. pp. 153-169.

Wiersma, G. B. ed. "Growing Megacities of Asia: A Case of Karachi, Pakistan". *Environmental Monitoring and Assessment*, Vol. 44 No1-3. Orono Miami, USA: Kluwer Academic Publisher.

World Bank. *Environmental Matters, World Bank Magazine*. Washington: WB. 2001

Zhang, Fu Shen, Yanasaki, S. Nanzyo, M. "Wastes Ashes for Use in Agricultural production, Liming Effect, Content of Plant Nutrients and Chemical Characteristics of Some Metals". *The Science of Total Environment*, Vol. 284. Nos. 1-3. Feb. 2002, pp. 21-225

Books

Ahmad, O.K., Ahmed, Nilufar and Rashid, K. B. Sassadur. eds. *Resources, Environment and Development in Bangladesh*. Dhaka: BUP & Academic Publishing. 1994.

Ahmed, M. Firoz. "The Effect of Bio-degradable Organic Pollutants on Aquatic Ecosystem of the River Buriganga", Max A Tilzer and Moniruzzaman Khondaker, eds., *Hyper-tropic & Polluted Freshwater Ecosystems: Ecological Basis for Water Reserves Management*. Dhaka: Department of Botany, DU. 1993.

Ahmed, M. Firoz. "The Effect of Bio-degradable Organic Pollutants on Aquatic Ecosystem of the River Buriganga". Tilzer, Max A. and Khondaker, Moniruzzaman. eds. *Hyper-tropic & Polluted Freshwater Ecosystems: Ecological Basis for Water Reserves Management*. Dhaka: Department of Botany, DU. 1993.

Ahrens, C. Donald. *Metrology Today: An Introduction to Weather, Climate and the Environment*. USA: Thomson Book. 2003.

Akhter Sakina & Farooque, Mostafa Kamal. "State of Environment". Mohiuddin Ahmed, ed., *Bangladesh Towards 21st Century*. Dhaka: Community Development Library. 1999.

Akter, Nasima. "Scenario of Hospital Waste Management in Bangladesh". Ahmed, M. Feroze, Tanveer, A Saleh, and Badruzzaman, ABM. eds. *Bangladesh Environment 2002*. Vol. 2. Dhaka: Bangladesh Poribesh Andolon (Environment Movement). 2002. pp. 674-689.

Alam, A.K.M Mazharul, et al. "Aspects of Solid Waste management- A Case Study at Nirala Residential Area, Khulna". Ahmed, M. Feroze. et al. eds. *Bangladesh Environment 2002*. Vol. 2. pp.698-702.

Alam, Nasreen. *Simple Facts about Environmental Pollution*. Dhaka: Luthfun Nesa Ahmed. 2002 .

Alam, R, Chwodhury. et al. "A Study on Municipal Waste Water in Sylhet City". Ahmed, M. Feroze. et al. eds. *Bangladesh Environment 2002*. Vol. 2. pp. 703-711.

Ali, Mansoor. *Down to Earth*. UK: WEDC. 1999.

Allaby Mechael. *Dictionary of the Environment*, 3rd ed. Washington: University Press. 1989.

Alter, Harver & Dunn, J.J Jr. *Solid Waste Conversion to Energy*. New York: Marcell Dekker Inc.1980.

Ayoade, Prof. J.O. "Climate Factors Affecting Pollutants in Waste Disposal Sites in Developing Countries". Rogers W'u Okot-UMA et al. eds. *Pollution Control & Waste Management in Developing Countries*. London: The Commonwealth Secretariat. 2000. pp. 253-258.

- Banargee, A.K. "Pollution: A Natural Process". Trivedi, R.N. ed. *Environmental Pollution and its Impact on the Organisms*. Patna: Bharati Bhawan.
- Bangladesh Centre for Advanced Studies. *Guide to the Environmental Conservations Act 1995 and Rules 1997*. Dhaka: University Publishers Ltd. 1999.
- Bari, Q. Hamidul and Koenig A. "Measuring Solid Waste Compost Maturity: A Review and Practice". Ahmed, M. Feroze. et al. eds. *Bangladesh Environment 2002*. Vol. 2. pp.712-722.
- Bella, Dennis Sr. "Environmental and Health Management in Developing Countries". Okot-UMA, et al., eds.
- BEN, *Bangladesh Environment Network*. Atlanta: BEN, 2001.
- Berg, L. Van den. "Bioconversion of Biomass into Methane". *Food Feed & fuel from Biomass*. D.S. Chatal ed. New Delhi: Oxford IBH Publishing Co. 1991.
- Bhatia, Dr. H.S. *A Text Book on Environmental Pollution & Control*. Delhi: Galgotia Publications (P) Ltd. 1998.
- Bhatia, S.C. *Handbook of Industrial Pollution & Its Control*. Vol. 1 & 2. New Delhi: CBS Publishers and Distributors. 2002.
- Bhuiyan Md. Amir Hossain. et. al. "Unplanned Waste Disposal and its Possible Impact on Subsurface Environment of Dhaka City, Bangladesh". Ahmed, M. Feroze. et al. eds. *Bangladesh Environment 2002*. Vol. 2. pp. 723-731.
- Blocks, PA de. "Re-infiltration of Waste Tip Leachate: An inexpensive Alternative". Dewal, JKA. ed. *Environmental Technology*. Holland, 1987.
- Bogatsu, Yvonne Gotlop. "Towards Effective Waste Disposal in Developing Countries". Okot-UMA, et al.,
- Bridgwater, A.V. and Manford, C.J. *Waste Recycling and Pollution Control Handbook*. London: George Godwin Ltd, 1979.
- BUP. *Perspective on Sustainable Development*. Dhaka: Bangladesh Unnayan Parishad. 2002.
- Cech, Thomas V. *Principals of Water Resources History, Development and Policy*. Washington: John Willy & Sons Inc. 2002.
- Chae, Yong S. and Hamidi, Ahmed. "Ground Water and Surface Water Pollution". Liu, David HF. ed. *Environmental Engineers Handbook*. 2nd ed. New York: Lewis Publishers. 1997.
- Chase P. D and Singletary, J. H, "Biodegradable Potential of Pretreated Municipal Solid Waste". *Fuels from Biomass and Wastes*. Klass, Donald L. and Emert, George H. eds. Mihcigan: Ann Arbur Science, 1981.
- Chhatwal, GR. et al.. *Encyclopedia of Environmental Pollution and Its Control*. New Delhi: Anmal Publication. 1989.
- Chowdhury, A. M. and Faruqui, Ms. Shabnam. "Physical Growth of Dhaka City", Dhaka: Past Present Future, in Sharif Uddin Ahmed ed. Dhaka: The Asiatic society of Bangladesh, 1991.
- Chowdhury, Quamrul Islam ed., *Bangladesh Road to Sustainable Development: People's Voice*. Dhaka: Forum of Environmental Journalists of Bangladesh (FEJB), Ministry of Environment & Forest and UNDP, 2002.

- Chowdhury, Quamrul Islam. ed. *Air Pollution in Asian Cities*. Dhaka: FEJB, MoEF & UNDP, 2000.
- Chowdhury, Quamrul Islam. ed. *Air Pollution in Asian Cities*. Dhaka: FEJB, MoEF & UNDP, 2000.
- Contreau, Sandra j. *Environmental Management of Urban Solid Wastes in Developing Countries: A Project Guide*. Washington: WB. 1982.
- Corbitt, Robert A. "Air Quality Control". *Standard handbook of Environmental Engineering*. 2nd ed. Corbitt. Robert A. ed. New York: McGrawhill. 1999.
- Cotton, Andrew, Sohail, M and Tayler, W.K. *Community Initiatives in Urban Infrastructure*. Loughborough, UK: WEDC Publications, 1998.
- Darkoh, Kwesi Darkoh. "Environmental Impacts of Urbanization". Okot-UMA *et al.* eds. *Pollution Control & Waste Management*. London: The Commonwealth Secretariat. 2000. pp. 381-399.
- Darkoh, Kwesi. "Environmental Impacts of Urbanization". Okot-UMA, *et al.*, eds. *Pollution Control & Waste Development*. Dhaka: BUP, 2002.
- DFID, EC, UNDP & WB. *Linking Poverty Reduction and Environmental Management: Policy Challenges and Opportunities*. Washington: WB. 2002.
- Dhyan, S. N. *Management of Environmental Hazards*. New Delhi: Vikash Publishing House Pvt. Ltd. 1993.
- Elkington John and Shopley, Jonathon. *Cleaning up: US Waste Management Technology and Third World Development*. Washington: World Resource Institute. 1989
- Farooque, Mohiuddin. *Bangladesh Environmental Laws*. Dhaka: BELA. 2001.
- FTK Sefe, FTK. "The Role of EIA in Waste Disposal and Management". *Pollution Control & Gain*, Philip & Moral, Shishir eds. *Leather Industry: Environment Pollution & Mitigation Measures*. Dhaka: SHED. 2002
- Gain, Philip. ed., *Bangladesh Environment: Facing 21st Century*. Dhaka: Society for Human and Environment Development (SHED). 1998.
- Ganter, Larry W. *Environmental Impact Assessment*. 2nd ed. New York: Mcgrall Hill Inc. 1996.
- Ganter, Larry W. *Environmental Impact Assessment*. International ed. New York: McGraw-Hill Inc. 1997
- Gardner, Gary. "Organic Waste Reuse Surging: Vital Sings," Linda Starke, ed., *The Environmental Trend that are Shaping our Future*. New York: World watch Institute, 1988.
- Gardner, Gray "Organic Waste Reuse Surging: Vital Sings". Starke, Linda. ed. *The Environmental Trend that are Shaping our Future*. New York: Worldwatch Institute. 1988.
- Glysson, Eugene A. "Solid Waste". *Standard Handbook of Environmental Engineering*. 2nd ed, Robert A Corbitt, eds. New York. Lewis Publishers, 1999.
- Goodsrein, Eban S. *Economics and the Environment*. 3rd ed. New York: John Willy & Sons Incorporation. 2001.
- Goodstein, Eban S. *Economics and the Environment*. 3rd ed. (New York: John Willy & Sons Incorporation, 2001.

- Gould, Jon E. "Solid Waste Reuse and Recycling". Okot-UMA, *et al.*, eds. *Pollution Control & Waste Management*. pp. 353-359.
- Haider, Azimussshan. "Dacca (Dhaka) through the Ages", *A City and its Civic Body*, in Azimussshan Haider, ed. Dhaka: Dhaka Municipality, 1966.
- Hamid, Abdul, Dr. "Underground Water Resource: Bane Bashe Boon (Waste goes to water)". *Development Review*. Vol. 11, no. 1 & 2, Dhaka: 1999 (January and Jun), pp. 76-80.
- Hamid, Noved and Huq, Saleemul. eds., *Asian Cities in the 21st Century: Reforming Dhaka City Management*, Vol. 3. Dhaka: Asian Development Bank, 1998.
- Hasan, J. "Managing the Hospital Waste". *Bangladesh State of Environment*. Dhaka: Ministry of Environment & Forest. 2001
- Hinrichs, Robert A. & Kleinbach, Merlin. *Energy and its use and the Environment*. 3rd ed. USA: Thomson Learning Inc. 2002.
- Huda, K. M Nurul. "Municipal Solid Waste Management-Dhaka City Perspective". Ahmed, M. Feroze. *et al.* eds. *Bangladesh Environment 2002*. Vol. 2. pp. 732-746.
- Huq, Nasser Ejazul. "Optimum Landuse in the Lowlying Areas Around Dhaka City: A Geological Perspective". Ahmed, M. Feroze. *et al.* eds. *Bangladesh Environment 2002*. Vol. 2. pp. 465-475.
- Imtiaz, N and Alam M. S. "Health-care Waste of Dhaka City: A Socio-environmental Assessment". Ahmed, M. Feroze. *et al.* eds. *Bangladesh Environment 2002*. Vol. 2. pp. 751-769.
- Integrity & Economic Efficiency, *Man & the Biosphere Series*. Volume 9. Paris: UNESCO & the Parthenon Publishing Group. 1992
- Islam, Dr. Engineer K. "Application of Potential of Renewable Energy Technologies with Special Reference to Solar PV Electrification of Remote Rural Areas of Bangladesh", Dhaka: AI Publication Ltd.
- Islam, Nazrul and Khan, Nazrul Islam. "Urban Governance in Bangladesh and Pakistan". Islam, Nazrul. ed. *Urban Governance in Asia: Sub-regional & City Perspective*. Dhaka: CUS & Pathak Samaj. 2000.
- Islam, Nazrul and Khan, Nazrul Islam. "Urban Governance in Bangladesh and Pakistan", *Urban Governance in Asia: Sub-regional & City Perspective*, in Nazrul Islam, ed. Dhaka: CUS & Pathak Samaj, 2000.
- Islam, Nazrul. "The State of Urban Environment in Bangladesh". Islam, Nazrul and Ahsan, Rosie Majid. eds. *Urban Bangladesh: Geographical Studies*. Dhaka: Geography Department, Dhaka University. 1996.
- Islam, Nazrul. "Urbanization and the Urban Environment in Bangladesh", A Atik Rahman, *et al.* eds. *Environment and Development in Bangladesh*. Dhaka: UPL, 1994.
- Islam, Nazrul. "Urbanization and the Urban Environment in Bangladesh". A Atik Rahman. *et al.* eds. *Environment and Development in Bangladesh*. Dhaka: UPL, 1994
- Jalil, A. Rabbani, G. and Hossain, M.K. "Radioactive Waste Management and Disposal: Present Status and Future in Bangladesh". Ahmed, M. Feroze. *et al.* eds. *Bangladesh Environment 2002*. Vol. 2. pp. 747-750.
- Kaonga, Brihton. "The Application of Appropriate Technologies in Waste Management in Developing Countries". *Pollution Control & Waste Management*.

- Karim, Abdul. "Origin and Development of Mughal Dhaka", *Dhaka: Past Present Future*, Sharif Uddin Ahmed ed. Dhaka: The Asiatic society of Bangladesh, 1991.
- Keller, Edward A. *Environmental Geography*. 4th ed. Ohio: USA, Charles E. Merrill Publishing Co. 1985.
- Khan, Enayetullah. "Reflection on Water". *State of World Water*. Qumrul Islam Chowdhury, ed. Dhaka: WWFJ, MoEF& UNEP, 2003.
- Khan, M. Salar *et al.* eds. *Wetlands of Bangladesh*. Dhaka: Bangladesh Center for Advances Studies & Nature Conservation Movements. 1994.
- Kholiquzzaman, Qazi and Ahsan Uddin Ahmed, eds., *Bangladesh Citizens Perspective on Sustainable Development* (Dhaka: BUP,2002) 152-155.
- Kodise, Selotlegeng A. "A Review of Waste Management in Developing Countries with Rference to Botswana". Okot-UMA, *et al.*, eds. *Pollution Control & Waste Management*. pp. 363-372.
- Kumar, Ranjit. *Research Methodology: A Step by Step Guide for Beginners*. London: SAGE Publications Ltd., 1999.
- Lee, James A. *The Environment, Public Health, and Human Ecology*. Baltimore and London: The John Hopkins University Press. 1985.
- Little, Dennis L., Dils, Robert E. & Gray, John. eds. *Renewable Natural Resources: A Management Handbook for the 1980s*. USA: West View Press. 1982.
- Liu,David & Liptak, Bela G. *Environmental Engineering Handbook*. 2nd ed. New York: McGraw-Hill, 1999.
- Loftnes, Robert L. *Energy Handbook*. New York: Van Nostrand Reinhold Co. Inc. 1984
- Lund, Herbert F. *Industrial Pollution Control Handbook*. New York: McGraw-Hill Book Co.1971.
- Mahmood, Hassan. "Importance of Sanitary Landfilling of Municipal Solid Waste in Bangldesh". Ahmed, M. Feroze. *et al.* eds. *Bangladesh Environment 2002*. Vol. 2. pp. 785-799.
- Mallow, Alex. *Hazardous Waste Regulation*. New York: Van Nostrand Reinhold Co. 1981
- Management*. pp. 261-267.
- Manhan, Stanly E. *Environmental Chemistry*. 6th ed. Columbia: USA, Lew's Publishers. 1994.
- Mayer, P. H & Schlochtern, Zu. "Waste Management: A comprehensive Service to Industry". *Environmental Technology*. Dewal, KJA, Brink, WJ and Van Sen. eds. Dordrecht, Holland: Martinus Nijhoff Publishers, 1978.
- Mayer, Richard. *Connection in Environmental Science: A Case Study Approach*. Boston: McGraw-Hill Higher Education. 2001.
- Mokrzychi, Eugenius, Uliasz, Alicja and Sarnz, Mieczyslaw, "Waste as Alternative Fuels in Cement Industry" Peter Chatania, ed., *Energy 2000; the Beginning of a New Millennium*. Italy: Technomic Publishing Co. Inc. and Bala Ban Publishers. 2000.
- Mokrzychi, Eugenius, Uliasz, Alicja and Sarnz, Mieczyslaw. "Waste as Alternative Fuels in Cement Industry" Peter Chatania, ed., *Energy 2000*. Italy: Technomic Publishing Co. Inc. and Bala Ban Publishers, 2000.

- Mortula, M. M. Rahaman, M. S. and Rahman, M. M. "Studies on Waste Disposal at DEPZ". Ahmed, M. Feroze. et al. eds. *Bangladesh Environment 2002*. Vol. 2. pp. 807-817.
- O'Meara, Molly. "Exploring a New Vision for Cities". *The Challenges of Urban Government: Policies and Practices*. Mila Freire & Richard Stren, eds. Washington: The World Bank Institute, 2001.
- Paebke, Robert. "Environmental Sustainability and Urban Life in America". Vig, Norman J. and Kraft, Michael E. eds. *Environmental Policy: New Dimension for the Twenty First Century*. Washington DC: C.Q Press. 1992.
- Pickford, John, et al. eds. *Affordable Water Supply and Sanitation*. London: WEDC, 1994.
- Pringle, Lawrence. *Lives at Stake*. New York: Macmillan Publishing Co. 1980 .
- Rahman, A. Lee. HK and Khan. MA. "Domestic Water Contamination in Rapidly Growing Megacities of Asia: A Case of Karachi, Pakistan", *Environmental Monitoring and Assessment*, G.B Wiersma, ed., Vol. 44 No1-3. Orono Miami, USA: Kluwer Academic Publisher. Pp. 339-360.
- Rahman, Md. Mujibur and Ali, M. Ashraf. "Waste Management and Environmental Pollution in Bangladesh". *Bangladesh Environment 2000*. Dhaka: Bapa. 2000
- Roger, Peter P. et al, *Measuring Environmental Quality in Asia*. USA: Harvard University and ADB, 1997.
- Roger, Peter P. et al., *Measuring Environmental Quality in Asia*. USA: Harvard University and ADB. 1997.
- Roosmalen, G.R.E.M.U. et al., "The Effect of Processing on the Heavy Metal Content in Compost". Dewal, JKA. ed. *Environmental Technology*. Holland, 1987. pp. 77-86.
- Rouse, Jonathan and Ali, Mansoor. *Waste Pickers in Dhaka*. Loughborough, UK: WEDC Publications, 2001.
- Sadeque, Zahir. *Environment and Natural Resource Management in Bangladesh*. Dhaka: Bangladesh Sociological Association. 1992.
- Sefe, FTK. "The Role of EIA in Waste Disposal and Management". Okot-UMA, et al., eds. Okot-UMA, *Pollution Control & Waste Management in Developing Countries*
- Segosebe, E. M. "Waste Management: the Role of NGOs", Okot-UMA, et al., eds. *Pollution Control & Waste Management in Developing Countries*.
- Shahabuddin, Khwja. "Foreword of the Book", *A City and its Civic Body*, in Azimussan Haider, ed. Dhaka: Dhaka Municipality. 1966.
- Shahnaz and Karim, "Out Goes Polybag in Comes Jute Bag", *State of Environment Report 2001*, Chowdhury, Dhaka: MoEF, 2003.
- Shivkumar, P, Thandaveswa and Chandarsekeran, KD. "Solid Waste Leachate Quality and its Effects on Soil Properties". *Pollution Research*. Dr. R.K Trivedi. ed. Vol. 23(1). Kerad, India. 2004.
- Siddayno, Corazon M. ed. *Energy Investments and the Environment: Selected Topics*. Washington: World Bank. 1993.
- Simpaya, M.F. "Biomedical Medical Waste Management in Developing countries". Okot-UMA, et al., eds.

- Sinha, A.H.M. Maqsood and Enayetullah, Iftekhar. *Community Based Solid Waste Management: The Asian Experience*. Dhaka: Waste Concern, 2000.
- Srivastava, Jotendra P., Smith, Nigel J.H. and Forno, Douglas A. *Biodiversity and Agricultural Intensification, Environmentally Sustainable Development Studies and Monographs Series*. No.11. Washington: WB. 1996.
- Stearns, Robert P. and Wright, Thomas D. "Landfill Gas Recovery at the Ascon Disposal Site- A Case Study". *Fuels from Biomass and Wastes*, Donald L. Klass and George H. Emert, eds. Michigan: Ann Arbor Science, 1981.
- Swarup, R, Misra, SN & Jauhare, VP. eds. *Dimensions of Environmental Pollution, Encyclopedia of Ecology, Environment & Pollution Control*. New Delhi: Mittal Publication, 1992.
- The WB & Bangladesh Center for Advance Studies. *Bangladesh 2020*. Dhaka: UPL, 1999.
- Tillman, David A. "Energy from Waste: An Overview of Present Technologies & Programs" Anderson, Larry L. & Tillman, David. eds. *Fuels from Wastes*. New York: Academic Press Inc. 1977.
- Trivedi P. R & Raj, Gourdeep. eds. *Encyclopedia of Environmental Science*. Vol. 25. New Delhi: Akashdeep Publishing House, 1992.
- Turaban, Efraim. "Incineration of Solid Waste : A Case Study", *Cost Containment in Hospitals*, Efraim Turaban, ed. London: An Aspen Publication, 1980.
- Uddin, M. Kamal. "Management of Construction Waste: Utilization of Construction Debris as Road Sub-base Material in BD". *Bangladesh Environment 2000*. Ahmed Firoz. ed. Dhaka: Bapa: 2000.
- Uddin, M. Kamal. "Management of Construction Waste: Utilization of Construction Debris as Road Sub-base Material in Bangladesh", Firoze Ahmed, ed. *Bangladesh Environment 2000*, Dhaka: Bapa, 2000. pp. 413-424.
- Uddin, Zulhash Uddin and Keigo, Nakajo. "Technologh Selection for Sustainable Solid Waste Management, Bangladesh Aspects". Ahmed, M. Feroze. et al. eds. *Bangladesh Environment 2002*. Vol. 2. pp. 830-844.
- UN. *Environmental Management in the Transnational Corporation: Report on the Benchmark Corporate Environmental Survey*. Environmental Series No. 4. New York: UN. 1993.
- UN. *The Common Country Assessment: Bangladesh*. Dhaka: UPL. 2000.
- UNEP, UNCEF & WHO. *Children in the New Millennium*. Malta: UNEP, UNCEF & WHO. 2002.
- UNEP. *Environmental Sound Technology for Wastewater and Strom Water Management: An International Source Book*. Osaka/Siga: IWA Publishing. 2002.
- UNEP. TUNZA, *Acting for a Better World*. UNEP. 2003.
- United Nations Environment Program (UNEP), *Bangladesh: State of the Environment, 2001*. Klong Luang, Thailand: UNEP, 2001.
- Villa, Jill Gale de. ed. *Energy End Use: An Environmentally Sound Development Pathway*. Manilla: ADB.
- VTC Matsoga, VTC. "Waste Management Services in Botswana: Evolution of Problems, Perspectives and Waste Management in Developing Countries". Okot-UMA, et al., eds. *Pollution Control & Waste Management*. pp. 281-288.

- World Almanac Library. *21st Century Science, Climate: the Environment*. USA: Milwaukee, WI. 2002.
- World Bank Group. *Pollution, Prevention, Abatement Hand Book 1998*. Washington: World Bank Group. 1999.
- World Bank. *Decision Maker's Guide to Incineration of Municipal Solid Waste*. World Bank: Washington.
- World Bank. *Development and the Environment: World Development Report, 1992*. Washington: Oxford University Press. 2002.
- Yong, M. D. "Sustainable Investment & Resource Use". *Environmental Engineers Handbook*, 2nd ed. New York: Lewis Publishers, 1997, p. 1007.
- Yung-Hui, Chen and Shaw-Bing, Wen. "Preparation of Construction Brick from Mixture of Incineration Ash and Reservoir Sludge", Chatania, Peter. ed. *Energy 2000; the Beginning of a New Millennium*. Italy: Technomic Publishing Co. Inc. and Bala Ban Publishers. 2000. pp. 993-1010.

Annexure - A
Solid waste management questioner (for Family)-1

Serial No

date.....

1. Name of the Respondent. Address :Location 1.Old Dhaka 2. New and planned Dhaka 3. Mixed extended area of Dhaka
2. Profession 1.Govt. Service 2. Private Service 3.Business 4.Housewife 5. Professionals (physician, adv., eng. Etc) 6.Teachership 7. Others
3. Educational Qualification. 1. Illiterate 2. Primary 3. SSC 4. HSC 5. Graduate 6. Masters 7. Phd. Barrister etc. 8. Others
4. Number of family members.....
5. For how long residing in Dhaka? (1).1to 5 yrs (2).6 to 10 yrs (3). 11 to15 yrs (4).16 to 20 yrs. (5). Permanent resident
6. Name of head of the family -----
7. Profession: 1.Govt. Service 2. Private Service 3.Business 4.Housewife 5. Professionals (physician, adv., eng. Etc) 6.Teachership 7. Others
8. Educational Qualification. - Illiterate-1 / Primary-2 / SSC-3 / HSC-4 / Graduate-5 / Masters-6 / Phd. Barrister etc.-7 / Others -8
9. Description about the other members of the family -----
10. Total (income) of the family TK. -----
11. How much garbage produce daily -----kg.
12. Nature of garbage produced in the home. -----

Nature of garbage	Quantity(kg)	
Plants, vegetables and fruits and their parts/residues		
Animal: fish, meat relating cooking residues		
Paper, cardboard, packet etc.		
Broken cans, bottles and unused materials		
Plastics and synthetic materials		
Bricks, wood, and iron-steal materials		
Garden trimmings, dust etc.		

13. Day which create maximum garbage (day): 1.Saturday 2.Sunday 3.Monday 4.Tuesday 5.Wednesday 6.Thursday 7.Friday
14. Place where the garbage is deposited at home? 1.Kitchen 2.Veranda 3.Store Room 4.No Particular place (NPP) 5.No deposit rather thrown away to the road or outside 6. Others
15. Garbage depositing container used at home. 1.Jhury 2.Bucket 3. Poly Bag 4.closed drum 5.Garbage depositing Particular place (PP) 6.No deposit 7.Others
16. Is there any community Based organization (CBO) for residential collection? 1.Yes 2.No
(If answer is no then answer from the question no 31)
17. At what time of garbage collection by the CBO? 1.At down 2.Morning time (8-11am) 3.At noon 4.Afternoon (3-6pm) 5.Evening 6.At night 7. No particular time (NPT)
18. Whether the CBOs are collecting the garbage daily? 1. Yeas 2. No 3.Irregular
19. Day at which CBOs representative do not come for collection, then how do you dispose? 1. We dispose ourselves 2.Retained for next day (RND) 3. Others
20. Participation in CBOs services compulsory or not. 1. Yes 2. No

21. Fee/charge for CBOs collection service in a month, Tk. -----

22. Whether the CBOs collection fee is justifiable?

5. Very much justifiable	4. Justifiable	3. Average	2. Not justifiable	1. Extent unjustifiable
--------------------------	----------------	------------	--------------------	-------------------------

23. If you think the charge is not justifiable, then what should be the monthly charge/fee? Tk. -

24. Whether fee/charge fixed in consultation with local residents? 1. Yes 2. No 3. Fixed by CBO one sided.

25. Whether pressurize for taking the fee/charges? 1. Yes 2. No

26. Are you satisfied with the CBO activities?

5. Very much satisfied	4. Satisfied	3. Average	2. Not satisfied	1. Extent Dissatisfied
------------------------	--------------	------------	------------------	------------------------

27. How is the cleanliness in your area for operating CBOs?

5. Very good	4. Good	3. Average	2. Not good	1. Extremely bad
--------------	---------	------------	-------------	------------------

28. By giving the garbage collection responsibility to CBS, DCC has benefited the people, what is your evaluation?

5. Very much benefited	4. Good initiative	3. It could be done by DCC	2. Felled in trouble	1. Increased peoples sufferings	0. Others
------------------------	--------------------	----------------------------	----------------------	---------------------------------	-----------

29. What should be done by DCC if the charge/fee is too much high? 1. DCC can fixed the rate 2. Can cancelled the permission 3. Can give punishment 4. Select CBO on the basis of competition 5. Others

30. Do you think this sorts of CBOs should be all around Dhaka? 1. Yes 2. No 3. No remarks.

If no CBOs are working in the area please give the answer from here again.

31. At what frequency the garbage is outing from the home? 1. Daily 2. Every alternative day 3. Twice in a week 4. Once I a Week 5. There is no fixed time.

32. At what time the garbage is sent outside? 1. at dawn 2. in Morning 3. at noon 4. in the afternoon 5. Evening 6. at night 7. NO uniform time.

33. At where the garbage is placed/disposed? 1. Particular dustbin 2. Roadside dump spot 3. Demountable container 4. Ditch for garbage 5. Lake, drain or low lying areas 6. Thrown away from the roof or balcony 7. Others

34. Where is the garbage dispose place in your area? 1. Adjacent to home 2. Very near to home for 2/1 minute path 3. Little bit away 5/7 minute path 4. not near in the area 5. Not known

35. Normally who dispose the garbage from home? 1. Male servant 2. Maid servant 3. Guard 4. Driver 5. Gardener 6. The respondent 7. Others

36. whether you monitor others garbage disposal activities? 1. Monitor 2. Don't monitor 3. Sometime

37. Whether you monitor the garbage disposal of your neighbor? 1. Monitor 2. Don't monitor.

38. If your neighbor is not careful about the garbage disposal, have you ever told him to be more careful? 1. Yes 2. No 3. It never seem to me to tell him 4. He may mind for telling 5. For telling it has been quarreled 6. Other

39. Where do you dispose the garbage produce in passing time (say banana peels, nut shells, packet etc) 1. dispose in the path 2. fell in the nearest dustbin 3. carry in the home 4. Others

40. At what time the DCC's vehicle carry the garbage? 1. very early in the morning 2. 8.00-12.00 am 3. Noon 4. Afternoon 5. Evening 6. at midnight 7. Latenitht 8. Not Known 9. Others

41. Do you think the time DCC's vehicle carry the garbage is all right? 1.Yes 2.No
3.No comments

42. If the answer is no then what is the best time of collection? 1. very early in the morning 2. 8.00-12.00 am 3.Noon 4.Afternoon 5.Evening 6.at midnight 7.Latenight 8.Not Known 9. Others

43. By what type of vehicle use for collection? 1.Hand carrier Van 2.Push Cart 3. Animal Cart 4. Truck 5.Covered van/vehicle 6.Demountable container 7. others

44. How do you evaluate the DCC's process of carrying the garbage? 1.Very good 2.Good 3.Average 4.Bad 5. Very bad

45. DCC's worker do not collect the garbage nicely from the roadside/bins- what are the cause?. 1.No accountability 2. No supervision 3.No risk of losing job 4.less salary, so less initiative 5. It is the nature & if provided more do the same work 6.No motivation for cleanliness 7.Collect very rightly 8.Others

46. For efficient SWM there is needs an expert workforce, in that case what is the level of expert of DCC workforce?

5.Very efficient	4.Efficient	3.Average	2.Inefficient	1.Extent inefficient
------------------	-------------	-----------	---------------	----------------------

47. SWM workers need initiative and a very positive attitude. In this regard what is the level of DCC workers?

5.Very good	4.Good	3.Average	2.Below quality	1. Bad quality
-------------	--------	-----------	-----------------	----------------

48. For efficient SWM needs latest or good technological support. In this regard what is the level of DCC?

5. Very good	4.Good	3. average	2.Low quality	1. Very Bad quality	0. Not known
--------------	--------	------------	---------------	---------------------	--------------

49. For efficient SWM needs peoples awareness and cooperation. In this regard what is the level of DCC?

5.Very good	4. Good	3.Average	2. Not good	1. Extremely not good
-------------	---------	-----------	-------------	-----------------------

50. For efficient SWM needs structural framework (say sufficient bins/dustbins, width road, others machineries) etc. In this regard, what is the level of DCC?

5. Very good	4. Good	3. Average	2. Below standard	1. Extremely low quality
--------------	---------	------------	-------------------	--------------------------

51. For efficient SWM needs the Sincerity/ zeal of Mayors and other public representative (ward commissioners). In this regard, what is the level of DCC?

5. Highly sincere	4. Sincere	3. Average	2. Not sincere	1. No comments
-------------------	------------	------------	----------------	----------------

52. For efficient SWM needs timely and properly dispose of garbage into the bins. How far (s)he follows this rule?

5. Fell into the bins	4. Fell near the bins	3. Throw away from distant	2. Don't follow rules	1. Not known
-----------------------	-----------------------	----------------------------	-----------------------	--------------

53. For removing the problems of structural facilities in SWM what should be done? 1.Increase the frequency of dustbins 2. More than one time collection in narrow space/streets 3. More truck/container 4.Increase dumping place 5. Placing covered dustbins 6. Others

54. How do you evaluate the overall SWM of DCC? 1. Nicely successful 2. Successful 3. Average 4. Fail 5. Extremely fail

55. Whether DCC has informed any law/regulations regarding garbage disposal any time? 1. Yes 2. No

56. If informed, what is the process? 1.Through letter 2. Through Notice 3. Announcement through the Radio/TV 4. Announcement through Paper 5. Billboard 6. Others

57. Whether the DCC has given any punishment for improper disposal of garbage? 1.Yes
2. No 3. Not known

58. If punished, than what type of it? 1.Fine 2.Cencure 3. Jail 4. Not known 5.Others

59. There is a tendency of throwing refuse here and there man in our country. what are the reasons? 1.Unconconsciousness about the environment 2.Lack of education 3.No Monitoring of the authority 4.No Punishment for throwing refuse hither & thither 5.Nature of the nations 6.Others

60. It is stipulated in the Environment Protection Act that everyone have to clean his surroundings. Do you follow it? 1.Yes 2. do what is possible 3.Do what I fell good 4.Try 5.do not know what is in the law 6.Others

61. Peoples are throwing the refuse outside the bins even going nearest to the bins due to improper enforcing of law. What is your opinion?

5. 100% correct	4. Correct	3. Correct for somebody	2. Not correct	1. No comment
-----------------	------------	-------------------------	----------------	---------------

62. What could be done against them who throw their refuse out side the bins? 1.Drusic law and enforcement 2. Through Propaganda/publicity for consciousness building 3. Household training for efficient SWM Training 4.Mobile court action now and then for law breaking 5. If any other way

63. Have you ever that garbage could be a resource? 1. Yes 2. No 3. Never think

64. Garbage is resource if thought that what can be done through this? 1.some can be reused 2.Compost fertilizer 3. Biogas 4. Feeling low lands 5.Others 6.Never thought

65. Do you or in your family separate the kitchen garbage from others? 1. Yes 2. No

66. If separate, then why? .For Odor 2.due cause Bad for health 3.Unsightly 4.For separate disposal 5.For easier SWM 6.Others

67. There are lot decomposable refuse that could be reuse, do you do it? 1.Yes 2. No 3.Did not think (DN think) 5.If DCC take initiative then we will do

68. For efficient SWM, with the DCC the, peoples has responsibility. How could be done that responsibility? (please give only a best answer) 1.Source separation 2.dispose the refuse in right time in right place 3.refuse disposal into the bins 4.At any cause do not thrown away the refuse here and there 5.Community participation for efficient SWM 6.Others

69. Do you think that the SWM should be handed over to the private sectors? 1. Yes 2. No

70. If SWM handed to the private sector it will incur some additional cost. Do you support it? 1. Yes 2.No

71. No tax is taken for SWM, Only 2% of total rent is gained/deposited for conservancy tax. What is your opinion in this regard? 1. It is too low 2. Low 3. Justified 4.More 5. Too much 6. No comments

72. If DCC charge more revenue in this head, SWM would be more efficient. What is your idea? 1.For good management need more fund charged from citizens 2. It is possible good management by the present resource 3.No development would happen rather increasing tax 4.Others

73. As the part of the SWM, any official has inspected your home ever? 1. Yes 2.No

74. If inspect, why? 1.To make conscious 2.To facilitate 3.To make lesion how to manage the refuse 4.To present the worse effect of the refuse 5.Others

75. Is there any awareness building for effective SWM in your area by the DCC? 1.Yes 2.No

76. If no such program, what initiative could DCC can take for the building awareness for good management of solid wastes? Which one would be best effective? 1.Publicity/propaganda by the radio/TV 2.Workshop and Seminar arrangement 3.On the job training 4.SWM program should be treated as the national movement like Sanitation, tree plantation, EPI etc 5. Others if you think fit

77. SWM from starting to end disposal, what could be done in your opinion. -----

Solid waste management questioner (for Market/Businessman) -2

Question No

Date.....

Name of the Bazar or Marke

1. Name :
 2. Age:
 3. Name of the Business:
 4. Nature of the Business: 1.Retail 2.Whole selling 3.Arat 4.Grossary 5.Stationary 6. Readymade Garments 7.Others
 5. How did you relate with the business or market? No need
 6. Relation with the market. 1.Business 2.Bazar managing committee 3.Business organization 4.Leasing party 5.Others
 7. How much garbage production form your business ? -----Kg.
 8. What are the nature of garbage in your business organization 1.Fruits, vegetables and their parts 2.Straw, covering for baggage 3.Animals(fish, birds etc.) 4.Meat related intestines 5.torned bags, clothes, packs etc. 6. Drainage sludge 7. Others
 9. How much garbage produce in this market? 1. ----- MT/ 2. No idea
 10. Nature of the garbage 1.Fruits, vegetables and their parts 2.Straw, out covering for baggage 3.Animals(fish, birds etc.) 4.Meat related intestines 5.torned bags, clothes, packs etc. 6. Drainage sludge 7. Others
 11. which kind of garbage is more? 1.Fruits, vegetables and their parts 2.Straw, out covering for baggage 3.Animals (fish, birds etc.) 4.Meat related intestines 5.Torned bags, clothes, packs etc. 6. Drainage sludge 7. Others
 12. Where do you deposit your garbage from your shop or business center? 1.In front of the shop 2.Particular dustbins 3.As there is no bins, where everyone dispose 4.Ditch, drain or low lying areas 5.Rail line side 6.Others
 13. Who discharge this garbage? 1.DCC 2. Businessman himself 3.CBOs 4.Businessmen dispose up to transfer stations at their own expense and DCC dispose from that place 5.Others
 14. When the DCC discharge the garbage? 1.Moring 2.At noon 3.Afternoon 4.Evening 5.At night 6. No particular time
 15. What is the best time of discharging? 1.Early Morning 2.Within 10 a.m. 3.At noon 4.Afternoon 5.Evening 6. at night 7. No comments
 16. What is the frequency of discharging garbage by DCC? 1.Once in everyday 2.More than once everyday 3.Every alternative day 4.After two days 5.Once in a week 6.Others
 17. Whether the DCC employees discharge the garbage cleanly? 1.Very ordinary 2.Seems to be Good 3.Good 4.Very good 5.Very carelessly
 18. What is your evaluation of garbage discharging by DCC?
- | | | | | |
|--------------|--------|-----------|-------|-------------|
| 5. Very good | 4.Good | 3.Average | 2.Bad | 1. Very bad |
|--------------|--------|-----------|-------|-------------|
19. No need
 20. The markets and Bazaars produced lot of garbage. Which is the acute problem for this end? 1.Serious odors 2.Disturbing movements 3.Bitter health problems 4.Clogging the drains 5.Others
 21. Whether the businessmen pay conservancy tax for cleanliness? 1. Yes 2. No 3.Don't separate con. Tax 4.Not known 5.Otherx
 22. The businesspersons who produce more garbage should pay more tax? 1.Yes 2. No
 23. The cost incurred for collecting the garbage from the market should give by the businesspersons. 1.Yes 2. No
 24. Do you think that inefficiency in SWM due to less conservancy cost? 1.Yes 2. No
 25. Garbage is thrown here and there for weak enforcement of law. 1.Yes 2. No

26. Whether the DCC is fully successful in SWM? 1.Fully Success 2. Success 3.Average 4.Failure 5.Certainly failure
27. who is responsible for mismanagement in the Hat-bazar? 1.Business persons 2.Public 3.Passars by 4.Mgt System 5.Sweepers or cleaner 6.Supervisor 7.Negligence of the employee 8.More or less all
28. Do you support to handover the waste management through the NGOs? 1.Yes 2. No
29. Are you ready to pay more NGO service? 1.Yes 2. No
30. Do you know that this garbage could be resource? 1.Know 2.Don't know
31. What do we do with market waste, which are maximum in organic nature? 1.Compost 2.Biogas 3.Reclaimed low land 4. Others
32. Do you support the garbage transporting system of DCC? 1.Do agree 2. Don't agree
33. Whether the situation will be improve if garbage management is given to the CBO or business communities? 1.Yes 2. No
34. How the waste of the industry, hospitals and clinics can be managed? 1.Separate Dustbins 2. Incinerate 3.Separate sorting, transporting and disposing 4.Others
35. Whether any officials has inspected your business center as part of the waste management? 1.Yes 2. No
36. If inspected why 1.Make conscious 2.To associate SWM 3. To Teach the SWM 4.To analysis the Porosity of SW 5.Others
37. Whether DCC has taken any action for mishandling the garbage produces from business center? 1.Yes, do 2. No, don't 3. Not known
38. If taken action, then what type of action? (act type) 1.Fine 2. Censure 3.Jail 4.Others
39. What are causes of throwing garbage back and forth among the society? 1.Unconsciousness about environment. 2. Lack of ed, Culture 3.No Supervision of the authority 4.No punishment for throwing garbage everywhere
47. Do you follow the rule of cleaning your surroundings according to the EPA, 1995? (EPA95) 1. Yes, I follow 2.How much possible, follow 3. What I thinks fit, do that 4. I try 5.Don't know what is in the law.
48. Due to the absence of strict enforcement of law, peoples are even throwing the garbage going near to the dustbins, do you agree?

Certainly right	Right	Right for some one	Not right	No comments
-----------------	-------	--------------------	-----------	-------------

49. What could be done against them who throw their refuse out side the bins? 1.Drusic law and enforcement 2. Through Propaganda/publicity for consciousness building 3. Household training for efficient SWM Training 4.Movile court action now and then for law breaking 5. Others
50. Whether any awareness building activity in the market in waste management issues? 1. Yes have 2. No don't have
51. If yes, please mention.
52. Any suggestion for efficient waste management.

Solid waste management questioner (for DCC Officials)-3

Serial No

date.....

- Name of the Respondent:
- Designation: 1.CCO. 2. DCCO 3. CO 4. CSI 5. CI 6.Driver 7.Sweeper 8. Street cleaner 9. Other departmental Officer/Staff
- Address of your working place. 1.Head Office 2. Zonal Office 3. Word 4.Street
- Responsibility at what stage? 1.Decision Making 2.Official desk work 3. Supervision 4. Garbage collection 5.Stree sweeping 6.Driver 7.Supervision
- Average garbage produced per family per day in Dhaka? ---kg

6. How much garbage is produced in Dhaka? -----MT
7. What is the time of garbage collection from the area? 1.Morning 2.At noon, 3.Afternoon, 4.Evening 5. At night 6. No fixed time 7. The whole day collection is going on cyclically 8.Others
8. Who collect the garbage from the household? 1. DCC 2.CBO 3. It is the responsibility of local commissioner 4. Self help
9. Which time is appropriate for garbage removal from the locality? 1.At dawn 2.At noon 3.Afternoon (3-6pm) 4.Evening 5.At night 6.Only at mid night 7. No particular time
11. Whether the DCC completely clean the garbage? 1. Yes 2.No 3. Partially Yes.
12. There is a serious complain that DCC officials doesn't clearly remove the garbage from the bins/transfer stations? Why? 1.No accountability 2. No supervision 3.No risk of losing job 4.People do not dispose their garbage properly 5. Few workforce 6. Want of essential technology and properties 7.Less budget 8.Others
13. What are the causes of failure for clean removal of garbage? 1.refuse is so scattered that can't be remove completely 2.Few employee 3.Heavy work pressure 4.No accountability 5.Others
14. Which method of collection will improve the environment 1.Increase the frequency of bins/dustbins 2. At least 3 times collection from bins to transfer station 3. Handcart use in the narrow streets 4.Use demountable container 5.Others
15. What are the causes of unsuccessfulness in SWM? 1.Lack of efficiency 2.Negligence in duty 3. Less budget 4. Indecision of authority 5. Peoples are unconscious 6.Corruption 7.Lack of willfulness of the authority 8.lack of essential materials 9. No incentive 10. Others
16. Who is more responsible inefficient SWM? 1.Sweeper/cleaner 2.Public 3.Specially Conservancy dept as a whole 4. Management system 5. Top mgt 6. Political leaders 7.Waste pickers 8.Others
17. Everywhere in Dhaka city, garbage is scattered, What are the remedies? No need.
18. The markets are largely responsible for garbage scattering and environmental degradation. Do you agree with it? 1.100% correct 2. Partially correct 3.Correct 4.Not correct
19. How much dumping spot is using for garbage disposal now? 1 / 2 / 3 / 4
20. What are the dumping spots?
21. How long this dumping spot can be used? 1. Three months 2. Six months 3.One year 4. Two years 5.Three years 6.Five years 7. More than five years.
22. If the dumping spots are about to full, what will be the next program? 1.New dumpsite has been taken by this time 2. It is under process of taking new dumping place 3. It is now under planning/thinking stage 4.Others
23. Where should the new dumping place? 1.Far from city barren areas 2.In Savar red-soil land 3.Gazipur forest land 4.Low lying areas near city 5.extension of Matuail spot 6. Others
27. SWM became inefficient due to the less amount of conservancy tax. 1. Yes 2.No 3. No comments
28. If the public do not dispose their garbage into the bins then what legal action can take the DCC? 1.Fine 2. Jail 3. Others
29. Do you know the provisions are there in DCC Ordinance or Environment Protection Act about solid waste disposal? 1.Yes, I know 2.No, I don't know 3. It never seems to me that I should know it 4.I don't need to know 5.Others
30. For the noncompliance of legal system of garbage disposed, what procedure of action should be taken against a person? 1.Direct Fine 2.To file a suit 3.Giving a notice 4. Other
31. People have the tendency of throwing garbage here and there, what are the causes?

- 1.No enforcement of drastic legal action 2.Unconscious about the environment 3.A long lasting habit 4.there is no initiative of consciousness 5.Others
32. Do you think that SWM has big problem for throwing garbage outside the bins? 1. Yes 2. No
33. How can the tendency of throwing garbage outside the bins can be stopped? Which one is the best method? 1.Setting frequent bins 2.Training or Motivation 3.Enforcing drastic legal action 4.increasing conservancy tax and improving the SWM through that money 5.Privatization 6.CBOs system of SWM 7. Others
34. Do you think that Drastic law and its enforcement will increase the efficiency in SWM? 1.Yes 2. No 3. No comments
35. Do you support the complete privatization of SWM? 1. Yes 2. No
36. If you don't support, what are the reasons? 1.In fear of jobless 2.No confidence on Private sector 3.DCC activity will lessen 4.DCC image will lessen 5.Opportunity of corruption will lessen 6.Other.
37. The situation SWM of DCC will improve if it handed over to the NGOs in terms of money. Do you agree? 1. Yes 2. No
38. CBOs system of collection has increase or decreases the public harassment. 1.Increase 2. decrease 3. No comments
39. Is there any control of DCC over the CBOs who are taking money for collection? 1. Has control 2. No control 3. No comments
40. Who has fixed the CBO's charge or fee? 1.CBO itself 2.Fixed by DCC 3.Local Ward Commissioner 4.Not known 5. Others
41. Is the rate of CBO's charge for collection justifiable? 1.Rightly justified 2.Justifiable 3.Average 4. Unjustified 5. Extremely unjustified.
42. If the CBO's charge is unjustified, then what kind of action DCC can take? 1.DCC can fixed the rate 2.Can cancelled the permission 3.Can give punishment 4.Select CBO on the basis of competition 5.Others
43. DCC has complete his duty to dispose the garbage into the dump station. Is there nothing to be done other than this? 1. Yes, has 2. No, nothing to be done
44. What can do the DCC? Which one is best? 1.Separation for reusing 2.composting plant 3.Sanitary landfill 4.Lease out the SWM to the foreign investors 5. Others
45. What happens for improper SWM. NO need
48. Any suggestion (if you have)

Solid waste management questioner (for Waste Pickers)-4

Serial No

date.....

1. Name of the respondent
2. Address
3. Number of the family.
4. Profession of husband/wife
5. For how long you are doing waste picking? ----- Years
6. What type of garbage you collect? 1.Paper 2.cloth 3. Plastic can, bottles etc 4.clinical item 5.Metals 6.Utentencils 7.Poly bag 8.Bricks, wood 9.Fruits/vegetables 10. Others
7. What do you do with this garbage? 1.Sell 2. Use 1.Sell 2. Use
8. What have to do before selling ? 1.Sorting 2.Clean 3.Washing 4.Emaciating (Heating by sun) 5.Packing
9. Where do you sell it? 1.Whole seller come to buy 2. To be sent the Whole selling shop 3. To sent factory or godown 4. No particular system
10. How much income monthly? Tk.-----
11. Does your family run with this money? 1. Yes 2. No 3. Run miserably
12. From where you collect the materials 1.From Road 2.From dustbins 3.Dumping spot 4. Others

13. How much amount (%) of useable materials you collect from the bins or place? 1. Half 2. One third 3. One fourth 4. One fifth 5. One sixth
14. What type of benefit you provide the DCC? 1.Reduce the amount of garbage 2. Reduce the cost DCC 3.Reduce the dumping space 4. Others
15. Somebody told that waste pickers scattered garbage and that is problematic for waste collection and disposal. Is it true? 1. It is right 2. It is not right
16. Do you think that the procedure of collection by DCC is alright? 1. Agree 2. Don't agree
17. The time of garbage collected is right. 1. Agree 2. Don't agree
18. If not, when should collect? 1.Early Morning 2.From 8-12am 3.At noon 4.Afternoon 5.Evening 6.Mid night
19. There is a serious malodor in the place of garbage dump place for non complete removal. How this problem can be solved? 1.garbage should be dispose into the bins 2. garbage should removed completely 3.use of demountable container 4.garbage should be removed everyday 5. Others
20. Does the DCC is successful in SWM? 1.Successful 2. Failure 3. no comments
21. If failure, what should be done? 1.Setting frequent bins 2.More than one time removal of garbage 3.Provide more salary 4.More supervision employees work 5.More public consciousness 6. More activate CBOs system 7. Others
22. What aspect of WM is untoward in your opinion? 1.Collect garbage with negligence 2.Untime garbage collection 3.Deceive work 4.No supervision of employee work 5. Others
23. Have you ever got some valuable things scavenging garbage? 1. Yes 2. No
24. If yes, What is that item? No need.
25. Are you well/fine by scattering the refuse in an unhealthy environment? 1. Accustomed with 2.Often sick 3.No other alternative 4.No capacity to go elsewhere 5.If opportunity, leave this profession
26. What types of illness suffer you? 1.Often fever 2.Cough 3.Stomach disease 4.Headach 5.Vomitting 6.Chest Pain 7. Eyesight problem 8. Others.
27. How DCC employee behaves you? 1.Good behave 2.as it is 3. Very rough behave
28. By collecting a significant amount of garbage, you reduce the work of the DCC. What should do the DCC for you? 1.Provide remuneration 2.Heath facilities 3.Safe costumes 4.Price for sorted materials
29. What sufferings can do the garbage for environment? 1. Serious health problems 2.Unhealthy environment 3.Transportation problems
30. Who is mainly responsible for failure in the SWM? 1.Conservancy dept. 2.Public 3. Waste Pickers 4.DCC employees 5.Political leaders
31. No need
32. SWM should be handed to the private sector against money and it will improve the situation. Do you agree? 1.Yes 2. No
33. Is it increase or decrease the peoples sufferings for giving the CBO service? 1.Increased 2. Decreased 3. No comment
34. The charge or fee taking the CBO is too much or justifiable? 1.Too much high 2.High 3.Justifiable 4.No comments
35. Do you support the collection system followed by the CBOs? 1.Do agree 2. Don't agree
36. The CBO collection has benefited or enhance sufferings of the public? 1.Make benefit 2.Increase pressure
37. The charge/fee has fixed by CBO is alright? 1.Rightly justifiable 2. Justifiable 3.Average 4.Unjustified 5.Extremely unjustified
38. What should do the DCC if the charge is too high? 1. DCC can fixed the rate 2.Can cancelled the permission 3.Can punished 4.Select CBO on the basis of competition 5.Others

Solid waste management questioner (for community Based Organization)-5

Question No

Date.....

1. Name of the respondent and CBO
2. Date of born of the CBO (birth) 1.Year----- 2. Non known
3. Working for how much Ward or part? Ward No- Full or Part
4. From when (date) this organization is working?
5. Whether permission from DCC for garbage collection 1.Permission has 2. No permission 3. Not known
6. Whether permission from beginning or afterwards? 1.Started first & then Permission from DCC 2.Work after permission 3.Working but don't get permission 4. Permission under process 5.No need permission.
7. Kalabagan has started the garbage collection from household. Your organization has inspired from Kalabagan model or DCC inspired? 1.With inspired from Kalabagan model 2.In response to DCC's call 3.Not known
8. How many person involved in the program. 1/2/3/4/5/6/7/8/9/10 /11/12/13/ 14/ 15/ 16/17/18/19//20/or more than 20
9. Who is the principal entrepreneur? 1.Local Commissioner 2.Local political leader 3.Dedicated Social worker 4.Coordinated initiative 5.Not known
10. Is the organization registered 1.Yes 2. No 3. Not known
11. Whether the organization born only for garbage collection or it was also for other purpose? 1. It was from early date 2.Birth on for Waste collection
- 12.What are the other functions of the organizations? 1. public health 2. mass education 3. social welfare 4. micro credit 5. Others
13. From how many households or flats you collect garbage? 1.No 2.Tentitive no 3. Not known
- 14.Total work force in this regard?1. Total----- 2.Worker----- 3. Supervisor----- 4. Management-----
15. Total instrument used 1.Van-----, 2.Cart-----, 3. Push cart 4. truck----- ,5.Others--
16. Whether the CBO collect only garbage? 1.Yes 2. No
17. If answer of 16 is no, what other functions? No need
18. When do the CBO collect garbage in a week? 1.Once in a day 2.Twice in a day 3.Every alternative day 4.After every 2 days 3. after every 4 days
19. What is the level of cooperation from the householders? 1.Excellently nice 2.Very nice 3.Nice 4.Average 5.Some one non-operate
20. Where do deposit your collected garbage? 1.Near main road dustbins 2.Nearly demountable container 3.Open space 4.No particular place 5.Others.
21. At what frequency DCC collect your deposited refuse? 1.Every day carry 2.Every alternative day 3.After 2 days 4.Others
22. When do DCC carry the refuse from transfer stations? 1.Early morning 2. Morning 3. At noon 4. Afternoon 5.Evening 6. At night 7.Others
23. What aspect of DCC employees is untoward in your opinion? 1.Collect garbage with negligence 2.Untime garbage collection 3. Deceive work 4.No supervision of employee work 5. Others
24. How much money you charge for garbage collection? 1. Tk.10 2. Tk. 15 3. Tk.20 4.Tk. 25 5.Tk.30 6.Tk.50 7.Tk.75 8. Tk. 100
25. Who fixed the charge? 1.DCC 2.CBO 3.Fixed with discussing localities 4.Local Commissioner 5.Others
26. In all cases the charge is equal or not ? 1.Different in different place 2.Equal in everywhere 3.Not known
27. Whether provide receipt on payment or not ? 1.Yes 2.No
28. What is the management of earned revenue? 1.Deposit in the CBO's fund 2.Taken by the owner or authority 3.Do not know 4.One portion to be given to DCC 5.Others
29. How is the expenditure maintained of the CBO? 1. By earned revenue 2.Owners Pay 3.Owners Pay initially and now maintain by earned revenue 4.DCC provides subsidy 5. Others
30. It is reported in the newspaper that in some cases the CBO collects revenue by force? 1.Charged with fixed rate 2.No pressure 3.Some body don't want to pay 4.Our rate is very justifiable 5.No comments.
31. In your opinion how much refuse generated in a family? 1/2/3/4/5/ or more than 5 kg.

32. What are the level of confidence on your organization? 1.Public are happy 2.Public is disturbed 3.A few disturbed but maximum happy 4.We work with peoples love
33. Like all other your organization has taken the refuse collection as a profitable business. What is your opinion? 1.good business 2.business and social welfare 3.Only social welfare
4. business through social welfare is not harmful 5.It is present need
34. How does the payment system of organization? 1.Montly salaried 2.Part of earnings 3.Parts of profit
- 35.If payment is monthly, then what 1.Workers Salary Tk. ----- 2. Supervisors Salary Tk.----- 3.Managers salary Tk.-----
- 36.Rate of service charge earned. 1. 100% 2. 90% 3. 80% 4. 70% 5. 60% 5. 50%
37. What should do the DCC if the charge is too high? 1.DCC fixed the rate 2.cancel the permission 3.take punishment 4.CBO selection through competition 5.Charge is justifiable so DCC has nothing to do 6. Others
38. Whether you have pay earned revenue to DCC? 1. Yes 2. No
39. If yes, For what purpose? 1. Licensee fee 2. Tax 3. Part of rev.
40. Whether the participation is compulsory for the householders? 1.Yes 2. No
41. Do you separate some garbage for reuse, recycling etc.? 1. Yes 2. No
42. If yes then what is the portion? (%sort) 1. 10 2.25 3.35 4. 40 5.50 6. more
43. The money comes from sell proceed, go to the fund of. 1.Added wit CBO's fund 2.Takes who sorts 3.There is no accounts 4.Not known
44. What should be done for efficient waste management? 1.increase frequency of bins 2.collection more than once daily 3.More salary to employees 4.more supervise 5.increase public consciousness 6.More effective the CBOs 7. Others

Solid waste management questioner (for household- Gulshan Uttara) -6

Question No

Date.....

1. Name of the Respondent. Address: Location 1.Old Dhaka 2. New and planned Dhaka 3. Mixed extended area of Dhaka
2. Profession: 1.Govt. Service 2. Private Service 3.Business 4.Housewife 5. Professionals (physician, adv., eng. Etc) 6.Teachership 7. Others
3. Educational Qualification. 1. Illiterate 2. Primary 3. SSC 4. HSC 5. Graduate 6. Masters 7. Ph d. Barrister etc. 8. Others
4. Number of family members
5. For how long residing in Dhaka? (1) 1to 5 yrs (2)6 to 10 yrs (3) 11 to15 yrs (4) 16 to 20 yrs. (5) Permanent resident
6. Total (income) of the family TK. -----
7. How much garbage produce daily -----kg.
8. Nature of garbage produced in the home. -----
9. Day which create maximum garbage 1.Saturday 2.Sunday 3.Monday 4.Tuesday 5.Wednesday 6.Thursday 7.Friday
10. Place where the garbage is deposited at home? 1.Kitchen 2.Veranda 3.Store Room 4. No Particular place 5.No deposit rather thrown away to the road or outside 6. Others
11. Garbage depositing container used at home. 1.Jhury 2.Bucket 3. Poly Bag 4.closed drum 5.Garbage depositing Particular place 6.Not deposit 7.Others
12. Is there any community Based organization (CBO) for residential collection? 1.Yes 2.No
13. At what time of garbage collection by the CBO? 1.At down 2.Morning time (8-11am) 3.At noon 4.Afternoon(3-6pm) 5.Evening 6.At night 7. No particular time
14. Whether the CBOs collect the garbage daily? 1. Yeas 2. No
15. Day at which CBOs representative do not come for collection, then how do you dispose your garbage? 1. We dispose ourselves 2.Retained for next day 3. Others
16. Participation in CBOs services compulsory or not. 1. Yes 2. No
17. Fee/charge for CBOs collection service in a month. Tk. -----
18. Whether the CBOs collection fee is justifiable?

5. Very much justifiable	4.Justifiable	3.Average	2.Not justifiable	1. Extent unjustifiable
--------------------------	---------------	-----------	-------------------	-------------------------

19. If you think the charge is not justifiable, then what should be the monthly charge/fee? Tk. -

20. Whether fee/charge fixed in consultation with local residents? 1.Yes 2. No 3. Fixed by CBO one sided (FOS)

21. Whether pressurize for taking the fee/charges? 1.Yes 2.No

22. Are you satisfied with the CBO activities?

5. Very much satisfied	4. Satisfied	3. Average	2. Not satisfied	1. Extent Dissatisfied
------------------------	--------------	------------	------------------	------------------------

23. How is the cleanliness in your area for operating CBOs?

5. Very good	4. Good	3. Average	2. Not good	1. Extremely bad
--------------	---------	------------	-------------	------------------

24. By giving the garbage collection responsibility to CBS, DCC has benefited the people, what is your evaluation?

5. Very much benefited	4. Good initiative	3. It could be done by DCC	2. Felled in trouble	1. Increased peoples sufferings	0. Others
------------------------	--------------------	----------------------------	----------------------	---------------------------------	-----------

25. What should be done by DCC if the charge/fee is too much high? 1. DCC can fixed the rate 2. Can cancelled the permission 3. Can give punishment 4. Select CBO on the basis of competition 5. Others

26. Do you think this sorts of CBOs should be all around Dhaka? 1. Yes 2. No 3. No remarks.

27. DCC has sift the responsibility to the private organization The function which was done by DCC handed over to the forum in exchange of money. Do you know the matter? 1. Yes 2. No

28. Do you find any change (development) in the area after shifting the responsibility to the forum? 1. Yes 2. No 3. No comments

29. The workers of the forum have clean the drain, roads etc better than earlier? 1. Yes 2. No 3. No comments

30. Whether the workers of the forum collect the refuse very clean from the dustbins? 1. Yes 2. No 3. No comments

31. At what time the Forum's vehicle carry the garbage? . Very early in the morning 2. 8.00-11.00 am 3. Noon 4. Afternoon 5. Evening 6. at midnight 7. Late night 8. Not Known

32. By what type of vehicle use for collection? 1. Hand carrier Van 2. Push Cart 3. Animal Cart 4. Truck 5. Covered van/vehicle 6. Demountable container 7. others

33. whether any change has come after in SWM after having the responsibility to the Forum? 1. Yes changed 2. No change 3. No comments

34. whether any development in around the garbage dustbins after having the responsibility to the Forum? 1. developed 2. as like as earlier 3. worst than earlier 4. no comments.

35. whether the overall environment of the area has developed after taking the responsibility to the Forum? 1. developed 2. as like as earlier 3. worst than earlier 4. no comments.

36. If compare the Forum workers do better than DCC workers. What is your evaluation? 1. yes 2. no 3. no comments

37. Responsibility of SWM should be lies on whom ? DCC or Forum. 1. DCC 2. Forum

38. Efficient SWM need an expert workforce, then what is the level of skill of the workforce of the Forum . too skill 2. skill 3. average 4. unskill 5. extreme unskillful

39. Forum's worker do not collect the garbage nicely from the roadside/bins- what are the cause? 1. lack of experience 2. No supervision 3. less salary, so less initiative 5. business attitude 8. unskillful

40. Taking the SWM as a business, the Forum has increased the expenditure as well as trouble. What is your opinion? 1. 100% correct 2. correct 3. partly correct 4. not correct

41. Without giving the responsibility to the Forum, the DCC could do the job nicely. What is your opinion? 1. 100% correct 2. correct 3. not correct

42. For efficient SWM needs latest or good technological support. In this regard what is the level of Forum

5. Very good	4. Good	3. average	2. Low quality	1. Very Bad quality	0. Not known
--------------	---------	------------	----------------	---------------------	--------------

43. SWM workers need initiative and a very positive attitude. In this regard what is the level of Forum workers?

5. Very good	4. Good	3. Average	2. Below quality	1. Bad quality
--------------	---------	------------	------------------	----------------

44. For efficient SWM needs latest or good technological support. In this regard what is the level of DCC

5. Very good	4. Good	3. average	2. Low quality	1. Very Bad quality	0. Not known
--------------	---------	------------	----------------	---------------------	--------------

45. For efficient SWM needs peoples awareness and cooperation. In this regard what is the level of awareness and cooperation.

5. Very good	4. Good	3. Average	2. Not good	1. Extremely not good
--------------	---------	------------	-------------	-----------------------

46. For efficient SWM needs structural framework (say sufficient bins/dustbins, width road, others machineries) etc. In this regard, what is the level of DCC?

5. Very good	4. Good	3. Average	2. Below standard	1. Extremely low quality
--------------	---------	------------	-------------------	--------------------------

47. For efficient SWM needs the Sincerity/ zeal of Mayors and other public reprehensive (ward commissioners). In this regard, what is the level of DCC?

5. Highly sincere	4. Sincere	3. Average	2. Not sincere	1. No comments
-------------------	------------	------------	----------------	----------------

48. Do you have any other suggestion for efficient SWM?



Waste Disposing Sites



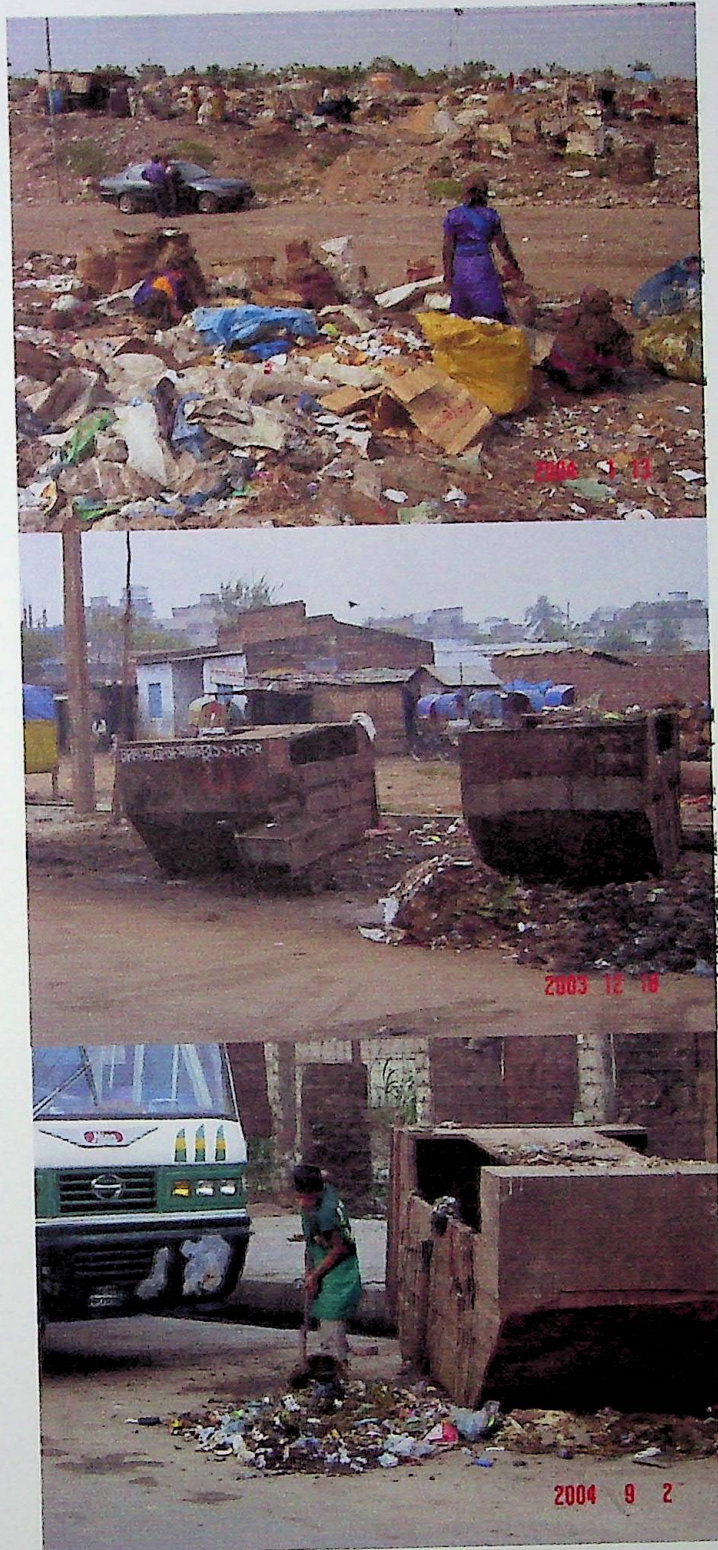
Waste Disposing Sites and Procedure



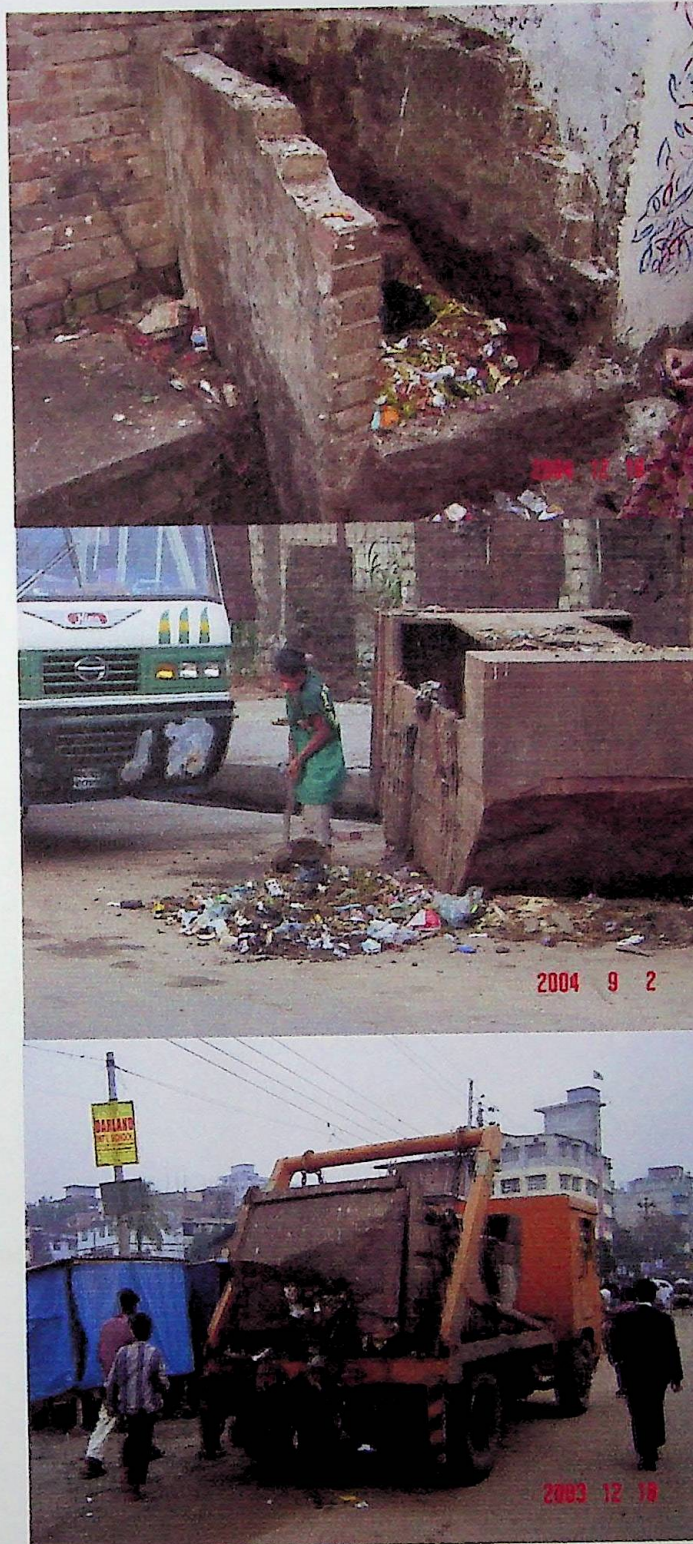
Waste Carrying Vehicles



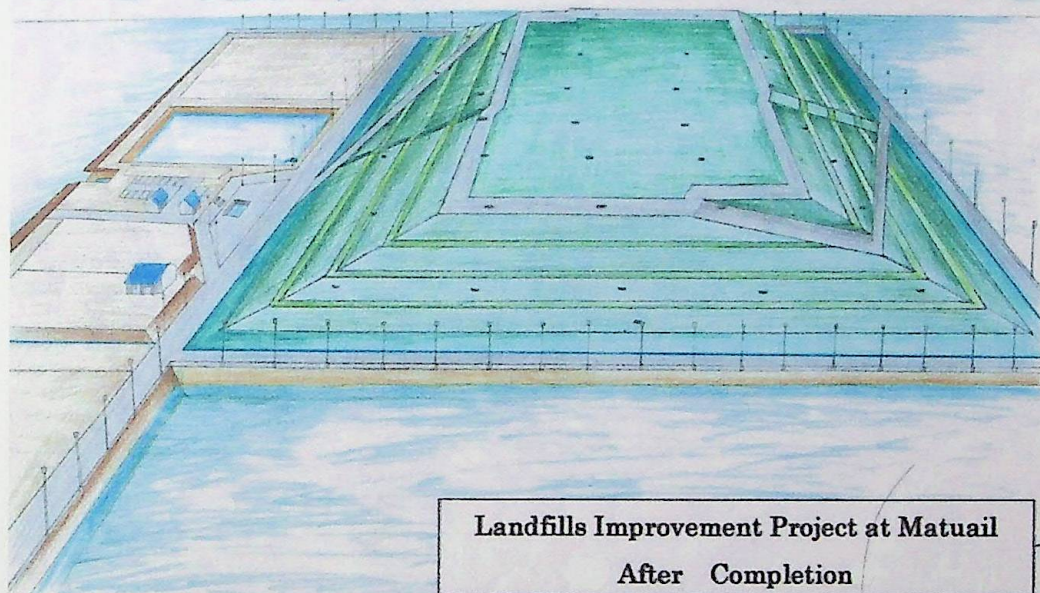
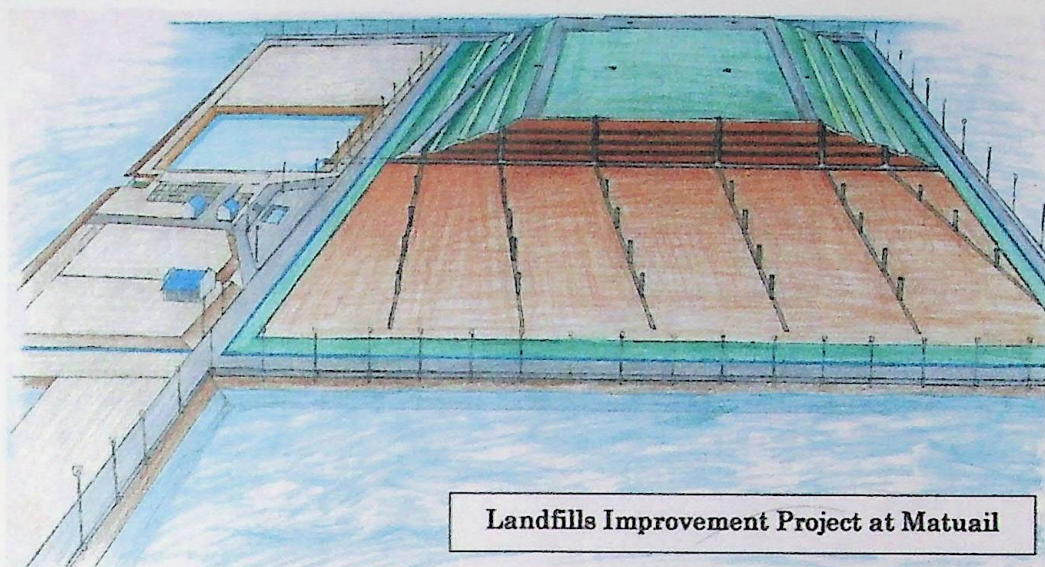
Waste Pickers



Dustbins and Waste Pickers



Dustbins and Containers



Landfills Design Developed by JICA under Clean Dhaka Master Plan

Rajshahi University Library
Document No. D. 2540
Date... 27/5/06