SOME CHARACTERISTICS OF VARIOUS WATERS IN AND AROUND DACCA CITY

A Thesis

by

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ABSTRACT

This thesis represents an attempt to show experimentally the various physical, chemical and biological qualities of water of the rivers Buriganga, Sitalakhya and Ballu in order to determine its characteristics and potability i.e., whether it is safe to drink, pleasant to taste and suitable for domestic uses. Investigations were also made on ground waters from various localities in and around Dacca City. Water samples were collected from various surface and sub-surface sources at regular intervals throughout the year and routine laboratory analysis were made for important water quality parameters like turbidity, pH, dissolved oxygen (DO), bio-chemical oxygen demand (BOD), total acidity and alkalinity, hardness, total bacterial counts, total coliform counts and other related parameters. The results are tabulated and graphically presented. All the experimental findings are critically discussed, conclusions drawn and recommendations made for proper treatment and further studies.

ABBREVIATIONS AND SYMBOLS

The following symbols and abbreviations are employed throughout this thesis:

mgd	million gallons daily
WASA	Water Supply and Sewerage Authority
WHO	World Health Organization
gpcd	gallon per capita daily
gpm	gallon per minute
ppm	part per million
mg/l	milligram per liter
CO_2	carbon dioxide
pH	Hydrogen-ion-concentration
DO	dissolved oxygen
COD	chemical oxygen demand
BOD	biochemical oxygen demand
Cl^-	chloride
E.C	electric conductivity
SO_4	sulphate
NO_3	nitrate
Fe	iron
Mn	manganese
Cu	copper
Zn	Zinc
MPN	most probable number
ml	milliliter
ft	feet
Cusec	cubic feet per second
C	centigrade degrees
cc	cubic centimeter
$CaCO_3$	calcium carbonate

Min	minimum
Av	average
Max	maximum
CE	Civil engineering
BUET	Bangladesh University of Engineering and Technology
WPCB	Water Pollution Control Board
HP	horsepower
AC	asbestos cement
CI	cast iron
MS	mild steel
PVC	polyvinyl chloride
PS	pump station
BS	brass strainer
SS	stainless steel strainer
SWL	static water level
PWL	pumping water level
DD	draw down
Q	discharge
S	specific
OT	Overhead tank
TSC	teacher student centre

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Water is absolutely essential for human life. Adequate water of good quality is a vital requirement for the maintenance and development of public health. Hence the important consideration and main responsibility of the modern public health Engineers is to supply potable water to the community. A potable water is one which is safe to drink, pleasant to taste and suitable for domestic uses.

Health problems related to the inadequacy of water supplies are universal but, generally, of greater magnitude and significance in the underdeveloped and developing nations. It has been estimated that about two-third of the population of the developing countries obtain their water from contaminated sources[1]. The World Health Organization estimates that each year 500 million people suffer from diseases associated with unsafe water supplies. Due largely to poor water supplies, an estimated 5,000,000 infants die each year from diarrheal diseases[1].

In Bangladesh, there is an increasing demand for potable waters. This increasing demand is due to the higher population growth rate in the country. As a result, there exists persistently a chronic shortage of potable water all over Bangladesh. Even in the City of Dacca, there is an acute shortage of potable water. The present population of Dacca is

1.31 million and the number is expected to be 3 millions in the next 20 years[2]. To satisfy the demand of the present population, 80 mgd of water is required only for domestic uses. Of the total demand of 80 mgd, only 50 mgd is supplied by the Dacca WASA[3] and other Government agencies. Adequate water supply is limited to certain developed areas of the city. Only 63% of the total demand of the existing population can be met by the present supply. People, therefore, collect waters from hand tubewells, open wells, lakes, ponds, rivers and other nearby available sources for domestic uses. A systematic study of all these sources of water in and around the City of Dacca is of prime importance to study its potability and the degree of pollution. Such a study is also essential for the selection of suitable sources for the extension of the water supply of the city.

1.2 WATER SUPPLY IN DACCA CITY

Dacca was a district town at the time of partition in 1947 with a nominal water supply. After the partition it became the capital of the then East Pakistan and served as the centre of administration, industry, education and commerce. After the creation of Bangladesh in 1971, it became the capital of Bangladesh.

The limit and importance of Dacca has been increasing day by day. The greater Dacca is located within the Buriganga,

the Lakhya and the Ballu river systems. In this area the inhabitable land lies generally between elevations 20 to 25 feet above sea level, and only a few isolated areas have slightly higher elevations. During the monsoon season, the urban and the other inhabitable areas in the vicinity form an island in the river systems shown in Fig. 1.1. Besides these three rivers, there are lakes, ponds, marshy lands and a good reserve of underground water.

The history of water supply of Dacca City dates back to 1872 which consisted of a 0.2 mgd capacity water treatment plant treating water from the Buriganga river and having a $4\frac{1}{2}$ miles network of distribution mains. The system was expanded later increasing the capacity of water treatment plant to 2.4 mgd and the distribution mains to 57 miles by 1939. Since 1947, a number of noninterconnected water supply systems were developed to meet a portion of the growing water requirements of the City. Total present available water supply in the city of Dacca is about 59 mgd. 95% of this water is supplied through 122 tubewells, scattered over the entire city area shown in Fig. 1.2. Water supply from the Buriganga river through the Chandnighat Dacca Water Works continues to serve a portion of the old city. The water supply systems in the city is managed by Dacca WASA, some Government, Semi-Government and private agencies like industrial and commercial enterprises.

Except some model towns in the city, the remaining vast areas developed in a hapazard way wherein it is very difficult

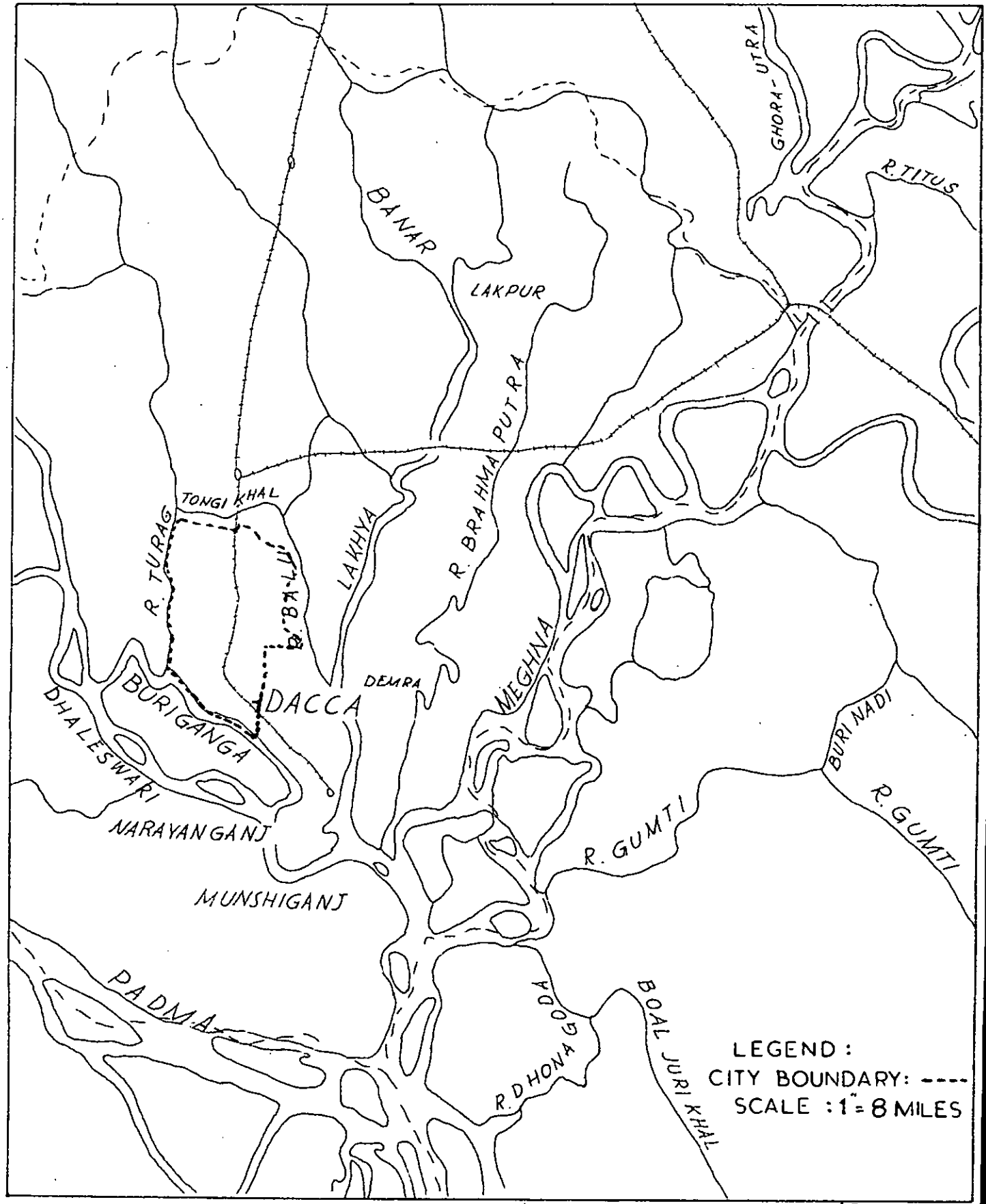
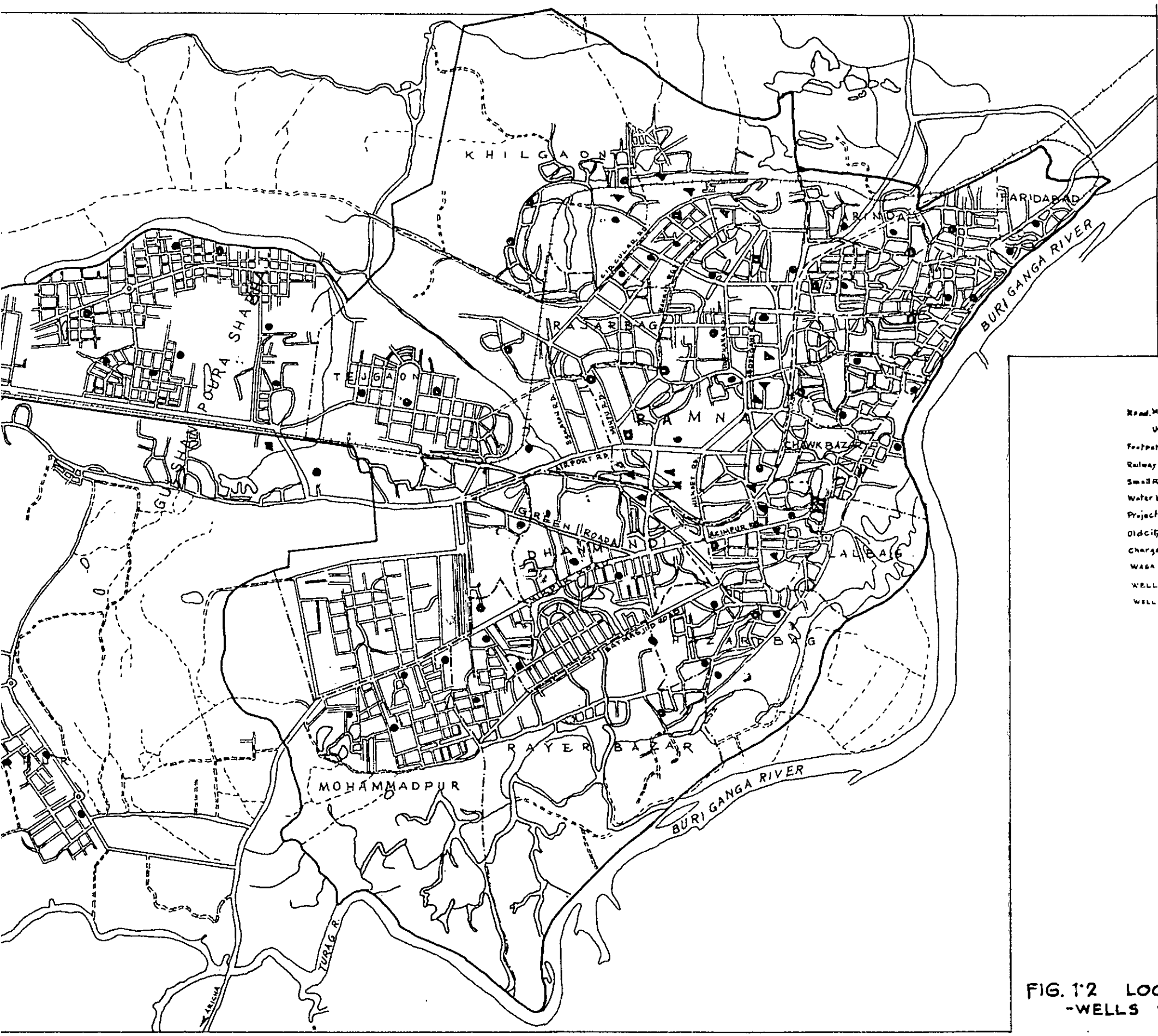


Fig.1.1 Important surface water sources in and around Dacca[18]



LEGEND

- Road, Metalled
- Unmetalled
- Footpath
- Railway with bridge
- Small River or Khal
- Water bodies
- Project area boundary Dacca ward
- Old city Limit
- Charge Boundary
- WASA WELL
- WELL OF OTHER GOVT AGENCIES
- WELL FOR COMMERCE & INDUSTRIES

Feet 1000 0 1000 2000 3000 4000 5000 6000 FEET
Scale

FIG. 1·2 LOCATION OF DEEP TUBE-WELLS WITHIN DACCA CITY AREA

to obtain land in the desired place. Moreover, no additional benefit can be obtained by sinking wells within the zones of interference. The present tubewell system will not meet the needs of a city of this size as already operational difficulties are being experienced principally due to electricity and well failures. It is apprehended that those difficulties may increase to a point where the tubewells may not feeable provide the required quantity of water[4]. In order to have full assurance for adequate, dependable and safe water supply, collection of surface water for treatment and distribution may get due consideration.

1.3 WATER QUALITY PARAMETERS

Chemically pure water is not available in nature and also is not desirable. In order to control the water quality parameters to the extent of International standards of Drinking Water, systematic study of these parameters is of prime importance. All the parameters can generally be grouped in three major heads: (i) Physical, (ii) Chemical and (iii) bacteriological qualities. Some of the water quality parameters with their relative importance in water supply are discussed here.

Solid contents: Solids in water may be found in dissolved or in suspended state. For domestic purposes, the amount of total solids is of importance for the determination of suitability

for uses. The idea of solid content is also essential for softening procedure and corrosion control. For these effects the International Standards for Drinking Water, WHO, 1971 restricts the amount of total dissolved solids to a highest desirable level of 500 ppm.

Turbidity: A water is turbid when it contains visible material in suspension. From considerations of aesthetic, filterability, and disinfection turbidity is a very important factor in public water supply. For its significant role in water supply Engineering, the USDPH has restricted the limit of turbidity to 10 ppm for potable water. While International Standards for Drinking Water, WHO, 1971 and Bangladesh Standards for Drinking Water recommended maximum permissible level of 25 units of turbidity for potable water.

Colour: Colour in water is usually due to organic matters in colloidal suspension. It is undesirable aesthetically. USDPH limits the intensity of colour of water to 20 ppm. Bangladesh standard has restricted the highest level of colour to 30 units in drinking water.

Taste and odour: There are only four true taste sensation: Sour, Sweet, salty, and bitter. Odours occur due to the presence of organic substances, in water. Evaluation of odours is dependent on the sense of smell. Taste and odour tests are useful as a check on the quality of finished water, for control

of odour through the plant and determination of treatment dosages. As per drinking water standards, water should be completely free from taste and odour.

Alkalinity: The alkalinity produced by carbonates is due to their hydrolyses into hydroxide and carbonic acid, the alkalinity of the hydroxide over balancing the acidity of the weak carbonic acid. All carbonates produce alkalinity, but only calcium and magnesium carbonates produce carbonate or temporary hardness. The determination of alkalinity is of importance in connection with corrosiveness of water and methods used in preventing the corrosion of distribution system, and also in the control of the coagulation of water. International standards for Drinking Water restrict the amount of carbonate alkalinity to a maximum of 120 ppm.

Acidity: Acidity in water is usually due to CO_2, mineral acids and hydrolized salts. The corrosive characteristics of acid waters are of great concern to sanitary engineers. Acidity in water is dangerous for health, though a very little amount of acidity is good for human digestive system[1].

Carbon Dioxide: Free carbon dioxide (CO_2) may be considered physically as a gas dissolved in water. Surface water normally contain less than 10 ppm Carbondioxide[5] while ground water contain it upto 50 ppm[1]. The Carbondioxide content of a water may contribute significantly to some corrosive situations.

pH: Alkalinity and acidity of water, sewage, and sludge are frequently expressed in terms of their pH which is a symbol for hydrogen ion concentration. A pH test determines the strength of the acid or alkali in a water, while the chemical tests for acidity and alkalinity determine the amounts of the acid or alkali present. pH values below 7 represent acidity, while pH values above 7 represent alkalinity. International Standards for Drinking Water, WHO, 1971 recommended that the highest desirable pH range is 7 to 8.5 and maximum permissible range is 6.5 to 9.2.

Hardness: Hardness is defined as a characteristic of water which represents the total concentration of calcium and magnesium ions expressed as calcium carbonate. However, if present in significant amounts, other hardness producing metallic ions should be included. The hardness may range from zero to hundreds of milligrams per liter in terms of calcium carbonate, depending on the source and treatment to which the water has been subjected.

Iron: Iron is objectionable in a public water supply because it causes strains on plumbing fixtures, on clothing and on textiles in the laundry. It may cause tastes and odour and it offers difficulties in manufacturing processes. Sulphate of iron causes acidity andcorrodes ferrous metal and brass. International Standards for Drinking Water, WHO, 1971 recommended the highest desirable level of iron as 0.1 ppm and

maximum permissible level as 1.0 ppm. Bangladesh Standards allowed it upto 5 ppm, in the absence of better water source.

Manganese: Manganese behaves so much like iron in natural waters that it is sometimes difficult to distinguish between them. Manganese is not so widely distributed as iron in nature so that it is less frequently encountered. The total content of iron and manganese in potable water is limited to 0.3 ppm.

Dissolved Oxygen: Adequate dissolved oxygen (DO) is necessary for the life of fish and others aquatic organisms. The DO concentration may also be associated with corrosivity of water, photosynthetic activity, and septicity. Bangladesh Standards for fishing water has restricted the limit of dissolved oxygen to a minimum of 4 ppm.

The chemical oxygen demand (COD): The chemical oxygen demand test indicates the quantity of oxidizable compounds present in water and will vary with water composition, concentration of reagent, temperature, period of contract, and other factors. Since chemical oxidation and biological oxidation are different processes, the result may differ to a large degree.

Biochemical Oxygen demand (BOD): BOD is a measure of the amount of oxygen demand by living organisms in the water to oxidize organic matter present as food for the organisms.

BOD is a characteristic, not a constituent, of the water. Unpolluted water should have less than 5 ppm of BOD.

Chloride: Chloride, in the form of Cl^- ion, is one of the major inorganic anions which is increased in sewage over the raw water because sodium chloride is a common article of diet and passes unchanged through the digestive system. Along the sea coast, chloride is present in high concentrations in surface and ground water. International Standards for Drinking Water, WHO, 1971 has restricted the limit of chloride in potable water to the highest desirable level at 200 ppm and maximum permissible level of 600 ppm. The maximum allowable limit in Bangladesh Standards is 600 ppm.

Electric Conductivity: Electric conductivity is a measure of a water's capacity to convey an electric current. This property is related to total concentration of the ionized substance in a water and the temperature at which the measurement is made. The nature of the various dissolved substances, their actual and relative concentrations and ionic strength of the water sample vitally affect the electric conductivity.

Sulphate: Sulphates are of hygienic significance because of their laxative affects[1]. The concentration is limited therefore to higher concentrations which are in use in some communities; the higher concentration being disturbing only to persons not accustomed to them.

Bacteriological qualities: The numbers and kinds of bacteria in natural waters depend largely on the available nutrient supply, the environment, other organisms present, and physical factors. The available nutrient substances in the water is of prime importance for bacterial population. Most natural surface waters contain all of the minerals necessary for all bacteria life.

Some waters contain substances unfavourable to certain bacteria. For example, sea water is too saline for many species. Acidic and metallic industrial wastes kill not only bacteria but tons of larger aquatic and marine plants and fish.

Some of the most common types of bacteria which may be present in water include the coliform group, fecal streptococcus, fluorescent bacteria, chromogenic bacteria, protens group, spore producing rods, and archromobacter. Many of these bacteria are without sanitary significance because they die rapidly in water come from unknown sources, are widely distributed in air or soil, or have not known suspected association with pathogenic organisms. Coliform groups are generally not pathogenic, except certain strains of Escherichia Coli that cause infant diarrohea and other diseases. The detection of this particular type of bacteria is very important as all pathogenic bacteria die much before the death of this type of bacteria in the process of water treatment.

1.4 WATER BORNE DISEASES

Water borne diseases are caused by pathogenic microorganisms. Unfortunately, their inclation from natural water is difficult by laboratory means. There is, however, a group of harmless bacteria known as Escherichia Coli, normally present in the intestinal tract of warm-blooded animals, which can be relatively easily isolated and identified[6]. E. Coli test is a search for E. Coli bacteria, the presence of which is taken to indicate the presence of fecal matter in the water and is a warning that pathogenic bacteria indigenous to the intestinal environment may also be present. The Table 1.1 shows pathogenic bacteria and viruses responsible for some common water-borne diseases.

Table 1.1 Water-Borne Diseases and Associated Pathogens.

Name of Diseases	Organisms responsible
Typhoid Fever	Bacillus typhi, Eberthela Typhosa } Bacteria
Paratyphoid Fever	Salmonella Paratyphi (Bacteria)
Amoebic Dysentery	Endamoeba Hystolytica (Protozoa)
Bacillary Dysentery	Shigella Dysenterie (Bacteria)
Cholera	Vibrio comma (Bacteria)
Gastroenteristis	Enteric Viruses
Poliomyelitis	Neurotropic viruses
Schistosomiasis	Cercarnie (animal parasites)
Infections Hepatities (jaundice)	Enteric Viruses
Anthrax	Bacillus Anthracis (Bacteria)
Tularemia	Spirochetes (Bacteria)
Influenga, colds	Pneumotropic viruses
Pheumonia, Broncho-Pheumonia	Diplo coccus pheumonia (Bacteria)
Diphtheria	Corynebacterium Diphtheria (Bacteria)
Cancer	Viscerotropic Viruses
Polio-like diseases	Enteric Viruses
Urinary Inflamation	Escherichia coli (Bacteria)
Whooping cough	Hemophilus pertussis (Bacteria)
Tuberculosis	Mycobacterium Tuberculosis (Bacteria)
Leprosy	Mycobacterium leprae

1.5 INTERNATIONAL STANDARDS FOR WATER QUALITY

(A) Water qualities of the Source: Water supplies should be drawn from the best available source. The WHO, in 1963 prescribed the maximum allowable limits of water qualities for water sources[1]. Table 1.2 shows the standards of some important water qualities for a source.

Table 1.2 International Standards of Quality for Water Sources

Qualities	Maximum allowable limits (mg/l)
Colour	300
Total dissolved solid	1500
Iron	50
Manganese	5
Copper and Zinc	1.5
NO_3	45
Fluoride	1.5
Phenolic substances	0.002
Arsenic and Lead	0.05
COD	10
Nitrogen Except NO_3	1
BOD	6
Bacteriological quality requires:	
Disinfection only	0-50*
Usual treatment	50-5000*
Extensive treatment	5000-50000 *

* MPN/100 ml.

(B) Drinking Water Qualities: The USPHS and WHO standardise the physical and chemical parameters measuring water qualities of drinking water. Table 1.3 shows the maximum allowable limits of some important parameters for drinking water[1].

Table 1.3 Drinking Water Standards

Quality	WHO(1971) Highest desirable level	WHO(1971) Maximum permissible level	USPHS (1962)	European WHO (1961)
Physical				
Total dissolved solids	500	1500	500	250
Turbidity	5	25	10	5
Colour	5	50	20	10
Temperature			$50^{o}F$	$50^{o}F$
Taste and odour	Nil	Nil	Nil	Nil
Chemical				
Chloride	200	600	250	250
Iron, Fe	0.1	1	0.25	0.1
Manganese, Mn	0.05	0.5	0.05	0.1
Iron and Manganese			0.3	0.2
Sulphate, SO_4	200	400	250	250
Total Hardness	100	500	150	100
Total Alkalinity			120	100
Fluoride			0.6	0.5
pH	7 to 8.5	6.5 to 9.2	7 to 8*	7 to 8*
Bacteriological				
Pathogenic Microorganisms			Nil	Nil

* No units.

1.6 BANGLADESH STANDARDS FOR WATER QUALITIES

Bangladesh Water Pollution Control Board suggested a water quality standard for Bangladesh. This water quality standard is based on available data and at the same time keeping in view the International Standard. Deviation from the International Standard has only been suggested by the Board[7] for two reasons:

(1) better quality of water is not yet available with economical viability

(2) such deviated water quality is reasonably acceptable without much hazard

Table 1.4 Shows Bangladesh Drinking Water Standard:

Table 1.4 Bangladesh Drinking Water Standards

Quality	Maximum allowable limits
Physical	
Turbidity	25 units
Colour	30 units
Threshold Odour number	Unobjectionable
Chemical	
Total Dissolved solids	1500 ppm
Chloride	600 (maxm. 1000 ppm)
Iron	1.0 ppm (Max. 5 ppm*)
Manganese	0.5 ppm
Zinc	15 ppm
Copper	1.50 ppm
pH	6.5-9.2
SO_4	400 ppm
Total Hardness as $CaCO_3$	250 (Max.450 ppm*)
Floride	1.0 ppm(2 ppm Maxm.tolerance limit)
NO_3	45 (50 ppm Maxm.tolerance limit)
Phenolic Substances	0.002 ppm

*In absence of an alternate better sources, these maximum limits may be tolerated.

1.7 OBJECTIVES OF THE RESEARCH

The major objectives of this research work were

(a) To make a systematic and elaborate examination of physical, chemical and bacteriological qualities of water samples from available major and minor sources in and around Dacca City to study their characteristics, potability and degree of pollution.

(b) To study the seasonal fluctuation of water quality parameters of the three major surface water sources; the Buriganga, the Shitalakhya and the Ballu around Dacca City.

(c) To find out a suitable sorface water source of adequate quantity and of comparatively good quality for future expansion of Dacca Water Supply.

CHAPTER 2

LITERATURE REVIEW

2.1 HISTORY OF WATER SUPPLY

The history of water supply is as ancient as the history of human civilization. Water works structures are found in excavation of prehistoric ruins. The remains of lake Moeris in Egypt indicates its construction about 2000 B.C. It was the largest of the reservoirs of the Nile Valley which is believed to supply water for 20,000,000 people[1]. Among others, the supply of water in the cities of Jerusalem, Rome and Mohenjodaro were specially notable, Wells were also used at remote periods in ancient Greece, Italy and India to utilize the underground water. Artesian wells were also found to be sunk in China in early times[1,8]. Ancient China possesses the deepest well in the World as it was known to be 1500 ft deep[1].

The water supply of towns in very early times was derived from large tanks excavated on minor drainage lines which collected and stored the rain water in the wet season to provide a supply during the dry periods. Especially notable are the structures of water supply, drainage, sewerage and swimming pools of Mohenjodaro Civilization in the Indus Valley.

The water supply for the city of ancient Rome was done by bringing water from the surrounding hills in aqueducts totalling about 385 miles in length[1]. As early as 312 B.C., these aqueducts were constructed along the hydraulic grade line.

Lead pipe was the only material available to carry water under pressure. London was perhaps the first modern city in the world which at the end of the 16th century used lead pipes for conveyance of water.

The early water supplies were contaminated by various impurities and people were suffering from various water-borne diseases. This urged the chemist to develop procedure for purifying water. Techniques for the examination of water, first for potability, then for safety as well, developed rapidly which ultimately led to the present day sanitary water analysis.

In British India, water supply on modern lines started in the later part of ninteenth century. The first work for the supply of water to Dacca city was completed by the Nowab of Dacca (Sir Nowab Abdul Ghani) in 1878. The water works in Calcutta was completed in 1870 and those of Bombay, Madras and Poona in 1875, 1880 and 1890 respectively.

At present, mostly ground water is collected all over Bangladesh for the water supply in the important cities and towns. The people in the remaining areas particularly the villages are to depend on hand tubewells, rivers, lakes, ponds, open wells etc. for drinking water.

As Civilization advances, the difficulty in obtaining potable water becomes greater. Because the population of towns increases to such an extent that the existing sources of natural supplies are neither within an easy reach of the majority of the public, nor they are sufficient. Contaminated

Water causes cholera, typoid, dysentery and diarrhea in epidemic form. Hence public water supply systems, which could deliver safe water to the houses, industries, public places and trade centres, are urgently felt by the authority concerned to be installed.

2.2 PREVIOUS WORKS

Study of the potability of the water of the river Sitalakhya[9] has been done by an American Consulting Farm Messers PARSONS CORPORATION; attached to WASA, Dacca. The farm was entrusted with the responsibilities of studying water supply potential for the city of Dacca and Chittagong, feasibility of constructing water supply system on modern trend with necessary treatment plants and distribution. In 1959-60, the farm conducted elaborated laboratory analyses of water samples of the river Sitalakhya and based on the test results, the corporation concluded that the water of the river contains more turbidity, hardness, total alkalinity, soluble iron, manganese etc. for which treatment in required to make it potable.

Islam[10] investigated the water quality of the river Sitalakhya near Demra in the year 1967. The average test results show that the water of the river Sitalakhya has a higher value of pH, colour, turbidity, acidity than the United States Public Health Services Standards for drinking water. If compared

carefully with the study of Messers PARSONS CORPORATION it is found that the average value of solid content increased from 138 ppm to 245 ppm and that of hardness from 93 ppm to 143 ppm. Bangladesh Water Pollution Control Board Studied[17] the river Sitalakhya near Demra ghat in the year 1974-75. This recent study of the river near Demraghat also indicate that the river water is being polluted increasingly day by day. The amonia content of the river was found to vary between the limit 0.20 to 1.70 ppm in 1974-75 where as the average amonia content was 0.13 in 1959-60. Near Chorashal Fertilizer Factory, maximum ammonia content found in the Sitalakhya river was as high as 35 ppm. Although some of the important water quality parameters was found almost constant in the river water during the period of study.

Kalam[11] investigated the water quality of the river Buriganga near the intake point of Dacca Water Works at Chandnighat in the year 1967-68. Kalam observed that the Buriganga river water is required to be treated for the removal of turbidity, hardness, alkalinity, soluable iron, manganese etc. to make it potable.

Das[12] investigated the water quality of the river Buriganga in the year 1967. Based on the test results, the investigator also concluded that treatment for controlling the water quality parameters like colour, turbidity, pH, hardness is required to make the water potable.

From September 1973 to June 1975, Bangladesh Water Pollution Control Board[17] also studied the Buriganga river water near Chandnighat and concluded that the raw water at Chandnighat is heavily polluted from sanitary discharges and the MPN count quite often exceeds the WHO international standards of raw water quality for drinking water supply. Other remarkable findings were that the coliform count exceeded the allowable limit and ammonia concentration in theriver water was also high. BOD, solid content and other water quality parameters were found within the limit of drinking water standard. Poul[13] investigated the water quality of the pond water in Dacca in the year 1973 and obtained turbidity units for the pond water higher than the permissible limit.

Nizam and Kabir[14] investigated the water sources in and around Dacca for the determination of the degree of pollution of thewaters. Based on the test result it was concluded that the waters were required to be treated for controlling pH, colour, turbidity and hardness for making them potable waters.

Ground water and tap water in different parts of the city were examined by Dacca WASA[15] from time to time. Except vary small number of coliform colonies, ground water tapped through deep tubewells found absolutely suitable for domestic purposes.

2.3 CONCLUSIONS

It is evident from the results of studies on different occassions that the waters in all the sources are getting more and more polluted with the passage of time. This is may be due to the fact that with the increase in the population of the city, untreated domestic sewage, industrial wastes are being discharged in the water sources at an increasing rate. The problem is becoming more severe with the increase in the use of various toxic chemicals in agricultural lands and other purposes. Now-a-days, surface water in rivers, ponds, lakes etc. are so contaminated that it cannot be used for domestic purposes without proper treatment.

Considering the population growth and probable future expansion of the city, a comprehensive water supply scheme is required to be made for Dacca after careful investigation of all available water sources. Physical, chemical and bacteriological examinations of the waters are essential to determine the water quality and the degree of pollution of the avail of water sources around the city and based on the test results, simple methods of treatment is to be devised.

CHAPTER 3

EXPERIMENTAL APPROACH

3.1 WATER SOURCES CONSIDERED FOR EXAMINATION

Water samples were collected from various available water sources in and around the city of Dacca for routine laboratory analysis. The following are the short descriptions of the sources from where water samples were collected at different seasons of the year for analysis.

3.1.1 The River Buriganga

The course of the river Buriganga is shown in Fig. 3.1. It is a tidal river and carries different kinds of domestic and industrial wastes. The dumping of garbage in the river by public is also rather indiscriminate. Large and small scale industries have been established on both banks of the river and innumerable municipal drains carrying sewage and sullage find their way into the river. Dacca Water Works at Chandnighat situated on the southern side of Dacca city draws 3.5 mgd raw water from the river Buriganga and supplies to a vast area of old part of the city after conventional treatment (coagulation sedimentation, filtration and chlorination).

One sampling point near the intake structure of Dacca Water Works was selected for the collection of raw water samples for routine laboratory analysis. Water samples from

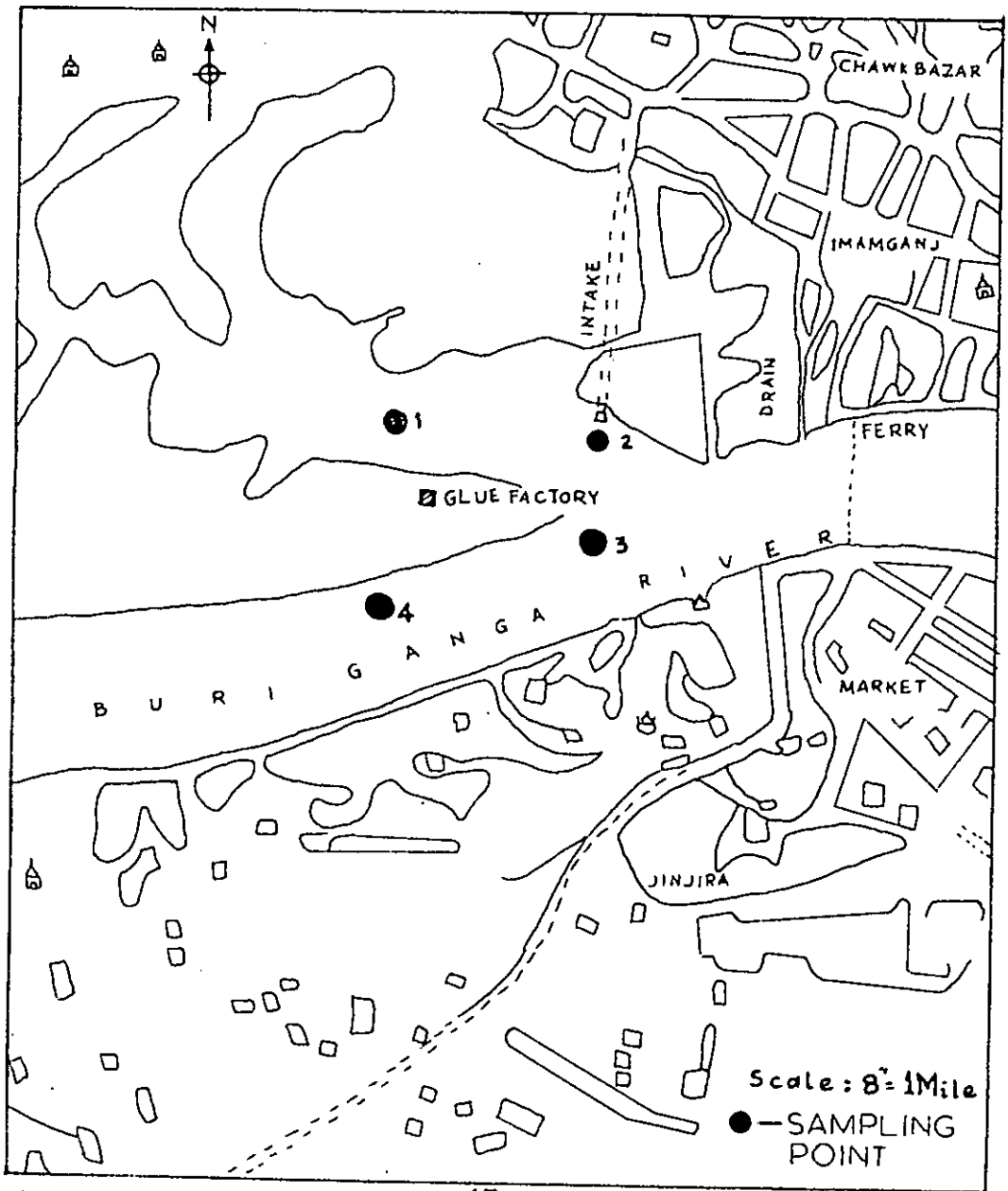


Fig. 3·1 The Buriganga[17]

this point fairly represent the water of the river Buriganga Moreover, laboratory analyses of the samples reveal the quality of raw water used by Dacca Water Works.

3.1.2 The River Sitalakhya

The river Sitalakhya was previously known to be an independent branch of the Brahmaputra. It is now nothing more than a mere continuation of the old Brahmaputra and Banar (Fig. 1.1). The upper reach of the river above Lakpur is called Banar River. It flows by the eastern side of Dacca district and falls into Dhalleswari at Madanganj near Narayanganj after traversing a length of 68 miles[18]. The river is navigable to country boats throughout the whole year and carries mostly silt free water in dry season. The river hardly spills over the banks and follow more or less a straight course. Tidal effect is observed as far as Lakpur in Winter and upto Demra during monsoon. The discharge of the river at Ghorasal varies from 2,200 cusecs to 65,300 cusecs as recorded by Bangladesh Water Development Board in 1962. At Demra, the maximum peak discharge was 65,000 cusec recorded in the year 1972 while the minimum discharge was 19,000 cusec observed in 1966.

The Industries though dispersed all along the lenoth of the river are more clustered around Demra at the down stream end of the river. The types of industries are mainly Jute and Textile. About 22 Jute mills and 11 Textile mills constitute the bulk of the industries. Another important industry situated

at the upstream side is the Ghorashal Fertilizer Factory. Some of the industries are quite big.

Most of the industries use ground water as source of their water supply. Few of them are found to use surface source with treatments as per their requirements. Large industries use as much as one lakh gallon per day of processed water and have residential facilities for its staff and worker producing appreciable amount of domestic waste[7]. Most important among the wastes discharged into the Sitalakhya is perhaps that from Ghorashal Fertilizer Factory, because of substantial amount of ammonia discharged along with the waste. Small scale industires do not, in most cases, discharge their waste in the river.

One sampling point near proposed Water Treatment Plant of Dacca WASA at Demra was selected for routine laboratory analysis of water samples. From the water supply point of view this location was considered most important for the sampling station in the whole length of the river.

3.1.3 The River Ballu

The Ballu river originates in the Balai beel in the district of Dacca and falls into the Lakhya river at Demra. It receives some of the drainage of the Bhowal forests through the chilai Khal above Pubail and spill during monsoon from Turag and Buriganga river[19]. The river is tidal during dry season throughout its whole length upto Belai beel. The length

of the river is about 27 miles. The course of the river is shown in Fig. 1.1. The maximum and minimum discharges of the river near Demra in the year 1972/73 were 10,500 cusec and 2500 cusec respectively. One water sampling point was selected near Demra Bazar for collecting water for routine laboratory analysis. This was considered to be the heavily polluted point of the river where investigations were made to know the characteristics of the water of the river.

3.1.4 Dhanmondi Lake

The location of Dhanmondi lake is shown in Fig. 3.2 . The lake water receives maximum quantity of organic pollution during the dry period. Most of the load of septic tank or even raw sewage indirectly find ways into the lake water. There are quite a good number of private houses in Dhanmondi Residential area which have practically no sewage disposal arrangement. Large volume of sewage from such buildings are discharged into underground soak pits whence sepitic effluents gravitate and pollute the lake water. There are innumberable other similar instances which are responsible for pollution of the lake water[7].

The sampling point as shown in Fig. 3.2 was selected for taking water sample for routine laboratory analysis. This sampling point approximately at the middle length of the lake was selected to know the average condition of the lake.

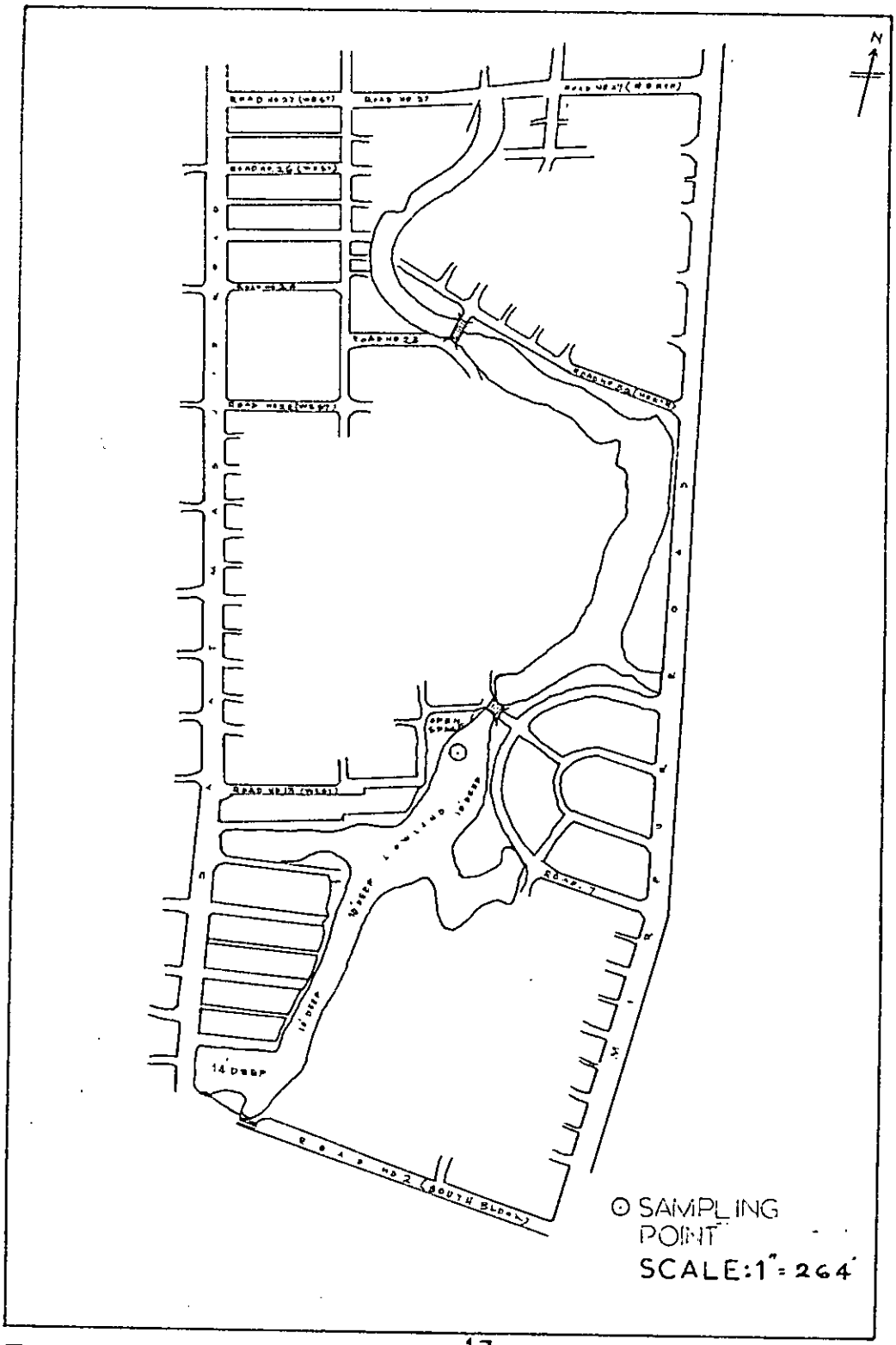


Fig. 3.2 Dhanmondi Lake[17]

3.1.5 Ramna Lake

The characteristics of the raw water of the lake was studied by selecting a sampling point at the middle length of lake.

3.1.6 Other Sources

The location of the other sampling point are as follows: (i) Pond water - one pond within Dacca University campus (ii) Deep tubewell water from the nearest tap of the deep tubewell within BUET campus (iii) Hand tubewell and open well water taken from Mugdapara area near Kamalapur Railway station.

Moreover water samples from different phases of Treatment were collected from Dacca Water Works and some random samples are also collected from different tubewell and taps within the Dacca city.

3.2 SAMPLING

Clean glass bottles having capacity of 500 cc were used for preserving the water sample for physical and chemical examinations. Separate samples were collected for bacteriological examinations in sterile bottles.

Utmost care was exercised to ensure that the analyses were representative of the actual composition of the water sample, Prior to filling, the sampling bottle was rinsed out two to three times with the water to be collected. The sampling

techniques as described in LABORATORY MANUAL AND STANDARD METHODS[5], were followed with little modifications depending on the local condition.

Samples from wells were collected only after the well has been pumped for a surficient time to ensure that the sample would represent the ground water which feeds the well.

When samples are collected from a river or stream, the analytical values may vary with depth, stream flows and distance from bank, and from one bank to the other. In order to avoid it, the best representative sampling points were determined by physical investigation. In most of the cases the best representative sample was collected from middle depth. Lakes and ponds are subject to considerable variations due to seasonal stratification, rainfall runoff and wind.

3.3 PARAMETERS CONSIDERED

In this investigation, water samples from rivers, ponds, lakes and underground sources were collected from various sources in and around Dacca for the following physical, chemical and bacteriological examinations to determine the water quality and the degree of pollution and the test results are critically discussed as to its potability in conformity with International Standards of Drinking Water Supplies. (table 1.3) and Bangladesh Standards for Water qualities (table 1.4).

A. Physical Examination:

1. Total solids (both dissolved and suspended)
2. Turbidity
3. Colour
4. Temperature
5. Taste and odour

B. Chemical Examination:

1. Alkalinity
2. Acidity
3. Carbon-dioxide (CO_2)
4. pH
5. Total Hardness
6. Iron and Manganese
7. Dissolved Oxygen (DO)
8. Chemical Oxygen Demand (COD)
9. Biochemical Oxygen Demand (BOD)
10. Chlorides
11. Sulphates
12. Nitrate
13. Phosphate
14. Ammonia
15. Electrical conductivity
16. Silica (SiO_2)
17. Fluoride

C. Bacteriological Examination

1. Coliform colonies per 100 ml in water sample
2. Total colonies at agar at 37°C per c.c.
3. Bact. Coli Faecal type per 100 c.c.

3.4 EXPERIMENTAL APPARATUS AND METHODOLOGY

Jackson Candle Turbidimeter, Chemical Balance, Nessler Tube, Thermometer, Conductivity Bridge, Titration Unit, Incubator etc. are the few instruments used in the analysis. Jackson Candle Turbidimeter is a standard instrument used for measuring turbidity. Conductivity Bridge consists of a wheatstone bridge and a telephone, instead of a galvanometer as null point indicator. Two specific conductance cell of the immersion type, having platinized platinum electrodes, were used with the bridge.

Water samples from various surface and ground water sources in and around Dacca described in Art. 3.1.1 to Art. 3.1.6 were collected and routine laboratory analyses were made for physical, chemical and Bacteriological qualities according to the Standard Methods[5,20]. Physical, chemical and Bacteriological qualities of the water at different phases of treatment at Dacca water works were also determined. The analysis were made for the water quality parameters mentioned in Art. 3.3.

CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSION

4.1 INTRODUCTION

Study of the potability of water from different sources in and around Dacca city area was conducted for the period from May 1973 to April 1974. Laboratory tests were performed at regular intervals for physical qualities, chemical contents and bacteriological counts of the waters. The test results are presented in Table A.1 to A.24 in Appendix-A. The important water quality parameter, showing the seasonal fluctuations are also presented graphically in Figs. 4.1 to 4.17.

4.2 SOLID CONTENT

Total solids, dissolved solids and suspended solids are shown in Figs. 4.1, 4.2, and 4.3 respectively. It is observed that the minimum solid contents occurs in the month of September and maximum solid content occurs in the months of April-May. In the month of September the river water is less turbulent and has the minimum capability of holding the solid substances in suspension. At this period the solid contents of the water was found to be minimum due to the sedimentation of settleable solids in relatively calm water. In the month of April-May, the flood water carries more substances in dissolved and suspended state from the sorrounding flood plains. Among all the three major rivers around the city of Dacca, the river

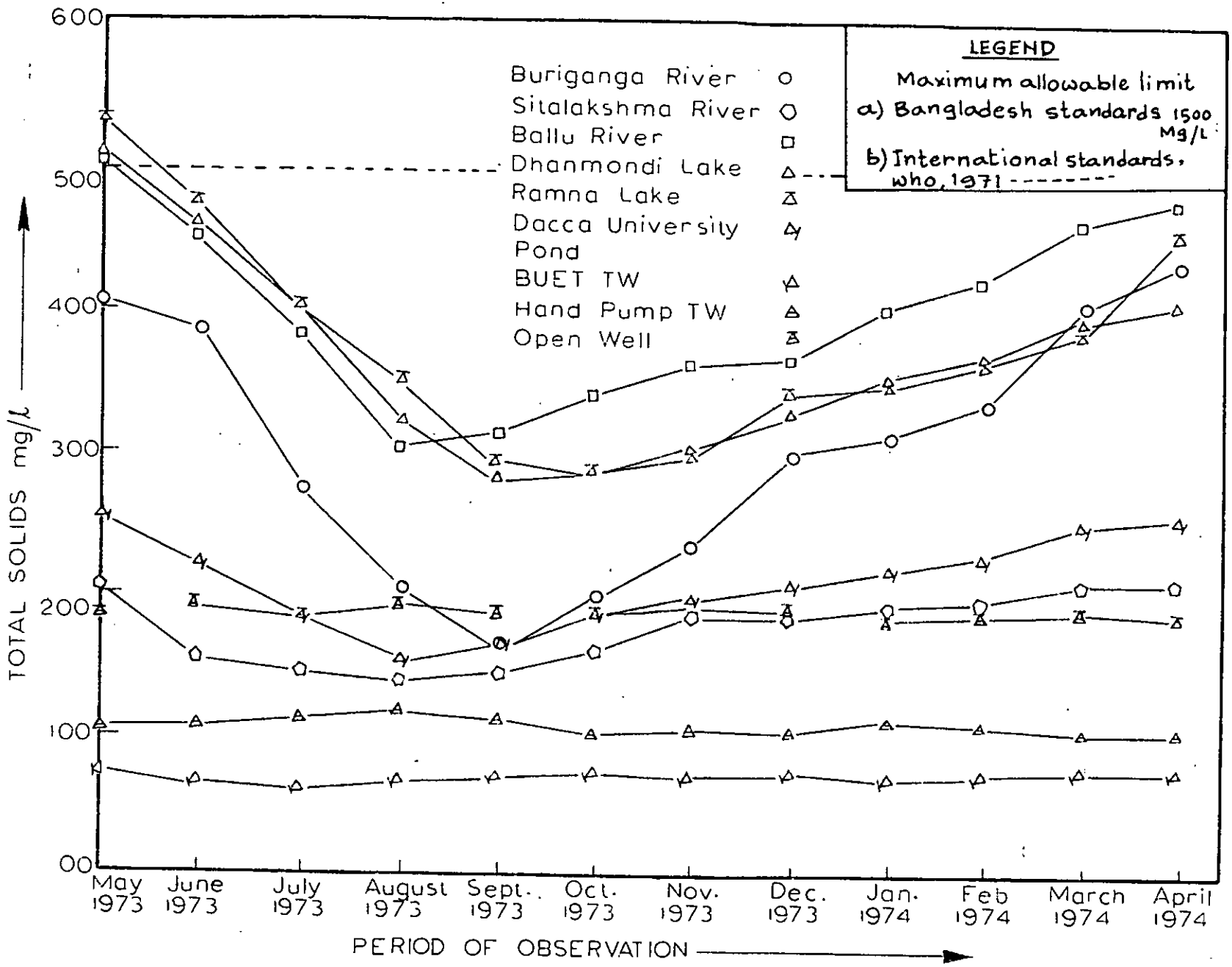


Fig.41 Total Solid Contents of Various Water Samples.

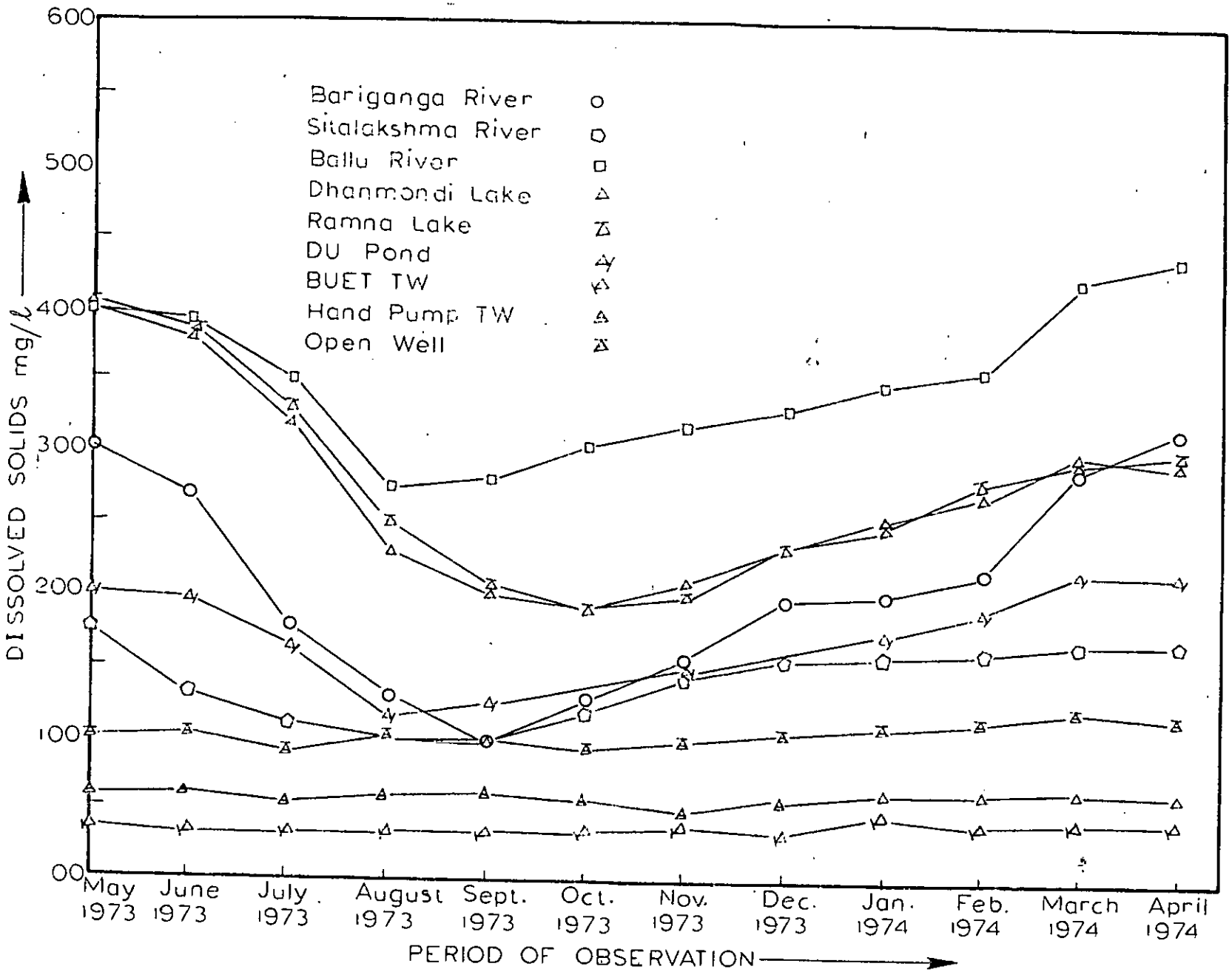


Fig. 42 Dissolve Solid Contents of Various Water Samples.

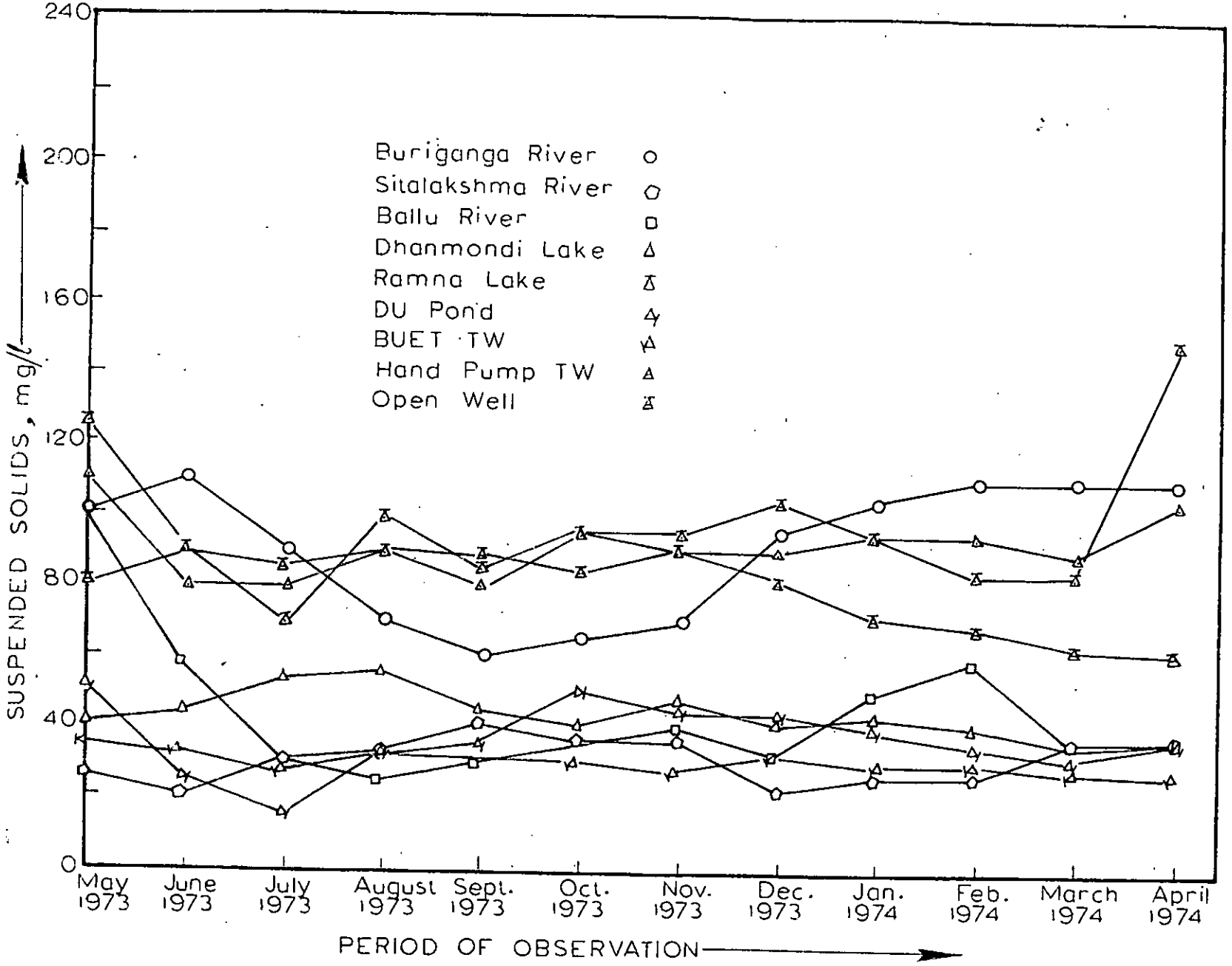


Fig.43 Suspended Solid Contents of Various Water Samples.

Sitalakhya water contained less total and dissolved solids. In no time of the year it was found more than 206 ppm. Among the three major rivers, the water of the river Ballu contained maximum total solids. Dhanmondi and Ramna lake water contained total solids more than 500 ppm in the month of May. But during the remaining months it was less than 500 ppm. Pond water under investigation contained comparatively less total solids. The total solid content in all ground water collected from deep tubewell, hand tubewell and open kucha well were found to be minimum. Of course the water of open kucha well and Hand tubewell contained more total solids than the water of the deep tubewell.

4.3 TURBIDITY AND COLOUR

Figs. 4.4 and 4.5 are the presentation of test result for turbidity and colour units in water samples. Buriganga water was found to be very turbid in the months of May, June and July. During the period, the maximum turbidity units obtained was 80. The Sitalakhya river water was a little bit less turbid than the Buriganga water. The river Ballu was turbid almost all through the year. In the months of April to July, the turbidity units were more than the remaining months. Lake water were found turbid in between 85 to 32 units. Tubewell waters are very clear and have turbidity less than 25 units in all cases. Fig. 4.5 shows that there are three

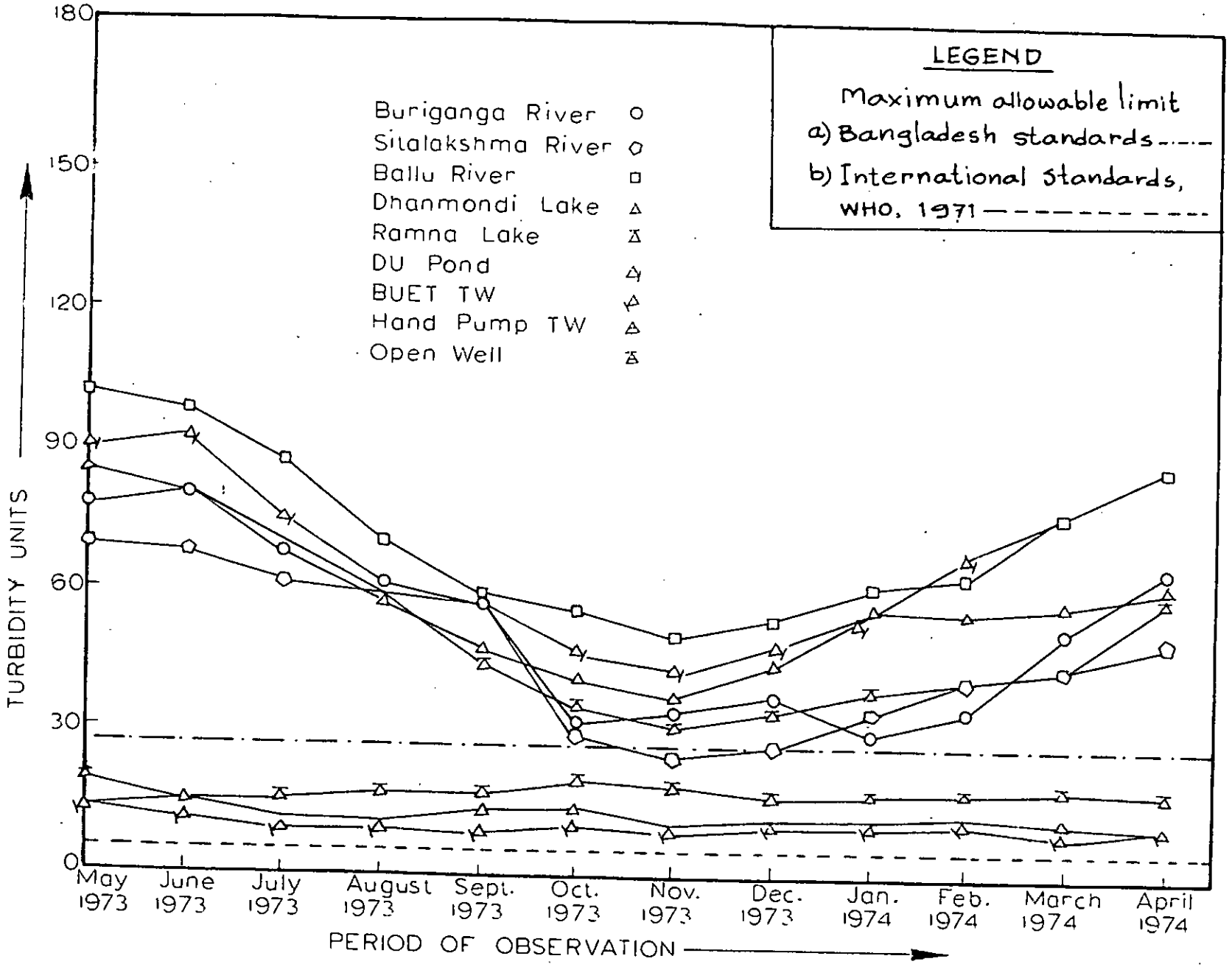


Fig. 44 Turbidity Units Contents of Various Water Samples.

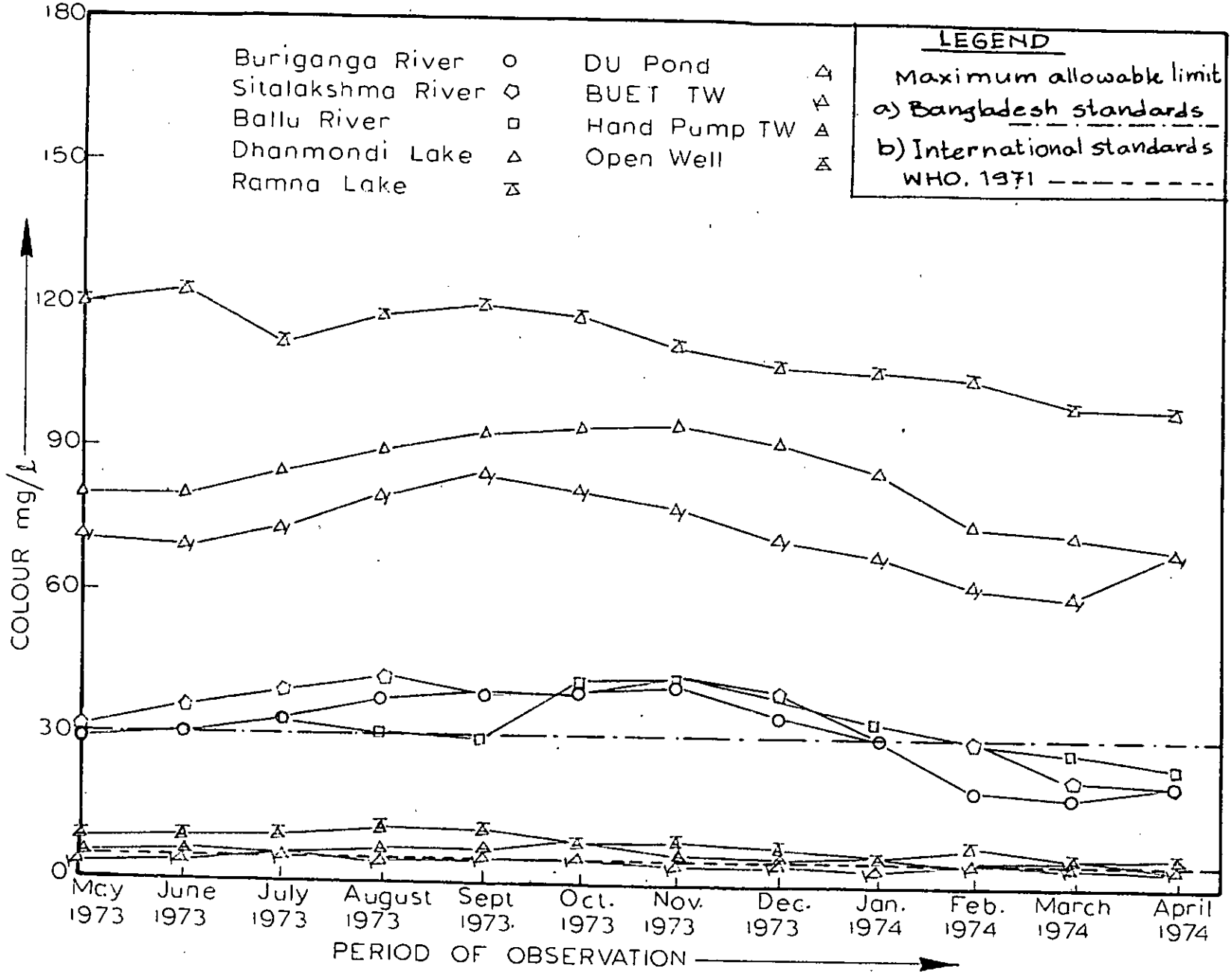


Fig. 45 Colour Contents of Various Water Samples.

distinct zones, 0 to 10,25 to 35 and 65 to 120 to represents colour of ground, river and lake waters. It clearly indicate that stagnant waters in pond and lake contain more decomposable organic matter to produce colour whereas in ground water in the absence of organic waste the colour is mostly due to the small concentration of oxides of iron and manganese.

4.4 TASTE AND ODOUR

Table A-6.1 to A-6.4 are the presentation of the taste and odour in water sample. The river water Buriganga, Sitalakhya and Ballu have less or no taste and odour. Lake and pond water also do not contain any objectionable taste and odour. Ground water under investigation also do not have any taste and odour.

4.5 ALKALINITY AND ACIDITY

Fig. 4.7 and Fig. 4.8 are the presentation of total alkalinity and acidity in ppm as $CaCO_3$ in water samples. The total alkalinity of the Buriganga water in the months of October and November were 13 and 12 ppm only whereas 175 and 210 ppm of total alkalinity was found in the months of March and April respectively. Alkalinity of all the samples maintain a sag curve between maximum and minimum and has not exceeded the permissible limit of 400 mg/l for water source in any case. In no water whether surface or ground, acidity was more than 52 ppm. In the river Buriganga it was found to vary from 8 to 15 ppm.

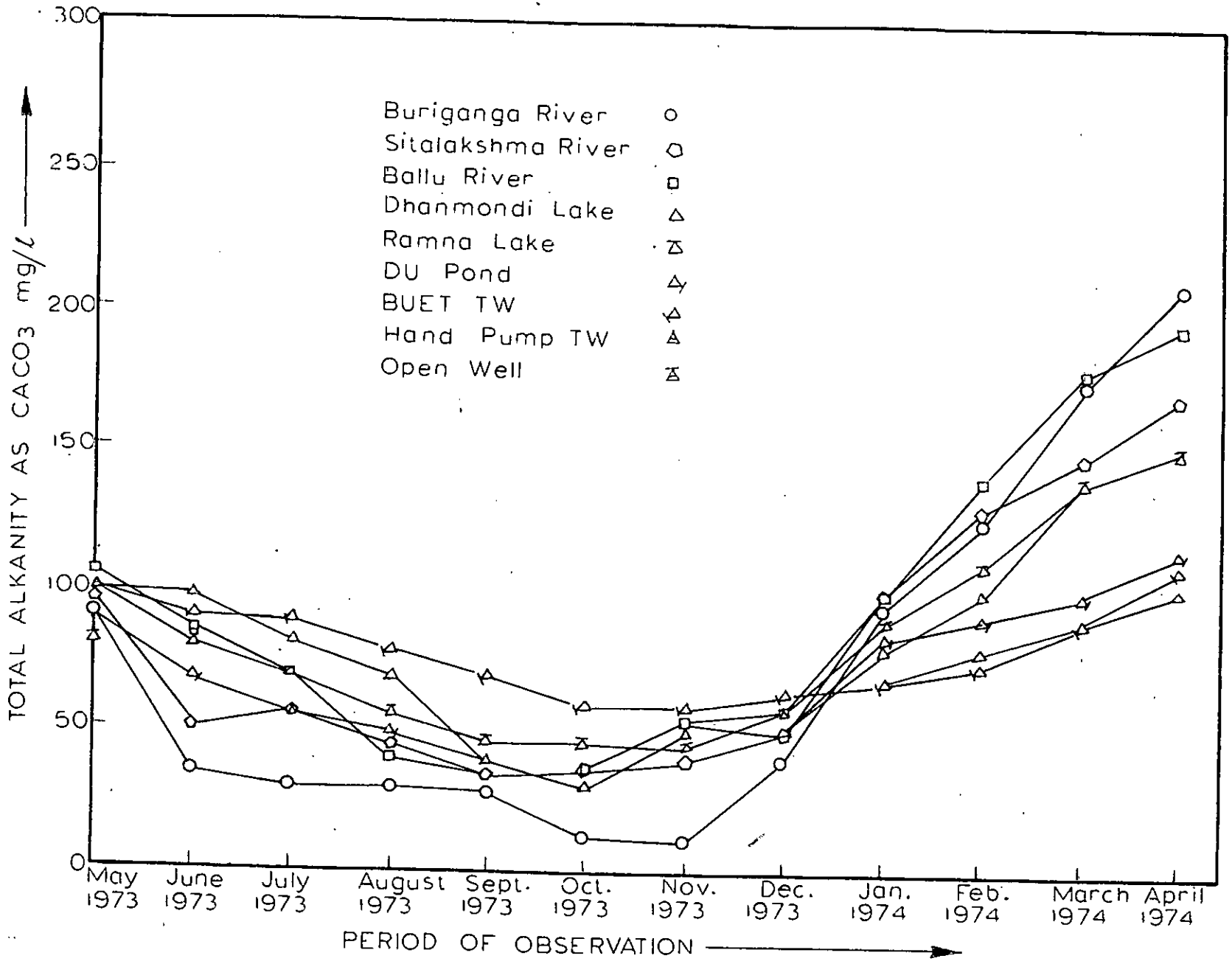


Fig. 47 Total Alkalinity as $CaCO_3$ Contents of Various Water Samples

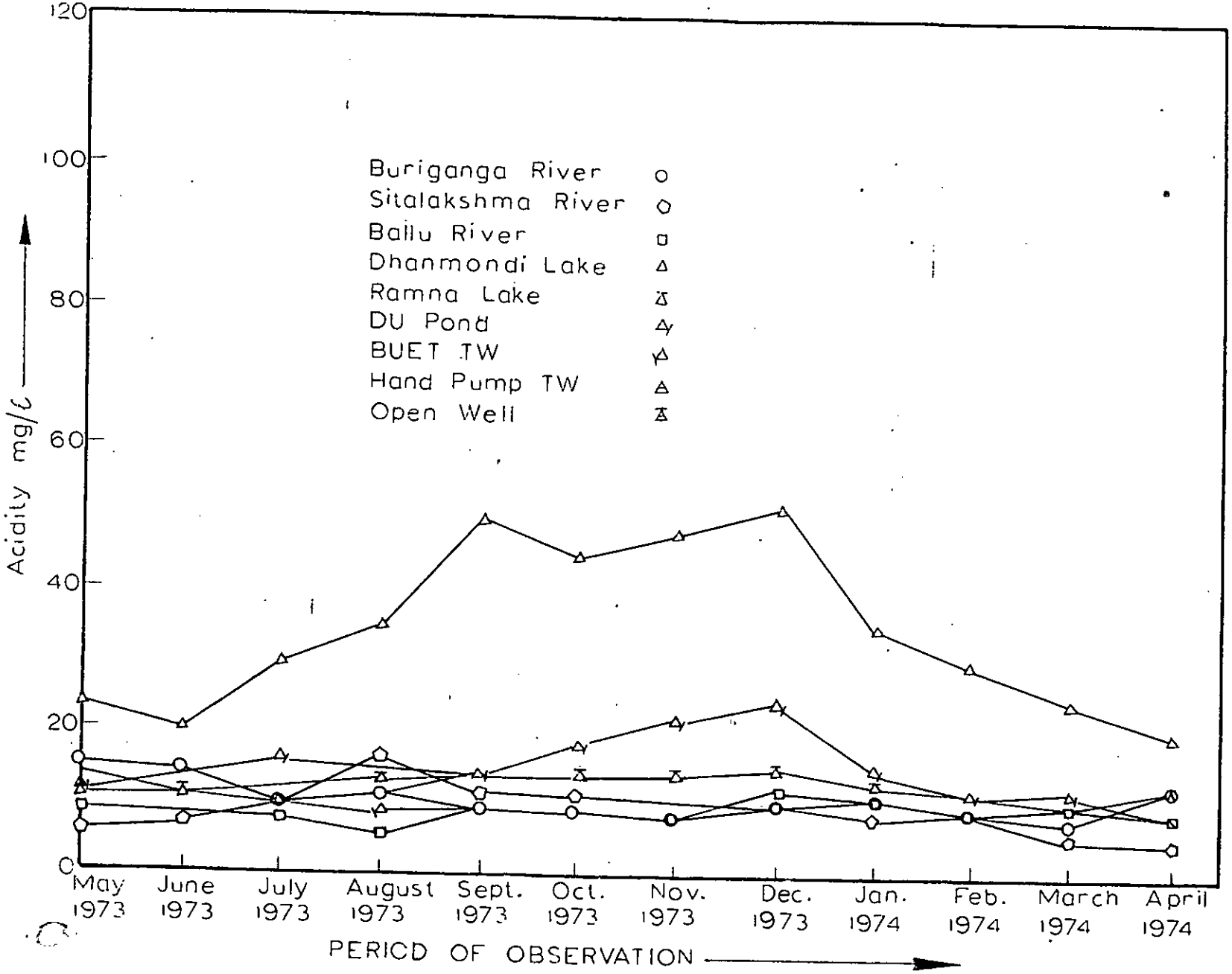


Fig.48 Acidity Contents of Various Samples.

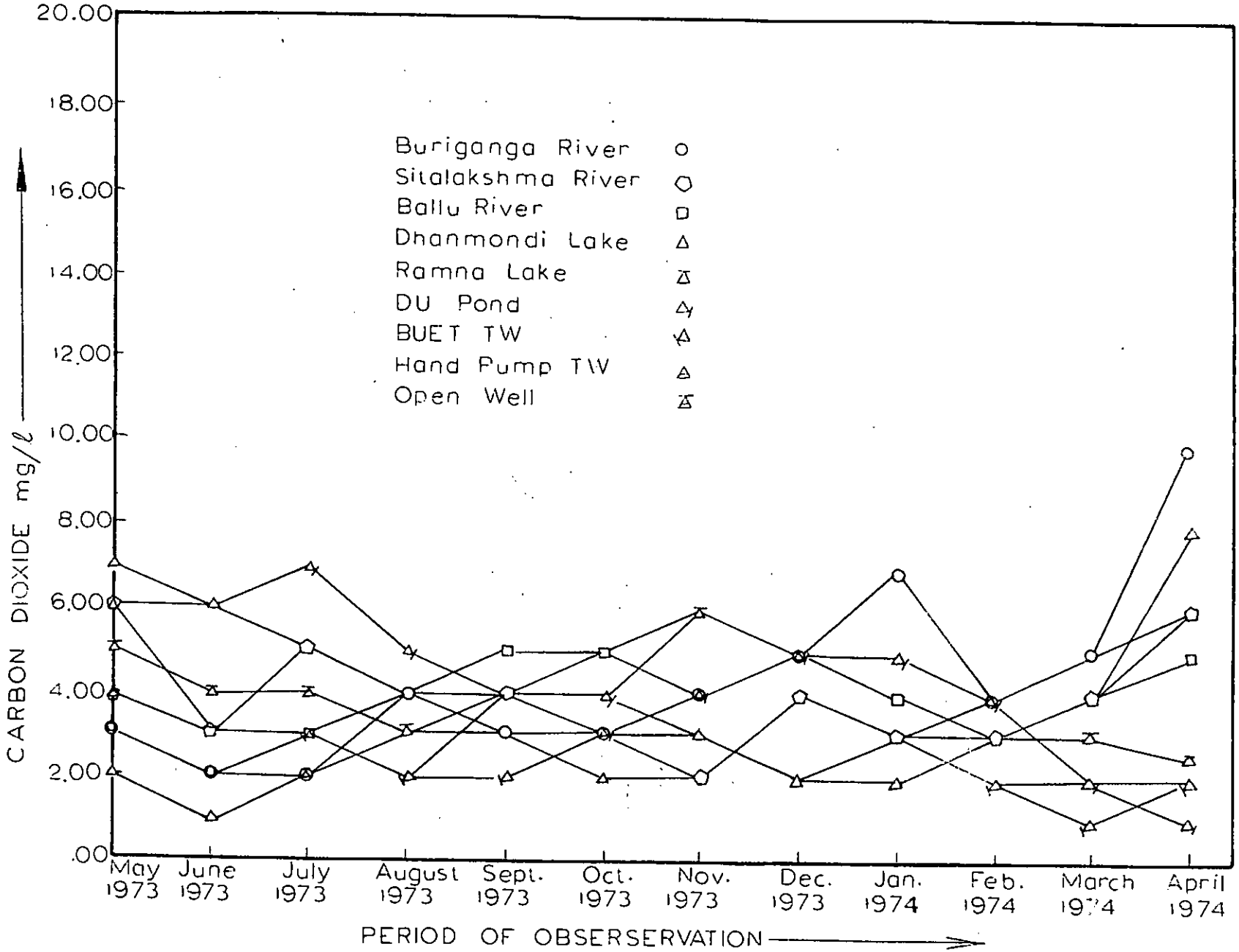


Fig. 4.9 Carbondioxide Contents of Various Water Samples.

4.6 CARBON DIOXIDE

Figure 4.9 is the presentation of the carbon dioxide in water sample. The Buriganga water contained 7 and 10 ppm carbon dioxide in the months of January and April respectively. In the other months of the year it was 2 to 5 ppm. The concentration of carbon dioxide in all other samples lies between 2 and 8 ppm.

4.7 pH

Figure 4.10 is the presentation of pH in water samples. The variations of pH in different seasons were very small. For example, in the Buriganga river water, it was only between 7.10 to 7.55. In the water collected by Dacca water works for treatment, the minimum pH value was only 6.80 in the months of October and November. During the other months of the year it was found to vary from 7.10 to 7.60. In the Sitalakhya river water, it was found also to vary from 7.20 to 7.60.

All other surface water was found to have similar pH value. Only exception was found in the Ramna lake water wherein the pH was found to be 8.10 in the month of April. In the months of August and December, the hand tubewell water was found to have the pH value of 6.80 only. Whereas in other months of the year, all ground waters in hand tubewell and open kucha well were found to have pH within 7.10 to 7.55.

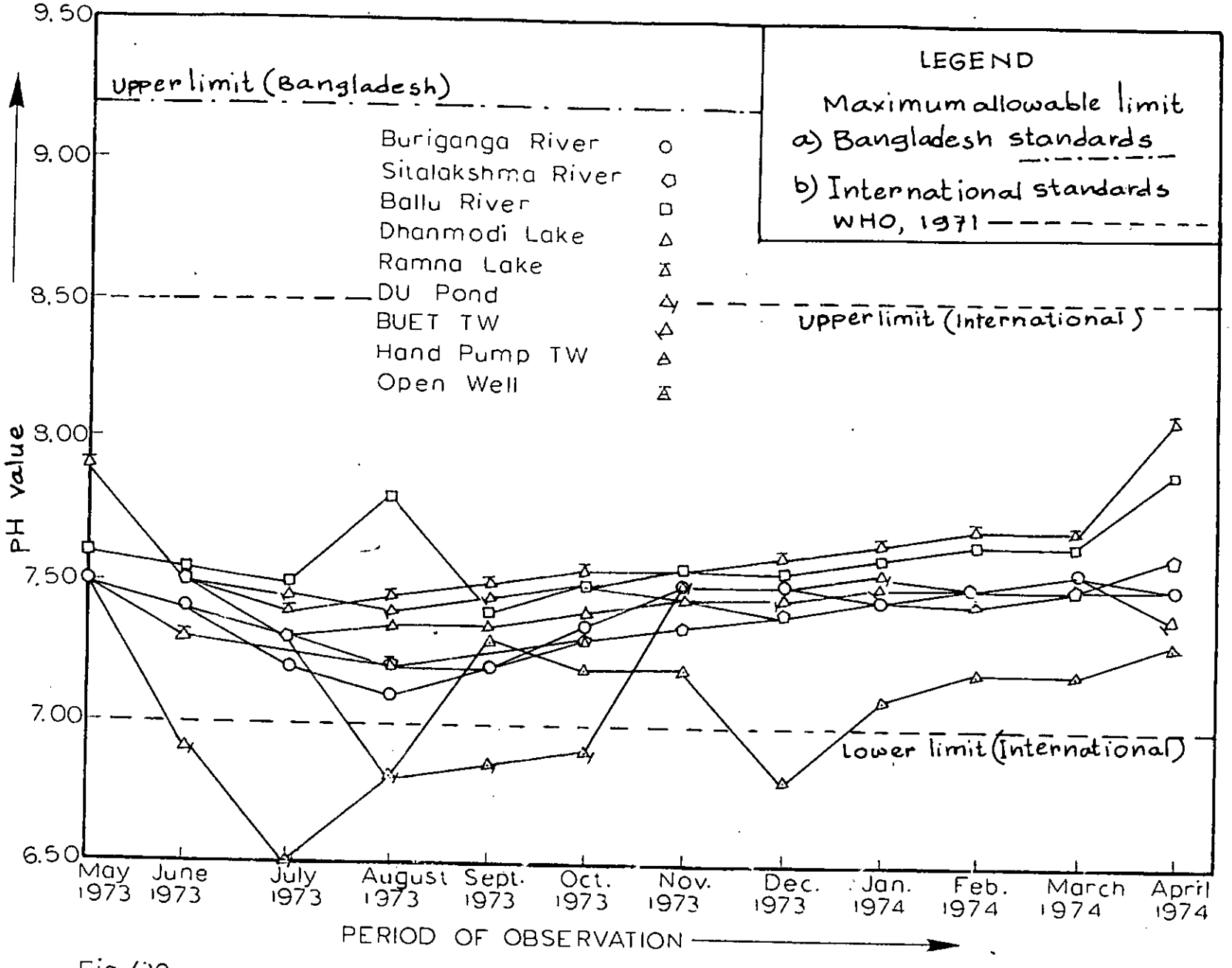


Fig.410 PH value of Various Water Samples.

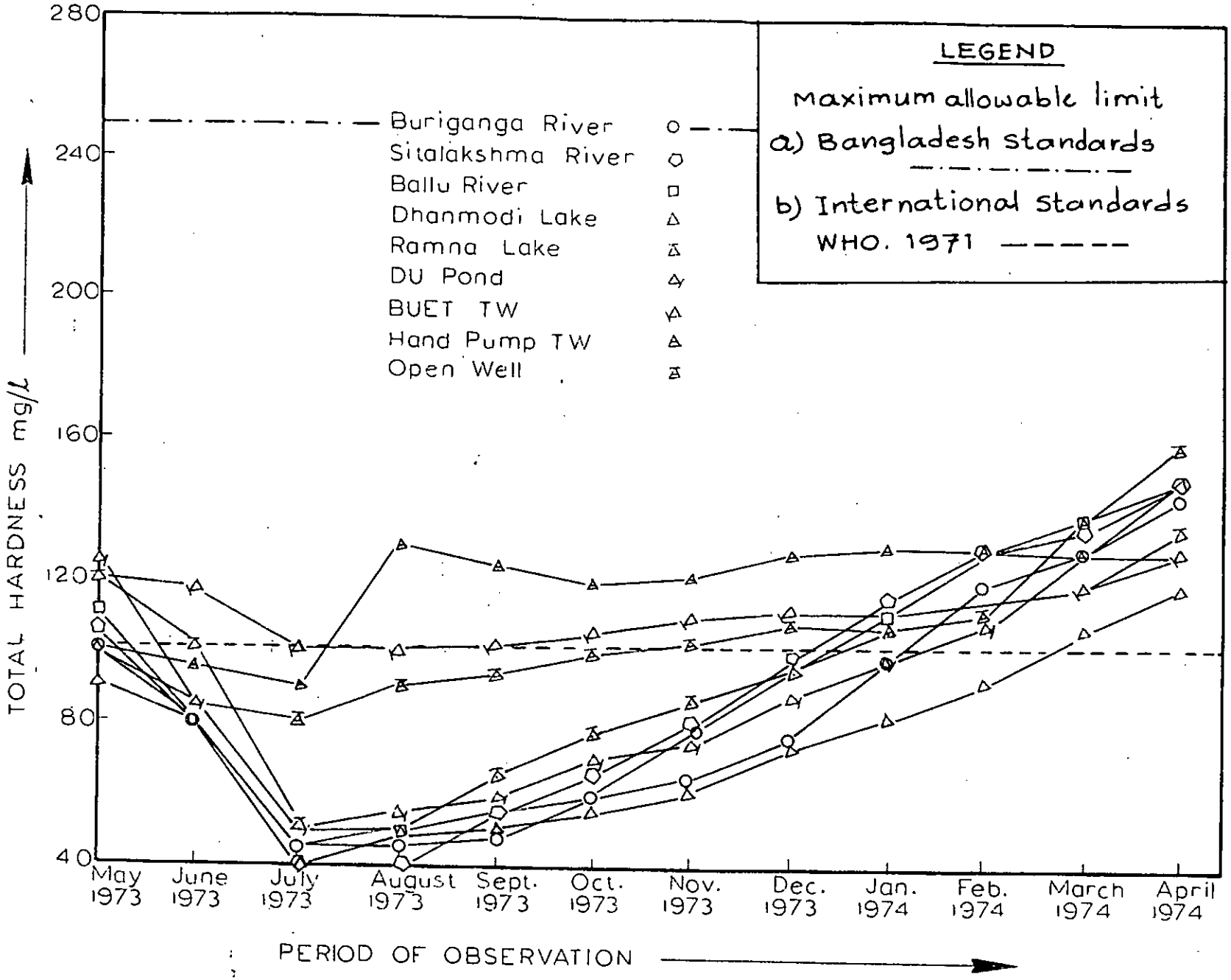


Fig.4|| Total Hardness Contents of Various Water Samples.

4.8 TOTAL HARDNESS

Figure 4.11 is the presentation of total hardness in water samples. In general, all ground waters were found to be more hard than the surface waters. Test results also indicate that the water were more hard in the dry seasons than the rainy season. This may be due to the fact that during the rainy season water is dilute, with less concentration of salts causing hardness. In dry season, Buriganga water was as hard as 145 ppm whereas in rainy season the it was only 45 ppm. Similar results were also obtained for water from Sitalakhya and Ballu. The hardness in tube well waters is relatively constants as there is little scope in the change of salt concentrations in ground water with the change of season.

4.9 IRON AND MANGANESE

Figure 4.12 is the presentation of soluable iron as Fe^{+++} in water sample. In general, the soluable iron content of ground water was more than that found in surface waters in the rivers, lake and pond. In the river Buriganga maximum iron content of 0.60 ppm was found in the month of October. In the month of July, August and March it was found to be zero. Comparatively less iron content was found in the water collected from the rivers Sitalakhya and Ballu. Lake and pond water contained very little or no iron. In deep tubewell water maximum iron content was found to be 0.80 ppm in month of May.

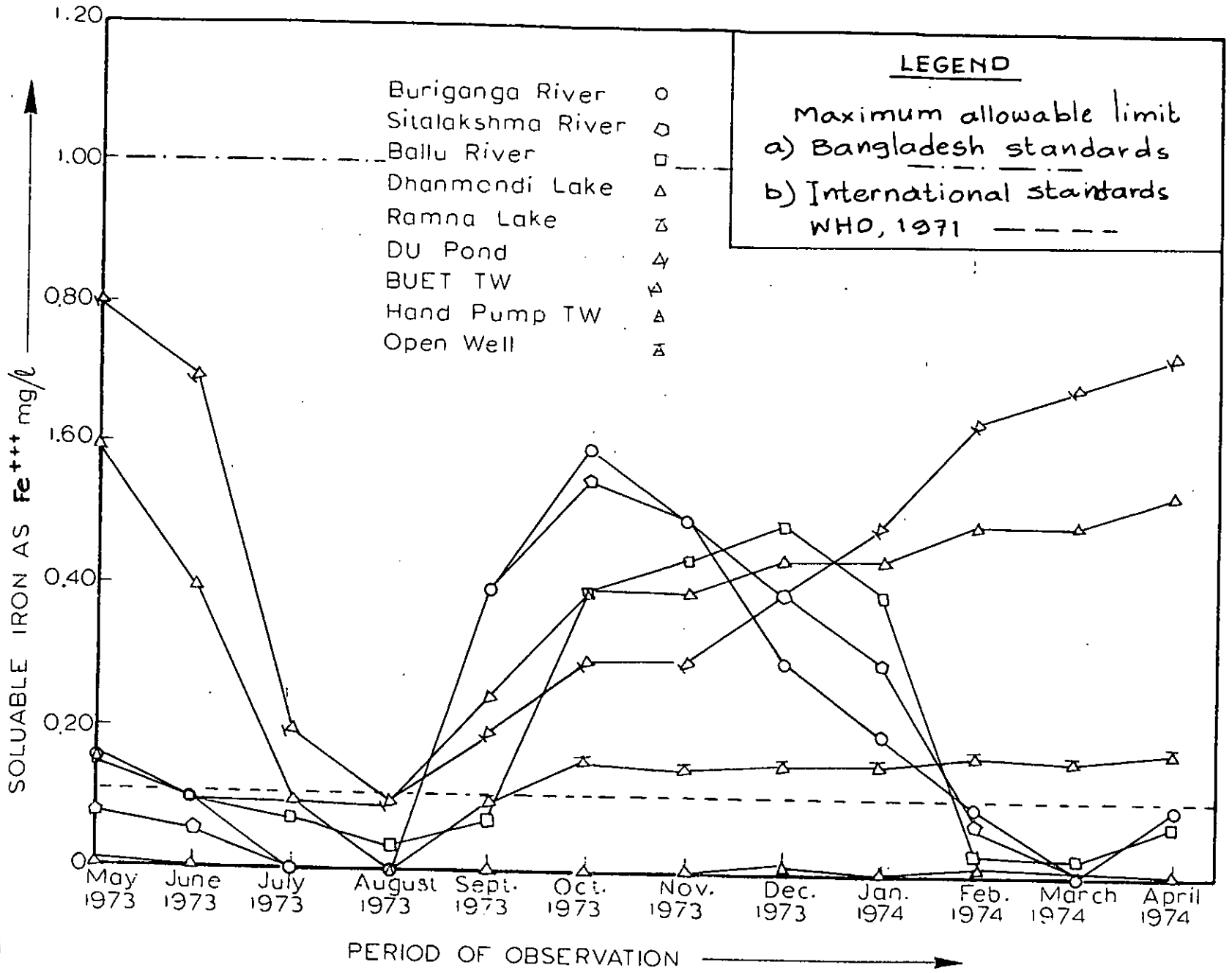


Fig.4.12 Soluable Iron Contents of Various Water Samples

In no time of the year it was less than 0.1 ppm. In hand tubewell water it varied from 0.1 to 0.60 ppm. The iron content of open kucha well water was not more than 0.18 ppm in any time of the year. The iron contents of Nowabganj and Lalbagh tubewell water were recorded to be 1.00 and 0.8 ppm respectively (Table A-19, Appendix-A).

Table A-13 is the presentation of test result for manganese content in water sample. Almost all surface and ground water sources, show a trace amount or nil manganese content. But in Nowabganj and Lalbagh Tubewell waters the concentration was found to be 0.25 and 0.2 ppm in the months of October and November respectively (Table A-19, Appendix-A).

4.10 DO, COD and BOD

The test results of DO, COD and BOD are presented in Figs. 4.13 to 4.15. The average dissolved oxygen content in all surface water was about 6.5 ppm. The DO Content of the ground waters was found to be less than that of surface waters. In average about 4 ppm dissolved oxygen content was found in the ground water. Chemical oxygen demand in the Buriganga river water was zero in the month of July and August and it was maximum (1.20 ppm) in the month of April. Almost similar results were found for the river Sitalakhya and Ballu. Pond water has a chemical oxygen demand as high as 2 ppm during the dry water season. Ground waters in deep tubewell, hand tubewell and open kucha well showed a very small amount of chemical oxygen demand.

Biochemical oxygen demand of the most of the samples are very low. Only pond waters show a BOD of around 4.0 ppm in all the months. Deep and hand tubewell waters were found to be have biochemical oxygen demand in the range of 0.80 to 1.40 ppm. Open kucha well water however showed a comparatively higher biochemical oxygen demand than all other ground waters under investigation. This may be due to contamination of these waters from some unknown sources.

4.11 CHLORIDES AND SULPHATES

Figures 4.16 and 4.17 are the presentation of the test result for chloride and sulphate in water samples. In the river water chloride concentration was as small as 1 ppm in rainy season and as high as 10 ppm during the dry season. In lake and pond water, it was however found to very from 4 to 50 ppm. Ground waters in deep tubewell, hand tubewell and open kucha well were found to have chlorides content in the range of 5 to 20 ppm.

The concentration of sulphates in the Buriganga water was only 6 ppm in the months of August and September whereas 15 and 16 ppm in the months of May and April respectively. Almost similar variation was found in other river waters. In lake water the variation of sulphate cocentration was 6.5 to 15 ppm and that in the pond water was 4 to 11 ppm. Sulphates content in ground waters was found more than that in the

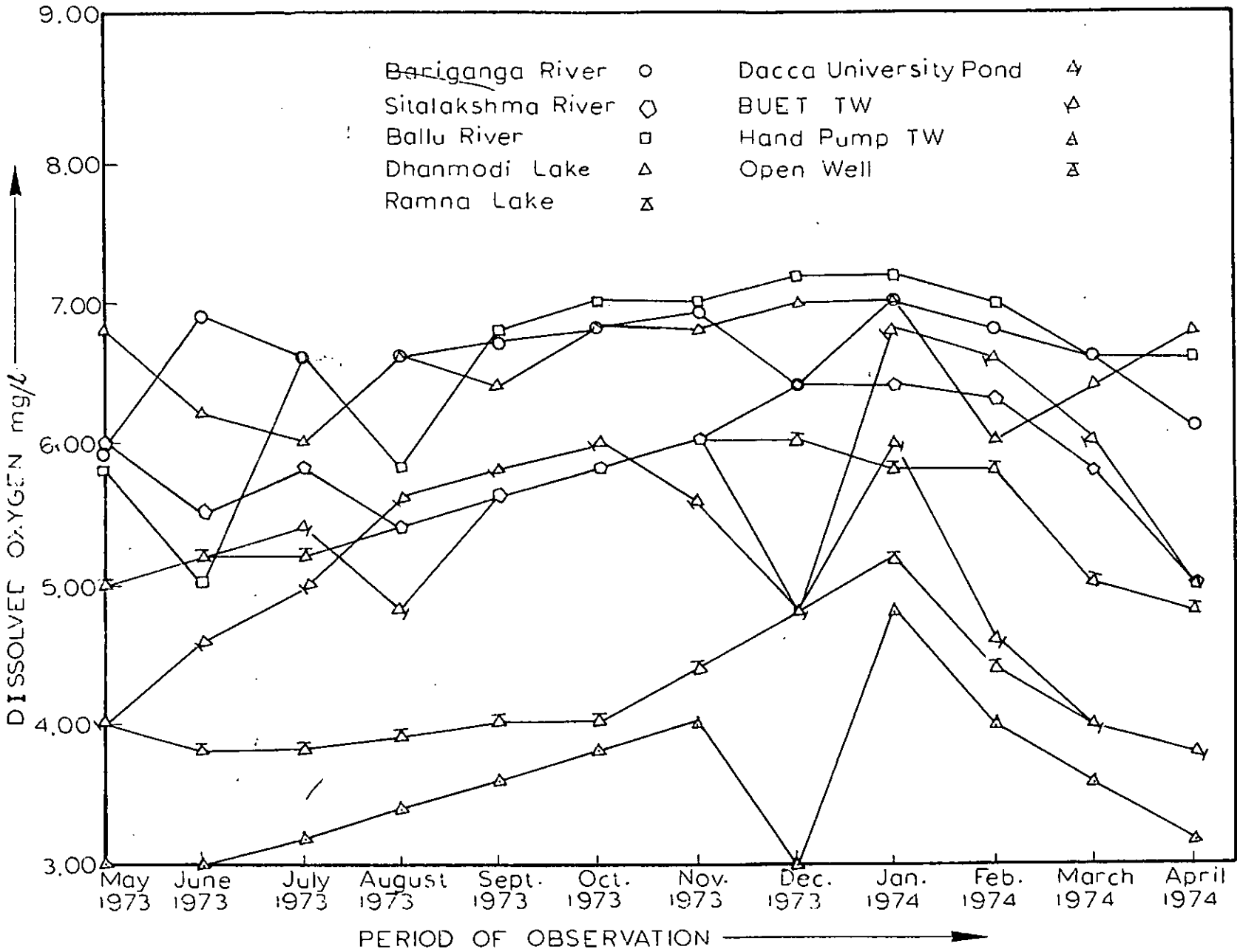


Fig. 4.13 Dissolved Oxygen Contents of Various Water Samples.

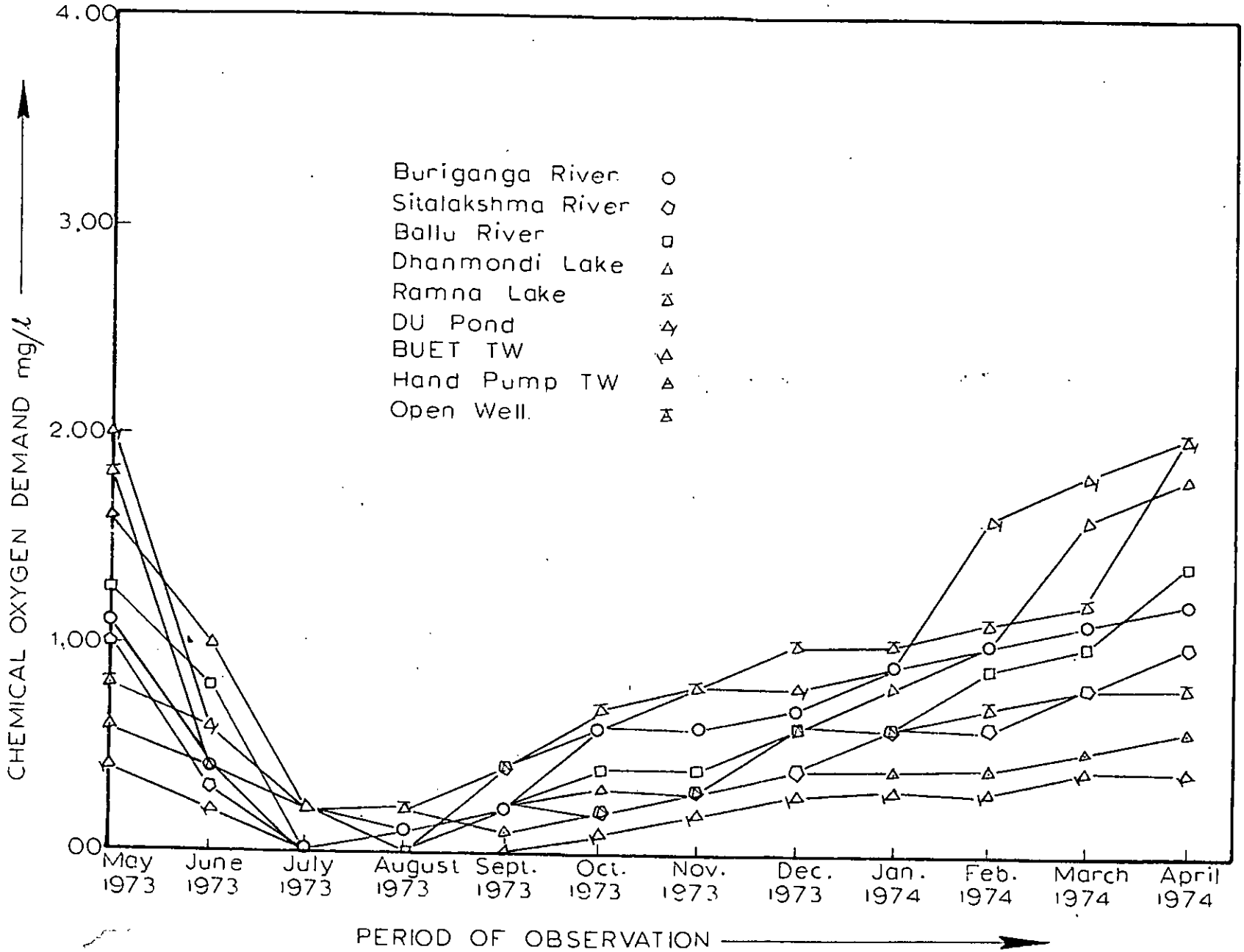


Fig.4|4 Chemical Oxygen Demand of Various Water Samples.

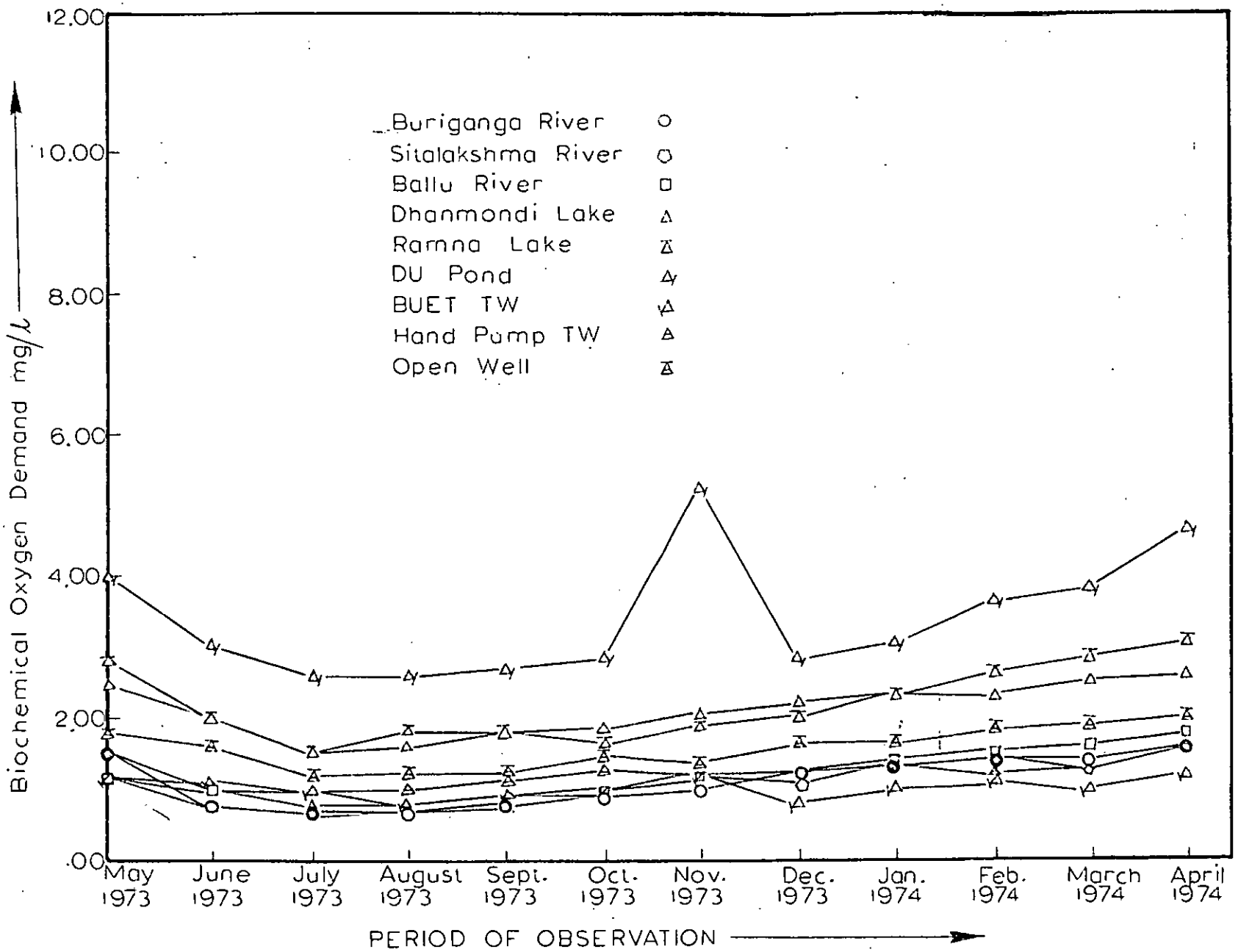


Fig.4.15 Biochemical Oxygen Demand of Various Water Samples.

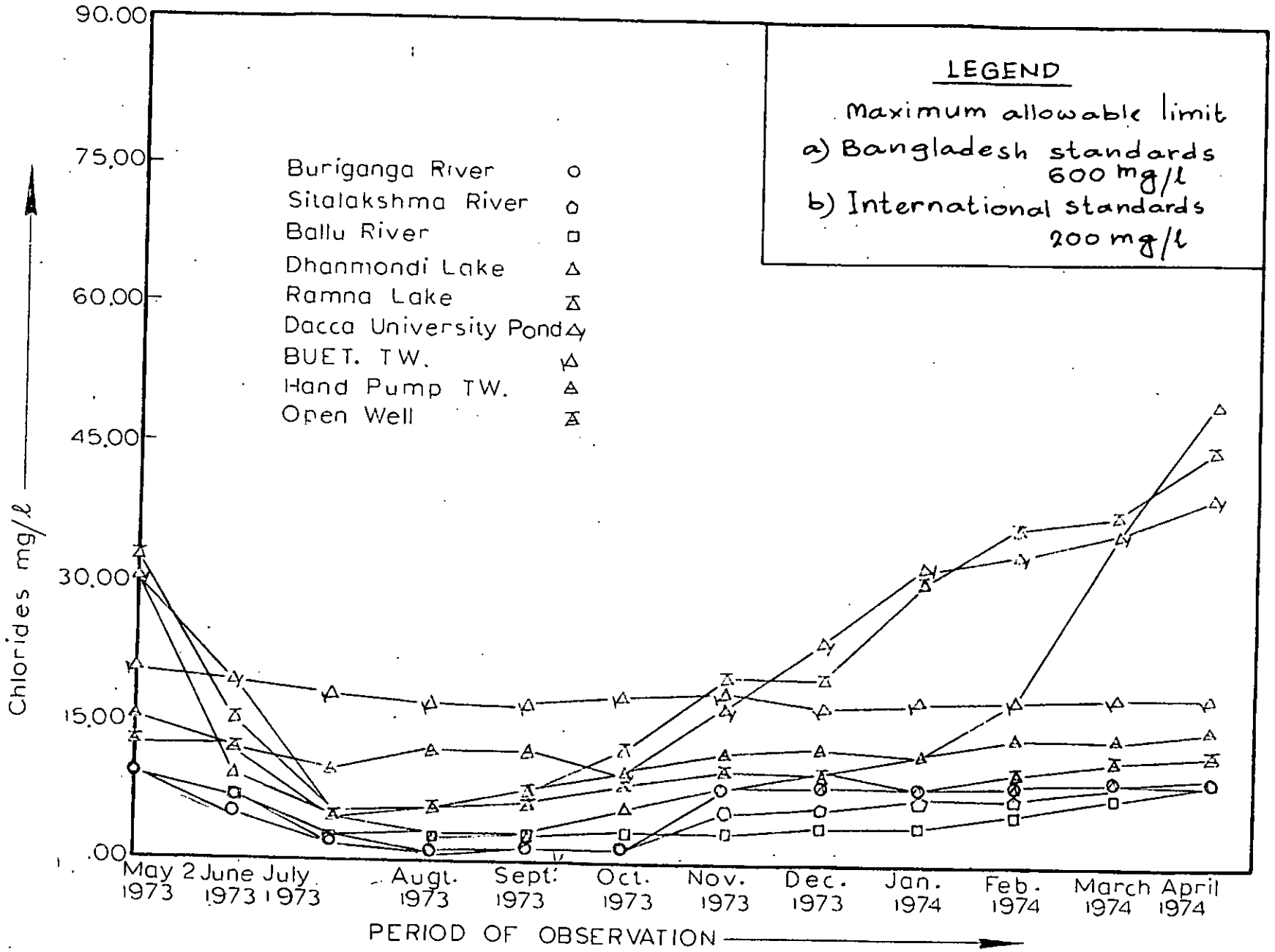


Fig. 4.16 Chlorides Contents of Various Water Samples.

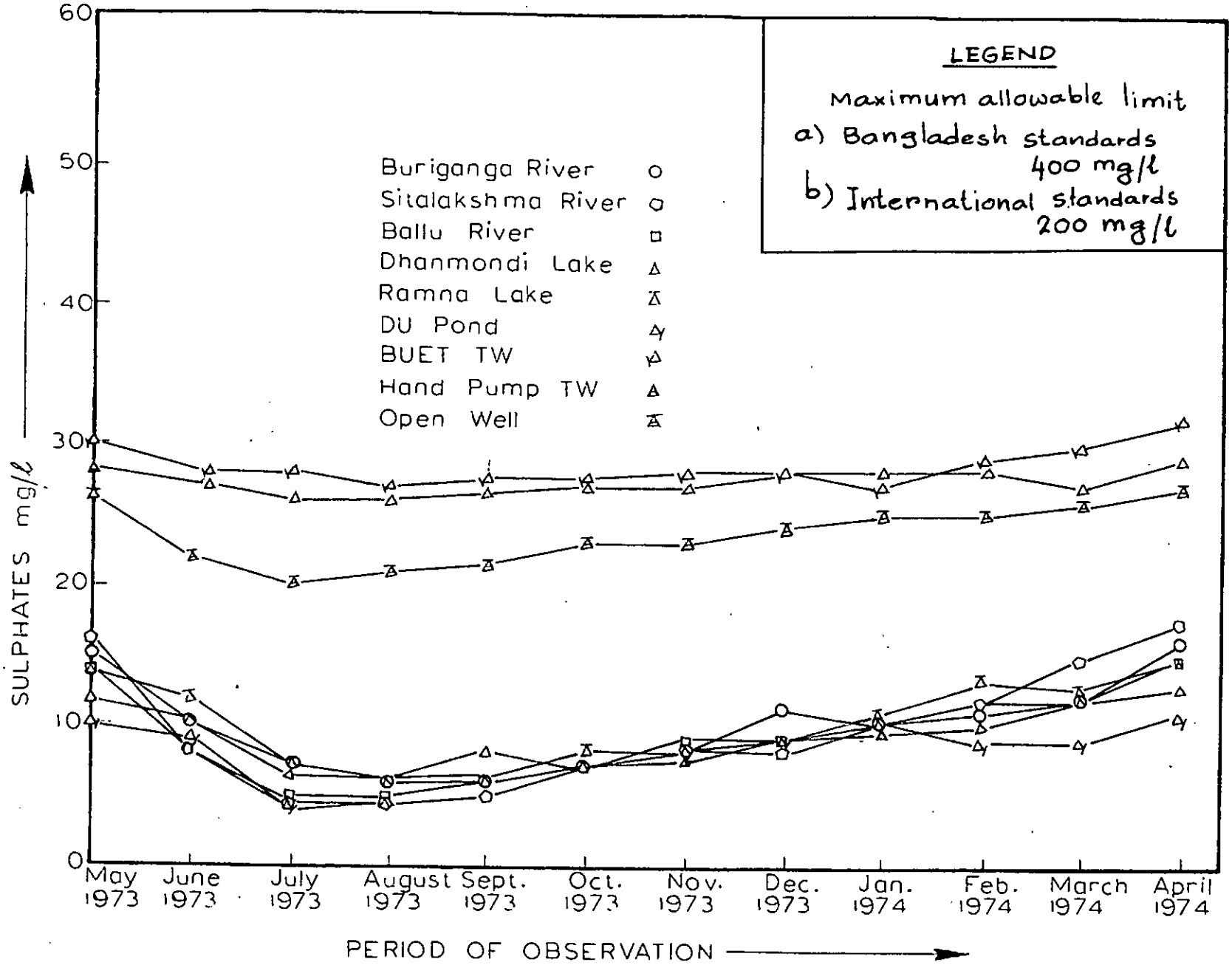


Fig.4.17 Sulphates Contents of Various Water Samples

surface waters. In deep tubewell, hand tubewell and open kucha wells, the range of variations were 27 to 32 ppm, 26 to 29 ppm and 21 to 27 ppm respectively.

4.12 ELECTRIC CONDUCTIVITY, SILICA, MANGANESE, FLUORIDE

Table A-19 (in Appendix-A) is the presentation of test result for Electric conductivity, silica as SiO_2 and Fluoride in water samples. In the month of December, Banani Tubewell water gave electric conductivity of 120 μ mohs/cm only whereas in the month of February, Dhakeswari Tubewell water gave it as high as 560 μ mohs/cm. Most of the other tubewell water showed electric conductivity within the range of 200 to 500 μ mohs/cm. Maximum silica (SiO_2) content was found as 86 and 84 ppm in the Mitford and Nawabganj Tubewell waters in the month of October. In other water under investigation, it was found to vary from 23 to 74 ppm. Fluoride content was found within the range of 0.18 to 0.42 ppm.

4.13 COLIFORM COLONIES

Table A-22 is the presentation of test result for coliform colonies per 100 ml. in water sample in Dacca water works and ground waters in different tubewell. In most of the months of the year, numerous coliform colonies were found in the water samples of the river Buriganga. During the dry season specially in the months from December to April, the coliform

count was found within the range of 200 to 1700. Coagulation and settling do not show any significant effect upon it. Filtration however, has shown some effects upon the number of coliform colonies. After chlorination, practically nil or very small number of coliform colonies were found in the water sample. Ground water samples from different tubewells show no or very small number of coliform colonies.

4.14 TOTAL COLONIES

Table A-23 is the presentation of test result for total colonies in agar at $37^{o}C$ per cc in the water samples at differnt phases of treatment at Dacca Water Works and for ground waters of various tubewells. In Buriganga river water the colonies were found as more as 10^{8}x4.6 in the month of October, whereas in the month of March, it was found as small as 10^{2}x1.20. Significant reduction of colonies was observed when water is allowed to pass through sedimentation and filtration. After chlorination, the total colonies were reduced to nil or very negligible.

4.15 BACT. COLI FAECAL TYPE

Table A-24 is the presentation of test result for Bact. coli faecal type per 100 cc. In the month of April, it was found to be 1800 in the Buriganga water whereas in other months of the year it was only 6 to 8 only. Settling and filtration

have some adverse affect upon it but after chlorination no trace of it was found in the water. Ground water under investigation contained no Bact. coli faecal type.

4.16 DISCUSSION

Water, both surface and ground, are available in and around Dacca. But all such water cannot be directly used for domestic consumption unless at least a slight physical/chemical treatment is done to the water to make it absolutely suitable for the purpose.

Test results (Table A-2, A-7, A-11, A-12, A-19, A-20 in Appendix-A) indicate that all ground water collected by Deep Tubewells satisfy most of the characteristics of potable water. In some of the Deep tubewells the total hardness and concentration of iron exceeds the permissible limits for international drinking water standards. Hardness in the tubewell waters collected from Mitford, Hazaribagh, Dhakeswari, Lalbagh, Medical college, Fulbaria, BDR HQ found to be 239, 169, 202, 152, 155, 152 and 200 ppm respectively which is not within the Drinking Water Standard (Table 1.3). In Nawabganj tubewell, maximum iron content obtained is 1 ppm whereas the permissible maximum limit is 0.1 ppm, pH value of some of the tube well waters is found to be less than 7 which indicate an acidic water. Water with such qualities are not physiologically unsafe for drinking purpose. The important observation made is

that the bacteriological examination of deep tubewell water at source did not show any bacterials growth but the presence of coliform colonies were found in tap water. It indicates that water might have been contaminated in the distribution system. To prevent such contamination, at least chlorination is essential to make the water absolutely safe.

A comparative study (Appendix-D) show that ground water is about 6% cheaper than surface water for water supply in Dacca when the river Sitalakhya is used as surface water source. From the past record of deep tubewells in the Dacca City[15], it has been observed that the life of the wells does not exceed on an average 10 to 12 years due to the poorly designed and inferrior quality of tubewell materials. However, the life time may be increased if superior quality strainers like stainless steel strainers are used. To meet the water requirements of the growing population more number of new tube wells are to be commissioned. Installation of new tube-well in the city is very difficult job because of scarce availability of land. Moreover no additional benefit can be obtained by sinking tubewells within the zone of interference. Attempts were however, been made to examine the interference of the tubewells but it could not be possible for want of similar tubewells in a particular locality. Considering the future increase in water demand and the unavoidable difficulties in the tubewell project, the utilization of surface waters for Dacca water supply should receive due consideration.

So far as the surface waters are concerned the major sources are the three rivers, the Buriganga, the Sitalakhya and the Ballu. The minimum, average and maximum value of the important water quality parameters are shown in Table 4.1. These results when compared with the previous works[9,11,14] can be found that the degree of pollution of these rivers are gradually increasing with time. Kalam[11] in 1967-68 found that the average value of total solids, turbidity, and colour of Buriganga river was 155, 32 and 27 ppm respectively, whereas the average value of these parameters during the time of study have increased to 297, 53, and 34 ppm respectively. The other important qualities like BOD, COD and bacterial count have also increased significantly. The water quality parameters of the river Sitalakhya are found to be more or less constant when compared with previous works[9]. Only the noted change is the increased in the concentration of ammonia from 0.13 ppm to 0.83 ppm.

Among the three major river water sources around Dacca the Sitalakhya is by far the best source in respect of water quality. As the Buriganga runs very adjacent to the city, it has high potentiality for large scale water works and thereby has the advantage over Sitalakhya in respect of distance. Although the Buriganga water is more polluted than that of Sitalakhya, but the chemical examination indicates that the Buriganga water until now has not gone to such a limit which cannot be treated economically for the water supply of the city

TABLE 4.1 SUMMARY OF WATER QUALITY DATA OF RIVERS

Determination (mg/l)	The Buriganga			The Sitalakhya			The Balu		
	Min	Av	Max	Min	Av	Max	Min	Av	Max
Total solids	160	297	430	135	172	206	300	397	500
Dissolved solids	100	209	320	100	142	175	275	353	440
Suspended solids	60	91	110	20	30	37	25	44	100
Turbidity	30	53	80	25	48	70	50	73	102
Colour	19	34	41	20	35	42	25	33	42
Total Alkalinity as $CaCO_3$	12	74	270	34	79	170	30	90	195
Acidity	8	10	15	5	9	16	6	9	12
Carbondioxide	2	4.3	10	2	4	6	2	4	5
pH*	7.10	7.38	7.55	7.20	7.40	7.60	7.40	7.61	7.90
Total hardness	45	84	145	40	92	150	45	92	118
Soluble Iron, Fe^{+++}	00	0.20	0.60	00	0.20	0.50	0.04	0.20	0.50
Dissolved oxygen	5.90	6.60	7.00	5.00	5.83	6.40	5.00	6.55	7.20
Chemical Oxygen demand (COD)	00	0.66	1.20	00	0.46	1.00	00	0.62	1.40
Bio-chemical oxygen demand (BOD)	0.70	1.10	1.60	0.60	1.04	1.50	0.80	1.20	1.80
Chlorides	1.00	5.95	9.00	1.41	5.80	10.00	3.00	5.30	9.00
Sulphates	6	9.90	16	4.6	9.64	17.5	5	0.30	15
Ammonia	0.2	1.20	2.8	0.2	0.83	1.4	00	0.6	1.3
Nitrate	00	1.03	7.0	0.0	1.08	6	00	0.64	3

* No units.

Ahmed[2] has shown that water with such turbidity and colour can be clarified with alum coagulation in alkaline media effectively and economically. It is also shown that once the water is clarified, a nominal dose of chlorine can successfully disinfect these surface waters. Test conducted at different stage of water treatment in the Dacca Water works are tabulated in Appendix-A. These results also indicate that Buriganga river water can be treated successfully. It may further be stated that in order to check further pollution which may render the water unfit for treatment economically, there should be some legal measures against the indiscriminate discharge of sewage effluent and other polluting agents to the river particularly from industrial units located on the bank. Effect of Hazaribagh tannery and Glue factory on the Buriganga, industrial wastes on the Ballu at Tongi and the Sitalakhya at Gorashal are summarised in Appendix-C. These studies of Bangladesh WPCB shows that some of the water qualities have exceeded the limit of international standards of quality for water sources.

Other than surface water in the rivers, there are also handpump tubewells, open wells, lakes, ponds, tanks, canals, khals, ditches and other sources of water in the city area. The large number of city population particularly the low income groups who reside in the area where no water supply facilities have been extended, depend on such water for all their domestic consumptions. The test results show that water

from these source are also polluted and exposed to easy contamination. All these sources are practically in the private capacity where no economic arrangement may be possible to control the water quality. In fact, to overcome the contamination from such water, there is uptill now no remedy practice has been made available except boiling and alum treatment. Of course these practices are extremely in limited scale which does not guarantee total purification.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

After careful interpretations and critical examinations of the experimental results the following conclusions are drawn:

(a) Ground water collected through deep tube wells is the best source for safe drinking water supply. But the presence of caliform colonies in the tap water indicates its contamination in the supply lines. To prevent such contamination, at least chlorination is required before ground water is supplied in the distribution system.

(b) Surface waters are being increasingly polluted with the passage of time, but the degree of pollution has not reached such an extent as to make the sources unsuitable for large scale treatment.

(c) The three potential surface water sources for Dacca city water supply are the rivers Buriganga, Sitalakhya and Ballu. The river Sitalakhya as the potential water source, is advantageous over the rivers Buriganga and Ballu in respect of water quality while Buriganga river water may be considered advantageous over others when distance is taken into account. Considering the other aspects water from

both Buriganga and Sitalakhya can be treated effectively and economically for Dacca water supply.

(d) Water from other minor sources also require elaborate treatment to make them suitable for public water supply. Considering the inadequate quantity, these cannot be used as source of water for the metropolitan city.

5.2 RECOMMENDATIONS FOR FUTURE STUDY

The investigation into the multinatural aspect of water sources in and around Dacca is no doubt a painstaking job. One year or short duration study is definitely insufficient to look into the different aspect such as the physical, chemical and bacteriological characteristics of water. There are numerous agents for contamination, the details of which can only be detected through physical, chemical and bacteriological tests for individual elements including poisonous chemical such as arsenic, cyanide, lead, barium, selenium, chromium, cadmium, silver, detergents, copper, chloroform extract, phenols, zinc, and some disease causing bacteria such as streptococci, bacillus etc. More extensive study by taking more sampling point is also required to know the actual characteristics of the water of each water source.

To find out the effective treatment method suitable for each source may be studied in the next phase. As there is a

tendency of the increase in the water pollution by various human activities, more elaborate study of this nature from time to time is recommended.

CHAPTER 6

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APPENDIX-A

TEST RESULTS

TABLE A-1 TOTAL SOLIDS, mg/l

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	March 1	April 1
Buriganga at Chandnighat	400	380	270	200	160	195	230	295	308	330	400	430
Sitalakhya at Demra	200	150	142	135	140	155	180	180	186	190	205	206
Ballu at Demra	500	450	380	300	310	340	360	365	400	420	460	475
Dhanmondi Lake	510	460	400	320	280	285	300	325	350	365	390	400
Ramna Lake	530	475	400	350	290	285	295	340	345	360	380	450
DU Pond	250	220	180	150	160	185	195	205	215	225	250	254
BUET Tubewell	70	65	60	65	68	72	68	70	68	70	72	71
Mugdapara Hand pump Tubewell	100	105	110	115	110	100	102	101	108	105	100	100
Mugdapara open well	180	190	178	190	185	180	190	188	182	185	185	180

TABLE A-2.1 DISSOLVED SOLIDS, mg/l

Date of collection	1973					1974						
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov. 1	Dec 1	Jan 1	Feb 1	March 1	April 1
Buriganga at Chandnighat	300	270	180	130	100	130	160	200	205	220	290	320
Sitalakhya at Demra	175	130	112	102	100	120	145	158	160	163	168	170
Balu at Demra	400	392	360	275	280	305	320	332	350	360	425	440
Dhanmondi Lake	400	380	320	230	200	190	210	235	255	270	300	295
Raman Lake	405	385	330	250	205	190	200	235	250	275	295	300
DU Pond	200	196	165	118	125	135	150	162	175	190	218	216
BUET Tubewell	36	33	32	33	35	37	40	37	39	40	44	44
Mugdapara Hand pump Tubewell	60	52	56	60	65	60	54	60	65	65	66	63
Mugdapara open well	100	102	92	100	98	96	100	106	110	116	122	118

TABLE A-2.2 DISSOLVED SOLIDS (mg/1) AT DIFFERENT PHASE OF TREATMENT IN DACCA WATER WORKS

Date of collection (1973-74)	Location of Sample				
	Buriganga	Outlet of coagulation Tank	Outlet of settling Tank	Filtered water before chlorination	Filtered water after chlorination
July 23	109	118	116	109	121
June 5	80	82	82	83	93
June 20	83	79	81	85	98
July 3	56	-	56	60	70
July 11	88	86	93	70	103
July 19	74	81	74	97	91
July 30	64	62	66	56	74
August 7	70	62	64	62	71
September 4	68	66	73	64	73
September 11	64	73	68	77	76
September 24	72	72	77	73	80
October 12	68	60	60	57	53
November 13	103	96	99	116	130
November 22	119	123	104	444	125
November 29	143	144	94	135	148
December 14	176	177	170	205	189
December 20	164	163	165	193	200
January 17	225	235	232	277	284
January 24	232	231	230	242	235
March 13	243	254	249	255	251
March 21	273	282	257	281	293
April 3	227	282	281	291	279

TABLE A-2.3 DISSOLVED SOLIDS (mg/l) IN DIFFERENT TUBEWELL WATERS

Location of Sample	Date	Test Result
I.G.Gate TW(after chlorination)	23.7.73	180
I.G.Gate TW(before chlorination)	23.7.73	167
Narinda TW (before chlorination)	24.7.73	210
Narinda TW (after chlorination)	24.7.73	214
Abdul Gani Road TW	28.7.73	229
Azimpur TW	6.8.73	311
Dhakeswari TW	6.8.73	401
Medical College TW	6.8.73	324
Dhakeswari TW	7.8.73	420
Bonogram TW(after chlorination)	10.8.73	396
Bonogram TW(before chlorination)	10.8.73	392
Laxmibazar TW(before chlorination)	10.8.73	198
Laxmibazar TW(after chlorination)	10.8.73	196
Basaboo TW	28.8.73	169
Khilgaon TW	20.8.73	182
Hatkhola TW	20.8.73	207
Motijheel TW	6.9.73	209
Kakrail TW	6.9.73	152
Shahjahanpur TW	17.9.73	170
Bijoynagar TW	17.9.73	189
Assembly TW	10.10.73	125
Sukrabad TW	10.10.73	178
Green Road TW	10.10.73	243
Islampur Road (Tap Water)	15.10.73	144
Mitford TW	15.10.73	463

TABLE A-2.3 (Contd..)

Location of Sample	Date	Test Result
Jagannath Shaha Road (Tap Water)	15.10.73	361
Nawabganj TW	15.10.73	320
Rayer Bazar TW	15.11.73	275
Hazaribagh TW	15.11.73	281
Gulshan TW No.4	19.11.73	160
Gulshan TW No.3	19.11.73	155
Agasadek Road	22.11.73	519
Nayabazar area, tap water	22.11.73	357
Azimpur TW	26.11.73	278
Dhakeswari TW	26.11.73	401
Lalbagh TW	26.11.73	322
Medical College TW	26.11.73	320
Tejgaon TW	18.12.73	233
T.B. Hospital TW	18.12.73	150
Banani TW No.1	18.12.73	155
Banani TW No.2	18.12.73	112
Lichubagan TW	21.1.74	191
Fulbaria TW	21.1.74	351
BDR TW	29.1.74	425
Dacca College TW	29.1.74	276
Tejgaon TW	7.2.74	160
Moghbazar TW	7.2.74	222
Medical College TW	16.2.74	319
Dhakeswari TW	16.2.74	410

TABLE A-3 SUSPENDED SOLIDS, mg/l

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	Mar 1	Apr 1
Buriganga at Chandnighat	100	110	90	70	60	65	70	95	104	110	110	110
Sitalakhya at Demra	25	20	30	33	40	35	35	22	26	27	37	36
Balu at Demra	100	58	30	25	30	35	40	33	50	60	35	35
Dhanmondi Lake	110	80	80	90	88	95	90	98	95	96	190	105
Ramna Lake	125	90	70	100	85	95	95	105	95	85	85	150
DU Pond	50	24	15	32	35	50	45	43	40	35	32	38
BUET Tubewell	34	32	28	32	33	35	28	33	29	30	28	27
Mugdapara Hand TW	40	43	54	55	45	40	46	41	43	40	34	37
Mugdapara open well	80	88	86	90	87	84	90	82	72	69	63	62

TABLE A-4.1 TURBIDITY UNITS

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	Mar 1	Apr 1
Buriganga at Chandnighat	78	80	68	62	58	32	35	38	30	36	52	66
Sitalakhya at Demra	70	68	62	60	58	30	25	28	35	42	45	50
Ballu at Demra	102	98	88	71	60	56	50	55	62	65	78	88
Dhanmondi Lake	85	80	70	58	48	42	38	45	57	56	58	62
Ramna Lake	80	81	71	60	45	36	32	36	40	42	45	60
DU Pond	90	92	76	62	58	48	44	49	55	69	78	88
BUET Tubewell	13	12	10	10	10	11	10	11	11	12	10	11
Mugdapara Hand pump TW	14	15	12	11	14	14	12	12	12	13	12	11
Mugdapara open well	20	15	16	17	18	20	19	17	17	18	19	18

TABLE A-4.2 TURBIDITY UNITS AT DIFFERENT PHASE OF TREATMENT IN DACCA WATER WORKS

Date of collection (1973-74)	Location of Sample				
	Buriganga	Outlet of coagulation tank	Outlet of settling tank	Filtered water before chlorination	Filtered water after chlorination
May 23	48	Less than 25	Less than 25	Less than 25	Less than 25
June 5	Less than 25	do	do	do	do
June 20	do	do	do	do	do
July 3	do	do	do	do	do
July 11	do	do	do	do	do
July 19	do	do	do	do	do
July 30	do	do	do	do	do
August 7	do	do	do	do	do
September 4	do	do	do	do	do
September 11	do	do	do	do	do
September 24	do	do	do	do	do
October 12	do	do	do	do	do
November 13	do	do	do	do	do
November 22	do	do	do	do	do
November 29	do	do	do	do	do
December 14	do	do	do	do	do
December 20	do	do	do	do	do
January 17	do	do	do	do	do
January 24	do	do	do	do	do
May 13	do	do	do	do	do
March 21	do	do	do	do	do
April 3	do	do	do	do	do

TABLE A-4.3 TURBIDITY UNITS OF TUBEWELL WATERS

Location of sample	Date	Test Result
I.G. Gate TW (after chlorination)	23.7.73	Less than 25
I.G. Gate TW (before chlorination)	23.7.73	do
Narinda TW (before chlorination)	24.7.73	do
Narinda TW (after chlorination)	24.7.73	do
Abdul Gani Road TW	3.8.73	do
Azimpur TW	6.8.73	do
Dhakeswari TW	6.8.73	do
Medical College TW	6.8.73	do
Dhakeswari TW	7.8.73	do
Bonogram TW (after chlorination)	10.8.73	do
Bonogram TW (before chlorination)	10.8.73	do
Laxibazar TW (before chlorination)	10.8.73	do
Laxibazar TW (after chlorination)	10.8.73	do
Agasadek Road	22.11.73	do
Nayabazar Area	22.11.73	do

TABLE A-5.1 COLOUR, mg/l

Date of collection	1973 May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	1974 Jan 1	Feb 1	Mar 1	Apr 1
Buriganga at Chandnighat	30	31	34	38	39	40	41	35	31	21	19	22
Sitalakhya at Demra	33	36	39	42	40	39	42	40	32	30	22	20
Ballu at Demra	34	31	33	31	30	42	41	38	34	30	28	25
Dhanmondi Lake	80	80	85	90	94	95	96	92	86	75	73	70
Ramna Lake	120	123	112	118	120	118	112	108	107	106	100	100
DU Pond	71	69	73	80	85	82	78	72	68	62	60	70
BUET TW	4	4	5	4	5	5	4	4	3	5	4	4
Mugdapara Hand pump TW	6	6	7	7	7	8	6	6	5	4	5	4
Mugdpara open well	8	9	10	11	11	9	8	7	6	8	6	6

TABLE A-5.2 COLOUR AT DIFFERENT PHASE OF TREATMENT IN DACCA WATER WORKS

Date of collection (1973-74)	Location of Sample				
	Buriganga	Outlet of coagulation Tank	Outlet of settling Tank	Filtered water before chlorination	Filtered water after chlorination
May 23	Muddy	T	T	T	T
June 5	T	do	do	do	do
June 20	do	do	do	do	do
July 11	do	do	do	do	do
July 19	do	do	do	do	do
July 30	do	do	do	do	do
August 7	do	do	do	do	do
September 4	do	do	do	do	do
September 11	do	do	do	do	do
September 24	None	None	None	None	None
October 12	T	T	T	T	T
November 13	None	None	None	None	None
November 22	do	do	do	do	do
November 29	do	do	do	do	do
December 14	do	do	do	do	do
December 20	do	do	do	do	do
January 17	T	T	T	T	T
January 24	None	None	None	None	None

T = Transparent

TABLE A-5.3 COLOUR OF TUBEWELL WATERS

Location of Sample	Date	Test Results
I.g Gate TW (before and after chlorination	23.7.73	Transparent
Narinda TW (before and after chlorination)	24.7.73	do
Abdul Gani Road TW	3.8.73	do
Azimpur TW No. 4	6.8.73	do
Dhakeswari TW	6.8.73	do
Medical College TW	6.8.73	do
Dhakeswari TW	7.8.73	do
Banagram TW, (before and after chlorination)	10.8.73	do
Laxibazar TW (before and after chlorination)	10.8.73	do
135, Agasadek Road	22.11.73	None
Naya Bazar Area	22.11.73	None

TABLE A-6.1 TASTE AND ODOUR

Date of collection	1973						1974				
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Jan 1	Feb 1	Mar 1	Apr 1
Buriganga at Chandni ghat											
Sitalakhya at Demra											
Balu at Demra											
Dhammondi Lake	No objectionable										
Ramna Lake	taste and odour										
DU pond											
BUET Tubewell											
Muqdapara hand pump TW											
Muqdapara open well											

TABLE A-6.2 TASTE AND ODOUR AT DIFFERENT PHASE OF TREATMENT OF DACCA WATER WORKS

Date of collection (1973-74)	Location of Sample				
	Buriganga	Outlet of coagulation Tank	Outlet of settling Tank	Filtered water before chlorination	Filtered water after chlorination
July 3	Less	Smell of mud	Smell of mud	Less	Smell of chlorine
July 11	None	None	Less	None	Chlorine is present
July 19	do	do	None	do	do
July 30	do	do	do	do	Smell of chlorine
August 7	do	do	do	do	do
September 4	do	do	do	do	None
September 11	do	do	do	do	do
September 24	do	do	do	do	do
October 12	do	do	do	do	do
November 13	do	do	do	do	do
November 22	do	do	do	do	do
November 29	do	do	do	do	do
December 14	do	do	do	do	do
December 20	do	do	do	do	do
January 17	do	do	do	do	do
January 24	do	do	do	do	do

TABLE A-6.3 TASTE AND ODOUR OF TUBEWELL WATERS

Location of Sample	Date	Test Results
I.G. Gate TW (after chlorination)	23.7.73	
I.G Gate TW (before chlorination)	23.7.73	
Narinda TW (before chlorination)	23.7.73	
Abdul Gani Road, TW	3.8.73	
Azimpur TW	6.8.73	None
Dhakeswari TW	6.8.73	
Medical College TW	6.8.73	
Dhakeswari TW	7.8.73	
Banagram TW(before chlorination)	10.8.73	
Banagram TW(after chlorination)	10.8.73	
Laxmibazar TW (before chlorination)	10.8.73	
Agasadek Road	22.11.73	
Nayabazar area	22.11.73	

TABLE A-7.1 TOTAL ALKALINITY AS $CaCO_3$, mg/l

Date of collection	1973 May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	1974 Jan 1	Feb 1	Mar 1	April 1
Buriganga at Chandnighat	90	35	30	30	28	13	12	40	95	125	175	210
Sitalakhya at Demra	95	50	56	44	34	36	39	50	100	130	148	170
Balu at Demra	105	85	70	40	30	34	55	60	95	140	178	195
Dhanmondi Lake	100	90	82	70	38	31	50	50	80	101	140	152
Ramna Lake	80	80	70	55	40	38	44	58	90	110	139	150
DU pond	90	68	54	48	40	40	42	50	85	92	100	115
BUET, Tubewell	100	92	88	77	70	60	60	65	70	75	120	110
Mugdapara Hand TW	98	98	79	58	40	40	62	60	70	880	88	100
Mugdapara open well	100	82	67	58	45	45	50	58	70	88	92	110

TABLE A-7.2 TOTAL ALKALINITY AS $CaCO_3$ (mg/l) AT DIFFERENT PHASE OF TREATMENT OF DACCA WATER WORKS

Date of collection (1973-74)	Location of Sample				
	Buriganga	Outlet of coagulation Tank	Outlet of settling Tank	Filtered water before chlorination	Filtered water after chlorination
May 23	52	36	42	38	36
June 5	39	27	26	26	28
June 20	46	40	36	38	44
July 3	-	35	39	39	41
July 11	48	42	48	47	54
July 19	53	50	50	46	48
July 30	38	38	36	37	36
August 7	38	35	33	34	34
September 4	50	46	44	46	46
September 11	48	48	48	50	48
September 24	33	32	27	28	29
October 12	40	35	32	33	34
November 13	58	54	50	51	57
November 22	74	64	72	130	72
November 29	92	94	82	104	86
December 14	118	104	117	118	118
December 20	116	108	110	110	112
January 17	173	159	170	159	160
January 24	161	158	159	155	157
March 13	163	156	160	158	161
March 21	165	166	164	164	160
April 3	154	156	152	148	147

TABLE A-7.3 TOTAL ALKALINITY AS $CaCO_3$, (mg/l) OF TUBEWELL WATER

Location of sample	Date	Test Result
I.G. Gate P.S.(before chlorination)	23.7.73	101
I.G. Gate P.S. (after chlorination)	23.7.73	98
Narindah P.S. (before chlorination)	24.7.73	84
Narindah P.S.(after chlorination)	24.7.73	86
Abdul Gani Rd. P.S.	3.8.73	88
Azimpur P.S.	6.8.73	988
Dhakeswari P.S.	6.8.73	138
Medical College P.S.	6.8.73	104
Dhakeswari P.S.	7.8.73	148
Banagram P.S. (before chlorination)	10.8.73	84
Banagram P.S.(after chlorination)	10.8.73	86
Laxmibazar P.S. (before chlorination)	10.8.73	78
Laxmibazar P.S. (after chlorination)	10.8.73	79
Jagannath Saha Rd. P.S.	15.10.73	124
Nawabgonj P.S.	15.10.73	110
Rayerbazar P.S.	15.11.73	108
Hazaribagh P.S.	15.11.73	106
Gulshan P.S. 4	19.11.73	86
135, Agasadek Rd.	22.11.73	158
Gulshan P.S. 3	19.11.73	82
Nayabazar Area	22.11.73	122
Azimpur P.S.	26.11.73	100
Dhakeswari P.S.	26.11.73	144
Lalbagh P.S.	26.11.73	112
Medical College P.S.	26.11.73	116
Tejgaon P.S. No. 6	18.12.73	56
T.B. Hospital P.S. No. 2	18.12.73	74
Banani P.S. No. 1	18.12.73	77

TABLE A-7.3 (Contd...)

Location of sample	Date	Test Result
Bonani P.S. No.2	18.12.73	55
Lichu Bagan P.S.	21.1.74	78
Fulbaria P.S. No.2	21.1.74	90
Bangladesh Rifle P.S.	29.1.74	107
Dacca College P.S.	29.1.74	89
Tejgaon P.S. No. 7	7.2.74	100
Moghbazar P.S.	7.2.74	103
Basabo P.S.	20.8.74	86
Khilgaon P.S. No.3	20.8.73	100
Hatkhola P.S.	20.8.73	104
Motijheel R.A. P.S. 4	6.9.73	97
Kakrail P.S.	6.9.73	64
Shahjahanpur P.S.	17.9.73	90
Bijoynagar P.S.	17.9.73	89
Assembly P.S.	10.10.73	74
Green Rd. P.S. 2	10.10.73	132
Islampur Tap Water	15.10.73	60
Mitford P.S.	15.10.73	154
Medical College P.S.	16.2.74	113
Dhakeswari P.S.	16.2.74	134

TABLE A-8 ACIDITY, mg/l

Date of Collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept. 1	Oct. 1	Nov. 1	Dec. 1	Jan 1	Feb 1	March 1	April 1
Buriganga at Chandnighat	15	14	10	11	9	9	8	10	11	9	8	13
Sitalakhya at Demra	6	7	10	16	11	11	10	10	8	8	5.50	5
Balu at Demra	9	8	8	6	8	9	9	12	11	10	100	9
Dhanmondi Lake	11	11	10	12	13	15	14	15	13	12	12	12
Ramna Lake	10	10	11	12	14	13	14	16	14	13	12	10
DU Pond	12	13	16	15	14	18	22	25	15	12	10	14
BUET TW	11	10	9	9	8	9	10	10	9	8	9	10
Mugdapara Hand TW	24	20	30	35	50	45	48	52	35	30	25	20
Mugdapara open well	14	12	12	13	12	14	15	15	14	13	14	13

TABLE A-9 CARBON DIOXIDE, mg/l

Date of collection	1973 May 2	June 1	Jul. 1	Aug. 1	Sept. 1	Oct. 1	Nov. 1	Dec. 1	1974 Jan. 1	Feb. 1	Mar. 1	Apr. 1
Buriganga at Chandnighat	3	2	2	4	3	3	4	5	7	4	5	10
Sitalakhya at Demra	6	3	5	4	4	3	2	4	3	3	4	6
Balu at Demra	3	2	3	4	5	5	4	5	4	3	4	5
Dhanmondi Lake	7	6	5	4	4	3	3	2	2	3	4	8
Ramna Lake	5	4	4	3	4	5	6	5	4	3	3	2.5
DU Pond	6	6	7	5	4	4	6	5	5	4	5	6
BUET Tubewell	3	2	3	2	2	3	2	4	3	2	1	2
Mugdapara hand Tubewell	2	1	2	3	3	2	2	4	3	2	2	1
Mugdapara open well	4	3	3	2	4	4	3	2	3	4	2	2

TABLE A-10.1 pH VALUE

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug. 1	Sept. 1	Oct. 1	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	Apr. 1
Buriganga at Chandnighat	7.50	7.40	7.20	7.10	7.20	7.35	7.50	7.50	7.45	7.50	7.55	7.50
Sitalakhya at Demra	7.50	7.50	7.30	7.20	7.20	7.30	7.35	7.40	7.45	7.50	7.50	7.60
Balu at Demra	7.60	7.55	7.50	7.80	7.40	7.50	7.55	7.55	7.60	7.65	7.65	7.90
Dhanmondi Lake	7.50	7.40	7.30	7.35	7.35	7.40	7.45	7.40	7.45	7.90	7.50	7.50
Ramna Lake	7.90	7.50	7.40	7.45	7.50	7.55	7.55	7.60	7.65	7.70	7.70	8.10
DU Pond	7.50	6.90	6.50	6.80	6.85	6.90	7.50	7.50	7.55	7.50	7.50	7.50
BUET Tubewell	7.50	7.50	7.45	7.40	7.45	7.50	7.45	7.45	7.50	7.50	7.55	7.40
Mugdapara hand TW	7.50	7.40	7.30	6.80	7.30	7.20	7.20	6.80	7.10	7.20	7.20	7.30
Mugdapara open well	7.50	7.30	7.25	7.20	7.25	7.30	7.35	7.40	7.45	7.45	7.50	7.50

TABLE A-10.2 pH VALUE AT DIFFERENT PHASE OF TREATMENT OF DACCA WATER WORKS

Date of collection	1973 May 23	Aug. 22	Oct. 16	Nov. 12	Dec. 24	1974 Feb. 5	Mar. 1	Mar. 13	Mar. 21	Apr. 1	Apr. 3
Buriganga	7.10	7.40	6.80	6.80	7.60	7.40	7.40	7.45	7.40	7.40	7.50
Out let of coagulation Tank	6.55	-	-	-	-	-	-	7.30	7.55	-	7.35
Outlet of settling Tank	6.75	7.40	6.80	6.80	7.60	7.40	7.20	7.50	6.70	7.00	7.45
Filtered water before chlorination	7.75	7.40	7.00	7.00	7.60	7.40	7.20	7.45	7.70	7.00	7.20
Filtered water after chlorination	6.50	7.40	7.20	7.20	7.40	7.60	7.00	7.65	7.40	7.20	7.30

TABLE A-10.3 pH VALUE OF TUBE WELL WATERS

Location of sample	Date	Test Result
Basaboo P.S.	20.8.73	6.70
Khilgaon P.S.	20.8.73	6.50
Hatkhola P.S.	20.8.73	6.80
Jagannath Saha Rd.(Tap Water)	22.8.73	7.40
Motijheel R.A. P.S.4	6.9.73	7.00
Khilgaon P.S.	6.9.73	7.00
Shahjahanpur P.S.	17.9.73	7.00
Bijoynagar P.S.	17.9.73	6.90
Assembly P.S.	10.10.73	6.60
Green Rd. P.S.	10.10.73	6.80
Sukrabad P.S.	10.10.73	6.50
Islampur Rd.(Tap Water)	15.10.73	6.60
Mitford P.S.	15.10.73	6.60
Jagannath Saha Rd.	15.10.73	6.70
Nawabganj P.S.	15.10.73	7.00
Nayabazar (Tap Water)	16.10.73	7.20
Agasadeque Rd.(Tap water)	16.10.73	7.20
Islampur (Tap water)	12.11.73	7.20
Lalbagh Rd. TW	12.11.73	7.20
Rayer Bazar P.S.	15.11.73	7.10
Hazaribagh P.S.	15.11.73	6.30
Gulshan P.S. 4	19.11.73	7.15
Gulshan P.S. 3	19.11.73	6.80

TABLE A-10.3 (Contd...)

Location of sample	Date	Test Result
Azimpur P.S.	26.11.73	6.65
Dhakeswari P.S.	26.11.73	6.50
Lalbagh P.S.	26.11.73	7.10
Medical College P.S.	26.11.73	6.50
Tejgaon P.S. No.6	18.12.73	6.50
T.B. Hospital P.S.-2	18.12.73	6.75
Banani P.S. No.1	18.12.73	6.60
Banani P.S. No.2	18.12.73	6.50
Champatoli lane (Tap water)	24.12.73	7.40
Khajedwan Rd. (Tap water)	24.12.73	7.40
Lichu Bagan P.S.	21.1.74	6.70
Fulbaria P.S.	21.1.74	6.30
Bangladesh Rifle P.S.	29.1.74	6.95
Dacca College P.S.	29.1.74	6.50
Bangshal Rd (Tap water)	5.2.74	7.60
Islampur Rd. (Tap water)	5.2.74	7.60
Tejgaon P.S. No.7	7.2.74	6.60
Moghbazar P.S.	7.2.74	6.40
Medical College P.S.	16.2.74	6.50
Dhakeswari P.S.	16.2.74	6.50
Hazaribagh (Tap water)	1.3.74	7.00
Imamganj (Tap Water)	1.3.74	7.00
Asheque Lane (Tap Water)	1.4.74	7.20
Nazirabazar (Tap water)	1.4.74	7.20

TABLE A-11 TOTAL HARDNESS, mg/l

Date of collection	1973 May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	1974 Jan 1	Feb 1	March 1	April 1
Buriganga at Chandnighat	100	80	45	46	48	59	65	76	98	120	130	145
Sitalakhya	105	78	40	40	54	65	80	98	115	130	135	150
Balu at Demra	115	80	45	50	55	60	78	95	112	128	140	148
Dhanmondi Lake	90	80	40	48	50	55	61	73	82	92	107	120
Ramna Lake	120	100	50	50	66	78	87	96	108	112	138	160
DU Pond	125	85	50	55	59	69	74	88	98	108	128	150
BUET TW	120	118	100	100	102	106	110	112	111	115	120	130
Mugdapara hand TW	100	95	90	130	125	120	122	128	130	130	128	130
Mugdapara open well	98	85	80	90	94	99	102	108	110	115	120	135

TABLE A-12 SOLUBLE IRON, Fe^{+++}, mg/l

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	March 1	April 1
Buriganga at Chandnighat	.15	.10	0	0	.40	.60	.50	.30	.20	.10	0	.10
Sitalakhya at Demra	.08	.06	0	0	.40	.50	.50	.40	.30	.08	0	.10
Balu at Demra	.18	.10	.08	.04	.08	.40	.45	.50	.40	.04	.03	.08
Dhanmondi Lake	.01	Trace	0	0	0	Trace	.01	.02	.01	.015	.01	.01
Ramna Lake	.02	Trace	Trace	0	0	0	Trace	.01	.01	.02	.02	.01
DU Pond	.01	.01	Trace	Trace	0	0	0	Trace	.01	.01	.02	.01
BUET TW	.80	.70	.20	.10	.20	.30	.30	.40	.50	.65	.70	.75
Mugdapara hand TW	.60	.40	.10	.10	.25	.40	.40	.45	.45	.50	.50	.55
Mugdapara open well	.18	.10	.10	Trace	.10	.16	.15	.16	.16	.17	.17	.18

TABLE A-13 MANGANESE AS Mn^{+++}, mg/l

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	March 1	April 1
Buriganga at Chandnighat												
Sitalakhya at Demra												
Balu at Demra												
Dhanmondi Lake												
Ramna Lake						Trace amount or nil						
DU Pond												
BUET TW												
Mugdapara Hand TW												
Mugdapara open well												

TABLE A-14 DISSOLVED OXYGEN, mg/l

Date of collection	1973							1974				
	May 2	June 1	July 1	Aug. 1	Sept. 1	Oct. 1	Nov. 1	Dec. 1	Jan. 1	Feb. 1	March 1	April 1
Buriganga at Chandnighat	5.90	6.90	6.60	6.60	6.70	6.80	6.90	6.40	7.00	6.80	6.60	6.10
Sitalakhya at Demra	6.00	5.50	5.80	5.40	5.60	5.80	6.00	6.40	6.40	6.30	5.80	5.00
Balu at Demra	5.80	5.00	6.60	5.80	6.80	7.00	7.00	7.20	7.20	7.00	6.60	6.60
Dhanmondi Lake	6.80	6.20	6.00	6.60	6.40	6.80	6.80	7.00	7.00	6.00	6.40	6.80
Ramna Lake	5.00	5.20	5.20	5.40	5.60	5.80	6.00	6.00	5.80	5.80	5.00	4.80
DU Pond	5.00	5.20	5.40	4.80	5.60	5.80	6.00	4.80	6.00	4.60	4.00	3.80
BUET TW	4.00	4.60	5.00	5.60	5.80	6.00	5.60	4.80	6.80	6.60	6.00	5.00
Mugdapara Hand TW	3.00	3.00	3.20	3.40	3.60	3.80	4.00	3.00	4.80	4.00	3.60	3.20
Mugdapara open well	4.00	3.80	3.80	3.90	4.00	4.00	4.40	4.80	5.20	4.40	4.00	3.80

TABLE A-15 CHEMICAL OXYGEN DEMAND (COD), mg/l

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	Mar 1	Apr 1
Buriganga at Chandnighat	1.10	.40	0	0	.40	.60	.60	.70	.90	1.0	1.10	1.20
Sitalakhya at Demra	1.00	.30	0	.10	.20	.20	.30	.40	.60	.60	.80	1.00
Balu at Demra	1.20	.80	0	0	.20	.40	.40	.60	.60	.90	1.00	1.40
Dhanmondi Lake	1.10	1.00	.20	.10	.20	.30	.30	.60	1.80	1.00	1.60	1.80
Ramna Lake	1.80	.40	.20	.20	.40	.70	.80	1.00	1.00	1.10	1.20	2.00
DU Pond	2.00	.60	.20	.20	.40	.60	.80	.80	.90	1.60	1.80	2.00
BUET TW	.40	.20	0	0	0	.10	.20	.30	.30	.30	.40	.40
Mugdapara hand TW	.60	.40	.20	.20	.10	.20	.30	.40	.40	.40	.50	.60
Mugdapara open well	.80	.60	.20	0	.20	.40	.40	.60	.60	.70	.80	.80

TABLE A-16 BIO-CHEMICAL OXYGEN DEMAND (BOD), mg/l

Date of collection	1973 May 2	June 1	July 1	Aug 1	Sept: 1	Oct. 1	Nov. 1	Dec. 1	1974 Jan. 1	Feb 1	March 1	April 1
Buriganga at Chandnighat	1.50	.80	.70	.70	.80	.90	1.30	1.20	1.30	1.40	1.40	1.60
Sitalakhya at Demra	1.20	.70	.60	.70	.70	.90	1.10	1.10	1.30	1.40	1.30	1.50
Balu at Demra	1.60	1.00	.80	.80	.90	.90	1.00	1.00	1.20	1.40	1.50	1.80
Dhanmondi Lake	2.60	2.00	1.50	1.60	1.80	1.80	2.00	2.20	2.30	2.30	2.50	2.60
Ramna Lake	2.80	2.00	1.50	1.80	1.80	1.60	1.90	2.00	2.40	2.80	2.80	3.00
DU Pond	4.00	3.00	2.60	2.60	2.70	2.80	5.20	2.80	3.00	3.60	3.80	4.60
BUET TW	1.10	1.00	1.00	.80	.90	1.00	1.20	.80	1.00	1.10	1.00	1.20
Muggdapara hand TW	1.20	1.10	1.00	1.00	1.10	1.20	1.20	1.20	1.30	1.20	1.30	1.40
Muggdapara Open well	1.80	1.60	1.20	1.20	1.20	1.40	1.30	1.60	1.60	1.80	1.90	2.00

TABLE A-17 CHLORIDES, mg/l

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept. 1	Oct. 1	Nov. 1	Dec. 1	Jan 1	Feb. 1	Mar 1	April 1
Buriganga at Chandnighat	9.00	5.00	2.00	1.00	1.50	1.50	8.00	8.20	8.40	8.80	9.00	9.00
Sitalakhya at Demra	8.00	7.00	2.80	1.50	1.40	1.50	6.00	7.00	7.60	7.80	9.00	10.00
Balu at Demra	7.80	7.00	3.60	3.00	3.00	3.40	4.00	4.40	4.60	6.00	7.80	9.00
Dhanmondi Lake	30	10	5	4	4	6	8	10	12	18	36	50
Ramna Lake	32	16	6	6	8	12	20	20	31	37	38	45
DU Pond	30	18	6	6.50	8	10	17	24	32	34	36	40
BUET TW	20	19	18	17	17	18	18.5	17	18	19	19	19
Mugdapara hand TW	12	11	5	6	7	8	10	10.5	8	10	11	12
Mugdapara open well	15	12	10	12	12	10	12	13	13	14	14	15

TABLE A-18 SULPHATES, mg/l

Date of collection	1973								1974			
	May 2	June 1	July 1	Aug 1	Sept 1	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	Mar 1	Apr. 1
Buriganga at Chandnighat	15	10	7	6	6	7	8	11	10	11	12	16
Sitalakhya at Demra	16	8	4.6	4.6	6	7	8	8	10	12	15	17.5
Balu at Demra	14	8	5	5	6	7	9	9	10	12	12	15
Dhanmondi Lake	12	10	6.5	6.5	8	7	7.5	9	9.5	10	12	13
Ramna Lake	14	12	7	7.5	7.5	8	8	9	11	13.5	13	15
DU Pond	10	9	4	4.5	5	7	7.5	8.5	10	9	9	11
BUET TW	30	28	28	27	27.5	27.5	28	28	27	29	30	32
Mugdapara hand TW	28	27	26	26	26.5	27	27	28	28	28.5	27	29
Mugdapara open well	26	22	20	21	21.5	23	23	24	25	25	26	27

TABLE A-19 TOTAL HARDNESS, CALCIUM HARDNESS, TOTAL IRON, SILICA, MANGANESE, FLUORIDE, (mg/l), ELECTRIC CONDUCTIVITY (micro-mohs/cm)OF TUBE WELL WATER.

Location of sample	Date	Total Hard-ness mg/l	Calcium Hardness mg/l	Total irong mg/l	Electric conduc-tivity micro-mohs/cm	Silica as SiO_2 mg/l	Total Manga-nese mg/l	Fluoride mg/l
Hatkhola TW	20.8.73	86	64	.2	270	67	0	
Basaboo TW	20.8.73	69	51	.1	240	62	0	
Khilgaon TW	20.8.73	88	46	.1	245	65	0	
Kakrail TW	6.9.73	58	37	.3	195	57	0	.26
Motijheel TW	6.9.73	88	55	.1	260	57	.16	.42
Shahjahanpur TW	17.9.73	59	34	.6	195	68	0	.34
Bijoynagar TW	17.9.73	86	54	.1	255	62	0	.22
Assembly TW	10.10.73	54	30	.2	160	66	.01	.34
Sukrabad TW	10.10.73	72	40	.2	200	57	.1	.36
Green Rd.TW	10.10.73	122	72	.4	320	60	.05	.36
Islampur Rd.	15.10.73	80	54	.1	220	23	0	.22
Mitford TW	15.10.73	239	150	.1	550	86	0	.28
Jaganath Saha Rd	15.10.73	186	115	.1	500	55	.09	.22
Nowabganj TW	15.10.73	147	91	1.0	440	84	.25	.22
Rayerbazar TW	15.11.73	123	80	.2	350	62	.01	.26
Hazaribagh TW	15.11.73	169	104	.2	475	64	0	.22
Gulshan TW No.4	19.11.73	59	37	.1	180	73	0	.26
Gulshan TW No.3	19.11.73	66	29	.1	170	73	0	.28
Azimpur TW	26.11.73	141	88	.2	380	65	.1	.22
Dhakeswari TW	26.11.73	202	128	.1	540	62	.1	.22

TABLE A-19 (Contd.....)

Location of sample	Date	Total hard-ness mg/l	Calcium hardness mg/l	Total iron mg/l	Electric conduc-tivity micro-mohs/cm	Silica as SiO_2 mg/l	Total Manga-nese mg/l	Fluoride mg/l
Lalbagh TW	26.11.73	152	93	.8	425	67	.2	.2
Medical College TW	26.11.73	155	95	.1	420	61	.09	.22
T.B. Hospital TW	18.12.73	47	30	.1	155	70	0	.28
Bonani TW No.1	18.12.73	47	29	.1	160	74	0	.30
Banani TW No.2	18.12.73	33	29	.1	120	69	0	.20
Tejgaon TW	18.12.73	48	30	.2	260	65	0	.21
Lichubagan TW	21.1.74	66	38	.1	200	71	0	.24
Fulbaria TW	21.1.74	152	98	.1	460	67	0	.21
BDR TW	29.1.74	200	128	.1	520	65	.01	.24
Dacca College TW	29.1.74	113	75	.1	349	72	0	.18
Tejgaon TW	7.2.74	58	36	.1	180	70	0	.24
Mogbazar TW	7.2.74	96	58	.1	280	71	0	.3
Midical College TW	16.2.74	152	98	.1	430	64	.01	
Dhakeswari TW	16.2.74	199	121	.1	560	63	0	

TABLE A-20 AMMONIA CONTENT (mg/l) OF THE MAJOR RIVER WATERS

Date of collection	Buriganga at Chandnighat	Sitalakha at Demra	Ballu at Demra
May 2, 1973	2.8	1.4	1.3
June 1, 1973	1.6	1.0	1.2
July 1, 1973	1.0	1.2	1.0
Aug. 1, 1973	.2	.5	.6
Sept. 1, 1973	.2	.3	0
October 1, 1973	.8	.7	0
Nov.1, 1973	1.0	.5	.1
Dec. 1, 1973	1.0	.6	.2
Jan. 1, 1974	1.1	.8	.1
Feb. 1, 1974	1.4	.2	.1
March 1, 1974	1.8	1.4	1.3
April 1, 1974	1.5	1.4	1.0

TABLE A-21 NITRATE CONTENT (mg/l) OF THE MAJOR RIVER WATERS

Date of collection	Buriganga at Chandnighat	Sitalakhya at Demra	Ballu at Demra
May 2, 1973	.01	.8	.5
June 1, 1973	.01	1.0	.6
July 1, 1973	.01	1.2	.1
Aug. 1, 1973	.01	.01	.01
Sept. 1, 1973	0	0	0
Oct. 1, 1973	0	0	0
Nov. 1, 1973	0	1.1	1.0
Dec. 1, 1973	.1	1.7	1.8
Jan. 1, 1974	.8	.6	.1
Feb. 1, 1974	1.4	.5	.6
Mar. 1, 1974	3.0	.1	.01
April 1, 1974	7.0	6.0	3.0

TABLE A-22.1 COLIFORM COLONIES (per 100 ml) AT DIFFERENT PHASE OF TREATMENT OF DACCA WATER WORKS

Date of collection (1973-74)	Location of Sample				
	Buriganga (Intake poing)	Outlet of coagulation Tank	Outlet of settling Tank	Filtered water before chlorination	Filtered water after chlorination
May 23	I	I	I	I	0
June 5	I	190	20	0	0
June 25	I	I	I	110	0
July 3	I	150	80	10	0
July 11	I	I	I	40	10
July 19	I	I	I	60	10
July 30	I	120	I	140	0
August 7	I	I	250	150	10
September 4	I	I	I	80	40
September 11	I	I	I	600	10
September 24	I	I	700	120	0
October 12	380	500	450	340	1
November 13	I	I	700	520	20
November 22	770	400	650	240	10
November 29	I	I	I	I	13
December 14	450	670	680	810	1
December 20	240	1390	780	710	0
January 17	900	950	820	800	1
January 24	1700	1400	100	1300	40
March 13	300	400	200	150	50
March 21	200	200	100	30	20
April 3	350	150	500	1000	60

I = Innumerous

TABLE A-22.2 COLIFORM COLONIES PER 100 ml OF TUBEWELL WATERS

Location of sample	Date	Test Result
Tejgaon, Tap Water	8.5.73	20
I.G. Gate P.S.(before chlorination)	23.7.73	15
I.G.Gate P.S.(after chlorination)	23.7.73	3
I.G. Gate P.S. (Tap water)	23.7.73	10
Narinda P.S. (before chlorination)	24.7.73	20
Narinda P.S.(after chlorination)	24.7.73	5
Abdul Ghani Rd. P.S.	3.8.73	10
Azimpur P.S.	6.8.73	0
Medical College P.S.	6.8.73	0
Dhakeswari P.S.	6.8.73	0
Bonagram P.S.(before chlorination)	10.8.73	0
Bonagram P.S.(after chlorination)	10.8.73	0
Laxmibazar P.S. (before chlorination)	10.8.73	0
Laxmibazar P.S.(after chlorination)	10.8.73	0
Basaboo P.S.	20.8.73	0
Hatkhola P.S.	20.8.73	0
Khilgaon P.S.	20.8.73	0
Nowabganj P.S.	15.10.73	0
Jagannath Saha Rd.(Tap water)	15.10.73	0
Mitford W.S.P.S.	15.10.73	0
Islampur Rd. Tap Water	15.10.73	0
Nayabazar Area, Tap Water	22.11.73	0

TABLE A-23.1 TOTAL COLONIES AT AGAR AT 37°C PER c.c. AT DIFFERENT PHASE OF TREATMENT OF DACCA WATER WORKS

Date of collection	1973			1974			
	Aug 22	Oct 16	Nov 12	Dec 24	Feb 5	Mar 1	Apr 1
Buriganga water	$10^8 \times 4.6$	$10^8 \times 6.5$	$10^8 \times 4.7$	$10^4 \times 2.4$	$10^3 \times 2.5$	$10^2 \times 1.2$	$10^2 \times 3.0$
Settling tank water	$10^7 \times 3.2$	$10^7 \times 4.6$	$10^7 \times 6.3$	$10^4 \times 1.8$	$10^3 \times 2.0$	$10^2 \times 1.8$	$10^2 \times 2.5$
Filtered water before chlorination	$10^2 \times 2.0$	$10^2 \times 2.3$	$10^2 \times 2.0$	$10^4 \times 1.0$	$10^2 \times 2.9$	$10^2 \times 1.6$	$10^2 \times 2.0$
Filtered water after chlorination	0	0	4	15	0	12	2

TABLE A-23.2 TOTAL COLONIES OF TUBEWELL WATERS

Location of sample	Date	Test Results
Jagannâth Saha Road	22.8.73	0
Islampur Road	22.8.73	0
Nayabazar Road	16.10.73	0
Agashadique Road	16.10.73	0
Islampur Road	12.11.73	2
Lalbagh Road	12.11.73	2
Champatoli Lane	24.12.73	12
Khajedwan Road	24.12.73	5
Bangshal Road	5.2.74	0
Islampur Road	5.2.74	0
Hajaribagh	1.3.74	16
Imamganj	1.3.74	14
Asheque Lane	1.4.74	2
Njirabazar	1.4.74	3

TABLE A-24.1 BACT. COLI FAECAL TYPE PER 100 c.c. AT DIFFERENT PHASE OF TREATMENT OF DACCA WATER WORKS

Date of collection	1973				1974		
	Aug 22	Oct 16	Nov 16	Dec 24	Feb 8	March 1	April 1
Buriganga	8	6	6	P	P	P	1800
Settling Tank	6	4	4	P	P	P	110
Filtered water before chlorination	3	2	3	P	P	P	180
Filtered water after chlorination	N	N	N	N	N	N	N

P = Present , N = Nil

TABLE A-24.2 BACT.COLI FAECAL TYPE PER 100 c.c. OF TUBEWELL WATERS

Location of sample	Date	Test Result
Jagannath Saha Road	22.8.73	
Islampur Road	22.8.73	
Nayabazar Road	16.10.73	
Agashadique Road	16.10.73	
Islampur Road	12.11.73	
Lalbagh Road	12.11.73	Nil
Champatoli Lane	24.12.73	
Khajedwan Road	24.12.73	
Bongshal Road	5.2.74	
Islampur Road	5.2.74	
Hazaribagh	1.3.74	
Imamganj	1.3.74	
Asheque Lane	1.4.74	
Nazirabazar	1.4.74	

APPENDIX-B

DACCA CITY PRODUCTION WELL DATA

B-1 PRODUCTION WELL DATA

Sl. No.	Location of wells	Date of completion	well depth	Screen length	Completion well test DATA					Remarks
					SWL (ft)	PWL (ft)	DD (ft)	Q gpm (US)	S Capacity	
1	Banani North End	Nov,'67	416'0"	200'0"	15.33					BS
2	Middle Banani	July,67	430'0"	200'0"	14.80	70.68	55.88	566	11.00	"
3	Gulshan O.T	June,'65	438'0"	179'0"	26.10	52.30	26.20	493	18.40	"
4	Assembly House	Jan,'63	430'0"	168'0"	13.60	36.42	22.82	350	15.50	"
5	Lalmatia	Feb,'64	411'0"	176'0"	30.80	59.70	28.90	481	15.90	"
6	Satmosjid Road									"
7	Sukrabad	March,'66			20.40	32.80	12.40	533	43.00	"
8	Kalabagan	Dec,'64	429'0"	204'0"	26.20	42.10	15.90	489	30.70	"
9	Khilgaon									"
10	T and T, Police Club									"
11	Narinda	Dec,'64			26.30	68.20	41.90	846	20.20	"
12	Hazaribagh O.T	Nov,'61	413'7"	206'0"	33.80	66.00	32.20	683	21.10	"
13	Dhakeswari	June,'61	387'6"	230'0"	28.10	53.00	24.90	866	34.60	"
14	Serajudullah Park	Dec,'61	470'5"	200'0"	23.20	56.40	33.20	625	18.80	"
15	I.G. Gate	Dec,'61			22.80	76.40	43.60	745	17.10	"
16	Hatkhola O.T	Dec,'61	456'9"	200'0"	28.90	66.70	37.80	673	17.50	"
17	Lakshmibazar	June,'66	462'9"	201'0"	26.20	78.50	52.30	715	13.60	"
18	Medical College	Nov,'67	450'0"	144'0"	28.10	56.10	28.00	937	33.50	"
19	Mitford	April,'68	284'0"	152'0"	22.86	51.48	28.62	735	25.70	"
20	Abul Hasnat Road	April,'68	296'0"	152'0"	30.00	55.80	25.80	827	32.00	"
21	P and T Post Office	Oct,'68	340'0"	153'0"	20.60	57.00	36.40	540	15.00	"
22	Dhanmondi Rd. 1	Oct,'68	382'0"	152'0"	29.80	76.20	46.40	664	14.30	"
23	Bejoynagar OT	June, '69	378'0"	152'0"	26.40	41.60	15.20	556	36.60	"
24	DIT Super Market	July,'69	358'0"	152'-0"	27.80	67.00	39.20	810	20.70	"
25	Bonogram	Aug,'68	329'0"	158'0"	28.40	62.50	34.10	855	25.00	"
26	Gandaria	Aug'68	406'0"	138'0"	26.00	54.00	28.00	925	17.30	"

PRODUCTION WELL DATA

Sl. No.	Location of wells	Date of completion	well depth	Screen length	Completion well test DATA					
					SWL (ft)	PWL (ft)	DD (ft)	Q gpm (US)	S Capacity	Remarks
27	JN College	April,'70	376'0"	145'0"	28.00	67.00	39.00	660	17.00	8" SS
28	Kawranbazar	April,'70	349'0"	162'0"	26.00	64.50	38.50	1130	29.40	"
29	Fakirapool OT	May,'70	401'9"	156'0"	28.00	84.33	55.33	1063	19.00	"
30	Rayer Bazar	Oct,'70	374'6"	170'0"	16.00	41.00	25.00	1126	45.00	"
31	Lichubagan	Sept,'70	435'0"	170'0"	18.00	65.00	47.00	1145	24.40	"
32	Basaboo	Sept,'70	415'0"	170'0"	17.00	61.24	44.24	1125	25.40	"
33	Bangladesh Rifle	Oct,'70	399'0"	170'0"	18.00	49.00	31.00	1350	43.50	"
34	Tejgaon (Oxygen)	Oct,'70	378'0"	170'0"	21.00	47.25	26.26	1350	51.40	"
35	Khilgaon	Oct,'70	330'7"	117'0"	16.00	57.00	41.00	1356	33.00	"
36	Hatirpool	Oct,'70	391'10"	170'0"	17.00	44.00	27.00	1350	50.00	"
37	Mohakhali OT	Oct,'70	443'0"	170'0"	23.16	55.00	31.84	1346	42.30	"
38	Banani S. End	Oct,'70	428'0"	170'0"	23.00	50.00	26.00	1452	53.10	"
39	Babar Road	Sept,'70	410'0"	170'0"	21.00	51.00	30.00	1350	45.00	"
40	Asad Gate	Feb,'71	376'7"	170'0"	30.00	71.75	41.75	1394	33.40	"
41	Dacca Water Works	Nov,'71	423'6"	131'0"	27.67	52.00	24.33	1270	52.00	"
42	Kakrail OT	Dec,'71	408'5"	131'0"	20.00	53.00	33.00	1350	41.00	"
43	Shahjahanpur	Feb,'72	435'0"	170'0"	28.58	69.84	40.26	1190	29.50	"
44	Fulbaria	June, '72	390'0"	160'0"	23.00	99.00	75.98	980	13.00	8" BS
45	Bara Moghbazar	June,'72	346'0"	152'0"	25.25	70.00	44.75	1192	26.50	" SS
46	Dhanmondi Rd.No.23	June,'72	375'0"	160'0"	26.00	61.00	35.00	1300	37.00	"
47	Gulshan	Aug,'72	402'0"	166'0"	8.00	43.00	37.00	1100	30.00	"
48	Tejgaon	Sept.'72	338'0"	160'0"	15.58	50.16	34.58	1054	30.00	6" SS
49	Agamashi Lane	Jan,'73	450'0"	138'0"	26.00	74.00	48.00	930	19.00	8" "
50	Farashgonj	June,'73	400'0"	150'0"	22.75	70.00	47.25	950	20.00	"
51	Nawabganj	June,'73	448'0"	150'0"	22.58	58.75	36.17	1103	30.00	"
52	Azimpur	July,'73	425'0"	150'0"	23.25	55.84	32.59	1103	34.00	"

PRODUCTION WELL DATA

Sl. No.	Location of wells	Date of completion	Well depth	Screen length	Completion well test DATA					
					SWL (ft)	PWL (ft)	DD (ft)	Q gpm (US)	S Capacity	Remarks
53	High court	Aug,'74	460'0"	180'0"	20.08	51.03	30.97	1347	43.50	8"SS
54	Mohammedpur N. Rd.	Nov,'73	405'0"	144'0"	32.50	81.42	48.92	1192	22.50	"
55	Bangabhaban	June, '74	465'0"	171'0"	27.58	94.42	66.84	1316	20.10	"
56	Ziktola	Aug,'74	440'0"	168'0"	14.92	76.00	61.00	1350	22.10	"
57	Green Road.	Aug,'74	440'0"	160'0"	21.00	55.85	34.84	1350	38.71	"
58	Rajarbagh	Oct,'74	481'4"	172'0"						"
59	Green Road		440'0"	160'0"				1350	17.93	"
60	Rajarbagh		481'0"	172'0"				1350		"
61	Lalmatia		405'0"	160'0"				1350		"
62	Mohakhali		460'0"	160'0"				1350		"
63	Jimkhana	May,'75	441'0"	160'0"				1350		"
64	Hatkhola		457'0"	160'0"				1350		"
65	Azimpur		414'0"	150'0"				1350		"
66	Stadium		483'0"	161'0"				1350		"
67	Tejgaon Industrial Area		484'0"	180'0"				1350		"
68	Hazaribagh OT		406'0"	160'0"				1350		"
69	Raisaheb Bazar		494'0"	170'0"				1350		"
70	Mill Barak									
71	Dayagonj									
72	Shahjahanpur	Dec,'76	305'0"	175'0"			22 to 34	1583	29.76	
73	Ramna Rly Workshop	Feb,'64	439'10"	152'6"			53.60	605	11.30	
74	Kamalapur	Sept,'75	444'6"	200'0"			59.50	1350	22.50	
75	Rly Loco shed	Jan,'76	438'0"	210'0"			29.88	1100		
76	Shahjahanpur	July,'75	408'0"	200'0"						
77	Kamalapur Rly yard	Feb,'64	489'11"	246'0"			47.80	933		

PRODUCTION WELL DATA

Sl. No.	Location of wells	Sl. No.	Location of wells
78	Mirpur Sec. 1	101	Hoque Brothers
79	Mirpur Sec. 2	102	Nabisco Bread and confectionary
80	Mirpur Sec.6	103	Nabisco Bread and confectionary
81	Mirpur Sec.7	104	Kohinoor Chemical Industries
82	Mirpur Sec. 10	105	Kohinoor Chemical Industries
83	Mirpur Sec. 11	106	Bangladesh Oxygen
84	Mirpur Sec. 12	107	Albert David Ltd.
85	Curzon Hall compound	108	Albert David Ltd.
86	Dacca Hall	109	Tabani Bevarage Co.
87	DU new Art Bldg. 88. TSC	110	Electric Industries
89	Jahurul Hoq Hall	111	Eastern Industries Cooperative Ltd.
90	Azimpur DU staff quarter	112	Rahim Metal Industries
91	Bangladesh Bank Colony	113	Domestic Metal Industries
92	Bangladesh Bank Colony	114	GMG
93	Shahbag WAPDA colony	115	Purbani Hotel
94	CG Colony (BWD)	116	Hotel Intercontinental
95	Engg. University Staff quarter	117	Hotel Intercontinental
96	Engg. University main store	118	Hazaribagh East Asia Tanneries
97	BWD pump near Pirgangi mazar	119	Hazaribagh National Tanneries
98	Central Secretariat	120	Hazaribagh Bangladesh Tanneries
99	Commissioner's Office	121	Hazaribagh pioneer Tanneries
100	Bangladesh Tobacco Co.	122	Ice Factory

Production well data of 50 tubewells (Sl.No.6,9,10,70,71,78-122) is not available.

B.2 Yearwise average daily production of water of Dacca WASA.

Year	Production(mgd)
1968	26.00
1969	30.70
1970	32.10
1971	32.70
1972	34.90
1973	35.80
1974	38.20
1975	40.30

B.3 Average daily production of water within Dacca city area

Source	Production(mgd)
65 nos major wells, 6 nos minor wells, Dacca water works	43.00
7 nos deep tubewells in Mirpur Housing Estate	3.32
6 nos DU tubewells, 6 nos Rly tubewells, 2 nos Engineering University tubewells, 7 nos tubewells of other Govt. Agencies, 10 nos major, 13 nos minor wells used for commerceand industries	12.30
Total	58.62
Say	59.00 mgd

Per capita per day water use including commerce and industrial use, loss and wastage (for 1.31 million population of Dacca city) = 45 gallon.

APPENDIX-C

SUMMARY OF WATER QUALITY DATA

TABLE C-1 QUALITY OF DHANMONDI LAKE WATER[17]

Parameter considered	Minimum	Average	Maximum	Maximum permissible limit WHO, 1971	Maximum permissible limit Bangladesh standard '76
pH	5.60	7.38	8.50	7 to 8.5	6.5 to 9.2
Turbidity, mg/l	∠25.00	-	170.00	5 units	25 units
Total solids, mg/l	130.00	282.50	867.00	500	1500
Total Alkalinity, mg/l	50.00	106.80	212.00	100	
Chloride, mg/l	11.00	42.12	108.00	200	1000
Ammonia, mg/l	0	11.00	22.00		3*
Nitrate, mg/l	0	6.26	17.70	45	50
Chromium, mg/l	0	0	0	0.05	
E.C. micro-mohs/cm	155.00	359.00	650.00	500+	800*
DO, mg/l	0	4.55	13.70		4*
BOD, mg/l	2.00	13.28	70.00	∠ 5+	
COD, mg/l	0	0	0		
Coliform colonies per 100 ml	0	49.00	7500.00	Nil	

* Standards for Fishing waters

\+ Ref. 1

TABLE C-2 QUALITY OF WASTE WATER FROM HAZARIBAGH TANNERIES [17]

Parameter considered	Minimum	Average	Maximum	Maximum permissible limit	
				WHO, 1971	Bangladesh standard '76
pH	7.45	8.55	10.00	7 to 8.5	6.5 to 9.2
Total solids, mg/l	1570	4480	7316	500	1500
Total dissolved solids, mg/l	1015	3664	5379		
Suspended solids, mg/l	376	845	1950		
Phenolphthalein Alkalinity, mg/l	0	114	615		
Total Alkalinity mg/l	220	610	1320	100	
Chloride, mg/l	30	1307	3000	200	1000
Electrical conductance micro mohs/cm	2420	5345	9000	500+	800*
Ammonia, mg/l	112	432	693		3*
Chromium, mg/l	0	14	92	0.05	
DO, mg/l	0	0	0		
BOD, mg/l	250	502	1000	$\angle$ 5+	4*
COD, mg/l	640	2250	8000		
Col, colonies per 100 ml	0	0	0	Nil	

* Standards for Fishing waters

+ Ref. 1

TABLE C-3 BACTERIAL COUNT FOR THE UP AND DOWN STREAM OF THE GLUE INDUSTRIES NEAR CHANDNIGHAT WATER WORKS[17]

Date	Points as shwon in Fig. 3.1	Coliform count/100 ml	
		High tide	Low tide
March, 1975	1	3,250 ↑	3,500 ↓
	2	1,600	5,500
	3	16,750 ↓	7,750 ↑
	4	20,000	6,000
3rd May, 1975	1	600 ↑	300 ↓
	2	250	500
	3	1,250 ↓	1,700 ↑
	4	1,100	1,000
16th May, 1975	1	500 ↑	500 ↓
	2	600	3000
	3	800 ↓	400 ↑
	4	1,000	250
2nd June, 1975	1	400 ↑	600 ↓
	2	2,100	12,500
	3	800 ↓	500 ↑
	4	12,500	70

The arrow heads in the table shows the direction of flow.

TABLE C-4 SUMMARY OF WATER QUALITY DATA OF BURIGANGA RIVER NEAR CHANDNIGHAT[11]

Parameter considered	Mini-mum	Average	Maxi-mum	Maximum permissible limit WHO,'71	Maximum permissible limit Bangladesh standard'76
* Turbidity Units	13	32.7	80	5	25
Total solids, mg/l	76	155.3	250	500	1500
Dissolved solids, mg/l	60	137.3	225		
Colour, mg/l	10	27.7	50	5	30
Total hardness as $CaCO_3$, mg/l	42	93.2	168	100	250 (Max.450)
Total alkalinity as $CaCO_3$, mg/l	42	97.4	176		
* pH	7.1	7.7	8.2	7 to 8.5	6.5 to 9.2
Carbon Dioxide, mg/l	1	2.9	7.2		
Acidity as $CaCO_3$ mg/l	7.8	9.6	12		
Dissolved oxygen, mg/l	5.4	6.7	8		
Soluble Iron as Fe^{+++}, mg/l	0	0.6	2.4	0.1	1 (max.)
Copper as Cu^{++}, mg/l	0	0.5	0.2	0.05	1.5
Calcium as Ca^{++}, mg/l	12	27.8	38	75	
Magnesium as Mg^{++}, mg/l	2	8.1	15	150	
Manganese as Mn^{+++}, mg/l	0	0.03	0.3	0.05	0.5
Sodium as Na^{+}, mg/l	1.5	6.4	16		
Chloride as cl^{-}, mg/l	1	3.1	7	200	600 (maxm.1000)
Fluoride as F^{-}, mg/l	0.1	0.2	0.3	1 (maxm.2)	
Sulphate as SO_4^{-}, mg/l	5	10.3	19	200	400
Nitrates as NO_3^{-} mg/l	0.1	0.3	0.6	45(max.50)	
Bicarbonates as HCO_3^{-}, mg/l	51	119.6	195		
Carbonate as $CO_3^{=}$ mg/l	0	0.2	2.4		
Silica as SiO_2, mg/l	6	19	40		
Phosphate as $PO_4^{\equiv}$, mg/l	Trace	0.1	0.5		
Biochemical oxygen demand, mg/l	0	0.8	1.5		
Specific conductivity, mhos/cm	95	207.5	332		
Coliform group per 100 ml	268	1450	4600		
Total plate count per ml	1440	6331	12300		

* No units.

TABLE C-5 SUMMARY OF WATER QUALITY DATA OF BALLU RIVER NEAR TONGI[17]

Parameter Considered	Minimum	Average	Maximum	Maximum permissible limit	
				WHO,'71	Bangladesh standard,'76
pH	5.85	7.31	8.40	7-8.5	6.5-9.2
Total Solids,mg/l	56	175	301	500	1500
Dissolved solids,mg/l	62	153	235		
Suspended solids,mg/l	7	36	126		
Phenolphthalien Alkalinity,mg/l	0	0	0		
Total Alkalinity,mg/l	24	90	218	100	
Chlorides,mg/l	0	.70	19	200	1000
Electrical conductance micro mohs/cm	58	198	370	500+	800*
Ammonia,mg/l	0	1	1.5		3*
Nitrate,mg/l	∠.01	1	8.62		
Chromium, mg/l	0	0	0	0.05	
DO, mg/l	0.70	5.00	7.40		4*
BOD, mg/l	0.40	3.73	18.00	5+	
COD, mg/l	0	0	0		
Coli. Colonies/100 ml	50	1818	8750	Nil	

* Standards for Fishing Water

\+ Ref. 1

TABLE C-6 SUMMARY OF WATER QUALITY DATA OF SITALAKHYA RIVER NEAR GHORASHAL FERTILIZER FACTORY[17]

parameter considered	Minimum	Average	Maximum	Maximum permissible limit	
				WHO, '71	Bangladesh standard '76
pH	6.00	7.81	9.70	7-8.5	6.5-9.2
Total solids, mg/l	97	265	2600	500	1500
Total dissolved solids, mg/l	80	148	224		
Suspended solids, mg/l	10	69	364		
Phenolphthalien Alkalinity, mg/l	0	5	170		
Total Alkalinity, mg/l	16	117	1180	100	
Chloride, mg/l	0	6.4	195	200	1000
Electrical Conductance micro mhos/cm	0	218	1100	500+	800*
Nitrate, mg/l	0	3.65	53		
Ammonia, mg/l	0	5.54	35		3*
Chromium, mg/l	0	0	0	0.05	
DO, mg/l	1	7	10		4*
BOD, mg/l	.15	2.5	7.00	≯ 5+	
COD, mg/l	0	0	0		
Coli Colonies/100 ml	100	817	3100	Nil	

* Standard for Fishing Water

\+ Ref. 1

TABLE C-7 SUMMARY OF WATER QUALITY DATA OF SITALAKHYA RIVER NEAR DEMRA[9]

Parameter considered	Minimum	Average	Maximum	Maximum permissible limit	
				WHO, '71	Bangladesh Standard, '76
* pH	7.2	7.9	8.73	7-8.5	6.5-9.2
Total dissolved residue, mg/l	50	138	223	500	1500
* Turbidity Units	12	81	380	5	25
Total hardness as $CaCO_3$ mg/l	35	93	156	100	
Total alkalinity as $CaCO_3$, mg/l	34	101	168		
Calcium as Ca^{++}, mg/l	10	25.6	42	75	
Magnesium as Mg^{++}, mg/l	2	6.8	13	150	
Sodium as Na^{+}, mg/l	1.5	5.4	12		
Potassium as K^{+}, mg/l	1.7	2.96	5		
Soluble iron as Fe^{+++}, mg/l	0	-	0.54	0.1	1 (max. 5)
Manganese as Mn^{+++}, mg/l	0	-	0.3	0.05	0.5
Ammonia Nitrogen as NH_4^{+}, mg/l	0	0.13	2.19		
Copper as Cu^{++}, mg/l	0	-	0.14	0.05	1.5
Aluminum as Al^{+++}, mg/l	0	-	0.06		
Carbonate as CO_3^{-}, mg/l	0	2.7	12		
Bicarbonate as HCO_3^{-}, mg/l	41	113	258		
Sulphate as SO_4^{-}, mg/l	4.6	9.2	16	200	
Chloride as Cl^{-}, mg/l	1	3.5	8.1	200	600(max.1000)
Nitrate as NO_3^{-}, mg/l	0	0.41	6.3		45(max.50)
Nitrates as NO_2^{-}, mg/l	0	-	0.72		
Phosphates as PO_4^{-}, mg/l	0	-	0.3		
Fluorides as F^{-}, mg/l	0	-	0.5		1(max. 2)
Boron as BO_2^{-}, mg/l	0	-	4.6		
Silica as SiO_2, mg/l	1	14.7	30		

* No units

APPENDIX-D

COMPARATIVE COST ANALYSIS OF GROUND AND SURFACE WATER FOR PUBLIC WATER SUPPLY

D-1 GROUND WATER

The following material plus labour cost may be required for one 8" diameter deep tubewell operating for 20 hours in a day with 75 HP pump drawing approximately 40,000 gallon ground water per hour.

Sl. No.	Description	Quantity	Unit	Rate (Taka)	Amount (Taka)
1.	$\frac{3}{8}$" thick, 8" diameter seamless steel casing pipe	200 rft	p/rft	315	63,000
2.	8" diameter stainless strainer with slot opening 50/100 inch	170 rft	p/rft	950	1,61,500
3.	$\frac{3}{8}$" thick, 16" diameter seamless steel housing pipe	140 rft	p/rft	375	52,500
4.	16"x8" reducing cone 20" long	1 no.	each	1900	1,900
5.	Centralizer made of $\frac{5}{8}$" diameter steel bars or $\frac{1}{8}$"x1" strap steel	12 nos.	each	220	2,640
6.	Well graded filter gravel for filling the gap in 22" diameter bore hole excluding the portion occupied by the blind pipe, screen and housing pipe etc.	450 rft	p/rft	27.5	12,375
7.	Sanitary grout seal with 1:1:2 cement grout	20 rft	p/rft	33	660
8.	3" diameter steel gravel fill pipe with cap	55 rft	p/rft	33	1,815
9.	8" diameter AC water main	26 rft	p/rft	17	442
10.	8" diameter $22\frac{1}{2}^{0}$ CI bend	1 no.	each	950	950
11.	12"x8"x12" CI tee	1 no.	each	1600	1,600
				Sub total:	2,99,382

Sl. No.	Description	Quantity	Unit	Rate (Taka)	Amount (Taka)
					B.F.2,99,382
12.	4" diameter water meter	1 no.	each	3000	3,000
13.	10"x12" MS reducer	2 nos.	each	900	1,800
14.	12" diameter MS dresser coupling complete with nuts bolts, and rubber ring	4 nos.	each	500	2,000
15.	8" diameter MS dresser coupling complete with nuts bolts and rubber ring	2 nos.	each	350	700
16.	10" diameter MS dresser coupling complete with nuts bolts and rubber ring	2 nos.	each	460	920
17.	12" diameter SV with tail pieces	2 nos.	each	4000	8,000
18.	Construction of sluice valve chamber	2 nos.	each	300	600
19.	12" diameter PVC valve box	2 nos.	each	450	900
20.	Construction of cement concrete thurst block (1:3:6)	20 cft	p/cft	19	380
21.	Mechanical and Electrical goods like submerssible turbine pump, column pipe, motor, H.T and L.T. transformer etc.	1 unit	p/unit	8 lakh	8,00,000
22.	Construction of PS building including HT and LT foundation, pump base foundation;chlorine room,boundry wall, gate etc. all complete	1 unit	p/unit	1 lakh	1,00,000
23.	Cost of land (about 3 katha)	1 unit	p/unit	50000	50,000
24.	Labour cost for sinking, development and testing of the tubewell	1 unit	p/unit	1 lakh	1,00,000
				Sub total :	13,67,682

Sl. No.	Description	Quantity	Unit	Rate (Taka)	Amount (Taka)
				B.F.	13,67,682
25.	Labour charge for mechanical and electrical installations	1 unit	p/unit	60000	60,000
				Total:	14,27,682
				Say	14,28,000
	which includes about US dollar 45,734 foreign exchange				
	Considering 12 years as the age of the tubewell, yearly valuation of the tubewell				1,19,000
	Monthly valuation of the tubewell				9,916

Monthly recurring cost

Power	Tk.	18,000
Chemicals	Tk.	2,000
Maintenance	Tk.	100
Labour and administration	Tk.	2,000
Depreciation	Tk.	100
Interest	Tk.	300
Total:	Tk.	22,500

	22,500
Grand total, monthly valuation	32,416
Daily valuation	1,080

Daily available supply from the deep tubewell under consideration = 0.8 million gallon. So, the cost of per million gallon ground water = Tk. 1350.

D-2 SURFACE WATER

PARSONS CORPORATION, Engineering Consultant of Dacca Water Supply and Sewerage Authority prepared an estimate in the year 1973 for the proposed 50 mgd surface water treatment plant at Demra. The estimated cost of the farm is as follows:

Sl. No.	Description	Local cost (Taka)	Foreign exchange (US dollar)
1.	Dock and raw water intake structure	4,37,500	1,20,000
2.	Alum storage tank 1 no.	25,000	16,000
3.	Raw water PS and Switch gear room including necessary pumps for 50 mgd	10,00,000	8,80,000
4.	Raw water and pre-treatment structure(coagulation tanks)	1,25,000	40,000
5.	Settling basins 3 nos. and flow control chamber	15,00,000	8,00,000
6.	Rapid sand filters and control building	50,00,000	16,00,000
7.	Clear water storage tanks(2 nos.) and low service PS including pumps	11,25,000	4,80,000
8.	Chemical operation building and equipments for feeding	11,25,000	6,40,000
9.	Wash water storage tank	1,40,000	1,00,000
10.	Wash water recovery basin	50,000	10,000
11.	Electrical sub-station	12,50,000	4,80,000
12.	Engineer's Field office building	75,000	20,000
13.	Sewage lagoons	25,000	5,000
14.	Storage tanks(capacity 12 mg)	12,50,000	4,80,000
15.	High service PS including pumps for 20 mgd	10,00,000	8,00,000
	Sub total :	1,41,27,500	63,11,000

Sl. No.	Description	Local cost (Taka)	Foreign exchange (US dollar)
	B.F	1,41,27,500	63,11,000
16.	Site development including fencing, internal roads etc.	50,00,000	
17.	Earth work for structures including back filling and removing excess earth	2,50,000	
18.	R.C.C piling in foundation of structures (from 12" to 22" for 3,50,000 rft)	1,00,00,000	6,40,000
19.	Gravel and sand for filters	7,50,000	
20.	Piping within the water works including valves (sizes vary from 4" to 90")	1,25,00,000	16,00,000
21.	Miscellaneous	50,00,000	
	Sub total:	4,76,27,500	87,11,000
22.	36" diameter transmission main from Demra-Jatrabari	2,37,50,000	26,40,000
23.	Land acquisition and development for future booster pump station and storage tanks(14 acres)	15,00,000	
24.	Booster plant 2 nos.	67,00,000	10,00,000
25.	30" and 24" supply main connecting from Jatrabari to Gulshan Model town with inter-connections to 18" main at different places through East interceptor sewer alignment(40,000 ft)	93,75,000	8,00,000
26.	Rehabilitation and extension of old existing water distribution system for an adequate supply to the capital area (4" to 18" =2,50,000 ft)	50,00,000	5,00,000
	Sub total:	9,39,52,500	1,36,51000
	Escalation 5%	46,97,625	6,82,550
	Sub total:	9,86,50,125	1,43,33,550
	Unallocated contingency 10%	98,65,012	14,33,355
	Sub total:	10,85,15,137	1,57,66,905

Sl. No.	Description	Local cost (Taka)	Foreign exchange (US dollar)
		B.F 10,85,15,137	1,57,66,905
27.	Land acqn. and development (126 acre in Treatment plant area plus 30' wide land from Demra to Jatrabari for water supply main)	2,00,00,000	
28.	Feasibility study, design and specification etc.	6,00,000	1,00,000
29.	Engineering services during construction by consultant	80,00,000	15,00,000
30.	Authority's supervision	40,00,000	
	Sub total:	14,11,15,137	1,73,66,905
31.	Duties and Taxes	7,66,00,000	
	Total:	21,77,15,137	1,73,66,905

Say 21.80 crores

Say US dollar 1.74 crores
= Tk. 26.10 crores

Total (local cost + Foreign exchange) = Tk.47.90 crores.

Yearly valuation (considering 100 years as the age of the water works) = Tk.47.90 lakh

Yearly operating cost	Taka in lakh	
Power	66	
Chemicals	25	
Maintenance	22	
Labour and Administration	19	
Depreciation	10	
Interest	8	
Annual recurring cost	150	150.00
Total Annual cost		Tk. 197.90 lakh

Say Tk. 198.00 lakh

B.F. Tk.198.00 lakh

Enhancement of cost due to increase in the prices of labour and material both in the international market and within the country. 30% Tk. 59.40 lakh

Grand total: Tk.257.40 lakh

So, the cost of per million gallon surface water =Tk. 1430.00

D-3 COMPARATIVE COST BETWEEN GROUND AND SURFACE WATER

The cost of one million gallon ground and surface water is calculated in art. D-1 and D-2. The calculated cost per million gallon ground and surface water are Tk.1350.00 and Tk. 1430.00 respectively which shows that ground water is about 6% cheaper than surface water.