ASSESSSMENT OF SURFACE AND GROUNDWATER QUALITY IN KUSHTIA FOR AGRICUTURAL USES

A

THESIS

BY

MD. RAKIBUL ISLAM

Student No. 1205074

Session: 2012-2013

Thesis Semester: January-June, 2013

MASTER OF SCIENCE (M.S.)

IN

AGRICULTURAL CHEMISTRY

DEPARTMENT OF AGRICULTURAL CHEMISTRY
HAJEE MOHAMMAD DAESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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June, 2013

Dedicated to
My
Parents

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The Author
June 2013

ABSTRACT

The assessment of water quality in agriculture is essential for irrigating various crops. An investigation was conducted during January-March, 2013 to assess the ionic constituents of groundwater and surface water of the Kustia district in Bangladesh. Exactly 40 water samples were collected and analyzed for pH, EC, TDS, cations (Ca, Mg, Na, K, and P) and anions (HCO_3 and CO_3) of different locations in the Kustia district. The calcium content in different sources varied from 11.86 to trace amount. The highest amount was recorded in Padma river water while rain and dew water shoed no Ca content. Highest amount (10.52 mg L^{-1}) of Mg was found in Padma river water. Likewise Ca content, Mg was also nil in rain and dew water. The SO_4-S content ranged from 0.521 mg L^{-1} to trace) was found in the treatment of Canal water. The soluble P content ranged from 0.412 mg L^{-1} to trace. The soluble K content varied from 0.324 mg L^{-1} to trace which is suitable for irrigated agriculture. The dissolved Na content was nil in rain and dew water but the 4.20 mg L^{-1} was observed in pond water which is not problematic for irrigated agriculture. Maximum amount (3.226 mg L^{-1}) of carbonate and bicarbonate was found in the pond water while the trace amount of CO_3 & HCO3 was found in the rain and dew water. Maximum amount (2.34 μS cm^{-1}) of electrical conductivity was found in the pond water. The EC ranged from 3.24 to nil. The pH of the solution is very important in plant nutrition, and range pH beyond the limit can lead to problems. In the analysis of kustia district water the pH was slightly acidic to slightly alkaline ranging from 6.30 to 7.6. The concentration of TDS was found within the safe range for agricultural uses. The electrical conductivity was found suitable for irrigation uses.

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INTRODUCTION

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INTRODUCTION

Agriculture is the greatest uses of water accounting for 80% of all consumption. Water quality for irrigation is a most important criterion for successful crop production as it contains different ions in varying concentrations. Irrigated agriculture is dependent on water of useable quality. If low quality of water is used for irrigation, toxic elements may accumulate in the soils and deteriorates soil properties. In Bangladesh, major part of arable land is under rain fed ecosystem. Farmers face acute shortage of irrigation water during dry season and use irrigation water from groundwater sources. Besides, agricultural point of view, water of desirable quality is absolutely essential for drinking, aquaculture and industrial usage. Thus water quality assessment is the most significant aspect of water management irrespective of its utility.

Surface water is an important source of freshwater for agricultural and domestic uses in many regions of the world and also in Bangladesh. Demand of surface water has been increasing day by day for irrigation by bringing more area under cultivation. Water generally contains different species of cations and anions in varying amounts. The principle soluble ions are Ca, Mg, Na, and K as cations and Cl, SO_4, CO_3 and HCO_3 as anions. Besides these, Cu, PO_4, Fe, Mn, Zn, As, B, Si and F are present in small amounts. Out of soluble constituents Ca, Mg, Fe, Na, Cl, HCO_3, SO_4 and B are of prime importance in determining the quality and suitability of irrigation water, especially for rice. Certain soluble ions at relatively high concentrations have a direct toxic effect on sensitive crops. The toxic elements are B, Na, Cl and Li. Specific water may be suitable for irrigation but may not be suitable for drinking and industrial uses due to presence of some other ions at toxic level. Most toxic elements for drinking water are As, Cd, Cr, Cl, Pb, Hg, Fe and Zn. The quality of water is generally judged by its total salts concentrations, relative proportion of cations or sodium absorption ratio (SAR) and the contents of HCO_3. The concentrations of some important chemical constituents of water are necessary to assess their suitability for irrigation drinking and industrial uses.

Some studies on the quality of water in some selected areas of Bangladesh namely, Thakurgoan, Rangpur, Comilla, Narayangong, Gazipur, Jamalpur, Pabna and many other regions of Bangladesh. Most of the chemical analyses of these investigation included pH, EC, Ca, Mg, CO_3, HCO_3, Cl, Na, Cu, Mn, Zn and Fe. But little attention has been given to the concentration of micronutrients and toxic elements (e.g. Cu, Mn, Zn, Fe, As, Cr, Pb, Hg, Cd etc.). Now-a-days, analyses of water from groundwater sources to determine the toxic elements are very important for irrigating crops, domestic uses, drinking, livestock, poultry, aquaculture and industrial usage. Unfortunately, there is no laboratory for systematic investigation of the water quality in Bangladesh.

Ground water seems to be pure and free from suspended material in comparison to surface water, yet many compound and/or ions in varying amounts may be present in dissolved and/or ionic forms. If low quality water is used for drinking, domestic and beneficial uses, ionic toxicity as well as health hazards may occur. Sometimes, those substances are found at an objectionable level in groundwater and considered as contaminated. When these waters are used in various irrigation, drinking and industrial purposes, they deteriorate the quality of the products. In some cases, ionic toxicity may occur and respective products become unsuitable for beneficial uses. For each use there is a water quality recipe that specifies limiting concentrations of such variables as pH, total dissolved solid (TDS), total hardness (H_T), temperature and some ionic constituents. In spite of these chlorine and sulphate are the significant variables to assess the toxicity and suitability of the water for industrial usage (Raghunath, 1987).

In view of importance for the formulation of a base line data an investigation has been conducted to assess the toxicity of surface water for irrigation & industrial usage in Kustia District.

In the study area, there is different water source in which of shallow machine were mainly applied for irrigation. In cropping sequences; rice, vegetable and rabi crops were also found to be cultivated. Farmers apply irrigation water from surface water sources without testing of water quality. But there is no organization to assess the extent of water toxicity systematically at field level. Keeping all these facts in mind, this area was selected to evaluate the toxicity levels of surface water.

Objectives:

An attempt has been made to conduct a research work with the following objectives:

1. To assess the usability of some surface water of Kustia district.
2. To predict the suitability and acceptability of water for irrigation and industrial uses.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Water is a universal solvent and contains variable quantities of inorganic and organic substances. Sometimes, suspended and colloidal materials are also found in it. It is necessary to determine the quality of water and its possible effects on soil properties due to long term irrigation and it's suitability for drinking and industrial usage. Few research works have been conducted on this perspective at home and abroad. But systematic research work on the Kustia is limited. An attempt has been made in this chapter to review the pertinent research information related to water pollution or quality assessment. Some relevant research reports are mention here under the following heads:

Ground and surface water pH of Matiranga Thana in Khagrachari district ranged from 4.02 to 7.54 indicating acidic to slightly alkaline (Helaluddin, 1996).

The pH of ground and surface waters of Meherpur ranged from 7.80 to 8.10 and all waters under test were not problematic for irrigating agricultural crops (Quddus and Zaman, 1996). The water quality at different, locations in Northeast, North and Northwest of China was evaluated by Zheng *et al.* (1996). They observed that pH were high at most of the locations. Research work with 15 water samples collected from river, deep and shallow tubewells of Shahjadpur thana under the district of Sirajgonj showed that the pH values varied from 8.20 to 8.50 (Zaman and Rahman, 1996). Zaman and Mohiuddin (1995) conducted an experiment at Pangsha Thana in Rajbari district and found that the pH varied from 8.10 to 8.30. Groundwater pH of Modhupur under Tangail district was within the limit of 8.20 to 8.50 (Zaman and Majid, 1995).

The pH of different sources of irrigation water of Khalihati and Ghatail thans under Tangail district varied from 6.88 to 8.29 (Razzaque, 1995). Groundwater pH of Phulpur Thana under Mymensingh district was within the range of 8.10 to 8.30 (Shahidullah, 1995). In groundwater samples collected from Gazipur recorded the pH ranging of 7.25 to 8.62 (Quayum, 1995). Ibrahim and Salmon (1992) observed that the pH of irrigated water of Faisalabad City, Pakistan effluent ranged from 7.00 to 8.20.

The electrical conductivity (EC) of collected from Lakshmipur and Noakhali district water samples was within the limit of 159.86 to 1087.97 $\mu S\ cm^{-1}$ (Uddin, 2005). The electrical conductivity (EC) of 136 groundwater samples from Eastern Surma Kushiara floodplain and neighbouring region of Sylhet division were found 19.57 to 1655.40 $\mu S\ cm^{-1}$ (Ahsan, 2004). The EC of 93 groundwater samples from Dinajpur district to ranged from 75.47 to 565.35 $\mu S\ cm^{-1}$ (Uddin, 2004). The EC of 85 groundwater samples collected from Kushtia and Chuadanga districts were found to range from 412 to 1331 $\mu S\ cm^{-1}$ (Azad, 2004). The EC of 46 groundwater samples collected from Pabna sadar upazila were found varried from 0.47 to 0.90 $dS\ cm^{-1}$ (Arefin, 2002). Latha *et al.* (2002) analysed 133 water samples from Avinashi, Pollachi and Palladam areas of Tamil Nadu, the EC values was varied from 0.45 to 4.50, 2.27 to 9.95 and 0.2 to 2.7 $dS\ m^{-1}$, respectively and also observed that EC > 3 $dS\ m^{-1}$ were unsuitable for irrigation as they liable to cause salinity and sodicity in soils. The EC of 50 groundwater samples collected from Sherpur upazila under Bogra district were found to range from 442.80 to 670.80 $\mu S\ cm^{-1}$ (Rahman, 2001).

The EC of surface and groundwater samples of Narayangonj aquifers varied from 164 to 1894 $\mu S\ cm^{-1}$ (Sarker, 1997). The EC of groundwater at Madhupur districts ranged from 247.78 to 870.45 mg L^{-1} (Azad, 2004). Thirumathal and Sivakumar (2004) studied groundwater quality at Swaminathapuram, Dindigul districts and Tamil Nadu showed that groundwater samples contained total dissolved solids to range from 86 to 1165 mg L^{-1}. The total dissolved solids of groundwater of Pabna sadar upazila under Pabna district ranged from 336.26 to 671.89 mg L^{-1} (Arefin, 2002). The total dissolved solids of groundwater of Sherpur under Bogra district ranged from 194.85 to 458.48 mg L^{-1} (Rahman, 2001). The TDS of some surface and groundwater of Tongi under Gazipur district ranged from 123 to 675 mg L^{-1} (Sen *et al,* 2000). The total dissolved solids of ground water in Gaibandha aquifers ranged from 192 to 1000 mg L^{-1} (Jesmin, 2000).

The TDS of irrigation water collected from sadar Thana under Gazipur district ranged from 70 to 260 mg L^{-1} (Quayum, 1995). The TDS of both ground and surface waters at Kalihati and Ghatail thanas of Tangail district varied from 90 to 212 mg L^{-1} (Razzaque, 1995). Zaman and Majid (1995) stated that the ground waters of Madhupur Thana under Tangail district contained TDS ranging from 100 to 600 mg L^{-1} showing freshwater in quality. Hussain *et al.* (1991) observed that the mean TDS of groundwater of 15 Punjab districts was 1252 mg L^{-1}.

The Ca content in groundwater of Bagmara, Mahadebpur and Nachoul Upazilas varied from 0.80 to 4.00, 0.20 to 3.60 and 1.50 to 3.50 me L^{-1}, respectively (Zaman, 2000). Quddus and Zaman (1996) reported that Ca, Mg, Na and K contents in surface and groundwater of Meherpur ranged from 2.06 to 2.80, 1.01 to 1.60, 0.28 to 0.68 and 0.12 to 0.32 me L^{-1}, respectively. The contents of these four elements in irrigation water collected from Shahzadpur upazilla under Sirajgonj district varied from 2.00 to 4.40, 1.09 to 2.19, 0.10 to

0.42 and 0.91 to 1.39 me L^{-1}, respectively (Rahman and Zaman, 1995) and in groundwater samples of Pangsha thana under Rajbari district varied from 1.20 to 2.90, 1.00 to 1.30, 0.43 to 3.05 and 0.05 to 0.18 me L^{-1} respectively (Zaman and Mohiuddin, 1995).

The Ca, Mg, Na and K contents in of groundwater of Mukatagacha ranged from 0.20 to 1.50, 0.63 to 1.73, 0.35 to 4.09 and 0.021 to 0.056 me L^{-1} with the mean values of 1.10, 1.09, 1.86 and 0.039 me L^{-1} respectively (Hossain and Ahmed, 1999). Mitra and Gupta (1999) observed that during monsoon season, Ca, Mg, Na and K contents in tubewell water in vegetable growing area around Kolkata were 8.00, 3.40, 1.30, 0.50 me L^{-1} while in winter season the concentrations of those cations were 9.00, 4.20, 1.60 and 0.90 me L^{-1}, respectively.

Anil Sood *et al.* (1998) reported that the concentration of (Ca + Mg) and Na of underground water of Bathinda district of the Punjab in India ranged from 1.30 to 47.30 and 3.00 to 90.10 me L^{-1}, respectively. The contents of Ca, Mg, Na and K in tubewell waters of Bikaner district of Rajastan in India varied 0.20 to 0.80, 0.10 to 1.90, 0.50 to and 0.10 to 0.70 m mol L^{-1}, respectively (Lal *et al.,* 1998).

The waters of pond, hand-pump and tubewells of Bulandshahar district, Uttar Pradesh in India contained Ca, Mg, Na and K within the limit of 0.00 to 11.20, 0.00 to 26.30, 0.00 to 22.70 cmol L^{-1}, 13.20 to 37.60, 12.20 to 75.20, 16.90 to 4.40 cmol L^{-1}; 7.00 to 13.90, 1.40 to 13.90, 1.60 to 4.30 cmol L^{-1} and 0.30 to 1.10, 0.10 to 0.70, 0.20 to 0.80 cmol L^{-1}, respectively (Ashok Kumar *et al.,* 1998).

Shahidullah (1995) reported that the concentrations of Ca, Mg, Na and K in ground water of Phulphur thana under Mymensingh district ranged from 1.40 to 2.65, 0.65 to 1.08. 0.23 to 1.40 and 0.04 to 0.26 me L^{-1}, respectively and of ground water samples collected from some villages of Madhupur thana under Tangail district varied from 0.72 to 3.12, 0.78 to 3.12, 0.10 to 0.80 and 0.14 to 0.58 me L^{-1}, respectively (Zaman and Majid, 1995). Quayum (1995) showed that the groundwater collected from Gazipur sadar Thana contained Ca, Mg, Na and K within the range of 0.55 to 1.65, 0.04, 0.43 to 1.00 and 0.02 to 0.05 me L^{-1}, respectively. Pucci *et al.* (1992) carried out an experiment on confixing unit effects on water quality in the New Jersey Coastal Plain and stated that the concentrations of Ca and Mg ranged from 1.70 to 666.00 mg L^{-1} and 0.30 to 140.00 mg L^{-1}, respectively.

The Fe contents in groundwater of Bagmara, Mahadebpur and Nachoul ranged from 0.005 to 0.39, 0.01 to 3.72 and trace to 0.44 mg L^{-1} respectively (Zaman *et al,* 2000). Hossain and Ahamed (1999) reported that the Fe concentrations of Muktagacha aquifers ranged from 0.01 to 0.06 mg L^{-1}, with the mean value of 0.03 mg L^{-1}. Mitra and Gupta (1999) reported that the Fe content of tubewell water of vegetable growing area around Kolkata during monsoon and winter were 17.60 and 80.60 μg L^{-1}, respectively. Sarker (1997) found that the Fe content of Narayangonj aquifers varied from 0.025 to 0.16 mg L^{-1}.

The concentration of Fe in groundwater of Phulpur Thana under Mymensingh district was within the range of 0.10 to 1.30 mg L^{-1} (Shahidullah, 1995). Quayam (1995) reported that Fe content in groundwater of Gazipur sadar thana ranged from traces to 2.30 mg L^{-1} .The irrigation water samples of Pangsha thana of Rajbari contained Fe within the range of 0.10 to 2.00 mg L^{-1} (Mohiuddin, 1995). Rahman (1993) reported that the surface and groundwater of Shahzadpur thana in Sirajgonj district contained Fe within the range of 0.10 to 0.42 mg L^{-1} and iron was dominant in groundwater compared to surface water. Quddus (1993) cited that the concentrations of Fe in surface and groundwater of Meherpur sadar thana ranged from traces to 0.05 mg L^{-1}.

An investigation was conducted by Hoque (2000) to evaluate the water quality in Sherpur upazila under Sherpur district. He observed that the concentrations of Mn in these areas varied from 0.05 to 0.58 mg L^{-1}. The concentrations of Mn in surface and groundwater collected from Tongi aquifers ranged from trace to 0.30 mg L^{-1} (Sen *et al.,* 2000). Zaman *et al.* (2000) conducted a study at three upazillas (Bagmara, Mahadebpur and Nachoul) in Barind area and observed that the mean values of Mn in groundwaters were 0.11, 0.134 and 0.0478 mg L^{-1}, respectively.

From the results of chemical analyses, Razzaque (1995) reported that the Mn content of some surface and groundwater samples of Kalihati and Ghatail thana under Tangail district ranged from 0.01 to 0.07 mg L^{-1} in Shahzadpur contained Mn within the ranged of 0.030 to 0.064 mg L^{-1} (Rahman, 1993), in Meherpur Sadar thana it ranged from trace to 0.20 mg L^{-1} (Quddus, 1993), in Narayangonj aquifers it varied from trace to 0.03 mg L^{-1} (Sarker, 1997) and in Nachoul at High Barind it was within the limit of 0.003 to 0.102 mg L^{-1} (Ali, 1997).

The content of PO_4 in surface and groundwater samples collected from Bhaluka upazila under Mymensingh district ranged from trace to 0.47 mg L^{-1} (Nizam, 2000). Groundwater samples collected from Gaibandha aquifer contained small amount trace to 1.10 mg L^{-1} of PO_4 (Jesmin, 2000). Rahman (2000) assessed the groundwater quality of Atrai upazila under Naogaon district and observed that the contents of PO_4 ranged from trace to 2.19 mg L^{-1}. Phosphate content of groundwaters collected from Bagmara, Mahadebpur and Nachoul upazilas varied from trace to 0.07, trace to 0.22 and 0.03 to 0.45 mg L^{-1}, respectively

(Zaman, 2000) and that of Muktagacha aquifers ranged from 0.10 to 1.40 mg L^{-1} with the mean value of 0.85 mg L^{-1} (Hossain and Ahmed, 1999).

The concentration of PO_4 during both monsoon and winter seasons was 0.02 mgL^{-1}in tubewell water of vegetable growing area around Kolkata (Mitra and Gupta,1999). The PO_4 content in waters collected from Narayangonj aquifers variedfrom 0.005 to 2.12 mg L^{-1} (Sarker, 1997). An experiment was earned out by Zaman and Majid (1995) to evaluate the groundwater pollution at Rajbari district and showed that the PO_4 concentration in all collected water samples ranged from 0.02 to 0.09 mg L^{-1}. The PO_4 content of surface, shallow and deep tubewell waters of Meherpur sadar under Meherpur district ranged from 0.12 to 0.32 mg L^{-1} (Quddus and Zaman, 1996).

The boron (B) content of groundwater of of Lakshmipur and Noakhali district ranged from 0.45 to 1.2 mg L^{-1} (Uddin, 2005). The boron (B) content of groundwater of Eastern Surma Kushiara floodplain and neighbouring regions of Sylhet division ranged from 0.01 to 0.3 mg L^{-1} (Ashan, 2004), that of Dinajpur district ranged from 0.10 to 0.58 mg L^{-1} (Uddin, 2004) and of Kushtia and Chuadanga districts varied from trace to 0.1 mg L^{-1} (Azad, 2004). Nizam (2000) stated that B content in surface and ground water samples collected from 11 unions of Bhaluka upazila under Madhupur Tract ranged from 0.06 to 1.10 mg L^{-1}. Alamgir *et al.* (1999) analyzed groundwater samples of Madhupur Tract and recorded that the concentration of B ranged from 0.10 to 0.20 mg L^{-1} and these waters were not problematic for irrigating agricultural crops.

The B content in Narayanganj aquifers ranged from 0.06 to 0.62 mg L^{-1} (Sarker, 1997), that of Nachoul Thana under High Barind area was within the range of 0.003 to 0.53 mg L^{-1} (Ali, 1997). Quddus and Zaman (1996) reported that B content in surface and ground waters in some villages of Meherpur sadar under Meherpur district ranged from 0.10 to 0.63 mg L^{-1} that of Shahzadpur Thana under the district of Sirajganj ranged from 0.10 to 0.40 mg L^{-1} and all the waters under test were safe for irrigation (Rahman and Zaman, 1995). Zaman and Mohiuddin (1995) found that B content in ground waters of Pangsha Thana under Rajbari district varied from 0.08 to 0.45 mg L^{-1}. The content of B in water samples collected from Ghalial Thana under Tangail district was within the range of 0.01 to 0.45 mg L^{-1} and all the waters were 'excellent' to 'good' in quality for irrigation usage (Razzaque, 1995). An investigation was conducted by Quayum (1995) and to evaluate the quality of groundwater collected from Gazipur sadar under Gazipur district and showed that B concentration varied from 0.15 to 0.54 mg L^{-1}. Out of the 160 water samples B concentration was recorded over 1.50 mg L^{-1} for only 8% samples from the Catoledo Rochamicro region (Costa *et al.,* 1995). The amount of B in surface and groundwater of some village of Meherpur sadar thana ranged from 0.10 to 0.63 mg L^{-1} (Quddus and Zaman, 1996).

The concentration of arsenic (As) in groundwater of of Lakshmipur and Noakhali district ranged from 0.004 to 0.369 mg L^{-1} (Uddin, 2005). The concentration of arsenic (As) in groundwater of Eastern Surma Kushiara floodplain and neighbouring regions of Sylhet division varied trace to 0.25 mg L^{-1} (Ahsan, 2004). The concentration of As in groundwater of Dinajpur districts ranged from 0.006 to 0.509 mg L^{-1} (Uddin, 2004). Azad (2004) reported that As content in groundwater samples collected from Kushtia and Chuadanga district ranged from 0.02 to 1.1 mg L^{-1}. The concentration of As in groundwater of Pabna sadar upazila was not detectable (Arefin, 2002). Zaman *et al.* (2001) analyzed 18 groundwater samples collected from shallow and

The tubewell waters collected from Fakirapara in 24 Parganas district of West Bangal, 89% tubewell waters contained above 0.50 mg L^{-1} As, 4.3% having <0.01 mg L^{-1}, 6.5% having 0.01 to 0.05 and 0.051 to 0.099 mg L^{-1}, 26.1% having 0.01 to 0.299 mg L^{-1}, 21.74% having 0.30 to 0.499 mg L^{-1}, 17.5% having 0.50 to 0.699 mg L^{-1} and 10.9% having 0.70 to 1.00 mg L^{-1} (Mondal *et al.,* 1998). Arsenic (As) pollution was not delected in all the waters samples collected from Tongi aquifers because the content of As was below 0.05 mg L^{-1} as cited by Sen *et al.* (1997). Brooks (1996) noted that chromated copper arsenic treated wood poles, which has been used worldwide since 1993, were one of the most important sources of As in aquatic environment.

The surface and groundwater of Tongi under Gazipur district contained SO_4 within the ranged from trace to 11.00 mg L^{-1} (Sen *et al.,* 2000). Jesmin (2000) reported that groundwater collected from Gaibandha aquifers SO_4 content ranged from trace to 61.00 me L^{-1}. Rahman (2000) carried out an experiment for the assessment of water quality in Lower Atrai Basin and stated that SO_4 concentrations varied from trace to 0.40 me L^{-1}. Zaman and Majid (1995) stated that the concentrations of SO_4 in groundwater in some villages of Madhupur under Tangail district ranged from 0.12 to 2.16 me L^{-1}. Cl ion was dominant along with SO_4 ion in small amounts in river and groundwater collected from Shahzadpur under Sirajgonj district (Rahman and Zaman, 1995). The contents of SO_4 in surface and groundwater in some village of Meherpur sadar under Meherpur district varied from trace to 7.20 me L^{-1} (Quddus and Zaman, 1996).

The concentration of CO_3 in groundwater of Lakshmipur and Noakhali district ranged from trace to 45 mg L^{-1} and the concentration of HCO_3 ranged from 12 to 356 mg L^{-1} (Uddin, 2005). The concentration of CO_3 in Eastern Surma Kushiara floodplain and neighbouring region of Sylhet division was not detectable and the concentration of HCO_3 ranged from 8.5 to 569.1 mg L^{-1} (Ahsan, 2004), in Dinajpur district CO_3 varied from 21.97 to 266.05 mg L^{-1} (Uddin, 2004). In Kushtia and Chuadanga districts the amount of CO_3 in all the groundwater samples varied from trace to 25.8 mg L^{-1} and HCO_3 concentration was within the range of 115.33 to 475.96 mg L^{-1} (Azad, 2004), in Pabna sadar upazila CO_3 was not detectable and the concentration of HCO_3 ranged from 3.50 to 7.00 me L^{-1} (Arefm, 2002). In Madhupur Tract, the concentration of CO_3 in water ranged from trace to 2 00 mg L^{-1} and HCO_3 content varied from 0.50 to 8.00 me L^{-1} (Nizam, 2000). Sen *et al.* (2000) found that in ground water of Tongi under Gazipur district the concentration HCO_3 varied from 0.80 to 6.20 me L^{-1}. Hoque (2000) reported that in ground water of Old Brahmaputra Flood plain the concentrations of CO_3 and HCO_3 in surface and groundwater varied from 0.05 to 1.50 me L^{-1} and 0.60 to 3.50 me L^{-1}, respectively and in Gaibandha aquifers CO_3 content was not within detectable range and HCO_3 concentration was within the limit of 1.50 of 6.00 mg L^{-1} (Jesmin, 2000).

The concentration of CO_3 and HCO_3 of groundwater collected from Bagmara, Mahadebpur and Nachoul aquifers varied from trace to 1.20, 1.0 to 4.40; trace to 1.20, 1.20 to 3.60 and trace to trace, 4.22 to 5.40 me L^{-1}, respectively (Zaman, 2000). Hossain and Ahmed (1999) collecting 25 groundwater samples from Muktagacha aquifer stated that CO_3 and HCO_3 contents of those waters varied from 0.10 to 0.30 and 1.00 to 3.58 mg L^{-1} respectively. Lal *et al.* (1998) determined the quality of underground waters of non-command area of Bikaner district Rajasthan, India slated that CO_3 + HCO_3 contents were within the range of 1.60 to 7.80 mmol L^{-1} concentration of CO_3 and HCO_3 of groundwater collected from Narayangonj aquifers varied from 0.08 to 1.16 and 0.32 to 6.10 me L^{-1}, respectively (Sarker, 1997).

Ali (1997) assessed the groundwater quality of high Barind Tract and showed that HCO_3 content of those waters varied from 2.00 to 5.40 me L^{-1}. 66 water samples were collected from 5 different surface and groundwater sources of Tangail district and were analyzed. All the samples contained HCO_3 and CO_3 within the range of 0.60 to 0.85 me L^{-1} (Razzaque, 1995). Zaman and Majid (1995) found that groundwater of Meherpur Sadar under Meherpur district contained CO_3 and HCO_3 within the range of 0.04 to 0.04 and 0.80 to 2.52 me L^{-1}, respectively in Pangshathana under Rajbari district these ranged from 0.16 to 1.12 and 2.24 to 3.52 me L^{-1}, respectively (Zaman and Mohiuddin, 1995).

The computed SAR of groundwater of Lakshmipur and Noakhali district ranged from 0.40 to 4.20 (Uddin, 2005). The computed SAR of groundwater from Eastern Surma Kushiara floodplain and neighbouring region of Sylhet division ranged within 0.082 to 35.79 (Ahsan, 2004), that of Dinajpur district ranged from 0.187 to 3.244 (Uddin, 2004), and in Kushtia and Chuadanga district it ranged from 0.08 to 1.19 % (Azad, 2004). The SAR of groundwater of Pabna sadar upazila ranged from 0.38 to 1.05 with the mean value of 0.74 (Arefin, 2002), that of Sherpur upazila in Bogra district it ranged from 0.22 to 0.90 (Rahman, 2001) and in Sherpur sadar under Sherpur district ranged from 0.07 to 2.69 (Hoque, 2000). Jesmin (2000) observed that the SAR of groundwater collected from Gaibandha aquifers ranged from 0.29 to 3.28.

The SAR of groundwater of Bhaluka upazila under Madhupur Tract ranged from 0.06 to 0.30 (Nizam, 2000), that of Bagmara, Mahadebpur and Naehoul upazilas ranged from 0.73 to 5.05, 0.51 to 3.29 and 0.36 to 1.83, respectively (Zaman, 2000). The SAR of tubewell waters of Kolkata during both monsoon and winter seasons were 0.55 and 0.65, respectively as reported by Mitra and Gupta (1999). Hossain and Ahmed (1999) observed that the SAR of groundwater of Muktagacha thana under Mymensingh district varied from 0.35 to 4.31.

The SAR values of 63 tubewell water samples of Bikaner district of Rajasthan Pradesh in India was from 5.50 to 41.80 (Lal *et al.,* 1998). Anil Sood *et al.* (1998) sated that the SAR of irrigation water of Bathinda district of Punjab in India ranged from 2.30 to 31.30 and showed excellent to poor in quality with respect to SAR; Ali (1997) observed that the SAR of groundwater of Nachoul Thana at high Barind Tract ranged from 0.36 to 2.70 and the waters were categorized as 'excellent'for irrigation. Sarker (1997) found that the SAR of most of the groundwaters of Narayangonj aquifers was of excellent class for irrigation. Quddus and Zaman (1996) analyzed waters collected from some villages of Meherpur sadar under Meherpur district and stated that the SAR ranged from 0.21 to 0.49. The SAR of water samples of Gazipur sadar varied from 0.50 to 0.94 as reported by Quayum (1995).

The SAR values of surface and groundwaters collected from Shahzadpur thana under Sirajgonj district varied from 0.56 to 0.85 and waters were classified into low sodium waters, S1 (Rahman and Zaman, 1995). Razzaque (1995) cited that the SAR values of water collected from Kalihati and Ghatail thanas under the district of Tangail varied from 16.95 to 43.61. SAR values of the irrigation waters of Madhupur under Tangail district were categorized as low alkalinity hazard (S1) (Zaman and Majid, 1995).

The SSP values in groundwater of Lakshmipur and Noakhali district ranged from 17.03 to 90.92 % (Uddin, 2005). The SSP values in groundwater of Eastern Surma Kushiara floodplain and neighbouring region of Sylhet division were within the range of 6.43 to 98.61% (Ahsan, 2004) that of Dinajpur district ranged from 11.36 to 81.98% (Uddin, 2004), that of Kushtia and Chuadanga districts ranged from 4.38 to 28.98% (Azad, 2004) and in Pabna sadar upazila ranged from 11.85 to 28.85% (Arefin, 2002). The SSP values of surface and groundwater samples collected from Bhaluka upazila under Madhupur Tract ranged from 2.38 to 17.41 percent as observed by Nizam (2000). The SSP values of groundwater samples in Gaibandha aquifers ranged from 9.20 to 45.75 per cent (Jesmin, 2000).

The SSP values of groundwater collected from Bagmara, Mahadebpur and Nachoul upazilas of Barind area varied from 25.53 to 75.61, 21.20 to 79.42 and 17.00 to 51.56 %, respectively (Zaman, 2000). Exactly 25 groundwater samples were collected from the Muktagacha aquifers to evaluate the water quality for irrigation and the computed SSP value ranged from 15.99 to 69.67 % showing excellent in quality (Hossain and Ahmed, 1999). Ali (1997) analyzed groundwater of Nachoul upazila at High Barind Tract and found that the SSP of those waters varied from 17.00 to 51.56 %. The SSP of groundwater collected from Narayangonj ranged from 6.31 to 91.2 % and on the basis of SSP, the water samples of that area were classified as excellent, good, permissible and doubtful.

The SSP values of hand tubewell and surface waters of Matiranga thana under Khagrachari district ranged from 20.39 to 69.37% (Helaluddin, 1996). Quddus and Zaman (1996) earned out an experiment to assess the quality of groundwater collected from Meherpur sadar under Meherpur district and showed that the SSP of those waters was within the limit of 8.14 to 14.70% and all water was excellent in class. Quayum (1995) found that the values of SSP ranged from 18.31 to 40.95% in groundwater of Gazipur sadar under the district of Gazipur. The SSP of 19 surfaces and groundwater of Shahzadpur thana under Sirajgonj district were within the limit of 13.18 to 21.93 %. Fourteen samples lied under the category of excellent and the rest 5 under good (Rahman and Zaman, 1995).

The computed SSP values of 41 groundwater samples of Phulpur thana under Mymensingh district ranged from 6.81 to 28.99 %, 3 samples were found as excellent and the rest were under good class (Shahidullah, 1995). The SSP of groundwater of Madhupur thana under Tangail district varied from 2.14 to 31.50% and found that 20 samples were 'excellent' and 3 were in 'good' classes (Zaman and Majid, 1995). Another study conducted by Zaman and Mohiuddin (1995) the SSP of Pangsha thana under Rajbari district fluctuated from 14.91 to 46.67% and all waters under test were graded as 'excellent', 'good' and 'permissible' classes.

The RSC values of groundwater collected from Lakshmipur and Noakhali district ranged from -1.21 to 3.13 me L^{-1} (Uddin, 2005). The RSC values of groundwater collected from Eastern Surma Kushiara floodplain and neighbouring regions of Sylhet division fluctuated between -1.002 to 7.5 me L^{-1} (Ahsan, 2004). The RSC values of groundwater samples of Dinajpur ranged from -0.01 to 1.48 me L^{-1} (Uddin, 2004) that of Kushtia and Chuadanga districts varied from -6.799 to -0.204 me L^{-1} (Azad; 2004) and of Pabna sadar upazila ranged from 1.80 to 0.10 meL^{-1} (Arefin, 2002). The concentration of RSC in groundwater samples from Avinashi, Pollachi and Palladam in Tamil Nadu varied from 5.0 to 7.5 me L^{-1} (Latha *et al,* 2002).

The RSC values of groundwater samples of Sherpur upazila in Bogra district were found between -0.1 to 2.40 me L^{-1} (Rahman, 2001), that of Sherpur sadar under Sherpur district varied from 1.10 to -0.10 and 0.00 to 1.90 me L^{-1}

(Haque, 2000). Jesmin (2000) observed that RSC of groundwater collected from Gaibandha aquifers ranged from 0.10 to 0.61 me L^{-1}. Nizam (2000) stated that the RSC values of surface and groundwater collected from Madhupur Tract fluctuated between -0.30 to 5.8 me L^{-1}. Sen *et al.* (2000) observed that ground and surface water samples in Tongi aquifers contained RSC within the limit of trace to 11.00 me L^{-1}.

An experiment was conducted by Anil Sood *et al.* (1998) with underground water collected from the 88 villages of Bathinda district of Punjab Pradesh in India and found that the RSC of those waters ranged from nil to 14.60 me L^{-1} and 55 percent samples had RSC less than 2.50 me L^{-1} where as 33 per cent samples showed RSC more than 5.00 me L^{-1}.They apprehended that the continuous and indiscriminate use of these underground waters were might build up excessive Na in soil solution and exchange complex would lead to drainage problem. Lai *et al.* (1998) collecting 173 water samples from Bikaner district of Rajasthan Pradesh in India studied the quality of ground waters for their suitability for irrigation they reported that 75.70, 21.20 and 3.00 per cent samples had RSC of < 2.50, 2.50 to 5.00 and < 5.00 mmol L^{-1} respectively.

The value of RSC of groundwater of Narayangonj aquifers fluctuated between 0.64 to 2.93 me L^{-1} with the mean value of -1.84 me L^{-1} (Sarker, 1997) and out of 112 water samples, 109 were in suitable and the rest 3 were in marginal class. Ali (1997) found that the RSC of groundwater collected from Nachoul Thana under Ndwabgonj district varied from -0.03 to 0.75 me L^{-1}. 25 surface and groundwater samples collected from some villages of Meherpur sadar under Meherpur district were analysed and RSC value was found to be (0.23 to -0.93) and were found suitable for irrigation (Quddus and Zaman, 1996). Zaman and Mohiuddin (1995) carried out an experiment on 15 groundwater of

Pangsha Thana under Rajbari district and observed that 14 samples were suitable for irrigation, as RSC values were below 1.25 me L^{-1} and one sample was found marginal for irrigation with RSC value of 1.34 me L^{-1}. 23 groundwater samples from some villages of Madhupur Thana, Tangail were analyzed by Zaman and Majid (1995). They reported that 22 samples were free from residual sodium carbonate and the rest one sample showed RSC value of 0.38 me L^{-1}. The RSC value of 19 surface and groundwater samples from Shahzadpur Thana, Sirajgonj district were negative which meant that all samples were free from residual sodium carbonate and were suitable for irrigation (Rahman and Zaman, 1995).

The hardness (H_T) of groundwater samples in Lakshmipur and Noakhali district ranged from 29.83 to 217.13 mg L^{-1} (Uddin, 2005). The H_T of groundwater samples in Eastern Surma Kushiara floodplain and neighbouring regions of Sylhet division fluctuated between 3.71 to 322.35 mg L^{-1} (Ahsan, 2004), that of Dinajpur district ranged from 14.01 to 242.19 mg L^{-1} (Uddin, 2004) and in Kushtia and Chuadanga districts varied from 172.90 to 642.53 mg L^{-1} (Azad, 2004). The hardness in groundwater of Pabna sadar upazila ranged from 183.08 to 376.72 mg L^{-1} (Arefin, 2002).

The H_T of groundwatcr in Nanded district in India ranged from 216 to 648 mg L^{-1} (Islam and Gyananath, 2002). Rahman (2001) mentioned that the H_T values ranged from 84.9 to 265.9 mg L^{-1} in groundwater of Sherpur upazila in Bogra district. The hardness of ground and surface waters collected from Bhaluka upazila under Mymensingh district varied from 29.94 to 304.39 mg L^{-1} (Nizam, 2000) and that of Sherpur sadar under Sherpur district varied from 36.96 to 159.91 mg L^{-1} (Hoque, 2000). H_T of natural water resulted due to the presence of divalent cations like Ca and Mg (Todd, 1980). Zaman (2000) showed that the

H_T of groundwaters collected from Bagmara, Mahadebpur and Nachoul upazilas ranged from 79.94 to 279.68, 39.97 to 459.38 and 101.60 to 227.02 mg L^{-1}, respectively.

The groundwater samples collected from the different locations of Narayangonj aquifers had the H_T value ranging from 49.00 to 569.60 mg L^{-1} (Sarker, 1997). Out of 112 samples of this study 16 were 'soft', 39 were 'moderately hard', 45 were 'hard' and the rest 12 were in 'very hard', classes. The H_T values of groundwaters of Nachoul upazila at High Barind Tract ranged from 49.98 to 227.02 mg L^{-1} with the average value of 149.69 mg L^{-1} and out of 50 samples, 25 samples were in 'hard class' (Ali, 1997). Helaluddin (1996) studied 88 water samples of surface and ground sources collected from the Khagrachari Hill district and revealed that the H_T of pond and well waters varied from 2.93 to 46.72 and 1.27 to 16.90 mg L^{-1}, respectively.

The surface waters of Pangsha Thana under Rajbari district were in moderately hard and 'hard' classes (Zaman and Mohiuddin, 1995). Quddus and Zaman, (1996) stated that some surface and groundwater used for irrigation at Meherpur sadar under Meherpur district were rated as 'hard' in quality. Rahman and Zaman (1995) analysed 19 surface and groundwater samples collected from Shahazadpur thana under Sirajgonj district and observed that H_T varied from 159.83 to 324.20 mg L^{-1}. They classified 15 samples as hard and 4 samples as very hard class. The groundwaters samples collected from Gazipur sadar under Gazipur district were in 'soft' class (Quayum, 1995).

CHAPTER III

MATERIALS AND METHODS

Water quality is an important factor in using water for various purposes because its quality bears importance in successful crop production. The chemical analyses of surface water samples are necessary to assess the extent of surface water pollution caused by the higher concentration of dissolved constituents. An attempt has been taken to analyze surface water samples collected from 12 union of Kustia district and the chemical analyses include the estimation of pH, electrical conductivity (EC), total dissolved solids (TDS) and major ionic constituents like Ca, Mg, K, Na, P, SO_4, CO_3, HCO_3 and Cl.

3.1 Collection and preparation of surface water samples

3.1.1 Site

Surface water sampling sites were selected in Kustia District.

3.1.2 Collection of Water Samples

The first consideration for assessment of ionic toxicity of water is obtaining a sample or series of representative samples. Forty samples were collected during irrigation season of which are Padma river water, Hand pressure tube wells, Deep tubewell, Pond water, Rain water, Rice field water, Canal water and Dew water. Five samples were collected from each of eight sources. The samples were collected from the January to March in the year of 2013. All sources of water have widely used as irrigation for the production of major agricultural crops such as cereals, pulses, fiber, spices and vegetable crops.

vii) Sulphate (SO_4)

The water samples were collected in one litre plastic bottles. These bottles were cleaned with dilute hydrochloric acid (1:1) and then washed with tap water followed by distilled water. Before sampling, containers were again rinsed 3 to 4 times with water to be sampled. The water carried to the laboratory of the department of Agricultural Chemistry & Bio-Chemistry, HSTU, Dinajpur for testing. The samples were analysed as quickly as possible on arrival at the laboratory.

3.2 Methods of Water Analysis

The major chemical constituents or compounds both ionic and nonionic forms which all essentially can take part in water pollution. The major chemical constituents or salient features considered for analyses were as follows:

A. Hydrogen ion concentration (pH)

B. Electrical conductivity (EC)

C. Total dissolved solids (TDS)

D. Ionic constituents:
- i) Calcium (Ca)
- ii) Magnesium (Mg)
- iii) Potassium (K)
- iv) Sodium (Na)
- v) Phosphorus (P)
- vi) Carbonate (CO_3)and Bicarbonate (HCO_3)
- vii) Sulphate (SO_4)

3.2.1 pH

The pH of water sample were determined electrometrically following the procedure mentioned by Ghosh *et al.* (1983) using pH meters (Harna instrument-211 model) in the laboratory of Soil Science Department, HSTU, Dinajpur.

3.2.2 Electrical conductivity (EC)

The EC of a system actually represents the total salinity in water excluding the amount of silica. The EC of collected water samples were determined by conductivity bridge (Hanna instrument-HI8033 model) as outlined by Ghosh *et al.* (1983) in the laboratory of the Department of Soil Science, HSTU, Dinajpur.

3.2.3 Total dissolved solids (TDS)

TDS was determined by weighing the solid residue obtained by evaporating a measured aliquot of filtered water samples were dry, according to the procedure described by Chopra and Kanwar (1980).

3.2.4 Carbonate and bicarbonate

Carbonates and bicarbonates of water samples were determined by acidimetric method of titration using phenolphthalein indicator ($C_{20}H_{14}O_4$) for carbonate. With dilute sulphuric acid, carbonate forms colourless and bicarbonate forms rose red colour complex at the end of titration. The carbonate and bicarbonates were estimated titrimetrically as described by Chopra and Kanwar (1980) and Ghose *et al.* (1983). The reactions are mentioned below:

$$Na_2CO_3 + H_2SO_4 \longrightarrow NaHCO_3 + Na_2SO_4$$

$$NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$$

3.2.5 Phosphorus

Phosphorus was determined colorimtrically from the water samples using stannous chloride a reducing agent as described by Clesceri *et al.* (1989). In this method molybdophosphoric acid was reduced to the intensity complex molybdophosphate blue by stannous chloride. The colour intensity was measured at 660 nm wavelength with a spectrophotometer (Hitechi-U-2800) within 15 minutes after stannous chloride addition following the procedure outlined by Olsen *et al.* (1954). The principal hypothetical reaction is as follows:

$$H_3PO_4 + 12\ H_2MoO_4 \longrightarrow H_3P\ (Mo_3O_{10})_4 + 12H2O$$

3.2.6 Sulphate sulphur

Sulphate S was determined turbidimetrically with the help of spectrophotometer. Turbidimetric reagent ($BaCl_2.2H_2O$) was added in a definite volume of sample. Sulphate ion reacted with barium chloride to form barium sulphate. Readings were taken in spectrophotometer (Hitachi-U-2800) after 30 minutes of $BaCl_2$ addition al 425 nm wavelengths following the methods of Wolf (1982).

3.2.7 Calcium

Complexometric titration was used for measuring the Ca from the water samples using disodium ethylene diamine tetraacetate ($Na_2H_2C_{10}H_{12}O_{28}N_2.2H_2O$) as a chelating agent. This analytical method was carried on eliminating possible interfering ions such as Fe, Mn, Cu, Zn, Ni and PO_4 adding respective masking agents at pH 12 in presence of calcon indicator ($C_{20}H_{13}N_2NaO_5S$).

Sodium hydroxide (NaOH) was first added to the water samples for the precipitation of Mg as insoluble magnesium hydroxide [$Mg(OH)_2$]. Potassium ferrocyanide [$K_4Fe\ (CN)_6.3H_2O$], hydroxylamine-hydrochloride ($NH_2OH.HCl$) and triethanolamime ($C_6H_{15}NO_3$) were added to eliminate this interference of various non-target ions (Page *et al.*, 1982).

3.2.8 Magnesium

Magnesium was analysed by coplexometric method of titration using disodium ethylene diamine tetraacetate ($Na_2H_2C_{10}H_{12}O_{28}N_2.2H_2O$) as a chelating agent. This analytical method was practiced for eliminating possible interfering non-target ions in presence of Eriochrome Black T indicator ($C_{20}H_{12}N_3NaO_7S$) with adjusting the required pH 10. To determine Mg alone, Ca was first precipitated from water samples as calcium tumgastate ($CaWO_4$) with sodium tungastate solution ($Na_2WO_4.2H_2O$). Potassium ferrocyanide [$K_4Fe(CN)_6.3H_2O$], hydroxylamine-hydrochloride ($NH_2OH.HCl$) and triethanolamine ($C_6H_{15}NO_3$) were also added to eliminate the competition of various ions (Fe, Mn, Cu, Zn and PO_4) by the EDTA molecule in the raction after Page *et al.* (1982).

3.2.9 Sodium and potassium

Sodium and potassium were determined with the help of a flame emission spectrophotometer by using Na and K filters respectively. The sample was aspirated into a gas flame and excitation was carried out in a carefully controlled and reproducible conditions. The air pressure was fixed at 10 psi. The desired spectral line was isolated using interference filters. The intensity of light at 589 nm and at 768 nm is approximately proportional to the concentration of the elements sodium and potassium respectively. The percent emission was recorded following the methods outlined by Golterman (1971) and Ghosh *et al.* (1983).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

Chemically and physically accessible, sufficient, safe, and affordable water is needed in irrigation, drinking and industrial purposes. Natural waters contain ionic constituents in different concentration and composition which is depended on sources and spaces. Water testing is initially judged the quality and extent of chemical, biological compounds related with soils and crops. So, the quality of water is of equal importance to quantity. Several ionic constituents in collected water like Ca, Mg, Na, K, P, Cl, HCO_3, CO_3, Na were analyzed and variable amounts were present in different water sources and spaces. The results have been discussed in following headings.

4.1 Ionic constituents

In the present study, major ions like Ca, Mg, K, Na, CO_3, HCO_3, and Cl were in dominant quantities but Fe, Zn and Cu detected in trace amounts. The estimated amounts of these ions present in all the samples in relation to irrigation water quality have been described and discussed as follows:

4.1. 1 Calcium content in different sources of water

Calcium is found in natural waters over a wide range of concentrations. The level of calcium in water is related closely to the geology of the source areas, the calcium being derived by weathering processes from minerals such as gypsum, limestone and dolomite. The concentration of Ca was found within the range from trace to 11.86 mg L^{-1}. The highest amount (11.86 mg L^{-1}) of Ca was found in the Padma river water which was statistically different with the other sources of water. And the lowest amount of Ca was almost nil in rain water, which was statistically similar with the dew water.

Table 1. Calcium and magnesium content in different sources water

Sources of water	Calcium content ($mg\ L^{-1}$)	Magnesium Content ($mg\ L^{-1}$)
Padma river water	11.86	10.52
Tube well water	4.92	7.660
Deep tubewell water	5.20	7.880
Pond water	4.00	2.50
Rain water	Trace	Trace
Rice field water	1.80	3.04
Canal water	1.46	3.06
Dew water	Trace	Trace

Calcium is found in natural waters over a wide range of concentrations. Some of the groundwater samples exhibited higher Ca values probably due to enrichment of calcium bearing rocks and minerals at lower profile of aquifers. The level of calcium in water is related closely to the geology of the source areas, the calcium being derived by weathering processes from minerals such as gypsum, limestone and dolomite. It might be due to geochemical processes while the water flows through the soils, rocks containing Na, clay minerals; evaporating such as halite (NaCl). High concentrations of sodium, relative to calcium and magnesium, in irrigation water can adversely affect plant growth and soil structure and thus lead to reduce permeability, aeration, infiltration, leaching and soil workability. The degree to which soil dispersion occurs is also dependent on the soil's clay content and mineralogy, pH, Ca/Mg ratio, EC, organic matter content and the presence of iron and aluminium oxides (ANZECC and ARMCANZ, 2000). Similar observation was reported by Glover (1996) mentioned that when the clay particle adsorb sodium, they tend to disperse and create "slick spots". Sodium-affected soils take water slowly and form dry, hard clods that melt when wetted and tend to seal the soil surface, leaving a slick appearance. Sodium not only affects the soil structure, but also may have a toxic effect on plants. According to Mass (1990), if the concentration of Na is 46 to 230 mg L^{-1}, most of crops were susceptible by foliar injury. Similar findings given by Grattan (2002) revealed that sodium injury on avocado, citrus and stone-fruit trees has been reported at concentrations as low as 115 ppm. Initially, sodium is retained in the trees and lower trunk, but after 3 to 4 years the conversion of sapwood to heartwood apparently release the accumulated sodium, which then moves to the leaves causing leaf burn. But in present study areas no sample was found to contain Na concentration at above the 100 mg L^{-1}, so foliar injury was not present in the crops. Rest of the samples contained lower concentration of Na which was 'suitable' for all crops and soils.

4.1. 2 Magnesium content in different sources of water

The concentration of Mg was found within the range of 1.250 to 23.80 mg L^{-1}. The highest amount (10.52 mg L^{-1}) of Mg was found in the water of Padma river while the lowest amount of Mg (trace) was found in the rain and dew water. In the study area, all the water sources were 'suitable' for irrigation with respect to Mg content.

According to Ayers and Westcot (1985), all the irrigation waters contained below 5.0 meqL^{-1} of Mg ion. In the study area, not a single sample did not exceed this limit (Table 1). Therefore, all water samples were suitable for irrigation regarding Mg ion.

4.1. 3 Sulfur content mg L^{-1} in different sources of water

Sulphate is found in most natural waters as a result of the dissolution of sulfate-bearing minerals in soils and rocks. The concentration of S was observed within the range of trace to 0.521 mg L^{-1}. Maximum amount (0.521) of S was found in the Padma river water, which was statistically different with other sources of water and the lowest amount of S (trace) was found in rain water and dew water, respectively. In the study area, all the water sources were 'suitable' for irrigation with respect to S content. On the basis of this limit, no samples were found problematic for irrigation. Sulphate concentrations had no any remarkable influence on water quality because their concentrations were below the toxic levels.

Table 2: Sulphate-Sulfur and Phosphorus content in different sources of water

Sources of water	Sulfur (S) Content mg L^{-1}	Phosphorus (P) Content mg L^{-1}
Padma river water	0.521	0.412
Tube well water	0.025	0.069
Deep tubewell water	0.017	0.070
Pond water	0.335	0.255
Rain water	0.001	0.001
Rice field water	0.193	0.326
Canal water	0.011	0.043
Dew water	Trace	Trace

4.1.4 Phosphorus content in different sources of water

Phosphates are the most common forms of phosphorus found in natural waters. Compared to nitrate, phosphates dissolve less readily and are less mobile in soil-water and groundwater because they tend to bind to soil and aquifer particles. The phosphorus attached to soil particles can be transported off field and can enter streams and lakes. The P content in groundwater and surface ranged from trace to 0.412 mg L^{-1}. The maximum amount (0.412 mg L^{-1}) of P was found in the Dew water which was statistically similar with the rain water. And the lowest amount of P was almost nil found in the rain and dew, which was statistically not similar with the treatments padma river water, tube well water, deep tubewell water, pond water and canal water, respectively. In the study area, all the water sources were 'suitable' for irrigation with respect to P content. However, in areas where soil is saturated with phosphate or where particle-sorbed P is transported through macropores there is a chance of phosphate reaching groundwater (Baskaran *et al.*, 2002).

4.1.5 Potassium content in different sources of water

The concentration of K was found within the range of 0.0 to 3.24 mg L^{-1}. Maximum amount (3.24 mg L^{-1}) of K was found in the pond but the rain and Dew water had the lowest amount of K (0.0 mg L^{-1}) in the study area, all the water sources were 'suitable' for irrigation with respect to Mg content. Many samples of the study area contained lowest amount of K and the presence of lower amount of K in water due to some mineral in the parent material in soils like sylvite (KCl), nitre (KNO_3) in the aquifers (Karanth, 1994). The detected quantity of K in all the collected groundwater samples had no significant influence on water quality for irrigation.

Table 3: Potassium (K) and Sodium (Na) content mg L^{-1} in different sources of water

Sources of water	Potassium Content (mg L^{-1})	Sodium (Na) Content (mg L^{-1})
Padma river water	1.28	2.20
Tube well water	0.26	2.20
Deep tubewell water	0.26	1.8 0
Pond water	3.24	4.00
Rain water	0.0	0.0
Rice field water	0.44	2.00
Canal water	0.24	2.8
Dew water	0.0	0.0

4.1.6 Sodium content in different sources of water

The concentration of Na was found within the range from nil to 4.0 mg L^{-1}. Maximum amount (4.0 mg L^{-1}) of Na was found in the pond water which was different from other sources of water. And the lowest amount of Na (0.0 mg L^{-1}) was found in the treatment of rain and dew water. In the study area, all the water sources were 'suitable' for irrigation with respect to Mg content.

4. 1.7 Carbonate and Bicarbonate content in different sources of water

The presence of bicarbonate ions in water, particularly when there is high residual sodium carbonate, must be given special attention because of its tendency to precipitate calcium and magnesium as carbonates in the soil. High bicarbonate water has also been shown to induce iron chlorosis (Finkel, 1993). The recorded highest value of HCO_3 was 3.31 and may not create problem in soils. However, HCO_3 concentrations in other samples were found in normal level.

The concentration of CO_3 & HCO_3 was found within the range of 0.34 mg L^{-1} to 1.8 mg L^{-1}. Maximum amount (2.34 mg L^{-1}) of carbonate and bicarbonate was found in the pond water which was statistically similar with the treatments of tubewell water and Dew water, respectively. And the lowest amount of CO_3 & HCO_3 (0.34 mg L^{-1}) was found in the treatment of pond water, which was statistically different from the other sources of water. In the study area, all the water sources were 'suitable' for irrigation with respect to CO_3 & HCO_3 content.

Table 4: CO_3 & HCO_3 and EC in different sources of water

Sources of water	CO_3 & HCO_3	Electric conductivity $\mu S\ cm^{-1}$
Padma river water	1.0	3.226
Tube well water	1.56	2.322
Deep tubewell water	1.80	0.576
Pond water	2.34	2.058
Rain water	0.0	0.0
Rice field water	0.66	0.816
Canal water	0.76	0.322
Dew water	0.00	0.4

4. 2 Electrical conductivity (EC) in different sources of water

EC is an essential parameter that reflects all dissolved soluble salts in a sample. This includes negatively and positively charged ions (e.g. Cl^-, NO_3^-, Ca^{2+}, Na^+). The electrical conductivity i.e. total concentration of soluble salts in all water samples ranged within the limit of 0.058 to 3.226 μS cm^{-1} at 25°C. Maximum amount (3.226 μS cm^{-1}) of electrical conductivity was found in the tubewell water which was statistically different from other sources of water. And the lowest amount of electrical conductivity (0.058 μS cm^{-1}) was found in the treatment of pond water, which was statistically different from the other sources of water.

According to Richards (1968) irrigation waters were categorized into four salinity classes (Fig.5) with respect to EC. On the basis of this classification, out of 108 samples, 9 samples were 'low salinity (C1)', 90 samples were 'medium salinity (C2)' and 9 samples were 'high salinity (C3)' water. Irrigation water also categorized into 5 groups (Wilcox, 1955) and among the 108 samples 90 samples were 'good', 9 samples were under 'permissible' and the rest 9 samples were of 'excellent' water quality.

4.3 pH of different sources of water

The pH is the indicator of acidity and alkalinity of water (<7.0 acidity; >7.0 alkalinity). Table 5 shows the pH of surface and groundwater in different places of Kustia district. The pH of the irrigation water is very important in plant nutrition, and the pH range beyond the limit can lead to problems. In the analysis of Kustia district water the highest P^H (7.438) was found in the Padma river water, which was statistically similar with the treatment deep tubewell water and the lowest (6.110) was found in the pond water which is statistically different from other sources of water. The pH directly affects the availability of many plant nutrients, especially micronutrients. Too low (<4.0) of a pH can result in increased micronutrient availability that can lead

Table 5: pH and Total Dissolved Solids in various sources of water

Sources of water	P^H	Total Dissolved Solid (mg L^{-1})
Padma river water	7.73	330
Tube well water	7.36	149
Deep tubewell water	7.41	137
Pond water	6.11	366
Rain water	6.30	20
Rice field water	7.15	234
Canal water	7.35	334
Dew water	6.30	20

4.4 Total dissolved solids (TDS) in different sources of water

Total dissolved solids (TDS) is a measure of all inorganic salts dissolved in water and is a guide to water quality. The measurement also includes other dissolved substances such as organic compounds, when present. The concentration of TDS was found within the range of 20 to 366 mg L^{-1}. Maximum amount (366 mg L^{-1}) of Total dissolved solids was found in the pond water which was statistically different from other sources of water. And the lowest amount of TDS (20 mg L^{-1}) was found in the treatment of dew water, which was different from the other sources of water. TDS values of ground waters collected from four unions Sherpur upazila under Bogra district were within the limit of 275.4 to 440.7 mg L^{-1} reflecting fresh water in quality (Rahman *et al.,* 2007). Rahman, *et al.* (2006) showed that the TDS value of ground waters collected from five unions under Atrai upazila of Naogaon district varied from 242.0 to 479.2 mg L^{-1} showing fresh water.

The TDS of natural waters reflects the geology of source areas; surface waters generally have lower TDS concentrations than ground waters. In streams, TDS can increase through the continual addition of salts by both natural weathering processes and human activities, such as discharges of domestic and industrial effluents and runoff from urban and rural areas. The major contributing ions are typically the cations like calcium, magnesium, sodium and potassium, and the anions such as bicarbonate, chloride, sulphate and in some cases, nitrate. Todd (1980) reported that if the value of TDS exceeds 500 mgL^{-1} is considered as 'undesirable'. In addition to this, Puntamkar *et al.* (1988) indicated that the degree of soil properties deterioration depends on the total dissolved salt contents in irrigation water. All water samples (except Fhakirpara i.e., sample no. 3) contained far less than 1000 mgL^{-1} TDS and were considered to be 'fresh water' (Carroll, 1962; Freeze and Cherry, 1979; Appendix II).

The primary effect of high TDS in water on crop productivity is the inability of the plant to compete with ions in the soil solution for water (physiological drought). Because plants can only transpire "pure" water, usable plant water in the soil solution decreases dramatically as TDS increases as present in Fhakirpara. The higher TDS value might be Dew to the release of polluted water bodies. These waters were 'brackish water' (Freeze and Cherry, 1979) and were not suitable for irrigation. Except Fhakirpara the water under study area would not affect the osmotic pressure of the soil solution and cell sap of the plants. The value of TDS is directly proportional with that of total soluble mineral ions and other dissolved substances in water bodies. Similar observations were expressed by Sarker *et al.* (2000); Quayum (1995); Rahman and Zaman (1995).

CHAPTER V

SUMMARY AND CONCLUSION

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SUMMARY AND CONCLUSION

A study was conducted to evaluate the status of surface, sub-surface water chemistry at Kustia district under the Agro Ecological Zone (AEZ) no. 11 viz.,

High Ganges River Flood Plain Soil, Surface and water samples were collected randomly to investigate the chemical composition of water and also to classify them according to their comparative suitability for irrigation purposes.

The pH values of water samples were within the range of 6.30 to 7.73 indicating slight alkaline in nature and were not problematic for irrigating agricultural crops. As per TDS, it ranged from 20 to 366 mg L^{-1} and all the collected surface and water samples were categorized as freshwater in quality. All the water samples were within safe limit for irrigation.

On the basis of SO_4-S, all the water samples under investigation were not problematic for irrigation except any toxic effect on soils and crops grown in the study area. In respect of HCO_3 content, all water samples were not problematic for irrigation on soils and crops without few samples. In respect of K, its content in all the collected water samples were below the acceptable limit and all water samples were not problematic for irrigation. On the basis of Na content, its quantity in all collected water samples were below the recommended limit and were not hazardous for irrigation. The status of PO_4 in two water samples was problematic for long-term irrigation.

In conclusion, all the collected water samples under test would not create problem for soils and crops grown in the study area. In addition to the chemical

CHAPTER VI

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quality of water, the biological and radiological qualities of waters should also be evaluated in future for the efficient management of water use. Therefore, it is inferred that the water quality of the study area might be used for irrigation purpose with safety.

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