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# Quality status of groundwater of some selected villages of Bhaluka upazila in Bangladesh for drinking, irrigation and livestock consumption

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## Abstract

Groundwater samples of shallow and deep tubewells were collected from the different villages of Bhaluka upazilla in Bangladesh to assess their quality status for drinking, irrigation and livestock consumption. Different parameters of waters were determined to evaluate the quality. All the waters were alkaline in nature and electrical conductivity classified the samples as “good” for irrigation, while the TDS categorized the samples “highest desirable” limit for drinking and “fresh water” for irrigation and were suitable for drinking, irrigation and livestock consumption. Chloride content rated 2 samples unsuitable for livestock consumption. The concentrations of Zn were within safe limit, but Fe and Mn contents rated almost all the samples unsuitable for drinking and livestock consumption.With respect to Cu concentration, 8 samples were found unsuitable for long- term irrigation on all types of soils. Out of 17 samples, 12 samples classified as “excellent”, 4 as “good” and 1 as “doubtful” for irrigation due to different level of B. Ca, Mg, Na, K and P quantities of all the samples were within safe limit. SAR and EC rated all the samples as “medium salinity” and “low alkalinity” class and hardness of most of the waters were “hard water” class for irrigation.

**Keywords:** Groundwater, Irrigation, Drinking, Livestock consumption

## Introduction

Water is a natural component beneficial for human civilization. The quality of water is a great challenge for this century. The use of water for drinking, irrigation, aquaculture and other domestic purposes by human beings is generally conceded to be its highest and most essential use. On an average a person uses about 70000 litres of water during his lifetime. In U.K. demand for domestic water in 2000 A. D. was about 235 litres per person per day, while it was only 156 litres in 1966. In warmer region of the world, the domestic demand may go up to 500 liters (Goel, 2006). Total quantity of water used for irrigation is rather large. According to an estimate about 41% of all the water used in USA is for irrigation. In India, agriculture accounts for over 80% of total water use. It is estimated that nearly 3500 litres of water per person per day is used just for irrigation. This quantity is several times higher than the average domestic demand. Estimates also show that for obtaining 1 kg each of wheat, rice, meat and milk about 600, 2000, 25000 and 400 litres of water is required, respectively (Goel, 2006). The quality of water depends upon purpose of water use.

The supplies for the drinking and domestic uses should be pure that is without risk from chemical and biological contents. It should also not contain dissolved mineral and organic matter above recommended limit. The international standards of Zn, Cu, Fe and Mn for drinking are 5.0, 0.05, 0.1 and 0.05 ppm, respectively (WHO, 1971). Where as the concentration of these elements for irrigation are 2.0, 0.2, 5.0 and 0.2 ppm respectively (Ayers and Westcot, 1985). Water is called the universal solvent as it dissolves more substances than any other solvent. Being a polar molecule, it is very efficient in dissolving particularly the substances in which the atoms are held by ionic bonds. Besides this, several gases and organic molecules can also be dissolved in water. The inertness properties of water makes it a very important substance in the living beings where all essential material can be transported, unchanged within the body of plant and animals. A large portion of about 70% of the body weight of most organisms including human being is constituted with water. In fact, life on this planet could have been possible only because of the presence of abundant water. All the organisms use water for their metabolic processes and all the biochemical reactions in the body of the organisms take place in the water medium. Water has got an exceptional quality of dissolving a number of substances without changing their chemical nature and therefore plays an important role in transporting materials in the body of the organisms. Unfortunately, this very important property of dissolving also makes water highly prone to get polluted by various means.

All natural waters containing soluble inorganic ions mainly the weathering products of rocks and minerals released and transported by the action of water. Hence the nature and concentration of ion in water depends upon the nature of rocks and minerals, its solubility and weatherability in fresh water or carbonated water, climate and local topography. Whatever may be the source of water some soluble salts are always dissolved in it. However, the nature and quantity of dissolved salts depend upon the source of water and its course before use. The main soluble constituents of water are Ca, Mg, Na and sometimes K as cations and Cl, $SO_4$, $HCO_3$, and sometimes $CO_3$ as anions. However, ions of some other elements such as Li, Si, Br, I, Cu, Ni, Co, F, B, Zr, Ti, V, Ba, Ru, Ce, As, Bi, Sb, Be, Cr, Mn, Pb, Mo, Se, and P and organic matter are present in minor quantities (Michael,1997).Quality water is necessary for every type of use ,but the quality of natural water is judged by its total salt concentration ,relative proportion of cations and anions ,the concentration of toxic substances like As, Cd, Cr , Pb, Hg, Co, Cu, Mn , Fe, Mo, B, etc. It can be said that any element present in water above international recommended limit for specific use may be treated as pollutant. The chemical composition of water is major factor in determining its quality. Toxicity levels of trace elements range from 20 to 50 $fgg^{-1}$ (fg means femtogram, 1 femtogram = $10^{-15}$ grams) for Cu and billion to several hundred $fgg^{-1}$ for Mn ,Mo and Zn (Gupta and Gupta,1998). If low quality water is used for irrigation, drinking, aquaculture, livestock and poultry consumption and other purposes, ionic toxicity may appear (Zaman and Rahman, 1996). However, the groundwater status of the study area was assessed to find their suitability for drinking, irrigation and livestock consumption based on international standard.

## Materials and Methods

Seventeen water samples were collected from the shallow and deep tubewells of Bhaluka Upazilla under Mymensingh district in Bangladesh. Among these, eight samples were collected from deep tubewell and nine samples were collected from shallow tubewell following methods outline by APHA (2000) and Tendon (1995).The analytical works were performed in the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh.

The pH, EC and TDS were determined following methods mentioned by Tandon (1995). $CO_3$ and $HCO_3$ were determined acidimetrically and argentometric titration was followed for the determination of Cl after Upadhyay and Sharma (2002). Ca and Mg were determined by complexometric method of titration Chopra and Kanwar (1986). Na and K were determined flame photometrically while Zn, Cu, Fe and Mn were determined with the help of AAS following method outlined by APHA (2000). Spectrophotometric method was followed for the determination of P and B Page *et al.* (1982). Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC) and Hardness ($H_T$) of samples were calculated following standard formula mentioned by Mishra and Ahmed (1993), Richards (1968) and Michael (1997). Quality classification and suitability judgments of water samples for drinking was done according to the standard of WHO (1971) and USEPA (1975). The samples were rated for irrigation following standard as mentioned by Wilcox (1955), Ayers and Westcot (1985), Freeze and Cherry (1979), Todd (1980), Sawyer and McCarty (1967), Eaton (1950) and Richards (1968). Water quality used for livestock was rated following standard outlined by Ayers and Westcot (1985), respectively. Statistical analyses were done following methods outlined by Gomez and Gomez (1984) with the help of computer package M-STAT.

## Results and Discussion

### pH, electrical conductivity (EC) and total dissolved solids (TDS)

The pH of the water samples varied from 7.22 to 9.35 with the mean value of 8.20 (Table 1). All the waters were alkaline and none of the sample was found acidic or neutral. According to WHO (1971), 14 samples were in “highest desirable” and 3 were “maximum permissible” limit (Table 2). The maximum recommended limit of pH for irrigation is 6.5 to 8.5 Ayers and Westcot (1985). Based on their recommendation, out of 17 samples 4samples were unsuitable for long- term irrigation. EC of the waters ranged from 331.36 to 667.20 $\mu S\ cm^{-1}$ having mean, SD and %CV of 445.17, 93.00 and 20.89, respectively (Table 1). All the samples were “good” class for irrigation according to Wilcox (1955). Salinity and alkalinity hazard rated the samples “medium salinity” (C2) and “low alkalinity” (S1) class (Richards, 1968). Total dissolved solids (TDS) ranged from 200.00 to 450.00 mg $L^{-1}$ with the average value of 355.05 mg $L^{-1}$. The respective SD and %CV were 56.81 and 16 (Table1). TDS categorized all the samples under “highest desirable” limit for drinking and “fresh water” for irrigation (Table 2 and 3), according to WHO (1971) and Freeze and Cherry (1979). TDS rated all the samples suitable for drinking, irrigation and livestock consumption.

**Table 1. Sampling information and chemical constituents of water samples**

| Sample no. | Sampling location (Name of village) | Sources of water | Depth of well (m) | pH | EC ( Scm$^{-1}$) | TDS (mg L$^{1}$) | Cl | $CO_3$ | $HCO_3$ | Ca | Mg | Na | K | Zn | Cu | Fe | Mn | P | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | me L$^{-1}$ | | | | | | | mg L$^{-1}$ | | | | | |
| 1 | Goair | STW | 22 | 9.35 | 311.36 | 200 | 0.6 | Trace | 1.0 | 0.7 | 1.9 | 0.239 | 0.006 | 0.059 | Trace | 0.489 | 0.400 | 0.02 | 0.240 |
| 2 | Bhawalia Bazu | DTW | 92 | 8.16 | 378.08 | 345 | 0.4 | Trace | 4.0 | 1.1 | 2.0 | 0.248 | 0.012 | 0.049 | 0.270 | 0.651 | 0.145 | 0.10 | 0.260 |
| 3 | Bhawalia Bazu | STW | 16 | 7.4 | 667.2 | 420.2 | 2.4 | Trace | 3.5 | 2.0 | 3.7 | 0.282 | 0.012 | 0.060 | 0.250 | 0.500 | 0.112 | 0.01 | 0.230 |
| 4 | Birunia | STW | 22 | 7.22 | 600.98 | 415.3 | 2.6 | Trace | 3.0 | 2.0 | 3.5 | 0.282 | 0.012 | 0.075 | 0.140 | 0.767 | 0.140 | Trace | 0.210 |
| 5 | Boa | STW | 52 | 8.68 | 444.8 | 350.2 | 0.8 | Trace | 4.0 | 1.0 | 1.5 | 0.315 | 0.012 | 0.046 | 0.160 | 0.682 | 0.201 | Trace | 0.360 |
| 6 | Chandratia | DTW | 113 | 8 | 378.08 | 340.5 | 0.4 | Trace | 4.0 | 1.2 | 1.9 | 0.282 | 0.012 | 0.092 | 0.110 | 0.269 | 0.425 | 0.01 | 0.160 |
| 7 | Rajai | DTW | 85 | 8 | 378.8 | 340.2 | 0.4 | Trace | 4.0 | 1.2 | 2.0 | 0.26 | 0.011 | 0.071 | 0.170 | 0.729 | 0.095 | 0.04 | 0.320 |
| 8 | Panasair | STW | 66 | 8.68 | 444.8 | 360.5 | 0.4 | Trace | 4.5 | 0.9 | 1.7 | 0.304 | 0.009 | 0.106 | 0.270 | 0.646 | 0.104 | Trace | 0.140 |
| 9 | Balijuri | STW | 63 | 8.28 | 333.6 | 300 | 0.4 | Trace | 3.5 | 0.8 | 2.1 | 0.315 | 0.006 | 0.082 | 0.160 | 0.563 | 0.116 | Trace | 0.210 |
| 10 | Balijuri | STW | 64 | 8.34 | 449.28 | 400 | 0.6 | Trace | 4.5 | 1.1 | 3.2 | 0.304 | 0.006 | 0.069 | 0.160 | 0.722 | 0.117 | 0.17 | 0.160 |
| 11 | Balijuri | DTW | 86 | 8.35 | 533.76 | 450 | 0.6 | Trace | 5.5 | 1.2 | 2.3 | 0.282 | 0.006 | 0.004 | 0.280 | 0.763 | 0.068 | 0.22 | 0.230 |
| 12 | Bhaluka | DTW | 83 | 8.15 | 490 | 380 | 0.4 | Trace | 4.5 | 1.3 | 3.2 | 0.25 | 0.013 | 0.116 | 0.202 | 0.675 | 0.080 | 0.02 | 0.340 |
| 13 | Bhaluka | STW | 31 | 8.25 | 478.16 | 324 | 0.2 | Trace | 4.0 | 1.1 | 4.0 | 0.25 | 0.013 | 0.116 | 0.202 | 0.675 | 0.030 | 0.02 | 0.340 |
| 14 | Bhaluka | STW | 52 | 7.4 | 478.16 | 340 | 0.4 | Trace | 4.0 | 1.3 | 2.8 | 0.282 | 0.02 | 0.025 | 0.210 | 0.507 | 0.218 | Trace | 0.390 |
| 15 | Bhaluka | DTW | 83 | 8.14 | 444.8 | 400.5 | 0.4 | Trace | 5.0 | 1.2 | 2.8 | 0.243 | 0.02 | 0.174 | 0.304 | 0.462 | 0.170 | 0.29 | 1.100 |
| 16 | Mishagonj | DTW | 118 | 8.0 | 378.08 | 350 | 0.4 | Trace | 4.0 | 1.1 | 2.4 | 0.239 | 0.31 | 0.046 | 0.070 | 0.668 | 0.181 | 0.02 | 0.310 |
| 17 | Kathuli | DTW | 118 | 9.0 | 378.08 | 320 | 0.4 | Trace | 4.0 | 0.8 | 2.0 | 0.239 | 0.006 | 0.098 | 0.170 | 0.703 | 0.092 | 0.06 | 0.290 |
| Range | | | | 7.22 - 9.35 | 311.36 - 667.20 | 200.00 - 450.00 | 0.20 - 2.60 | - | 1.00 - 5.50 | 0.80 - 2.00 | 1.50 - 4.00 | 0.250 - 0.351 | 0.006 - 0.300 | 0.004 - 0.174 | 0.070 - 0.304 | 0.462 - 0.767 | 0.030 - 0.425 | Trace - 0.290 | 0.140 - 1.100 |
| Mean | | | | 8.2 | 445.17 | 355.05 | 0.694 | - | 3.94 | 1.176 | 2.529 | 0.271 | 0.029 | 0.08 | 0.19 | 0.62 | 0.16 | 0.06 | 0.31 |
| SD | | | | 0.55 | 93 | 56.81 | 0.693 | - | 0.95 | 0.356 | 0.756 | 0.027 | 0.073 | 0.04 | 0.08 | 0.13 | 0.1 | 0.09 | 0.22 |
| %CV | | | | 6.707 | 20.89 | 16 | 99.85 | - | 24.11 | 30.29 | 29.9 | 10.12 | 251.72 | 50 | 42.11 | 20.97 | 65.05 | 145.48 | 70.97 |

Legend: STW- Shallow tubewell, DTW- Deep tubewell, Trace=< 0.001me L$^{-1}$and < 0.001 mg L$^{-1}$

**Table 2. Quality classification and suitability judgments of water samples for drinking**

| sample No. | pH | | TDS | | Ca | | Mg | | Zn | | Cu | | Fe | | Mn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Value | Class | Value (mg $L^{-1}$) | Class | Value (mg $L^{-1}$) | Class | Value (mg $L^{-1}$) | Class | Value (mg $L^{-1}$) | Class | (Value (mg $L^{-1}$) | Class | Value (mg $L^{-1}$) | Class | Value (mg $L^{-1}$) | Class |
| 1 | 9.35 | MP | 200.00 | HD | 14.00 | MP | 24.09 | HD | 0.059 | Suit. | Trace | Suit. | 0.489 | Unsuit. | 0.400 | Unsuit. |
| 2 | 8.16 | HD | 345.00 | HD | 22.00 | MP | 24.30 | HD | 0.049 | Suit. | 0.270 | Suit. | 0.651 | Unsuit. | 0.145 | Unsuit. |
| 3 | 7.40 | HD | 420.20 | HD | 40.08 | MP | 44.96 | HD | 0.060 | Suit. | o.250 | Suit. | 0.500 | Unsuit. | 0.112 | Unsuit. |
| 4 | 7.22 | HD | 415.30 | HD | 40.08 | MP | 42.53 | MP | 0.075 | Suit. | 0.140 | Suit. | 0.767 | Unsuit. | 0.140 | Unsuit. |
| 5 | 8.68 | MP | 350.20 | HD | 20.04 | MP | 18.22 | HD | 0.046 | Suit. | 0.160 | Suit. | 0.682 | Unsuit. | 0.201 | Unsuit. |
| 6 | 8.00 | HD | 340.50 | HD | 24.05 | MP | 23.09 | HD | 0.092 | Suit. | 0.110 | Suit. | 0.269 | Suit. | 0.425 | Unsuit. |
| 7 | 8.00 | HD | 340.20 | HD | 24.05 | MP | 24.30 | HD | 0.071 | Suit. | 0.170 | Suit. | 0.729 | Unsuit. | 0.095 | Unsuit. |
| 8 | 8.68 | MP | 360.50 | HD | 18.03 | MP | 20.66 | HD | 0.106 | Suit. | 0.270 | Suit. | 0.646 | Unsuit. | 0.104 | Unsuit. |
| 9 | 8.28 | HD | 300.00 | HD | 16.03 | MP | 25.52 | HD | 0.082 | Suit. | 0.160 | Suit. | 0.563 | Unsuit. | 0.116 | Unsuit. |
| 10 | 8.34 | HD | 400.00 | HD | 22.04 | MP | 38.88 | MP | 0.069 | Suit. | 0.160 | Suit. | 0.722 | Unsuit. | 0.117 | Unsuit. |
| 11 | 8.35 | HD | 450.00 | HD | 24.08 | MP | 27.95 | HD | 0.004 | Suit. | 0.280 | Suit. | 0.763 | Unsuit. | 0.068 | Unsuit. |
| 12 | 8.15 | HD | 380.00 | HD | 26.05 | MP | 38.88 | MP | 0.116 | Suit. | 0.202 | Suit. | 0.675 | Unsuit. | 0.080 | Unsuit. |
| 13 | 8.25 | HD | 324.00 | HD | 22.04 | MP | 48.60 | MP | 0.116 | Suit. | 0.202 | Suit. | 0.675 | Unsuit. | 0.030 | Suit. |
| 14 | 7.40 | HD | 340.00 | HD | 26.05 | MP | 34.02 | MP | 0.025 | Suit. | 0.210 | Suit. | 0.507 | Unsuit. | 0.218 | Unsuit. |
| 15 | 8.14 | HD | 400.50 | HD | 24.04 | MP | 34.02 | MP | 0.174 | Suit. | 0.304 | Suit. | 0.462 | Unsuit. | 0.170 | Unsuit. |
| 16 | 8.00 | HD | 350.00 | HD | 22.04 | MP | 29.16 | HD | 0.046 | Suit. | 0.070 | Suit. | 0.668 | Unsuit. | 0.181 | Unsuit. |
| 17 | 9.00 | MP | 320.00 | HD | 16.03 | MP | 24.30 | HD | 0.098 | Suit. | 0.170 | Suit. | 0.703 | Unsuit. | 0.092 | Unsuit. |

Legend: Trace < 0.001 mg$L^{-1}$, HD= Highest Desirable, MP. = Maximum Permissible, Suit. = Suitable, Unsuit. = Unsuitable

**Table 3. Quality rating and suitability of water samples for irrigation**

| Sl. No. | EC | | TDS | | SAR | | SSP | | RSC | | $H_T$ | | Alkalinity and salinity hazard | Mn | | Cu | | Fe | | B | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | µS$cm^{-1}$ | Class | mg $L^{-1}$ | Class | Ratio | Class | % | Class | me$L^{-1}$ | Class | mg $L^{-1}$ | Class | | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class |
| 1 | 311.36 | Good | 200.00 | FW | 0.209 | Ex | 8.61 | Ex | -0.6 | Suit. | 133.02 | MH | C2S1 | 0.400 | Unsuit | Trace | Suit | 0.489 | Suit | 0.240 | Ex. |
| 2 | 378.08 | Good | 345.00 | FW | 0.199 | Ex | 7.73 | Ex | 0.9 | Suit. | 154.74 | H | C2S1 | 0.145 | Suit | 0.270 | Unsuit | 0.651 | Suit | 0.260 | Ex. |
| 3 | 667.20 | Good | 420.20 | FW | 0.167 | Ex | 4.90 | Ex | -2.2 | Suit. | 284.54 | H | C2S1 | 0.112 | Suit | 0.250 | Unsuit | 0.500 | Suit | 0.230 | Ex. |
| 4 | 600.98 | Good | 415.30 | FW | 0.170 | Ex | 5.07 | Ex | -2.5 | Suit. | 174.57 | H | C2S1 | 0.140 | Suit | 0.140 | Suit | 0.767 | Suit | 0.210 | Ex. |
| 5 | 444.80 | Good | 350.20 | FW | 0.226 | Ex | 11.56 | Ex | 1.5 | Mar | 124.80 | MH | C2S1 | 0.201 | Unsuit | 0.160 | Suit | 0.682 | Suit | 0.360 | Good |
| 6 | 378.08 | Good | 340.50 | FW | 0.281 | Ex | 8.66 | Ex | 0.9 | Suit. | 154.78 | H | C2S1 | 0.425 | Unsuit | 0.110 | Suit | 0.269 | Suit | 0.160 | Ex. |
| 7 | 378.80 | Good | 340.20 | FW | 0.205 | Ex | 7.82 | Ex | 0.8 | Suit. | 159.75 | H | C2S1 | 0.095 | Suit | 0.170 | Suit | 0.729 | Suit | 0.320 | Ex. |
| 8 | 444.80 | Good | 360.50 | FW | 0.266 | Ex | 10.74 | Ex | 1.9 | Mar. | 129.79 | MH | C2S1 | 0.104 | Suit | 0.270 | Unsuit | 0.646 | Suit | 0.140 | Ex. |
| 9 | 333.60 | Good | 300.00 | FW | 0.261 | Ex | 9.96 | Ex | 0.6 | Suit. | 144.71 | H | C2S1 | 0.116 | Suit | 0.160 | Suit | 0.563 | Suit | 0.210 | Ex. |
| 10 | 449.28 | Good | 400.00 | FW | 0.207 | Ex | 6.72 | Ex | 0.2 | Suit. | 214.51 | H | C2S1 | 0.117 | Suit | 0.160 | Suit | 0.722 | Suit | 0.160 | Ex. |
| 11 | 533.76 | Good | 450.00 | FW | 0.168 | Ex | 7.60 | Ex | 2.0 | Mar. | 174.71 | H | C2S1 | 0.068 | Suit | 0.280 | Unsuit | 0.763 | Suit | 0.230 | Ex. |
| 12 | 490.00 | Good | 380.00 | FW | 0.166 | Ex | 5.52 | Ex | 0.0 | Suit. | 224.54 | H | C2S1 | 0.080 | Suit. | 0.202 | Unsuit | 0.675 | Suit | 0.340 | Good |
| 13 | 478.16 | Good | 324.00 | FW | 0.162 | Ex | 5.08 | Ex | -1.3 | Suit. | 214.50 | H | C2S1 | 0.030 | Suit. | 0.202 | Unsuit | 0.675 | Suit | 0.340 | Good |
| 14 | 478.16 | Good | 340.00 | FW | 0.196 | Ex | 6.86 | Ex | 0.5 | Suit. | 204.63 | H | C2S1 | 0.218 | Unsuit | 0.210 | Unsuit | 0.507 | Suit | 0.390 | Good |
| 15 | 444.80 | Good | 400.50 | FW | 0.171 | Ex | 6.16 | Ex | 1.0 | Suit. | 200.35 | H | C2S1 | 0.170 | Suit | 0.304 | Unsuit | 0.462 | Suit | 1.100 | Doubtful |
| 16 | 378.08 | Good | 350.00 | FW | 0.180 | Ex | 7.16 | Ex | 0.5 | Suit. | 174.69 | H | C2S1 | 0.181 | Suit | 0.070 | Suit | 0.668 | Suit | 0.310 | Ex. |
| 17 | 378.08 | Good | 320.00 | FW | 0.201 | Ex | 8.08 | Ex | 1.2 | Suit. | 137.71 | MH | C2S1 | 0.092 | Suit | 0.170 | Suit | 0.703 | Suit | 0.290 | Ex. |

Legend: Trace < 0.001 mg$L^{-1}$, FW= Fresh water, Ex.= Excellent, Suit.= Suitable, Unsuit.= Unsuitable Mar.= Marginal, H= Hard water,
MH = Moderately Hard water , C2= Medium Salinity and S1=Low alkalinity, $H_T$ =Hardness

**Chloride (Cl), carbonate ($CO_3$) and bicarbonate ($HCO_3$)**

The Cl concentration of the samples ranged from 0.20 to 2.60 me $L^{-1}$, with the mean, SD and %CV of 0.694, 0.693 and 99.85, respectively, which were higher than the findings of Nizam *et al*.(1999) and Zaman *et a*l., (2001). Average Cl content of the present study was much below the average Cl contents of the samples studied by Karim *et al*. (2013) in the coastal area of BAngladesh. Their study area was very close to the coastal belt of Bangladesh for that reason they obtained such type of higher Cl content. Since the present study area was far away from coastal belt therefore such type of low Cl contents were obtained and from the result it was also clear that the Cl content of ground water generally decreased with the increase of distance of sea level. Cl contents rated all the sample suitable for drinking (Table 2) and 2 samples (no. 3 and 4) collected from Bhawaliabazu and Birunia village unsuitable for livestock drinking because of Cl > 30 mg $L^{-1}$ (Table 4), since the recommended concentration for drinking was 250 mg $L^{-1}$ and for livestock drinking was 30 mg $L^{-1}$ Ayers and Westcot (1985).

**Table 4. Suitability test of water samples for livestock consumption**

| Sl. No. | TDS | | $H_T$ | | Cl | | Fe | | Mn | | Zn | | Cu | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class | mg $L^{-1}$ | Class |
| 1 | 200.00 | Suit. | 133.02 | Suit. | 21.30 | Suit. | 0.489 | Unsuit | 0.400 | Unsuit | 0.049 | Suit. | Trace | Suit. |
| 2 | 345.00 | Suit. | 154.74 | Suit. | 14.20 | Suit. | 0.651 | Unsuit | 0.145 | Unsuit | 0.060 | Suit. | 0.270 | Suit. |
| 3 | 420.20 | Suit. | 284.54 | Unsuit | 85.20 | Unsuit. | 0.500 | Unsuit | 0.112 | Unsuit | 0.075 | Suit. | 0.250 | Suit. |
| 4 | 415.30 | Suit. | 174.57 | Suit. | 92.30 | Unsuit. | 0.767 | Unsuit | 0.140 | Unsuit | 0.046 | Suit. | 0.140 | Suit. |
| 5 | 350.20 | Suit. | 124.80 | Suit. | 28.40 | Suit. | 0.682 | Unsuit | 0.201 | Unsuit | 0.092 | Suit. | 0.160 | Suit. |
| 6 | 340.50 | Suit. | 154.78 | Suit. | 14.20 | Suit. | 0.269 | Suit. | 0.425 | Suit. | 0.071 | Suit. | 0.110 | Suit. |
| 7 | 340.20 | Suit. | 159.75 | Suit. | 14.20 | Suit. | 0.729 | Unsuit | 0.095 | Unsuit | 0.106 | Suit. | 0.170 | Suit. |
| 8 | 360.50 | Suit. | 129.79 | Suit. | 14.20 | Suit. | 0.646 | Unsuit | 0.104 | Unsuit | 0.082 | Suit. | 0.270 | Suit. |
| 9 | 300.00 | Suit. | 144.71 | Suit. | 14.20 | Suit. | 0.563 | Unsuit | 0.116 | Unsuit | 0.069 | Suit. | 0.160 | Suit. |
| 10 | 400.00 | Suit. | 214.51 | Unsuit | 21.30 | Suit. | 0.722 | Unsuit | 0.117 | Unsuit | 0.004 | Suit. | 0.160 | Suit. |
| 11 | 450.00 | Suit. | 174.71 | Suit. | 21.30 | Suit. | 0.763 | Unsuit | 0.068 | Unsuit | 0.116 | Suit. | 0.280 | Suit. |
| 12 | 380.00 | Suit. | 224.54 | Unsuit | 14.20 | Suit. | 0.675 | Unsuit | 0.080 | Unsuit | 0.116 | Suit. | 0.202 | Suit. |
| 13 | 324.00 | Suit. | 214.50 | Unsuit | 7.10 | Suit. | 0.675 | Unsuit | 0.030 | Suit. | 0.025 | Suit. | 0.202 | Suit. |
| 14 | 340.00 | Suit. | 204.63 | Unsuit | 14.20 | Suit. | 0.507 | Unsuit | 0.218 | Unsuit | 0.174 | Suit. | 0.210 | Suit. |
| 15 | 400.50 | Suit. | 200.35 | Unsuit | 14.20 | Suit. | 0.462 | Unsuit | 0.170 | Unsuit | 0.046 | Suit. | 0.304 | Suit. |
| 16 | 350.00 | Suit. | 174.69 | Suit. | 14.20 | Suit. | 0.668 | Unsuit | 0.181 | Unsuit | 0.098 | Suit. | 0.070 | Suit. |
| 17 | 320.00 | Suit. | 137.71 | Suit. | 14.20 | Suit. | 0.703 | Unsuit | 0.092 | Unsuit | 0.098 | Suit. | 0.170 | Suit. |

Legend: Trace < 0.001 mg$L^{-1}$, Suit. = Suitable, Unsuit. = Unsuitable, $H_T$ =Hardness.

None of the samples were found to be responsive for $CO_3$ test. $HCO_3$ values fluctuated from 1.00 to 5.50 me $L^{-1}$. The respective mean, SD and %CV were 3.00, 94, 0.95 and 24.11. The presented average value of $HCO_3$ was very close to the average value of the samples analysed by Nizam *et al.* (2012) and very less than that of the result of Karim *et al*. (2013). $HCO_3$ content of the present samples would not be harmful for plumber fixing.

**Calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K)**

The quantities of Ca and Mg were within the limit of 0.80 to 2.00 me $L^{-1}$ and 1.50 to 4.00 me $L^{-1}$ .The respective mean values were1.176 and 2.529 me $L^{-1}$ (Table 1). The average Ca and Mg contents were higher than the results of Rahman and Zaman (1995), Zaman and Majid (1995) and Zaman *et al*. (2001). But Ca content was less and Mg content was higher than the results of Karim *et al*. (2013). It might be due to the differences of ground aquifers and mineral contents of the soils. However, according to the recommendation of WHO (1971), Ca contents categorized all the samples as “maximum permissible” and for Mg 11 samples as “highest desirable” and 6 were “maximum permissible” limit (Table 2).

The values of Na and K of the samples were varied from 0.250 to 0.351 and 0.006 to 0.300 me $L^{-1}$, with the respective mean value of 0.271 and 0.029 me $L^{-1}$ (Table 1). The average value of Na and K contents were far below the results of Karim *et al*. (2013) it might be because of variations of mineral contents soils of the study area.

### Zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn)

Zn, Cu, Fe and Mn concentration of the samples fluctuated from 0.004 to 0.174, 0.070 to 0.304, 0.462 to 0.767 and 0.030 to 0.425 mg $L^{-1}$, respectively (Table1). With respect to Zn and Cu contents all the 17 samples were within the recommended limit of USEPA (1975) and were not toxic for drinking and livestock consumption (Table2 and 4). Cu concentration given in Table 3 indicated that 8 samples were unsuitable for irrigating continuously on all soils. Based on Fe content only one sample was suitable for drinking and livestock consumption as recommended by WHO (1971), USEPA (1975) and Ayers and Westcot (1985). Moreover, rest 16 samples were unsuitable for drinking and livestock consumption (Table 2 and Table 4). Mn values suited only one sample for drinking and 13 samples for irrigation and only two samples for livestock consumption. Besides this, due to higher Mn concentration 16 samples were unsuitable for drinking and 15 for livestock consumption.

### Phosphorus (P) and boron (B)

P and B content ranged from trace to 0.290 and 0.140 to 1.10 mg $L^{-1}$, with the mean value of 0.060 and 0.310 mg $L^{-1}$ (Table1). Based on Wilcox (1955), B contents rated 12 samples under “excellent”, 4 were “good” and 1 as “doubtful” class for irrigation (Table3). Water containing B of doubtful grade should not be used for irrigating agricultural crops, resulting ionic toxicity may appear.

### Soluble adsorption ratio (SAR), soluble sodium percentage (SSP), residual sodium carbonate (RSC) and hardness ($H_T$)

According to the classification of Todd (1980) and Wilcox (1955) the SAR and SSP values categorized all the samples under “excellent” class for irrigation (Table3). SAR and EC rated the samples as “low alkalinity” (S1) and “medium salinity” (C2), combinedly expressed as (C2S1). RSC rated 3 samples as “marginal” and 14 samples “suitable” for irrigation (Table3). Following Sawyer and McCarty's (1967) classification most of the samples were rated as “hard water” only 3 samples were found as “moderately hard” for irrigation.

## Conclusion

From the results of chemical analysis of water samples and comparing the values with international quality standard for different purposes it was concluded that Cu, Mn and Fe contents of most of the samples were found above recommended limit for drinking, irrigation and livestock consumption. Finally, it is recommended that the chemical quality of ground water of the study area must be checked before use for different purpose.

## References

APHA. 2000. *Standard Methods for the Examination of Water and Wastewater*. 20th Edn. American Public Health Association, Washington DC, 20005.

Ayers, R.S. and Westcot, D.W. 1985. *Water quality for Agriculture*. FAO Irrigation and Drainage Paper **29** (Rev. I): 1-144.

Chopra, S.L. and Kanwar, J.S. 1991. *Analytical Agricultural Chemistry*. 4thEdn. Kalyani Publishers, Ludiana, New Deihi.

Eaton, F.M. 1950. Significance of Carbonation Irrigation Waters. *Soil Sc*ience. **67**: 12-133.

Freeze, A.R. and Cherry, J.A. 1979. *Groundwater*. Prentice Hall Inc. England Cliffs, New Jersey 07632: 84-387.

Goel, P.K. 2006. *Water Pollution Causes Effects and Control*. 2ndEdn. New Age International Publishers. New Delhi.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*. 2nd Edn. John Wiley and Sons. New York.

Gupta, U.C. and Gupta, S.C. 1998. Trace Element Toxicity Relationships to Crop Production and Livestock and Human Health: Implication for Management. *Communications in Soil Science and Plant Analysis.* 29: 11-14, 1491-1522.

Karim, M.F., Zaman, M.W., Nizam, M.U , Sultana, R. and Rummana, A. 2013. Groundwater Quality of Status of Bhola Sadar Upazila in Bangladesh for Drinking, Irrigation, Livestock Consumption and Aquaculture. *J. Agrofor. Environ***. 7** (1): 131-136.

Michael, A.M. 1997. *Irrigation Theory and Practice*. Vikas Publishing House Pvt. Ltd. New Delhi.

Mishra, R.D. and Ahmed, M. 1993. *Manual on Irrigation Agronomy*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Nizam, M.U., Zaman , M.W., Islam, M.S and Kader, H.A. 2012. Quality Rating and Suitability of Some Groundwater Samples of Mymensingh District for Drinking Irrigation and Livestock Consumption. *J. Patuakhali Sci. and Tech. Univ.* **3** (2): 129-136.

Nizam, M.U., Zaman, M.W., Rahman, M.M., Wadia, R. and Zakir, H.M. 1999. Copper, manganese and Iron Toxicities in Water Sources of Two Unions of Bhaluka Upazilla in Bangladesh. *Bangladesh Journal of Environmental Science*. **5:** 104-109.

Page, A.L., Miller, R.H. and Kenny, D.R. 1982. *Methods of Soil Analysis*. Part-2. Chemical and Microbial Properties. 2nd Edn. American Society of Agronomy, Inc. Soil Science Society of American Inc. Madison, Wisconsin, USA.

Rahman, M.M. and Zaman, M.W. 1995. Quality Assessment of River and Groundwater for Irrigation at Shahajadpur in Bangladesh. *Progressive Agri*culture **6** (2): 89-96.

Richard, L.A.(Ed). 1968. *Diagnosis and Improvement of Saline and Alkali Soils*. Agricultural Handbook. USDA and IBH. Publishing Co. Ltd. New Delhi, India.

Sawyer, C.N. and McCarty, P.L. 1967. *Chemistry for Sanitary Engineers*. 2nd Edn. McGraw Hill, New York.

Tandon, H.L.S. 1995. *Methods of Analysis of Soil, Plants,Water and Fertilizers*. Fertilizer Development and Consultation Organization, New Delhi.

Todd, D.K. 1980. *Groundwater Hydrology*. 2nd Edn. Jhon Wiley and Sons. Inc. New York 10016.

Upadhyay, R.M. and Sharma, N.L. 2002. *Manual of Soil, Plant, Water and Fertilizer Analysis*. Kalyani Publishers, Ludiana, New Deihi.

USEPA (United States Environmental Protection Agency). 1975. *Federal Register*. **40** (248).

WHO (World Health Organization). 1971. *International Standards for Drinking Water.* Cited from Groundwater Assessment Development and Management : 248-249.

Wilcox, L.V. 1955. *Classification and Use of Irrigation Water*. United States Department of Agriculture. Circular No. 969. Washington D.C.

Zaman, M.W. and Majid, M.A. 1995. Irrigation Water Quality of Madhupur in Bangladesh. *Progressive Agriculture* **6** (2): 103-108.

Zaman, M.W., Nizam, M.U. and Rahman, M.M. 2001. Arsenic and Trace Element Toxicitiy in Groundwater for Agricultural, Drinking and Industrial Usage. *Bangladesh Journal of Agricultural Research* **26** (2): 167-177.

Zaman, M.W. and Rahman, M.M. 1996. Ionic Toxicity of Industrial Process Waters in Some Selected Sites of Sirajgonj in Bangladesh. *Bangladesh Journal of Environmental Science* **2**: 27-34.