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ASSESSMENT OF TUBE WELL AND CANAL WATER QUALITIES AT BOGRA CITY AREA OF BANGLADESH

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ABSTRACT
A study was conducted at Bangladesh Sugarcrop Research Institute, Pabna to determine major ionic constituents including heavy metals in waters collected from fourteen different locations of Bogra city. The concentration of heavy metals in water samples were determined by using an atomic absorption spectrophotometer (AAS). The electrical conductivity (EC) values of water samples varied from 326 to 1265 µS cm^{-1} while the pH range was 6.26 to 7.25. In respect of total dissolved solids (TDS), all water samples were categorized as fresh water. Dissolved oxygen (DO) values of samples were within the range of 0.3 to 0.6 mg L^{-1}, indicating severe stress for aquatic biota. The mean concentrations of Ca^{2+}, Mg^{3+}, Na^{+}, K^{+}, BO_3^{3-}, PO_4^{3-} and SO_4^{2-} in water samples were 51.67, 26.07, 32.77, 11.98, 0.25, 0.67 and 10.85 µg mL^{-1}, respectively. Considering Cl^{-1} content, 50% water samples were found within the permissible limit of irrigation, but in respect of HCO_3^{1-} content, all water samples were problematic for irrigation. According to drinking water quality guideline, all water samples of the study area were found unsuitable in respect of HCO_3^{1-} and Cl^{-} contents. The mean concentrations of total Fe, Mn, Cr and Ni in water samples were 0.79. 0.25, 0.005 and 0.012 µg mL^{-1}, respectively while the amount of Zn, Cu and Pb were below the detectable limit. The quality assessment showed relatively high values of Fe and Mn in most of the water samples, which would make them unsafe for drinking and irrigation purpose, respectively.
Key words: Water quality, ions, heavy metal.

Introduction

In Bangladesh, there is a progressive increase in industrial wastes and due to the rapid industrialization such waste products have been causing severe contamination to the air, water and soils, thus polluting the environment. Wastewater is mainly used for irrigation purpose, because this contains nutrients that enhance the growth of crop plants but it is also known to have significant contribution to the heavy metal content of soils. About 80% of the diseases in developing countries are related to contaminated water and the resulting death toll is as much as 10 million per year. Heavy metal can cause surface and ground water contamination and are taken up by plants, released as gases into atmosphere or bound semi permanently by soil components such as organic matter and clay particles which later affect human health (Krishna and Govil, 2007). The presence of any metal may vary from site to site, depending upon the source of individual pollutant. Excessive uptake of metals by plants may produce toxicity in human nutrition, and cause acute and chronic diseases. For instance, Cd and Zn can lead to acute gastrointestinal and respiratory damages and acute heart, brain and kidney damages. Heavy metal pollution in the environment is quite relevant in the present scenario due to its deleterious effect on human health via food chain. Biosphere pollution by heavy metals has accelerated dramatically during the last few decades as a result of discharge of wastewater from various industries and urban population. Therefore, the present research work was carried out to determine the concentration of major ionic constituents including heavy metals in waters collected from different areas of Bogra city of Bangladesh with a view to assess the level of contamination by using worldwide standards.

Materials and Methods

Bogra district has an area of 2919.9 sq. km. with annual average temperature maximum 34.6^{0}C and minimum 11.9^{0}C, and annual rainfall 1610 mm. Bogra is one among the newly industrial based areas of

Bangladesh, which is highly susceptible to environmental pollution due to over population, rapid industrialization and urbanization in last 10 years. There are several types of industrial units including aluminium and ceramic factories, pharmaceutical and cosmetics industries, diesel plants, packaging industries, brick fields, garments and many others. Fourteen water samples were collected from (Table 1) following a standard procedure as outline by APHA (2005). Sampling was done during the month of October and November, 2014. Laboratory analysis was carried out in Bangladesh Sugarcrop Research Institute. The pH, EC, TDS and DO values of water samples were measured by pH meter (Model-WTW pH 5.22), EC meter (Model-D.6072 Dreieich, West Germany), TDS meter (Model-HACH sens ION^{TM} + EC5, USA) and DO meter (Model-OXi 3 150i, Germany), respectively. Carbonate, bicarbonate and chloride concentrations were determined by titrimetric method. Amount of phosphate and sulphate were measured following the procedure outlined by Wolf (1982). Concentrations of calcium and magnesium were determined from water samples by titrimetric method using Na_2EDTA as a chelating agent (Page *et at.*,1982). Flame emission spectrophotometer (Model: Jenway PEP7, UK) was used to determine potassium and sodium contents. Determination of different heavy metal concentrations in water samples was done by using an atomic absorption spectrophotometer (AAS) (Varian Spectra AA55B, Australia). Mono element hollow cathode lamp was employed for the determination of each heavy metal of interest.

Table 1: Sources and sampling sites of waters collected from Bogra city, Bangladesh

Sample ID	Source of water	Sampling site
1	Canal	Sabujbag
2	Canal	Fuldighi
3	Canal	Latifpur
4	Canal	Chakfarid
5	Tubewell	Thonthonia
6	Tube well	Jamil Madrasa
7	Tube well	Khander
8	Tube well	Sakpala
9	Tube well	Bonani
10	Tube well	Tinmatha
11	Tube well	Charmatha
12	Tube well	Satmatha
13	Tube well	Matidali
14	Tube well	Coloni

Results and Discussion

Physio-chemical properties of water

The physicochemical properties of water samples are presented in Table 2. The pH value of water samples varied from 6.26 to 7.25. Out of 14 samples, 6 samples showed pH lower than 7.0 and the rest 8 samples represented above the neutral value. According to Ayers and Westcot (1985), the acceptable range of pH for irrigation water is 6.0 to 8.4. On the other hand, the guideline value of pH for drinking water is varied from 6.5-8.5 (USEPA, 2009). Considering these values as standard, all samples were found suitable for drinking and irrigation purposes except only one (ID 14) (Table 2). Electrical conductivity (EC) of the water samples ranged from 326 to 1265 µS cm^{-1} with an average value of 842.07 µS cm^{-1} (Table 2). Higher EC value reflected the higher amount of salt concentration which affected irrigation water quality related to salinity hazard. TDS values of water samples in the study area were within the limit of 132 to 607 mg L^{-1} and the average value was 388.71 mg L^{-1} (Table 2). FAO standard range of TDS for long-term irrigation practices 450 to 2000 mg L^{-1} 1 (Ayers &Wescot, 1985). According to US-EPA (2009), the guideline value of TDS for drinking water is less than 500 mg L^{-1}. Considering this value as standard, 7 water samples were within the limit and could safely be used for drinking without any bad impact. But, the rest 7 samples exceeded the limit which may because problems related to health hazard. Dissolved oxygen (DO) contents of waters in the study area were within the range of 0.3-0.6 mg L^{-1}, with an average value of 0.46 mg L^{-1} (Table 2). As dissolved oxygen levels in waters dropped below 5.0 mg L^{-1}, aquatic life in the study area may put under stress, and the lower the concentration, the greater the stress (DEP, 2010).

Table 2: Physicochemical properties and major anionic constituents of water samples collected from different areas of Bogra city, Bangladesh

Sample no	pH	EC (μScm^{-1})	TDS	DO	CO_3^{2-}	HCO_3^{1-}	Cl	BO_3^{3-}	PO_4^{2-}	SO_4^{2-}
			(mgL^{-1})					(μgmL^{-1})		
1	7.21	1215	572	0.40	0.40	15.60	6.20	0.56	1.87	16.95
2	7.14	1200	554	0.50	0.40	15.40	6.04	0.58	0.76	15.73
3	7.21	1265	588	0.30	0.80	15.60	6.37	0.04	0.69	14.83
4	7.09	1228	607	0.40	0.00	17.80	6.37	0.44	0.08	16.04
5	7.14	1255	601	0.50	0.80	15.40	6.26	0.10	0.74	13.51
6	6.91	326	132	0.40	0.80	13.80	1.30	0.10	0.01	0.20
7	6.85	333	138	0.50	0.40	13.80	0.85	0.33	BDL	BDL
8	6.97	359	282	0.50	0.80	11.40	3.33	0.21	BDL	BDL
9	6.76	542	227	0.50	0.80	13.60	2.93	0.04	BDL	0.13
10	6.75	492	202	0.50	0.80	11.60	1.58	0.16	BDL	2.40
11	7.09	1208	582	0.40	0.00	13.00	6.26	0.33	1.33	15.58
12	7.25	1171	565	0.60	0.40	16.00	5.58	0.38	0.54	17.78
13	7.03	530	223	0.40	0.80	15.20	1.75	0.10	BDL	6.87
14	6.36	375	169	0.50	1.20	15.80	0.34	0.38	0.02	10.56
Range	6.26-7.25	326-1265	132-607	0.30-0.60	0.00-1.20	11.40-17.80	0.34-6.37	0.04-0.56	BDL-1.87	BDL-17.78
Mean	-	842.07	388.71	0.46	0.60	14.57	3.94	0.25	0.67	10.85
DWGV	6.585 *	-	<507*	-	-	-	<0.141 *	0.5*	-	-
IWGV	6.00-8.4*	-	450-2000*	-	-	<151*	<4.0*	0.75*	2*	20*

BDL=Below Detectable limit, DWGV (Drinking Water Guideline value) and IWGV (Irrigation Water Guideline value) = *WHO (2008).

Major anionic constituents in water

The anion chemistry of the analyzed water samples shows SO_4^{2-}, $HCO_3^-$and Cl^- to be the dominant anions towards the total mass balance in water samples of Bogra city. The concentration of CO_3^{2-} and HCO_3^- in water samples were within the range of 0-1.2 me L^{-1} and 11.4- 17.8 meL^{-1} with the mean value of 0.60 me L^{-1} and 14.57 me L^{-1}, respectively (Table 2). HCO_3^- is contributing 38% to the total anionic balance in the study area. In respect of HCO_3^- content, all water samples were found unsuitable for irrigation, which exceeded the recommended limit (1.51 me L^{-1}) as reported by Ayers and Westcot (1985). Chloride constituted 15% of the total anionic balance in the study area and its concentration in water samples collected from the study area ranged from 0.34 to 6.37 me L^{-1} with an average value of 3.94 me L^{-1}, while the maximum permissible limit of Cl^- in irrigation water is 4.00 me L^{-1} (Ayers and Westcot. 1985). Out of 14 samples, 7 samples were found within the permissible value and these waters can be used safely for irrigation. On the other hand, according to WHO (2008), the guideline value of C1 for drinking water is 0.141 me L^{-1}or 5.0 mg L^{-1}, which indicates that all the waters collected from the study area were unsuitable for drinking purpose. The large variation in the chloride concentrations and the high observed concentrations in some water indicate local recharge and attributed to contamination by untreated industrial and municipal waste effluents.

Major cationic constituents in water

Major nutrients and heavy metal concentrations in water samples are presented in Table 3. It is evident that the cationic chemistry of the water samples of Bogra city is dominated as the sequence of Ca^{2+}> Na^{-} > Mg^{2+}> K^{-}. The content of Ca^{2-} in water samples collected from different areas of Bogra city varied from 18.04 to 86.17 µg mL^{-1} with an average value of 51.67 µg mL^{-1} (Table 3). On average, Ca^{2+} accounts for 43% of the total cations. The content of Ca^{2+} in waters is largely dependent on the solubility of $CaCO_3$, $CaSO_4$ and rarely on $CaCI_2$. Irrigation waters containing less than 20 me L^{-1} (800 µg mL^{-1}) Ca^{2+} is suitable for irrigating crops (Ayers and Westcot, 1985). On the basis of Ca^{2+} content, all water samples could safely be used for long-term irrigation and would not be affected soils quality. Magnesium is a common constituent of natural water. In the analyzed water samples, Mg^{2+} constitutes 2l%of the total cationic balance and its concentration ranged from 6.01 to 42.08 µg mL^{-1} with an average value of 26.07 µg mL^{-1} (Table 3). According to Ayers and Westcot (1985), irrigation water containing below 5.0 meL^{-1} (121.5 $µgmL^{-1}$) Mg^{2+} is suitable for crops and soils. In the investigated areas, all water samples were within the limit and could safely be used for irrigation without any bad impact on soils.

Table 3: Major cationic constituents in water samples collected from different areas of Bogra city, Bangladesh

Sample ID	Nutrient concentration ($µgmL^{-1}$)		
	Ca	Mg	Na
1	68.14	34.07	38.70
2	56.11	38.08	41.24
3	24.05	34.07	43.80
4	62.12	40.08	42.94
5	8.16	42.08	42.94
6	36.07	14.03	18.48
7	36.07	36.07	16.48
8	50.10	28.06	25.74
9	46.09	36.07	18.39
10	18.04	20.04	19.48
11	78.16	42.08	42.94
12	86.09	32.06	42.94
13	46.09	16.03	43.80
14	42.08	12.02	21.44
Range	18.00-86.17	6.01-42.08	16-43.80
Mean	51.67	26.07	32.77
DWGV	-	-	20[a]
IWGV	800	121.50	920

DWGV (Drinking Water Guideline value) and IWGV (Irrigation Water Guideline value) = WHO (2008); USEPA (2009); Ayers and Westcot (1985); USEPA (1999).

Heavy metal concentration in water

The concentration of 8 heavy metals analyzed from the 14 water samples collected from different areas of Bogra city are presented in Table 4. Among the heavy metals the concentration of Zn, Cu and Pb were below detectable limit. On the other hand, the concentration of Cr and Ni in water sample ranged from 0.002 to 0.006 and 0.002 to 0.10 µg mL^{-1} with a mean value of 0.005 and 0.012 µg mL^{-1}, respectively. It can be inferred from Table 4 that Ni concentration in sample ID 11(0.10 µg mL^{-1}) exceeded both the guideline values for drinking and irrigation water quality as reported by WHO (2008) and US-EPA (2009), respectively. All water samples contained comparatively less amount of iron (Fe) and the range was varied from 0.63 to 1.02µg mL^{-1} with the mean value of 0.79 µg mL^{-1}(Table 4). The recorded Fe concentration of all water samples were far below the acceptable limit (5.00 µg mL^{-1}) for irrigation quality as reported by Ayers and Westcot 1985, and due to this reason, all samples under test may use for long term irrigation without any detrimental effect on soil and crops. On the other hand, in all sites, concentration of Fe was above the desirable limit for drinking water (0.30 µg mL^{-1}) of US-EPA (2009), and as per this result.

Table 4: Major heavy metal concentration in water samples collected from different areas of Bogra city, Bangladesh

Sample ID	Heavy metal concentration (µgmL^{-1})							
	K	Fe	Mn	Cr	Ni	Zn	Cu	Pb
1	19.59	0.63	0.11	0.004	0.006	BDL	BDL	BDL
2	20.40	0.76	0.10	0.002	0.002	BDL	BDL	BDL
3	20.00	0.89	BDL	0.004	0.008	BDL	BDL	BDL
4	22.85	0.83	0.20	0.006	0.005	BDL	BDL	BDL
5	20.18	0.76	0.35	0.007	0.007	BDL	BDL	BDL
6	1.72	0.63	0.14	0.003	0.002	BDL	BDL	BDL
7	2.53	0.76	0.25	0.005	0.005	BDL	BDL	BDL
8	2.53	0.89	0.35	0.003	0.003	BDL	BDL	BDL
9	1.72	0.95	0.23	0.006	0.006	BDL	BDL	BDL
10	0.90	1.02	0.11	0.004	0.004	BDL	BDL	BDL
11	26.10	0.80	0.60	0.005	0.100	BDL	BDL	BDL
12	22.44	0.63	0.63	0.006	0.007	BDL	BDL	BDL
13	3.35	0.70	0.35	0.003	0.003	BDL	BDL	BDL
14	3.35	0.76	0.21	0.008	0.011	BDL	BDL	BDL
Range	0.90-26.1	0.63-1.02	BDL-0.63	0.002-0.006	0.002-0.100	-	-	-
Mean	11.98	0.79	0.25	0.005	0.012	-	-	-
DWGV	-	0.3[b]	0.4[a]	0.05[a]	0.07[a]	0.05	2	0.01
IWGV	2	5	0.2	0.011	<052	-	-	-

BDL = Below Detectable limit; DWGV (Drinking Water Guideline value) and IWGV (Irrigation Water Guideline value) = WHO (2008); USEPA (2009); Ayers and Westcot (1985).

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