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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 mgL^{-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	
	μScm^{-1}	Class	mg L^{-1}	Class	Ratio	Class	%	Class	meL^{-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 mgL^{-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 mgL^{-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.

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