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Toxicity Assessment of Surface Water in Different Remote Aquifers of Khagrachari in Bangladesh

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Abstract: An investigation was conducted to evaluate the surface water quality at Matrianga Upazilla under very remote areas of Khagrachrari Hill District of Bangladesh. The chemical analyses of water collected from canals included pH, EC, total cations (Ca, Mg, Na, K, Zn, Cu, Mn, Fe, As, P and B), Total anions (CO_3, HCO_3, SO_4, NO_3, C1), TDS, SAR, SSP, RSC and hardness (H_T). pH values (6.75-7.27) indicated that the waters were slightly acidic to neutral. waters contained Ca, Mg, Na, K, HOC_3 and C1 predominantly along with Zn, P and B in lesser amounts. Mn, Cu and As were found trace to very little amount. Fe and SO_4 were found trace. TDS and SAR values indicated that all waters were under 'good' and 'permissible' classes. SAR and EC categorized the waters as C1-S1. All waters were found under 'soft' class regarding hardness with 'suitable' RSC. Based on As, Fe, Mn, Zn, So_4, NO_3 and C1 all waters were within the 'safe' limit for drinking except one sample for As.

Key words: Toxicity, canal water, irrigation, Khagrachari, Bangladesh

Introduction

Water naturally contains different ions in varying amounts. Thus the concentration and composition of dissolved constituents in water is an important determinant concerning its quality. Among the chemical constituents Ca, Mg, Fe, Na, C1, HCO_3, SO_4 and B are of prime importance in determining the quality and suitability for irrigation uses. The assessment of water quality indicates their potential to foster soil conditions detrimental in surface water collected from different regions of Bangladesh (Rahman and Zaman, 1995; Quddus and Zaman, 1996).

Currently 16% of the cultivated area are irrigated from different sources. Among the sources canal/brook (locally known as chara) waters are widely used for irrigation purposes and also in small scale for drinking. It is mentionable that in the study areas three is no shallow or deep tube well. Use of groundwater from hand tube well has limited use in the vegetable fields. Therefore, the present study has been conducted to assess the quality of so far major utilized irrigation and small scale drinking from canal/brook in different sites of Matirange Upazilla under Khagrachari Hill District of Bangladesh and to compare them with the standards of acceptable quality for irrigation and drinking.

Materials and Methods

The study was conducted at some parts of Matiranga Upazilla during the month of March, 2001. Within the study areas, 21 sites were selected for collecting representative water samples. Information regarding different sampling locations are given in Table 1. In order to assess their suitability for irrigation and drinking uses, the important inorganic constituents of groundwater were pH, electrical conductance (EC), total dissolved solids (TDS), Ca, Mg, Na, K, Zn, Cu, Mn, Fe, As, P, B, CO_3, HCO_3, SO_4, NO_3 and C1. Water samples were collected following the techniques as outlined by Hunt and Wilson (1986) and Anonymous (1989).

The pH and electrical conductance was determined electrometrically (Anonymous, 1989). TDS was estimated after Chopra and Kanwar (1980). Ca and Mg were analysed by complexometric titration (Page ***et al.***, 1982) whereas K and Na were estimated by flame emission spectrophotometer (Ghosh ***et al.***, 1983). Sulfate was determined turbidimetrically (Wolf, 1982) while CO_3 and HCO_3 were analysed titrimetrically (Ghosh ***et al.***, 1983; Chopra and Kanwar, 1980). Chloride was estimated by argentometric titration (Anonymous, 1989; Ghosh ***et al.***, 1983) and P, B and NO_3 were determined calorimetrically. Arsenic was determined by atomic absorption spectrophotometer equipped with hydride generator situated at Soil Resources Development Institute (SRDI) Laboratory in Bangladesh (Anonymous, 1989), Fe, Zn, Cu and Mu were analysed by atomic absorption spectrophotometer (Anonymous, 1989) in the Laboratory of Soil Chemistry Division, Bangladesh Rice Research Institute (BARRI), Joydebpur, Bangladesh. Waters under test were classified using few standard equations as per the results obtained from the data generated out of chemical analyses. These equations are as fellow:

a) Sodium adsorption ratio (SAR)

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Table 1: Information regarding different sources of waters

Sample No.	Sampling Location Village	Union	Duration of irrigation
1	North Achalong	Taindong	25
2	South Taindong	”	25
3	Barabil	Tabalchari	25
4	Thailapr Chowdhury Para	Barnal	25
5	Thailafang	”	25
6	Gomti	Gomti	25
7	Karaillachari	”	25
8	Gargarianala North	”	25
9	Gargarianala South	”	25
10	Belchari	Belchari	25
11	Khadachara East	”	25
12	Guimara East	Guimara	25
13	Guimara West	”	25
14	Dargiling Tilla	”	25
15	Sadua Para	”	25
16	Taimatai North	”	50
17	East Alutilla	Matiranga	10
18	Charpara	”	25
19	West Alutilla	”	10
20	Natun Para	”	25
21	East Billachari	Guimara	25

b) Soluble sodium percentage (SSP)

$$SSP = \frac{\text{Soluble Na concentration}}{\text{Total cation concentration}} \times 100$$

c) Residual sodium carbonate (RSC)

$RSC = (CO_3 + HCO_3) - (Ca + Mg)$

d) Hardness or total hardness (H_T)

$H_T - 205 \times Ca^{++} + 4.1 \times Mg^{++}$

where, concentrations of ionic constituents for calculating all parameters except hardness in me L^{-1} and in case of hardness as mg L^{-1}.

Results and Discussion

The results of chemical analyses and quality classification of irrigation waters have been presented in Table 2, 3 and 4. pH varied from 6.75 to 7.27 indicating slightly acidic to neutral nature of waters. EC ranged from 29 to 200 μS cm^{-1} (Table 2) and waters were under 'low' (100-250 μS cm^{-1}) salinity class according to Richards (1968). The amount of total dissolved solids (TDS) in the study areas was reported to vary from 20 to 120 mg L^{-1}. Waters containing TDS less than 1000 mg L^{-1} could be considered to be of 'good' quality for irrigation uses (Freeze and Cherry, 1979) and would not affect the osmotic pressure of the soil solution. Toxic element As was within the range of trace to mg L^{-1}. Although it is not an essential nutrient element for plant growth and development but high concentration of As in water or soil may lead to plant to uptake excess amount of As which is not describe.

Table 2: pH, EC, TDS, As and anionic concentration of surface water at Matiranga

Sample No.	pH	EC μS cm^{-1}	TDS mg L^{-1}	As mg L^{-1}	SO_4 me L^{-1}	NO_3 mg L^{-1}	HCO_3 me L^{-1}	Cl me L^{-1}
1	7.20	200	120	Trace	Trace	0.45	0.60	1.00
2	7.27	150	94	Trace	Trace	0.80	0.50	0.80
3	7.24	115	70	Trace	Trace	1.00	0.40	0.50
4	7.02	46	30	Trace	Trace	1.25	0.15	0.20
5	6.90	83	50	Trace	Trace	0.40	0.35	0.40
6	7.02	115	70	Trace	Trace	0.80	0.20	0.80
7	7.04	100	70	Trace	Trace	0.75	0.35	0.40
8	7.16	154	105	Trace	Trace	0.60	0.35	0.80
9	6.95	73	45	Trace	Trace	0.08	0.20	0.40
10	6.80	82	50	Trace	Trace	0.20	0.20	0.40
11	6.78	62	38	0.10	Trace	0.95	0.20	0.30
12	6.98	112	63	Trace	Trace	1.10	0.30	0.80
13	6.84	69	45	Trace	Trace	0.75	0.20	0.35
14	7.13	145	90	Trace	Trace	0.60	0.50	0.80
15	6.90	47	30	Trace	Trace	0.90	0.20	0.20
16	6.75	70	40	Trace	Trace	1.40	0.20	0.40
17	6.77	29	20	Trace	Trace	0.75	0.10	0.20
18	7.10	153	100	0.05	Trace	0.08	0.50	0.80
19	6.94	92	60	Trace	Trace	0.23	0.35	0.50
20	6.88	58	35	Trace	Trace	0.71	0.15	0.30
21	6.93	115	70	Trace	Trace	1.30	0.35	0.50
Range	6.75-7.27	29-200	20-120	Trace -0.10	-	0.08-1.40	0.10-0.60	0.20-1.00
Mean	-	98.57	61.66	0.007	-	0.71	0.30	0.52
SD	-	43.74	27.56	0.023	-	0.38	0.13	0.24
CV(%)	-	44.37	44.69	328.57	-	53.52	46.02	46.15
Recommended limit for irrigation	-	0-750	0-1000	0.10	0-20	-	1.50	4.00
Recommended limit for drinking	6.5-8.5	-	500	0.01	5.20	5.00	-	250.00

Traces for sulfate and As were considered <0.001 me L^{-1} and <0.01 mg L^{-1} respectively

Table 3: Cationic composition of groundwater at Matiranga

Sample No.	Fe^{+++} mg L^{-1}	Zn^{++} mg L^{-1}	Mn^{++} mg L^{-1}	Cu^{++} mg L^{-1}	P^{5+} mg L^{-1}	B^{3+} mg L^{-1}	Ca^{++} mg L^{-1}	Mg^{++} mg L^{-1}	K^{+} mg L^{-1}	Na^{+} mg L^{-1}
1	Trace	0.04	0.05	0.05	0.010	0.014	7.2	6.60	10.00	14.25
2	Trace	0.06	Trace	Trace	0.020	0.009	4.8	6.30	6.50	10.50
3	Trace	0.06	Trace	0.05	Trace	0.005	3.7	4.60	5.00	6.25
4	Trace	0.06	Trace	0.05	0.015	Trace	0.7	0.90	3.50	4.00
5	Trace	Trace	Trace	Trace	0.020	Trace	0.5	1.40	7.25	11.50
6	Trace	Trace	Trace	Trace	Trace	0.006	3.3	5.30	5.25	8.75
7	Trace	0.02	Trace	Trace	Trace	Trace	1.1	1.65	6.25	10.50
8	Trace	0.04	Trace	Trace	0.020	0.009	3.0	5.50	8.50	10.50
9	Trace	0.04	Trace	Trace	0.020	Trace	0.8	1.75	7.25	7.00
10	Trace	0.02	Trace	Trace	0.030	Trace	0.7	1.05	5.00	10.00
11	Trace	0.04	Trace	Trace	0.015	Trace	0.6	0.90	3.75	7.75
12	Trace	Trace	Trace	Trace	0.015	Trace	5.5	5.30	5.00	7.75
13	Trace	0.02	Trace	Trace	0.015	0.006	0.8	1.05	4.50	8.50
14	Trace	0.02	Trace	Trace	0.055	0.008	4.3	0.20	6.50	11.00
15	Trace	0.02	Trace	Trace	0.030	0.005	1.0	0.80	3.50	4.75
16	Trace	Trace	Trace	Trace	0.020	Trace	1.1	2.45	4.00	6.75
17	Trace	0.02	Trace	Trace	0.035	0.007	0.2	0.70	2.50	4.00
18	Trace	Trace	Trace	Trace	0.650	Trace	6.6	6.00	7.20	10.50
19	Trace	0.02	Trace	Trace	0.650	0.006	2.1	4.35	4.50	7.00
20	Trace	0.02	Trace	Trace	0.070	0.005	1.3	1.60	3.75	5.00
21	Trace	0.04	Trace	Trace	0.095	0.006	1.6	3.95	7.50	7.75
Range	-	Trace -0.06	Trace -0.05	Trace -0.05	Trace -0.65	Trace -0.014	0.20-7.20	0.70-6.60	2.50-10.00	4.00-14.25
Mean	-	0.034	0.05	0.05	0.099	0.007	2.42	3.25	5.58	8.28
SD	-	0.016	0.00	0.00	0.202	0.002	2.15	2.22	1.91	2.71
CV(%)	-	46.66	0.00	0.00	203.6	36.96	88.81	68.32	34.25	32.72
Recommended limit for irrigation	5.00	2.00	0.20	0.20	0-2.00	<0.75	100	50.00	2.00	40.00
Recommended limit for drinking	0.30	5.00	0.05	1.00	-	-	75	-	-	-

Traces for Fe, Mn, Cu, P and B were considered <0.01, <0.01, <0.01, <0.01 and <0.001 mg L^{-1}, respectively

The ionic concentrations of Ca, Mg, K and Na were found to very from 0.20-7.20, 0.70-6.60, 2.50-10.00 and 4.00-14.25 mg L^{-1} with the respective average values of 242, 325, 558 and 8.28 mg L^{-1} (Table 3). According to Todd (1980) irrigation water generally contains less than 100 mg L^{-1} Ca and 50 mg L^{-1} Mg and higher amounts may not suitable for irrigation. The recorded Na concentration was far below the recommended limits for irrigation after Ayers and Westcot (1985). The status of Fe, Zn, MN and Cu of all waters were in between trace, trace to 0.06, trace to 0.05 and trace to 0.05 mg L^{-1}, respectively and all the values were far below the maximum recommended limits for irrigation and could be safely used without harmful effects on soil and crops (Todd, 1980).

The concentration of B was within the range of trace to 0.014 mg L^{-1} with a mean value of 0.007 mg L^{-1} and the co-efficient of variation was 36.96%. Boron content of waters were under

Table 4: Quality classification of water samples for irrigation

Sample				Hardness	Water class based on						Alkali and Salinity
No.	SAR	SSP	RSC	mg L^{-1}	TDS	B^{3+}	SAR	SSP	RSC	Hardness	hazard class
1	0.92	34.84	-0.301	45.06	FW	Ex	Ex	Good	Suit	Soft	C1-S1
2	0.74	32.99	-0.257	37.83	"	"	"	"	"	"	C1-S1
3	0.51	28.22	-0.162	28.11	"	"	"	"	"	"	C1-S1
4	0.74	46.24	0.042	5.44	"	"	"	Permissible	"	"	C1-S1
5	1.90	60.44	0.211	6.99	"	"	"	Doubtful	"	"	C1-S1
6	0.69	34.14	-0.384	29.98	"	"	"	Good	"	"	C1-S1
7	1.48	56.71	0.161	9.51	"	"	"	Permissible	"	"	C1-S1
8	0.83	35.70	-0.251	30.05	"	"	"	Good	"	"	C1-S1
9	1.00	45.09	0.018	7.12	"	"	"	Permissible	"	"	C1-S1
10	1.77	66.28	0.080	6.05	"	"	"	Doubtful	"	"	C1-S1
11	1.48	62.63	0.097	5.19	"	"	"	Doubtful	"	"	C1-S1
12	0.56	28.61	-0.409	22.48	"	"	"	Good	"	"	C1-S1
13	1.47	60.35	0.075	6.30	"	"	"	Doubtful	"	"	C1-S1
14	0.79	34.74	-0.223	36.17	"	"	"	Good	"	"	C1-S1
15	0.86	49.78	0.006	5.78	"	"	"	Permissible	"	"	C1-S1
16	0.82	44.85	-0.085	12.79	"	"	"	Permissible	"	"	C1-S1
17	0.94	56.24	0.034	3.37	"	"	"	Permissible	"	"	C1-S1
18	1.10	30.94	-0.322	41.10	"	"	"	Good	"	"	C1-S1
19	0.63	34.14	0.111	23.11	"	"	"	Good	"	"	C1-S1
20	0.69	41.87	-0.045	9.81	"	"	"	Permissible	"	"	C1-S1
21	0.75	35.54	-0.053	20.19		"		Good	"	"	C1-S1

Legend: FW= Fresh water, Ex= Excellent, Suit.= Suitable, SAR= Sodium adsorption ration, SSP= Soluble sodium percentage, RSC= Residual sodium carbonate, TDS= Total dissolved solids, C1= Low salinity, S1= Low sodium

'excellent' class (<0.33 mg L^{-1}) for sensitive crops after Wilcox (1955). Concentration of P (trace to 0.65 mg L^{-1}) also indicated that it had a little influence on irrigation water quality. The sulfur concentration was found trace. The presence of chloride was within the range 0.20 to 1.00 me L^{-1} with the mean value of 0.52 me L^{-1} and the co-efficient of variation was 46.15% (Table 2). For irrigation use chloride ion would not be problematic because the recommended limit is 4.00 me L^{-1}. All samples contained small amount of nitrate (0.08 to 1.40 mg L^{-1}) hence its concentration had little influence on irrigation water quality. The presence of HCO_3 was within the range of 0.10-0.60 me L^{-1} and the present co-efficient of variation was 46.02. Irrigation waters containing HCO_3 higher than 1.50 me L^{-1} is not generally recommended (Ayers and Westcot, 1985) and all of the samples were within the suitable limit. The results were at per with that of Rahman and Zaman (1995) and Quddus and Zaman (1996).

Sodium adsorption ratio (SAR) varied from 0.51 to 190 (Table 4). Todd (1980) classified irrigation waters with SAR values less than 10 as 'excellent'. SSP values reflected that the waters were under the category of 'good' (20-40% Na), 'permissible' (40-60% Na) and 'doubtful' (60-80% Na) class according to Wilcox (1955). Residual sodium carbonate (RSC) values ranged from -0.045 to 0.211.

Based on RSC, 11 samples were free from RSC and 10 were categorized 'suitable' for irrigation as they were well within the limit (<1.25). Hardness values were within the range of 3.37 to 45.06

mg L^{-1} and were categorized as 'soft' (0-75 mg L^{-1}as $CaCO_3$) reported by Sawyer and McCarty (1967) and this is due to in abundance of divalent cations such as Ca and Mg (Todd, 1980). According to Richards (1968) all irrigation waters were under C1S1 categories. C1 indicated 'low' salinity (EC=100-250 μS cm^{-1}) and S1 indicated 'low sodium' with respect to SAR. Finally it can be concluded that the water under test can safely be used for irrigation all type of crops usually grown in Matrianga without any harmful effects on soil and crops.

As the waters were used for drinking in small scale it may be worth enough to find their suitability for drinking purposes. According to drinking water standards on the basis of C1, Fe, Cu, Zn, Mn, MO_3 and SO_4 contents as per Anonymous (1975), all waters were found 'unsuitable' (Recommended limit of As for drinking is 0.01 mg L^{-1}) for drinking.

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