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Evaluation of groundwater quality and environmental health in the coastal belt of Khulna, Bangladesh

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ABSTRACT

The study comprised suitability assessment of groundwater of western peri-urban area of Khulna City Corporation (KCC) for drinking and irrigation use. A total of 40 groundwater samples representative of 4 different seasons were collected from 5 different sampling locations from Rayermahal to Sachibunia to analyse major physico-chemical parameters and trace metals according to the Standard Methods. The results of the study, comparing with the World Health Organization and Bangladesh Standards, reveal the suitability of the groundwater for drinking purpose. Suitability for irrigation was also assessed and found low as most of the calculated parameters reveal high values which can render salinity and alkali hazard to soils on long term use in irrigation. The results shown that all the groundwater samples were contaminated with high salinity in the study area, and are in the 'Doubtful to Unsuitable' or 'Unsuitable' category and are unsuitable to irrigate all soils.

Keywords: Groundwater, quality assessment, drinking purpose, microbial contamination, WHO, irrigation purpose, SAR, KI.

INTRODUCTION

Groundwater is one of the major sources of potable water and acts as an important environmental determinant of the health. One-third of the world's population use groundwater for drinking and other household purposes (Nickson*et al*., 2005). Groundwater always contains small amounts of soluble salts. Untreated municipal sewage, effluents, and unplanned industrial and agricultural operation render the groundwater non-potable and unfit for agriculture (Bruce and McMahon, 1996). In addition, the presence of toxic pollutants like pesticides, arsenic, nitrate (Bruce and McMahon, 1996), fluoride (Chandrawanshi and Patel, 1999), hardness and iron (Sikder et al., 2012) etc. in groundwater may cause potential health hazard to human. Pollution of ground water has been reported to cause 80% of human diseases and 30% infant mortality in developing countries

(Chakroborty, 1999). The coastal areas are vulnerable due to high salinity in both surface and groundwater with the presence of total dissolved solids (TDS) and some specific chemical constituents, such as Cl^-, Na^+, Mg^{2+}, and SO_4^{2-}.

In Bangladesh, the major source of drinking and agricultural water in both urban and peri-urban areas is groundwater. It is reported in some recent reports that both the shallow and deep tubewells in Bangladesh are heavily contaminated with brackish water, toxic heavy metals and arsenic. The quality of shallow and deep ground water of Khulna City Corporation (KCC) western fringe is assumed to be more vulnerable due to some ionic compounds. This study area lies on young Holocene-Recent Alluvium of the Ganges deltaic plain in north and is considered as one of the most saline affected areas of the country (Roy *et. al*., 2005). Out of approximately one million population of KCC, only Around 17% of total population of KCC are under the coverage of piped water supply, whereas the remaining depends on privately installed tubewell water. As a matter of fact, groundwater of deep aquifers are becoming an increasingly popular resource for domestic as well as for irrigation practices in this study area. Though several studies have been conducted on natural waters in the purpose of drinking within the KCC area but no study has yet been conducted on groundwater of deep aquifers to screen the quality of water for drinking an agricultural use in this peri urban area . Therfore, in view of the above facts, an effort has been made to characterize and evaluate the suitability of groundwater in peri-urban area of this southwest part of the KCC.

MATERIALS AND METHOD

Collection of Samples

The samples were collected from 5 different sampling locations along the both banks of the Mayur River from Rayer-Mahal to Sachibunia (Fig. 1) at an approximately same distance of 2 Km. From each sampling locations, two DTWs (deep-tube well) water samples of correspondents of the each bank of the Mayur River were collected following the standard guidelines and continued for 4 times at an interval of 2 months from August, 2011 to May, 2012. The samples were collected after 10 min of pumping the tubewell and stored in polyethylene bottles at 4°C until the analyses were finished. All bottles washed well had been rinsed with deionised water before sampling. Two samples were collected from each area of Rayermahal, Shonadanga, Gollamari, Mohammed Nagar and Sachibunia and labelled as R-1, R-2; S-1, S-2; G-1, G-2; M-1, M-2 and S-1, S-2, respectively.

Analysis of Water Samples

pH, Total Dissolved Solid (TDS), and Electrical Conductivity (EC) were measured immediately after collecting the samples by using a portable pH (Hanna) and an EC/TDS meter (Hanna) at the spot. Major cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) and major anions (Cl^- , NO_3^-, SO_4^{2-} and PO_4^{3-}) were analyzed were done in the water-chemistry laboratory of Khuna University, Khulna following the guidelines and procedures of Standard Methods (APHA, 1999). Moreover some trace metals of samples R-1 (located at Rayermahal upstream reach) and C-1 (located at Sachibunia downstream reach) were also analyzed in BCSIR laboratory (Bangladesh Council of Scientific and Industrial Research), Dhaka and finally data were arranged for four seasons like Pre-monsoon, Monsoon, Post-monsoon and Winter**.**

RESULTS AND DISCUSSION

The groundwater samples collected from the study area were analyzed for their physical and chemical constituents to evaluate their quality and suitability for drinking use in the study area.

General bio-pysico-chemical characterization and ion contributions of the groundwater samples is given in Table 1.

Pysiochemical Parameters

The analytical results of pH, EC and major ions of groundwater of the study area were compared with the standard guideline values recommended by the World Health Organization (WHO, 2011) and Bngladesh Standard (Ahmed and Rahman, 2000) to ascertain the suitabilty for drinking purpose (Table 1). The table shows the maximum allowable limits of the water quality parameters *

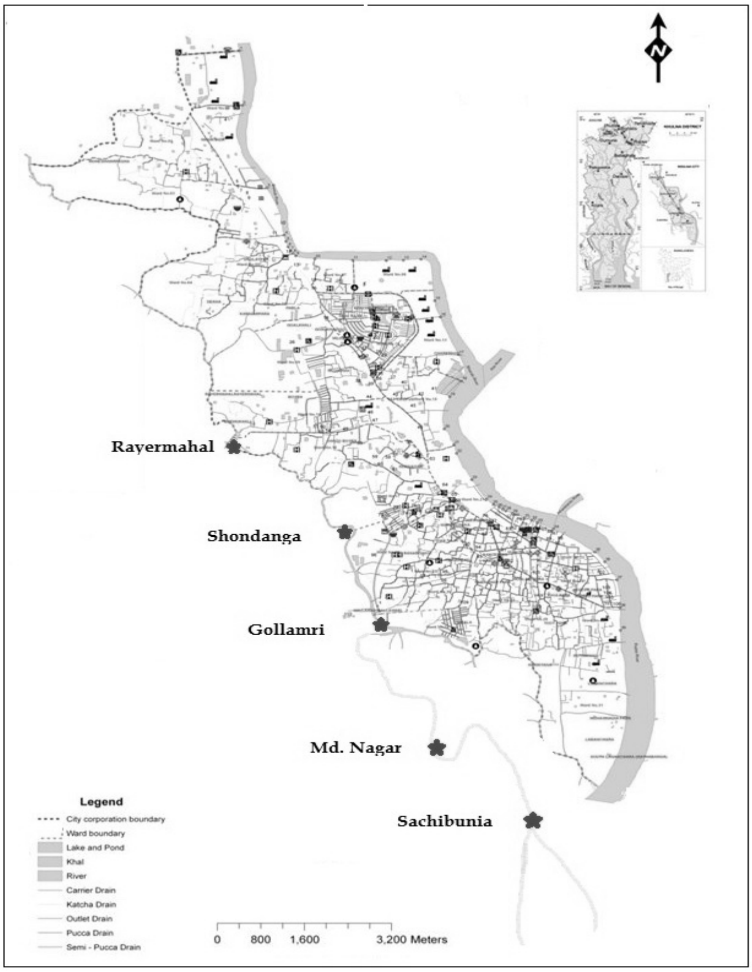

Figure 1. Study areas and sampling locations.

and the samples exceeding the recommended limits. It indicates that the values of pH were quite satisfactory as being within the standards irrespective of all seasons. Conductivity is a measurement of the ability of an aqueous solution to carry an electrical current. The values of EC in all sampling regions exceeded the standard limit in all seasons of pre-monsoon, monsson, post-monsoon and winter. It indicates the presence of high amount of ionic compounds in the ground water that eventually contributes high salinity in this southern region. In addition, it also contributes high TDS in the water sample and thus make the water vulnerable for drinking purpose. The values of TDS is high in compare with the standard of WHO, 2011 in the samples of Rayermahal area in all seasons; in Shonadanga and Gollamari during monsoon. Elevated dissolved solids can cause "mineral tastes" in drinking water. Corrosion or encrustation of metallic surfaces by waters high in dissolved solids causes problems with industrial equipment and boilers as well as domestic plumbing, hot water heaters, toilet flushing mechanisms, faucets, and washing machines and dishwashers. Indirect effects of excess dissolved solids are primarily the elimination of desirable food plants and habitat-forming plant species. Agricultural uses of water for livestock watering are limited by excessive dissolved solids and high dissolved solids can be a problem in water used for irrigation. Dissolved oxygen (DO) is said to be the controlling parameter of healthy potable water. All sampling stations in study area were within the threshold limit recommended by the WHO and thus suitable for both drinking and agricultural purposes.

Among the cations, sodium is the most dominant cation in groundwater of the study area and shows a excedding concentration of Na^+ comparative to the WHO (WHO, 2011) and Bangladesh standards (Ahmed and Rahman, 2000). The table shows that samples those exceeded the standard limits for Na^+ were counted for about 30%, 40%, 60% and 60% in the months of pre-monsoon, monsoon, post-monsoon and winter. The other major cations and anions of all samples, beyond the seasonal classifications, were completely within the maximmum permissible limits of WHO and Bangladesh Standards indicating their suitability for drinking use.

According to Davies and DeWiest (1966) classification the groundater samples of the study area were within the desireable to permisisble limit. In the classification based on Freeze and Cherry (1979), irrespective to the seasons all the samples were considered as freshwater type. The classification of groundwater shows that most of the samples fall in the soft category for all the seasons of the years. Only S-1 of pre-monsoon and M-1 of post-monsoon shows hard to moderately hard quality respectively. Phosphates enter waterways from human and animal waste, phosphorus rich bedrock, laundry, cleaning, industrial effluents, and fertilizer runoff. These phosphates become detrimental when they over fertilize aquatic plants and cause stepped up eutrophication. If too much phosphate is present in the water the algae and weeds will grow rapidly and thus directly affects human health. Unfortunately, all samples consisted high amount of PO_4^{3-} ions. The variance of data for all sampling stations in all seasons were calculated to measure the difference of data value from the mean value in all sampling stations. Surprisingly, there were significant differences among all calculated variances in all sampling stations. This analysis clearly depicts the individuality of water quality in all sampling regions. Furthermore, it can be also predicted that the parameters will show different trend in different seasons and thus the water quality scnerio of groundwater in the study area will be surely different in each seasons

Metals Ions

Again, the analyzed trace metal concentrations (Table 2) in the groundwater samples (R-1 and C-1) of the study area were within the permissible limit of the WHO (WHO, 2011) and Bangladesh Standards (Ahmed and Rahman, 2000) except iron, indicating their suitabiltiy for the use in drinking purpose. Thus, the geo-accmulation factors and the enrichment factors of these metals will be surely low.

Correlation Analysis

The correlation matrix was calculated with the physiochemical parameters. Accordingly, it was evident that pH, EC and TDS were highly correlated with EC, TDS, NO_3^-, SO_4^{2-} and PO_4^{3-}. pH was also highly correlated with EC and TDS. DO was correlated with K^+, Ca^+ and Cl^-. Na^+ and K^+ were correlated with SO_4^{2-} and Ca^+, respectively. NO_3^- was variably correlated with SO_4^{2-} and PO_4^{3-}. In addition, SO_4^{2-} was highly correlated with PO_4^{3-}. Furthermore, the total cation and the total anion were shown some positive correlation with the physiochemical parameters as expected (Table 3). Alternatively, some negative correlation were also noted (Table 3).

Table 1. Physiochemical characteristics of ground water samples in Western peri urban part of KCC.

Sample ID	Seasons	pH	EC (µS/cm)	TDS (mg/L)	DO (mg/L)	Na^+ (mg/L)	K^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Cl^- (mg/L)	NO_3^- (mg/L)	SO_4^{2-} (mg/L)	PO_4^{3-} (mg/L)	Total cation	Total anion
R-1	Pre-monsoon	7.78	1230	615	2.3	429.1	3.15	6	6	106.3	4.205	1.57	0.52	19.54	17.6
	Monsoon	8.19	1300	649	1.5	253.9	3.34	8	4.8	59.6	3.81	5.11	0.48	11.92	13.28
	Post-monsoon	7.92	1192	596	3.5	344.4	1.37	8	3.6	80.7	3.456	1.4	0.66	15.71	13.18
	Winter	7.78	1230	615	2.3	429.1	3.1	6	6	88.6	4.2	1.5	0.52	19.54	17.1
	Average	7.92	1238.00	618.75	2.40	364.13	2.74	7.00	5.10	83.80	3.92	2.40	0.55	16.68	15.29
	STDEV	0.19	45.05	22.07	0.82	83.63	0.92	1.15	1.15	19.36	0.36	1.81	0.08	3.65	2.39
	Variance	0.04	2029.33	486.92	0.68	6994.04	0.84	1.33	1.32	374.85	0.13	3.28	0.01	13.32	5.70
R-2	Pre-monsoon	7.92	1024	511	3.9	196.9	0.95	7	4.2	59.1	2.6	1.4	0.72	9.28	11.46
	Monsoon	7.11	1093	546	1	229.6	3.09	7	3.6	53.2	3	2.14	0.43	10.71	12.04
	Post-monsoon	7.11	1055	527	1.9	334.1	5.98	5	5.4	63.2	0.94	4.39	0.47	15.38	12.14
	Winter	7.8	1003	501	4.4	265.4	3.26	4	7.2	53.2	7.3	1.08	0.56	12.42	15.58
	Average	7.49	1043.75	521.25	2.80	256.50	3.32	5.75	5.10	57.18	3.46	2.25	0.55	11.95	12.81
	STDEV	0.44	39.17	19.67	1.61	58.81	2.06	1.50	1.59	4.89	2.71	1.49	0.13	2.62	1.87
	Variance	0.19	1534.25	386.92	2.61	3458.91	4.25	2.25	2.52	23.87	7.35	2.23	0.02	6.88	3.51
S-1	Pre-monsoon	8.21	950	474	2.4	150.5	0.54	4	3	53.2	2.32	1.57	1.22	7.01	9.97
	Monsoon	7.91	1020	510	1.8	191.2	1.32	3	3.6	35.45	2.44	4.44	0.83	8.8	9.9
	Post-monsoon	7.91	907	454	1.8	238.4	3.61	2	2.4	48.1	0.93	5.83	0.52	10.76	9.49
	Winter	7.83	953	477	1.5	160.6	1.62	3	2.4	53.2	3.67	1	1.12	7.37	10.71
	Average	7.97	957.50	478.75	1.88	185.18	1.77	3.00	2.85	47.49	2.34	3.21	0.92	8.49	10.02
	STDEV	0.17	46.67	23.20	0.38	39.48	1.31	0.82	0.57	8.38	1.12	2.31	0.32	1.70	0.51
	Variance	0.03	2177.67	538.25	0.14	1558.50	1.71	0.67	0.33	70.18	1.26	5.32	0.10	2.90	0.26
S-2	Pre-monsoon	7.94	789	394	3.1	144	0.95	5	45	35.45	0.56	0.76	0.73	10.24	9.05
	Monsoon	8.07	846	423	1.3	162.3	2.33	3	4.2	25.5	2.16	1.18	0.34	7.61	8.86
	Post-monsoon	8.07	779	391	2	193.6	4.99	3	3	27.3	0.36	2.49	0.44	8.95	8.05

	Winter	7.87	790	395	1.9	141	2.13	4	3	38.3	1.74	1.73	0.5	6.63	8.27
	Average	7.99	801.00	400.75	2.08	160.23	2.60	3.75	13.80	31.64	1.21	1.54	0.50	8.36	8.56
	STDEV	0.10	30.41	14.93	0.75	24.16	1.71	0.96	20.81	6.20	0.88	0.75	0.17	1.57	0.47
	Variance	0.01	924.67	222.92	0.56	583.68	2.91	0.92	432.96	38.47	0.78	0.56	0.03	2.48	0.22
G-1	Pre-monsoon	8.27	955	476	1.9	208.6	0.44	5	0.6	53.2	3.77	2.7	1.46	9.38	12.86
	Monsoon	7.02	1068	534	1.4	315.1	1.07	4	1.8	35.5	4.25	3.96	0.98	14.08	12.52
	Post-monsoon	8.3	974	488	1.5	302.2	3.41	2	2.4	27.3	0.49	6.02	0.61	13.53	11.16
	Winter	7.94	990	495	2.7	265.4	1.52	2.5	2.7	53.2	5.29	3.99	1.56	11.93	12.23
	Average	7.88	996.75	498.25	1.88	272.83	1.61	3.38	1.88	42.30	3.45	4.17	1.15	12.23	12.19
	STDEV	0.60	49.61	25.09	0.59	47.71	1.28	1.38	0.93	13.02	2.07	1.37	0.44	2.11	0.73
	Variance	0.36	2460.92	629.58	0.35	2276.68	1.64	1.90	0.86	169.62	4.30	1.89	0.19	4.44	0.54
G-2	Pre-monsoon	8.09	921	460	2.4	196.3	0.44	4	1.2	102.5	0.47	0.03	1.03	8.85	11.33
	Monsoon	8.16	960	480	1.7	212.9	1.07	3	1.2	58.6	1.33	2.81	0.82	9.54	9.88
	Post-monsoon	8.16	899	449	2.2	251.2	3.31	2	1.8	70.9	0.45	4.08	0.66	11.26	9.75
	Winter	7.78	906	453	1.8	199.9	1.22	3	1.8	88.6	2.31	1.01	1.24	9.02	9.71
	Average	8.05	921.50	460.50	2.03	215.08	1.51	3.00	1.50	80.15	1.14	1.98	0.94	9.67	10.17
	STDEV	0.18	27.26	13.77	0.33	25.12	1.25	0.82	0.35	19.33	0.88	1.81	0.25	1.10	0.78
	Variance	0.03	743.00	189.67	0.11	630.84	1.55	0.67	0.12	373.63	0.78	3.28	0.06	1.21	0.61
M-1	Pre-monsoon	7.76	827	413	3.6	163.4	1.47	6	3.6	70.9	0.25	1.01	0.55	7.74	11.14
	Monsoon	8.11	837	419	1.3	276.7	3.34	3	4.8	53.2	0.77	2.81	0.23	12.67	10.13
	Post monsoon	8.11	821	409	2	200.2	6.38	24	7.4	67.3	0.22	3.88	0.3	10.68	8.99
	Winter	7.8	795	401	2.2	154.1	14.2	5	3.6	70.9	2.23	1.4	0.3	7.61	9.18
	Average	7.95	820.00	410.50	2.28	198.60	6.35	9.50	4.85	65.58	0.87	2.28	0.35	9.68	9.86
	STDEV	0.19	17.93	7.55	0.96	55.74	5.61	9.75	1.79	8.42	0.94	1.32	0.14	2.45	0.99
	Variance	0.04	321.33	57.00	0.93	3107.15	31.50	95.00	3.21	70.94	0.89	1.74	0.02	6.00	0.98
M-2	Pre-monsoon	7.67	800	401	3.3	168.4	2.89	12	4.8	70.9	0.56	1.73	0.62	8.39	9.46
	Monsoon	7.82	804	403	1.6	174.6	4.09	8	6.6	50.9	0.39	0.99	0.22	8.64	8.71
	Post monsoon	7.82	788	395	2.1	136.4	7.86	6	6	43.3	0.09	2.96	0.24	6.93	7.59
	Winter	7.38	781	392	3.2	429.1	2.75	7	7.2	70.9	1.11	1.57	0.26	19.68	8.6
	Average	7.67	793.25	397.75	2.55	227.13	4.40	8.25	6.15	59.00	0.54	1.81	0.34	10.91	8.59
	STDEV	0.21	10.63	5.12	0.83	135.69	2.39	2.63	1.02	14.09	0.43	0.83	0.19	5.90	0.77
	Variance	0.04	112.92	26.25	0.70	18410.81	5.69	6.92	1.05	198.44	0.18	0.69	0.04	34.75	0.59
C-1	Pre-monsoon	8	853	427	4	189.2	1.47	6	5.4	88.6	0.39	0.6	0.43	9.01	10.53
	Monsoon	7.93	944	472	1.5	175.4	3.34	6	5.4	70.9	1.05	4.15	0.47	8.46	10.5
	Post-	7.93	900	450	1.8	245.3	6.68	5	5.8	85.6	0.25	3.66	0.54	11.57	10.52

	monsoon														
	Winter	7.74	860	431	3.2	178.6	8.87	5	8.4	129.5	2.1	3.1	0.65	8.94	11.45
	Average	7.90	889.25	445.00	2.63	197.13	5.09	5.50	6.25	93.65	0.95	2.88	0.52	9.50	10.75
	STDEV	0.11	41.96	20.61	1.18	32.65	3.32	0.58	1.45	25.12	0.84	1.58	0.10	1.40	0.47
	Variance	0.01	1760.92	424.67	1.39	1066.26	10.99	0.33	2.09	631.03	0.71	2.49	0.01	1.97	0.22
C-2	Pre-monsoon	7.21	931	467	3.8	292.7	6.29	7	4.8	106.3	5.81	0.03	0.34	13.64	12
	Monsoon	8.04	972	486	1.5	221.2	3.59	6	5.4	80.6	1.48	4.24	0.26	10.46	10.98
	Post-monsoon	8.04	865	433	2	233.6	6.78	7.5	5.3	88.6	0.46	3.67	0.35	11.15	10.28
	Winter	7.68	946	471	3	147.5	3.36	5	6	106.3	2.17	1.49	0.32	7.25	11.32
	Average	7.74	928.50	464.25	2.58	223.75	5.01	6.38	5.38	95.45	2.48	2.36	0.32	10.63	11.15
	STDEV	0.39	45.60	22.38	1.03	59.64	1.78	1.11	0.49	12.95	2.33	1.95	0.04	2.63	0.72
	Variance	0.15	2079.00	500.92	1.06	3557.23	3.17	1.23	0.24	167.63	5.42	3.81	0.00	6.93	0.51
WHO -2011		6.5-8.5	250	500	4	200	-	75-200	30	200	0.45	250	0.01	-	-

- = Not known.

Table 2 Concentration of trace metals in groundwater of the study area.

Sample ID	Cu (mg/mL)	Fe (mg/mL)	Mn (mg/mL)	Zn (mg/mL)	Pb (mg/mL)	Cd (mg/mL)	Cr (mg/mL)	As (mg/mL)	Ni (mg/mL)
R-1	0.68	43	7	15	0.76	0.015	1.89	0.75	1.5
C-1	0.54	64	6	19	1.02	0.008	1.96	0.4	1.25
WHO-2011	2000	50	10	3000	10	3	50	10	20

Table 3. Correlation analysis of physiochemical parameters at all sampling points.

	pH	*EC*	*TDS*	*DO*	*Na⁺*	*K⁺*	*Ca⁺*	*Mg⁺*	*Cl⁻*	*NO3-*	*SO4²⁻*	*PO4³⁻*	*Total cation*	*Total anion*
pH	1													
EC	**0.57**	1.00												
TDS	**0.56**	1.00	1.00											
DO	-0.95	-0.40	-0.40	1.00										
Na^+	-0.12	0.45	0.45	0.02	1.00									
K^+	-0.98	-0.66	-0.66	**0.95**	-0.06	1.00								
Ca^+	-0.91	-0.81	-0.80	**0.76**	0.05	**0.92**	1.00							
Mg+	-0.08	-0.55	-0.55	0.18	-0.98	0.26	0.13	1.00						
Cl^-	-0.70	0.18	0.19	**0.82**	0.42	0.62	0.36	-0.26	1.00					
NO_3^-	**0.73**	**0.97**	**0.97**	-0.56	0.25	-0.79	-0.93	-0.39	-0.03	1.00				
SO_4^{2-}	**0.52**	**0.98**	**0.98**	-0.40	**0.60**	-0.64	-0.73	-0.70	0.20	**0.92**	1.00			
PO_4^{3-}	**0.88**	**0.78**	**0.78**	-0.86	0.36	-0.95	-0.86	-0.54	-0.42	**0.84**	**0.81**	1.00		
Total cation	-0.32	0.29	0.29	0.21	**0.98**	0.14	0.25	-0.92	**0.51**	0.06	0.45	0.16	1.00	
Total anion	0.08	**0.86**	**0.86**	0.06	**0.71**	-0.22	-0.40	-0.71	**0.62**	**0.71**	**0.89**	0.45	**0.63**	1

Values in bold are different from 0 with a significance level of alpha = 0.05.

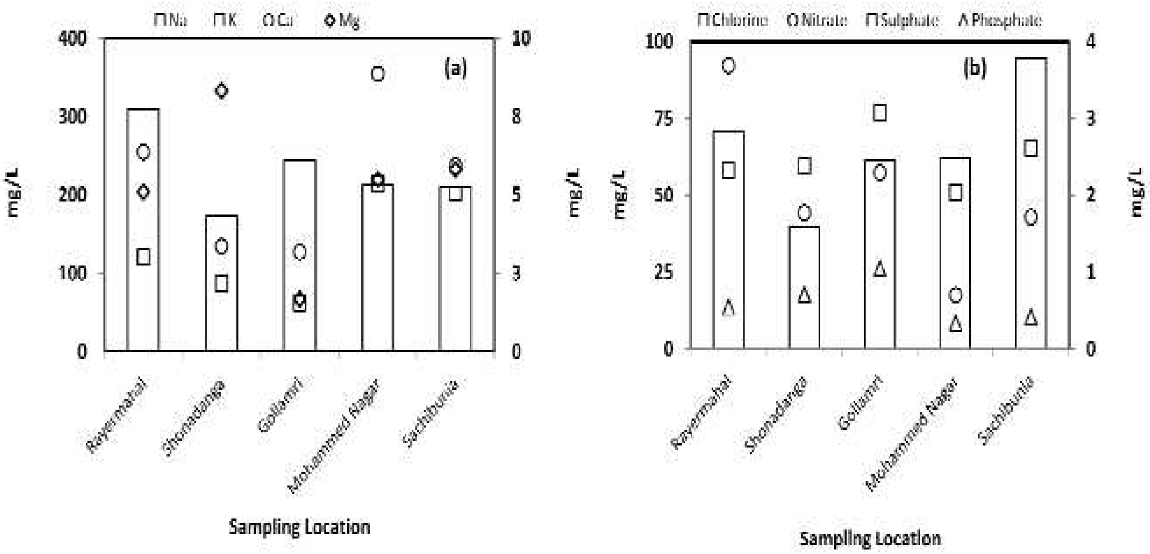

Figure 2. Presence of cationic and anionic compounds in the samples.

Correlation of the parameters may be due to an interaction between the different parameters in the adjacent water samples in the study area. The sources of these parameters may be the industrial operations on the banks of rivers (Sikder et al., 2013). Urban runoff and sea water intrusion could be a source of these parameters, especially in the rainy season, as all sampling location were in the coastal belt. The results were also supported by the presence of high level of K^+, Ca^+ , Na^+ and Ca^+ along with the presence of NO_3^-, SO_4^{2-} , PO_4^{3-} and Cl^- (Figure 3).

A maximum of 60% sodium in groundwater is allowed for agricultural purposes (Ramakrishna, 1998). The Na% in the groundwater samples of all seasons indicate that most of the samples (90%) are unsuitable for irrigation. Only one sample of pre-monsoon is within permissible limit. In addition to this, some indices such as residual sodium carbonate (RSC), permeability index (PI), Kelly’s index (KI), magnesium hazard (MH), Base exchange and Meteorogenesis have been utilize to verify the quality of groundwater for irrigation use.

CONCLUSION

The groundwater of the western peri-urban fringe of the KCC is dominated by Na^+ and Cl^- ions. pH values reveal that the groundwater is alkaline in nature. The overall groundwater quality of the study area was evaluated by WHO and Bangladesh standards and found suitable for drinking purposes. With respect to the agricultural use, it was found that most of the sources had high value of SAR, RSC, SSP, and Magnesium hazard and water from these sources was found to be unsuitable for irrigation on long-term use. Such water can be used over coarse textured, high organic content soils with good drainage or long-term use might render the soil infertile.

REFERENCES

[1]. APHA; AWWA; WEF. Standard methods for the examination of water and wastewater, 20th ed., Washington DC, 1998; American Public Health Association.

[2]. BW Bruce; PB McMahon. Shallow ground water quality beneath a major urban center: Denver, Colorado, USA Journal of Hydrology, 1996, 186, 129–151.

[3]. CK Chandrawanshi; KS Patel; Fluoridendeposition in central India. Environmental Monitoring and Assessment, 1999, 55, 251–265.

[4]. M F Ahmed; MM Rahman. Water Supply and Sanitation, 1st ed., ITN, Bangladesh, 2000; pp. 328.

[5]. MK Roy; DK Datta, DK Adhikari, BK Chowdhury, Pj Roy; Geology of the Khulna City Corporation. J Life Earth Sci, 2005, 57–63.

[6]. MT Sikder; M Yasuda; Yustiawati; MS Syawal; S Tanaka; T Saito; M Kurasaki; Comparative assessment of water quality in the major rivers of Dhaka and West Java, International journal of Environmental Protection, 2012, 2, 8-13.

[7]. MT Sikder; Y Kihara; M Yasuda; Yustiawati; Y Mihara; S Tanaka; D Odgerel; B Mijiddorj; SM Syawal; T Hosokawa; T Saito; M Kurasaki; River Water Pollution in Developed and Developing Countries: Judge and Assessment of Physicochemical Characteristics and Selected Dissolved Metal Concentration, Clean- soil air and water, 2013, 41, 60-68.

[8].PK Chakroborty; Need of applied research on water quality management. Indian Journal of Environmental Protection, 1999, 19, 595–597.

[9]. RA Freeze; JA Cherry; Groundwater. Prentice-Hall, 1979, New Jersey.

[10]. RT Nickson; JM McArthur; B Shrestha; TO Kyaw-Nyint; D Lowry; Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan, 2005, Appl Geochem 20:55–68.

[11]. SN Davis; RJ Dewiest; The use of hydrochemical sections to identify recharge areas and saline intrusions in alluvial aquifers, Southeast Queensland, Australian Journal of Hydrology, 1966, 135, 259–274.
[12]. WHO (World Health Organization), Guidelines for Drinking Water Quality-1, Recommendations, 4th Ed., World Health Organization, Geneva, 2011.