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Arsenic contamination and ionic toxicity for suitability assessment of ground water and surface water for irrigated agriculture in Comilla region

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Abstract: An investigation was carried out using 25 water samples of Comilla district in Bangladesh to examine the quality of both ground water (shallow tube well, hand tube well) and surface water (pond, river) in relation to toxicity and suitability for irrigation. All waters were alkaline in nature as their pH values were above 7.0 ranging from 7.01 to 7.81. Na, Cl, Ca, Mg, and HCO_3 dominancy were found in the study area, and the average values were 3.94, 5.21, 4.35, and 5.48meL^{-1}, respectively. All hand tube wells and other sources of waters exceeded the standard limit in respect to Na, Cl, Ca, Mg, and HCO_3. The other ions (K, Fe, Mn, Zn, Cu, B, SO_4 and NO_3 ions) were acceptable range. Seventy six percent water samples were got sever contamination by As. Electrical conductivity (EC), pH, total dissolved solid (TDS), sodium adsorption ratio (SAR), and soluble sodium percentage (SSP) were used to classify the waters determining suitability prediction. Almost all waters were considered suitable for irrigation purpose. Correlation coefficient analysis showed a significant interrelationship within the pH, EC, TDS, SAR, and SSP. From this investigation, it is inferred that ionic toxicity especially As toxicity of waters should be taken into account for irrigated agriculture with due care.
Key words: Ionic toxicity, Arsenic contamination, irrigated agriculture.

Introduction

Water quality for irrigation is a prime factor for successful crop production as its quality. There are several factors that affect water quality. Ground water is the major source of irrigation, although surface water is also used on limited scale in some rural areas. And, thus, the concentration and consumption of dissolved constituents in water are on important determinant concerning its quality. The different ions in varying amounts present in dissolved forms at toxic levels are generally regarded as water pollutants. The water that runs off the fields carrier with sediments, fertilizers, herbicides, pesticides (if these chemicals are used on the fields), and natural salts leach out the soil and flow into rivers, lakes, and groundwater supplies, and make water quality low. Soil properties, crop yield and quality will deteriorate using this low quality water for irrigation (Sarker *et al*. 2000).

Irrigation water with high concentration of Na, B, Cl and HCO_3 ions affects directly the yield of crop (Sarker *et al.*, 2000). Osmotic effects of excessive salinity adverse soil physical properties and reduce crop growth. Alfalfa yield decreased by irrigating with poor quality water was reported by Prunty *et al.* (1991). Salts from the irrigation water accumulate in the soil profile and cause soil dispersion and surface seal development during irrigation, thus, decreasing infiltration rate and amount (Sarker, 2001).

Comilla district is an arsenic contaminated area. Agricultural crops, like, cereals, particularly high yielding variety rice, vegetables, and other crops are also contaminated by As. People of Comilla district are severely affected by using As contaminated water. Arsenic contaminated water affects skin, mainly, hand and leg first, and its severe infection causes skin cancer. People have died from As contamination in the study area and some are suffering still. Davies *et al*. (1993) reported that 20% crop production loss occurred due to high concentration (20 ppm) of As in plant body. Thus, like other heavy metals, discharge of As into environment must be carefully controlled and minimized. So, water quality assessment is necessary prior to its use for agricultural purposes. The present study investigated the chemical properties of ground water and surface water and assesses the ionic toxicity and suitability for irrigation and soil properties.

Materials and Methods

For this study, 25 water samples were collected from different locations at Homna thana of Comilla district. Water samples were from various sources, viz., shallow tube well, hand tube well, river and pond; and were collected in April, 2007, to cover most of the study area following the instructions outlined by Eaton *et al.* (1995). After collection, the samples were immediately brought to the laboratory of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology for chemical analysis. The pH and EC of sampled waters were determined electrically by using pH meter (Hanna instrument-211) and Conductivity bridge (Hanna instrument-H18033), respectively, (Ghosh *et al.* 1983). The values of total dissolved solid (TDS) of waters were estimated by evaporating a measured aliquot of filtered samples. Sodium (Na) and K were estimated by frame-photometer. Calcium (Ca) and Mg were determined by complexometric titration method using Na_2EDTA as titrant. The other cations like Fe, Mn, Cu, Zn, B, and anions like Cl, NO_3-N, SO_4-S, HCO_3, and CO_3 were determined as per standard procedure. Qualitative test was done to detect the presence or absence of Arsenic (As). Irrigated water quality parameters viz. SAR, SSP, and H_T were used to classify the suitability of waters, along with pH, EC, and TDS. The values of SAR, SSP, and H_T were calculated from the analyzed data using following formula: $SAR = [Na^+] / \{([Ca^{2+}] + [Mg^{2+}]) /2\}^{1/2}$

$$SSP = \frac{\text{Soluble Na concentration (meL}^{-1})}{\text{Total cation concentration (meL}^{-1})} \times 100$$

$H_T\ (mgL^{-1}) = 2.5 \times Ca^{2+} + 4.1 \times Mg^{2+}$

Correlation coefficient analysis was done for all possible combinations within the quality parameter.

Results and Discussion

Chemical properties of waters (shallow tube well, hand tube well, river and pond): In the study area, the pH values of sampled waters were ranged from 7.01 to 7.81 with an average value of 7.24. It indicated that the pH of all sources of waters were within the normal range from 6.5 to 8.4 (Ayers and Westcot, 1985) and these waters might not be harmful for soils and crops. As major ions, Ca, Mg, Na, K, Cl, and HCO_3 distributed at varying concentrations in the water samples. The concentrations of major ions varied from 1.8 to 8.82, 1.01 to 9.51, 1.65 to 6.42, 0.0013 to 0.0282, 3.5 to 10, and 2.1 to 10.8 me L^{-} with the average values of 4.35, 4.93, 3.49, 0.0037, 5.21and 5.5 meL^{-1}, respectively. In the study area, waters from all sources ware within acceptable limits and were suitable for irrigation purpose with respect to major ions. Some other ions like, NO_3, CO_3, SO_4, and also B were carefully analyzed and the concentration of was found nil to very low in amount. The concentrations of SO_4 and B were found within the range of 0.0087 to 0.3892, 0.001 to 0.2 mgL^{-1}, respectively, and were within acceptable limits (Ayers and Westcot, 1976; Acceptable limit: <0.75 mgL^{-1}). The concentrations of SO_4 and B were far lower then the standards values (20 mgL^{-1} for SO_4 and 0.75 mgL^{-1} for B) and were not creating any problem for irrigation.

Table1. Chemical composition and computed parameters for suitability classification of water

S/N	Source	pH	Ca meL^{-1}	Mg meL^{-1}	Na meL^{-1}	K meL^{-1}	B mgL^{-1}	Cl meL^{-1}	SO_4 meL^{-1}	HCO_3 meL^{-1}	Arsenic
1	HTW	7.47	2.80	2.83	4.8	0.0028	0.12	5.2	0.0265	3.6	ND
2	HTW	7.15	3.20	1.01	5.2	0.0026	0.1	3.5	0.026	4.8	M
3	Pond	7.26	2.80	2.62	4.5	0.0028	0.05	4.1	0.0087	4.2	M
4	STW	7.17	1.80	1.72	3.9	0.0027	0.03	4.2	0.0185	2.1	M
5	HTW	7.03	1.80	5.77	2.95	0.0282	0.15	4.8	0.3892	4	ND
6	STW	7.23	2.10	2.33	3.6	0.0025	0.12	4.4	0.0142	2.6	M
7	HTW	7.13	3.30	3.34	3.34	0.0023	0.01	4.8	0.0165	3.6	M
8	HTW	7.13	2.10	2.02	3.3	0.0021	0.01	4	0.026	2.2	M
9	HTW	7.29	3.01	3.24	2.78	0.0021	0.03	3.6	0.026	4	H
10	HTW	7.1	4.30	2.53	3.4	0.0025	0.06	5.2	0.0185	3.2	ND
11	River	7.81	3.10	3.54	2.8	0.0013	0.09	4.2	0.054	3.6	L
12	HTW	7.81	4.60	6.48	2.1	0.0021	0.05	6.1	0.019	4.8	ND
13	Pond	7.15	5.41	6.17	2.3	0.0036	0.01	5.2	0.0263	6.8	L
14	HTW	7.14	4.40	4.66	1.93	0.0026	0.08	4.4	0.0185	5.4	H
15	STW	7.13	7.61	9.21	2.2	0.0036	0.13	5.6	0.0142	10	LL
16	HTW	7.08	8.82	9.31	2.41	0.0029	0.08	6.2	0.019	10.8	L
17	HTW	7.01	4.91	5.46	2.8	0.0022	0.06	4.8	0.0171	6	H
18	Pond	7.45	5.01	5.57	1.96	0.0023	0.09	4.2	0.019	6.2	L
19	HTW	7.14	3.71	3.64	4.2	0.0023	0.17	5.6	0.019	4.2	H
20	HTW	7.07	2.81	9.21	1.65	0.0044	0.12	5.2	0.0254	6.2	H
21	STW	7.13	8.22	4.15	6.42	0.0039	0.15	10	0.0863	5.6	ND
22	STW	7.26	6.41	1.42	6.21	0.0024	0.11	6.2	0.019	5.4	ND
23	HTW	7.36	5.41	9.51	5.6	0.0023	0.09	7.6	0.1892	9.8	H
24	HTW	7.13	6.01	9.41	3.1	0.0036	0.2	5.6	0.0952	9.8	L
25	River	7.31	5.01	7.99	3.8	0.0028	0.013	5.6	0.0863	8.2	L
Mean		7.24	4.35	4.93	3.49	0.0037	0.08	5.21	0.0511	5.5	
CV		2.88	45.14	57.12	38.43	138.35	62.396	26.3	158.2	45.8	

Key: HTW and STW indicate hand tube well and shallow tube well, respectively. H, M, L, and ND indicate high level, medium level, low level, and not present, respectively.

Heavy metals like Fe, Mn, Zn, and Cu were analyzed. The concentrations of Mn, Zn, and Cu were nil and was very low in case of Fe. So, the waters were free from the toxic effect of heavy metals and suitable for crop production. A heavy toxic metal, As was tested by qualitatively using $AgNO_3$. In the study area, both surface and ground water contain As at different level. Out of 25 samples, 19 (76%) were As contaminated by different levels. Arsenic concentration in different places varies due to As containing parent material. Among 25 samples, only 6 samples (sample no. 1, 5, 9, 11, 21, and 22) were As free; 7 samples contained low level which were not harmful for irrigation purpose. Medium level As contamination were found in 6 samples and high level As were identified in 6 samples in different sources. As these waters are used for irrigation purpose that are affecting the crops and making the soil contaminated. Dr Ravi Naidu have detected significant amount of arsenic transferred from groundwater to crops. On the other hand, exposure to arsenic has 'alarmingly' increased the infant death rate, cardiovascular and cancer deaths and skin lesions in the regions with high arsenic concentration.

EC, TDS, SAR, SSP, RSC, B, and H_T : Electrical conductivity of waters fluctuated between 620 and 1810 μScm^{-1} with an average value of 1085.19 μScm^{-1}. TDS of waters varied from 417 to 1223 mgL^{-1} with an average value of 745.6 mgL^{-1}. Most of the waters (20 samples) contained less than 1000 mgL^{-1} TDS and were suitable for irrigation purpose (Carroll, 1962; Freeze and Cherry, 1979). And 5 samples contained high amounts of TDS. The high TDS in water affect primarily on crops productivity is the inability of the plant to compete with ions in the soil solution for water (physiological draught). The important quality parameter viz. SAR, SSP, and H_T computed from the analyzed data are depicted in Table 2. The computed SAR of water samples were within the range from 0.606 to 2.699 with the mean value of 1.454. A high SAR can act separately to disperse soil aggregations, which in turn deduces the number of large pores in the soil. These large pores are responsible for aeration and drainage.

A negative effect from the breakdown of soil aggregates is soil sealing and crust formation (Gratton, 2002). The irrigation water with SAR less than 10 might not be toxic for agricultural crops (Todd, 1980). The SAR values of the sampled waters were far less from 10.00 SAR. So, the waters of all sources were safe for irrigation purpose. The calculated SSP values of all water samples were varied from 11.562 to 55.196 with the average of 29.877. Wilcox (1955) categorized that SSP with >80 are unsuitable for being irrigation. So, the waters contained less than 80 SSP were not harmfully affect irrigated crops and soil. The calculated H_T values of all water samples varied from 174.224 to 989.952 mgL^{-1} Among 25 samples, 6 contained low amount and most of the samples (19) exceeded acceptable limit (>3000 mgL^{-1}) (Saweyer and McCarty, 1967). The higher values of hardness indicated that the presences of higher amount of Mg and vice-versa (Karanth, 1994).

Table 2. Chemical composition and computed parameters for suitability classification of groundwater and surface water

S/N	EC µS cm^{-1}	TDS mg L^{-1}	SAR	SSP	H_T mg L^{-1}
1	810	602	2.336	45.968	279.693
2	820	610	2.699	55.196	210.110
3	900	590	2.219	45.337	269.045
4	620	421	2.390	52.514	174.824
5	810	605	1.363	27.962	373.985
6	920	465	1.991	44.808	219.728
7	880	571	1.497	33.438	329.638
8	660	417	1.869	44.412	204.791
9	720	534	1.293	30.798	309.629
10	920	573	1.440	33.199	339.906
11	820	538	1.268	29.631	329.576
12	1040	727	0.750	15.923	549.119
13	1200	834	0.789	16.562	574.261
14	940	674	0.744	17.551	449.476
15	1620	1121	0.629	11.562	833.853
16	1680	1222	0.657	11.733	898.952
17	1080	763	1.013	21.249	514.358
18	1000	739	0.702	15.632	524.347
19	920	667	1.786	36.354	364.615
20	1060	768	0.606	12.071	593.373
21	1540	1057	2.001	34.168	614.961
22	1210	833	2.327	44.224	390.347
23	1810	1223	1.756	27.283	738.570
24	1660	1103	0.947	16.732	763.651
25	1420	983	1.266	22.609	643.844

Chemical qualities: All the water samples were alkaline in nature irrespective of their sources as mentioned earlier, but all were within the normal range as per Ayers and Westcot, 1985 (acceptable pH range: 6.0 to 8.5). So, these waters were safe for agricultural crops. On the basis of EC values following Richards (1954), 3 samples belonged to good (C2) class and 22 were in permissible (C3) class. Considering EC values not a single sample was found 'excellent' for irrigation and soil properties. Higher EC value reflects the accumulation of profuse amount of salt concentration which sometimes harmfully affects irrigated crops and soil due to salinity hazard. As per TDS values, 20 samples out of 25 contained to be 'fresh' (Carrol, 1962; Freeze and Cherry, 1979); and 5 samples contained more than 1000 mgL^{-1} TDS and were 'brackish' in class and were not suitable for irrigation. The TDS of natural waters reflects the geology of source areas; surface waters generally have lower TDS concentrations than ground waters. In streams, TDS can increase through the continual addition of salt by both natural weathering process and human activities, such as discharges of domestic and industrial effluents and runoff from urban and rural areas. The value of TDS is directly proportionate with that of total soluble mineral ions and other dissolved substances in water bodies (Sarker *et al.*, 2000; Rahman and Zaman, 1995). In addition to this, Puntamkar *et al.* (1988) indicated that the degree of soil properties deterioration depends on the total dissolved salt contents in irrigation water.

Specific ions effect: In the present study, major ions like Ca, Mg, Na, K, Cl, SO_4, HCO_3, and As were in dominant quantities but the remaining detected ions (Fe, Mn, Zn, Cu, B, NO_3, CO_3) were also recorded in minor amounts, and in some cases (Mn, Zn, and Cu) were nil. The ions having excess quantity reduce crop growth, production, quality, and/or cause specific injure due to ionic toxicity. The level of Ca in water is related closely to the geology of the source areas, the Ca being derived by weathering of processes from minerals such as gypsum, limestone and dolomite (Tarek *et al.*, 2007). Calcium contributes to the hardness of the water which may cause soil crust and infiltration problems. Magnesium is essential for plant. Chemical reactions of Mg in the water are similar to those of Ca and cause water hardness. A considerable amount of K was present in the water. This might be due to the presence of K bearing mineral in the parent material in soils like sylvite (KCl), nitre (KNO_3) in the aquifers (Karanth, 1994). The high concentrations of Na and Cl ions were found in hand tube wells. The presence of high Na and Cl ions are considered potential threat for sodium hazard and salt problem. Thus, the soils of this area are assumed to cause sodicity and salinity problem in future. Irrigation water containing high Na ion might induce K deficiency. Where Na/Ca ions ratio is high, some cereals, such as, rice, wheat, maize and barley showed severe deficiency of Ca ion (Grieve and Mass, 1988; Grieve and Fujiyama, 1987). Sodium ion causes disturbance of Ca nutrition. On the other hand, the beneficial effects of Ca and/or Mg ions are well known for controlling the negative role of Na toxicity. The high concentration of Ca ion present in the pond water might reduce Na toxicity. The presence of Cl ion in the pond water might diminish the rate of NO_3 ion absorption by crops. The high amount of Cl ion can contribute osmotic stress and some cultivars of soybean that tend to accumulate excessive and toxic amounts of Cl ion (Parker *et al.*, 1983). Many woody species and fruit cultivars are also susceptible to Cl ion toxicity. The presence of heavy metal Fe was found in very low concentration and had no toxic effect. The other heavy metals, like, Mn, Zn, and Cu were found in nil. The NO_3-N, SO_4-S, and B played an important role for crop nutrition but their relative concentrations were very low. So, the heavy metals, Mn, Zn, and Cu; and other ionic groups, NO_3-N, SO_4-S, and B had no any effects to irrigated water and agricultural crops. And, considering CO_3, only 2 samples contained high amount. The presence of high concentration of CO_3 in water due to high residual sodium carbonate must be given special attention because of its tendency to precipitate Ca and Mg as carbonates in the oil. High bicarbonate water has been shown to induce iron chlorosis (Finkel, 1993). Arsenic contamination was found in different levels and was found more in the groundwater than on the surface water. The occurrence of As in groundwater is considered to be a process by weathering of As containing parent materials and by changing redox conditions whereby As is selectively desorbed in response to the reduction of Fe^{3+} to Fe^{2+} (Bhattacharya *et al.*, 1999). High concentration of As might be problematic for long-term irrigation and crops, like rice vegetables, and human beings. Arsenic is getting into rice, Bangladesh's staple crop, through irrigation water pumped from contaminated soils; researchers have found (Meharg, and Rahman, 2002). Another study shows that the act of pumping water for irrigation can raise its arsenic levels (Harvey, 2002). People of that area are contaminated severely by having those crops and drinking As contaminated water.

Proposed suitability classification: In irrigated agriculture, EC, SAR, and SSP are considered to be the major criteria for assessing suitability classification. All water samples were classified ‘permissible’ to ‘good’ for EC. So, these sources of water might not cause any harm for agriculture purpose. With respect to SAR, all samples were graded as ‘excellent’ in class.

Table 3. Quality classification and suitability of groundwater and surface water for irrigation purpose

S/N	Overall suitability classification						
	EC	TDS	SAR	SSP	Boron	Alkalinity and salinity hazard	Proposed suitability classification
1	Permissible	Fresh	Excellent	Permissible	Excellent	C3 S1	Permissible
2	Permissible	Fresh	Excellent	Permissible	Excellent	C3S1	Permissible
3	Permissible	Fresh	Excellent	Permissible	Excellent	C3S1	Permissible
4	Good	Fresh	Excellent	Permissible	Excellent	C2S1	Moderate suitable
5	Permissible	Fresh	Excellent	Good	Excellent	C3S1	Permissible
6	Permissible	Fresh	Excellent	Permissible	Excellent	C3S1	Permissible
7	Permissible	Fresh	Excellent	Good	Excellent	C3S1	Permissible
8	Good	Fresh	Excellent	Permissible	Excellent	C2S1	Moderate suitable
9	Good	Fresh	Excellent	Good	Excellent	C2S1	Moderate suitable
10	Permissible	Fresh	Excellent	Good	Excellent	C3S1	Permissible
11	Permissible	Fresh	Excellent	Good	Excellent	C3S1	Permissible
12	Permissible	Fresh	Excellent	Excellent	Excellent	C3S1	Permissible
13	Permissible	Fresh	Excellent	Excellent	Excellent	C3S1	Permissible
14	Permissible	Fresh	Excellent	Excellent	Excellent	C3S1	Permissible
15	Permissible	Brackish	Excellent	Excellent	Excellent	C3S1	Permissible
16	Permissible	Brackish	Excellent	Excellent	Excellent	C3S1	Permissible
17	Permissible	Fresh	Excellent	Good	Excellent	C3S1	Permissible
18	Permissible	Fresh	Excellent	Excellent	Excellent	C3S1	Permissible
19	Permissible	Fresh	Excellent	Good	Excellent	C3S1	Permissible
20	Permissible	Fresh	Excellent	Excellent	Excellent	C3S1	Permissible
21	Permissible	Brackish	Excellent	Good	Excellent	C3S1	Permissible
22	Permissible	Fresh	Excellent	Permissible	Excellent	C3S1	Permissible
23	Permissible	Brackish	Excellent	Good	Excellent	C3S1	Permissible
24	Permissible	Brackish	Excellent	Excellent	Excellent	C3S1	Permissible
25	Permissible	Fresh	Excellent	Good	Excellent	C3S1	Permissible

The suitability classification was based on Wilcox (1955), Freeze and Cherry (1979), Todd (1980), Wilcox (1955), Eaton(1950), Richards (1954), and Sawyer and McCarty (1967), respectively. C1, C2, C3, and C4 represent low, medium, high,and very high salinity hazard; and S1, S2, S3, and S4 represent low, medium, high, and very high sodium hazard, respectively.

The irrigation water with SAR less than 10 might not be toxic for agriculture crop (Todd, 1980). According to this classification, all the samples were rated as low alkalinity hazard (S1) class for irrigation as per SAR value (Table 3). So, in the study area, alkalinity problem might not occur using this water. From the calculated value of SSP, 7 samples were ‘permissible’, 10 were ‘good’ and 8 were ‘excellent’ in class. Based on suitability class of B, all waters were graded as ‘excellent’ for irrigation, and can safely be used for successful crop production.

For the irrigation water, EC, SAR, and SSP are considered to be the major criteria for assessing suitability classification, whereas TDA and B are minor. The waters were classified as suitable, moderately suitable, permissible and unsuitable. Accordingly, the *suitable* classed water was these in which EC, SAR, and SSP belonged to the excellent to good category. No water was found in this class. The waters were categorized as *moderate suitable* when SAR for excellent, good and permissible for EC and SSP, respectively. In the study area, only 3 waters (S/N. 4, 8 and 9) were categorized this class. The *permissible* category comprised the samples that were excellent foe SAR, good and permissible belong to EC and SSP, respectively irrespective of the major criteria. When all the major criteria of water samples were doubtful to unsuitable, then the category was referred to as unsuitable. Based on these criteria, out of 25 samples, 22 were in this category.

Correlation coefficient analysis: Correlation coefficient analysis was performed amongst the parameters viz. pH, EC, SAR, and SSP in all possible combinations (Table 4). It was evident that pH value was no significantly correlated with EC, TDS, SAR, and SSP. EC value was significantly correlated with TDS, SAR and SSP at 1% level of significance. It indicated that EC had influence on TDS, SAR, and SSP. TDS value had significantly correlated with SAR and SSP at 1% level of significant. SAR value showed a close relationship with SSP at 1% level of significant. The significant coefficient analyses were performed among EC-TDS, -SAR, -SSP; TDS-SAR, -SSP; and SAR-SSP; reported that the quality of free soil solution may indicate the distribution of Na ion in the absorbed phase. The presence of Na in irrigation water influences the physical properties of the soil, particularly the permeability by affecting the swelling and dispersion of the clay (Finkel, 1993). Besides, when the excess carbonate (residual) concentration becomes too high, the combine with Ca and Mg to form a solid material (scale) which settles out of the water. The end result is an increase in both the Na percentage and SAR (Johnson *et al.*, 2003). At the same time as per result, it may create alkali hazard in soil and may encumber successful crop production. On the other hand insignificant correlation of coefficient among pH-EC, -TDS, -SAR and -SSP indicated that the increase of one parameter will result in the decreasing of the aforementioned parameters.

Table 4. Correlation matrix among the standard parameters of suitability classification.

	pH	EC	TDS	SAR	SSP
EC	-0.11598^{NS}				
TDS	-0.12005^{NS}	0.97991^{**}			
SAR	-0.02148^{NS}	-0.35176^{**}	-0.39264^{**}		
SSP	-0.01392^{NS}	-0.54803^{**}	-0.59479^{**}	0.96686^{**}	

Legend: NS, *, and ** indicate not significant, significant at 5% and 1% level, respectively

From the result it appeared that some water samples contained undesirable level of EC, TDS, and SSP whereas the SAR and B contents were within safety limit. The quality of such waters exerted a significant impact on the crop production and the soil properties. In the study area, the suitable and moderately suitable waters could be used for irrigation purpose without any detrimental effects. However, permissible water may be harmful for irrigated crops and soil properties. Higher EC value reveals the presence of an adequate high salt concentration results the development of soil salinity. After prolonged irrigation with permissible waters, crop production may be hampered. In the study area, only 24% waters As free and 24% contained low level which were safe and might be used for irrigation purpose without ant harmful effects. Whereas, 52% waters contained undesirable quantity of As which posses toxicity for soil environment and crops. Now a day, Scientists (Dr Lena Ma and colleagues, of the University of Florida, US,) have discovered a fern, Brake fern, is native to Africa, Asia and Australia, that thrives on arsenic. They suggest the plant (*Pteris vittata*) could be used to clean up land and water that has been contaminated with the toxic element or its compounds. Dr. Ma suggests the water in Bangladesh could flow through reservoirs planted with brake fern to filter out the arsenic. Further studies should be carried out to establishment Dr. Ms’s plant to filter out arsenic for getting As free pure water.

References

Ayers, R.S. and Westcot, D.W. 1985. Water quality for agriculture. FAO Irrigation and Drainage Paper 29 (Rcv. 1): 40-96.

Bhattacharya, P., Larson, M., Leiss, A., Jacks, G., Sracek, A. and Chatterjee, D. 1999. Genesis of arseniferous groundwater in the alluvial aquifers of Bengal Delta Plans and strategies for low-cost remediation. West Bengal and Bangladesh arsenic crisis information centre. pp. 1-3.

Carroll, D. 1962. Rain water as a chemical agent of geologic process. A review. United States Geological Survey Water Supply Paper. 1535-G: 18.

Davies, T.C., Chowdhury, R.N. and Sivakumar, M. 1993. Pollution studies on surface waters of the Thika area, Kenya. *Proc. of Inter. Conf. Wollongong,* New South Wales, Australia. 8-11 Feb. 1993. pp. 131-136.

Eaton, A.D., Clescri, L.S. and Greenberg, A.E. 1995. Standard Methods for the Examination of water and Wastewater. (19^{th} Ed.). American public health association. American water works association. Water Environment Federation. Washington DC.

Finkel, H.J. 1993. CRC Handbook of irrigation Technology. CRC Press, Inc. Boca Raton, Florida. Vol. I. p. 88.

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

Ghosh, A.B., Bajaj, J.C., Hasan, R. and Singh, D. 1983. Soil and Water Testing Method. A Laboratory Manual, Division of Soil Science and Agricultural Chemistry. IARI, New Delhi. pp. 1-48.

Grattan, S.R. 2002. Irrigation water salinity and crop reproduction. Oakland: University of California Division of Agriculture and Natural Resources. Publication 8066.

Grieve, C.M. and Maas, E.V. 1988. Different effects of sodium/calcium ratio on sorghum genotype. *Crop. Sci.* 29: 659-665.

Grieve, C.M. and Fujiyama, H. 1987. The response of two rice cultivars to external Na/Ca ration. *Plant and Soil.* 103: 245-250.

Harvey, C.F. 2002. Arsenic mobility and groundwater extraction in Bangladesh. Science, 298, pp. 1602 - 1606.

Johnson, G. and Hhang, H. 2003. Classification of irrigation Water Quality. Oklahoma Cooperative Extension. Fact Sheet 2401 (www.osuextra.com).

Karanth, K.R. 1994. Groundwater assessment development and management. TATA McGraw-Hill Publishing Company Limited. New Delhi, pp. 217-273.

Meharg, A.A. and Rahman, M. 2002. Arsenic contamination of Bangladeshi paddy field soils: implications for rice contribution to arsenic consumption. Environmental Science and Technology.

Parker, M.B., Gascho, G.J. and. Gaines, T.P. 1983. Chloride toxicity of Soybeans grown Atlantic coast flatwood siol. *Agron. J.* 75: 439-442.

Prunty, L., Montgomery, B.R. and Sweeney, M.D. 1991. Water quality effects on soils and alfalfa: I. Water use, ureld and nutrient concentration. *Soil Sci. Soc. Am. J.,* 55: 196-202.

Puntamker, S.S., Kant, K. and Mathur, S.K. 1988. The effect of saline water on soil properties. Transaction of India Society of Desert Technology, Ktishi Bhawan, Bikaner, Rajasthan, India, No. 2. pp. 69-72.

Richards, L.A. 1954. Diagnosis and improvement of saline and alkali soils. (Ed.) U.S. Agricultural Hand Book 60, and IBM. Publishing Co. Ltd. New Delhi, India. pp. 98-99.

Sarker, B.C. 2001. Water quality assessment for agriculture: sodium and chloride toxicity. *Bangladesh J. Agril. Res*. 26 (1) :15-26.

Sarker, B.C., Hara, M. and. Zaman, M.W. 2000. Suitability assessment of natural water in relation to irrigation and soil properties. *Soil Sci. Plant Nutr*. 46 (4), 773-786.

Sawyer, C.N. and McCarty, P.L. 1967. Chemistry for sanitary engineers. 2nd ed. McGraw-Hill, New York. p. 518

Todd, D.K. 1980. Groundwater Hydrology (2nd Ed). John-Wiley and Sons. Inc., New York 10016. pp. 267-315.

Wilcox, L.V. 1955. Classification and use of irrigation water. United Status Department of Agriculture. Circular No. 969. Washington DC. p. 19.