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Assessment of Ground Water Quality for Drinking Purpose of Jalalabad Cantonment Area in Sylhet City, Bangladesh

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ABSTRACT

Groundwater quality of Jalalabad cantonment area in Sylhet city is deteriorating. The study was conducted for assessing the ground water quality in drinking purpose of Jalalabad cantonment area in Sylhet city. For human survival, water is a vital resource. Total twenty-five water samples were collected from different parts of Jalalabad Cantonment area from deep aquifer-based tube wells. The collected water samples were analyzed for different physicochemical properties like Color, taste, odor, pH, electrical conductivity (EC), total dissolved solids (TDS), calcium, magnesium, sodium, potassium, boron, sulphur, copper, iron, manganese, and zinc concentrations. All the analyzed parameters compared with the standards prescribed by World Health Organization (WHO) and Bureau of Bangladesh Standard (BBS), in order to assess the ground water quality for drinking purpose. For different parameters of drinking water, the correlation matrix was also calculated. Almost all the physicochemical parameters were found within the prescribed permissible limit. Findings show that some of the parameters Cu and Zn were negatively associated with TDS, Ca2+, Mg2+, S contents.

INTRODUCTION

The survival of all living organisms, water is extremely essential and is also essential for our health and our economy. In developing countries like Bangladesh, drinking water quality has always been a major issue (Moe and Rheingans, 2006). The safe drinking water is a basic demandfor the people of all over the world. A huge percentage of people of the world are deprived from the pure drinking water including Bangladesh (Chowdhury et al., 2014).

Ground water is a very valuable natural resource for the economic development and secure provision of potable water supply in both urban and rural environments (Ghezelsofloo and Ardalan, 2012; Wakode et al., 2014). Day by day ground water is depleting prominently in Asia, South America, North America and ecosystems are threatened (Gleeson et al., 2012). Nowadays groundwater pollution has become one of the most serious problems throughout the world. The groundwater quantity and qualityaffect the urbanization, industrialization, and agricultural activity (Jat et al., 2009; Tiwari et al., 2015; Rubia et al., 2015; Khan and Jhariya, 2016). In recentyears it has been recognized that the quality of groundwater is of nearly equal importance as the quantity (Todd, 1976; Jhariya et al., 2012).

For good health, the safe drinking water is a basic need and it is also a basic right of humans.About 97% water is exists in oceans that is not suitable for drinking and only 3% is fresh water wherein 2.97% is comprised by glaciers and ice caps and remaining little portion of 0.3% is available as a surface and ground water for human use (Miller, 1997).Due to increased population, urbanization and climate change (Jackson et al., 2001) it will become even more limiting, in the next century. It was reported that at least 2 billion people globally used a drinking water source contaminated with feces (WHO, 2018).

Most of the people in Bangladesh think that ground water or water from tube wells is free from contamination. For this reason, Hand pumped tube-well water is used as primarily source of safe drinking water in Bangladesh. Almost 90% of the households use this Hand pumped tube-well technology in Bangladesh (Emch et al., 2010). About 11% of all deaths in rural area of Bangladesh are caused by diarrheal disease (Streatfield et al., 2001).

To increase access to clean and safe drinking water, improved sanitation and other development agenda are being championed under the newly launched UN Sustainable Development Goals (SDGs) (2015-2030) (UN, 2016).

Hand pumped tube-well water andgroundwater is the primary source of drinking water for more than 98% of the populations in Sylhet, Bangladesh.Organic and nutrient material in drinking water are found in many cities in Bangladesh, due to the discharge of untreated domestic and industrial waste water into these resources (Annachhatre, 2006). Water quality monitoring and assessment is the foundation of water quality management.

Thus, there has been an increasing demand for monitoring water quality of ground water by regular measurements of various water quality parameters.

The study will be conducted to achieve the following objectives: 1. To assess the water quality parameters (Color, taste, odor, PH, electrical conductivity (EC), total dissolved solids (TDS), calcium (Ca2+), magnesium (Mg2+), sodium (Na+), potassium (K+), boron (B), sulphur (S), copper(Cu), Iron (Fe), manganese (Mn) and zine (Zn) from the source of tube wellsin the study area. 2. To compare the ground water suitability for drinking purposes with WHO and BBS.

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MATERIALS AND METHODS

Study area

The experiment was conducted at the Jalalabad Cantonment area of Sylhet city, Bangladesh. There were twenty-five ground water samples collected from twenty-five different sampling pointsin Jalalabad Cantonment area. The study areas lie between the latitude 24.9456° or 24° 56' 44" North and longitude 91.97828°or 91° 58' 42 East.

Sample collection

Total 25 ground water samples were collected from 25 deep aquifer-based tube wells. After running the water for about 3-5 minutes, the water samples were collected directly from the tube wells. All thesamples were collected on 8th November and 10th December 2018. Precleaned, sterilized, polyethylene bottles of one liter capacity, the water samples were collected. Before taking the water samples the sterile container were rinsed three times with sample water for finding the accurate result. All the collected samples were stored in ice box and transported to the laboratory immediately for the experimental analysis.

Analysis

Physical parameters analysis

The purity of water indicates the color and odor. No color and odor present in pure water and it is not turbid. By visual inspection, the color of the sample was determined. By physical inspection, odor was analyzed by taking smell directly and taste was tasted by direct drinking the water sample.

Analysis of physico¬chemical parameters of water

The water samples were analyzed at the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. PH, electrical conductivity (EC), total dissolved solids (TDS), calcium (Ca2+), magnesium (Mg2+), sodium (Na+), potassium (K+), boron (B), sulphur (S), copper (Cu), Iron (Fe), manganese (Mn) and zinc (Zn) were analyzed for the water samples. Analytical Reagent grade and deionized water were used in the present study for experimental purpose. All the precautions were taken as given in APHA, AWWA, WPCF (2003) for sampling and analysis. The details of the sampling sites and results are presented in Table 1, Table 2, and Table 3.

Table 1: Sampling locations of Jalalabad Cantonment area

Sample No.	Sampling Locations	Approx. Depth (feets)	Age (Years) as on December
1	M. R. Housing	450	2
2	Bir Bikrom Amin Chowdhury Village	350	8
3	Cantonment Board School	500	7
4	Shimanto Residential Area	800	6
5	West Thakur Para	70	6
6	East Thakur Para	65	12
7	Ghater Choti	260	20
8	Wali Housing	440	4
9	Al-Barak Restaurant	380	3
10	Peuly Supermarket	250	2
11	Jalshiri Hostel	300	5
12	Sonarga Residential Area	300	5
13	Chuabahar, Bateshwar	400	7
14	Turianonda Primary School	290	11
15	UCEP Technical School	250	12
16	Banshbari Market	150	4
17	I B Complex	120	5
18	Ali Complex	600	5
19	Bateshwar Adarsha Academy	450	6
20	Shahid Cadet School	350	8
21	Bateshwar Mosque	400	2
22	Jalalabad Cantonment Public School & College	300	15
23	JCPSC Quatar	280	15
24	Mohona Market	250	10
25	Pirer Bazar	150	14

Table 2: Values and concentration of various water parameters in groundwater samples of Jalalabad Cantonment area

Sample No.	pH	EC(µs/cm)	TDS(mg/l)	Ca2+ppm	Mg2+ppm	Na+ppm	K+ppm
1	6.65	378	251	22.80	9.79	0.28	3.12
2	7.74	1225	410	46.00	19.74	0.32	3.48
3	7.97	465	375	51.60	22.15	0.15	1.68
4	6.23	420	390	23.60	10.13	0.33	3.64
5	6.89	385	288	34.80	14.94	0.61	6.66
6	7.04	590	315	26.00	11.16	0.66	7.30
7	6.85	770	275	26.00	11.16	0.23	2.48
8	6.71	450	290	16.40	7.04	0.22	2.44
9	6.81	520	350	23.60	10.13	0.20	2.20
10	6.83	315	320	14.80	6.35	0.22	2.46
11	7.22	510	262	30.00	12.88	0.39	4.24
12	7.04	705	355	19.20	8.24	0.36	3.92
13	6.14	624	304	39.60	17.00	0.28	3.06
14	7.16	308	210	16.40	7.04	0.24	2.68
15	6.46	533	266	16.80	7.21	0.21	2.26
16	6.82	375	264	11.20	4.81	0.21	2.34
17	7.75	980	291	20.00	8.58	0.30	3.34
18	6.61	820	395	34.40	14.76	0.24	2.66
19	6.61	433	275	20.00	8.58	0.30	3.32
20	7.35	450	170	6.40	2.75	0.19	2.10
21	6.34	319	285	13.20	5.67	0.43	4.68
22	6.82	438	203	5.60	2.40	0.34	3.78
23	6.65	440	350	20.40	8.76	0.20	2.22
24	6.98	510	307	19.60	8.41	0.46	5.04
25	6.01	605	279	13.20	5.67	0.13	1.48
Minimum	6.01	308	170	5.60	2.40	0.13	1.48
Maximum	7.97	1225	410	51.60	22.15	0.66	7.30

**Units of all the parameters are in ppm except EC (µs/cm) and pH.*

Table 2.1: Values and concentration of various water parameters in groundwater samples of Jalalabad Cantonment area

Sample No.	B ppm	S ppm	Cu ppm	Fe ppm	Mn ppm	Zn ppm
1	0.05	0.05	0.003	0.028	0.017	0.010
2	0.05	0.69	0.003	0.049	0.030	0.012
3	0.01	0.19	0.003	0.035	0.021	0.011
4	0.05	0.08	0.003	0.542	0.327	0.013
5	0.05	0.28	0.004	0.053	0.032	0.014
6	0.06	0.55	0.003	0.062	0.037	0.012
7	0.02	0.02	0.004	0.074	0.045	0.015
8	0.06	0.01	0.004	0.045	0.027	0.014
9	0.05	0.02	0.005	0.056	0.034	0.018
10	0.02	0.02	0.005	0.078	0.047	0.020
11	0.04	0.03	0.006	0.052	0.031	0.022
12	0.05	0.02	0.005	0.024	0.014	0.021
13	0.04	0.02	0.006	0.026	0.016	0.023
14	0.04	0.13	0.005	0.033	0.020	0.021
15	0.05	0.05	0.004	0.044	0.027	0.017

16	0.05	0.07	0.005	0.052	0.031	0.018
17	0.05	0.01	0.005	0.066	0.040	0.019
18	0.04	0.03	0.006	0.051	0.031	0.023
19	0.05	0.07	0.006	0.047	0.028	0.025
20	0.02	0.02	0.007	0.049	0.030	0.028
21	0.05	0.05	0.006	0.058	0.035	0.024
22	0.03	0.02	0.006	0.054	0.033	0.023
23	0.02	0.04	0.004	0.063	0.038	0.017
24	0.04	0.08	0.006	0.047	0.028	0.025
25	0.05	0.08	0.007	0.045	0.027	0.027
Minimum	0.01	0.01	0.003	0.024	0.014	0.010
Maximum	0.06	0.69	0.007	0.542	0.327	0.028

Table 3: Comparison of water quality parameters of groundwater samples of Jalalabad Cantonment area with drinking water quality standard (Bangladesh and WHO)

Parameters	**Range of samples**		**BBS Standards**	**WHO Limit**
	Minimum	**Maximum**	**Acceptable limit**	
pH	6.01	7.97	6.5-8.5	6.5-8.5
EC	315	1225	-	-
TDS	170	410	1000	500
Ca2+	5.60	51.60	75	75
Mg2+	2.40	22.15	30-35	150
Na+	0.13	0.66	200	200
K+	1.48	7.30	12	12
B	0.01	0.06	1.0	-
S	0.01	0.69		
Cu	0.003	0.007	1.0	2.0
Fe	0.024	0.542	0.3-1.0	
Mn	0.014	0.327	0.1	
Zn	0.010	0.028	5.0	

*Units of all the parameters are in ppm except EC (µs/cm) and pH.

Data analysis

The individual and interactive effects of various physico¬chemical parameters of groundwater were estimated taking into account Pearson correlation coefficient.

RESULTS AND DISCUSSION

Physical properties of water

The Physical properties of waters collected from of the study areas are given in Table 4.

Color

Decomposition of organic matter and leakage through sewage originates the colors in ground waters. The study area some of the collected ground waters were found clean, colorless, and transparent and some were yellowish or slightly yellowish. Generally, the yellowish color of water indicated the presence of iron (Fe) in the water.

Taste and odor

Various tastes and odors may be present in water. A number of factors including decaying organic matter, livingorganisms, iron, mixing industrial waste etc. are responsible for in taste of water. There was no bad odor found in collected ground water samples and its taste was sweet in some samples and rests were medium and brackish.

Physicochemical properties of water

Hydrogen Ion Activity (pH)

In assessing the water quality, the pH is an important parameter. The pH determines the suitability of water for various purposes. The pH value indicates the concentration of hydrogen ion in water and the acidic or alkaline nature in water. Acidic conditions indicate pH value decreases and alkaline conditions indicates as the pHvalue increases. The WHO limit for drinking water is 6.5-8.5 shown in Table 3. In analyzed water samples the pH value varied from 6.01 to 7.97. Any harmful effect does not cause the low pH (Boominathan and Khan, 1994). The results show that almost all the water samples were within permissible limits.

Table 4: Summary of measured physical properties of water

Sample No	Color	Taste	Odor
1	Transparent	Sweet	Odorless
2	Transparent	Medium	Odorless
3	Transparent	Medium	Odorless
4	Yellowish	Medium	Odorless
5	Yellowish	Sweet	Odorless
6	Yellowish	Medium	Odorless
7	Yellowish	Medium	Odorless
8	Transparent	Medium	Odorless
9	Yellowish	Medium	Odorless
10	Yellowish	Sweet	Odorless
11	Transparent	Medium	Odorless
12	Transparent	Medium	Odorless
13	Transparent	Medium	Odorless
14	Transparent	Sweet	Odorless
15	Transparent	Medium	Odorless
16	Transparent	Sweet	Odorless
17	Yellowish	Medium	Odorless
18	Transparent	Medium	Odorless
19	Transparent	Medium	Odorless
20	Transparent	Medium	Odorless
21	Yellowish	Sweet	Odorless
22	Yellowish	Medium	Odorless
23	Yellowish	Medium	Odorless
24	Transparent	Medium	Odorless
25	Transparent	Medium	Odorless

Electrical Conductivity (EC)

The total concentration of charged ionic species in water indicates the Electrical conductivity (EC). Generally standard limit of EC for drinking water is 1000µs/cm (WHO, 1996). The electrical conductivity of water enhances ions concentration. Pure water is not a good conductor of electric current rather a good insulator. The maximum EC value was 1225µs/cm at Bir Bikrom Amin Chowdhury village in Jalalabad cantonment area and 308µs/cmat Turianoda primary school. Different sampling points of EC values were smaller than 1000 µs/cm, which means water has no concentration of salts; therefore, water can be categorized as non-saline.

Total Dissolve Salts (TDS)

The total dissolved salts of water samplesare commonly known as the electrical conductivity of water samples correlates with the concentration of dissolved minerals. It is also an important chemical parameter of water (Kabir et al., 2002). The general nature of water quality and are usually related to conductivity indicates TDS values (Ahmed et al., 2010). The acceptable range of TDS is 500 mg/lwhich is recommended by WHO. The range of TDS of analyzed water samples varied between 170 to 410 mg/l as shown in Table 2. The highest TDS value was observed at location no. 2 (Bir Bikrom Amin Chowdhury village). All the water sample are non-saline as per WHO and BBS standard. So, it can be shown that groundwater of studied areas is suitable for drinking purposes from salinity point of view.

Calcium (Ca2+)

Calcium is 5th most abundant element on the earth crust and is very important for in the groundwater. Calcium may dissolve readily from carbonate rocks and lime stones or be leached from soils. In humans'rickets, poor blood clotting, bones fracturemay cause the high deficiency of calcium and cardiovascular diseasesproducedthe exceeding limit of calcium. According to WHO (1996) standards its permissible range in drinking water is 75 mg/l. The estimated Ca2+ content from collected water samples ranged from 5.60 to 51.60 mg/las shown in Table 2. Higher concentration of Ca2+ observed at location no. 3 and lower concentration of Ca2+shown at location no. 22.

Magnesium (Mg2+)

Magnesium is thenatural constituent of water and 8th most abundant element on earth crust. It is found in minerals like dolomite, magnesite etc. and an essential for proper functioning of living organisms. Human body contains about 25g of magnesium (60% in bones and 40% in muscles and tissues). Protein energy malnutrition occurs in magnesium deficiency. According to WHO standards the permissible range of magnesium in water should be 150 mg/l. The estimatedMg2+ content from collected water samples ranged from 2.40 to 22.15 mg/l as shown in Table 2. Lower concentration of Mg2+ observed at location no. 22 and higher concentration ofMg2+ observed at location no. 3.

Sodium (Na+)

Sodium is a silver white metallic element, and all sodium compounds are water soluble. It is found in less quantity in water. Many fatal diseases like kidney damages, hypertension, headache etc. prevents the proper quantity of sodium in human body. Heart problems occurs when higher concentration of Na+ ion present in drinking water. Higher Na+ ion may cause salinity problems in irrigation water. According to WHO standards, concentration of sodium in drinking water is 200 mg/l. In water samples the range of Na+ ions varied from a minimum of 0.13 to 0.66 mg/l (concentration in excess of 200 mg/l give rise to unacceptable taste). Na+concentration of all samples was found to be within the permissible limit, on comparison with BBS standards.

Potassium (K+)

Potassium is silver, white alkali. Both plant and human life, K+ is an essential nutrient. In human body, the total potassium amount lies between 110 to 140 g. It is necessary for human body functions like heart protection,

regulation of blood pressure, protein dissolution, muscle contraction, nerve stimulus etc. However, excessive amounts of ingestionmay prove detrimental to human beings. According to WHO standards the permissible limit of potassium is 12 mg/1. The concentration of potassium in analyzed water samples varied from 1.48 to 7.30 mg/l as shown in Table 2.

Boron (B)

B is anessential micronutrient, inboth plant and human life. According to BBS standards, its acceptable limit in drinking water is 1.0 mg/l. In collected water samples, the estimated B content ranged from 0.01 to 0.06 mg/l as shown in Table 2. At location no. 3 the higher concentration of Bobserved and lower concentration of Bshown at location no.6 and 10. These results shown that the quantity of boron in study areas was acceptablelimit.

Sulphur (S)

In study areas, the concentration of sulphur ranges from 0.01-0.69 mg/las shown in Table 2. These results indicate that the quantity of sulphur in study sites is acceptable limit. The higher concentration of sulphur shown at location no. 8 and lower concentration of sulphur observed at location no. 2.

Copper (Cu)

Several thousands of years, copper has been used from in different purposes because it is an ancient metal. The regulation of copper is complicated because it is both necessary to the normal functioning of the body and toxic to the body at too high a level. In the distribution system, copper can leach into drinking water from the pipes. The acceptable limit of copper in drinking water is 1 mg/l, according to BBS standards. The analyzed water samples copper content varied from 0.003 mg/l to 0.007 mg/l as shown in Table 2. According to WHO standards the permissible limit of copper is 2 mg/1.

Iron (Fe)

In the earth's crust, iron is the second most abundant metal. The Fe ions Fe2+ and Fe3+ readily combine with oxygenand sulfur-containing compounds to form oxides, hydroxides, carbonates, and sulfides. Commonly it is found in nature in the form of its oxides (Elinder, 1986; Knepper, 1981). Generally, the color of water in yellowish indicated the water presence of iron (Fe). In Bangladesh, permissible limit of Fe is 0.3-1.0 mg/l, whereas WHO standard level is 0.3 mg/l. In analyzed water samplesthe concentration of iron varied from 0.024 to 0.542 mg/l as shown in Table 2.

Manganese (Mn)

Manganese is an essential nutrient and neurotoxicant and chemical of potential concern for children's health. High levels of manganese presence in drinking water for a long time, children and adults who drink water may have problems with memory, attention, and motor skills. Learning and behavior problems may occur in infants (babies under one year old) if they drink water with too much manganese in it. According to BBS standards the permissible limit of manganese in drinking water is 0.1 mg/l. As shown in Table 2. Manganese content varied from 0.014 mg/l to 0.327 mg/l in the analyzed water samples that is acceptable limit.

Zinc (Zn)

Zincis an essential trace element in humans and animals. It takes part in various metabolic processes. Zinc (Zn) is found in food products because it is a naturally occurring element. An adult body mass Zn constitutes about 33µg/g and it is essential as a constituent of many enzymes involved in several physiological functions, such as protein synthesis and energy metabolism (Rubia et al., 2015). According to BBS standards the permissible range of zinc in water should be 5 mg/l. The estimated Zn content from collected water samples ranged from 0.010 to 0.028 mg/l as shown in Table 2. Lower concentration of Zn observed at location no. 1and higher concentration of Zn observed at location no. 20.

Correlation analysis

Pearson correlation analysis was performed to observe the linkage between various physico-chemical parameters of groundwater of Jalalabad Cantonment area as shown as Table 5.

It was observed that different physico¬chemical traits like Mg2+, K+, Mn, Zn were strongly positively correlated with Ca2+, Na+, Fe, Cu contents. There is also positive correlation of Ca2+, Mg2+ with total dissolved solids (TDS), electrical conductivity (EC) and pH; B with Na+, K+; S with EC, Ca2+, Mg2+, Na+, K+ and TDS with EC contents. But Cu and Zn was negatively associated with TDS, Ca2+, Mg2+, S contents.

Table 5: Pearson correlation of various physico chemical parameters in groundwater of Jalalabad Cantonment area

	pH	EC	TDS	Ca2+	Mg2+	Na+	K2+	B	S	Cu	Fe	Mn	Zn
pH	1												
EC	0.369	1											
TDS	0.067	0.448	1										
Ca2+	0.346	0.445	0.643	1									
Mg2+	0.346	0.444	0.642	0.996	1								
Na+	0.056	-0.007	0.033	0.125	0.126	1							
K2+	0.057	-0.013	0.029	0.119	0.119	0.999	1						
B	-0.294	0.139	0.08	-0.101	-0.102	0.411	0.412	1					
S	0.388	0.419	0.344	0.495	0.495	0.474	0.475	0.249	1				
Cu	-0.262	-0.119	-0.447	-0.461	-0.461	-0.167	-0.167	-0.103	-0.504	1			
Fe	-0.261	-0.107	0.317	-0.015	-0.016	0.062	0.064	0.095	-0.026	-0.298	1		
Mn	-0.261	-0.105	0.316	-0.015	-0.015	0.061	0.062	0.094	-0.026	-0.298	0.999	1	
Zn	-0.269	-0.119	-0.408	-0.489	-0.489	-0.15	-0.151	-0.124	-0.47	0.975	-0.234	-0.234	1

CONCLUSIONS

The present study aimed to expose drinking water samples for determining the physicochemical parameters of groundwater in twenty-fivesamplesat different locations in JalalabadCantonment area. Each parameter was compared with the standard desirable limits given by World health organization (WHO) and Bureau of Bangladesh Standard (BBS), to assess the quality of ground water. From the result, it was assessed thatgroundwater is safe for drinking purposesin almost all the physicochemical parameter of sample water. The overall groundwater and surface water quality of the greater Sylhet region is poorly understood, still now. The study does not cover surface water quality status of the study area, due to time constrain. To find out the source of contaminants which is due to soil types, industrialization, water chemistry and other human activities. Continuous monitoring and further intensive research are required to know overall groundwater of the greater Sylhet region.

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