A STUDY ON GROUNDWATER QUALITY AND ITS EFFECT ON HUMAN HEALTH IN JOGIPOLE UNION PARISHAD, KHULNA

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ABSTRACT

The people of Bangladesh are largely depended on the groundwater (GW) sources for drinking and domestic purposes. Almost 90% of potable water and about 70% of irrigation water are provided from the GW sources. So the GW plays a vital role in our daily life and all the groundwater quality (GWQ) parameters should be within the standard limit. The GW especially in southwestern coastal region of Bangladesh is contaminated with various problems. The salinity increment in coastal region of Bangladesh has been an alarming issue which affects the water supply system and scarcity of potable water. Two wards of Jogipole union parishad at Dighalia Upazila in Khulna are selected to conduct the study and a preliminary survey was done on the study area. GW sources are selected and eight samples are collected from each ward. All samples are tested according to the standard procedures of laboratory and values are compared with the standard values of drinking water. From a questionnaire survey on the dwellers of the study area it was found that most of the people have been suffering from high blood pressure, kidney disease, gastric and respiration problem. From the laboratory test it was found that the GW of the study area possesses with high concentration of color, turbidity and manganese. The salinity is very high for the excessive concentration of chloride present in GW. Total dissolves solids (TDS) in GW of the study area is very high although others parameters are within standard limit. Finally the suitability of GW samples are checked for suitability of drinking water by comparing all tests values with the standard value of ECR, 1997 and WHO, 2006.

Keywords: *Salinity Increment, Coastal Region, Groundwater Contamination, Health Effect.*

1. INTRODUCTION

Bangladesh is largely depended on groundwater (GW) sources for drinking and domestic purpose. About 90% of drinking water in Bangladesh is provided from the groundwater sources. The southwest coastal belt of the country is facing enormous challenges in meeting the rising freshwater demand due to limited water supply from the available GW and SW as they are affected by the salinity and other water quality problems (Adhikary et. al., 2011). Numerous water quality problems exist in GW and surface water (SW) systems in Bangladesh, especially in southwestern coastal belt, where salinity is a very alarming issue at present (Elahi and Hossain, 2011). The salinity was started to increase in Khulna after the commencement of Farrakka Barrage operation India in 1975, which significantly reduced the Ganges flow, located at upstream of the Gorai River, a major sources of freshwater to the river surrounding Khulna (Mirza *et al*., 1996). At present, the principle causes of salinity intrusion in Khulna region is the drop of hydraulic head during the dry period (November to May) into both SW and GW of the study area (Hassan et al., 1998). In case of fishery, excess salinity affects spawning ground leading to substantial reductions in the inland open water fishery (Rabbi and Ahmed, 1997). As being of divisional headquarter, a large number of industries has built up in the Khulna City. Most of the industries in the Khulna region are reported to have suffered from the increase in salinity. Groundwater (GW) is almost globally very important for human consumption as well as for the support of habitant and for the maintaining the quality of base flow to rivers. Worldwide, the most important aspect of any water resources planning and management strategy is to ensure adequate quantity of water with acceptable quality. GW is the main source of water supply for domestic, irrigation and industrial activities. About 90% of drinking water (Mridha *et al*., 1996) and almost 75% of irrigation water in Bangladesh (Shahid *et al*., 2006) are supplied from GW sources. Water supply in Khulna City Corporation (KCC) is also adversely affected by the plentiful presence of salinity in the groundwater (GW) as well as surface water (SW) sources. Recently the inhabitants of ward no 01 and 02 under

Jugipole union parishad have been extremely suffering from the high concentration of iron, manganese and saline problems. Excess amount of salinity, high concentration of iron have bad effect on human health. About 35% people of the two wards (ward no 01 and 02) has been suffering from high blood pressure and 17% for gastric problem. High chloride concentrations are corrosive to metals in the water distribution system, particularly in water of low alkalinity. Higher chloride content in inland water usually indicates sewage pollution (Ahmed and Rahman, 2010). Therefore, this study is an effort to investigate some physico-chemical parameters of groundwater such as pH, chloride, color, turbidity, alkalinity, iron, manganese etc. in the central part of Khulna city area of Bangladesh.

2. THE STUDY AREA

Dighalia upazila is situated in Khulna district which is consisted of six union parishad and Jogipole union parishad is one of them. The study area is wards no 01 and 02 at Telegati under Jogipole union parishad in Khulna. In the following figure-1, the blue circles indicate the selected ward no 01 and 02 which are the study area for the project. Khulna lies in the point where the river Bhairab meets the Sundarban route. The Bhairab in the north side, Rupsha River in the middle side and Posur in the southern side flows along the western side of the city. It is the divisional headquarters of Khulna division and a major industrial and commercial center. The city currently covers an area of 46 sq. km and the population of the city, under the jurisdiction of the city corporation, was about 1 million in 2010 estimation. The city along with its surrounding is bounded by the longitude 89028'-89037' east and latitude 22046'-22058' north and its elevation is 1 to 2 m above mean sea level. The mean annual temperature from 2001 to 2007 was 26.70C, the average for January is 18.8°C (Minimum) and for May 30.30°C (Maximum). Khulna receives a mean annual rainfall about 1620 mm. The mean monthly rainfall varies from 2 mm to 341 mm. The main source of rainfall is southwestern monsoon. However, about 90% rainfall occur between May to October (monsoon period) and rest 10% occurs in November to April (non-monsoon period) (Elahi and Hossain, 2011).

Figure 1: Location of the study area.

3. MATERIALS AND METHODS

At first, field reconnaissance survey is conducted and the sampling locations in each ward are selected. It is performed by taking the water supply network map of KCC as a key reference (Elahi and Hossain, 2011). After finalizing the sampling points GW samples (8 samples from each ward of the study area) are collected. Airtight plastic bottles of half-liter capacity are used for this purpose. They are thoroughly cleaned by rinsing three to four times with sampling water. Before sampling from tube wells, sufficient amount of water is pumped out so that the sample represents the GW from which the well is fed (Raghunath, 1990). Then the sampling bottles are filled up to the brim and are immediately sealed to avoid exposure to air (Clesceri et al., 1989). The sampling containers are labeled including its station name, source, identification number, date and time for identification. Collection and preservation of the samples are carried out according to the standard methods (APHA, 2000). The samples are immediately transferred to the environmental engineering laboratory at the Department of Civil Engineering of Khulna University of Engineering & Technology for subsequent laboratory testing and analysis. The collected GW samples are analyzed for pH, turbidity, color, electrical conductivity, hardness, alkalinity,

total solid, total dissolved solid, chloride, nitrate, iron, carbon dioxide, manganese and arsenic. All physicochemical analyses are performed according to the standard methods for the examination of water and wastewater (APHA, 2000). pH is determined by pH meter and turbidity is determined by Hellige turbid meter. Nitrate, iron, manganese and color were determined by Hellige turbid meter. Chloride and hardness are determined by titration method. The water quality parameters are assessed by comparing the test results with both Bangladesh Drinking Water Standard (ECR, 1997) and World Health Organization (WHO) guidelines for drinking water quality (WHO, 2006).

4. RESULTS AND DISCUSSIONS

After collecting the water samples, they are brought in laboratory and fourteen water quality (WQ) parameters for each sample are determined with necessary laboratory tests. Then, the evaluated WQ parameters are compared with their standard values which are provided by Bangladesh Drinking Water Standard (ECR, 1997) and World Health Organization (WHO) guideline for drinking water quality (WHO, 2006). This is how the suitability of water samples is checked. Fourteen WQ parameters with their standard values according to ECR (1997) and WHO (2006) guidelines of sixteen samples of two awards are given below:

Table 1: Tests results of the collected samples with its recommended standard quality (ward no. 01)

Parameters	Unit	Sample 1	Sample 2	Sample 3	Sample 4	Water Quality Standard	
						WHO (2006)	ECR (1997)
pH	-	7.39	7.37	7.33	7.34	6.50-8.50	6.50-8.50
Color	Pt/Co	127	165	108	168	15	15
Turbidity	NTU	15.5	22.4	20.30	17.70	5	10
Conductivity	ms/cm	2.08	2.20	2.18	1.93	-	-
Chloride	mg/l	930	1070	1480	1130	250	150-600
Alkalinity	mg/l	185	220	220	210	-	-
Carbon Dioxide	mg/l	15	20	25	20	-	500
Parameters	**Unit**	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Water Quality Standard**	
						WHO (2006)	**ECR (1997)**
Hardness	mg/l	805.62	333.36	157.42	240.76	-	200-500
TS	mg/l	2090	2380	2270	2110	-	-
TDS	mg/l	2000	2220	2110	2020	1000	1000
TSS	mg/l	90	160	160	90	-	-
Manganese	mg/l	0.90	3.40	1.0	1.10	0.10	0.10
Iron	mg/l	0.80	1.15	0.30	0.94	0.30	0.30-1.0
Nitrate	mg/l	1.10	2.10	2.10	1.90	50	10
Sulfate	mg/l	27	60	4	2	250	400
Arsenic	mg/l	0	0	0	0	0.01	0.05

Table 2: Tests results of the collected samples with its recommended standard quality (Ward no. 01)

Parameters	Unit	Sample 5	Sample 6	Sample 7	Sample 8	Water Quality Standard	
						WHO (2006)	ECR (1997)
pH	-	7.38	7.41	7.35	7.30	6.50-8.50	6.50-8.50
Color	Pt/Co	142	136	125	176	15	15
Turbidity	NTU	12.80	18.17	14.40	23.30	5	10
Conductivity	ms/cm	2.05	2.14	1.98	2.22		
Chloride	mg/l	1030	1235	965	1360	250	150-600
Alkalinity	mg/l	210	192	215	205		
Carbon Dioxide	mg/l	25	18	21	20	-	500
Hardness	mg/l	222.24	265.6	780.10	180.45	-	200-500
TS	mg/l	2160	2155	2270	2185		
TDS	mg/l	2120	2005	2230	2115	1000	1000
SS	mg/l	40	150	40	70		
Manganese	mg/l	1.40	1.20	1.59	1.05	0.10	0.10
Iron	mg/l	0.39	0.49	0.80	1.02	0.30	0.30-1.0
Nitrate	mg/l	0.50	2.10	0.70	0.91	50	10
Sulpahte	mg/l	25	23	45	6	250	400
Arsenic	mg/l	0	0	0	0	0.01	0.05

Comparison of different water quality parameters of water samples 1-8 of ward no. 01 with its recommended standard parameters are represented by in Table-1 and Table-2. It shows sixteen WQ parameters with their units which are determined in laboratory tests with standard values according to ECR (1997) and WHO (2006) guidelines to check the suitability of water quality. From the comparison of the values of the samples, a study is conducted on the effect of the GW on human health of the study area.

Table 3: Tests results of the collected samples with its recommended standard quality (Ward no. 02)

Parameters	Unit	Sample 1	Sample 2	Sample 3	Sample 4	Water Quality Standard	
						WHO (2006)	ECR (1997)
pH	-	6.68	6.77	6.33	6.69	6.50-8.50	6.50-8.50
Color	Pt/Co	57	44	55	90	15	15
Turbidity	NTU	17.6	7.47	28.5	16.70	5	10
Conductivity	ms/cm	1.935	1340	1906	1883		
Chloride	mg/l	890	680	830	790	250	150-600
Alkalinity	mg/l	690	150	60	150		
Carbon Dioxide	mg/l	25	20	30	15	-	500
Hardness	mg/l	300.95	236.13	314.84	328.73	-	200-500
TS	mg/l	193	151	352	146		
TDS	mg/l	181	147	334	134	1000	1000
SS	mg/l	12	4	18	12		
Manganese	mg/l	0.30	0.50	0.60	0.26	0.10	0.10
Iron	mg/l	0.33	0.38	0.14	0.23	0.30	0.30-1.0
Nitrate	mg/l	19	20.20	0.70	0	50	10
Sulphate	mg/l	-	-	-	-	250	400
Arsenic	mg/l	0	0	0	0	0.01	0.05

Table 4: Tests results of the collected samples with its recommended standard quality (Ward no. 02)

Parameters	Unit	Sample 5	Sample 6	Sample 7	Sample 8	Water Quality Standard	
						WHO (2006)	ECR (1997)
pH	-	6.16	6.16	7.15	6.70	6.50-8.50	6.50-8.50
Color	Pt/Co	0	57	0	0	15	15
Turbidity	NTU	21.0	14	3.23	13.8	5	10
Conductivity	ms/cm	1948	1941	519	1899		
Chloride	mg/l	880	830	100	750	250	150-600
Alkalinity	mg/l	150	165	195	160		
Carbon Dioxide	mg/l	25	15	15	15	-	500
Hardness	mg/l	351.88	319.47	78.71	300.95	-	200-500
TS	mg/l	263	237	48	241		
TDS	mg/l	236	234	47	239	1000	1000
SS	mg/l	27	3	1	2		
Manganese	mg/l	1.10	0.60	0.30	0.20	0.10	0.10
Iron	mg/l	0.42	0.21	0.16	0.34	0.30	0.30-1.0
Nitrate	mg/l	9.70	0	5.40	29.50	50	10
Sulfate	mg/l	-	-	-	-	250	400
Arsenic	mg/l	0	0	0	0	0.01	0.05

Comparison of different water quality parameters of water samples 1-8 of ward no. 02 with its recommended standard parameters are represented by in Table-3 and Table-4. It shows sixteen WQ parameters with their units which are determined in laboratory tests with standard values according to ECR (1997) and WHO (2006) guidelines to check the suitability of water quality. From the comparison of the samples values, a study is conducted on the effect of the GW on human health of the study area.

A questionnaire survey is conducted on the selected ward of the study area and the figure-1 shows the results. From the survey results it is observed that the people of the selected area have been suffering from high blood pressure, kidney disease, gastric, respiration and others problems. About 35% people of the study area have been suffering from high blood pressure and 10% people have been suffering from kidney disease. The percentage of people suffered from gastric is about 17% and respiration problem is about 8%. The people of the study area also have a problem of taste deficiency of curry and vegetable. Variation of chloride of the two wards of different samples is represented in Figure-3. The recommended value of chloride according to the ECR (1997) and WHO (2006) guideline are 150-600 mg/l and 250 mg/l respectively. From the figure-3 it is observed that most of the samples exceed the standard limit according to ECR (1997) and WHO (2006) standards. So it is observed that the GW of the study area possesses high concentration of choloride. Though sodium salt has a link to heart and kidney disease, it is not harmful till it is within the standard limit. But the causes of the high blood pressure and kidney disease of the people of the study area may be the presence of high concentration of saline in GW.

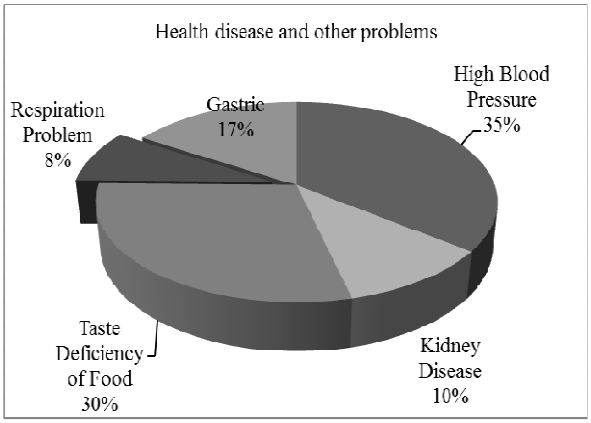

Figure 2: Survey results of various problems

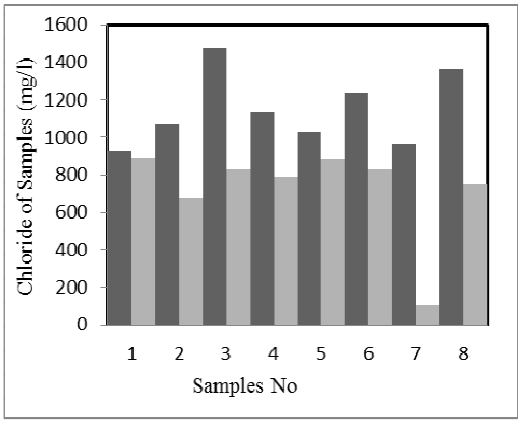

Figure 3 : Variation of Chloride of the two wards

The recommended value for manganese according to the ECR (1997) and WHO (2006) guideline are 0.10 mg/l from the figure-4 it is observed that all samples exceed the standard limit. So it may be said that the waters of the study area possess high manganese. Manganese is one out of three toxic essential trace elements, which means that it is not only necessary for humans to survive, but it is also toxic when too high concentrations are present in a human body .Manganese effects occur mainly in the respiratory tract and in the brains. Symptoms of manganese poisoning are hallucinations, forgetfulness and nerve damage. Manganese can also cause Parkinson, lung embolism and bronchitis. When men are exposed to manganese for a longer period of time they may become impotent. From the survey results it was observed that 8% people of the study area have been suffering from the respiration problems. So the cause of this disease may be high concentration of manganese in GW of the study area.The recommended value for iron according to the ECR (1997) and WHO (2006) guideline are 1.0 mg/l and 0.30 mg/l respectively. From the figure-5 it is observed that most of the samples exceed the standard limit for iron. Iron has a taste, hardness, and scaling effect on water and it has a negative effect of toxicity and diseases on human health. Iron in water may cause hardness, undesirable taste in beverages, staining in clothes and plumbing fixures, encrustation in water mains, and may impart a raddish brown colour to water. Iron in water is frequently accompanied by heavy growths of iron bacteria which exaggerate the staining pipe clogging, and other problems.

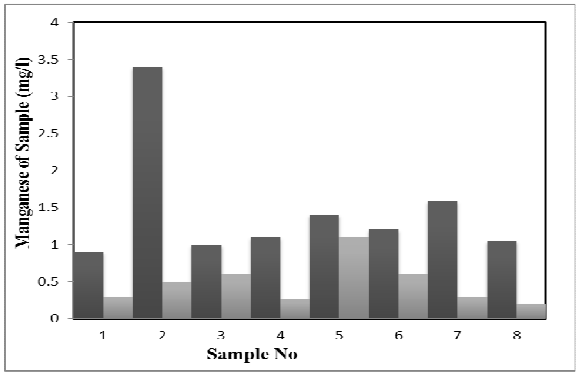

Figure 4: Variation of Manganese

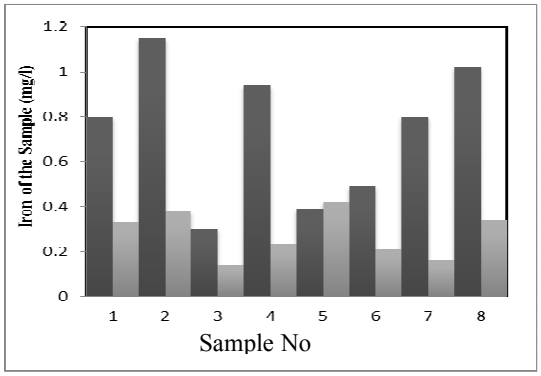

Figure 5: Variation of Iron

The color of GW of the study area is very high and the causes of the high color of GW may be the presence of the some living impurities. So GW of the study area is contaminated with living impurities which make diseases and toxicity in human body. Another cause of high color of the GW is having impurities of mineral & organic like vegetable dyes which also make diseases in human body.If the presence of TDS in GW is very excessive then the impurities in water will be very high and its conductivity will be higher. So higher conductivity represents the low quality water and low quality water is not acceptable to use in drinking purpose. The excessive present of carbon dioxide in GW has a bad effect on human health. Carbon dioxide causes lungs

disease, breathing and respiratory problems. Exposure to lower concentrations of carbon dioxide can cause hyperventilation, vision damage, lung congestion, central nervous system injury, abrupt muscle contractions, elevated blood pressure, and shortness of breath. From the questionnaire survey it was observed that the people of the study area have been suffered from respiration problems and the causes of this disease may be carbon dioxide present in GW of the study area.

5. CONCLUSIONS

P^H is within the range of standard limit (6.50-8.50), only three samples for color are below the standard limit but rest of all exceeds the standard limits and all samples for turbidity exceeds standard limit but only two samples are within the standard limit and these two values are 7.47 ntu and 3.23 ntu. All samples for chloride exceed the standard limit but only one is within the standard limit and its value is 100 mg/l and the hardness of the samples are within the standard limit but only two samples exceed the limit. Iron of the samples is within the standard limit but only two samples exceed the limit, nitrate of the samples are within the limit and arsenic of the samples is zero. Total dissolved solid (TDS) of the samples of ward no 01 is very high but it is comparatively low for ward no 02. From the questionnaire survey it was observed that 35%, 10%, 17%, 8% and 30% people have been suffered from high blood pressure, kidney disease, gastric, respiration problems and taste deficiency of food respectively. The GW of the study area possesses high concentration of color and turbidity which make diseases and toxicity in human body. The GW of the study area possesses high concentration of chloride which causes high blood pressure, heart and kidney disease and taste deficiency of foods. The GW of the study area possesses carbon dioxide which causes lungs disease, breathing and respiratory problem.

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