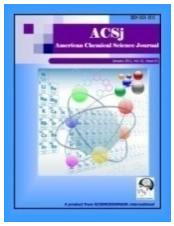

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Assessment of Health Hazard of Metal Concentration in Groundwater of Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author ARMTI designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors MAR, MSI and KJ managed the analyses of the study. Author MAP managed the literature searches and final editing of the total manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The study was to assess health hazard of metal concentation in groundwater of Bangladesh for drinking purposes. A number of 13 deep tube wells were selected purposively for collecting groundwater samples from the different sampling location of the study area. The study was carried out by laboratory analysis of chemical parameters which were analyzed by ion Chromatograph (IC) and atomic absorption spectrophotometer methods (AAS). The result shown that the concentration of iron and manganese were found to be more than permissible limit according to Bangladesh and WHO standard. The descriptive statistics revealed that most of the heavy metal concentrations like As, Cd, Fe and Mn were found to be range from 0.00 to 0.02 mg/l, 0.00 to 0.20 mg/l, 0.11 to 24.20 mg/l, 0.06 to 16.00 mg/l respectively within accessible limit for drinking

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according to Bangladesh and WHO standard except some water sampling locations were exceed the permissible limits. Pearson correlation matrix results were depicted that a strong positive correlation between the parameters such as Na^+ and SO_4^{2-} and K^+ and NH_3^- while low negative correlation were existed between Dissolved Oxygen and Mn^+. From the analysis of result, it suggests that using groundwater for drinking purposes in the study area is slightly detrimental to human health hazard and thier surrouding environment.

Keywords: Health hazard; groundwater; metal concentration; pearson correlation and drinking standard.

1. INTRODUCTION

Seventy-nine percent of rural people in Bangladesh drink groundwater extracted by shallow tube-wells [1]. Intermittent incidents of As contamination in groundwater and the subsequent ill health of people from As poisoning have been widely reported [2]. The provision of potable water to the rural and urban population is necessary to prevent health hazards [3,4]. Water of good drinking quality is of basic importance to human physiology and man's continued existence depends on its availability [5].

Groundwater study is the prime importance for all sorts of purposes such as household, industrial and agricultural activities in the worldwide [6]. Golekar et al. [7] studied that the estimation of groundwater quality is important for assessment and investigation associated with human health hazard. In recent years, there has been tremendous demand of groundwater for intensive agricultural activities and population growth [8]. Now a day, the availability and access to groundwater has become the most burning issue in the world. Groundwater is essential to human health, culture, industry and natural ecosystems, but is now running scarce in many regions of the world [9].

About 30% diseases occur due to intake of polluted water. Therefore, supply of drinking water should be healthier quality [10]. The groundwater pollutant can be adversely affected on human health even they are trace amount in groundwater [8]. Biswas et al. [11] reported that groundwater is good for health in the Patuakhali district, Bangladesh. Heavy metal in water and sediment in the Tembi River, Iran using groundwater for recreational purposes, washing and fishing are detrimental to human health [12]. In this regards, this research has an attempt to evaluate the health hazard of metal concentration in groundwater of Bangladesh.

2. METHODOLOGY

2.1 The Study Area

The study area is selected purposively all over the Bangladesh (Fig. 1). The selected water sampling areas are Homna, Comilla (S_1), Sonargaon, Narangonj (S_2), Kaliganj, Gazipur (S_3), Sharsha, Jessore (S_4), Chauddagram, Comilla (S_5), Mirsharai, Chittagong (S_6), Taherpur, Rajshahi (S_7), Sundorganj, Gaibandha (S_8), Tanore, Rajshahi (S_9), Dhamoinhat, Naogaon (S_{10}), Nandigram, Bogra (S_{11}), Mirzapur, Tangail (S_{12}), Muktagasa, Mymonsingh (S_{13}). The temperature of this area ranges from 28 to 32ºC on an average with an average rainfall of 1,458 mm [13]. Most of the people use groundwater in domestic and agricultural purposes.

2.2 Water Sampling Design

Groundwater samples were collected through random sampling in the field and same depth of aquifer. Sampling location represent the condition prevailing that time the samples were collected and tested was obtained the result. Ground water samples were collected in separate plastic container rinsed with concentrated nitric acid and distilled water and finally rinsed with the sample water to be collected for different analytical purposes. Groundwater samples were collected from 13 designated water sampling location within the study area. Before collecting samples each well was pumped for a few minutes and then water samples were collected in a new plastic bottle of 500 ml capacity, which was immediately stopper air light to protect it from air bubbles inside it. After collecting samples was acidified of with concentrated nitric acid (HNO_3) for determination of trace elements to prevent any reaction, another acidified with 0.5N HCl for determination iron concentration and other one was unacdified cations and anions analysis. After collecting samples are transported to the laboratory for analysis.

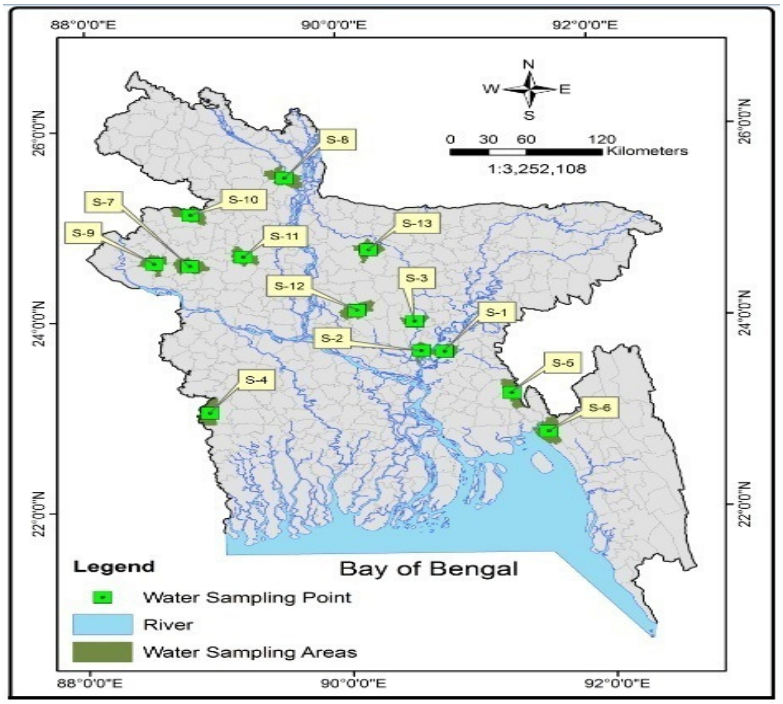

Fig. 1. Location map shows water sampling location in the study area

The chemical parameters were analyzed by laboratory of Department of Public Health Engineering (DPHE), Dhaka for selected water samples. Analysis of major cations- Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Fe^{total} and analysis of major anions- Cl^{-}, SO_4^{2-}, NH_3^{-}, PO_4^{2-} samples were preserved using suitable preservation techniques [14,15]. Laboratory analysis of chemical parameters of cation and anion were carried out by ion chromatograph system at DPHE, Dhaka, Bangladesh. Dissolved oxygen of water samples were determined on the spot by kit supplied by DPHE, Dhaka and phosphate and nitrate by standard methods [15]. Cadmium and arsenic, manganese were determined by atomic absorption spectrophotometer method (AAS). For the analysis of metals by UV-Visible Spectrophotometer and Atomic Absorption Spectrophotometry (AAS) methods were digested according to the wet-digestion method [16].

2.3 Statistical Analysis

A number of Statistical software were used to analyze the collected data. Chemical data were analyzed by Excel (2007 version). SPSS (11.5 version) was used for descriptive statistical analysis and Pearson correlation coefficient matrix analysis. Sigma plot (6 versions) was used for variability analyses for the study. Pearson correlation gives a relation between the variable of water sample quality. It indicate variables either increases or decreases and vice versa.

2.4 Ethical Consideration

The research work was performed by faculty member of the department of Disaster Management and approved by ethical evaluation committee. Permission was taken from the Project Director of Dept. of Public Health Engineering, Dhaka, Bangladesh.

3. RESULTS AND DISCUSSION

3.1 Metal Concentration in Ground Water

Metal concentrations in groundwater in different sample location of Bangladesh are shown in the (Table 1). Phosphorous and chloride concentration level of all the sample location in groundwater was noticed within accessible limit according to Bangladesh standard except sample location S_2 exceed the chloride level. The dissolved oxygen content of water sample ranged from 5.7 to 7.50 ppm indicated that most of the sample locations exceed dissolved oxygen content in term of DOE [17] and WHO [18]

standard. It was observed that dissolved oxygen content below 6 ppm in 3 samples location. Lower dissolved oxygen content was noticed in S_2, S_4, and S_5. This dissolved oxygen might be due to temperature, photosynthesis, respiration, aeration, organic waste and sediment concentration [19]. The reduced dissolved oxygen may affect the aquatic life [20]. However, there is no report of ill health effects arising directly from a deficiency of dissolved oxygen in potable water or from its complete absence [21].

In the study, the concentrations of arsenic and cadmium were found less than the prescribed permissible limits of WHO and Bangladesh standard [22]. Similar finding was found by Biswas et al. [11]. The concentration of iron and manganese were noticed that most of the sample locations were found more than permissible limit in order to Bangladesh standard except sample location S_6 and S_{11}. Higher concentration sodium was only noticed in sampling location S_3 in the study area. Other ammonia and sulfate concentration in groundwater were also noticeable in some sampling point.

In this study, the magnesium and potassium concentrations are much higher value exceeding often the permissible value and typical values elsewhere in the sampling point S_1, S_3 and S_7 of Bangladesh (Fig. 2). Excessive amount of iron and manganese in groundwater of Bangladesh were identified in the sample location of S_1, S_3 and S_8 (Fig. 3). The increased levels may cause damage to brain, kidney if taken in high concentration [23]. Exposure to iron causes health diseases hemochromatosis that it can lead to heart disease, liver problems and diabetes [24]. The accumulation of the high metals concentration in groundwater sample might be due to anthropogenic activities and significant in human health hazard. There was a proportional relation between magnesium and potassium versus iron and manganese indicated that increasing these concentrations in particular sampling point. High concentrations of iron in ground water are potential for human health hazard since it is used by human for drinking and cooking purposes. Iron and manganese concentration in groundwater are detrimental because of their form and taste of the water, their ability to cause staining. Nevertheless, very high concentration of iron and manganese can lead to stain clothes, discolor plumbing fixtures, and sometimes add an "oxidized" taste. Manganese may affect neurological and muscle function in humans [25]. Groundwater iron assessment and consumption by women in rural northwestern Bangladesh reported that potentially unpleasant organoleptic qualities of high iron content in water [26].

3.2 Descriptive Statistical Analysis

The concentration of the elements in groundwater depends on its availability, structural composition and solubility. Consequently, the concentration may vary from place to place which is implies to earth compositional variation and metal abundance. Most of the metal concentrations like PO4, Cl-, DO, As, Ca, Cd, Fe, Mn, Mg, K, Na, SO4 and NH3 was found to be range from 0.12 to 1.55 mg/l, 4.00 to 1158.00 mg/l, 5.70 to 7.50 mg/l, 0.00 to .02 mg/l, 4.60 to 171.00 mg/l, 0.00 to 0.20 mg/l, 0.11 to 24.20 mg/l, 0.06 to 16.00 mg/l, 2.00 to 70.00 mg/l, 1.60 to 15.00 mg/l, 5.70 to 599.00 mg/l, 0.56 to 53.00 and 0.10 to 1.67 respectively (Table 2). According to kurtosis, maximum metal concentration was observed in the scale of leptokurtic its value laid on <3. On the other hand, all the metal concentration was found to be positively skewed in the study groundwater samples (Table 2).

3.3 Correlation Matrix Analysis

Correlation analysis has been carried out, as a bivariated statistics in order to determine mutual relationships and strength of association between pairs of variables through calculation of linear Pearson correlation coefficient [27]. The results of Pearson correlation matrix analysis between the 13 studied variables were prepared and shown in (Tables 3). In the study, PO_4^- was shown a weak positive correlation with Cl^-, Ca^{2+}, Cd, Na^+, Mg^{2+}, NH_3^- and low negative correlation with DO and Mn^+. The values of Cl^- indicated that strong positive correlation with Ca^{2+}, Mg^{2+}, Fe, Na^+, and SO_4^- while other variable shown very weak negative correlation. The values of DO and As were depicted the significance moderate positive correlations whereas the most of the variables negative correlations were existed in the ground water samples. The As value revealed that significance high positive correlation with Mn^+. Mg^{2+} was shown very strong correlation with Na^+ and SO_4^{2-}. A positive high correlation was observed between Ca^+ with $Fe^{+\cdot}$, Mg^{2+}, Na^+, SO_4^{2-},. The values of Cd and Mn were shown that the weak negative correlation between all the studies variable in the groundwater samples. The strong positive correlations were existed between Na^+ and SO_4^{2-} and K^+ and NH_3^- (Table 3).

Table 1. Metal concentration of elements in different sample location

S. no.	PO_4^{2-}	Cl^-	DO	As	Ca^{2+}	Cd	Fe	Mn	Mg^{2+}	K^+	Na^+	SO_4^{2-}	NH_3
S_1	0.98	256.00	7.30	0.00	61.00	0.00	12.80	0.37	34.00	15.00	103.00	1.00	1.10
S_2	0.34	85.00	5.80	0.00	43.00	0.00	4.70	0.62	20.00	14.00	60.00	4.00	1.20
S_3	0.97	1158.00	6.10	0.00	171.00	0.01	24.20	1.90	70.00	5.70	599.00	53.00	0.12
S_4	1.55	10.00	5.70	0.00	91.38	0.01	3.94	0.29	16.56	14.00	57.00	0.56	1.67
S_5	0.46	4.00	5.70	0.00	13.40	0.00	1.22	0.34	4.22	14.00	29.00	7.00	0.50
S_6	0.98	5.00	6.90	0.01	4.60	0.20	0.21	0.06	2.00	1.60	5.70	1.00	0.10
S_7	0.74	60.00	6.80	0.01	97.55	0.01	4.80	1.18	27.83	5.20	35.34	5.00	0.50
S_8	0.35	22.00	7.40	0.02	35.50	0.00	15.10	16.00	11.00	3.80	15.70	1.00	0.48
S_9	0.28	27.00	6.40	0.01	86.34	0.00	3.74	0.42	15.55	4.20	51.77	1.00	0.50
S_{10}	0.48	70.00	6.40	0.00	36.00	0.00	0.58	0.37	9.50	7.50	38.80	1.00	0.68
S_{11}	0.12	19.00	7.40	0.00	47.50	0.01	0.11	0.18	10.00	5.20	41.30	1.00	0.32
S_{12}	0.98	30.00	7.50	0.01	12.80	0.00	0.42	0.30	15.00	6.00	21.00	1.20	0.10
S_{13}	0.98	60.00	6.00	0.01	33.00	0.00	2.00	0.60	15.00	5.00	34.00	1.00	0.10
Bang.STD	6.00	150-600	6 .00	0.05	75.00	0.01	0.3-1.0	0.10	30-35	12.00	200.00	400.00	0.50
WHO STD	6.00	250	6.00	0.05	9	0.005	0.01	0.1	50	12.00	200.00	400.00	0.50

Note- S1-Homra, Commila. S2-Sonargaon, Narangonj. S3-Kaliganj, Gazipur. S4-Sharsha, Jessore. S5-Chauddagram, Commilla. S6-Mirsharai, Chittagong. S7-Taherpur, Rajshahi. S8-Sundorganj, Gaibandha. S9-Tanore, Rajshahi. S10-Dhamoinhat, Naogaon. S11-Nandigram, Bogra. S12-Mirzapur, Tangail, S13-Muktagasa, Mymonsingh. STD-Standard Deviation

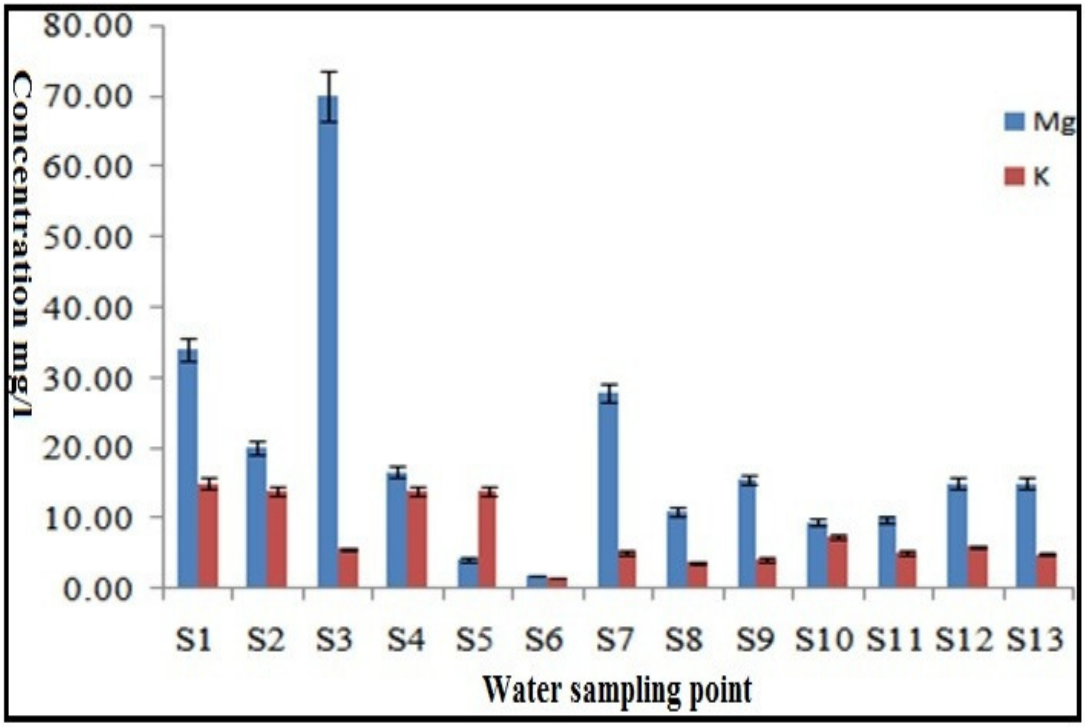

Fig. 2. Metal concentration of magnesium and potassium in the study sample

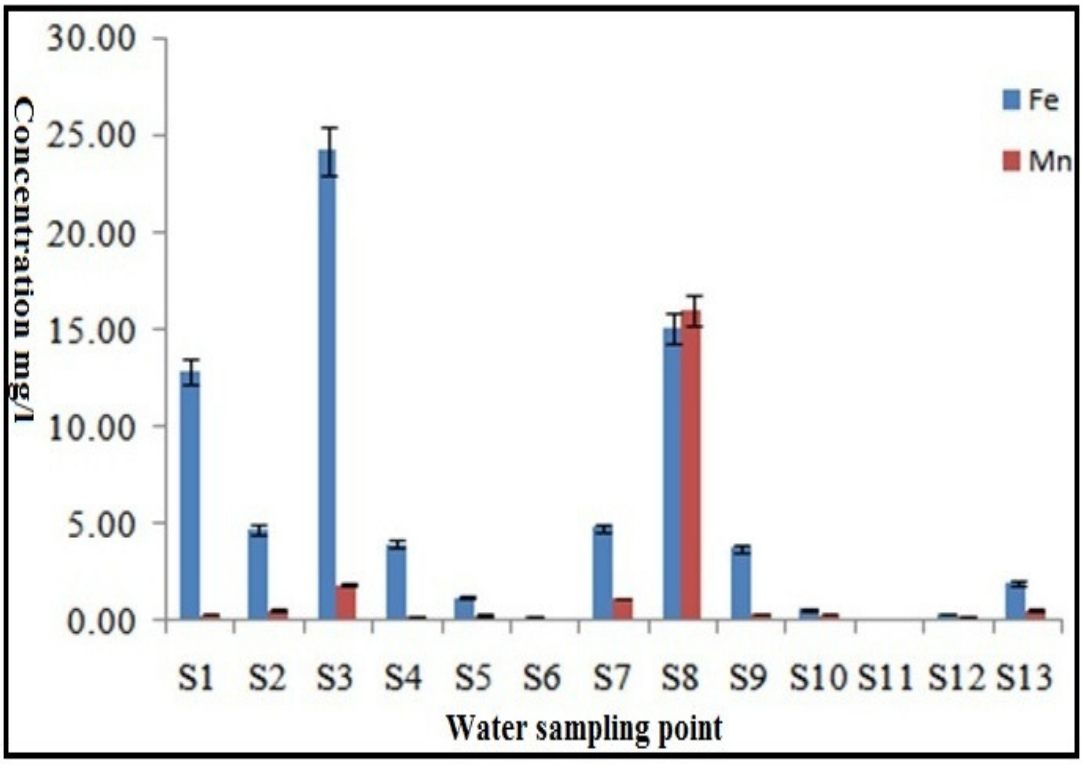

Fig. 3. Metal concentration of iron and manganese in groundwater sample

Table 2. Descriptive statistics analysis of identified groundwater sample

Statistics	PO4	Cl-	DO	As	Ca	Cd	Fe	Mn	Mg	K	Na	SO4	NH3
Mean	0.71	138.92	6.57	0.01	56.39	0.02	5.68	1.74	19.28	7.78	83.97	5.98	0.57
Median	0.74	30.00	6.40	0.00	43.00	0.00	3.74	0.37	15.00	5.70	38.80	1.00	0.50
Mode	0.98	60.00	5.70	0.00	N/A	0.00	N/A	0.37	15.00	14.00	N/A	1.00	0.50
STD	0.41	313.26	0.69	0.01	45.70	0.05	7.30	4.31	17.55	4.69	156.65	14.27	0.49
CV	0.17	98128.74	0.47	0.00	2088.35	0.00	53.25	18.59	308.04	21.97	24537.81	203.55	0.24
Kurtosis	-0.27	11.54	-1.66	3.75	2.16	12.83	2.49	12.58	6.00	-1.29	12.21	12.36	0.74
Skewness	0.42	3.35	0.10	1.84	1.35	3.57	1.72	3.53	2.24	0.65	3.46	3.49	1.14
Min	0.12	4.00	5.70	0.00	4.60	0.00	0.11	0.06	2.00	1.60	5.70	0.56	0.10
Max	1.55	1158.00	7.50	0.02	171.00	0.20	24.20	16.00	70.00	15.00	599.00	53.00	1.67

Note- STD= Standard Deviation, CV= Coefficient of Variation, N/A= Not Applicable

Table 3. Pearson correlation coefficient matrix analysis in the study groundwater samples

Parameters	PO_4	Cl^-	DO	As	Ca	Cd	Fe	Mn	Mg	K	Na	SO_4	NH_3
PO_4	1.00												
Cl^-	0.22	1.00											
DO	-0.19	-0.16	1.00										
As	0.04	-0.13	0.47	1.00									
Ca	0.22	0.76*	-0.25	-0.17	1.00								
Cd	0.21	-0.12	0.15	-0.05	-0.30	1.00							
Fe	0.13	0.82**	0.04	0.26	0.69*	-0.21	1.00						
Mn	-0.25	-0.02	0.34	0.80*	-0.04	-0.12	0.47	1.00					
Mg	0.28	0.93**	-0.11	-0.09	0.86**	-0.27	0.83**	-0.04	1.00				
K	0.19	-0.03	-0.44	-0.44	0.01	-0.41	0.02	-0.27	0.07	1.00			
Na	0.21	0.99**	-0.22	-0.17	0.80*	-0.14	0.79**	-0.04	0.92**	-0.03	1.00		
SO_4	0.16	0.96**	-0.26	-0.15	0.74*	-0.09	0.74*	-0.01	0.86**	-0.08	0.98**	1.00	
NH_3	0.23	-0.20	-0.35	-0.28	0.14	-0.29	0.00	-0.08	-0.03	0.79*	-0.17	-0.27	1.00

*Note- **Correlation is significant at the 0.01 level (1-tailed), *Correlation is significant at the 0.05 level (1-tailed)*

4. CONCLUSION

The present study embodies with the assessment of metal concentration of groundwater for drinking purposes all over the Bangladesh. The aim of the research was to evaluate the health hazard for using the groundwater of Bangladesh. Total 13 deep tube wells were selected randomly for collecting water samples from the same depth of aquifers. The dissolved oxygen content of water sample ranged from 5.7 to 7.50 ppm indicated that Homra, Commila (S_1), Mirsharai, Chittagong (S_6), Taherpur, Rajshahi (S_7), Sundorganj, Gaibandha (S_8), Tanore, Rajshahi (S_9), Dhamoinhat, Naogaon (S_{10}), Nandigram, Bogra (S_{11}), Mirzapur, Tangail (S_{12}) samples locations exceeded the Bangladesh and WHO standard. The concentrations of arsenic and cadmium, phosphorous and chloride were found less than the prescribed permissible limits of WHO and Bangladesh standard. But the iron and manganese concentrations are much higher value exceeding often the permissible limit in the Homra, Commila (S_1), Kaliganj, Gazipur (S_3), Sharsha, jessore (S_4), Sundorganj, Gaibandha (S_8), Tanore, Rajshahi (S_9), Muktagasa, Mymonsingh (S_{13}) sample location of the study area. Most of the heavy metal concentrations like As, Cd, Fe and Mn was found to be range from 0.00 to .02 mg/l, 0.00 to 0.20 mg/l, 0.11 to 24.20 mg/l, 0.06 to 16.00 mg/l respectively. Highest metal concentration was observed in the scale of leptokurtic its value laid on <3 in accordance to kurtosis. On the contrary, all the metal concentration was found to be positively skewed in the study samples. Pearson correlation matrix result between 13 groundwater sample revealed that there was a weak positive correlation with PO_4^{2-} and Cl^-, Ca^{2+}, Cd, Na^+, Mg^{2+} and NH_3^- while low negative correlation with DO and Mn^+. Based on the above mention result, it gets clear idea that groundwater use for selected sample location of Bangladesh is slightly unfavorable for human health and their surrounding environment.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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