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ANALYSIS OF GROUNDWATER QUALITY IN SYLHET DISTRICT

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Abstract

The present study was conducted to evaluate the groundwater quality at different locations in Sylhet district. The selected locations were Sylhet Agricultural University (SAU), Chowkideki, Tilagor, Golapgonj, South Surma and BADC pump at Daudpure. Temperature, pH, turbidity, total alkalinity, dissolved oxygen (DO), carbondioxide (CO_2) and iron (Fe) were tested in the water quality laboratory of Sylhet Agricultural University and Leading University, Sylhet. Further water concentration data in the form of pH, turbidity, temperature, total alkalinity, carbon di oxide (CO_2), iron (Fe), phosphate (PO_4), nitrate (NO_3), total hardness and total dissolved solids were collected from Bangladesh Agricultural Development Corporation (BADC). All the parameters were compared with laboratory tested samples and evaluated with Bangladesh water quality standard whether it is suitable or not. The tested quality parameters were found within the acceptable limit for irrigation and domestic purposes. At Golapgonj, the value of iron (2.01 mg l^{-1}) was beyond the acceptable limit. Total alkalinity was found beyond permissible limit for both domestic and irrigation purpose at Daudpure (124 mg l^{-1}) and Golapgonj (432 mg l^{-1}), respectively. From quality point of view, groundwater is suitable for domestic and irrigation purposes except excessive iron presence in the well. A correlation matrix was done to find out the interrelationship among different water quality parameters. It is found that significant positive correlation holds among the water quality parameters. Therefore, it is suggested that the geologic stratification of this region should be thoroughly investigated before installing a tubewell for both domestic and irrigation purposes.

***Keywords*:** Groundwater, quality parameters, iron, irrigation, Sylhet.

Introduction

Groundwater is the main source for domestic and industrial water supply and also for irrigation purposes (Tagy, 2013). Human health and survival depends upon the use of uncontaminated and clean water for drinking and other purposes. It is estimated that approximately one third of the world's population uses groundwater for drinking purposes and today more than half the world's population depends on groundwater for survival (Mohrir, 2002, Patil *et al.,* 2015). In recent years, an increasing threat to groundwater quality due to human activities has become of great importance. The adverse effects on groundwater quality are the results of man’s activity at ground surface, unintentionally by agriculture, domestic and industrial effluents, unexpectedly by sub-surface or surface disposal of sewage and industrial wastes. The quality of groundwater is of great importance in determining the suitability of particular groundwater for a certain use (public water supply, irrigation, industrial applications and power generation etc.). The quality of groundwater is the resultant of all the processes and reactions that have acted on the water from the moment it condensed in the atmosphere to the time it is discharged by a well (Bhavika *et al.,* 2014). According to World Health Organization (WHO) about 80 % of all the diseases in human beings are caused by water. Once the groundwater is contaminated, then it would be very hard to restore its quality back. Polluted groundwater also can hamper the activity of wells used for abstracting Groundwater (Dohare *et al.,* 2014). Table 1 shows the list of substances found naturally in some groundwater which can cause problems in operating wells. Nilson and Renofalt (2008) studied on how allocations of water interact with physicochemical variation of water. The flow regime and the water quality can impact ecosystem processes, and conclude that most problems are associated with low-flow conditions. Adhikary *et al,* (2012) studied the application of geographic information system (GIS) technology for mapping groundwater quality in shallow aquifer for drinking and irrigation purposes. Therefore, the current study is conducted with the objectives to analyze the water quality parameters, and to evaluate the groundwater quality for drinking and irrigation purposes.

Table 1. List of substances found naturally in some groundwater which can cause problems in operating wells (*Dohare et al.,* 2014)

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Substance	Types of problems
Iron (Fe^{+2},Fe^{+3})	Encrustation, staining of laundry and toilet fixtures
Manganese (Mn^{-2})	Encrustation, staining of laundry and toilet fixtures
Silica (SiO^{2})	Encrustation
Chloride (Cl^{-})	Portability, Corrosiveness
Fluoride (F^{-})	Fluorosis
Nitrate (NO^{3-})	Methemoglobenemia
Sulphate ($SO4^{-2}$)	Portability
Dissolved Gases	Corrosiveness
Dissolved Oxygen	Corrosiveness
Hydrogen Sulphide (H_2S)	Corrosiveness
Carbon dioxide (CO_2)	Corrosiveness
Radio Nuclides	Portability
Miner Constituents	Portability, Health aspects
Calcium and Magnesium ($Ca^{2+,}$ Mg^{2+})	Encrustation

Materials and Methods

Study site

Sylhet city is located between $23^{0}59'$ and $25^{0}13'$ north latitude and $90^{0}54'$ and $90^{0}30'$ east longitude in the north-eastern region of Bangladesh. It is situated on the bank of river Surma. Sylhet city has a population of 500,000 people having a high population density (Ahmed *et al.*, 2010). The main source of water supply is groundwater with deep tube well (DTW) in Sylhet city. Most of the city dwellers are highly dependent on groundwater to fulfill their daily needs. Such huge quantity of water is distributed by municipal water supply and privately installed DTW. The hydrogeological conditions in greater Sylhet are less favorable for the abstraction of groundwater than in most areas of Bangladesh (Rahman and Ravescroft, 2003). As a consequence, relatively few wells have been drilled in the area. The study sites are selected based on accessibility, aquifer depth, water quality status etc. (Fig. 1).

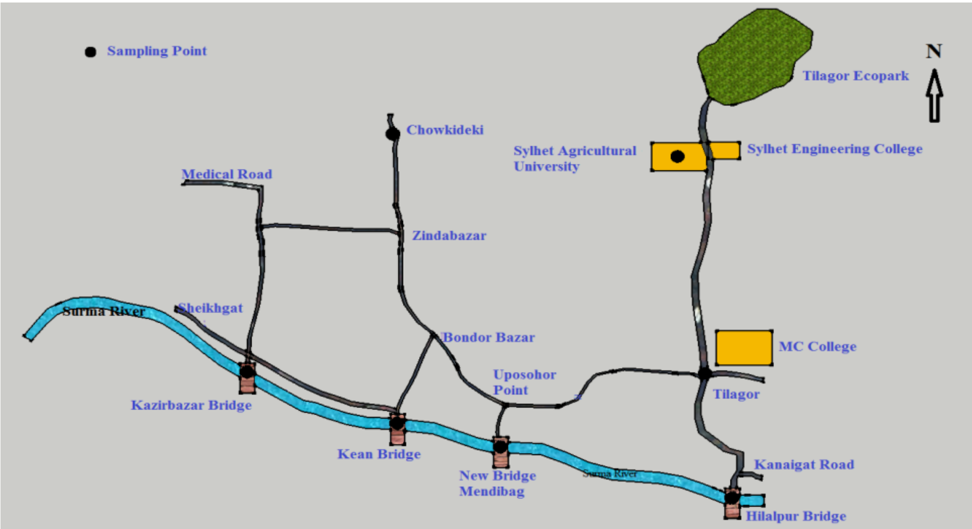

Fig. 1. Sampling point of groundwater

Parameters to be analyzed

Water quality parameters in the form of concentration were collected from both primary and secondary sources. The parameters are pH, turbidity, total dissolved solids, total hardness, dissolved oxygen, carbon dioxide, nitrate, total alkalinity, phosphate, iron and temperature.

Sampling procedure

Each sample was collected using a clean one liter plastic bottle with a screw cap which was thoroughly washed and cleaned with distilled water. The sampling tubewells were pumped for at least 30 minutes and then samples were taken in plastic bottles. The samples were taken monthly at 11.00 am in each location. The samples were packed properly to make the sample free from air contact. Then the samples were taken to the laboratory and tested within 24 hours. All the chemicals were used based on the analytical grade and the tests were conducted in accordance with the techniques described by American Public Health Association (APHA, 2005).

Determination of groundwater quality parameters

The pH was determined by using Lida instrument pH meter. It was standardized with a buffer solution of pH range between 4-9. Temperature of water samples were taken in situ measurement using a mobile thermometer. This was done by dipping the thermometer into the sample and stable readings were recorded. For determining total alkalinity100 ml of the sample was pipetted into a clean 250 ml conical flask. Two drops of methyl red indicator were then added and the solution titrated against a standard 0.02N H_2SO_4 solution to a pink end-point. Total alkalinity (mg l^{-1}) = Total ml of acid used * 10 ppm. Turbidity was determined using a standardized Hanna H198703 Turbidity meter. The samples were poured into the measuring bottle and the surface or the bottle was wiped with silicon oil. The bottle was then inserted into the turbidity meter and the reading was obtained. CO_2 was determined by taking 100 ml of sample into a beaker and same quantity of distilled water into another. 10 drops of phenolphthalein indicator to each beaker was added. N/44 solution hydroxide from a burette was added to the sample and stirred until permanent pink color appears as compared to distilled water. CO_2 (mg l^{-1}) = ml of N/44 * 10. For determining iron at first 100 ml sample was taken in a conical flask and taken distilled water in another. Then 5 ml dilute HCL and 5 ml potassium thiocyanate was added in both samples. 1 ml standard iron solution was added in distilled water and the change in color was compared with the sample. A modified Winkler method is used for measuring dissolved oxygen. Manganous ions read with oxygen in the presence of potassium hydroxide precipitate (Step-1). An azide is present to prevent any nitrite ions from interfering with the test. On addition of acid, manganese oxide hydroxide oxidizes the iodide to iodine (step-2). Since the amount of iodine generated is equivalent to the oxygen in the sample, the concentration of iodine is calculated by titration of thiosulphate ions that reduce the iodine back to iodide ions. All the tested parameters have been compared with the permissible limit set by guidelines of Bangladesh water standard 1997 (Table 2) and evaluated whether the water is suitable for drinking, irrigation and industrial purposes or not.

Table 2. Permissible limit for different water quality parameters (BADC, 2007)

Parameter	Permissible limit	
	Bangladesh standard (1997)	
	Drinking Limit	Irrigation Limit
pH	6.5-8.5	6.5-8.5
Turbidity (NTU)	10	-
Temperature (^oC)	20-30	20-30
Total Alkalinity (mg l^{-1})	100	-
TDS (mg l^{-1})	1000	2100
Total Hardness (mg l^{-1})	200-500	-
Fe (mg l^{-1})	0.3-1.0	1.0-2.0
PO_4 (mg l^{-1})	6	10
NO_3 (mg l^{-1}	10	-
CO_2 (mg l^{-1})	-	-
DO (mg l^{-1})	6	5 or more

Analysis of water quality parameter

Using the compiled data the spatial variations of chemical parameters were analyzed. Interpretive analyses for different users such as irrigation and domestic users were made in different locations. Statistical analysis was done in order to calculate correlation coefficients. Correlation matrix was constructed by calculating the coefficients of different pairs of parameters.

Results and Discussion

Evaluation of groundwater quality

pH: pH indicates whether the water is acidic or alkaline and measures the hydrogen ion concentration in water. It ranges from 0 to 14 with a value of 7, indicating neutral water, value between 0-7 indicates acidic and value between 7 and 14 indicates increasingly alkaline waters (Gorde and Jadhav, 2013). Carbon Di oxide in groundwater generally occurs at a much higher partial pressure than in the earth's atmosphere. When groundwater was exposed to the atmosphere, CO_2 will escape and the pH will rise. The highest pH value was found at DTW, South Surma (8.2) and the lowest in municipal water supply (6.51). All the samples from selected groundwater sites were found to be acidic except for DTW, South Surma (8.2) and DTW, Golapgonj (7.3) (Table 3). The value of pH was found to be within the permissible limit by Bangladesh standard (6.5-8.5) (Table 2) at all locations.

Table 3. Parameters of groundwater in different location

Parameter	Location						
	BADC pump	DTW, South Surma	DTW Golapganj, Sylhet	Supply Water	Chowkideki STW	Chowekiki STW	SAU hall
Depth (ft)	650	620	630	-	100	80	500
Turbidity (NTU)	-	-	-	-	0.04	0.41	5.85
pH	6.3	8.2	7.3	6.51	6.56	6.68	6.70
Temperature (^oC)	24	22	-	25	27	26	27.5
Total Alkalinty (mg l^{-1})	124	38	432	35	54	85	82
TDS (mg l^{-1})	175.7	59.0	348.60	-	-	-	-
Total Hardness (mg l^{-1})	25	25	328	-	-	-	-
Fe (mg l^{-1})	0.4	2	2.01	0.1	0.5	0.3	0.5
PO_4 (mg l^{-1})	2	-	0.30	-	-	-	-
NO_3 (mg l^{-1})	0.2	-	-	-	-	-	-
CO_2 (mg l^{-1})	-	-	-	29	23	44	5
DO (mg l^{-1})	-	-	-	3.5	5.5	-	5.1

Temperature: Temperature is a very important water quality parameter because it has effect on the chemical reactions and reaction rates, aquatic life and the suitability of the water for beneficial uses (BADC, 2007). Oxygen is less soluble in warm water than cold water. Sudden change in temperature can result in a high rate of mortality of aquatic life. Moreover abnormally high temperature can foster the growth of undesirable water plants and waste water fungus. The temperature of water for drinking and irrigation is 20-30ºC. The highest temperature value was found at SAU hall (27.5^{o}C) and the lowest at DTW, South Surma (22^{o}C) (Table 3). The value of temperature at all the locations was found to be within the permissible limit by Bangladesh standard (for drinking and for irrigation 20-30^{o}C) (Table 2).

Total alkalinity: Alkalinity is the sum of components in the water that have a propensity to raise the pH to the alkaline side of neutrality. It is measured by titration with standardized acid to a pH value of 4.5 and is expressed commonly as milligrams per liter as calcium carbonate (mg l^{-1}as $CaCO_3$). Commonly occurring materials in water that increase alkalinity are carbonate, phosphates and hydroxides (Gorde and Jadhav, 2013). Limestone bedrock and thick deposits of glacial till are good sources of carbonate buffering. The highest total alkalinity value of groundwater was found at DTW, Golapgonj (432 mg l^{-1}) and the lowest at municipal water supply (35 mg l^{-1}) (Table 3). The value of total alkalinity at all the locations was found to be within the permissible limit by Bangladesh standard (100 mg l^{-1}) (Table 2) except DTW, Golapgonj (432 mg l^{-1}).

Total hardness: The degree of hardness of drinking water has been classified in terms of the equivalent $CaCO_3$ concentration as follows: Soft 0-60 mg l^{-1}, Medium 60-120 mg l^{-1}, Hard 120-180 mg l^{-1}, Very hard >180 mg l^{-1} (BADC, 2007). The highest total hardness value was found at DTW, Golapganj (328 mg l^{-1}) and the lowest at BADC pump, Sylhet sadar (25 mg l^{-1}) (Table 3). The value of total hardness at all the locations was found to be within the permissible limit by Bangladesh standard (200-500 mg l^{-1}) (Table 2).

Total dissolved solid (TDS): Total dissolved solids refers to the sum of all the minerals and chlorides, sulfates etc. were found dissolved in water. TDS also comprises small amount of some organic matter (BADC, 2007). The common dissolved minerals salts affect the taste, hardness, corrosion and encrustation. TDS may exert adverse effect on aquatic animal and plant and may cause irrigation problem. The highest TDS value was found at DTW, Golapgonj (348.6 mg l^{-1}) and the lowest at DTW, South Surma (59.0 mg l^{-1}) (Table 3). The value of TDS at all the locations was found to be within the permissible limit by Bangladesh standard (for drinking 1000 mg l^{-1} and for irrigation 2100 mg l^{-1}) (Table 2).

Iron: Iron is available in water in soluble state but reacting with oxygen forms iron-oxide. Iron as well as manganese, creates serious problems in public water supply. Iron in water is the most significant problem in Sylhet region. The highest value of Iron was found at DTW (630 ft), Golapgonj (2.01 mg l^{-1}), lowest in Municipal Water Supply (0.1 mg l^{-1}) (Table 3). The value of iron was found beyond the permissible limit in some locations by Bangladesh Standard (for drinking 0.3-1.0 mg $l^{-1}$and for irrigation 1-2 mg l^{-1}) (Table 2).

Dissolved Oxygen (DO): Dissolved Oxygenis an important water quality parameter as it's indicates the physical, chemical and biological activities of the water body. Diffusion of oxygen from the air is the main source of DO. In groundwater it is important in terms of corrosiveness in tubewell. Among all parameters of groundwater dissolved oxygen fluctuates very rapidly. The highest value of DO was found at Chowkideki (5.5 mg l^{-1}) and lowest at Tilagor (3.5 mg l^{-1}) respectively (Table 3). In all selected locations the value of DO was within the permissible limit (5 mg l^{-1}) (Table 2). So, there is no possibility of corrosion of tube wells by the presence of DO.

Turbidity: Turbidity is an expression of optical property wherein light is scattered by different suspended and colloidal matter such as clay, silt, and finely divided organic and inorganic matter. Higher intensity of scattered light results in higher values of Turbidity. The highest value of turbidity was found at SAU hall (5.85 mg l^{-1}) and lowest at Chowkideki (0.04 mg l^{-1}) (Table 3). Turbidity in all selected locations was found within the acceptable limit by Bangladesh standard (10 mg l^{-1}) (Table 2) for drinking and irrigation purposes.

Phosphate: Phosphate determination is extremely important in assessing the potential biological productivity of surface water. Phosphate determination is getting importance in environmental engineering practices as it affects various phenomenons such as control of corrosion and scale information (Cristina *et al.*, 2012). In Sylhet region the water contains low concentration of phosphate. The highest phosphate value was found at BADC pump (2 mg l^{-1}) and lowest at DTW, Golapganj (0.30 mg l^{-1}) (Table 3). The value of phosphate at all the location is found within the permissible limit by Bangladesh standard (for drinking 6 mg $l^{-1}$and for irrigation 10 mg l^{-1}) (Table 2).

Nitrate: Nitrate is present in raw water and mainly it is a form of N_2 compound (of its oxidizing state). Nitrate is produced from chemical and fertilizer factories, matters of animals decline vegetables, domestic and industrial discharge (Cristina *et al.*, 2012). At BADC pump Nitrate is found (0.2 mg l^{-1}) (Table 3). The permissible limit of nitrate is 10 mg l^{-1} by Bangladesh standard (Table 2).

Interrelationship among different water quality parameters

The Simple linear correlation matrix among different water quality parameters are presented in Table 4. For groundwater, it was found that turbidity was positively correlated with pH, temperature (°C), total alkalinity (mg l^{-1}), Fe (mg l^{-1}), CO_2 (mg l^{-1}), DO (mg l^{-1}), having the highest correlation (r = 0.998). pH also had shown positive correlation with other parameter at all locations. The Water temperature showed significant and positive correlation with TDS, turbidity, total alkalinity (mg l^{-1}), Fe (mg l^{-1}), CO_2 (mg l^{-1}) and DO (mg l^{-1}).

Table 4. Correlation matrix for groundwater quality analysis

SL No	Turbidity	pH	Temperature	Total Alkalinity	Fe	CO_2	DO
Turbidity	1						
pH	0.968198	1					
Temperature	0.948945	0.98852	1				
Total Alkalinty	0.90728	0.969849	0.972437	1			
Fe	0.934622	0.986633	0.991211	0.994577	1		
CO_2	0.971023	0.985504	0.980018	0.979571	0.987414	1	
DO	0.964801	0.996486	0.99725	0.972512	0.990953	0.986957	1

The different water quality parameters were analyzed and evaluated in terms of water quality standards both domestic and irrigation purpose. Among the physicochemical and biological parameters considered for the study, most of them were within the limit by Bangladesh standards (1997), *viz*. pH, total dissolved solid, temperature, total hardness, phosphate, nitrate, carbon di-oxide and dissolved oxygen. However, in some locations, rests of the indicators like total alkalinity (Golapganj DTW and BADC pump), iron (Golapgonj, DTW) were found to be above the permissible limit. In particular only major indicator deemed to be a significant problem in Sylhet region is the high concentration of iron in STW and DTWs. It is well recognized that Sylhet region have complex diverse geomorphology and soil of this region is acidic. The problem of iron is most critical for groundwater that exists in soils and minerals as insoluble ferric oxide and iron sulfide. Iron containing water when exposed to air and mix with oxygen, water become turbid and highly unacceptable from the aesthetic viewpoint. CO_2 may be picked up by rainfall as it passes through the atmosphere to the land surface, but a much larger amount is dissolved by water flowing over or through soil where plants are growing. Groundwater that rich with CO_2 have the ability to dissolved limestone and or dolomite that increase hardness of water. pH in groundwater also controlled by amount of dissolved CO_2. The water quality parameters are highly correlated among each other. Before constructing a well for human need in this region it is suggested that the geologic stratification must be investigated.

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