IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 24, Issue 8, Ser. 4 (August. 2019) 35-42
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Application of Geographical Information System for Assessment of Water Quality: A Study of Lumbajong Block, KarbiAnglong, Assam

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Abstract:*Water is the most important needs for the survival of life on the planet. In India groundwater forms the major source of drinking water. In the rural areas the groundwater is the most important resource because of the non-availability of treated water.*
According to World Health Organisation (WHO) report about 80% of all diseases in human beings are caused by water. Therefore, the quality of water should be checked at regular interval, because contaminated water can cause various water borne diseases. The present study is carried out to examine water quality of groundwater in Lumbajong Block of KarbiAnglong district, Assam. For the purpose 45 water samples is collected from different location to analyse the physical and chemical properties of water. The physical parameters include appearances, pH, sediment and turbidity. The chemical parameter of water include Iron, Alkalinity, Fluoride, Chloride, Nitrate, and Total Hardness. The Water Quality Index (WQI) has been calculated for overall water quality quantification from the perspective of human consumption. A spatial mapping of groundwater quality has been done using Geographical Information System (GIS) softwareArcMap 10.3. The result obtained from the spatial mapping help us to identify the areas which needed water treatment for consumption.

Keywords:*Groundwater, Physical parameters, Chemical parameters, Water Quality Index, Geographical Information System (GIS).*

Date of Submission: 03-08-2019 Date of Acceptance: 19-08-2019

I. INTRODUCTION

Water is one of the important needs for the survival of life on this planet. In our country ground water forms the major source for drinking water. It consists of about 88% safe drinking water in rural areas, where the population is widely dispersed and the infrastructure needed for treatment and transportation of surface water does not exist. Ground water also plays an important role in agriculture, for both watering of crops and for irrigation of dry season crops. It is estimated that about 45% of irrigation water requirement is met from ground water sources (Jain et. al, 2010). In urban areas, 30 % of people's water need is met by ground water (Rakesh et. al, 2005).

Save drinking water is essential for human beings as well as to other organisms, although it does not contain any calories or organic nutrients. It is estimated that by 2025 over half of the world's population will be vulnerable to water shortages (Kulshreshtha, 1998). Groundwater is becoming scarce as the human population continues to grow and increase demand for domestic purposes and economic activities. Precipitation has become unpredictable due to climate change (Raisanen et al, 2004). Water quality is important for human health as well for all the living organism. The water quality has an effect on soils, crops and the environment (Hoek et al, 2001).

Measurement of Groundwater Quality using Geographical Information System (GIS)

The quality of groundwater is playing an important role in the uses of water for drinking purposes. The assessment of the physical and chemical parameters is significant to assess the quality of water (Fatombi et. al, 2012). The result of the physical and chemical parameters of water helps us to understand the quality of the groundwater of an area (Ranjan et. al, 2013). Geographic Information System (GIS) mapping technique is the best representative tool in the assessment of groundwater quality for its utilisation for irrigation, drinking and other purposes (Ravikumar et. al, 2013). The data that were acquired from both the primary and the secondary sources can be interpreted in computer based using specific GIS software for better interpretation of the results (Thiyagarajan&Baskaran, 2013).

Study area

The study area Lumbajong is one of the eleven blocks located in KarbiAnglong district of Assam**.** The study area has a very large population, compared to the other block of the district. The physiography of this block is characterised by high land. In this region, groundwater is the major source of drinking water. The main source of groundwater is mainly dependent from the ring well. The source of drinking water also is confined in some places only. For this reason, to identify the quality of the water is very much important.

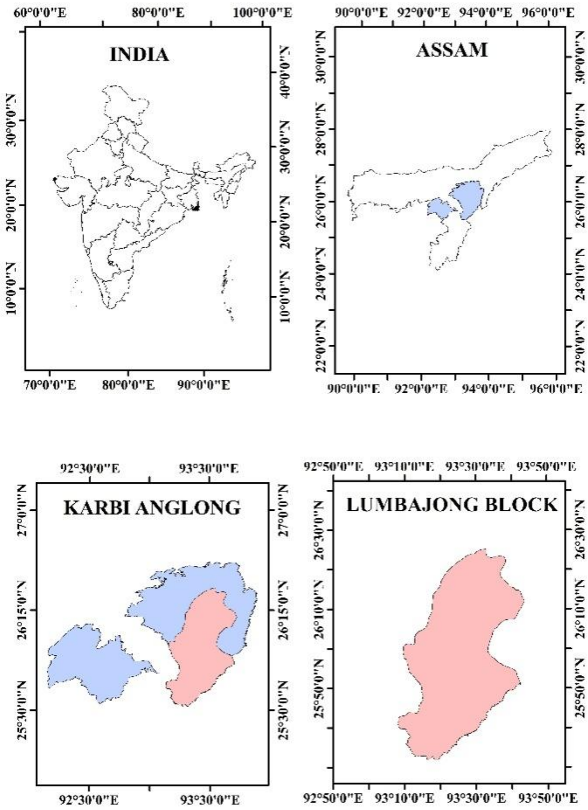

Fig.1. Location map of the study area

Methodology

A total of Forty-five ground water samples were collected from ring well, fallow well and bore well. The samples were analysed in the head office of Public Health Engineering Department (PHE) located at Diphu for testing the various physical and chemical parameters. The physical characteristics include Turbidity and pH. The chemical characteristics include Total dissolves Solids (TDS), Iron, Nitrate, Manganese, Fluoride, Chloride, Total hardness. The samplings were carried according to standard method prescribed by APHA (1998). Based on the results found from Water Quality Index (WQI), the hygienic condition of the ground water of the study area has been assessed.

Groundwater Quality Index

Water quality index (WQI) is a very useful tool for communicating the information on the overall quality of water (Abassi 1999; Pradhan et al. 2001; Adak et al. 2001).WQI is use to determine the suitability of the groundwaterfor drinking purposes (Tiwari and Mishra 1985; Singh 1992; SubbaRao 1997; Mishra and Patel 2001; NaikandPurohit 2001; Avvannavar and Shrihari 2008; Sahu and Sikdar 2008). The standards of water for drinking purposes as recommended by BIS(2009) have been considered for the calculation of WQI. In this study ten physiochemical parameters of water were used to compute the water quality index for the Lumbajong block of KarbiAnglong District, Assam state. The water quality index has been prepared to get the real picture of water quality in the district.

The WQI help us to summarize large amount of water quality data into simple terms, i.e., excellent, good, bad, etc., which are easily understandable and help Public Health Engineering Department (PHE) to identify water zonation.Mappingof the results of the index, the areas of high and low water quality can be easily specified. The water quality index for the purposes of this study was calculated following three steps. For the first step, a weight (wi) was assigned to each of the eleven parameters according to its relative importance in the overall quality of water for drinking (Ramakrishnaiah et al. 2009). The maximum weight 5 was assigned to nitrate due to its importance on public human health. Magnesium as low harmful has given weight 2. For the second step, the relative weight (Wi) was computed by

$$Wi = wi \ / \sum_{i=1}^{n} wi$$

where: (Wi) is the relative weight, (wi) is the weight for each parameter and (n) is the number of parameters. For the third step, a quality rating scale (qi) for each parameter was assigned by dividing its concentration in each water sample by its respective standard (BIS standard) and the result was multiplied by 100 to express it in percentage.

$$qi= (Ci/Si)x100$$

where: (qi) is the quality rating, (ci) is the concentration of each pollutant in water sample in mg\L, (Si) WHO standard concentration. For computing the WQI, the Si was determined for each chemical parameter. The sub index of ith quality parameter can be determined by:

$$SIi=Wi.qi$$

$$WQI=\Sigma SI_i$$

Where,
SIi =I is sub index of ith parameter.
qi = is the rating based on concentration of *i*th parameter.
n = is the number of parameters.

Table-1: Assigning of weight and relative weight for the chemical parameters

Chemical Parameters	Indian Standards (BIS 2009)	Weight	Relative Weight (Wi)
pH	6.5	4	0.097560976
Turbidity (NTU)	5	5	0.12195122
Iron	0.3	5	0.12195122
Flouride	1.5	5	0.12195122
Chloride	250	5	0.12195122
Hardness	200	2	0.024390244
Alkalinity	200	1	0.024390244
Manganese	0.1	4	0.097560976
Nitrate	45	5	0.12195122
Total Dissolved Solids	500	5	0.12195122
		Σw_i=41	ΣW_i= **0.975609756**

II. RESULTS AND DISCUSSIONS

Assessment of Physical Properties of water samples

The physical parameters of groundwater of Lumbajong block of KarbiAnglong District, Assam have been examined to know the physical parameters characteristics of water in the study area.

Turbidity:

Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when a light is shined through the water sample. It is measured by shining a light through the water and is reported in Nephelometric Turbidity units (NTU). Consumer acceptance for water decreases if a limit is above 5 NTU (BIS 2009). In the study area the concentration of turbidity is found to be concentrated in similar in all the area. The slight variation is found in the eastern part. It is found that the concentration of turbidity in the study area is found to be 5 NTU which is the acceptable limit prescribed by BIS.

pH

pH is an important parameter, which determines the suitability of water for various purposes. In the study area the concentration of pH varies from 6 to 7.29 mg/l. The result shows that the most of the area is acidic character.

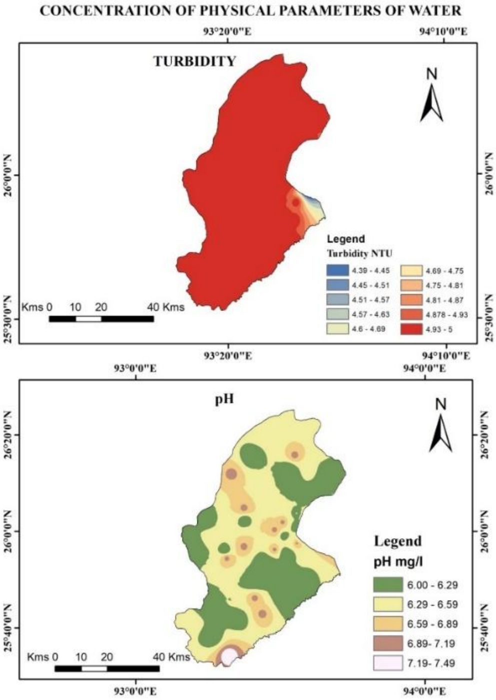

Fig. 2. Spatial distribution map of physical parameters of water

Assessment of Chemical Properties of water samples

The chemical parameters of groundwater of Lumbajong block of KarbiAnglong District, Assam have been examined to know the chemical parameters characteristics of water in the study area

Alkalinity

Alkalinity in water neutralizes the presence of acid in water. However the limit exceeding the desirable 200mg/l the water tastes becomes unpleasant (BIS 2009). In the study area the concentration of alkalinity ranges from 30.03 to 169.85 mg/l. The higher concentration of Alkalinity is found in the north-western and western side in small batches. The higher limit found concentrated in the study area is below the desirable limit.

Total Hardness

The concentration of water hardness has no known adverse effects, however, some evidence indicates its role in heart diseases (Schroeder 1960). In the study area the concentration of Hardness varies from 12.79 to 179.95. As a whole in the study area the concentration of within the desirable limit. In most part the concentration range is from 113.61-146.78 mg/l. The hardness of water is due to the presence of calcium carbonate and can be removed by boiling water.

Chloride

The BIS has issued a desirable limit of 250 mg/l in India. The concentration of Chloride beyond the desirable limit has a corrosion and palatability are also affected (BIS 2009). In the study area the concentration of Chloride varies from 40 mg/l to 139 mg/l. It is found that most part of the study area in the southern and the southern area has Chloride concentration of 99 mg/l to 199 mg/l. The highest concentration Chloride within the study area with 119 mg/l to 169 mg/l is found in small patches in the western part and in the southern most part.

Total Dissolved Solids

The concentration of Total Dissolved Solids in the study area is found to be concentrated within the desirable limits. In the study area the range of concentration range is from 12.79-199.99 mg/l. The major part of area in the northern and southern part of the study area is within the range from 162.55 to 199.99 mg/l. The other majority of the portion in the central and eastern part is in the range of 125.11 to 162.55 mg/l.

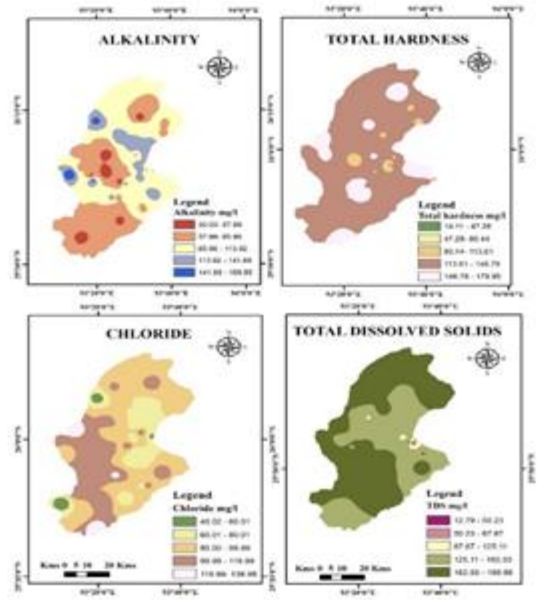

Fig. 3. Spatial distribution map of Chemical parameters of water

Nitrate

Nitrate in groundwater generally originates from sewage effluents, septic tanks and natural drains carrying municipal wastes. The BIS prescribed the desirable limit of 45mg/l and the limit beyond this limit causes mathamoglobina and indicative of pollution. In the study area it is found that the concentration of nitrate is found to be below the desirable limit. The northern part of the study area has a lesser concentration of nitrate in compared to the rest of the area. The concentration here is found here is 0.57 mg/l. In the central and the southern part the concentration is found to be 4.41 mg/l.

Manganese

Manganese is the essential element for many organism, including human, but it has adverse health effects can be caused by the inadequate intake or overexpose. Concentration below 0.1 mg/l is the desirable (BIS 2009). In the study area the concentration of Manganese is found to be concentrated 0.55 to 2.29 mg/l. Some batches of small areas located in the northern side and the concentration of manganese is very high range from 1.66 to 2.29. These areas has crossed the permissible limit of 0.30 mg/l prescribed by BIS 2009.

Iron

Iron is an essential element in the maintenance of human nutrition. Generally, the concentration of Iron in water is usually not noticeable when the concentration is below 0.30 mg/l (BIS 2009). In the study are the concentration of Iron is found to high in the northern side is from 0.41 to 0.89 mg/l. The higher concentration of iron results to sanitary ware to stain. The orange colour characteristics of water when exposed to open air is the effects of higher concentration of water.

Fluoride

Fluoride at low concentrations has beneficial effects on teeth by preventing and reducing the risk of tooth decay also results to stronger bones (Edmunds &Smedley , 2005). Whereas fluoride levels above 1.5 mg/l in drinking water can cause fluorosis (BIS, 2009). In the study area the concentration of fluoride range is from 0.06 to 16.99 mg/l. The spatial distribution map shows that the maximum concentration of fluoride is found in batches located in the north-eastern, south-eastern, southern and in the western part.

III. DETERMINATION OF WATER QUALITY INDEX

Water Quality Index calculated for Lumbajong block using the Equation No. 1, 2, 3 and 4. The Water Quality Index of Lumbajong district (Table 1) reveals that 33.33% of the samples indicated “excellent water,” 33.33 indicated “good water,” 22.22 “poor water,” and 11.11% indicated “very poor water,” the classification according to the given by Sahu and Sikdar (2008) (Table 2). The very poor water quality of water is concentrated in some pocket of the study area.

Table- 2: Showing the water sample site and Water Quality Index classification

Sample No	WQI	Classification
1	80.37940379	Good water
2	61.01626016	Good water
3	225.9783198	Very poor water
4	158.8373984	Poor water
5	47.00542005	Excellent
6	76.05691057	Good water
7	38.69918699	Excellent
8	209.0243902	Very poor water
9	82	Good water
10	48.65853659	Excellent
11	225.0785908	Very poor water
12	125.5474255	Poor water
13	97.23577236	Good water
14	77.01084011	Good water
15	71.40921409	Good water
16	95.81300813	Good water
17	71.8902439	Good water
18	59.26558266	Good water
19	74.29539295	Good water
20	137.6097561	Poor water
21	243.0650407	Very poor water
22	136.7886179	Poor water
23	40.83468835	Excellent
24	71.57181572	Good water
25	58.29268293	Good water
26	88.67208672	Good water
27	43.63414634	Excellent
28	137.6612466	Poor water
29	160.3685637	Poor water
30	226.197832	Very poor water
31	48.9295393	Excellent
32	135.9349593	Poor water
33	40.90785908	Excellent
34	42.42547425	Excellent
35	44.70189702	Excellent
36	164.0650407	Poor water
37	62.43089431	Good water
38	31.34146341	Excellent
39	154.0108401	Poor water
40	40.13550136	Excellent
41	30.6504065	Excellent
42	32.35772358	Excellent
43	170.3387534	Poor water
44	36.85636856	Excellent
45	37.66937669	Excellent

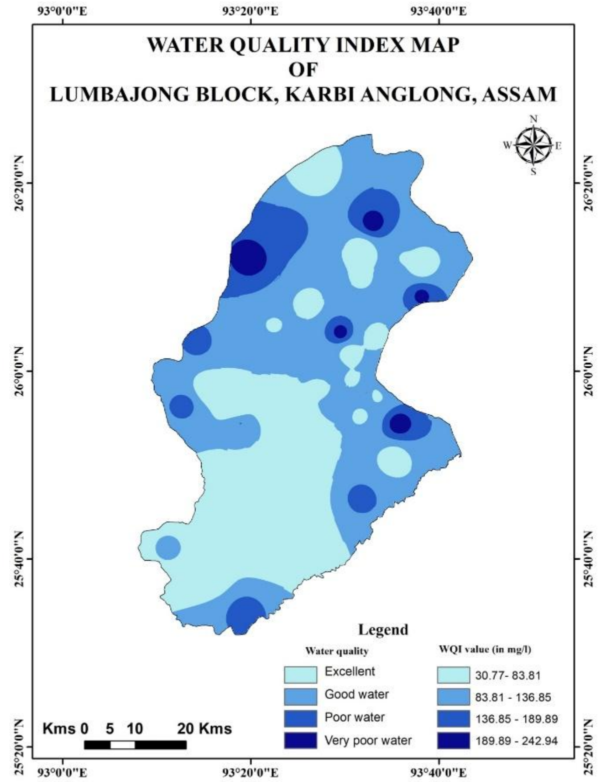

Fig. 4. Spatial distribution of Water Quality in the study area

The study of the relationship among all the parameters have been done to know the correlation whether there is negative or positive relation between one parameters of water with the other parameter. The strongest correlation if found between Alkalinity and the Manganese, with 0.41. The correlation table shows that strong correlation is found to exist between Fluoride and Total Hardness

Table 3: Correlation matrix between the physiochemical parameters of water

	pH	Iron	Fluoride	Chloride	Total Hardness	Alkalinity	Manganese	Nitrate	Total dis solved solids
pH	1								
Iron	-0.01	1							
Fluoride	-0.01	-0.11	1						
Chloride	0.02	-0.06	0.40	1					
Total Hardness	0.02	-0.19	0.07	0.24	1				
Alkalinity	-0.06	0.03	-0.18	-0.20	0.19	1			
Manganese	0.19	-0.08	-0.21	-0.22	0.13	0.41	1		
Nitrate	-0.05	-0.19	0.07	-0.03	-0.08	-0.35	-0.19	1	
Total Dissolved solids	-0.19	0.11	0.08	0.18	-0.07	0.06	0.09	0.02	1

IV. CONCLUSION

The application of GIS and remote sensing is very useful technique to study the Water Quality Index. Conventional method is very time consuming and involve huge resources to execute the same work. Remote sensing and GIS has help to generate thematic layer for assessing the water quality index of Lumbajong Block. Based on the result of the quality index the water quality has been divided into five region. Percentage of water samples has been computed depending upon the total number of water samples and from the calculation, it has been observed that 33.33 % of samples are falling under excellent and good category while 22% and 11% of samples are falling under poor and very poor water category of quality respectively.

The overall results of the study area suggest that the groundwater of some areas require treatment before consumption.

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Mindar Rongphar."Application of Geographical Information Systemfor Assessment of Water Quality: A Study of Lumbajong Block, KarbiAnglong, Assam." IOSR Journal of Humanities and Social Science (IOSR-JHSS). vol. 24 no. 08, 2019, pp. 35-42.