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APPLICATION OF GEO-SPATIAL TECHNOLOGY FOR GROUND WATER QUALITY MAPPING OF MAMIT DISTRICT, MIZORAM, INDIA

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KEYWORDS: GIS; Ground water; Water quality; Mamit district

ABSTRACT

One of the most important natural resources which is extremely crucial for our daily life is water. Surface water and ground water are the two types of sources from which we obtain this essential resource. Inconsistent and unequal availability of surface water leads to exploration of ground water for irrigation, industrial and domestic purposes. Therefore, the quality of ground water is equally important as its quantity. The present study utilizes geo-spatial technology to map the spatial variability of ground water quality. Ground water samples were collected from 83 point sources randomly distributed in Mamit district, Mizoram. The major water quality parameters such namely pH, Electrical Conductivity (EC), Total Dissolved Solids, Total hardness, Iron, Chloride, Nitrate and Fluoride have been estimated for all the sampling locations. The spatial variation maps of these ground water quality parameters were generated and utilize as thematic layers. These thematic layers were given ranks based on their relative importance. Different classes within each thematic layer were assigned weightages in numerical rating from 1 to 3 as attribute values in GIS environment. Summation of these attributes values and the corresponding rank values of the thematic layers were utilize to generate the final ground water quality map. This final map shows the different classes of ground water quality within the district which can be utilize to give a guideline for the suitability of ground water uses.

INTRODUCTION

Rapid urbanization, growth of population and extensive uses in domestic and agricultural sectors increase the demand for good quality of water supply [(1), (2), (3)]. Ground water is one of the most important natural resources and the major accessible source of fresh water [(4), (5), (6), (7), (8)]. Therefore, finding the potential areas, monitoring and conserving ground water have become highly crucial at the present moment [(9), (10)].

The geology of Mizoram comprises N-S trending ridges with high degree of slopes and narrow intervening synclinal valleys. Faulting in many locations has produced steep fault scarps (11). Therefore, majority of the rain water is lost as surface runoff even though the state received high amount of rainfall. Springs are the major sources of water in the area. Hence, the quality of water from such sources needs to be carefully analyzed and represented in a GIS environment (12).

Few efforts were made in studying the water quality within the state of Mizoram. These include Assessment of the water quality of Tlawng river in Aizawl, Mizoram [(13), Sulphate, phosphate-P and nitrate-N contents of Tlawng river, near Aizawl City, India (14), Seasonal variation in water quality of Tuirial River in vicinity of the hydel project in Mizoram, India (15), Physico-chemical characteristics of Tamdil in Mizoram, northeast India (16).

The arrival of geospatial technology allows fast and cost effective survey and management for natural resources (17). Geographical Information System (GIS), Global Positioning System (GPS) and remote sensing are the main tools in this recently introduced technology. Hence, this technique has wide-range applications in geo-scientific researches including ground water quality mapping [(18), (19)].

Therefore, many researchers have utilized these techniques successfully in ground water studies, both for prospecting and quality mapping [(20), (21), (22), (23), (24), (25)]. The same techniques have been proved to be of immense value not only in the field of hydrogeology but also for the development of surface water resources as well [(4), (26)].

STUDY AREA

2.1 Location and Extent: Mamit district is located in the north-west part of Mizoram, in north-east India. With a total area of 3025.00 sq km., the district is located between 92º 15′ 53" to 92º 40′ 43" E longitudes and 23º 15′ 10" to 24º 15′ 00" N latitudes. It falls under Survey of India topo sheet No. 83D/8, 83D/12, 84A/5, 84A/6, 84A/7, 84A/9, 84A/10 and 84A/11 . Location map of the study area is shown in Figure 1.

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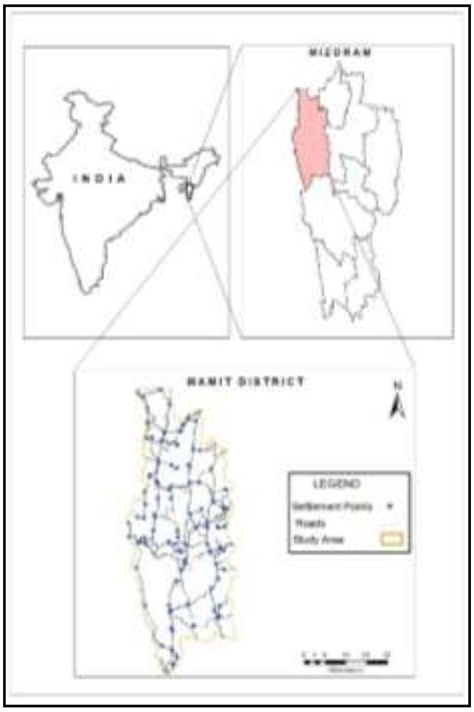

Figure 1: Location of study area

2.2 Climatic Condition: The climate of the study area ranges from moist tropical to moist sub-tropical. The entire district is under the direct influence of south west monsoon, with average annual rainfall of 2908.40 mm (27).

2.3 Geology: The earliest recorded work on geology of Mizoram reported that the area comprises great flysch facies of rocks made up of monotonous sequences of shale and sandstone (28). The study area lies over rocks of Middle Bhuban, Upper Bhuban and Bokabil formations of Surma Group of Tertiary age. Middle Bhuban and Bokabil formations consist mainly of argillaceous rocks while Upper Bhuban formation compirses mainly of arenaceous rocks (11). It was also observed that the rocks exposed within the study area were traversed by several faults and fractures of varying magnitude and length (29).

2.4 Geomorphology: The study area is characterized mainly by ridgelines and intervening valleys and less prominent ridges. Structural hills are the main geomorphic units which were divided as High, Moderate and Low Structural Hills based on their elevation. As the name implies, Structural Hills are of structural origin, associated with folding, faulting and other tectonic processes. Other geomorphic units like Valley Fill and Flood Plain are characterized by unconsolidated sediments, and were found along streams and major rivers respectively (30).

MATERIALS

3.1 Data Used: Base map of the study area was generated from thematic maps extracted from Natural Resources Atlas of Mizoram prepared by MIRSAC. Satellite data, SOI topographical maps and various ancillary data were also referred in the study. Records of ground water quality prepared by State Referral Institute (SRI), Aizawl were imported and plotted in a GIS environment.

3.2 Software: Prominent GIS softwares like Quantum GIS and ArcInfo 10.1 version were used for analysis and mapping. Hand held GPS device was also utilized in the field for locating sample points and for ground truth verification.

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METHODOLOGY

The base map was geo-referenced and digitized by using QGIS software and exported to ArcInfo 10.1 software for spatial analysis. The water samples were collected from one hundred and eighty eight locations and were tested for their physico-chemical parameters. The characteristics of the water were subsequently evaluated using the Indian Drinking Water Standards as per BIS Guideline. The major parameters namely pH, Electrical Conductivity (EC), Total Dissolved Solids, Total hardness, Iron, Chloride, Nitrate and Fluoride of the samples were analyzed.

Spatial interpolation technique through Inverse Distance Weighted (IDW) approach has been used in the present study for generating spatial distribution of the ground water quality. The spatial variation maps of major ground water quality parameters were prepared as thematic layers following BIS Guideline. This Guideline categorized each ground water parameters as Desirable limit, Permissible limit and Non-potable classes. The different classes within the BIS Guideline were represented in the present study as Good, Moderate and Poor classes respectively. All the spatial variation maps/layers were integrated and the final ground water quality map of Mamit district was then generated.

DATA ANALYSIS

All the thematic layers were assigned different ranks based on their role in controlling the quality of ground water. All the layers were individually divided into appropriate classes and weightage value is assigned for each class based on their influence on the quality of ground water. This process is done in such a manner that less weightage represents better influence whereas and more weightage represent poorer influence towards the ground water quality. The assignment of weightage values for the different categories within a parameter is done in accordance to their assumed or expected importance in inducing different classes of the ground water quality [(18), (24)].

Parameter	Ranking	Range	Weight
pH	15	<6.5	3
		6.5-8.5	1
		>8.5	3
Electrical conductivity (umhos/cm)	15	0-2250	1
		2250-3000	2
Total Dissolved Solids (mg/l)	15	0-500	1
		500-2000	2
Total Hardness (mg/l)	15	0-300	1
		300-600	2
Iron (mg/l)	10	<0.3	1
		0.3-1.0	2
		>1.0	3
Chlorides (mg/l)	10	<250	1
		250-1000	2
Nitrate (mg/l)	10	<45	1
		45-100	2
Fluoride (mg/l)	10	<1.0	1
		1.0-1.5	2

Table No.1: Rankings and weightages of parameters

RESULTS AND DISCUSSION

The spatial and the attribute database generated are integrated for the generation of spatial variation layers of major water quality parameters. Based on these spatial variation layers of major water quality parameters, an integrated ground water quality map of Mamit district was prepared using GIS technique. Results and discussion for the major parameters are as follows:

6.1 pH: pH is one of the important parameters of water which determines the acidic and alkaline nature of water. The pH value of water ranged between 6 and 9. The pH values of the samples were classified into two classes. As per BIS guideline, majority of the area falls within desirable limit (6.5-8.5). Few areas were below 6.5 and above 8.5. Area with desirable limit were categorized as Good class while those areas with pH value less than 6.5 or

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more than 8.5 were categorized as Poor class. The spatial variation map for pH was prepared and presented in Figure 2.

6.2 Electrical Conductivity (EC): The Electrical Conductivity (EC) of water was classified in to three ranges (0-2250 µmhos/cm, 2250-3000 µmhos/cm and >3000 µmhos/cm) by BIS guideline. Those areas which have Electrical Conductivity values between 0-2250 µmhos/cm were categorized as Good class; those which are having the values ranging between 2250-3000 µmhos/cm were categorized as Moderate class while those area having values greater than >3000 µmhos/cm were categorized as Poor class. The spatial variation map for Electrical Conductivity (EC) were prepared and presented in Figure 3.

6.3 Total Dissolved Solids (TDS): The Total Dissolved Solids (TDS) of water is classified in to three ranges (0-500 mg/l, 500-2000 mg/l and >2000 mg/l) by BIS guideline. The present study area has all the categories which are termed as Good class and Moderate class respectively. The spatial variation map for TDS was prepared based on these ranges and presented in Figure 4.

6.4 Total Hardness: The Total hardness is classified in to three ranges (0-300 mg/l, 300-600 mg/l and >600 mg/l) by BIS guideline. The present study area was categorized as Good class and Moderate class. Based on these ranges the spatial variation map for total hardness has been obtained and presented in Figure 5.

6.5 Iron: Iron was classified in to three ranges (<0.3 mg/l, 0.3-1.0 mg/l and >1.0 mg/l) by BIS guideline. Based on these ranges, the study area was divided into Good, Moderate and Poor classes. The spatial variation map for iron is presented in Figure 7.

6.6 Chlorides: Chlorides was classified in to three ranges (0-250 mg/l, 250-1000 mg/l and >1000 mg/l) by BIS guideline. The study area has the first two categories only which are termed Good and Moderate classes. The spatial variation map for chlorides has been presented in Figure 8.

6.7 Nitrate: Nitrate was classified in to three ranges (<45 mg/l, 45-100 mg/l and >100 mg/l) by BIS guideline. The study area was categorized as Good, Moderate and Poor classes based on the guideline. The spatial variation map for Nitrate is presented in Figure 9.

6.8 Fluoride: Fluoride was classified in to three ranges (<1.0 mg/l, 1.0-1.5 mg/l and >1.5 mg/l) by BIS guideline. The study was categorized as Good, Moderate and Poor classes. The spatial variation map for fluoride has been presented in Figure 10.

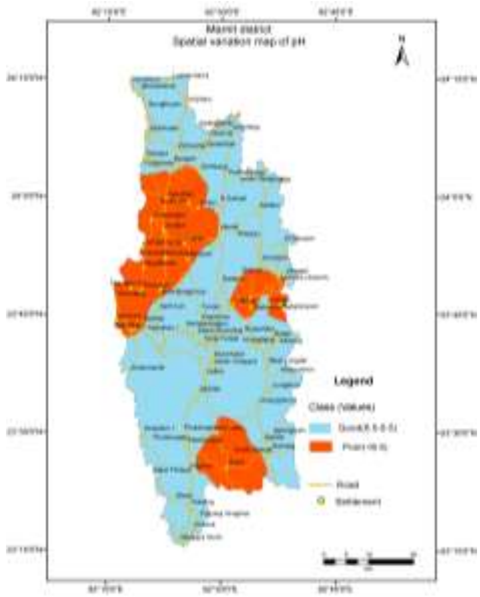

Figure 2: Spatial variation map of pH

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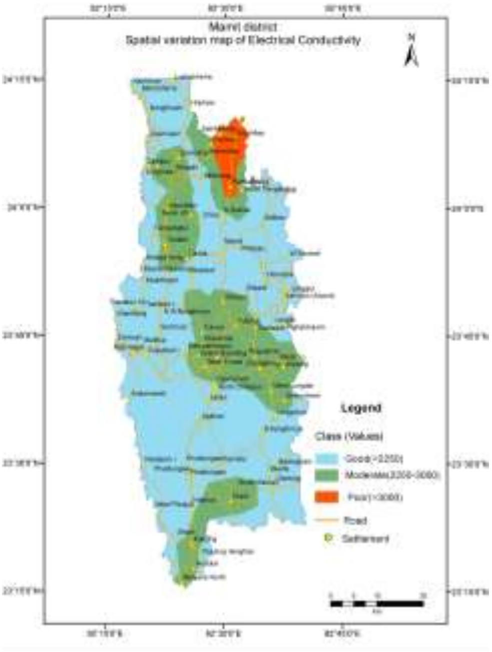

Figure 3: Spatial variation map of EC

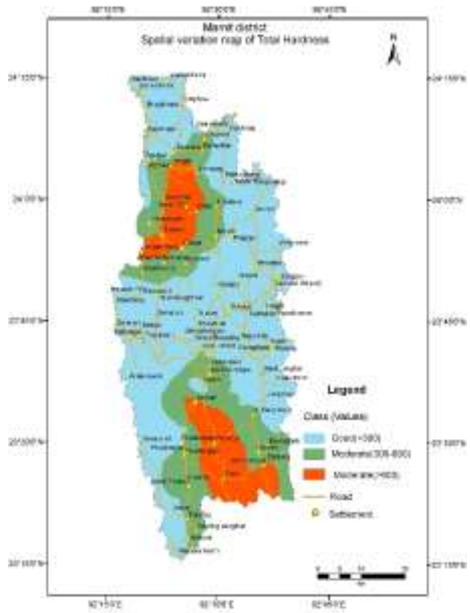

Figure 5: Spatial variation map of Total

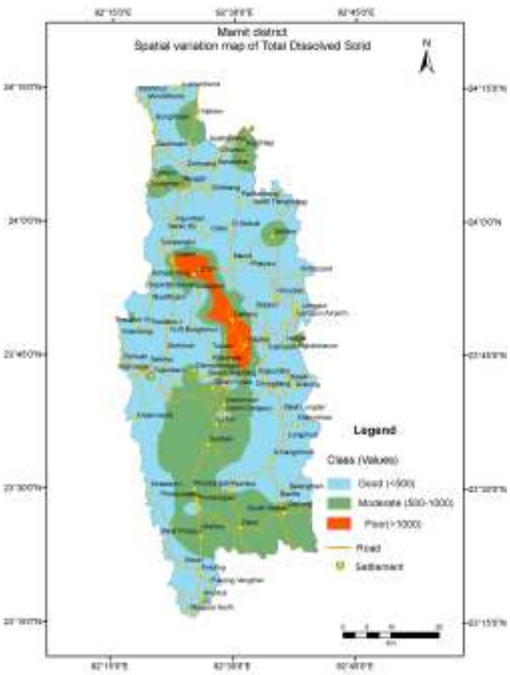

Figure 4: Spatial variation map of TDS

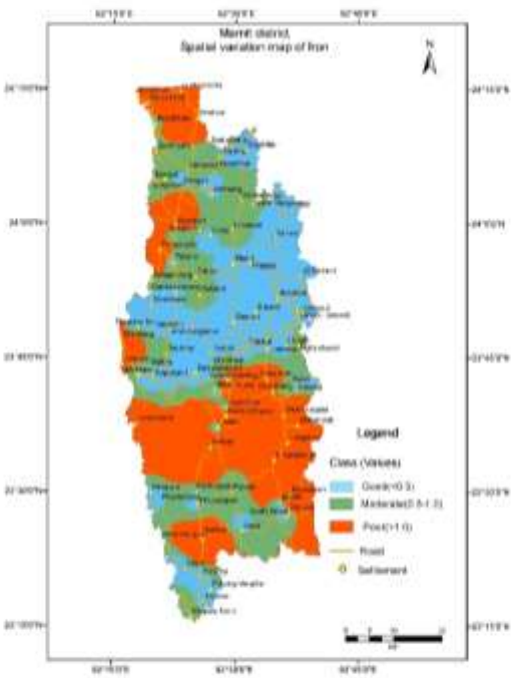

Figure 6: Spatial variation map of Iron

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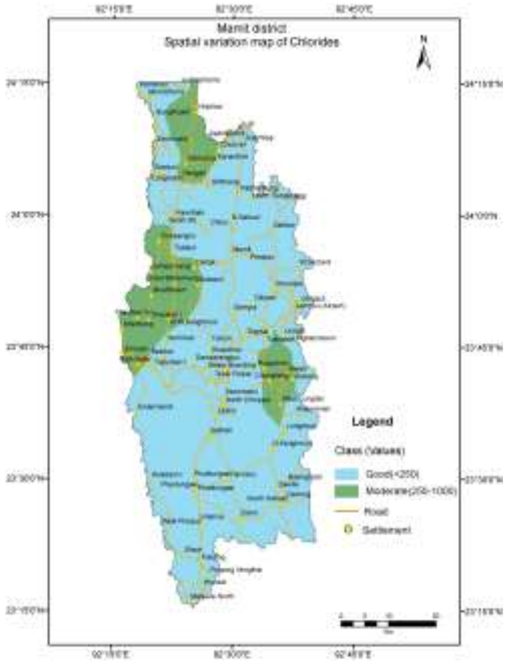

Figure 7: Spatial variation map of Chloride

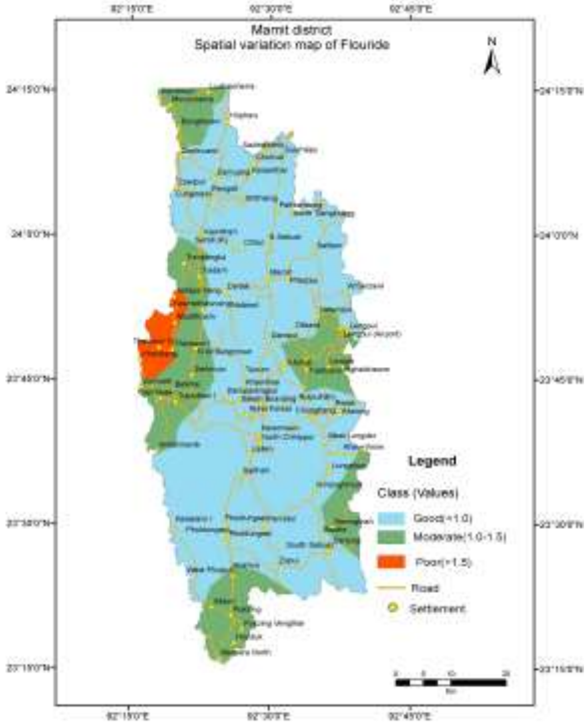

Figure 9: Spatial variation map of Fluoride

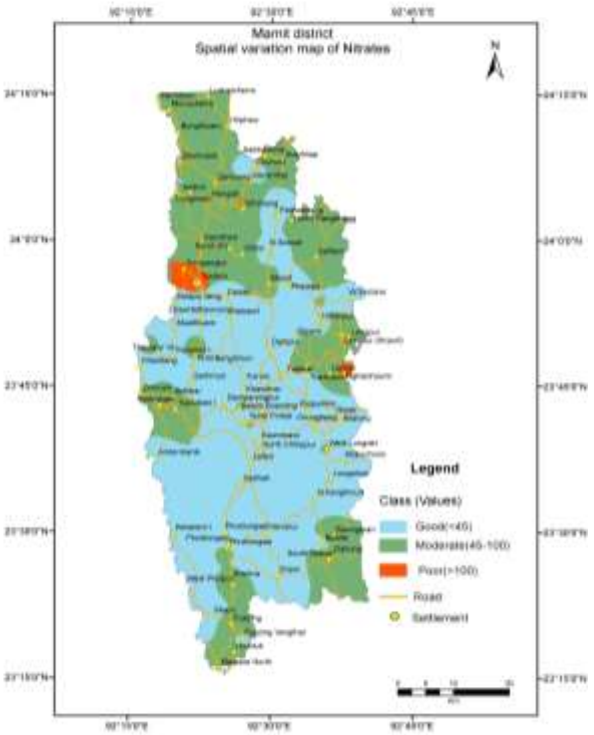

Figure 8: Spatial variation map of Nitrate

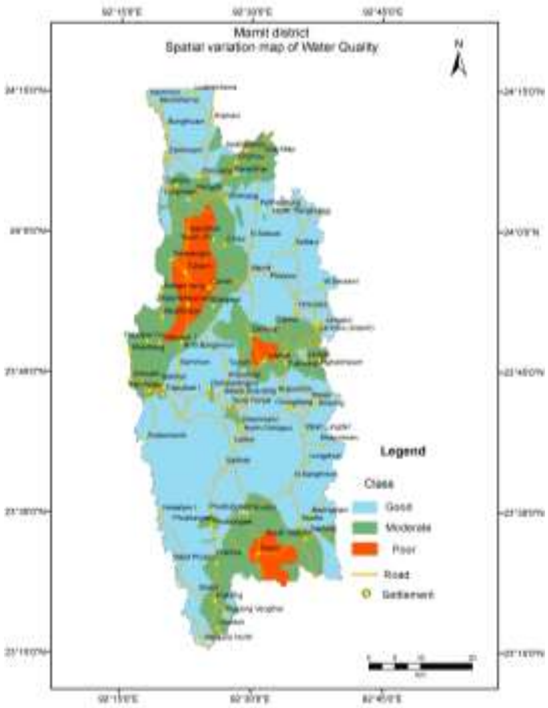

Figure 10: Ground water quality map of Mamit district

The final map shows the broad idea about good, moderate and poor ground water quality zones of the study area. The ground water quality has been classified quantitatively as good (62.27%), moderate (30.35%) and poor (7.37%) depending on the final weight values assigned to polygons in the final layer. From the map, it is evident that the ground water quality in the northern and southern parts of the study area is in the good condition while the Central part of the study area is in the moderate condition.

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CONCLUSION

The Ground water quality map helps us to know the existing ground water condition of the study area. It can be concluded that the quality of ground water need to be monitored and with the growing population and urbanization.

The integrated map shows the broad idea about good, moderate and poor ground water quality zones in the study area. The calculation of ground water quality zones can be used for ground water exploration, development and management programme.

Geo-spatial technology has been proven to be useful tools for mapping ground water quality. The ground water quality map prepared through this study will be useful for planning future ground water developmental programme.

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