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

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Abstract*— Water is one of the most important resources which is very crucial for our daily life. Surface water and ground water are the two types of sources from which we obtain this essential resource. Erratic 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. In the present study, geo-spatial technology has been applied for maping the spatial distribution of ground water quality in in Champhai district of Mizoram, India. Ground water samples were collected from 118 point sources randomly distributed within the study area. The concentration of major water quality parameters such namely pH, Total Dissolved Solids, Alkalinity, Total hardness, Iron, Chloride, Nitrate and Fluoride have been assessed for all the sampling locations. The spatial variation maps of these ground water quality parameters were generated and utilize as thematic layers. Different classes within each thematic layer were assigned weightages in numerical rating from 1 to 3 as attribute values in GIS environment. Summation of the attributes values of the thematic layers were utilizes 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.

***Index Terms*— GIS, Ground water, Water quality, Champhai district.**

I. 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 main source of freshwater for drinking and other household consumption in the Indian Himalayan Mountains including the state of Mizoram [12]. Hence, the quality of water from such sources needs to be carefully analyzed and represented in a GIS environment [13].

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 [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].

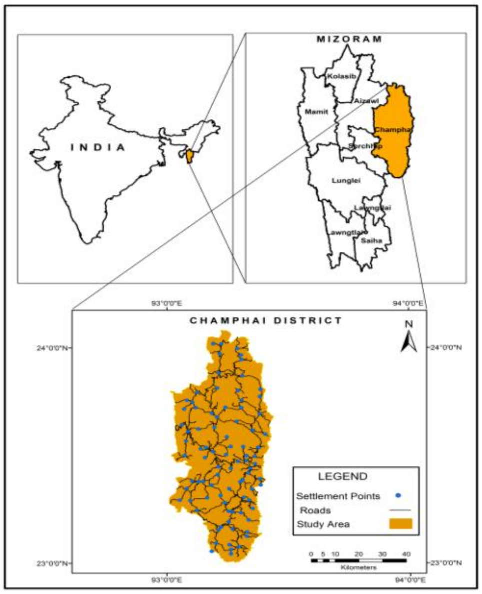
The arrival of geospatial technology allows fast and cost effective survey and management for natural resources [17]. Geographical Information System [GIS], Global Positioning System [GPS] and remote sensing are the main tools in this recently introduced technology. Hence, this technique has wide-range 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]}.

II. STUDY AREA

Location and Extent

Champhai District is situated in the north eastern part of Mizoram, between 24˚ 05' 03.99" and 23˚ 00' 03.25" N latitudes and 93˚ 00' 31.29" and 93˚ 26' 17.66" E longitudes. It is bounded on the east by Myanmar (Burma), on the west by Aizawl and Serchhip Districts, on the north by Manipur state and on the south by Serchhip District and Myanmar. The total geographical area of Champhai District is 3185.00 sq. km. It falls on Survey of India topo sheet nos. 84E/1, 84E/2, 84E/3, 84E/4, 84E/5, 84E/6, 84E/7, 84E/8, 83H/4 and 83H/8. The study area enjoys a moderate climate owing to its tropical location. Location map of study area is shown in figure1.



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].

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 Barail Group and Bhuban formation of Surma Group which belong to Tertiary age. Barail Group consist mainly of argillaceous rocks while Bhuban formation comprises alternating layers of arenaceous and argillaceous 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].

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.

III. Materials

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.

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.

IV. 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, Total Dissolved Solids, Alkalinity, 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. This method is one of the most commonly used techniques for interpolation of scatter points and has been used extensively in ground water quality mapping {[30], [31], [32], [33], [34]}.

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. All the spatial variation maps/layers were integrated and the final ground water quality map of Champhai district was then generated.

V. ANALYSIS

All the thematic 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]}.

VI. 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 Champhai district was prepared using GIS technique. Results and discussion for the major parameters are as follows:

pH

pH is one of the important parameters of water quality which determines the acidic and alkaline nature of water. 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). However, considerable part of the study area is below 6.5. The spatial variation map for pH was prepared and presented in Figure 2.

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 falls within the ranges of 0-500 mg/l and 500-1000mg/l which are desirable class and permissible class respectively. The spatial variation map for TDS was prepared based on these ranges and presented in Figure 3.

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 falls within the first two classes. Based on these ranges the spatial variation map for total hardness has been obtained and presented in Figure 4.

Alkalinity

According to BIS guideline, Alkalinity is categorized in to three ranges (0-200 mg/l, 200-600 mg/l and >600 mg/l). The present study area falls within desirable and permissible limits. Based on these ranges the spatial variation map for total hardness has been obtained and presented in Figure 5.

Iron

Concentration of iron was divided into three ranges as desirable, permissible and non-potable with values of <0.3 mg/l, 0.3-1.0 mg/l and >1.0 mg/l respectively according to BIS guideline. All the three classes were found within the study area. The spatial variation map for iron is presented in Figure 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 entire study area falls within desirable limit in terms of chlorides concentration. The spatial variation map for chlorides has been presented in Figure 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 falls within the desirable class in terms of this parameter. The spatial variation map for Nitrate is presented in Figure 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 area consist only the first two classes. The spatial variation map for fluoride has been presented in Figure 9.

The final ground water quality map was prepared after integrating the various parameters in a GIS environment. The spatial distribution map of ground water quality is shown in figure 10.

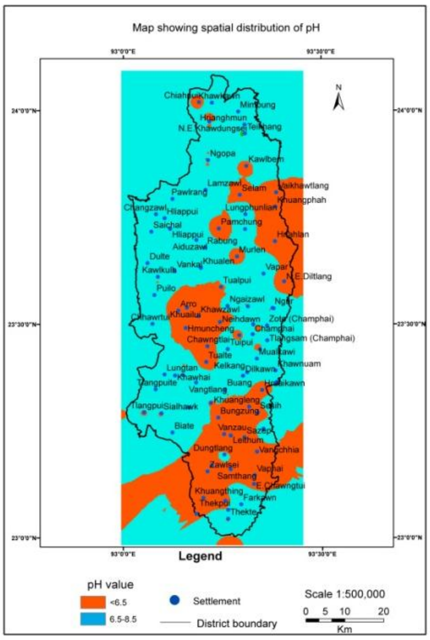


Figure 2: Spatial distribution of pH

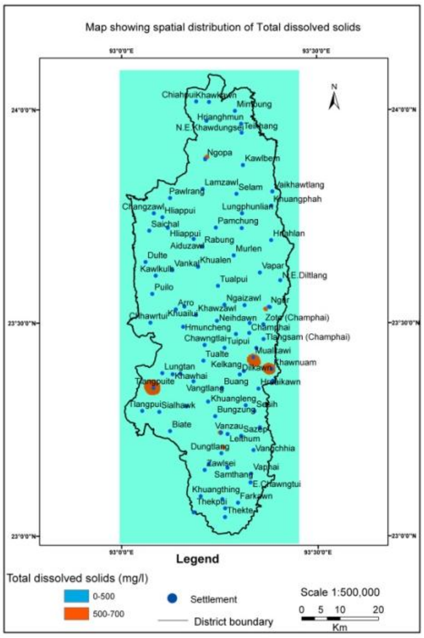


Figure 3: Spatial distribution of TDS

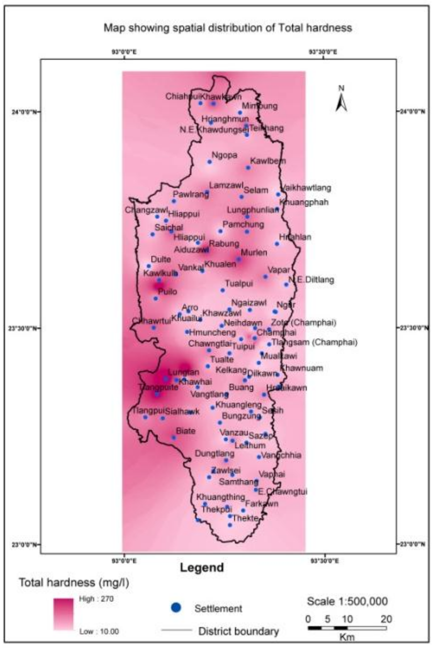


Figure 4: Spatial distribution Hardness

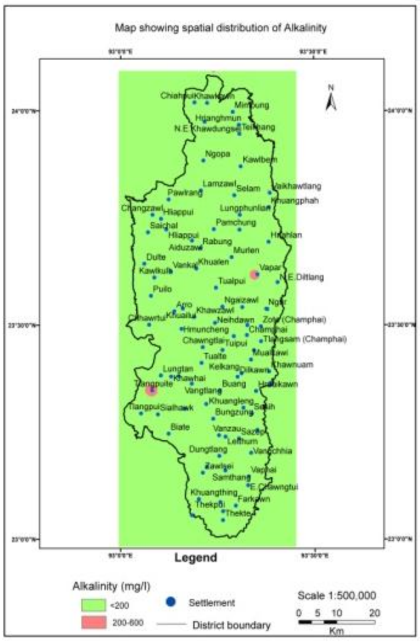


Figure 5: Spatial distribution of alkalinity

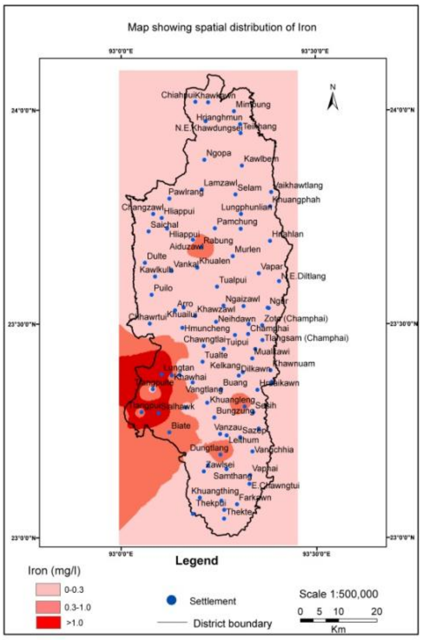


Figure 6: Spatial distribution of iron

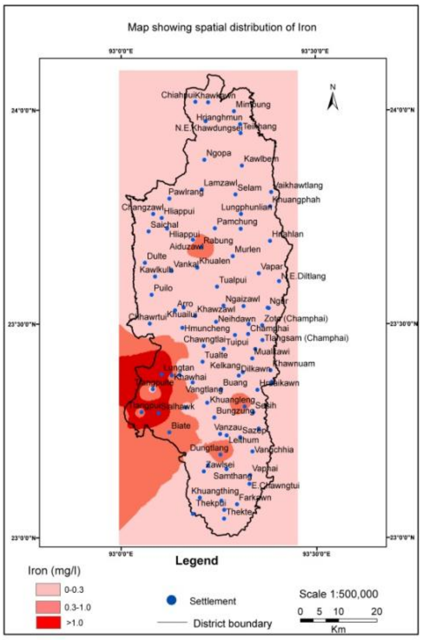


Figure 7: Spatial distribution of chlorides

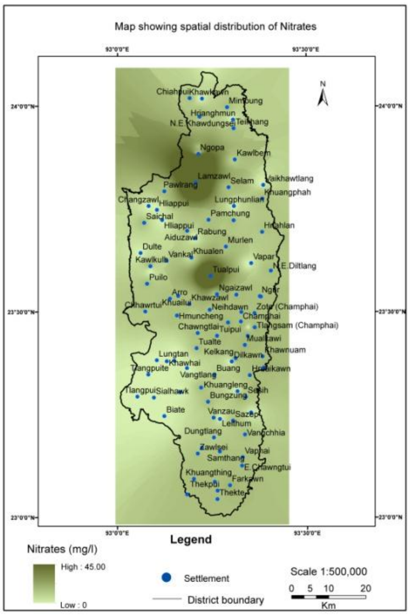


Figure 8: Spatial distribution of nitrates

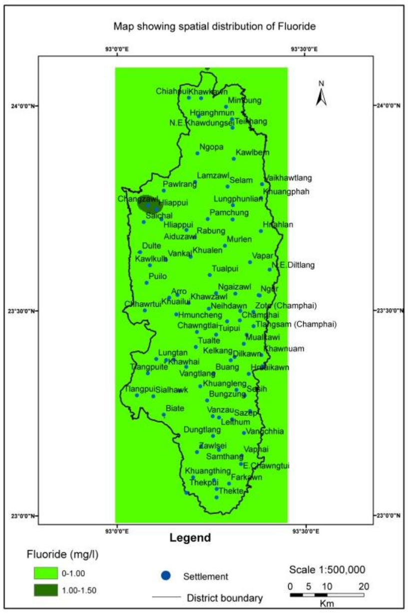


Figure 9: Spatial distribution of fluoride

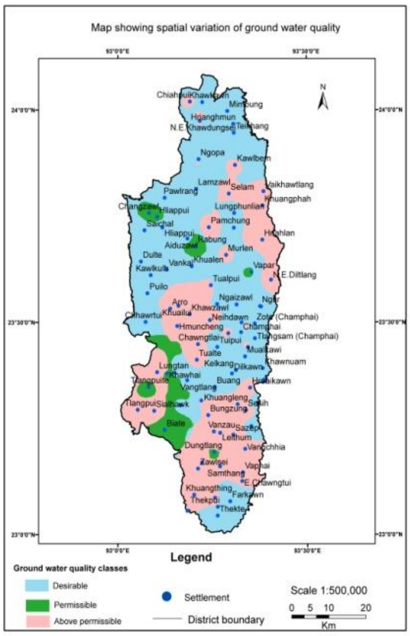


Figure 10: GW quality map

VII. CONCLUSION

The final map shows spatial variation in terms of ground water quality. From the various thematic and final maps, it is evident that pH and iron are the major problems within the study area. Other parameters are within desirable or permissible ranges.

The ground water quality maps help 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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