ASSESSMENT OF GROUNDWATER QUALITY USING GIS IN PATHANAMTHITTA DISTRICT

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Abstract — **Groundwater meets the drinking needs of 60% population of Kerala. Pathanamthitta is an inland district of Kerala, covering an area of 2731 sq.km and majority of its water requirements are met by groundwater. Groundwater from 150 locations, covering all panchayath in Pathanamthitta were collected and analyzed The study focuses on the physical, chemical and biological quality of water in Pathanamthitta. A spatial distribution of various parameters like pH, TDS, Alkalinity, EC, Chloride, Sulphide, Turbidity and Coliform had been generated using GIS. The main objective of this study was to assess the quality of groundwater for Pathanamthitta district and to do geospatial analysis using GIS and also identifies the ground water contamination sites if any.**

Keywords— Groundwater, quality, water level, parameter, spatial interpolation, GIS

INTRODUCTION

Groundwater is the water present beneath earth's surface in soil pores and in the fractures of rock formation. The depth at which the soil pores and fractures become completely saturated with water is called water table. Groundwater comprises around 97 percent of world's fresh water reserves. Ground water occurs under phreatic, semiconfined and confined conditions in the geological formations. The weathered crystallines, laterites and the alluvial formations forms the major phreatic aquifers, whereas the deep fractures in the crystallines and the granular zones in the tertiary sedimentary formations form the semi- confined and confined aquifers. Kerala is considered as a water surplus state, which is blessed with 44 rivers, back waters, lot of lakes and ponds. However Groundwater meets the drinking water requirement of nearly 60% of population in Kerala. The ease and simplicity of its extraction has played an important role in its development. Dug wells are the major ground water extraction structure in Kerala. The dug wells have a maximum depth of about 10 to 15 meters and have a diameter of about 1 to 2 meters in coastal region and 2 to 6 meters in the midland and high land. The open well density in Kerala is perhaps the highest in the country - 200 wells per sq.km in the coastal region, 150 wells per sq.km in the midland and 70 wells per sq.km in the high land.

I. MATERIALS AND METHODOLOGY

A. Study Area – Pathanamthitta District

Pathanamthitta is an inland district of Kerala State covering an area of 2731 sq.km. It is bordered by Kollam district in the south and Alappuzha in the west, Kottayam and Idukki districts in the north and Tamil Nadu state in the east. It lies between North latitude 905' and 9Q28' and East longitudes 16030' and 77017' falling in parts of Survey of India degree sheet No.58 C and G. 1.1 Administration The district has two revenue divisions namely Thiruvalla and Adoor and consists of five taluks as Adoor, Kozhencherry, Thiruvalla, Mallapally and Ranni. The five taluks are having 8 blocks with only three municipalities - Pathanamthitta, Adoor and Thiruvalla. There are eight blocks vizParakode, Pandalam, Elanthoor, Konni, Mallappally, Rani, Koipuram and Pulikeezhu. Ranni is the biggest block of Thiruvalla division with an area of 1004.6 sq.km and Konni block of Adoor division constituting an area of 841.26 sq.km. There are fifty four Gramapanchayats and sixty eight revenue villages in the district.

Figure 1 Map showing Pathanamthitta District

B. Data and Sample Collection

The water samples were taken from fixed well points. Latitude & longitude of sampled wells were taken using GPS. The samples were taken in plastic bottles which were properly washed and then labeled .Then they were taken to the laboratory and parameters like total dissolved solids, pH, electrical conductivity and bacteriological presence were determined. The remaining tests for alkalinity, pH, hardness, chlorides, iron, nitrate, sodium and potassium were carried out after refrigerating the samples. The results were then compared with drinking water standards (IS 10500-2012).

C. Water Quality Analysis

The main objective of ground water quality monitoring programme is to get information on the distribution of water quality on a regional scale as well as create a background data bank of different chemical constituents in ground water. One of the main objectives of the ground water quality monitoring is to assess the suitability of ground water for drinking purposes. The physical and chemical quality of ground water is important in deciding its suitability for drinking purposes. As such the suitability of ground water for potable uses with regard to its chemical quality has to be deciphered and defined on the basis of the some vital characteristics of the water. Bureau of Indian Standards (BIS) formally known as Indian Standard Institute (ISI) with its document IS: 10500:1991, Edition 2.2 (2003-09) has recommended the quality standards for drinking water and these have been used for finding the suitability of ground water (Table 3.1).Samples were collected from all the wards. Tested for parameters like:

1. Physical Parameters: Electrical Conductivity, Turbidity
2. Chemical Parameters: pH, Chloride, Sulphide, Alkalinity, Sulphide
3. Biological Parameters: Coliforms

Table 1 Drinking Water Standards (IS 10500-2012)

Sl. No	Parameter	Test method	Acceptable Limit	Permissible Limit
1	Turbidity	Turbidimeter	5 NTU	10 NTU
2	Electrical Conductivity	Water Quality Analyzer	Less than 1.410mS	No relaxation
3	pH	Water Quality Analyzer	6.5 - 8.5	No relaxation
4	Chloride	Argentometric Titration	250 mg/L	1000 mg/L
5	Hardness	EDTA Titration	200 mg/L	600 mg/L
6	Sulphide	Titration	0.05	No relaxation
7	Alkalinity	Titration	200 mg/L	600 mg/L
8	TDS	Water Quality Analyzer	500 ppm	2000 ppm
9	Coliforms	Bacteriological Kit	Zero	Zero

D. Data and Sample Collection

GIS (Geographical Information System) is a powerful tool for developing solutions for water resources problems to assess water quality, determining water availability, understanding the natural environment on a local and/or regional scale. The GIS which synthesizes different available water quality data into an easily understandable format provide a way to summarize overall water quality conditions that can be clearly communicated to policy makers. Therefore, this study was focused on the results of physico-chemical analysis of various parameters for domestic use and mapping of their spatial distribution using GIS techniques. QGIS (previously known as Quantum GIS) is a free and open-source crossplatform desktop geographic information system (GIS) application that supports viewing, editing, and analysis of geospatial data.

QGIS functions as geographic information system (GIS) software, allowing users to analyze and edit spatial information, in addition to composing and exporting graphical maps. QGIS supports both raster and vector layers; vector data is stored as point, line, or polygon features. We can add several data related to a particular region in QGIS. The data are added in the form of layers in this software. Depending on their features of data, several layers are added containing similar information. The layer files have the extension. In order to prepare map with QGIS, Print composer is used. It can be used for adding map, labels, legends, etc. With GIS gaining its foot as a decision support system, its use is gaining relevance, but high cost of commercial GIS software hinders the growth.

On the other hand, the Free/Open Source Software (FOSS) has opened up a gateway for many budget restricted institutions & users to venture into GIS development. The relevant proprietary GIS Software like Arc-GIS are very effective and has unlimited scope when it comes to its application. This makes it a right choice to process, analyze and provide a Decision Making Tool for various processes. Use of high cost proprietary GIS software limits the application possibilities of GIS to people and organizations who can afford this expensive software. This limits the possibilities of application of GIS technology in small and medium scale projects due to budget constraints. Due to this reason, the use of Open Source GIS like QGIS is gaining relevance as they help in developing projects without adding on the cost and expenses.

II. RESULTS AND DISCUSSIONS

A. Location of sampling wells

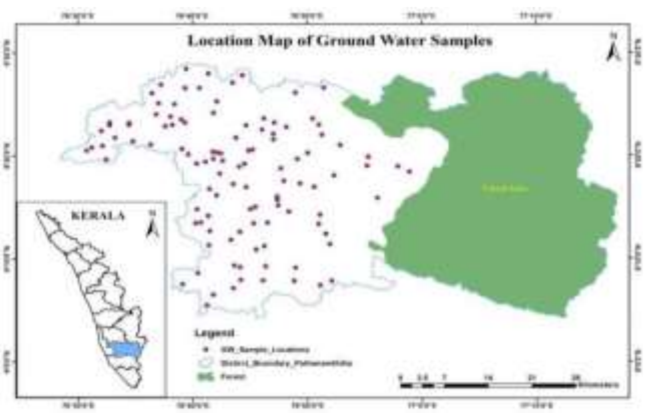

Figure 2 Location map of ground water sample

B. Spatial distribution of Electrical conductivity

The electrical conductivity indicates the presence of anions and cations present in the groundwater. According to the standards drinking water should have a conductivity value less than 1.410 mS. Higher EC in the study area indicates the enrichment of salts in the groundwater. The value of electrical conductivity may be an approximate index of the total content of dissolved substance in water. It depends upon temperature, concentration and types of ions present .The EC can be classified as type I, if the enrichments of salts are low (EC \1,500 lmhos/cm); type II, if the enrichment of salts are medium (EC 1,500 and 3,000 lmhos/cm); and type III, if the enrichments of salts are high (EC [3,000 lmhos/cm).

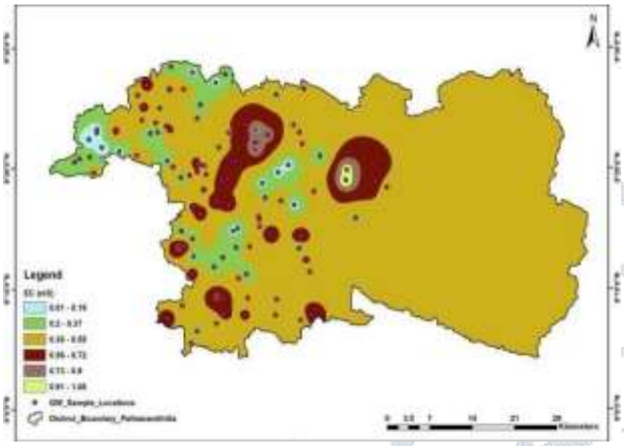

Figure 3 Spatial distribution of electrical conductivity

C. Spatial distribution of pH

The pH is a measure of alkalinity or acidity. It has no direct adverse effect on health, but produces a sour taste below 4 and an alkaline taste above 8.5. As per IS 10500-2012, the acceptable range of pH varies from 6.5-8.5.This may be attributed to the anthropogenic activities like sewage disposal and use of fertilizers in the highly populated coastal segment of the study area followed by natural phenomenon like intrusion of brackish water into the sandy aquifers, which initiates the weathering process of underlain geology.

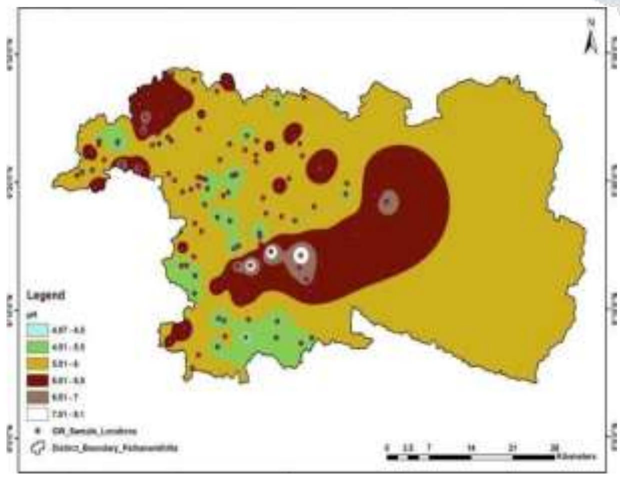

Figure 4 Spatial distribution of pH

D. Spatial distribution of TDS

The presence of Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride and Sulphate ions contribute to TDS in groundwater. The prescribed limit of TDS for Drinking water is 500 mg/l. According to the Davis and De Wiest (1966) classification of groundwater based on TDS, 82 % of the total groundwater samples are desirable for drinking (TDS \500 mg/l), 14 % permissible for drinking (500-1,000 mg/l) and 4% is suitable for irrigation purposes. High concentration of TDS in the groundwater sample is due to leaching of salts from soil and also domestic sewage may percolate into the groundwater, which may lead to increase in TDS values.

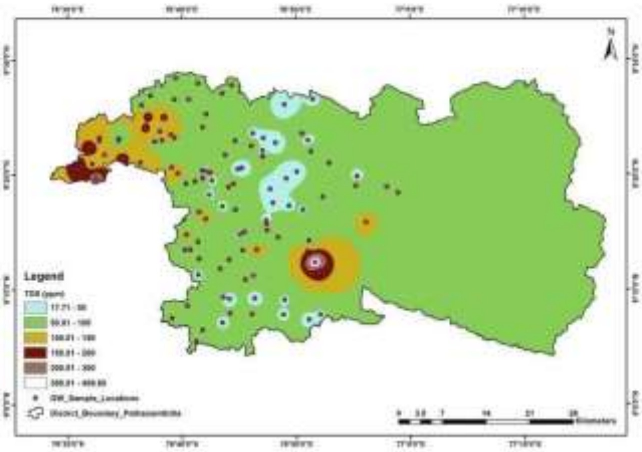

Figure 5 Spatial distribution of TDS

E. Spatial distribution of Chloride

Chloride in groundwater can be noted as a result of dissolution of salt deposits, discharges of effluents from chemical industries, oil well operations and seawater intrusion in coastal areas. The limit of chloride varies from 250 mg/L to 1000 mg/L according to IS 10500 2012. . The excess of chloride in the water is usually taken as an index of pollution and considered as tracer from groundwater contamination .In natural waters, the concentration of Cl bears strong correlation with the Na content and specific conductance. Chloride determinations may serve to indicate the intrusion of waters of different composition or to trace and measure rates and volumes of water mass movements.

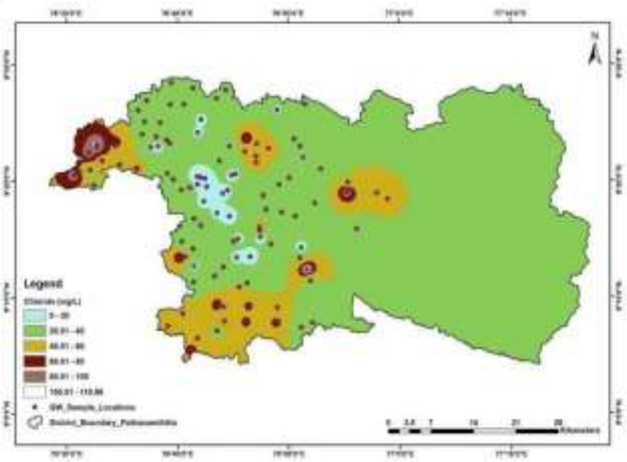

Figure 6 Spatial distribution of Chloride

F. Spatial distribution of Sulphur

Sulphur occurs naturally in soils, rocks and minerals. In the aquifer, groundwater comes in contact with these solid materials dissolving them, releasing their constituents, including sulfur, to the water. In groundwater, under typical pH conditions, sulphur can occur as three separate ions: sulfate, bisulphide and hydrogen sulfide. Sulfur molecules can be found in most groundwater. Whether it occurs as sulfate, bisulphide, or hydrogen sulfide depends on the amount of oxygen in the water and, to a lesser extent, upon its degree of acidity, i.e., its pH.

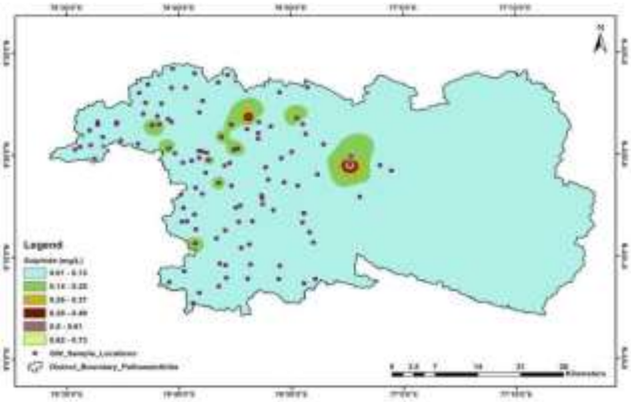

Figure 7 Spatial distribution of Sulphur

G. Spatial distribution of Turbidity

Turbidity in groundwater indicates a fast transport pathway connecting potentially contaminated surface water with the aquifer. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity. Primary contributors to turbidity include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton, and microscopic organisms. The measurement is qualitative and cannot be correlated directly as micrograms per liter of suspended solids. Turbidity is measured in nephelometric turbidity units (NTU) or Formazin turbidity units (FTU), depending on the method and equipment used. Turbidity measured in NTU uses nephelometric methods that depend on passing specific light of a specific wavelength through the sample.

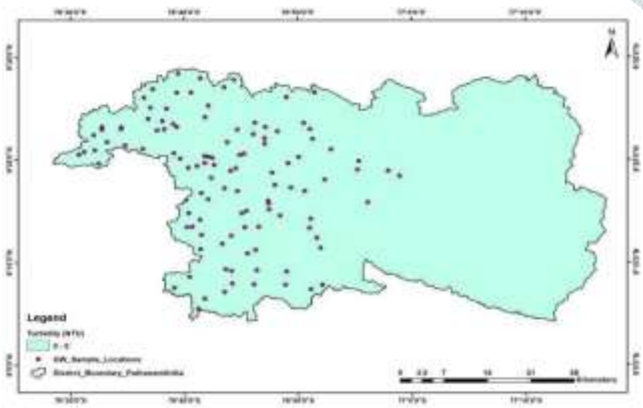

Figure 8 Spatial distribution of Turbidity

H. Spatial distribution of Alkalinity

Alkalinity influences chemical and biological reactions. Excessive amounts can also lead to corrosion. Alkalinity in medium concentration is required in potable water to nullify the corrosion effects of acids.

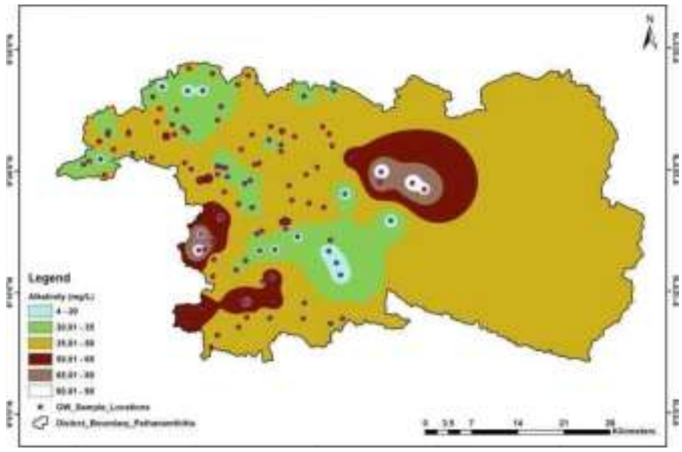

Figure 9 Spatial distribution of Alkalinity

III CONCLUSION

Groundwater is an important source of drinking water for many people around the world. Contamination of groundwater generally results in poor drinking water quality, loss of water supply, high cleanup costs, high-cost alternative water supplies and potential health problem. Ground water in Pathanamthitta district occurs under phreatic condition in the alluvium, laterites and weathered crystallines. It occurs under semi-confined to confined conditions in Tertiary sediments and deep seated fractured aquifers in crystalline rocks. The important aquifer systems in the district are: The weathered, fissured and fractured crystalline formations, semi-consolidated Tertiary formations, laterites and the alluvial formation.

The electrical conductivity values are less than 1.410ms for all the 112 samples. EC values range between 0.043 to 1micro Siemens per cm. The pH of groundwater varies from 5.05 to 8.06 indicating that the water are slightly acidic to neutral and are occasionally alkaline. All other parameters analyzed fall under the permissible limit. Thus water from all the bore wells tapping fractured aquifer in the hard rocks of the district is suitable for domestic and agricultural purposes. This study has also demonstrated the utility of GIS combined with laboratory analysis to assessment and mapping of groundwater quality.

65% of water samples are acidic nature because of the use of nitrate present in the fertilizer. Forest areas in panchayath helps to reduce runoff and hence good water quality. Water quality of all wells in Pathanamthitta district can found out using QGIS.

IV RECOMMENDATIONS

Following are the recommendations for preventing further groundwater deterioration and strategy for protecting the same in future.

- Recharging of groundwater can be an effective measure in maintaining the water table depth in areas where there is an excessive abstraction of groundwater through borewells and interference of seawater.
- Groundwater recharging structures can be formed at different parts of the area where groundwater has been depleted. Storm water drains can be linked with recharging structures to increase their potentials.
- Proper siting and construction of septic tanks from wells can prevent bacteriological contamination upto certain extent.
- The effluents entering the waste water drains must be given a pretreatment to minimize the groundwater pollution by this sewage.
- The water bodies in the municipality like canals, drains etc must be rejuvenated to prevent the groundwater sources from further contamination.
- The trenching ground should be replanned scientifically and the leachate must be monitored frequently.

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