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Assessment of Ground Water Quality in Ramanathapuram Municipality using Geographical Information System (GIS)

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Abstract : Water is the basic element of social and economic infrastructure and is essential for healthy society and sustainable development. Due to rapid increase in density of population, fast urbanization, industrialization and agricultural, use the demand of water is increasing day by day. As a result surface water and ground water level is decreasing, pollution and increased demand have made good quality water scarer and more expensive. Groundwater is the favorite alternative is facing threats due to anthropogenic activities in India, which has lead due to deterioration in ground water quality. The possibility of ground water contamination is due to the mixing up of toxic chemicals, fertilizers, waste disposed site and industrial sites. Hence monitoring of ground water quality has become indispensable. GIS not only facilitates data capture and processing but also serve as powerful computational tools that facilitate multimap integrations. In this project ground water quality analysis was carried out for Ramanathapuram Municipality in Ramanathapuram District water samples were collected all around the Municipality the strategically analyzed results are presented in a GIS based water quality mapping.
Keywords : Groundwater, Quality, GIS Application, Ramanathapuram Municipality.

1.0 Introduction

Water is the basic requirements of all life on Earth. The origin of life has been attributed is water along with other basic elements water the source of life is passionate. Too passionate to manage excess of, it leads to flood and lack of its results in drought and famine[1,2]. It must be remembered that any natural or manmade activity on the surface of the earth will have it's for most impact on the quality and quantity of water this will be taken into the biosphere systems and ultimately lead to hydrological extremes. The increase in population and urbanization and urbanization necessitates growth in the agricultural and industrial sectors which demand for more fresh water. When surface water is the non-available mode the alternative is to depend on ground water.

2.0 Literature Survey

In past years, the water quality analysis are done in many areas for example, Ground water quality mapping using geographical information system (GIS): A case study of Gulbarga city, Karnataka, india at 2011.

Water quality assessment of Yamuna river in Delhi region using index mapping at 2012.Assessment of water quality in tigris river-Iraq by using GIS mapping at 2013.

But there is no such case study or examination are done in India, tamilnadu.in this study, ground water samples were collected in 10 different areas of Ramanathapuram, municipality, Tamilnadu, India. Thee water samples were analysed for physico-chemical parameters like ph, hardness, calcium, magnesium, alkalinity, chloride, electrical conductivity and water quality index using standard the laboratory.

The final integrated values shows three priority classes such as excellent, good, poor and unsuitable ground water quality zones of the study areas and provides a guide line for the suitability of ground water or domestic purposes.

3.0 Methodology GIS

GIS is a power tool for collecting, storing, transforming the spatial information and arriving decision from the real world for particular set of purpose in real time, where the stored information are geo-references (or) geo-coded. In this project the water quality is analyzed using GIS and mapped[3].

3.1. Defining GIS

A GIS is an information system designed to work with data referenced by spatial/ geographical coordinates. In other words, GIS is both a database system with specific capabilities for spatially referenced data as well as a set of operations for working with the data. It may also be considered as a higher order map.

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprise for explaining events, predicting outcomes and planning strategies.A Geographic Information System is a computer based system which is used to digitally reproduce and analyze the feature present on earth surface and the events that take place on it. In the light of the fact that almost 70% of the data has geographical reference as its denominator, it becomes imperative to underline the importance of a system which can represent the given data geographically.

The four functions of GIS are:

1. Data acquisition and pre-processing
2. Data management, storage and retrieval
3. Manipulation and analysis
4. Product generation

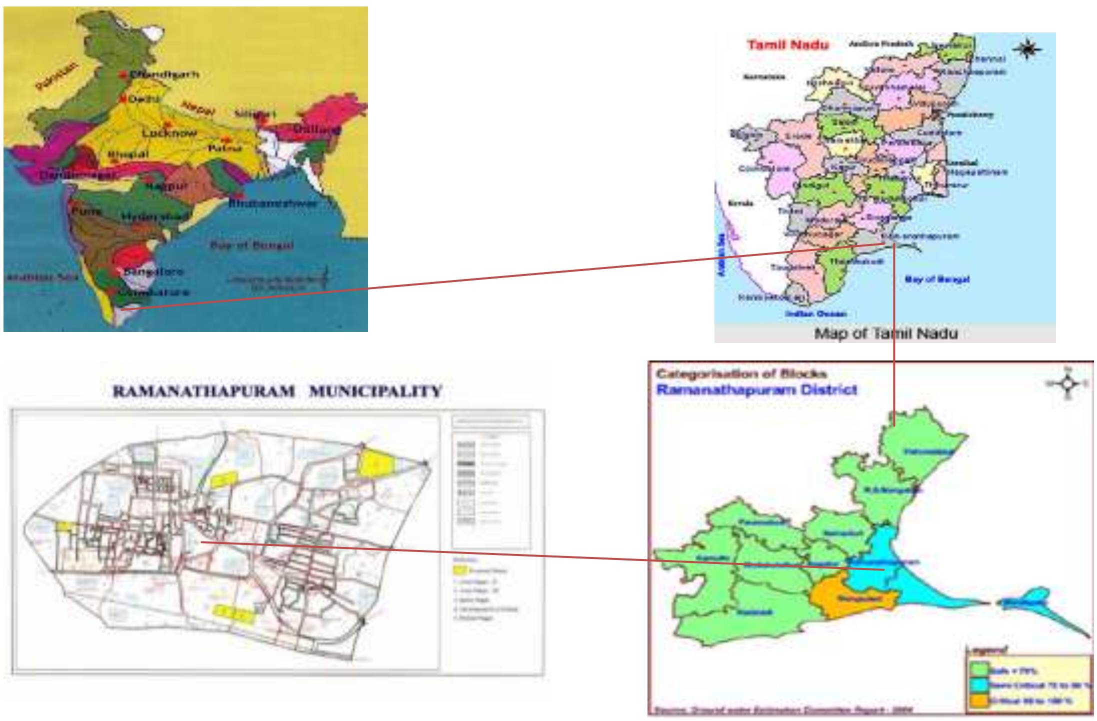


Figure 1: Study Area

The GIS has the power of organizing effective Social Information System (SIS) towards decision-making or resource management. The spatial information system comprises synthesis of spatial formation and non-spatial data within GIS framework. The GIS aims and works at bringing together, the diverse information, which are gathered from various different sources. Hence, this is also known as integrated analysis.

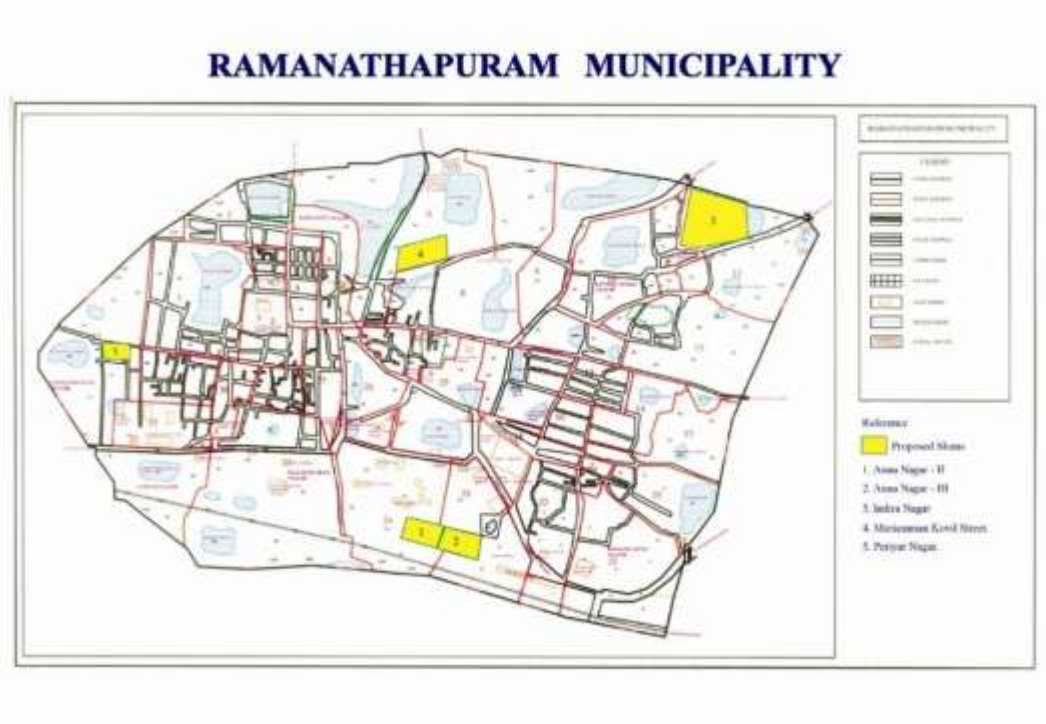


Figure 2: Location of sampling stations

3.2. Location of The Study Area

And our study area covers Ramanathapuram municipality which lies between North Latitudes 9˚ and 9˚ 55' East Longitudes 77˚ 02' and 77˚ 5'.

3.3 Instruments Used

1. GPS – Garmin
2. Water Quality Field Kit

3.4 Software Used

1. Surfer - 8
2. ARC GIS 10.4

3.5. Scanning of Toposheets

Scanning results in the conversion of the image into an array of pixels thereby producing an image in raster format. A raster file is an image created by a series of dots called "Pixels" that are arranged in rows and columns. A scanner captures the image by assigning a row in a column and a color value each dot. The Ramanathapuram municipality Map was scanned.

4.0 Digitization

A Raster image is a type of computerized image that consists of row after row of pixels. There are many different raster image file format. Digitization is the process which converts raster to vector format. Most of the GIS technologies are vector formats are more common, so the raster format is converted into a vector format. In the vector format the position of the line is determined by the co-ordinate which are present at the starting and ending points of the line. Digitization was done by Surfer - 8.

4.1 Query Analysis

Data query retrieves a data subset from a map by working with its attribute data. The selected data subset may be visually inspected or saved for further processing. Attribute data query requires the one of expressions which must be interpretable by a GIS. These expressions are often different from one system to another.

4.2 Spatial Interpolation

Spatial interpolation is a process of using points with known values to estimate values at other points. Spatial Interpolation is a means of converting point data to surface data.

4.3 Summary

The water quality parameters were tested in the laboratory. The Lab Test Procedure was done as per Indian standard code of Practice. The water quality parameters are given in the data base to GIS. The Ramanathapuram municipality map was scanned and digitized. Digitization was done by Surfer – 8. The spatial variation was done. Finally, integrated ground water quality map was created using ARC GIS 10.4.

5.0 Analysis

5.1 Ground Water Quality Parameters

The major ground water quality parameters such as,

1. pH
2. Total hardness
3. Electrical conductivity
4. Chloride
5. Calcium
6. Alkalinity
7. Magnesium

Have been estimated in 10 observation wells throughout the Ramanathapuram municipality. The ground water quality data of the study area and locations in study area map finally, integrated ground water quality map was created using ARC GIS 10.4.

6.0 Water Quality Index

House and Newsome, 1989, stated that the Water Quality Index (WQI) allows ‘good’ and ‘bad’ water quality to be quantified by reducing a large quantity of data on a range of physical, chemical and biological variables to be a single number in a simple, objective an reproducible manner (Liousmet al., 2004)[5]. The WQI concept is based on the comparison of the water quality parameter with respective regulatory standards (Khan F, et al., 2003)[4] and provides a single number that express overall water quality at certain location based on several water quality parameters (Yogendra and Puttaiah, 2008). WQI improves understanding of water quality issues by integrating complex data and generating a score that describes water quality status and evaluates water quality trends (Boyacioglu, 2007).In present study the WQI has been calculated by using standards of drinking water quality recommended by the Bureau of Indian standards (BIS) and Indian Council for Medical Research (ICMR) and weighted index method developed by Tiwari and Mishra 1985; As adiet al., 2007 to determine the suitability of groundwater for drinking purposes. In the present study ten water quality parameters, namely, pH, Electrical Conductivity (EC), Alkalinity, TDS, Total hardness, Calcium, Magnesium, Nitrate, Chloride and Sulphate were considered for computing WQI by using the following formulas.

WQI = Antilog [ΣW^{n} n=1 log10 qn]

Where,

W, Weightage factor (W) is computed using the following equation, (Table 1)
$W_n = K / S_n$

Where,

K, Proportionality constant is derived from,
$K = [1/ (\Sigma^{n}{}_{n=1} 1/S_n)]$ ⟶ (3)

Where,

Sn and S_i are the BIS/ICMR standards values of the water quality parameter.
And Quality rating (q) is calculated using the formula,
$qn_i = \{[(V_{actual}- V_{ideal}) / (V_{standard} - V_{ideal})]*100\}$ ⟶ (4)

Where,

qn_i = Quality rating of the parameter for a total of n water quality parameters
V_{actual} = Value of the water quality parameter obtained from laboratory analysis
V_{ideal} = Value of that water quality parameter can be obtained from the standard tables
V_{ideal} for pH = 7 and for other parameters it is equivalent to zero
$V_{standard}$ = BIS / ICMR standard of the water quality parameter

The standard of the water quality parameter is given in Table 2. Table 3 shows values of the all ten parameters that are experimented in the laboratory and values of WQI that is computed by using above formulae and Table 4 shows the indexing of WQI into categories of different types in order to assess the portability of ground water in the study area.

6.1. Water Quality Parameters, Their Icmar/Bis Standards, And Assigned Unit Weight

Table-2

Parameter	Standard (S_n&S_i)	1/ Sn	K	Weightage(W_n)
PH	8.5	0.11747	5.020014437	0.590589934
Electrical conductivity	300	0.003333	5.020014437	0.016733381
Hardness	300	0.003333	5.020014437	0.016733381
Calcium	75	0.013333	5.020014437	0.066933526
Magnesium	50	0.02	5.020014437	0.100400289
Alkalinity	120	0.008333	5.020014437	0.041833454
chloride	250	0.004	5.020014437	0.020080058

6.2. Water Quality Parameter

Table-3

Sample	PH	Electrical conductivity	Hardness	Calcium	Magnesium	Alkalinity	Chloride	WQI
1.	7.4	700	325	94.5	12.25	280	138.45	24.35
2.	7.6	670	345	91.87	11	300	146.97	53.49
3.	7.9	668	200	83.12	18.81	260	176.79	25.85
4.	7.7	552	210	68.25	17	345	106.5	56.52
5.	7.25	498	215	49.87	16.6	305	115.02	42.07
6.	7.69	726	215	48.12	37	205	80.94	23.84
7.	7.45	968	320	43.75	34.12	300	83.07	36.17
8.	7.41	750	425	52.5	34.2	280	85.2	26.74
9.	7.11	747	180	56.87	36	300	87.33	28.86
10.	7.34	658	190	31.5	14	300	78.81	34.92

All units except pH and conductivity are in mg/l.

Status Of Water Quality Table-4

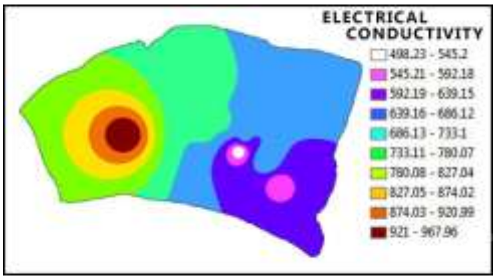
Water Quality Index	Water Quality Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unsuitable

7.0 Result and Discusssion

7.1. Spatial Distribution of Water Quality Parameters

7.1.1. PH

PH is important parameter,which determines the suitability of water for various purposes. In the study area pH level of water varies from 7.11 and 7.9and is in desirable limit ie. 6.5 to8.5 as specified by the BIS/ ICMR. Figure 3 shows that spatial distribution of pH in the study area, low concentration of pH was observed in southwest part of the study area, which comes under Ramanathapuram.



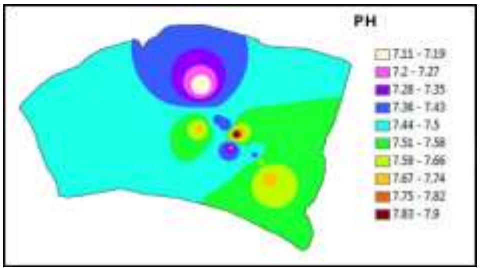
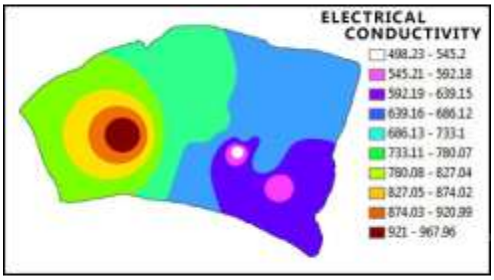


Figure 3: Spatial Distribution of pH **Figure 4: Spatial Distribution of Electrical Conductivity**

7.1.2. Electrical Conductivity

Electrical conductivity is the capacity of electrical current that passes through the water. It is directly related to concentration of ionized substances in water and may also be related to problems of excessive hardness[6,7].

In study area, electrical conductivity varies from 498 to 968 µm/cm. Figure 4 shows that spatial distribution of EC of water in the study area high concentration of EC has been observe in East part of the study area.



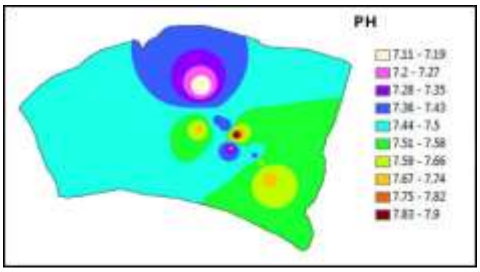
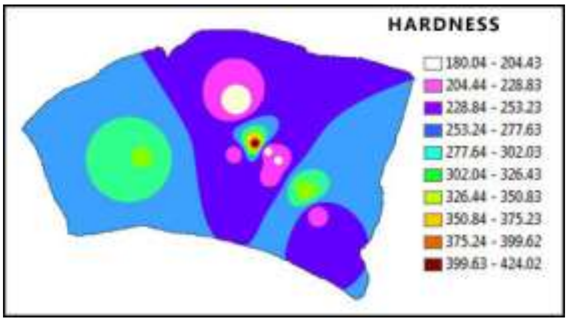


Figure 5: Spatial Distribution of Hardness

7.1.3 Hardness

The limit of total hardness value for drinking water is to be within 300 mg/l of CaCO3.Figure 5 shows the Spatial distribution of the ground water hardness in the study area and it varies from 180.04 to 424.02 mg/l. Higher concentration of hardness was found in Sakkara KottaiandPattanamKathan.This may be due to natural accumulation of salt, or surface runoff, water enter from direct pollution by human activities, low concentration of hardness was found in central part of the study area.i.e Anna Nagar.



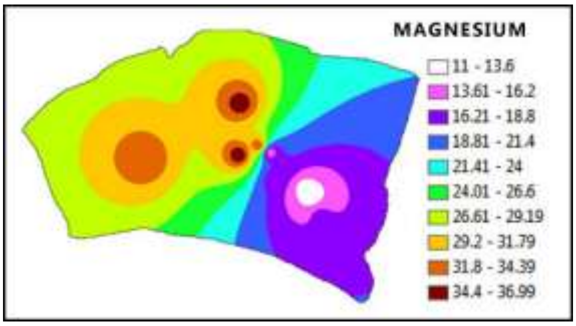


Figure 6: Spatial Distribution of Calcium

7.1.4 Calcium

Calcium is one of the most abundant substances in the water. Dissolve calcium and Magnesium in water are the two most common minerals that make water hard. Figure 6 shows the spatial distribution of Calcium in the groundwater of the study area, which ranges from 31.59 to94.47 mg/l. The high concentration of calcium was found in Sakkara Kottai which lies in south western part, and in the Pattanamkathan of the study area, which is in the central part of the study area.

7.1.5 Magnesium

Figure 7 spatial distribution of Magnesium in the groundwater of the study area and it varies in between 11 mg/l to 36.99 mg/l. High concentration of magnesium was found in south western part of the study area i.e. Kuuriyur, East part of the study area i.e., Indira Nagar and in the Mariam manKovil Street.

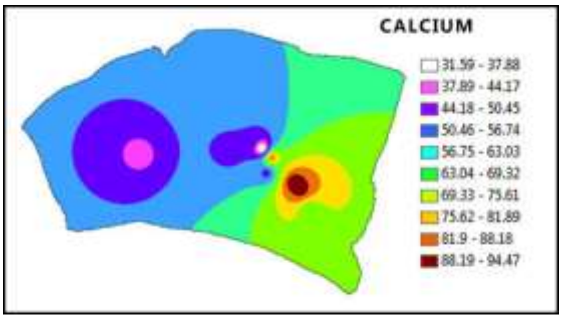


Figure 7: Spatial Distribution of Magnesium

7.1.6 Alkalinity

The standard desirable limit of alkalinity of potable water is 120 mg/l. The maximum Permissible level is 600 mg/l. Figure 8 shows spatial distribution of Total Alkalinity in the groundwater of the study area, it varies from 205.07 to 344.98 mg/l. High alkaline water has been observed in Periyarnagar . Excessive alkalinity may cause eye irritation in human and chlrosis in plants (Sisodia and Moundiotiya, 2006). Low concentration of alkalinity was observed in edges of the central part of the study area i.e. Annanagar.

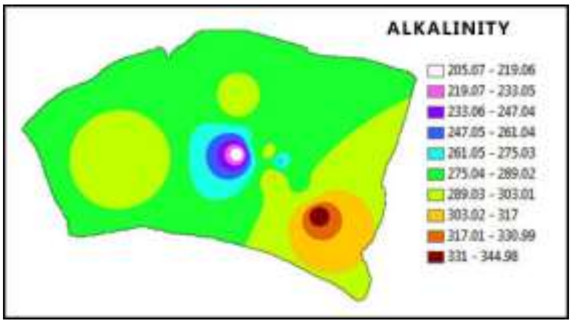


Figure 8: Spatial Distribution of Alkalinity

7.1.7 Chloride

Chloride is one of the most important parameter in assessing the water quality and higher concentration of chloride indicates higher degree of organic pollution (Yogendra and Puttaiah,). According to BIS/ICMR the permissible limit of chloride in drinking water is 250 mg/l. Figure 9 Spatial distribution of Chloride in the study area and it is fluctuating in between 78.93 to 176.6 mg/l. High concentration of chloride was observed as 176.6 mg/l near Taluk office Ramanathapuram. This may be due to natural processes such as the passage of water through natural salt formations in the earth or it may be an indication of pollution from industrial or domestic use (Renn, 1970) [8]. In drinking water, high chloride content may lead to laxative effects (Raviprakash and Rao, 1989; Dahiya and Kaur,). Low concentration of chloride was found in edges of the southern part of the study area.

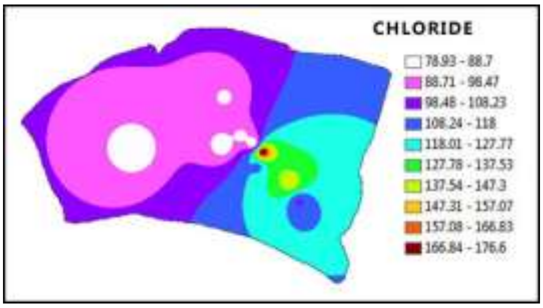


Figure 9: Spatial Distribution of Chloride

8. Water Quality Index Map

Figure 10 shows Spatial Distribution of WQI in the study area and it is varying from 23.85 to 56.52. High value of WQI has been observe in Taluk office. Low values of WQI was observed in surrounding area of behind Periyar Nagar and Anna Nagar. Figure 14 shows the Portability Index map of the study area, shows that surrounding areas of the samples 2 and 4 i.e., areas surrounding Institute of Environment, BVU and R Residency, Upper katraj are not potable. Most of the area having ground water is potable, people can use the ground water for drinking purpose.

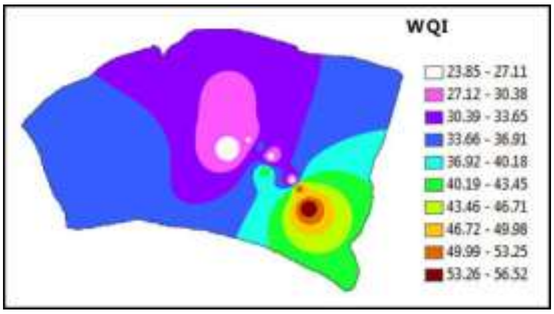


Figure 10: Spatial Distribution of Water Quality Index

9.0 Conclusion

This study has demonstrated the utility of GIS combined with laboratory analysis to assess and mapping of groundwater quality. The spatial distribution map of pH, Chloride, Magnesium and Sulphate shows that, these parameters are within the permissible limit in the study area. The interpreted water quality with respect to EC indicates that more than 90% of the study area groundwater lies in bad range for drinking purposes except at sample 10. The spatial distribution map of hardness concentrations illustrates that the majority of the samples are within the permissible limit except four samples i.e. sampling point 1, 2, 3 and 4. Calcium ion distribution is within the maximum permissible limits, except for three samples i.e. sampling point1, 2 and 3 which show Calcium concentration exceeding the permissible limit. The spatial distribution map of Alkalinity concentrations illustrates that all samples are beyond the permissible limit. TDS and Nitrate concentration in groundwater of the study area exceeds the maximum permissible limit in one location only i.e. sample 7 and sample 1 respectively. The overall view of the WQI of the present study showed that most of the area having a WQI value less than 50 except in the surrounding areas of sample 2 and sample 4.This study has shown that the use of GIS and is very useful tool for the assessment of ground water quality.

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