Cloud Publications
International Journal of Advanced Remote Sensing and GIS
2015, Volume 4, Issue 1, pp. 953-959, Article ID Tech-362
ISSN 2320 - 0243

Research Article **Open Access**

Mapping of Ground Water Quality for Ramanathapuram Taluk of Tamil Nadu Using Geographical Information System

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Publication Date: 31 March 2015

Article Link: http://technical.cloud-journals.com/index.php/IJARSG/article/view/Tech-362

Abstract Quality of groundwater is an important factor, for sustainable agricultural, industrial and domestic usages. Ramanathapuram is one of the coastal rural taluk which has high tourism activities and more issues on sea water intrusion in the past three decades. Since it has high rate of urbanization leads poor water quality in the urban areas. The study involves assessing the status of ground water quality the study has been designed to assess the ground water status and to prepare the spatial distribution map for water quality parameters such as pH, EC, TDS, calcium, magnesium, total hardness and chloride at Arc GIS environment. The data were used in the attribute table for preparing spatial distribution maps through IDW (Inverse Distance Weighting) interpolation techniques. It is observed that keelakarai town panchayat area has severely affected area in respective with ground water quality. Spatial distribution maps of each parameter were discussed in the full length paper. Also study has suggested suitable management planning strategies to improve the quality of ground water.
Keywords *Spatial Distribution; Ground Water Quality; Physico-Chemical Characteristics; Geographical Information System; Inverse Distance Weighting*

1. Introduction

The Indian environmental mangers and researchers have explained the condition of freshwater resources in India and their management as a serious environmental problem which includes nutrition enrichment, acidification and domestic waste, agricultural waste, sewage and industrial effluents toxic substances identified as major impacts (Laskar and Susmita, 2008). Every day, two million tons of sewage, industrial and agricultural waste is discharged into the world's water the equivalent of the weight of entire human population of 6.8 billion people. Nearly seventy million people living in Bangladesh are exposed to groundwater contaminated with arsenic beyond WHO recommended limits of 10 ug/L. The naturally occurring arsenic pollution in groundwater now affects nearly 140 million people in seventy countries on all continents (UN WWAP, 2003 and 2009). In India 70% of surface water resource and ground water reserves have been contaminated by biological, organic and inorganic wastes (Joseph and Claramma, 2010). Chennai city groundwater quality has resulted in saline groundwater nearly 10 km inland of the sea and similar problems can be found in populated coastal areas around the world (UNEP, 1996). GIS technology has previously facilitated laborious procedures (Shamsi, 2005; Assaf et al., 2008; An, 2012). During the past two decades, various researches have reported its application in ground water modeling and quality assessment. Balakrishnan et al. (2011) demonstrated spatial variations in ground water quality using GIS and ground water quality information maps of the entire polluted area in India. Assessment of ground water quality through spatial distribution mapping for various pollutants utilizing GIS technology and the resulted information on quality of water could be useful for policy makers to take remedial measures (Nageswara Rao et al., 2007; Pradhan et al., 2001; Swarna Latha et al., 2007). In the present work involves ground water quality assessment using GIS for Ramanathapuram taluk.

2. Study Area

Ramanathapuram Taluk located in Ramanathapuram District (Figure 1) in the Southern part of Tamil Nadu State on the East coast of India. Its geographical location extends between 9°22’ of North Latitude and 78°49’ of East Longitude. It has a long coastline of around 102.34 km and the mean sea level is 10 Meters. The climate prevails with an in maximum of 36° C in summer. And minimum temperature of 25° C in winter the annual average rainfall of the study area is recorded to be 500 mm. The soil of Ramanathapuram taluk can be assorted into the main type’s viz. clay, sandy loam, sandy clay, and sand and alluvium soil. Calcium carbonate concentrations of various sizes and shapes are present in majority of the block soil area. Vaigai is one of the important rivers of the taluk, which is flow and drain in the Tirupullani and Mandapam blocks. The total population of Ramanathapuram taluk is 1,66.232 as per the cencus 2011.

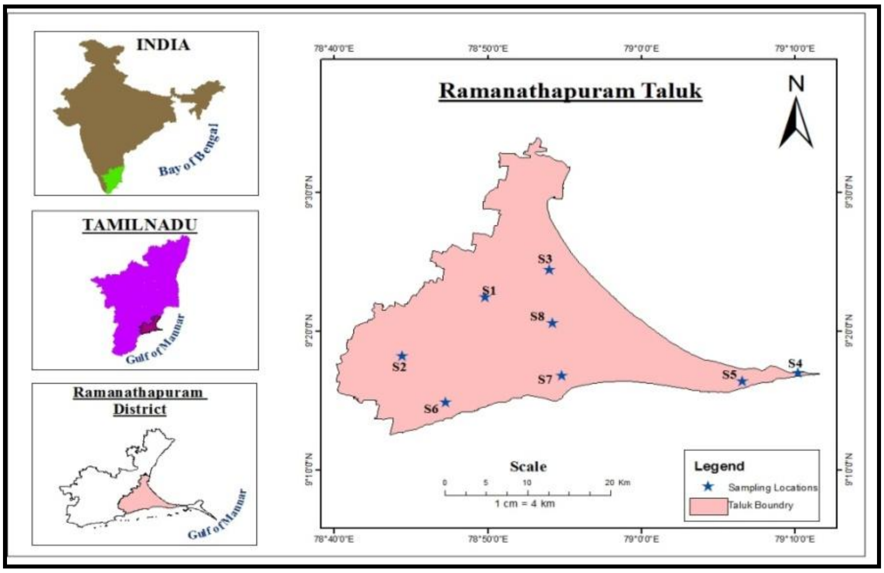

Figure 1: *Location Map of the Study Area*

3. Materials and Methods

3.1. Data Collection

In present study eight ground water sampling locations (Table 1) were identified for data collection based on its administrative locations within Ramanathapuram taluk. Water quality data were collected from Tamil Nadu Water Board Department (TWAD) for the year 2013 and Survey of India toposheets such as 58K/15, K/16, 58O/3 and 58O/4 in 1:50,000 scale were used.

Table 1: *Ground Water Sampling Locations*

Sample No.	Name of Sampling Location	Longitude /Latitude	
S1	Ramanathapuram	9°22'33"N	78°49'55"E
S2	Uthirakosamangai	9°18'18"N	78°44'29"E
S3	Chitharakottai	9°24'29"N	78°54'00"E
S4	Mandapam	9°17'01"N	79°10'09"E
S5	Idayarvalasai	9°16'27"N	79°06'34"E
S6	Keelakarai	9°14'58"N	78°47'18"E
S7	Ragunathapuram	9°16'49"N	78°54'45"E
S8	Valantaravai	9°20'37"N	78°54'12"E

3.2. Map Preparation

The collected toposheets were scanned and uploaded in GIS platform and geo-referenced. After geo-referencing, geo-databases were developed and taluk boundary was digitized and interpolated for the ground water quality parameters.

3.3. Spatial Data Conversion

All the data were entered into spatial database and spatial variations of the results were developed using IDW method. Arc GIS software (version 10.1) was applied for developing maps. IDW interpolation assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. The IDW tool fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. The general formula of IDW interpolation for 2-D problems is the following:

$$w(x,y) = \sum_{i=1}^{N} {}_{i} w_i \qquad {}_{i} = \frac{\left(\frac{1}{d}\right)^p}{\sum_{i=1}^{N}\left(\frac{1}{d}\right)^p} \qquad (1)$$

Where w(x,y) is the predicted value at location *(x,y)*, *N* is the number of nearest known points surrounding *(x,y), ƛi* are the weights assigned to each known point value wi at location (xi,yi), di are the 2-D Euclidean distances between each *(xi,yi)* and *(x,y),* and p is the experiment which influences the weighting of *wi* on *w* (Shekhar et al., 2008). The advantage of IDW is that it is intuitive and efficient, so that IDW method is widely used in spatial interpolation of ground water quality (Balakrishnan et al., 2011).

4. Results and Discussion

The ground water quality data were shown in Table 2 during the year of 2013. All the data were interpolated for the spatial distribution of ground water quality in the Ramanathapuram Taluk with the help of GIS. The spatial structures were also identified interpolating the scattered data, in order to have temporal series of spatially continuous maps of the parameters. We used Inverse Distance to a power gridding method as a smoothing interpolator. In this method data are weighted during interpolation such that the manipulate of one point relative to another declines with the distance. In particular, we use a quadratic law for computation of the weight, and a low value for smoothing parameters.

Table 2: *The Results of Ground Water Quality*
Source: TWAD board, Chennai, Tamil

Locations	pH	EC (µS)	TDS (mg/l)	TH (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)
S1	8.2	1055	620.5	275	45	39.487	149
S2	8.05	6414	3147.5	1160	130	202.95	1797
S3	8.44	1380	773.5	145	23	21.25	174
S4	8.2	1055	620.5	275	45	39.48	149
S5	8.05	950	519.5	277.5	15	58.32	117
S6	8.3	5450	3379.4	420	72	58.32	1063.5
S7	8.1	830	490.5	270	39	41.97	83.5
S8	8.3	2645	1598.5	875	178	104.49	585

The spatial distribution of the pH of e ground water shows that the values of 8.44 and 8.05 in the region respectively (Figure 2) and the highest value is occupied in chitharakottai. The alkaline nature of groundwater may be due to the presence of fine aquifer sediments mixed with clay and mud, which are unable to flush off the salts during the monsoon rain and hence maintained longer no other seasons (Venkataramann Sivasankar et al., 2012). Electrical Conductivity variations in taluk, indicating high concentration of salts. The values of electrical conductivity between 830 µS-6414 µS (Figure 3). The amount of Total dissolved solids ranged from 490.5 to 3,747.5 mg/l (Figure 4).

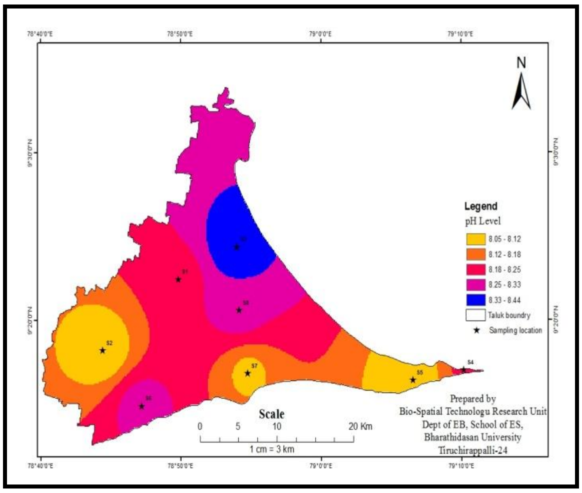

Figure 2: *pH Distribution in the Study Area*

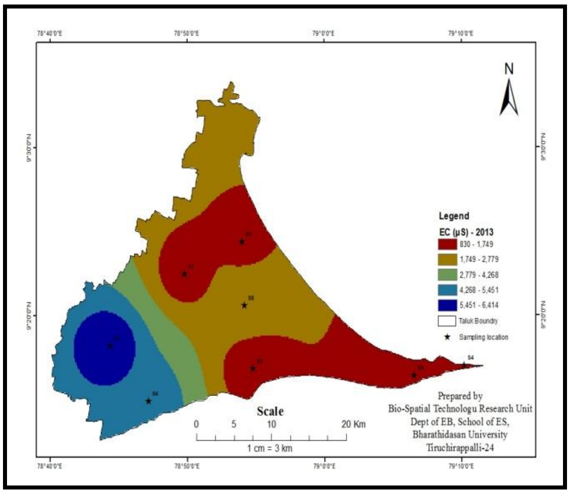

Figure 3: *EC Distribution in the Study Area*

The high TDS content may be assumed ground water through small pockets of waterlogged area as reported earlier (Palanivelu et al., 2006). It was reported that TDS value greater than 1000 mg/l may cause gastrointestinal irritation to the consumer (Giridharan et al., 2008). In the present study area, the amount of Total hardness of the ground water samples ranged between 145 to 1160 mg/l (Figure 5). From these values, the carbonate type nature in all ground water samples respectively, representing that the studied samples could be grouped as hard water. In a similar study in India, majority of the samples fall in very hard category (> 300 mg/l $CaCO_3$) (Balakrishnan et al., 2011).

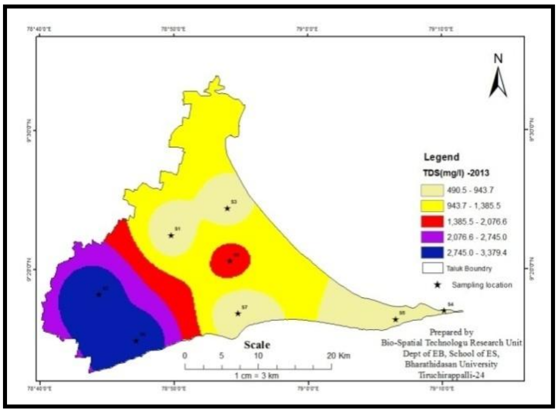

Figure 4: *TDS Distribution in the Study Area*

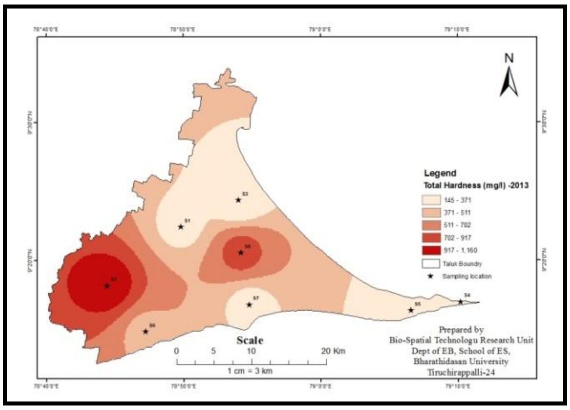

Figure 5: *Total Hardness Distribution in the Study Area*

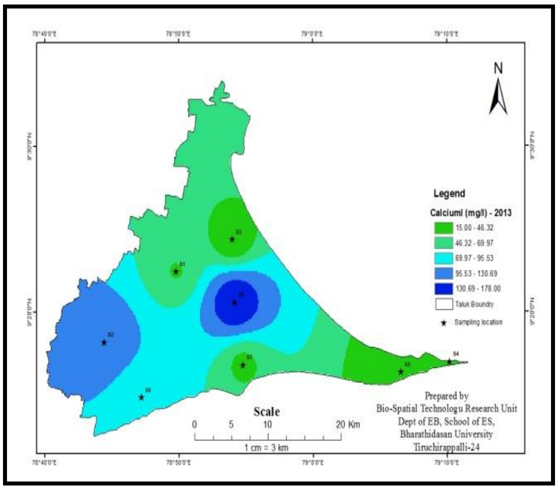

Figure 6: *Calcium Distribution in the Study Area*

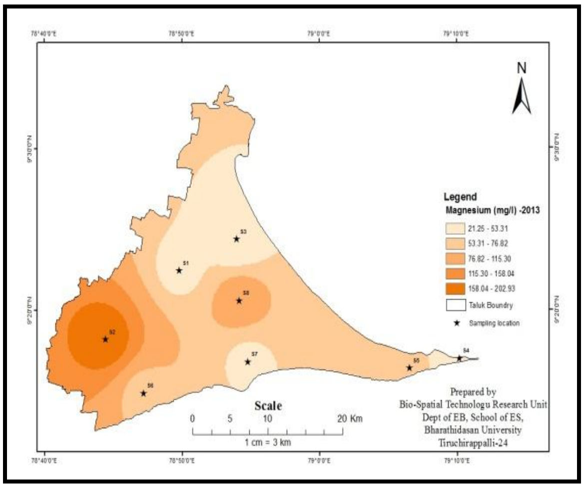

Figure 7: *Magnesium Distribution in the Study Area*

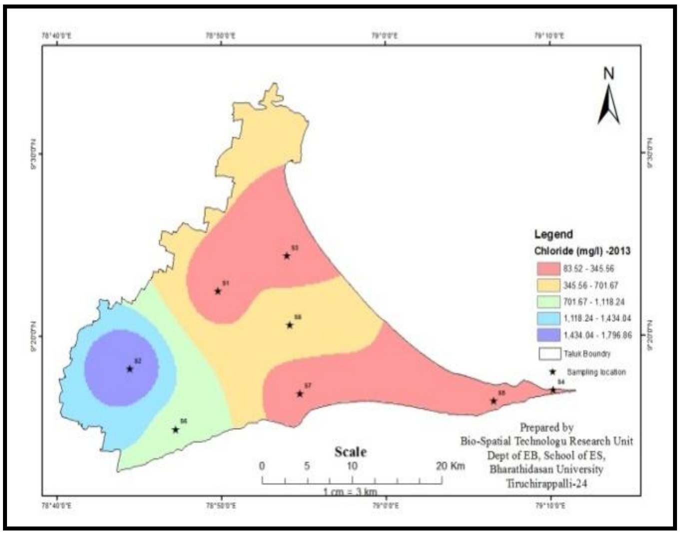

Figure 8: *Calcium Distribution in the Study Area*

The samples were estimated with high Calcium values varied from 15 mg/l to178 mg/l (Figure 6) and Mg hardness were 21.5mg/l – 202.95 mg/l (Figure 7). The chloride content ranged from 83 to 1797 mg/l and 10 to 2,000 mg/l (Figure 8) in the region aquifers respectively. The spatial distribution of the ground water quality parameters such as electrical conductivity, Total dissolved solids, Total hardness, calcium; magnesium and chloride were increased in surrounding of uthirakosamangai due to the sediment deposition rates in Uthirakosamangai tank and Gundar River. The geomorphology of western part of the study area has alluvial plain and the land also formed by flood basin deposits; it is observed that the high values are occurred in the west part of Ramanathapuram taluk. Anthropogenic activities are one of reason for the contamination of ground water quality. Keelakarai town panchayat is one of the important pilgrim areas so anthropogenic activities are increased in past three decades and sea water intrusion into the aquifer effect of ground water contamination.

5. Conclusion

The study has been concluded that the spatial distribution of ground water quality could be predict and assessed the distribution of ground water quality for the entire study area. It was found that the maximum parameters were highly distributed in western part of the Ramanathapuram taluk due to the geomorphology condition, soil formation and presence of gundar river deposition, salt water intrusion and also urbanization, are the major factors to damage ground water quality. So the study area needs effective management planning strategies to conserve the eater potential for public utility.

Acknowledgement

The authors are thankful to Natural Resources Development System - Department of Science and Technology, Government of India, New Delhi, for their financial assistance to the research work.

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