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Geochemical and Geophysical Assessment of Groundwater Quality and Suitability for Drinking Purposes in and around Udangudi Area, Tuticorin, Tamilnadu, India

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Abstract

Investigation has been made to identify groundwater vulnerability to pollution by using geoelectric and hydrochemical investigations in an around Udangudi area, Tamilnadu state of India. Schlumberger vertical electric soundings were carried out in 15 locations and groundwater samples collected from bore wells in the same locations. The resistivity value of the geological layers 15Ωm up to a depth of 20m which indicate that the aquifer polluted by seawater intrusion or other man made activities such as sewage management and agricultural practices. Dominant of sodium and chloride ions found in the study area from geochemical part of analysis. The calculated WQI values for the 15 water samples in the study area ranged from 19.5 to 85.Geochemical part of this study revealed that 33% of samples were poor quality and not suitable for drinking purpose

Keywords:* *Water Quality Index, Schlumberger, Vertical Electrical Sounding

1. Introduction

The groundwater is the major source for human survivals. It is mainly used for domestic, irrigation and industrial purpose all over the world.Groudwater act a vital role in arid and semiarid regions across the world for the production of food through irrigation. India is the well known agricultural based country. Rural areas in India, about 85% population mainly depends on groundwater for their daily need and approximately 50-80% of the irrigated land consumes groundwater for its development .The quality of groundwater is important for determining its uses for domestic, irrigation and industrial purposes. Groundwater quality degration made by human related activities and geochemical change. Detoriation of groundwater is affect usage of drinking, agriculture and industrial activities (Brindha and Elango 2011).one third of deaths in the developing countries and about 80% of the diseases are caused by contaminated drinking water (WHO 2004). Similar to India, around 80% of all diseases are related to poor drinking water quality and polluted conditions (Olajre and Imeokparia 2001). Physico-chemical parameters along with some calculated hydrogeochemical parameters and graphical representations are used to delineate suitability of groundwater for agricultural, municipal, industrial and domestic water supplies. Different researchers have done geochemistry of groundwater in Tirunelveli district. A detailed groundwater quality study for the drinking and irrigation purpose has not been reported in Udangudi area, Tuticorin, Tamilnadu. The aim of the present study is to assess the hydrochemistry and groundwater quality for drinking usage from Udangudi area located in Tuticorin district, Tamilnadu.

Geophysical method is one of the most efficient and recent techniques for groundwater quality and quantitative assessment. Geophysical investigations have evolved a rapid and simple approach for groundwater potential (Shahid and Nath, 2002), (Teeuw, 1999), and (Srivastava and Bhattacharya, 2006). The Vertical Electrical Sounding (VES) mainly useful tool for identify seawater intrusion (Sung-Ho S. et al 2006).

In the present study combined analysis of geophysical and hydro-chemical data were performed to reveal the seawater intrusion. By correlating geophysical and hydrogeochemical data with the earth resistivity and TDS empirical relation which used to identify the saline, fresh and brackish water zone.

2. Study Area

Udangudi area is situated in the southeast coast of bay , Tamilnadu. The geographical extent of the study area lies between $8^{0}25'30''$ North to latitudes and $78^{0}1'30''$ East longitudes. There is soil in red colour is locally called Kudiraimoli teri sand it contain sand grains of quartz, feldspar and garnet. This area comes mostly in plain terrain with a gentle slope. The study area receiving an average rainfall of 280mm,the highest rainfall occur in North East monsoon .The study area experiences subtropical climate conditions and poor precipitation in yearlong.

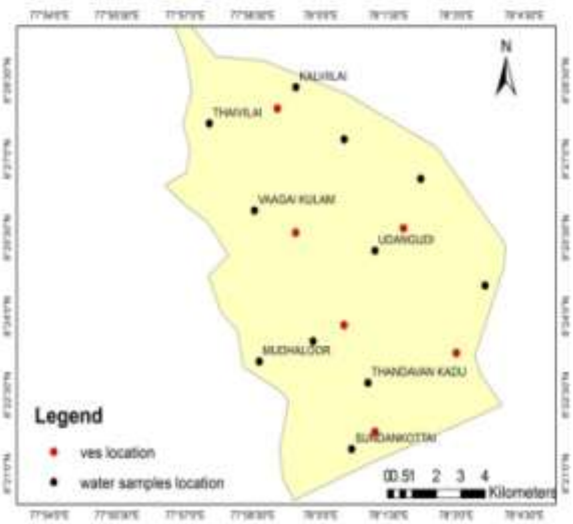

Fig.1: Study area map

3. Materials and Methods

A total number of fifteen water samples were collected in different sites in and around tuticorin from open wells, borewells and handpumps which were used for irrigation and drinking purposes. The water samples were collected after 10 minutes of pumping to remove stagnant water from the well. The high density polyethylene bottles with one litre capacity used for sample storage. The bottles were washed with dilute HNO_3 acid and distilled water in the laboratory. To avoid contamination each bottle was rinsed with samples. All the sample bottles were sealed with parafilms and double capped. Each bottle labeled with sample id from 1 to 25 and transferred into the laboratory for analysis at $4^{o}C$.

The instrument HANNA portable water quality meter (HI-928, USA) was used to measureinsitu field parameters like pH, electrical conductivity (EC),and total dissolved solids (TDS).Total hardness (TH), calcium, bicarbonate and chloride were estimated by titrimetric methods. The concentration of magnesium was estimated by the difference between hardness and calcium. The potassium and sodium concentrations were estimated by the instrument flame photometer, Deep Vision, Model-381.The concentrations of nitrate and sulfate ion were estimated by the instrument UV-Visible spectrophotometer model381. The analytical procedures proposed by the American Public Health Association (APHA1995).The aim of electrical geophysical prospecting to determine the resistivity of the subsurface soil with large number of measurement made from surface of ground (Telford et al. 1990; Store et al. 2000).Schlumberger Vertical Electrical Sounding (VES) survey were carried out at six locations in the study area with the maximum electrode spacing of 100m.The current electrode and potential electrode spacing varied from 1-100m and 0.5 to 10m respectively. The field data was interpreted by IPIWIN software (Bobachev 2002). The collected data are treated using ArcGIS for analysis and visualization.ArcGIS software was used for data analysis and further visualization.

4. Results and Discussion

The physicochemical data of groundwater are given in Table1.

Table 1: Physical and chemical properties of tube well as per IS 10500-2012

S. No	Parameter	Unit	Accept Limit	Avg	Max	Min
1	pH	-	6.5-8.5	7.2	7.5	6.8
2	EC	µS/cm		2487	8090	868
3	Total Dissolved Solids	mg/l	500	1591	5177	555
4	Calcium	mg/l	75	124	259	52
5	Chloride	mg/l	250	578	2234	102
6	Magnesium	mg/l	30	103	432	26
7	Sulphate	mg/l	200	148	321	29
8	Total Hardness	mg/l	200	729	2223	236
9	Sodium	mg/l	-	246	780	73
10	Pottasium	mg/l	12	45	198	4
11	Bicarbonate	mg/l	120	332	456	224

4.1 Water Quality Index:

The calculated WQI values for the 15 water samples in the study area ranged from19.5 to 85.The water sample 3,8,9,6 were very poor or unsuitable for drinking. It may occur due to saline water intrusion those samples were taken from the near coastal area. The samples 1,2,4,7 being under marginal condition and 10,5,12 were fair. The only one groundwater sample 11 was consider as good for drinking purpose (Hurley T , et al.,2012) (Fig.2 and table 3). The low WQI calculated for this study area because of high values of pH, EC, TDS, Ca, Mg, HCO_3, Cl, Na, K, SO_4 and total hardness.

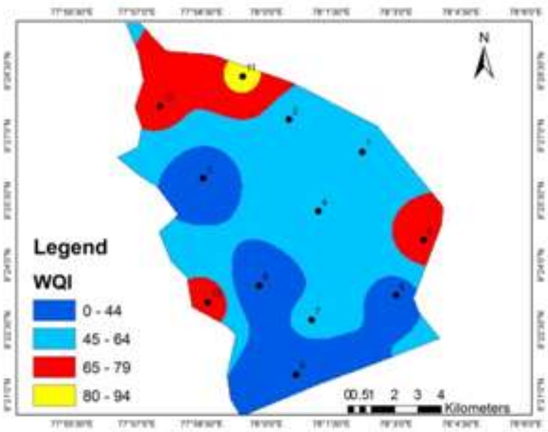

Figure 2: Spatial distribution map of Water Quality Index

Based on WQI of British Colombia the water quality index was developed by Canadian council is called as Canadian quality index (CWQI). The CWQI can be calculated using the following equation. In this equation i) Scope – F_1, ii) Frequency – F_2, iii) Amplitude – F_3. The calculated value as shown in table 2 for using equation 1. (Asohk Lumb, et al., 2006)

$$CWQI = 100 - \sqrt{(F_1^2 + F_2^2 + F_3^2)}/1.732 \quad (1)$$

a. Relation between TDS and Geoelectrical resistivity

The total amount of dissolved solid present in water is called TDS. The unit of TDs is milligram/litre. Dissolved solids contain dissolved mineral ion such as sodium, chloride, bicarbonate, sulphate, calcium, magnesium, potassium and other ions. More salt dissolved in water has higher electrical conductivity value. The relation between TDS and conductivity is given in equation 2 (APHA 2005).

$$\text{TDS (mg/L)} = 0.64.\text{EC } (\mu\text{S/cm}) \quad (2)$$

Groundwater quality can be classified based on TDS into four types. Total Dissolved Solid is less than value of 1000 mg/l called fresh water. Total Dissolved Solid is between the value of 1000 and 10000mg/l is called brackish water and the TDS value range from 10000 to 1000000mg/l is called saline water (Todd 1980). Electrical conductivity EC is capability of water to conduct the flow of electricity through it such that the enrichment of salts in the groundwater provides higher value of EC. Based on the salt enrichment the groundwater can be classified into type I (Low- EC less than 1500µS/cm), type II (Medium -1500 and 3000µS/cm) and typeIII (High-greater than 3000 µS/cm;

Geoelectical method is one of the valuable tool for asses water tables, impermeable formations, depths to bedrock and salinity of groundwater(Todd 1980). The vertical electrical sounding survey reveals various hydrogeological conditions in the subsurface of the study area varying between highly saline area and fresh water region. The station ves1 found to have 4geoelectrical layers with different resistivities (Ωm) 286, 42, 29, 5. The station 2 found to have three geoelectrical layers with different resistivities (Ωm) 1, 7, 6, 35, 2. The station3 found to have four geoelectrial layers with different resistivities (Ωm) 364, 603, 11,754. The station4 found to have four geoelectrial layers with different resistivities (Ωm) 119, 58, 188, 10. The station5 found to have four geoelectrial layers with different resistivities (Ωm) 349, 84, 14, 1.8. The station6 found to have four geoelectrial layers with different resistivities (Ωm) 401, 93, 32, 650 Ωm.

Resistivity is a measurement of water obstruction to the flow of electrical current over a distance. The ionic concentration in water increases that decrease the electrical resistivity because the resistivity and conductivity are inverse in relation. The low resistivity indicates the salty water (Srinivas Y, et al., 2015). The VES stations 1, 2 and 3 were found to have low aquifer resistivity value. This result is highly correlated with TDS of the study area water samples which strongly influenced by saline water intrusion (Fig 3).

Table 2: Calculated parameters and CWQI

F1	F2	F3	CCME WQI
45.5	45.5	30.8	58.9
45.5	45.5	25.9	60
81.8	81.8	53.8	26.3
27.3	27.3	52.3	62.5
27.3	27.3	8.3	77.2
63.6	63.6	58.8	37.9
54.5	54.5	41	49.6
81.8	81.8	71.2	21.6
81.8	81.8	77.7	19.5
27.3	27.3	1.7	77.7
18.2	18.2	2.8	85.1
36.4	36.4	13.3	69.3

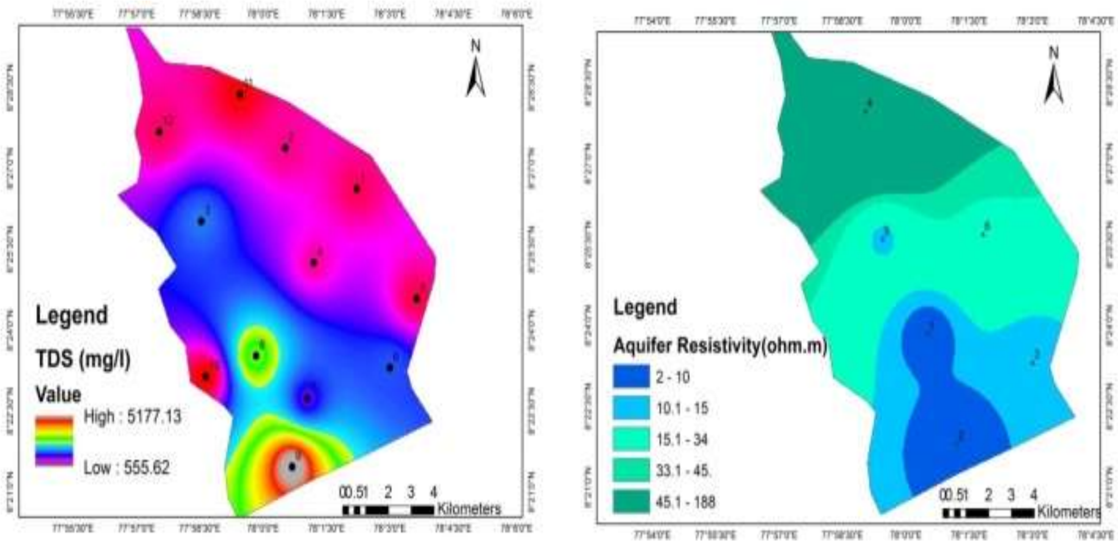

Fig. 3: Spatial distribution map of TDS and aquifer resistivity

Table3: Groundwater quality based on WQI

Rating of Water Quality	WQI Value	Water Samples
BAD	0-44	3,8,9,6
MARGIN	45-64	1,2,4,7
FAIR	65-79	10,5,12
GOOD	80-94	11
EXCELLENT	95-100	--------

5. Conclusion

The groundwater chemical composition and suitability for irrigation were evaluated for this study. The abundance of the major ion is as follows: Na>Ca>Mg>K and $Cl>HCO_3>SO_4$. The sodium anion and calcium cations were the major ions in the study area. Geochemical part of this study revealed that 33% of samples were poor quality and not suitable for drinking purpose. Similarly 33% of samples were under the marginal category. So it's also not suitable for drinking. The TDS value in near the coastal area was very high. The average values of TDS, Ca, Cl, Mg, Total hardness, K, and HCO_3 were exceeded IS accept limit. It may occur due to anthropogenic activities and saltwater intrusion. The geophysical part of the study revealed that four geoelectical layer was found in the study area. The VES1, VES2, VES3 have found fourth layer aquifer resistivity is too low at considerable depth due to saltwater intrusion. The TDS and aquifer resistivity value were correlated; it indicates the low quality of water due to saltwater intrusion.

References

[1] Brindha K. and Elango L. 2011.Hydrochemical characteristics of groundwater for domestic and irrigation purposes in Madhuranthakam, Tamil Nadu, India Earth Sci. Res. J. vol.15

[2] WHO 2004 guidelines for drinking water quality. Revision of the 1993 guidelines. FindTask Group Meeting Geneva, 21-25 September, 1992.

[3] Olajire A. A. and Imeokparia F. E.Environmental Monitoring and Assessment 2001, Volume 69, Issue 1, pp 17–28 | Cite as Water Quality Assessment of Osun River: Studies on Inorganic Nutrients Authors and affiliations.

[4] Shahid S and Nath SK (2002) GIS integration of remote sensing and electrical sounding data for hydrogeological exploration. J Spat Hydrol 2(1):1–12

[5] Teeuw RM (1999) Groundwater exploration using remote sensing and a low-cost geographical information

[6] system. Hydrogeol J 3:21–30

[7] Srivastava PK, Bhattacharya AK (2006) Groundwater assessment through an integrated approach using remote sensing, GIS and resistivity techniques: a case study from a hard rock terrain. Int J Remote Sens 27(20/20):4599–462.

[8] Sung-Ho S. Jin-Yong Lee. Namsik Park. 2006,Use of vertical electrical soundings to delineate seawater intrusion in a coastal area of Byunsan, Korea Environ Geol 52:1207–1219 DOI 10.1007/s00254-006-0559-8.

[9] APHA (1995) Standard method for the examinations of water and wastewater, 19th edn. American Public Association, Washington.

[10] Telford, W.M., Geldart, L.P., & Sheriff, R.E. (1990). Applied Geophysics. Cambridge University Press.770 pp.

[11] Store, H., Storz, W., & Jacobs, F. (2000).Electrical resistivity tomography to investigate geological structures of earth's upper crust. Geophysical Prospecting, 48, 455–471.

[12] Hurley T. Sadiq R. Mazumder A. 2012 Adaptation and evaluation of the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) for use as an effective tool to characterize drinking source water quality. Water Res, 46:3544–3552.

[13] Asohk Lumb, Halliwell D, Triben Sharma (2006) Application of CCME Water Quality Index to Monitor Water Quality: A Case Study of the Mackenzie River Basin, Canada. Environ Monit Assess , 113:411–429 DOI: 10.1007/s10661-005-9092-6.

[14] Todd DK (1980) Ground water hydrology. John Wiley& Sons, New York, p. 419.

[15] American public health Association (APHA) 2005 Standard methods for examination of water and wastewater,21st den. APHA, AWWA, WPCF, Washington.

[16] Srinivas Y. Oliver D.H. Raj .A.S. Chandrasekar N. 2015.Geophysical and geochemical approach to identify the groundwater quality in AgastheeswaramTaluk of Kanyakumari District, Tamil Nadu, India, Arab J Geosci 8:10647–10663 DOI 10.1007/s12517-015-1989-y