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GROUNDWATER QUALITY MONITORING FOR PTR-1 WATERSHED IN AKOLA DISTRICT, MAHARASHTRA, INDIA USING GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING TECHNIQUES

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Abstract: Water is an important natural resource of the Earth and plays a vital role in our life. Surface water and groundwater are the major sources of water. The surface water qualities of major river basins are contaminated by the municipal and industrial discharges. Mapping of spatial variability of surface water quality is of vital importance and it is particularly significant where it is primary source of potable water. Groundwater has become a necessary resource over the past decades due to the increase in its usage for drinking, water supply, irrigation an industrial uses etc. Ground-water is a favourite alternative is now facing threats due to anthropogenic activities. The groundwater quality is equally important as that of quantity. In order to assess the water quality the present study has been undertaken to map the spatial variability of water quality using Geographical Information System (GIS) approach. The groundwater quality of 7 wells randomly distributed in PTR-1 was selected for the present study. GIS is a powerful tool for representation and analysis of spatial information related to water resources. The major water quality parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids, Total hardness, Sulphates and Chlorides have been estimated for all the sampling locations. The spatial variation maps of these groundwater quality parameters were derived and integrated through GIS. The final integrated map shows three priority classes such as High, Medium and Low groundwater quality zones of the study area and provides a guideline for the suitability of groundwater for domestic purposes.

Keywords: GIS**,** Groundwater, drinking-water, physicochemical parameters, spatial interpolation

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INTRODUCTION

Groundwater is one of the most impotent natural resources. Due to rapid growth of population and anthropogenic activities the quality of groundwater is deteriorating day by day. Fresh water has become a scarce commodity due to over exploitation and pollution of water. The possibility of contamination of river water is due to the mixing of toxic chemicals, fertilizers and improper disposal of liquid wastes from the industries. (Ravi Shankar and Mohan 2006). In the absence of appropriate waste management strategies, many human activities and their by-products have the potential to pollute surface and subsurface water. Acute short fall of monsoon rains, poor watershed management, lavish use of water for domestic and agricultural purposes have led to the overexploitation of the surface water sources especially from the river bodies. On the other hand, surface water bodies become the dumping source for industrial effluent and domestic wastes. As a result, the naturally existing dynamic equilibrium among the environmental segments get affected leading to the state of polluted rivers. Hence monitoring of surface water quality has become indispensable. Sur-face water quality depends on various parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids, Ca, TH, Nitrate etc. A similar approach was adopted by Rangzan et al. (2008) where GIS was used to prepare layers of maps to locate promising well sites based on water quality and availability. Babiker et al. (2007) proposed a GIS-based groundwater quality index method which synthesizes different available water quality data (for example, Cl, Na, SO4) by indexing them numerically relative to the WHO standards. Water quality assessment involves evaluation of the physical, chemical, and biological nature of water in relation to natural quality, human effects, and intended uses, particularly uses which may affect human health and the health of the aquatic system itself (UNESCO/WHO/UNEP, 1996). The use of GIS technology has greatly simplified the assessment of natural resources and environmental concerns, including groundwater. In groundwater studies, GIS is commonly used for site suitability analyses, managing site inventory data, estimation of groundwater vulnerability to contamination, groundwater flow modelling solute transport and leaching, and integrating groundwater quality assessment models with spatial data to create spatial decision support systems (Engel and Navulur, 1999). The present study attempts to map the spatial variation of surface water quality parameters for PTR-1 using GIS. GIS is an effective tool for water quality mapping and essential for monitoring the environmental change detection. The water samples were collected from 7 locations randomly distributed in the study area. The physiochemical parameters namely pH, Electrical Conductivity (EC), Total Dissolved Solids, Ca, Th, Nitrate etc of the samples were analyzed. Considering the above aspects of groundwater contamination and use of GIS in groundwater quality mapping, the present study was undertaken to map the groundwater quality in PTR-1 watershed in the

Akola district of Maharashtra, India. This study aims to visualize the spatial variation of certain physicochemical parameters through GIS and also GIS is used to assess the existing condition of surface water quality and the contaminated areas can be identified for further monitoring and management. The main objective of the research work is to make a groundwater quality assessment using GIS, based on the available physicochemical data from 7 locations in PTR-1 watershed in the Akola district of Maharashtra. The purposes of this assessment are (1) to provide an overview of present groundwater quality, (2) to determine spatial distribution of groundwater quality parameters such as Hardness, pH, EC, TDS, Na, and Ca, etc. and (3) to generate groundwater quality zone map for the PTR-1 watershed. Also the present study encourages the stake holders of the PTR-1 for its suitability for drinking purposes.

Study Area

The study area lies in the Survey of India topographic sheets No. 55H /6, is bounded by Latitude of 20°51’ to 20° 51’ and Longitude of 77° 18’ to 77° 32’, (Figure 1) and is located at Akola District**.** Average annual rainfall is about 900 mm and the mean daily temperatures for the same period range from 40°C in winter to over 46°C in summer. The area of investigation is characterized by the presence of Deccan Trap lava flows with minor occurrence of alluvial zone. Soils in the area are basically derived from basaltic lava flows and alluvial deposits. The soils in the vicinity of part of Purna River are generally deep black to dark brownish grey in colour with calcareous concretions. Land use / Land cover: vegetation and manmade features and omits bare rocks and water. In the study area agriculture is the main land use. Other than the agriculture the area comprises of wasteland, forest land, water bodies and built up.

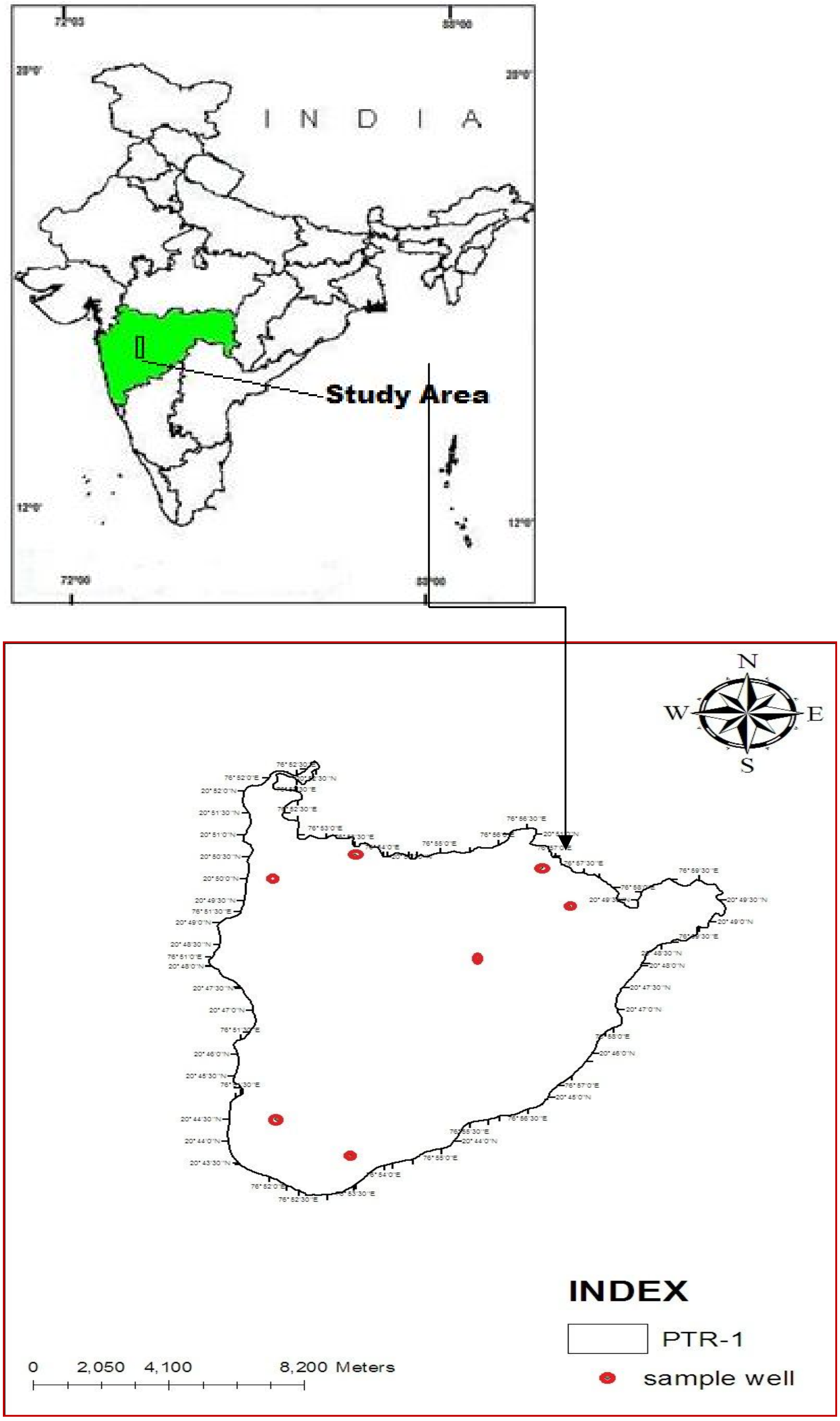

Fig. 1. Location map of the Study Area

Methodology

The water samples collected from 7 sampling stations was tested for physio-chemical parameters and compared with the prescribed drinking water standards by WHO. The samples taken during September 2013. Bottles used for water sample collection are first thoroughly washed with the water being sampled and then were filled. After collection of the samples, the samples are preserved and shifted to the laboratory for analysis. The major parameters namely pH, Elec-trical Conductivity (EC), Total Dissolved Solids, TH, Nitrate and Ca and these parameter compared with standard values recommended by World Health Organization (WHO, 1993) and Indian Standards Institution (ISI, 1991) (Table 1).

Table1. Parameters and recommended permissible and Desirable limits of Drinking water

Sr. No.	Water Quality Parameters	WHO (1984) Standard accept Max	Max allow limit limit	ISI (1983) Standard Max	Max allow accept limit Limit	Range in study area (mg/1)
1.	EC	1400	-	-	-	388 - 2020
2.	pH	6.5	8.5	6.5	9.2	06.8 - 08
4.	TDS	500	1500	-	1500	252 - 1314
5.	Turbidity	75	200	-	200	01 – 02
7.	SO4	-	200	-	-	10 – 33
8.	Fluorides	-	-	-	-	0.9 – 01
9..	Chloride	200	600	250	1000	98 – 1448
10.	Total Hardness as ($CaCO_3$)	100	500		-	184 -2000

Collection of well locations

The flow chart in Figure 2 was followed to develop a groundwater quality classification map from thematic maps based on the WHO (1993) and ISI (1991) standards for drinking water. We obtained the location of 7 wells all over the study area by using a handheld GPS instrument GARMIN GPS-60 receiver. GPS technology proved to be very useful for enhancing the spatial accuracy of the data integrated in the GIS. We utilized Arc GIS software in our study. Based on the location data we obtained, we prepared point feature showing the position of 7 wells (Figure 1). From these wells, we collected and analyzed groundwater samples for the study area. The water quality data thus obtained forms the non-spatial database. It is stored in excel format and linked with the spatial data by join option in Arc Map. The spatial and the non-spatial database formed are integrated for the generation of spatial distribution maps of the water quality parameters. For spatial techniques approach in GIS has been used in the present study to delineate the locational distribution of groundwater pollutants. Other spatial interpolation techniques include Cokriging, Spline etc. Kriging is based on the presence of a spatial structure where observations close to each other are more alike than those that are far apart (spatial autocorrelation) (Robinson and Metternicht, 2006; Goovaerts, 1999). In this method the experimental variogram measures the average degree of dissimilarity between unsampled values and a nearby data value (Deutsch and Journel, 1998) and thus can depict autocorrelation at various distances. From analysis of the experimental variogram, a suitable model (for example spherical and exponential) is derived by using weighted least squares and the parameters (for example range nugget and sill). Some advantages of this method are the incorporation of variable interdependence and the available error surface output. A disadvantage is that it requires substantially more computing and modelling time and spatial techniques requires more input from the user.

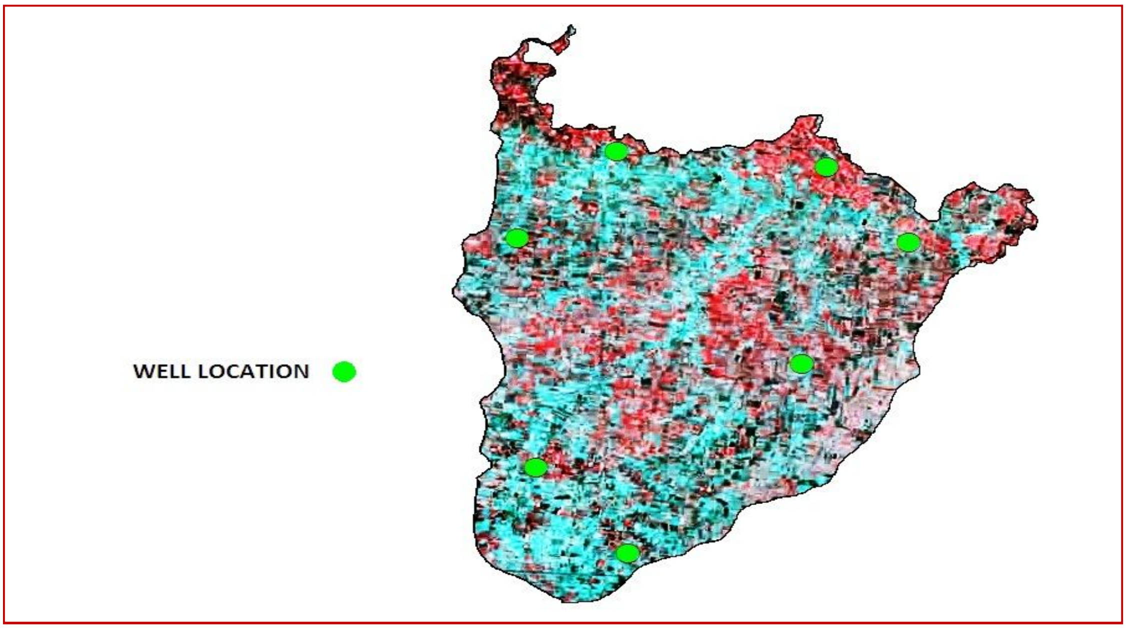

Fig. 2. Landsat satellite image of PTR-1 watershed in 2013

Generating groundwater quality map

The base map was georeferenced and digitized by using ARC GIS-10.1 software and exported to Arc view software for spatial analysis. Spatial interpolation technique through Inverse Distance Weighted (IDW) approach has been used in the present study to delineate the distribution of water pollutants. The Inverse Distance Weighted (IDW) referred to as deterministic interpolation methods because they assign values to locations based on the surrounding measured values and on specified mathematical formulas that determine the smoothness of the resulting surface. This method uses a defined or selected set of sample points for estimating the output grid cell value.**Results and discussion**

The spatial and the attribute database generated are integrated for the generation of spatial variation maps of major water quality parameters like pH, Electrical Conductivity (EC), Total Dissolved Solids, Ca, and Th. Based on these spatial variation maps of major water quality parameters, an Integrated Groundwater quality map of PTR-1 was prepared using GIS. This integrated Groundwater quality maps helps us to know the existing groundwater condition of the study area. pH is one of the important parameters of water and determines the acidic and alkaline nature of water. The pH of the good quality water ranges from 7 to 8.3. The pH of the samples was well within the prescribed standards for drinking water. The spatial variation map for pH was prepared and presented. The pH of analysed sample varies from **4.6 to 5** for pre monsoon of 2013.

Table 2. Showing values of various physic-chemical parameters.

Sr_no	Village	Lat_dd	Long_dd	pH	EC	TDS	Turbidity	hardness total	Cl
1	Gaigaon	20,43,0	76,54,13	7.4	2150	1376	2	472	200
2	Manali	20,43,29	76,53,9	7.6	2130	1363	2	152	60
3	Nimkarda	20,44,1	76,52,16	7.5	2080	1331	1	564	192
4	Hata	20,53,6	76,48,51	7.7	2720	1741	2	424	160
5	Hatrun	20,49,35	76,52,43	7.8	2530	1619	1	852	322
6	Morzadi	20,48,35	76,51,56	7.7	181	116	2	264	96
7	Lonagra	20,49,46	76,55,15	7.5	13280	8499	1	1888	1388

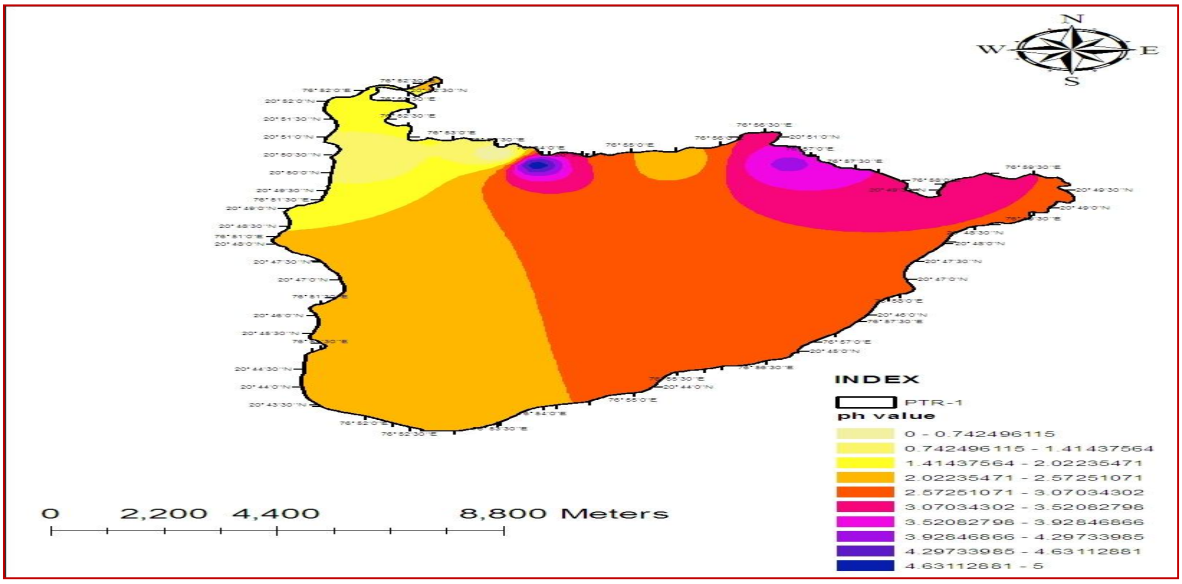

Fig. 3. pH spatial distribution in PTR-1 watershed area.

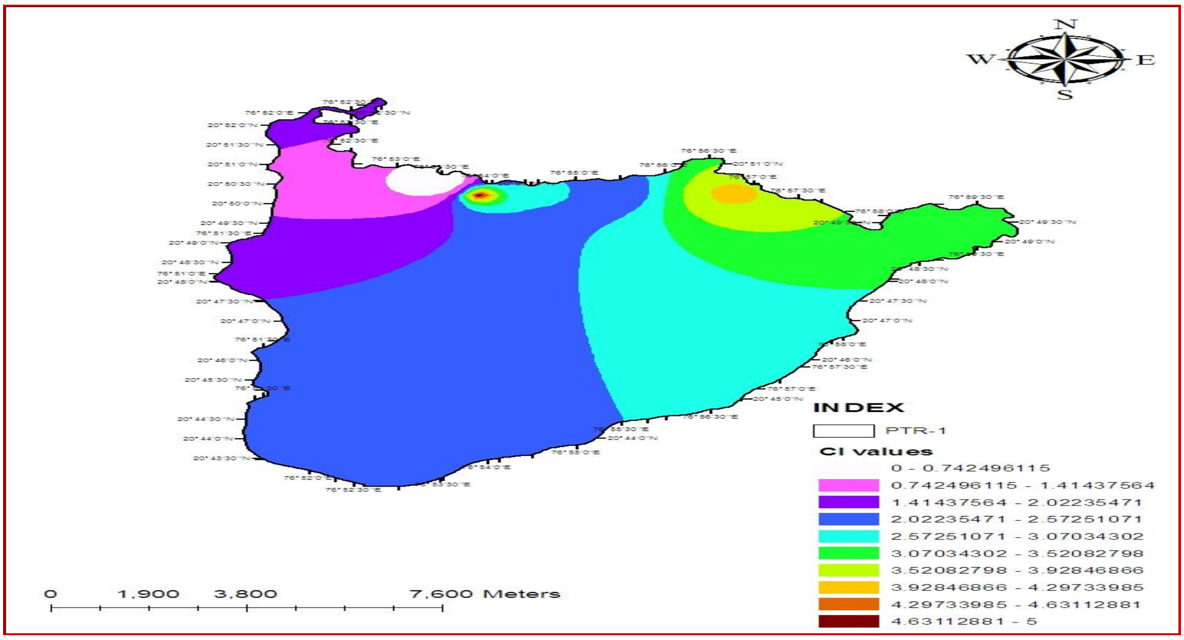

Fig. 4. Cl spatial distribution in PTR-1 watershed area.

Chloride (Cl)

The Chlorides was classified in to three ranges (0-250 mg/l, 250-500 mg/l and >500 mg/l) and based on these ranges the spa-tial variation map for chlorides has been obtained and presented in Fig 3. It is minor constituent of the earth's crust. Rain water contains less than 1 ppm Chloride. Chloride in drinking water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt, and saline intrusion (WHO, 1993). Its concentration in natural water is commonly less than 100mg/L unless the water is brackish or saline (Fetter, 1999). High concentration of chloride gives a salty taste to water and beverages and may cause physiological damages. In the present study Water with high chloride content usually has an unpleasant taste and may be objectionable for some agricultural purposes. The maximum chloride concentration in the study area is **1420 to 90** which indicates that the groundwater can be grouped as 'High chloride' water.

Electrical Conductivity (EC)

Electrical conductivity is the ability of a substance to conduct an electrical current, measured in micro-siemens per centimeter (mS/cm). Ions such as sodium, potassium, chloride give water its ability to conduct electricity. Conductivity is an indicator of the amount of dissolved salts in a stream often is used to estimate the amount of total dissolved solids (TDS) rather than measuring each dissolved constituent separately. The ability of a cube 1 cm. on a side to conduct an electrical current is called electrical conductivity; this is the reciprocal of resistivity and is measured in mhos. Since, mho is too large a unit for fresh water, micromho is used. This is a function of temperature and the kind of ions present and the concentration of other ions. These readings are adjusted to 25^0c so that variation in conductivity is a function only of the dissolved ions in water. Hence, the unit in micromhos/cm at 25^0c. The range of electrical conductivity (EC) in the area is **2010 to 380** for pre monsoon of 2013.

Total Dissolved Solids

The mineral constituents dissolved in water constitute dissolved solids. The concentration of dissolved solids in natural water is usually less than 500 mg/L, while water with more than 500 mg/L is undesirable for drinking and many industrial uses. Water with TDS less than 300 mg/L is desirable for dyeing of cloths and the manufacture of plastics, pulp paper, etc. (Durfer and Baker, 1964). The total concentration of dissolved minerals in water is a general indication of the over-all suitability of water for many types of uses. Subba Rao et al. (1998) and Deepali et al. (2001) reported that TDS concentration was high due to the pre- sence of bicarbonates, carbonates, sulphates, chlo- rides and calcium. TDS can be removed by reverse osmosis, electro dialysis, exchange and solar distillation process. It is the concentration of non-volatile substances present in the water in molecular dispersed and colloidal state. Due to surface & subsurface movement of water, it contains a wide variety of dissolved inorganic chemical constituent in various amount. Fundamentally, it is based on concentration of NaCl, which in turn determine the conductivity which has a bearing on TDS. Conversion between TDS and conductivity in micro siemens or micromho's/cm. at 25^0, TDS in ppm. and varies between 0.55–0.75. A value of 0.90 has been arrived at Sawayer and McCarthy, (1967); Walton, (1970) gave a relation that for groundwater in the range of 100–5000 micromoho's / cm at 25^0C in the study area ranges between **250 to 1300** for pre monsoon of 2013 (Table 3).

Table 3. Water quality standards

T D S	Water Quality
< 1000	Fresh
1000-10000	Brackish
10,000 – 1,00,000	Saline
> 1,00,000	Brine

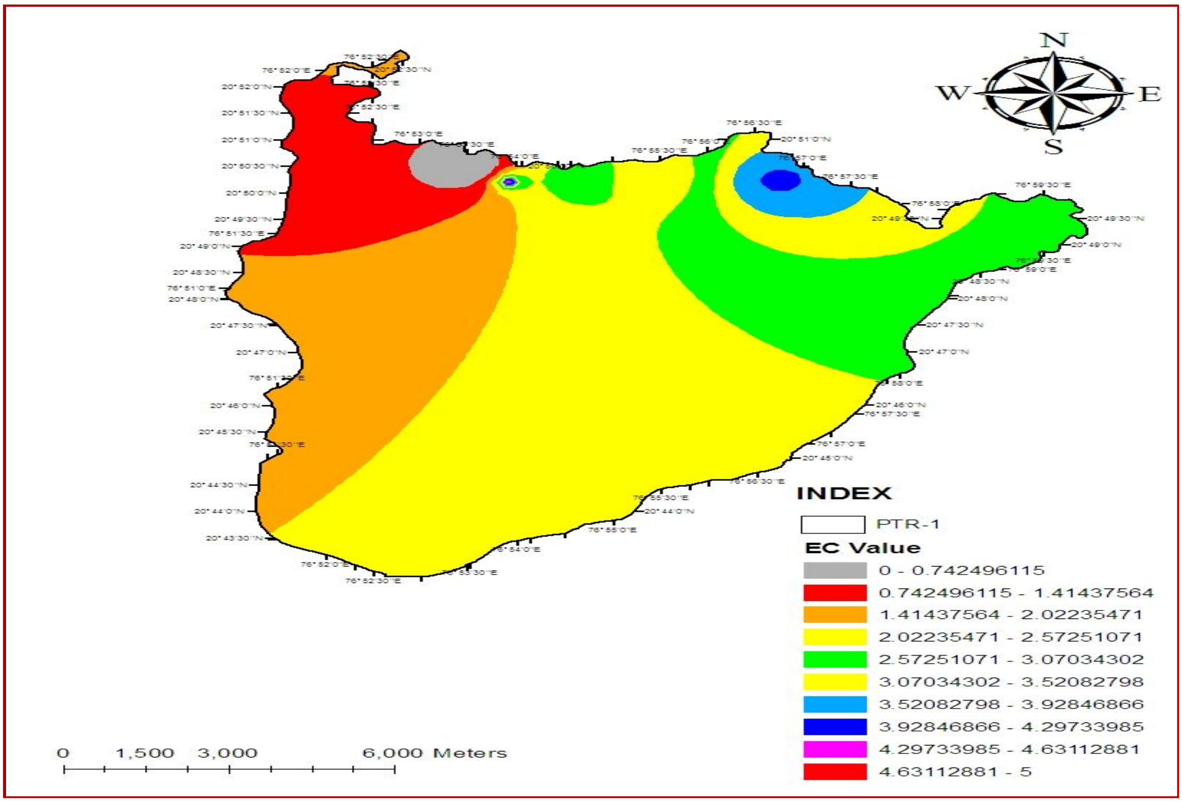

Fig. 4. EC spatial distribution in PTR-1 watershed area.

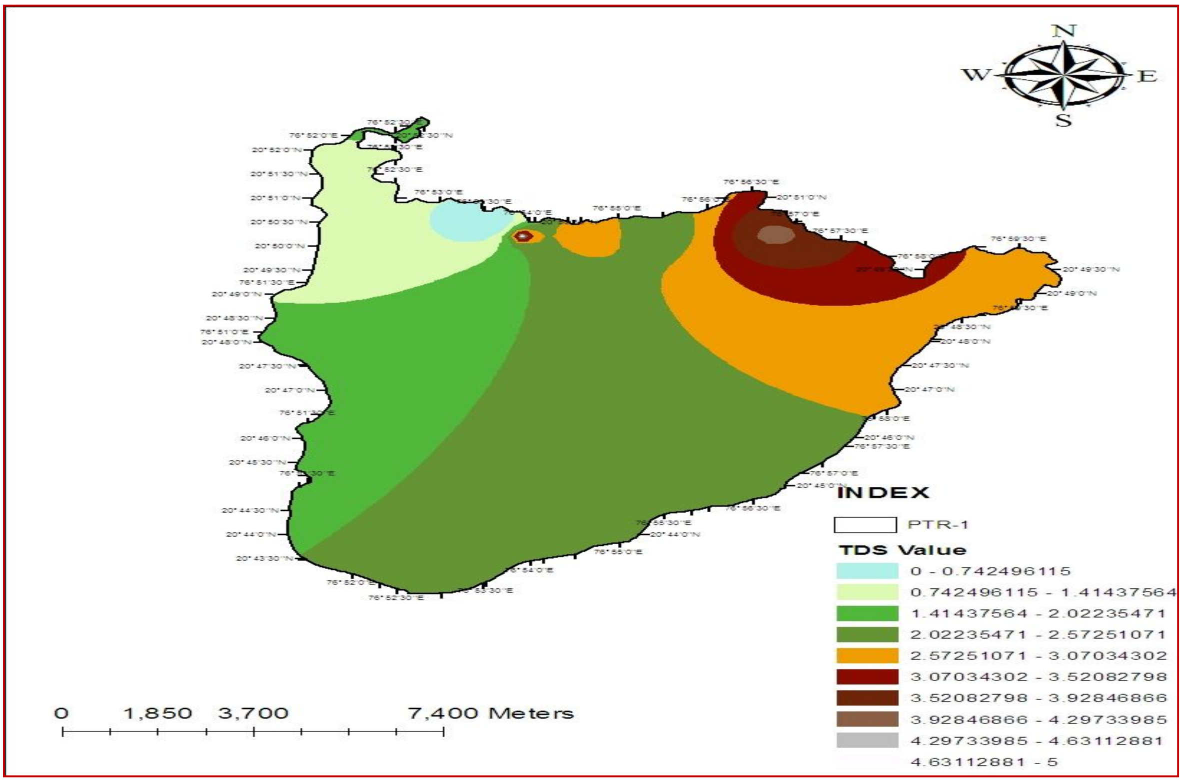

Fig.5. TDS spatial distribution in PTR-1 watershed area.

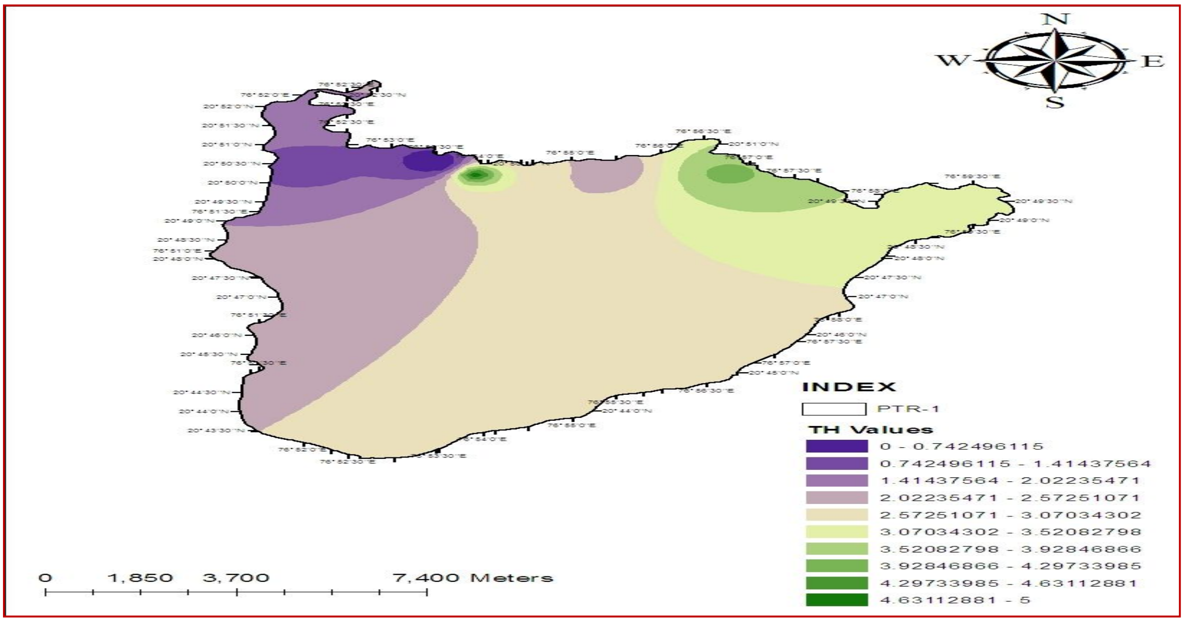

Fig. 6. TH spatial distribution in PTR-1 watershed area.

CONCLUSIONS

Groundwater is the major source of water is now facing threats due to rapid growth of population, urbanization and industrial activities. The groundwater quality is equally important as that of quantity. Groundwater is a valuable natural resource that is essential for human health, socio-economic development, and functioning of ecosystems (Zektser, 2000; Humphreys, 2009; Steube et al., 2009). Considering the above aspects of groundwater contamination and use of GIS in groundwater quality mapping, the present study was undertaken to map the groundwater quality in PTR-1 watershed in the Akola district of Maharashtra, India. This study aims to visualize the spatial variation of certain physico-chemical parameters through GIS. The main objective of the research work is to make a groundwater quality assessment using GIS, based on the available physico-chemical data from 8 locations in PTR-1 watershed in the Akola district of Maharashtra. The purposes of this assessment are (1) to provide an overview of present groundwater quality, (2) to determine spatial distribution of groundwater quality parameters such as Hardness, pH, EC, TDS, Na, and Cl, etc. The spatial distribution analysis of groundwater quality in the study area indicated that many of the samples collected are not satisfying the drinking water quality standards prescribed by the WHO and ISI. The government needs to make a scientific and feasible planning for identifying an effective groundwater quality management system and for its implementation. Since, in future the groundwater will have the major share of water supply schemes, plans for the protection of groundwater quality is needed. Present status of groundwater necessitates for the continuous monitoring and necessary groundwater quality improvement methodologies implementation.

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