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SPATIAL DISTRIBUTION OF TOTAL DISSOLVED SOLIDS IN THE GROUNDWATERS OF BANGALORE CITY, KARNATAKA, INDIA.

Shankar B. S.

Professor and Head, Civil Engineering Department, ACED, Alliance University, Bangalore- 560 062, Karnataka, India.

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***Corresponding Author**
Dr. Shankar. B. S.
Professor and Head, Civil Engineering Department, ACED, Alliance University, Bangalore-560062, Karnataka, India.

ABSTRACT

Enhanced level of TDS in drinking water produces harmful effects on human health and aquatic ecology. The present study deals with the spatial assessment of Total dissolved solids (TDS) levels in the ground waters of the industrial zones of Bangalore urban. Three major industrial zones comprising of 8 areas were selected for the study. 30 groundwater samples from each of these areas (total of 240 samples), were analyzed for TDS during the pre-monsoon and post-monsoon periods of 2015. Thus, overall 480 samples in the two seasons were analyzed as per the Standard methods for the examination of water and waste water (APHA, 2002) and the analyses results interpreted as per the Bureau of Indian standards (BIS 10,500: 2003). Based on the analyses results, 20% of the waters from the entire study area have recorded excess TDS concentration (>2000 mg/L) as per the upper limit of BIS, with the Tannery area of Bangalore North being worst affected, with 60% of the samples exceeding the TDS limits. The north, east and south zones recorded 40%, 11% and 16% non-potability due to excess TDS. TDS contours depicting the same have also been presented.

KEYWORDS: Concentration, Groundwater, Pollutant, Total Dissolved Solids.

1. INTRODUCTION

The term solid refers to the matters either filterable of non-filterable that remain as a residue in water i.e. TDS of water includes all soluble materials in solutions whether ionized or non-ionized. It does not include suspended sediments, colloids or dissolved gases.

Total dissolved solids (TDS) represent the total concentration of dissolved substance in the water and one can measure the quality of drinking water based on level of TDS (Akhtar and Tang, 2013). TDS in groundwater originate from natural sources, sewage, urban run-off and industrial wastes. A large number of salts are found dissolved in water. The common ions are bicarbonates, carbonates, chlorides, sulphates, phosphates, calcium, magnesium, sodium, potassium, and iron.

Polluted drinking water is eventually linked to hundreds of thousands of deaths in whole world in every year and is regarded as a prevalent health risk (Hussain et al., 2014). A high content of dissolved solids elevates the density of water, reduces the solubility of gases, and utility of water for drinking and other purposes.

According to World Health organization (WHO) and US-Environmental Protection Agency (US-EPA) permissible limit of TDS is 1000 mg/L while Pakistan Council of Research in Water Resources (PCRWR), Pakistan Standard and Quality Control Authority (PSQCA), it illustrates its permissible limit as 500-1500 mg/L (PCRWR, 2007). Some other countries like Thailand, China and Indonesia showed maximum acceptable limit not more than 500 mg/L while in Japan it should be less than 1000 mg/L (WHO, 2006). But Indian Water Quality Standards (BIS) places the desirable limit as 500 mg/L, while the excessive or maximum permissible limits are placed at 2000mg/L (BIS 10,500, 2003). Excessive concentrations of TDS are undesirable in water. Dissolved minerals, gases and organic constituents may produce aesthetically displeasing colour, taste and odor. Some dissolved organic chemicals may deplete the dissolved oxygen in the receiving waters. High concentration of dissolved solids about 3000 mg/L may also produce distress in livestock. In industries, the use of water with high amount of dissolved solid may lead to scaling in boilers, corrosion and degraded quality of the product. Excessive levels of TDS may cause gastrointestinal disorders and laxativeness in transient consumers in addition to various other disorders.

Details of study zones

Bangalore city lies between North Latitude $12^{0}52^{1}21^{11}$ to $13^{0}6^{1}0^{11}$ and East Longitude $77^{0}0^{1}45^{11}$ to $77^{0}32^{1}25^{11}$ covering an area of approximately 400 square km. The entire study area is covered in part of the Survey of India Toposheet No 57 G and 57 H series. The study area of Bangalore city has been divided into 3 industrial zones, namely,

Zone I: Bangalore North

Zone II: Bangalore East

Zone III: Bangalore South

The industrial areas selected in each zone are listed below.

Zone I: Bangalore North

1. Peenya industrial area
2. Tannery industrial area

Zone II: Bangalore East

1. K.R.Puram industrial area
2. Whitefield industrial area
3. Bellandur industrial area

Zone III: Bangalore South

1. Bommasandra industrial area
2. Bommanahalli industrial area
3. Kengeri industrial area

Figure 1 shows the key map of the entire study zone, and the individual study areas.

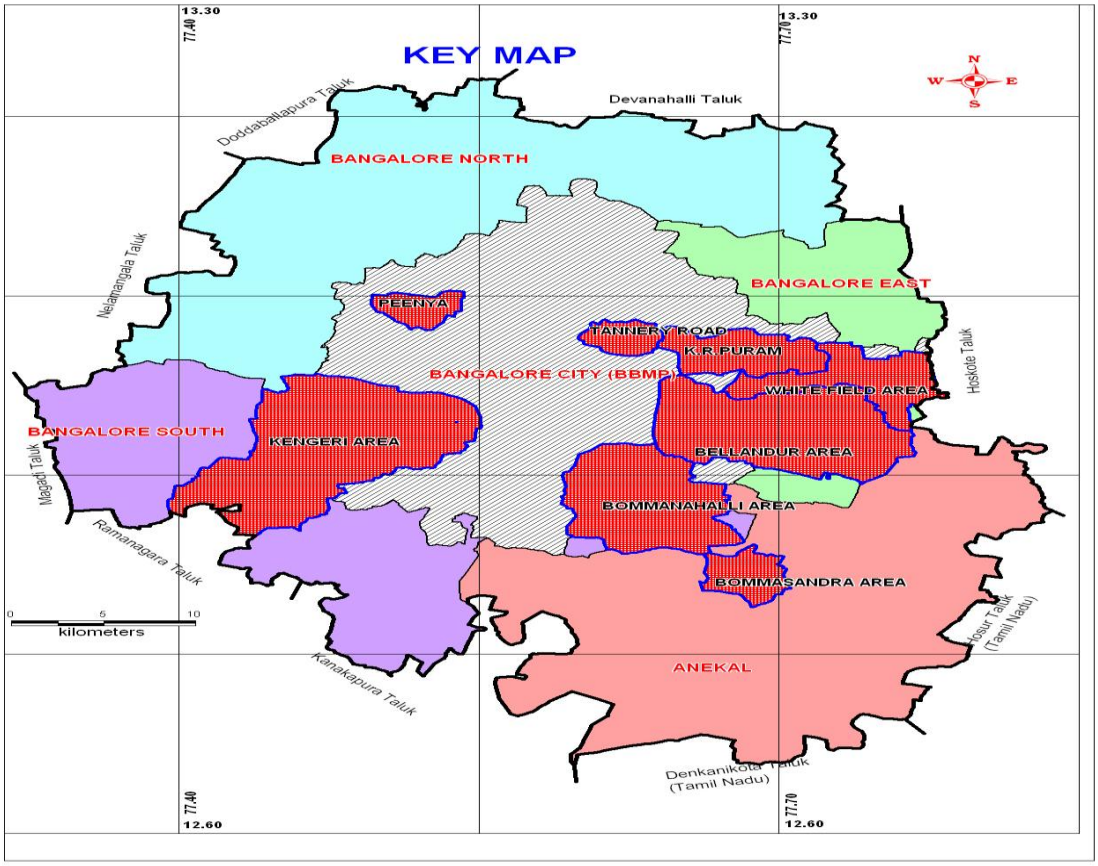

Fig 1: Key map of Study area (Bangalore) showing the individual study areas.

2. MATERIALS AND METHODS

Thirty water samples were collected from both the borewells and open wells in each of the 8 industrial areas during March and October 2015 seasons in two litre PVC containers and sealed and later analyzed for Total dissolved solids gravimetrically using a hot air oven as per the standard methods for examination of water and wastewater (APHA, 2002). Thus a sum total of 480 groundwater samples were analysed and the results obtained were evaluated in accordance with the standards prescribed under 'Indian Standard Drinking Water Specification IS 10500: 2003' of Bureau of Indian Standards.

3. RESULTS AND DISCUSSION

The TDS analysis results showing the minimum, maximum and mean seasonal concentrations (mg/L) has been presented in Table 1.

Legend for Tables.

S.No	Title
1	Minimum, maximum and mean seasonal concentrations of TDS in groundwaters

Legend for Figures.

Fig. No.	Title
1	Key map of Study area (Bangalore) showing the individual study areas.
2	TDS Contours for the groundwaters of Peenya industrial area during post-monsoon
3	TDS Contours for the groundwaters of Tannery industrial area
4	TDS Contours for the groundwaters of Bommasandra area

Table 1: Minimum, maximum and mean seasonal concentrations of TDS in groundwaters.

S. No	Study zone and areas	Pre-monsoon			Post-monsoon		
		Min	Max	Mean	Min	Max	Mean
North Zone							
1	Peenya	239	3814	1191.86	290	3575	1248.83
2	Tannery area	355	5075	2015.67	455	5390	2148.37
East Zone							
1	K.R.Puram	320	2435	1044.83	340	2545	1111.0
2	Whitefield	220	1160	700.67	215	1245	748.5
3	Bellandur	205	2650	1122.67	200	2745	1171.83
South Zone							
1	Bommasandra	400	2565	1335.83	450	2685	1416.5
2	Bommanahalli	250	2370	930.47	285	2605	987.17
3	Kengeri	226	2200	881.87	275	2845	949.0

The Table 1 indicates that TDS value varies from a minimum of 205 mg/L in the groundwater sample(W 22) of Whitefield area, to a maximum of 5075 mg/L in sample T13 of Tannery industrial area during the pre-monsoon season, with a maximum statistical mean of 2015.67 mg/L in Tannery industrial area. In post-monsoon, the TDS values vary from a minimum of 200 mg/L in sample no BE 17 of Bellandur area to a maximum of 5390 mg/L in sample no T13 of Tannery industrial area, with a maximum statistical mean of 2148.37 mg/L in the same Tannery area. The average concentrations of TDS during post-monsoon in North, East and south zones are 1699, 1010 and 1118 µ mg/L respectively. Further TDS values have exhibited an increasing trend in concentration during post-monsoon season compared to pre-monsoon due to mixing of surface pollutants during the infiltration and percolation of rainwater. Salts which are held back in the interstice or pores while groundwater is evaporated or water table falls, get leached back to the groundwater during the rainy period. Hence the post monsoon waters have higher TDS levels when compared to pre-monsoon season (Janardhana Raju 2007). Waters with high TDS (>2000mg/l) are of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer and gastro intestinal irritation (Ranjit Singh and Ajith Kumar 2004).

In the present study 20% of the waters from the entire study area have recorded excess TDS concentration (>2000 mg/L) as per the upper limit of BIS, with the Tannery area of Bangalore North being worst affected, with 60% of the samples exceeding the TDS limits. The north, east and south zones recorded 40%, 11% and 16% non-potability due to excess TDS.

It is observed that the TDS levels in tannery area are extremely and alarmingly high. This is because various chemicals are used in the tanneries, such as lime, sodium carbonate, common salt or sodium chloride, sodium sulphate, chromium sulphate etc. The biggest polluting material in these tanneries, which is very difficult to get rid of is common salt, used as a raw material, which has resulted in salinization of groundwater and increased the TDS levels immensely.

Further, (Carrol, 1962) classified the groundwaters based on TDS as

Fresh	0-1000 mg/L
Brackish	10000-10000 mg/L
Saline	10000-100000 mg/L
Brine	Above 100000 mg/L

This classification has helped in classifying the waters in the study area as brackish category. In the entire study areas, 52.5 % of the samples fall under fresh category, while the remaining 47.5 % fall under brackish category based on TDS classification. The maps showing the TDS contours for Peenya, Tannery area and Bommasandra industrial area has been presented in Figures 2 to 4.

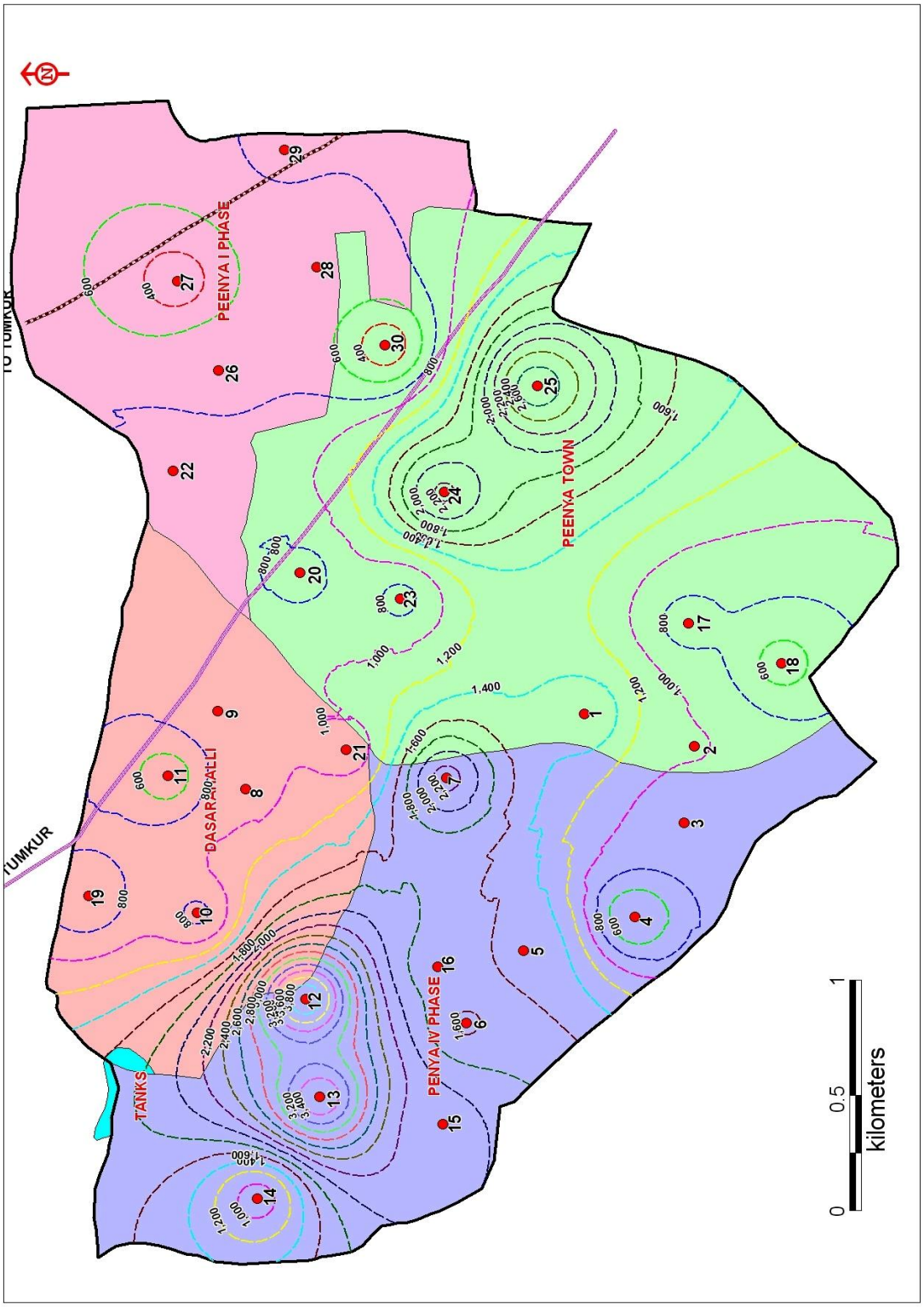

Fig.2: TDS Contours for the groundwaters of Peenya industrial area during post-monsoon

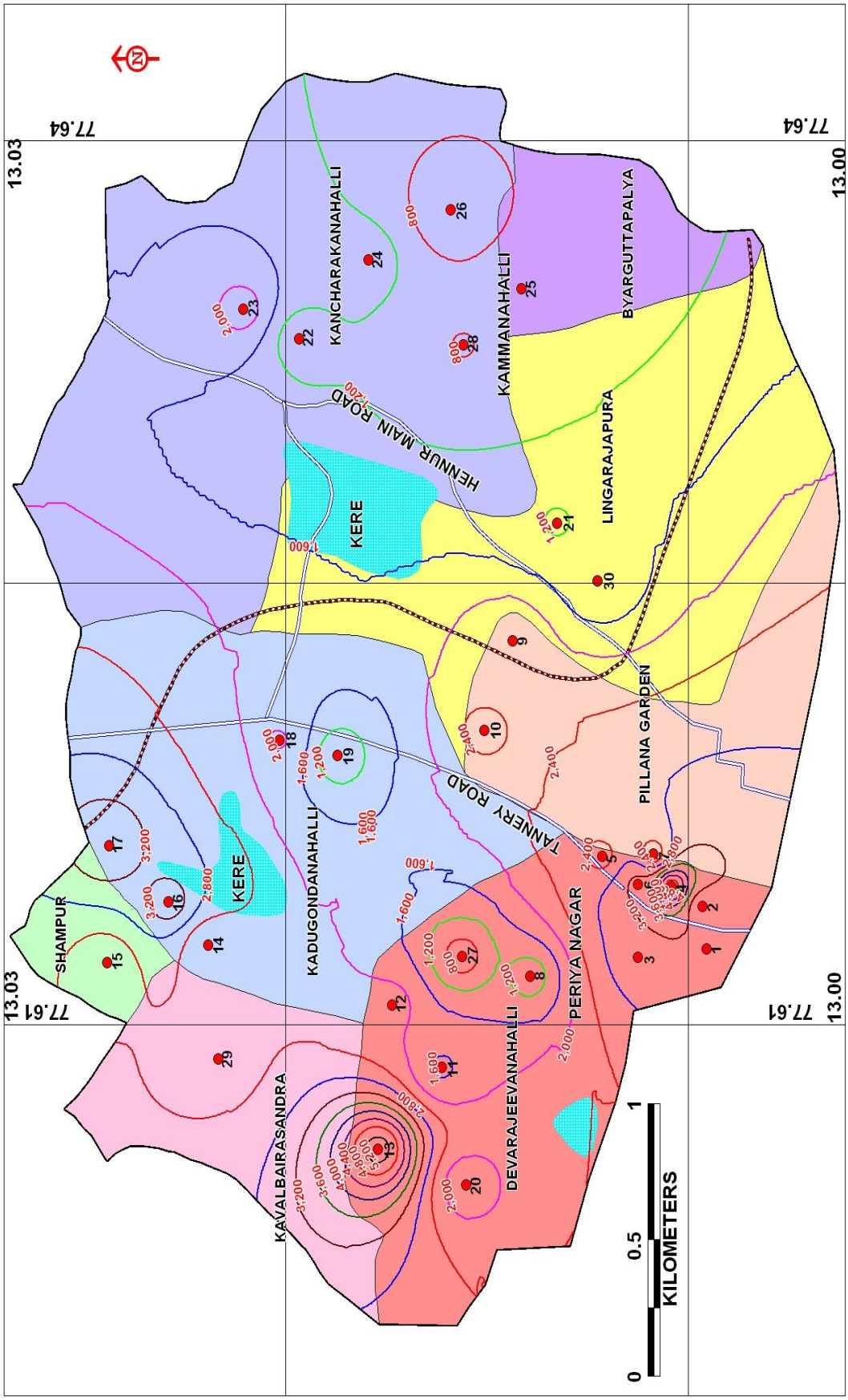

Fig. 3: TDS Contours for the groundwaters of Tannery industrial area

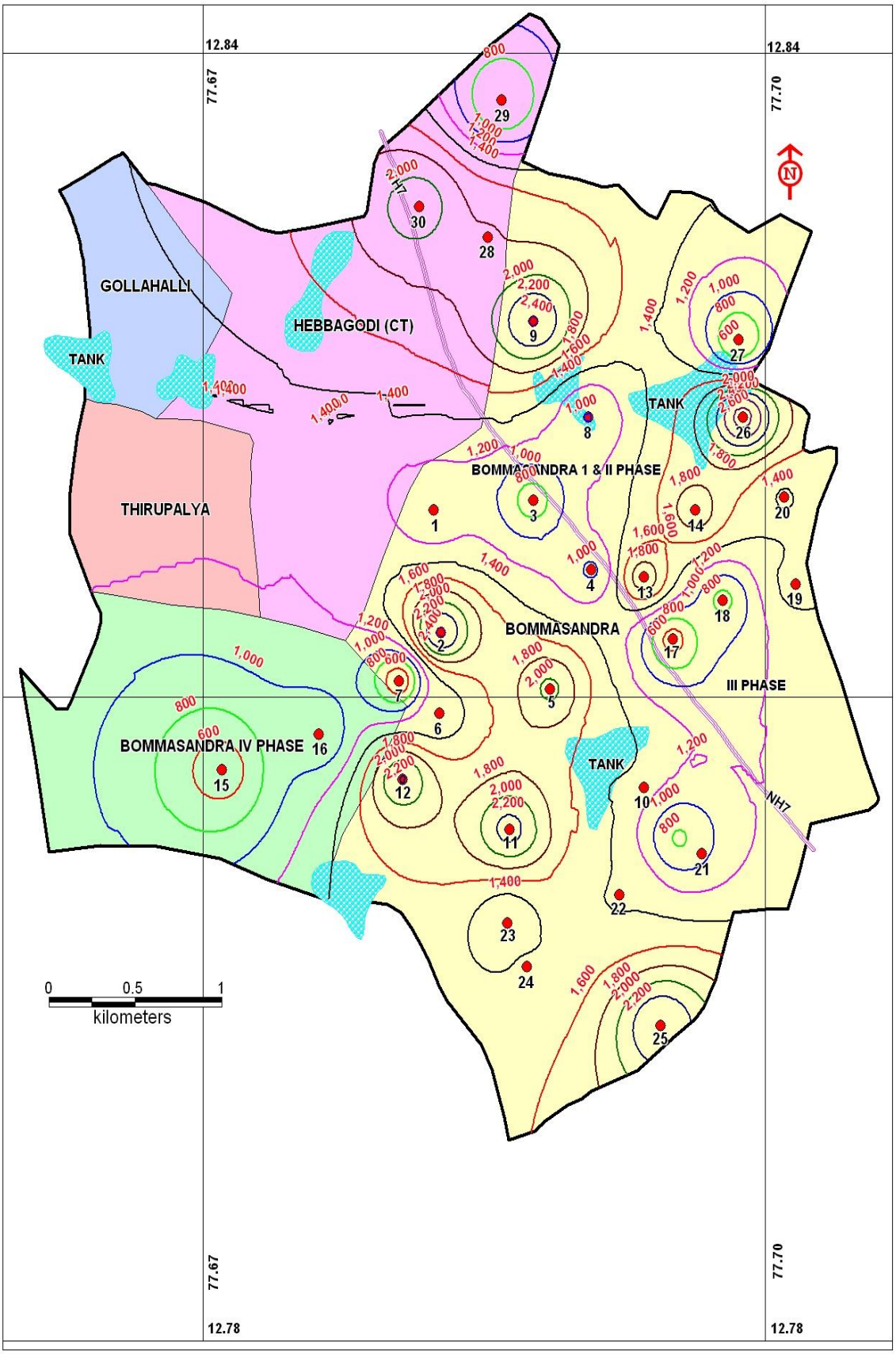

Fig. 4: TDS Contours for the groundwaters of Bommasandra area

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