

# Water Quality Index of Karkala Municipality, Karnataka

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**ABSTRACT:** Water Quality Index (WQI) computed based on certain hydrogeochemical parameters is one of the most effective tools to understand the overall quality and suitability of water for drinking, irrigation and industrial purposes. The spatial variation of the same can demonstrate the percentage of pollution in an area. 36 groundwater samples collected from Karkala Municipality, Karnataka have been analysed for various physico-chemical water quality parameters and their WQI. WQI computed and plotted for the study area shows that the groundwater quality in this area is of poor to very poor quality for drinking purposes. Unless proper sustainable water quality management plan and techniques are adopted to improve the quality of groundwater, the aquifers in this area will continue to be degraded.

**KEYWORDS:** Water Quality Index, Karkala Municipality, hydrogeochemical analysis, Spatial variation.

## I. INTRODUCTION

Groundwater is the major source for drinking, irrigation and industrial purposes in many regions of the world. Safe drinking water is only a dream for all human beings now. Hydrogeochemical analysis of groundwater has become more essential due to the recent development in urbanization, industrialization and modern agricultural practices. Groundwater quality is being threatened by the disposal of urban wastes, industrial wastes and agricultural chemicals. According to the Water-Aid works of British Geological Survey (2000) <sup>[1]</sup>, groundwater quality of southern India is strongly dependent on bedrock geology and climate, but may also be impacted in parts by pollution, particularly from agricultural and industrial sources.

The quality of groundwater may yield information about the geology, environments through which the water has been circulated and the quality of recharge water. Anthropogenic activities viz. agriculture, industry, urban development, increasing exploitation of water resources and also atmospheric input influence the groundwater quality <sup>[2, 3]</sup>. In developing countries infant mortality is mostly due to drinking of contaminated water (WHO 1993; 2000; 2002 and 2003) <sup>[4, 5, 6, 7]</sup>. More than one billion people world over are forced to rely on unsafe drinking water sources from lakes and rivers other than open wells (WHO/UNICEF, 2004) <sup>[8]</sup>. Seasonal monitoring and conservation of groundwater, by using advanced technological tools like remote sensing and GIS can also help in sustainable water quality management. Groundwater quality is not a static phenomenon; it shows seasonal and long term variations. Monitoring these changes will help us to maintain a sustainable water quality management. Water Quality Index (WQI) gives an idea about the suitability of the source water for drinking purposes based on quality weightage factor <sup>[9]</sup>. This becomes an important tool for the assessment and management of groundwater <sup>[10, 11]</sup>.

## II. STUDY AREA

Karkala Municipality (Fig.1), with a population density of 1089/km<sup>2</sup> sprawling in an area of about 23.06 Km<sup>2</sup> in Udupi district of Karnataka falls in between North latitudes 13°12'N to 13°19'N and East longitudes 74°57'E to 75°03'E. Karkala, meaning black stone *kari-kal* in the local vernacular language Tulu is an area dominated by hard impervious dark peninsular granitic gneiss intruded by occasional gabbroic and doleritic dykes and laterite capping. Karkala being blessed with the highest average annual rainfall of about 4500mm, situated on the foothills of Western Ghats,

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experience acute water shortage during recent years due to its geology and the ignorance towards the sustainable micro-watershed development and management concept<sup>[11]</sup>.

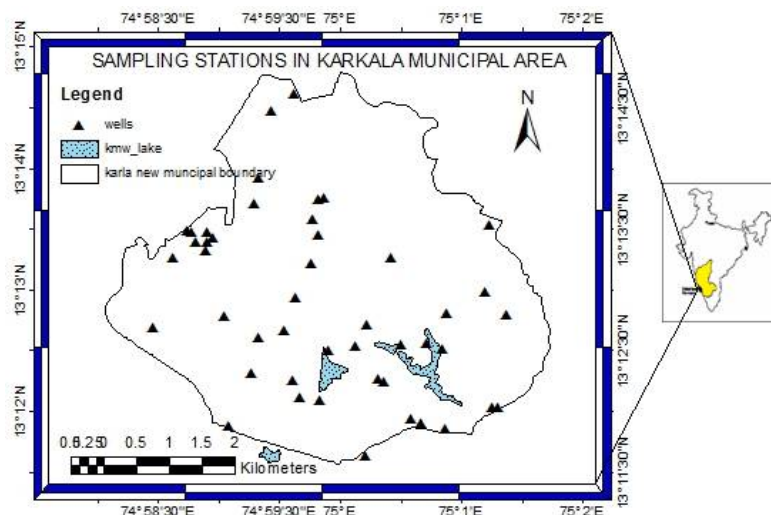


Figure.1 Study area with sampling locations

### III. METHODOLOGY

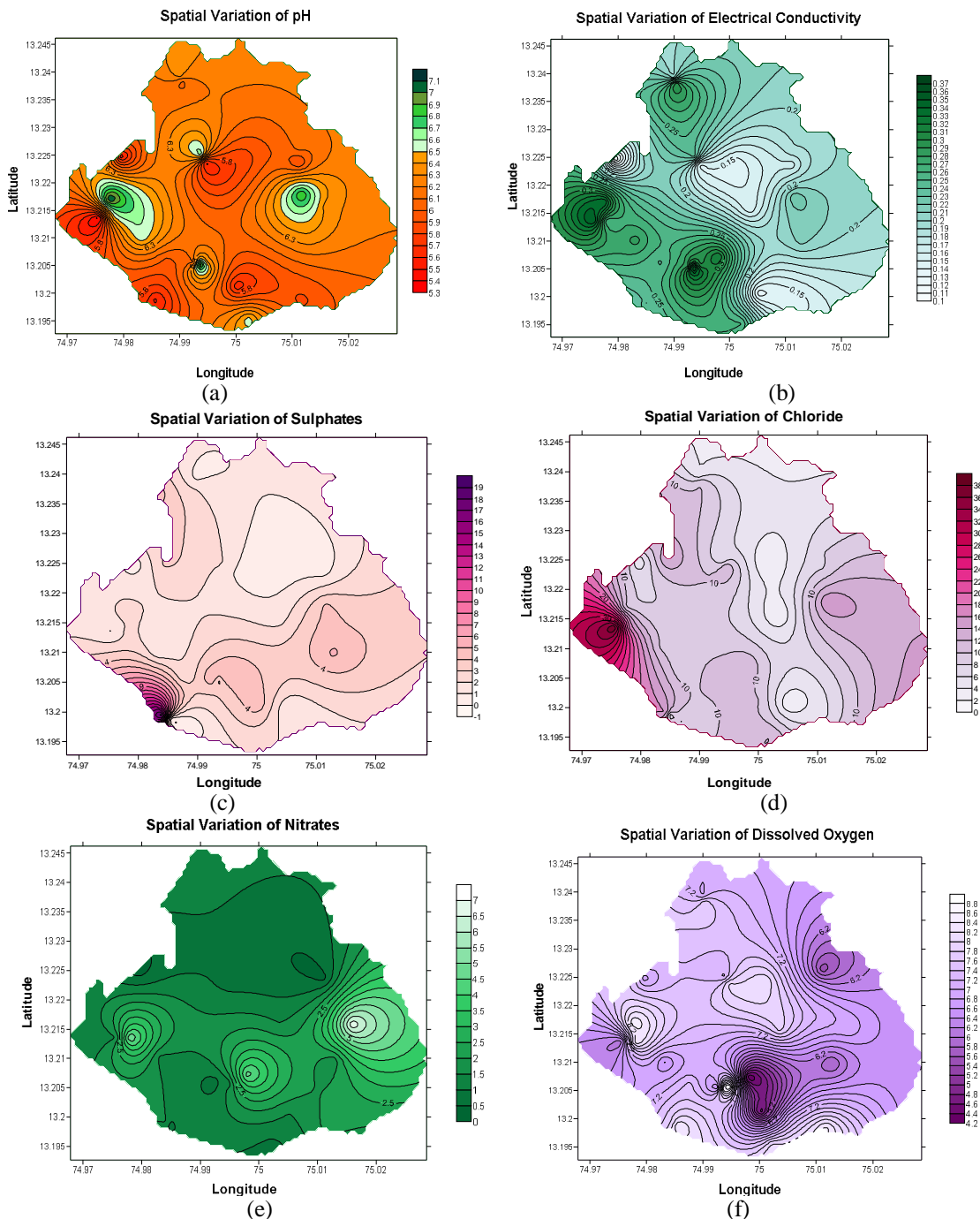
**Sampling locations:** Sampling locations (Fig.1) have been fixed randomly based on accessibility, availability of groundwater structures and population of the area falling within 2 km x 2km grids within the Municipal boundary. Public open wells or multiple user wells in populated areas have been given importance. The traversing routes and sampling locations were pre-fixed using the base map (SOI Toposheets 48K/16 and 48O/4) and road map of the area.

**Groundwater sample collection:** A total of thirty six groundwater samples were collected from open wells (OW1 to OW36) at 0.5m below the water table within the study area during the month of February 2016, as marked in the Fig.1. Standard methods of water sampling<sup>[12]</sup> and analysis<sup>[13]</sup> have been adopted and the locations have been marked using Garmin Montana 650 GPS receiver.

### IV. RESULTS AND DISCUSSION

**Hydrogeochemical Analysis:** A total of about fifteen physico-chemical water quality characteristics such as pH, Temperature, Electrical conductivity (EC), Turbidity, Total Dissolved Solids (TDS), Acidity, Alkalinity, Iron (Fe), Ca Hardness, Mg Hardness, Total Hardness (TH), Chlorides (Cl<sup>-</sup>), Sulphates (SO<sub>4</sub><sup>2-</sup>), Nitrates (NO<sub>3</sub><sup>-</sup>) and Dissolved Oxygen (DO) were determined using the standard analytical methods<sup>[12, 13]</sup>. The analytical results of some of the important hydrogeochemical parameters are discussed below and presented in the table (Table: 1) as well as in the spatial variation and distribution maps (Fig. 2).

- A. pH is the hydrogen ion concentration of water. The minimum pH noted is 5.35 (OW11) and the maximum is 7.14 (OW6). The mean value is 6.13 indicating the acidic nature. Fig. 2(a) represents the spatial variation and distribution of pH in the study area.
- B. Electrical Conductivity (EC) is the property of water to conduct electricity and is directly proportional to dissolved particles present in it. The EC varies from 0.10 μS/cm to 0.38 μS/cm in the study area. Fig. 2(b) represents the spatial variation and distribution of EC in the study area.



**Figure. 2 Spatial variation and distribution of (a) pH, (b) Electrical conductivity, (c) Sulphates, (d) Chloride, (e) Nitrates and (f) Dissolved oxygen.**

C. Sulphate ions particularly do not have any harmful effects. The important sources for sulphate ion concentration are mostly due to the rainwater and the anthropogenic activities. Fig. 2(c) represents the spatial variation and distribution of sulphates in the study area.

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- D. Chloride ions commonly occur in all types of water, but dominated in sea water. The chloride values are ranging from 1.99 to 37.99 mg/l. Fig. 2(d) represents the spatial variation and distribution of chloride in the study area.
- E. Nitrate ion concentration in groundwater is mainly due to human activities on hydrogeological systems<sup>[14],[15]</sup>. Nitrate occurs naturally in groundwater but can be harmful to the environment and human health at elevated concentrations<sup>[16]</sup>. The nitrate values are noted ranging between 0.25 and 6.91 mg/l. Fig. 2(e) represents the spatial variation and distribution of nitrates in the study area.
- F. Dissolved Oxygen (DO) variation is from 4.18 to 8.96 mg/l. Fig. 2(f) represents the spatial variation and distribution of Dissolved Oxygen in the study area.

The minimum and maximum values obtained for the various water quality parameters across the sampling stations along with the statistical analysis results mean, median, mode and standard deviation for these parameters within the study area are given below (Table 1). This shows that many important drinking water quality parameters are beyond the permissible limits in many of the sampling locations.

**Table 1: Summary of Statistical Results of the hydrogeochemical Parameters**

Chemical Properties	Minimum	Maximum	Mean	Median	Mode	Std. Deviation
pH	5.35	7.14	6.13	6.12	6.4	0.44
Turbidity (NTU)	1.60	8.10	4.60	5.10	2.10	1.68
Electrical Conductivity (µS/cm)	0.10	0.38	0.22	0.23	0.24	0.07
Alkalinity (mg/l)	16.00	108.00	38.16	36.00	20.00	20.91
Acidity (mg/l)	8.00	28.00	17.80	16.00	16.00	6.03
Chloride (mg/l)	2.00	38.00	10.38	10.00	10.00	6.44
Sulphate (mg/l)	0.13	19.08	2.73	2.08	0.13	3.23
Nitrate (mg/l)	0.25	6.91	1.64	1.35	1.48	1.38
Calcium (mg/l)	4.00	36.00	16.81	16.00	12.00	9.68
Magnesium (mg/l)	4.00	32.00	14.16	12.00	8.00	7.81
Iron (mg/l)	0.04	0.62	0.16	0.10	0.04	0.02
Total Hardness (mg/l)	12.00	68.00	31.10	28.00	44.00	14.72
D.O. (mg/l)	4.18	8.96	7.16	7.263	7.761	1.15

**Water Quality Index:** The WQI has been calculated by using the standard of drinking water quality recommended by the Bureau of Indian Standards (BIS), World Health Organization (WHO) and Indian Council for Medical Research (ICMR). The weighted arithmetic index method has been used for the calculation of WQI of the water bodies. Further quality rating or sub index ( $q_n$ ) is calculated using the following expression.

$$q_n = 100 \frac{[V_{\text{actual}} - V_{\text{ideal}}]}{[V_{\text{standard}} - V_{\text{ideal}}]} \quad (1)$$

where  $V_{\text{actual}}$  and  $V_{\text{ideal}}$  are the observed values and the ideal value for each parameters respectively,  $V_{\text{standard}}$  is the standard value for each parameter as per BIS/WHO standards.  $V_{\text{ideal}}$  for pH is taken as 7 and that for DO as 14.6ppm, when for all other parameters zero is assumed as the ideal value. Unit weight (Table 2) is calculated by a value inversely proportional to the recommended standard value  $S_n$  of the corresponding parameter.

$$W_n = \frac{K}{S_n} \quad (2)$$

where  $W_n$  = unit weight for the  $n^{\text{th}}$  parameters,  $S_n$  = Standard value for the  $n^{\text{th}}$  parameters, and  $K$  = Constant for proportionality.

The standard values as per BIS<sup>[17]</sup>/WHO<sup>[4]</sup> standards for drinking water and the weightages for each parameter are given in Table 2.

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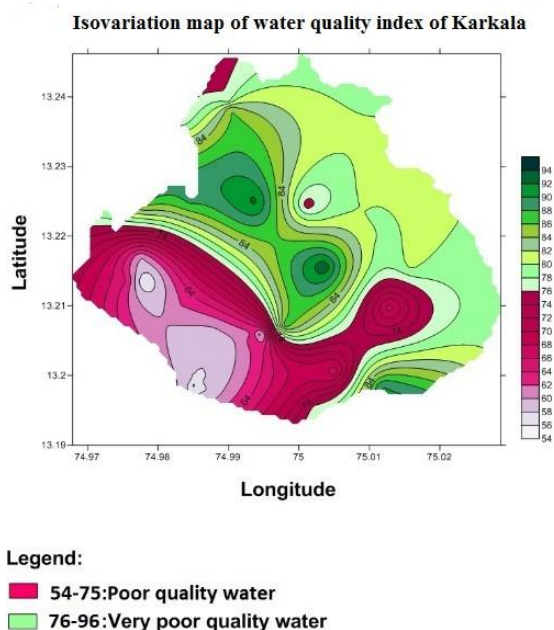
**Table 2: Drinking Water Standards and Unit Weights (BIS, 1991; WHO, 1993)**

Sl. No.	Parameters	Standard Value	Unit Weight
1	pH	6.5	0.2190
2	Electrical Conductivity	300 $\mu$ S/cm	0.3710
3	Total Alkalinity	200 mg/l	0.0155
4	Total Hardness	300mg/l	0.0062
5	Calcium Hardness	75 mg/l	0.0250
6	Magnesium Hardness	30 mg/l	0.0610
7	Chloride	250 mg/l	0.0074
8	Nitrates	45 mg/l	0.0412
9	Sulphate	200 mg/l	0.0124
10	D.O	4 mg/l	0.3723
11	B.O.D	5 mg/l	0.3723

The overall Water Quality Index is calculated by aggregating the quality rating with the unit weight linearly.

$$WQI = \frac{\sum q_n W_n}{\sum W_n} \quad (3)$$

Spatial variation map for the Water Quality Index has been prepared on the basis of the status obtained from the result (Fig. 3). The parameters selected include Turbidity, Chlorides (Cl<sup>-</sup>), Total dissolved solids (TDS), Ca hardness, Mg hardness, Total Hardness (TH), Sulphates (SO<sub>4</sub><sup>2-</sup>) and Dissolved Oxygen (DO). Water quality index computed for all the samples were plotted using ‘Surfer 10’ software and analysed for the spatial variation in distribution pattern as shown in the Fig. 3.



**Figure. 3 Spatial variation and distribution of Water Quality Index of all the samples in Karkala Municipality**

According to the range of WQI values, five levels were defined for the status of water quality index (Table 3). The computed WQI for the study area vary from a minimum of 54 to a maximum of 96 indicating that the status of ground water source in the Karkala Municipality falls in the Poor Water Quality (P) to Very Poor Water Quality (VP) (Table 3 & Fig. 3).



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**Table 3: Water Quality Index (WQI) and status of water quality**

WQI Level	Water Quality Status
0-25	Excellent Water Quality
26-50	Good Water Quality
51-75	Poor Water Quality (P)
76-100	Very Poor Water Quality (VP)
>100	Unfit for Drinking (UFD)

## V. CONCLUSION

The groundwater quality of Karkala Municipality was analysed for various physico-chemical parameters and the samples which are collected from the wells nearer to Anekere lake shows very poor quality. Water Quality Index computed for the study area shows that the groundwater quality in the area is of poor to very poor quality for drinking purposes. The degradation in quality indicates the pollution caused due to the urbanization trend and improper development of the area. It is necessary to have a proper sustainable water quality management plan for the study area in order to solve the water quality problem of this area. Unless proper management techniques are adopted to improve the quality of groundwater the aquifers in this area will continue to be degraded.

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