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CHARACTERIZATION OF GROUNDWATER USING WATER QUALITY INDEX OF SOLAPUR INDUSTRIAL BELT, MAHARASHTRA, INDIA

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ABSTRACT

Groundwater is an important source of drinking water supply throughout the world. WQI, a technique of rating water quality, is an effective tool to assess spatial and temporal changes in groundwater quality. Fifty groundwater samples were collected from dug wells and bore wells during the pre monsoon season. Water quality index rating was carried out to quantify overall groundwater quality status of the area. The values of WQI have been affected mainly by the concentration of dissolved ions in ground water. The values of WQI of the samples were found in the range of 61-1933. The majority of groundwater samples fall in Poor (40%) and Unsuitable (34%) category indicating groundwater not fit for drinking purposes. Because of the highly industrialized area, the impact of natural sources of contamination is as same as anthropogenic activities.

KEYWORDS: Industrial Belt, Groundwater, Solapur, Water Quality Index

INTRODUCTION

Groundwater is an important source of drinking water supply throughout the world. Urbanization and the unregulated growth of the population have altered the surface and sub-surface terrains of the many areas. Changes in local topography and drainage system directly affect both quality and quantity of the ground water (Vasanthavigar et al., 2010). Groundwater quality depends on the quality of recharged water, atmospheric precipitation, inland surface water and sub-surface geochemical processes.

Temporal changes in the origin and constitution of the recharged water, hydrologic and human factors may cause periodic changes in groundwater quality. Water pollution not only affects water quality but also threats human health, economic development and social prosperity (Milovanovic, 2007; Reza and Singh, 2010).

Water Quality Index (WQI) is an important technique for evaluating groundwater quality and its suitability for drinking purposes. The concept of WQI to represent gradation in water quality was first proposed by Horten (Horten, 1965). WQI a well known method as well as one of the most effective tools to express water quality that offers a simple, stable, reproducible unit of measure and communicate information of water quality to the policy makers and concerned citizens. It thus, becomes an important parameter for the assessment and management of groundwater (Chauhan et al., 2010; Sahu et al., 1991). The present study deals with the groundwater quality index of Solapur (city) Industrial Belt of Solapur district of Maharashtra, India.

Study Area

The study area is located between 17^0 $36^{'}$ to 17^0 $42^{'}$ N latitude and 75^0 $55^{'}$ to 75^0 $58^{'}$ E longitude (Figure 1).

The study area is situated on the south east fringe of Maharashtra State and lies entirely in the Seena river basin. Solapur is one of the major cities in the State of Maharashtra. It is located on the borders of the states of Karnataka and Andhra Pradesh. The temperature of the study area widely varies in the range of maximum up to 46 ^{0}C and minimum up to 9 ^{0}C. The average rainfall of the study area is about 545 mm; Solapur stands last in the list of cities in the State of Maharashtra.

MATERIALS AND METHODS

The groundwater samples were collected from fifty representatives dug and bore wells during the pre monsoon season 2008. Groundwater samples for physico-chemical analysis were collected directly into pre-cleaned plastic container of 1 liter capacity. The physico-chemical analysis of groundwater samples were carried out by adopting standard methods given by APHA (1985). Twelve parameters were analyzed for WQI such as pH, EC, TDS, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Alkalinity, Chloride, Nitrate and Sulphate.

Water Quality Index (WQI)

The WQI provides a comprehensive picture of the quality of surface/ground water for most domestic uses. WQI is defined as a rating that reflects the composite influence of different water quality parameters (Sahu and Sikdar, 2008). WQI is calculated from the point of view of the suitability of groundwater for human consumption. Hence, for calculating the WQI in the present study, 12 parameters have been considered (Table 1).

Table 1: BIS Standards Weight (Wi) and Calculated Relative Weight (Wi) for Each Parameter

Parameters	BIS Desirable Limit (1998)	Weight (Wi)	Relative Weight (Wi)
pH	8.5	3	0.0789474
EC	2000	3	0.0789474
TDS	1000	5	0.1315789
TH	300	3	0.0789474
Ca	75	2	0.0526316
Mg	30	2	0.0526316
Na	100	3	0.0789474
K	10	2	0.0526316
Cl	250	5	0.1315789
HCO_3	200	2	0.0526316
SO_4	200	3	0.0789474
NO_3	45	5	0.1315789
-	-	**$\sum$wi = 38**	**$\sum$Wi = 1.00**

There were three steps for computing WQI of a water sample.

- Each of the chemical parameters were assigned a weight (wi) based on their perceived effects on primary health/ their relative importance in the overall quality of water for drinking purposes (Table 1). The highest weight of 5 was assigned to parameters which have the major effects on water quality and their importance in quality (viz., NO_3^-, Cl^- and TDS) and a minimum of 2 was assigned to parameters which are considered as not harmful (Ca^{++}, Mg^{++}, K^+, HCO_3^-).
- Computing the relative weight (Wi) of each parameter using Eq. 1. Table 1 present the weight (wi) and calculated relative weight (Wi) values for each parameter.

- A quality rating scale (qi) for each parameter is computed by dividing its concentration in each water sample by its respective standard according to the guidelines laid down by BIS (1998) and then, the result was multiplied by 100 using Eq. 2. Finally, for computing the WQI, the water quality sub-index (SIi) for each chemical parameter is first determined, which is then used to determine the WQI as per the Eqs. 3 and 4 (Ravikumar et al., 2013)

$$W_i = \frac{w_i}{\sum_{n=1}^{n} w_i} \tag{1}$$

Where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters.

$$q_i = \left(\frac{C_i}{S_i}\right)100 \tag{2}$$

Where, qi= quality rating, Ci= concentration of each chemical parameter in each water sample in mg/L, Si= Indian drinking water standard (BIS 1998) for each chemical parameter in mg/L except for conductivity (lS/cm) and pH.

$$SI = Wiqi \tag{3}$$

$$\mathrm{WQI} = \sum_{i=1}^{n} \mathrm{SI}_i \tag{4}$$

Where, SIi is the sub-index of i^{th} parameter; qi is the rating based on concentration of i^{th} parameter and n is the number of parameters.

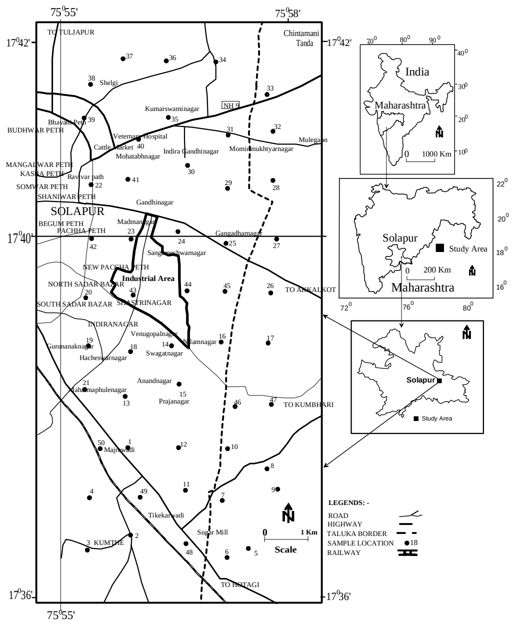

Figure 1: Map of Solapur Industrial Belt with Sampling Location

RESULTS AND DISCUSSIONS

In this research, the computed WQI values ranges from 61 to 1933. The minimum WQI has been recorded from

Indira Nagar (Sample No. 29), while maximum WQI has been recorded from MIDC (Sample No. 43). The average WQI of the groundwater is 460 in the study area. The computed WQI values are classified into five types namely, excellent water (WQI below 50), good water (WQI 50-100), poor water (WQI 100-200), very poor water (WQI 200-300) and water unsuitable for drinking (WQI above 300).

Table 2: WQI based Classification of Groundwater in Study Area

WQI Values	Category	Sample Numbers (%)
Below 50	Excellent	---- (00)
50-100	Good	25, 26, 27, 28, 29, 30, 32, 33, 45, 46, 47 **(22)**
100-200	Poor	1, 3, 5, 6, 10, 11, 13, 18, 19, 20, 21, 22, 34, 39, 40, 41, 42, 44, 49, 50 (40)
200-300	Very Poor	2, 31(04)
Above 300	Unsuitable	4, 7, 8, 9, 12, 14, 15, 16, 17, 23, 24, 35, 36, 37, 38, 43, 48 (34**)**

Table 2 shows the percentage of groundwater samples that falls under different quality. It is also observed that the majority of groundwater samples fall in Poor (40%) and Unsuitable (34%) category indicating groundwater not fit for drinking purposes. This suggests that the groundwater from study area is highly polluted due to leaching and anthropogenic activities such as discharge of effluents from industrial, agricultural and domestic uses. The high value of WQI at these stations has been found to be mainly from the higher values of EC, total dissolved solids, hardness, chloride and bicarbonate in the groundwater. The higher values of calcium and magnesium were significantly interrelated which indicates that the hardness of the water is permanent in nature. The concentration is higher due to the dissolution of $CaCO_3$, magnesium calcite, etc. The higher values of chloride may be due to the mixing of sewage and leaching from waste sites. The concentration of nitrate was found to be higher because of the leachate of crop nutrients, nitrate fertilizers and sewage waste. All these factors may pose health hazard on long term and can degrade the quality of drinking water, therefore require to be treated before using for drinking purpose (Neeraj and Patel, 2010; Mangukiya et al., 2012).

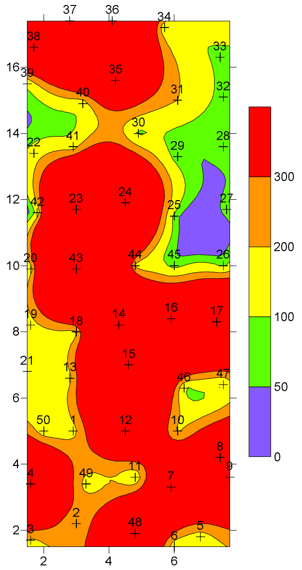

Figure 2: Spatial and Temporal Distribution Pattern of Water Quality Index (WQI) of Study Area

CONCLUSIONS

The computed WQI values ranges from 61 to 1933. The minimum WQI has been recorded from Indira Nagar

(Sample No. 29), while maximum WQI has been recorded from MIDC (Sample No. 43). The average WQI of the groundwater is 460 in the study area. The majority of groundwater samples fall in Poor (40%) and Unsuitable (34%) category indicating groundwater not fit for drinking purposes. Because of the highly industrialized area, the impact of natural sources of contamination is as same as anthropogenic activities. The above study indicates that natural (groundwater influenced by local lithology, weathering, moving and percolating) as well as anthropogenic sources are contaminating the groundwater in the study area. The analyses reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination.

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