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Original Research Paper

Evaluation of Quality Indices for the Groundwaters of an Industrial Area in Bangalore, India

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ABSTRACT

The present work is aimed at evaluating the water quality index (WQI) for the groundwaters of Whitefield industrial area in Bangalore. This has been determined by collecting thirty groundwater samples in and around the industrial area and subjecting the samples to a comprehensive physico-chemical analysis. For calculating the water quality index, ten critical parameters have been considered. The WQI for these thirty samples ranged from 11.58 to 495.07 with an average value of 69.95. 23.33 % of the samples (7 samples) exceeded 100, the upper limit for drinking water. The analysis reveals that the overall groundwater of the area, in general, can be considered fit for human consumption, barring the groundwater from these seven stations, which are non-potable and need some treatment.

INTRODUCTION

Freshwater being one of the basic necessities for sustenance of life, the human race through the ages has striven to locate and develop it. Water in its natural state is free from pollution, but when man tampers with water bodies, it loses its natural conditions (Asadi 2007). Groundwater is used for domestic and industrial water supply and irrigation all over the world. In the last few decades, there has been a tremendous increase in demand for freshwater due to rapid growth of population and the accelerated pace of industrialization (Tiwari & Nayak 2002). Anthropogenic activities can alter the relative contributions of the natural causes of variations and also introduce the effects of pollution (Mazac et al. 1987). Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater, a renewable resource, due to its overexploitation and improper waste disposal, especially in urban areas. According to World Health Organization, about 80% of all the diseases in human beings are caused by contaminated water (Meenambal 2005). Further, the flow of groundwater and the pollutants that it may contain is very slow as compared with flow on land surface. As a result of this, it may take considerable time for the contaminants to move away from the source of pollution, and degradation in the groundwater quality may remain undetected for years. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source (Purandara & Varadarajan 2003). It, therefore, becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it. Huge amounts of money and efforts have been spent by municipalities, governments and industries to protect the quality of surface and groundwater. However, very little effort has been made by these agencies to keep the general public and the policy makers informed, in simple and non-technical terms, as to what this huge investment of money and effort is achieving in term of water quality enhancement.

Water quality index is one of the most effective ways to communicate information on the quality of water to the concerned citizens and the policy makers. It, thus, becomes an important parameter for the assessment and management of groundwater. A water quality index (WQI) may be defined as a rating reflecting the composite influence of a number of water quality parameters on the overall quality of water. The main objective of WQI is to turn complex water quality data into information that is understandable and usable by the public. WQI based on some important parameters can provide a simple indicator of water quality. It gives the public, a general idea of the possible problems with water in a particular region. Thus, a water quality index synthesizes complex scientific data into an easily understood format.

Much effort has been directed, especially in developed countries, towards the definition of criteria for water quality and the formulation of water quality indices. In India, however, not much work has been done in this area except for some isolated studies by a few researchers. Tiwari & Nayak (2002) have evaluated the WQI for Sambalpur town in Orissa, based on the water quality data collected from 25 sampling stations from the town, considering 11 water quality parameters, and concluded that in 14 out of the 25 samples, the WQI exceeded the upper limit of 100. The average WQI of the town was 115.9, implying that the groundwater needed some treatment. Recently, Meenambal (2005) carried out studies for determining the WQI in the east zone of Coimbatore city and quoted that the WQI for the city fell within the range of 75-100, and hence concluded that the water could be safely used for drinking purposes. But, barring few studies, nothing much has been done in India and the present work is a small step in this direction.

MATERIALS AND METHODS OF ANALYSIS

Details of the study area: Bangalore city lies between north latitude 12°52'21" to 13°6'0" and east longitude 77°0'45" to 77°32'25" covering an area of approximately 400 square km. The study area, Whitefield industrial area, is located at a distance of about 20 km from the city and covered in part of the Survey of India toposheet No 57 H/9. This is one of the oldest industrial areas in Karnataka State with over 700 industries of all sizes and types.

One of the biggest problems of the area is the scarcity of water that plagues the entire region. The water levels in the borewells, which are the only water sources available in the area, is as deep as 500 feet. Most of the industries buy water from tankers for their requirements. Local Panchayats are unable to fulfil the needs of residential localities itself. The Cauvery Water Project that started 10 years back has failed to take off, compounding the problems of the already scarce and pollution prone groundwaters.

Collection and analysis of water: Thirty water samples were collected from both, the borewells and open wells, in and around the industrial area during October 2007 in two-L plastic containers, sealed and analyzed for 20 major physicochemical parameters in the lab. However, for the calculation of WQI, only 10 parameters (for which the Bureau of Indian Standards limits have been stipulated) have been considered. The physical parameters such as pH and electrical conductivity were

Table 1: Water quality parameters with their standards and unit weights.

Parameter (P_i)	Standard (S_i)	Unit weight (W_i)
pH	6.5-8.5	0.004
Total Hardness	300	0.003
Calcium	75	0.013
Magnesium	30	0.033
Chloride	250	0.004
Nitrate	45	0.022
Sulphate	200	0.006
TDS	500	0.002
Fluoride	1	1
Iron	0.3	3.33

Table 2: Sample calculation of the water quality index for sampling station 2.

Parameter (P_i)	Observed value (V_i)	Quality rating (q_i)	Sub-index (q_iw_i)
pH	8.20	80	0.32
Total Hardness	458	152.67	0.509
Calcium	136	181.33	2.42
Magnesium	29	96.67	3.19
Chloride	220	88	0.35
Nitrate	62	137.78	3.03
Sulphate	58	29	0.145
TDS	750	152	0.304
Fluoride	1.64	164	164
Iron	0.4	133.33	444

$WQI = [\Sigma (q_i.w_i)/\Sigma w_i] = 139.99$

determined in the field at the time of sample collection. The chemical characteristics including metals were determined as per the standard methods (APHA 2002). The results obtained were evaluated in accordance with the drinking water standards prescribed as IS: 10500 (BIS 2003).

Determination of water quality index (WQI): In the formulation of WQI, the importance of various water quality parameters depends on the intended use of water. This paper attempts to evaluate the water quality indices from the view point of suitability of water for human consumption. The 10 parameters chosen for the present study are shown in the first column of Table 1. The second column of this table gives the drinking water standards for these parameters as recommended by the BIS. The method of evaluating the WQI has been briefly discussed here.

In the first place, the more harmful a given pollutant of water, the smaller in magnitude is its standard for drinking water. So the unit weight W_i for the i^{th} parameter P_i is assumed to be inversely proportional to its recommended standard S_i (i = 1, 2,….., n) and n = no. of parameters considered (10 in the present case). Thus,

$$W_i = K/S_i \quad ...(1)$$

Where, the constant of proportionality K has been assumed to be equal to unity for the sake of simplicity. These unit weights W_i, for the 10 water quality parameters used here are shown in the last column of Table 1, where pH has been assigned the same weight as chloride.

The quality rating q_i for the i^{th} parameter P is given for all other parameters except pH, by the relation

$$q_i = 100\ (V_i/S_i) \quad ...(2)$$

Where, V_i is the observed value of the i^{th} parameter and S is its recommended standard for drinking water. For pH, the quality rating q_{pH} can be calculated from the relation:

$$q_{pH} = 100[(V_{pH}\sim 7.0)/1.5] \quad ...(3)$$

Where V_{pH} is the observed value of pH and the symbol "~" means simply the algebraic difference between V_{pH} and 7.0.

Finally, the water quality index (WQI) can be calculated by taking the weighted arithmetic mean of the quality rating q_i, thus,

$$WQI = [\Sigma\ (q_iW_i)/\Sigma W_i] \quad ...(4)$$

Where both the summations are taken from i = 1 to i = 10 (the total no. of parameters considered).

RESULTS AND DISCUSSION

A sample calculation of WQI for the first sampling station is shown in detail in Table 2. In this table, 10 water quality parameters are listed in the first column, while their actual values are given in the second column. The third column in table shows the quality ratings q for these parameters, while the last column gives sub-indices ($q_i w_i$). The water quality index for the second sampling station is calculated and shown in the last row of table and found to be equal to 139.99. In the same way, the water quality indices for all the 30 sampling stations of Whitefield industrial area have been calculated from the ground water quality data using the equations 1-4. The complete results have been presented in Table 3.

Table 3: Water quality index (WQI) for the groundwaters of Whitefield industrial area, Bangalore.

Sampling station	WQI	Sampling station	WQI	Sampling station	WQI
1	29.11	11	12.32	21	12.01
2	139.99	12	13.81	22	41.30
3	184.17	13	361.67	23	12.01
4	106.34	14	11.73	24	29.40
5	100.90	15	11.89	25	28.92
6	133.23	16	20.08	26	49.64
7	19.06	17	11.59	27	61.54
8	61.37	18	12.59	28	26.58
9	14.37	19	15.22	29	495.07
10	11.58	20	26.98	30	43.89

Average value of WQI = 69.95

The numerical value of the water quality index implies that the water under consideration is fit for human consumption if its WQI < 100, and is unfit for drinking without treatment if its WQI $\geq$ 100. Moreover, the larger the value of WQI, the more polluted the water concerned.

The WQI exceeds 100 (the limit for safe drinking water) at 7 out of the 30 sampling stations, that is, 23.33% of the samples can be deemed unfit for potable purpose without suitable treatment.

The overall quality of the ground water of this area is reflected in the average value of WQI, which is 69.95. This implies that the overall ground water of area, in general, can be considered fit for human consumption, barring the groundwater from the 7 stations, which exceed WQI limit, thus non-potable, and need some treatment.

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