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Scientific Note

Application of Water Quality Index to Monitor Groundwater Quality in Nagpur City

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Abstract: The present work is aimed at assessing the seasonal (pre-monsoon and post-monsoon) water quality index (WQI) for the groundwater of different areas of Nagpur city during the year 2006-2007. 15 locations (45 samples in each season) for three alternate weeks were studied for comprehensive, bacteriological and physico-chemical analysis. The WQI for these 15 locations ranges from 76 to 83 in pre-monsoon and 68 to 82 in post-monsoon season. Only 13% of the locations (two locations) showed the quality change from good to medium and other 87% showed variation in WQI but not change in water quality. The analysis reveals that the groundwater of few areas needs some treatment before consumption, and it also needs to be protected from the perils of contamination.

Key words: Groundwater, physico-chemical analysis, water quality, water quality index (WQI).

Introduction

Water is the most scare and precious natural resource. In arid areas, water is known as Liquid Gold. Water is, in short, a blessing for humanity (Bansil, 2004). The main source of water on this earth is rainfall. A portion of this is penetrated into the earth and is called groundwater.

Presently, the water quality assessment was carried out by determining various abiotic (physico-chemical) and biotic (biological) parameters, either individually or in combination. But, the determination of water quality is very important for knowing the suitability of water for various purposes (Ramkrishnaiah and Rao, 2003). Use of Water Quality Index (WQI) to determine the present water quality of aqua resources is considered as one of the most effective tool for comparing water resources (Kannan, 1991; Sinha and Shrivastava, 1994; Pradhan et al., 2001).

Water Quality Index (WQI) 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. 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 useable by the public. WQI is based on some important parameters, which can provide a simple indicator of water quality. It gives the public a general idea of the possible problems with water in particular region (Bangalore S. Shankar and Latha Sanjeev, 2008). In India not much work has been done on this topic except some studies by few researchers. Recently of Coimbatore carried out studies for determining the WQI in the east zone of Coimbatore city in India, and quoted that the WQI for this city fell within the range of 75 to 100, and hence concluded that the water could be safely used for drinking purposes (Meenambal, 2005). But, barring few studies, nothing much has been done in India, and present work is a small step in this direction.

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The main objectives of this study are to evaluate the groundwater quality by applying water quality index. The monitoring of groundwater quality is necessary in order to detect pollution and to prevent use of contaminated ground water for public water supply.

Methods

Sampling

Groundwater samples were collected from a total of 15 locations (45 samples in each season) for three alternate weeks, from the different areas of Nagpur city during the year 2006-2007 covering pre- and post-monsoon season. Samples for bacteriology were collected in sterilized glass bottles and for other parameters, pre-cleaned plastic polyethylene bottles were used. Prior to sampling, all the sampling containers were washed and rinsed thoroughly with the groundwater except bacteriological sampling bottles. The samples were analyzed for different bacteriological and physico-chemical parameters following standard methods (APHA, 2002).

Analytical Procedure

To study bacteriological quality of water, *Total Coliforms* (TC) and *Faecal Coliforms* (FC) were analysed using Membrane Filtration (MF) technique on M-Endo agar and M-FC agar respectively (Hi-Media, Mumbai). Other parameters like DO, pH and temperature were measured in the field itself and dissolved nutrients were estimated colourimetrically using UV-Visible Spectrophotometer (Hitachi U-2010). Water Quality Index (WQI) was calculated by NSF's calculator, using respective nine parameters like, *faecal coliforms* bacteria, pH, temperature, turbidity, total solid, dissolved oxygen, biochemical oxygen demand, nitrate and phosphate. In the present study WQI was calculated for the mean of estimated values of the respective parameters.

Results and Discussion

The *faecal coliforms* bacteria were found to be in range of 0 to 3 cfu/100 ml (0.2 ± 3) in pre-monsoon season and 0 to 5 cfu/100 ml (0.93 ± 1.27) in post-monsoon season. The pH values of groundwater varied from 6.8 to 8.4 (7.63 ± 0.48) during pre-monsoon season and 7.1 to 8.8 (7.91 ± 0.40) during post-monsoon season. The temperature varied from 27.8 °C to 31.1 °C (29.45 ± 0.64 pre-monsoon season and 24.7 to 29.0 °C (26.92 ±1.16) in post-monsoon season. The turbidity varied from 0.1 to 4.48 (1.6 ± 1.2) in pre-monsoon season and 0 to 14.5 (4 ± 2.94) in post-monsoon season. Total solids varied from 237 to 462 mg/L (345.67 ± 62.95) in pre-monsoon season which has been changed in post-monsoon season which was 324 to 639 mg/L (443.72 ± 83.38). Dissolved oxygen recorded in pre-monsoon varied from 2.9 to 5.32 mg/L (3.4 ± 1.02) which then slightly changed in post-monsoon season and was found to be 2.7 to 6.11 mg/L (3.97 ± 0.72). Biochemical oxygen demand recorded in pre-monsoon varied from 1 to 3 mg/L (2.26 ± 0.48) which then slightly changed in post-monsoon season and was found to be 0.8 to 2.9 mg/L (10.55 ± 0.47). The nitrate (as N) concentration of groundwater varied from 2.68 to 9.73 mg/L (5.66 ± 1.59) during pre-monsoon season and 8.9 to 12.8 mg/L (10.55 ±0.96) during post-monsoon season. The phosphate concentration of groundwater varied from 0.002 to 0.76 mg/L (0.03 ± 0.01) during pre-monsoon season and 0.027 to 0.795 mg/L (0.17 ± 0.25) during post-monsoon season (Table 1).

Table 1: Seasonal variation in bacteriological and physico-chemical parameters (mean values except WQI)

Parameters	*Seasons*	
	Pre-monsoon	*Post-monsoon*
Fecal coliforms (Cfu/100 ml)	0.2 ± 3 (0-3)	0.93 ± 1.27 (0-5)
pH	7.63 ± 0.48 (6.8-8.4)	7.91 ± 0.40 (7.1-8.8)
Temperature (°C)	29.45 ± 0.64 (27.8-31.1)	26.92 ± 1.16 (24.7-29)
Turbidity (mg/L)	1.60 ± 1.20 (0.1-4.48)	4 ± 2.94 (0-14.5)
TS (mg/L)	345.67 ± 62.95 (237-462)	443.72 ± 83.38 (324-639)
DO (mg/L)	4.10 ± 0.57 (2.9-5.32)	3.97 ± 0.72 (2.7-6.11)
BOD (mg/L)	2.26 ± 0.48 (1-3)	1.95 ± 0.47 (0.8-2.9)
Nitrate as N (mg/L)	5.66 ± 1.59 (2.68-9.73)	10.55 ± 0.96 (8.9-12.8)
Phosphate (mg/L)	0.03 ± 0.01 (0.002-0.076)	0.17 ± 0.25 (0.027-0.795)
WQI	76-83	68-82

The WQI showed slight variation in post-monsoon season. In pre-monsoon season the calculated WQI varied from 76 to 83 which reflects the good quality of water within the sampling locations which slightly changed (two samples only) in post-monsoon season and were found to be 68 to 82, which showed the change in water quality in two sampling locations only (Figure 1).

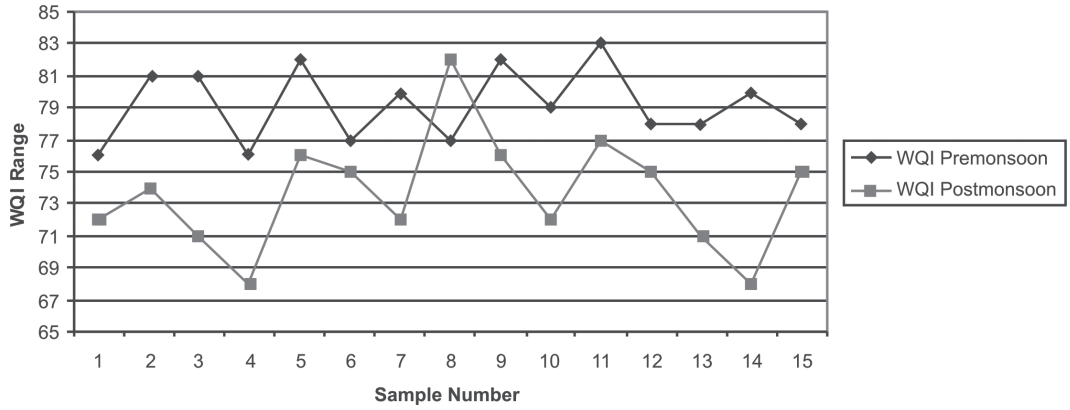

Figure 1: Variation of WQI at sampling locations within the district.

Fecal Coliforms Bacteria

In pre-monsoon season only five sampling locations showed the presence of fecal coliform bacteria (two samples of location numbers 6 and 9 and one sample of location number 10) but in post-monsoon season twenty three samples showed the presence of fecal coliform bacteria (two samples of location numbers 1, 2, 6, 7, 9 and 15; one sample of location numbers 3 and 4; and three samples of location numbers 10, 12 and 13).

pH

The pH of natural waters is often found slightly acidic (5.0–7.5). This may be due to the presence of dissolved carbon dioxide and organic acids (fulvic and humic acids). In the present study areas pH varied from 6.8 to 8.4 in pre-monsoon season and 7.1 to 8.8 in post-monsoon season. During the present investigation, pH value as low as 6.8 was recorded in a sample of location number 13 and high pH value was recorded in a sample of location number 14 in pre-monsoon season while in post-monsoon the low pH was recorded in a sample of location number 11 and high pH was recorded in a sample of location number 2. In general, the distribution of pH did not show any specific trend within the basin and is in range of WHO guidelines.

Temperature

The temperature ranges from 27.8 °C to 31.1 °C for sample of location numbers 10 and 15 respectively in pre-monsoon season and 24.7 °C to 29 °C for sample of location numbers 14 and 1 respectively were recorded in post-monsoon season. Slightly seasonal variations in temperature were found within the locations.

Turbidity

The WHO health-based guideline value for turbidity in drinking water is 5 NTU. In the present study 100% (45) samples were within the range in pre-monsoon season, all of which 24 % (11) samples were found slightly above the guideline value in post-monsoon season.

Total Solid (TS)

Total solids in the groundwater samples collected in 45 locations varied from 237 mg/L to 462 mg/L and 324 mg/L to 639 mg/L in pre- and post-monsoon season respectively. The mean concentration of TS in pre-monsoon was 345.67 mg/L, which then changed in post-monsoon season and was found to be 443.72 mg/L. TS was relatively higher (in few locations like 2, 6, 7 and 13) in post-monsoon season as compared to pre-monsoon season.

Dissolve Oxygen (DO)

The DO concentration of the groundwater ranged from 2.9 mg/L to 5.32 mg/L in pre monsoon season in samples of location numbers 10 and 2 respectively, in post-monsoon season DO concentration ranged from 2.7 mg/L to 6.11 mg/L where lowest and highest value were recorded in samples of location numbers 13 and 8 respectively.

Biochemical Oxygen Demand

The BOD concentration of the groundwater ranged from 1 mg/L to 3 mg/L in pre-monsoon season where lowest and highest BOD concentration were recorded in samples of location numbers 5 and 11 respectively. In post-monsoon season BOD concentration ranged from 0.8 mg/L to 2.9 mg/L, where lowest BOD concentration were recorded in samples of location numbers 10 and 11 and highest BOD concentration were recorded in sample of location number 5. The groundwater samples showed slight change in mean BOD concentration.

Nitrate

The WHO health-based guideline value for nitrate in drinking water is 10 mg/L (as N). Few data are available for concentrations of nitrate in groundwater from

sampling sites and were quoted values between 2.68 mg/L and 9.73 mg/L (as N) in pre-monsoon season where all the values were within the limit, but in post monsoon season in few locations it was slightly higher in which lowest to highest nitrate concentration was 8.9 mg/L and 12.8 mg/L (as N) respectively. These values are relatively low, with few exceeding the WHO guideline value. However, in each case the number of samples given was very small and it is hard to assess how representative these are of groundwater compositions across the sampling sites.

Phosphate

The total phosphate concentration of the groundwater ranged from 0.002 mg/L to 0.076 mg/L in pre-monsoon season where lowest phosphate concentration was recorded in sample of location 1, whereas highest concentration was recorded in sample of location 3. In post-monsoon season total phosphate concentration ranged from 0.027 mg/L to 0.795 mg/L, where lowest phosphate concentration was recorded in sample of location 6 and highest concentration was recorded in sample of location 3. The groundwater samples showed slight change in phosphate concentration.

Water Quality Index

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. In the present study the water quality index ranges from 76 to 83 in pre-monsoon and 68 to 82 in post-monsoon season. In pre-monsoon season WQI number of all locations showed good quality of water whereas in post-monsoon season two samples (location numbers 4 and 14) showed variation in WQI number and possessed the medium water quality where compared to the standard WQI values given by NSF (Table 2).

Table 2: Water quality index legend

Range	*Quality*
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

Source: National Sanitation Foundation.

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