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Anuj Kumar
Singhania University, Jhunjhunu, Rajasthan, India.

Dinesh Kumar
Birla Institute of Technology & Science, Pilani, Rajasthan, India.

Gajendra Singh Chahar
Excel Institute of Management and Technology, Mathura, Uttar Pradesh, India.

Correspondence
Anuj Kumar
Singhania University, Jhunjhunu, Rajasthan, India.

A study of water quality index for the assessment of suitability of water for drinking in rural & urban areas of Mathura Distt. of U.P.

Anuj Kumar, Dinesh Kumar and Gajendra Singh Chahar

Abstract
We present the physiochemical characteristics of the water sources of the rural and urban areas of the Mathura district based on computed water quality index (WQI). Water samples collected in different seasons from different sites of the Mathura District of Uttar Pradesh. The average temperature range is 3 – 26 ºC. Chloride was within the permissible limits. The annual average mean value of WQI for all sampling is 63.41 which indicated the poor quality of water. In summer and monsoon seasons, quality of water is more poor compared to the winter season.

Keywords: Yamuna River, Water Quality Index (WQI), Mathura, WQI of Yamuna River in Mathura region

1. Introduction
Water is one of the most vital natural resource for the life. The availability and quality of water have always played an important role in determining not only where people can live, but also their quality of life. It is therefore necessary that the quality of drinking water is checked at regular time intervals, because the human population can suffer from a variety of waterborne diseases due to contaminated drinking water.

Uttar Pradesh is also a state of having lack & pollution in water specially in Mathura district covering approximately 3811 sq.km. area, which covers 1.27% population of the state. It is noteworthy that 70.32% population live in the rural areas of the district. The people in the urban and rural areas depend up on untreated surface water resources.

The water quality index (WQI) is an effective tool to monitor water pollution. It is a dimensionless number that combines multiple water quality factors into a single number and helps in interpreting the quality of water with a single numerical value [1]. The objective of the present study is to provide information on the physiochemical characteristics of the water sources of the rural and urban the Mathura district areas of in order to assess the suitability of the water for human consumption based on computed WQI.

A total of 225 water samples, that is, 75 each in winter, summer and monsoon were collected during the period from January 2013 to December 2014 from 75 villages. For the study, 30% of the villages of the district were taken into account, thus 75 villages were selected out of a total of 251 villages. A sample of 500 ml of water was collected from each site in plastic cans and analyzed for nine physiochemical parameters. The parameters color, odor, pH, temperature, turbidity, total dissolved solids (TDS), and dissolved oxygen (DO) were monitored at the sampling site, and the parameters total hardness and chloride were analyzed in the laboratory as per the standard methods of the American Public Health Association (APHA, 1952) [2]. The WQI was calculated by using the standards of drinking water quality recommended by the Bureau of Indian Standards (BIS, 2009) and the Indian Council of Medical Research (ICMR, 1975) [3, 4]. The weighted arithmetic index method was used for the calculation of the WQI [5].

2. Methodology

A WQI is calculated from the point of view of the suitability of water for human consumption. The "standards" and "unit weights" of the parameters measured for the drinking water recommended by the ICMR and the BIS are given in Table-1.

The quality rating q_n for the nth water quality parameter was obtained from the following formula:

$$q_n = 100 \left[\frac{(V_n - V_{io})}{S_n - V_{io}}\right]$$

where, V_n = estimated value of the nth parameter at a given sampling site, S_n = standard permissible value of the nth parameter, and V_{io} = ideal value of the nth parameter in pure water. All the ideal values (V_{io}) were taken as zero for drinking water except for pH = 7 and DO = 14.6 mg/L.

The unit weight (W_n) was calculated for various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters, as and where:

$w_n = \frac{K}{S_n}$ where, W_n = unit weight for the nth parameters, S_n = standard value for the nth parameters, and K = constant for proportionality.

The WQI was calculated from the following equation:

$WQI = \Sigma q_n w_n / \Sigma w_n$

Water quality can be categorized into five forms (excellent, good, poor, very poor, and unsuitable) for drinking if the WQI value lies in the ranges of 0-25, 26-50, 51-75, 76-100 and above 100, respectively [6].

3. Result and Discussion

The data were processed using the Statistical Package for Social Sciences (SPSS Inc. Released 2007, SPSS for Windows, Version 16.0, Chicago, SPSS Inc.)

The WQI for the water samples ranged 32.01 – 98.4. Table 2 shows the WQI for the sampling sites in different seasons. Of the sampling sites, 76% were in the "poor" category in summer, followed by 70.6% in monsoon and 60% in winter; 34.6% of water samples were in the "good" category in winter and 25.3% were of "very poor" quality in monsoon. None of the samples were in the "excellent" or "unsuitable for drinking" categories. Water quality was better in winter compared to that in summer or monsoon [Table 2].

Table 1: Drinking water standards with unit weights recommended by ICMR/BIS*

Parameters	Standard Values	Desirable unit weight (W_n)
pH	6.5-8.5	0.2190
Turbidity (NTU)	10	0.01654
TDS	500	0.0037
Total hardness	300	0.0062
Chloride	250	0.0074
DO	5	0.3723
		$\Sigma W_n = 0.06251$

(* ICMR- Indian Council of Medical Research, BIS = Bureau of Indian Standards, TDS – Total dissolved solids, DO – Dissolved oxygen, All values except pH and turbidity area in mg/L)

Table 2: Water quality index (WQI) values of sampling sites in different seasons found din the study

WQI level	Water quality	Winter (%)	Summer (%)	Monsoon (%)
0-25	Excellent	-	-	-
26-50	Good	26 (34.6)	3 (4)	3 (4)
51-75	Poor	45 (60)	57 (76)	53 (70-6)
76-100	Very poor	4 (5.3)	15 (20)	19 (25.3)
>100	Unsuitable for drinking	-	-	-

The water samples were found to be colorless and odorless. The average temperature ranged 3–26ºC, with mean values 7.68 ± 2.18 in winter, 18.9 ± 3.87 in summer, and 15.16 ± 3.72 in monsoon. The pH ranged 5.5 – 7.5, with mean values 6.52 ± 0.39 in winter, 6.56 ± 0.33 in summer, and 6.36 ± 0.35 in monsoon. The pH was observed to decline during the monsoon and increase in the winter season. The range of turbidity in the study varied 2 – 25 NTU, with mean values 4.69 ±1.91 in winter, 13.20 ± 4.98 in summer, and 15.76 ± 3.72 in monsoon. TDS in the studied area varied in the range of 20 – 135 mp/L, with mean values 50.83 ± 21.35 in winter, 61.81 ± 21.31 in summer, and 62.81 ± 22.24 in monsoon. In the study, values of hardness fluctuated in the range of 48 – 129 mg/L, with mean values 99.92 ± 17.22 in winter, 83.76 ± 14.72 in summer, and 70.37 ± 12.24 in monsoon. The chloride concentration fluctuated in the range of 10 – 44 mg/L, with mean values 18.31 ± 5.27 in winter, 29.35 ± 6.79 in summer, and 23.44 ± 6.24 in monsoon. DO varied in the range of 3.1 – 9.8 mg/L, with mean values 8.02 ± 1.38 in winter, 6.13 ± 1.09 in summer, and 6.72 ± 1.42 in monsoon. All the parameters in all seasons differed statistically (P<0.01) from the standard values.

The water was found to be more turbid during the monsoon and summer seasons than during the winter season. This can be caused by soil erosion, water discharge, agricultural runoff, etc. Similarly, other authors in their studies reported high turbidity in summer and monsoon compared to winter[7]. Turbidity was within the permissible limits only in the winter seasons. TDS values in the studied area were within the permissible limits. The average value of TDS was found to be higher in summer than in winter season. Several other studies showed similar observations of TDS being high in summer [7, 8]. Hardness was found to be well within the permissible limits. The hardness was found to be the highest in winter, followed by summer and monsoon.

Chloride was within the permissible limits. Seasonally, chloride was found to be high in summer season, followed by monsoon and winter season. Similar observations have been made by several authors [7, 9]. The concentration of DO was the highest during winter, followed by monsoon and in summer season. This observation is in conformity with the observations of some other studies [9, 10]. In contrast to our study, some authors observed high concentrations of DO during the summer [7].

The mean values of WQI for all the sampling sites in the different seasons, that is, winters, summer, and monsoon are 55.17 ± 9.98, 66.77 ± 10.34, and 68.29 ± 11.5 respectively, which indicates poor quality of water [6]. Most of the samples, that is, 76% showed poor quality of water in summer. Several other studies based on WQI for untreated natural water conducted in India have also reported poor quality of water in summer and monsoon compared to the winter season [8, 9].

4. Conclusion

In this study, the overall quality of water was assessed by applying a WQI. WQI has some limitations- it may not carry enough information about the actual situation of the water bodies, with the aggregation of data perhaps masking short-term water quality problems. However, the WQI method more than compensates for such drawbacks. This method is more systematic and enables the comparative evaluation of water quality of multiple sampling sites. In this study, WQI values revealed that the present status of water quality is not suitable for drinking purposes, and therefore water should be treated properly before use. It is recommended that more surveys be

conducted covering more areas, to develop water treatment and purification plants in specific locations, and to propagate public health education. The results of this study are expected to be a helpful tool for the public and for water quality management also.

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