INVESTIGATION OF WATER QUALITY INDEX (WQI) OF DIFFERENT WATER SOURCES IN RATLAM TOWN, MADHYA PRADESH, INDIA

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Abstract: This work is aimed to determine the water quality index (WQI) of different water sources in Ratlam town. WQI is an effective tool in comparing the water quality of different sources. It gives a general idea of the possible problems with water in a particular region. The sampling sources of water were identified as source station I (Municipality), II (Tube well) and III (Open well) from October 2016 to January 2017. In this study, 7 parameters namely- pH, total alkalinity, TDS, chloride, sulphate, phosphate, and DO were considered.

From the outcome of this study we came to the conclusion that most of the water samples were in poor condition (above 50) and exceeded standard limits. Results indicated that WQI values of Station I were found to be very poor (96.91), Source Station II was good (46.95) and Source Station III was poor (69.71). This study suggests that expect Source Station II, the quality of water is poor at other two Stations and not entirely safe for drinking purpose; prior treatments are required before consumption.

Keywords: WQI, Ratlam, Surface water, Physiochemical analysis.

Introduction: Rapid urbanization has affected the availability and quality of ground and surface water due to its overexploitation and improper waste disposal, especially in urban areas [1]. Therefore, it is necessary to frequently test the quality of surface and groundwater to protect the drinking water sources. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the establishment of industrialization. Due to agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions, human health is at very big risk [2]. According to World Health Organization (WHO) [3] about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. For this reason, continuous examining and assessment of water quality helps to develop management strategies to control ground and surface water pollution and to protect it. WQI is an important technique for determining groundwater quality and its suitability for drinking purposes. WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption. It is simple and easy method for decision makers to understand about quality and possible uses of any water body [4].

Therefore, the present work has been carried out to evaluate water quality of different water sources and portability of Ratlam town by analyzing physio-chemical parameters and by determining WQI.

Study area- Ratlam city is the district headquarter of Madhya Pradesh region of Central India and is located at coordinates: 23°19′0″N 75°04′0″E (23.316667, 75.066667). The city has an area of 15.13 square miles (39.19 km² According to the 2011 Census, the city of Ratlam has a population of 2, 64,810, of which 1, 35,007 are male and 1, 29,803 are female. The moderate rainfall of Ratlam is 35 to 38 inches (890 to 970 mm) from July through September, due to the southwest monsoon. Ratlam district receive maximum rainfall during southwest monsoon period i.e. June to November. About 92.8% of annual rainfall is received during monsoon season.

Materials and Methods:- The estimation of WQI of Ratlam town is done to confirm the water quality of different Source Stations. The water samples were collected at an equal interval of 10 day and tested for 7 physiochemical parameters such as pH, Total Alkalinity, Total Dissolved Solids, Calcium, Chlorides, Sulphate and Dissolved Oxygen. In the present study, sample of water was collected from three different Source Stations namely Source Station I (Municipality), Source Station II (Tube Well) and Source Station III (Open Well). All the parameters were analysed in the laboratory as per the standard of American Public Health Association [5].

Collection of the sample- The water samples were collected from three different study stations in morning hours between 9:00 to 12:00AM, in 500 ml closed plastic bottles. These bottles were sterilized with dilute HNO_3 and detergent and

rinsed by distilled water. Just prior to the sampling, these bottled were again rinsed with sampling water. As the samples is collected the lid of the bottles were closed to avoid the contamination. After taking the sample, the bottles were preserved soon to avoid physical, chemical and biochemical reactions. The preservation of water samples was done by adding chemical preservatives, lowering the temperature or by the combination of both the method. In this experiment, the water samples were preserved by storing the bottles in refrigerator at 4°C and adding 3 – 4 drops of conc. HNO_3 to minimize the pH (below 2) to avoid precipitation or degradation of dissolved and suspended metallic elements. For analysis of dissolved oxygen content, water samples were used immediately after collection. The sustainability of the water samples from Ratlam Town, for drinking, domestic, and irrigation purposes was estimated by comparing the values of different water quality parameters with those of the World Health Organization (WHO) [3], bureau of Indian Standards (BIS) [6] and Indian Council for Medical Research (ICMR) [7] guideline values for drinking water.

Water Quality Index (wqi); WQI is a mathematical equation which converts large number of water quality data into a single number. It is expressed as a score that reveals the combined influence of different water quality parameters. Hence, water samples in three different study stations in different seasons of the year were collected during the period from October 2016 to January 2017. A sample of 250 ml of water was collected from each site in plastic bottles and analyzed for 7 physicochemical parameters. pH and dissolved oxygen (DO) were determined at the sampling site while the parameters like alkalinity, chloride, calcium and phosphate were analyzed in the laboratory as per the standard methods of the American Public Health Association [5]. The water quality index (WQI) was estimated by using the standards of drinking water quality recommended by the Bureau of Indian Standards [6] and the Indian Council of Medical Research [7]. WQI is computed by different steps. In the first step, estimated values of each of the 7 parameters (pH, TDS, Total alkalinity, Chloride, Sulphate, Calcium, DO) is divided by standard values of each parameters and Quality Rating (q_n) is obtained. In the second step, the quality rating (q_n) is multiplied with the relative weight assigned by the Recommended Agencies important in the overall quality of water for drinking purposes (Table 2). In the third step, Sum of all the W_nq_n is divided by the sum of all the values of unit weights which gives the WQI of different water samples. For the Calculation of WQI, Weighted Arithmetic Index Method [8] (Brown et. al.,) has been used. Quality rating (q_n) was determined using the following formula-

$$\mathbf{q_n = 100\ [V_n - V_{io}] / [S_n - V_{io}]}$$

(Let there be n water quality parameters and quality rating or sub index (q_n) corresponding to n^{th} parameter is a figure reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value.)

q_n =Quality rating for the n^{th} Water quality parameter

V_n=Estimated value of the n^{th} parameter at a given sampling station.

S_n =Standard permissible value of the n th parameter.

V_{io} = Ideal value of n^{th} parameter in pure water. . (i.e., 0 for all other parameters except the parameter pH and Dissolved oxygen (7.0 and 14.6 mg/L respectively).

Calculation of pH- For pH, the ideal value is 7.0 (for natural/pure water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following equation-

$$\mathbf{qpH = 100\ [(V_{pH} - 7.0) / (8.5 - 7.0)]}$$

Where, V_{pH} = observed value of pH.

Calculation of DO- For dissolved oxygen, the ideal value is 14.6 mg/L and the standard permissible value for drinking water is 5 mg/L. Therefore, its quality rating is calculated from the following equation:

$$\mathbf{qDO = 100\ [(V_{DO} - 14.6) / (5.0 - 14.6)]}$$

Where, V_{DO} = observed value of dissolved oxygen

The overall Water Quality Index (WQI) was calculated by multiplying the quality rating with the unit weight linearly

$$\mathbf{WQI = \sum q\ n\ Wn / \sum Wn}$$

Results and Discussion:- The physiochemical analysis of quality of water of the Ratlam town with Indian and WHO standards were found that three different source stations have different Water Quality Index (Table4, 5 and 6). The results for WQI are as follows- Source Station I (Municipality) is 96.91 indicates that the quality of water was very poor, Source Station II (Tube Well) is 46.95 was good and Source Station III (Open Well) is 69.71 was poor according to the Water Quality Index (WQI) of (WHO, 1985). So it was concluded that Source Station II was of good water quality and does not require any kind of treatments before use while Source Station I and III falls into poor category which indicates that the water is not suitable for direct consumption and requires treatment. After treatment, this

water can be used for drinking purpose and domestic use. The continuous monitoring of groundwater is required in the district to protect water in future from any possible contamination due to growing industrialization and agricultural practices.

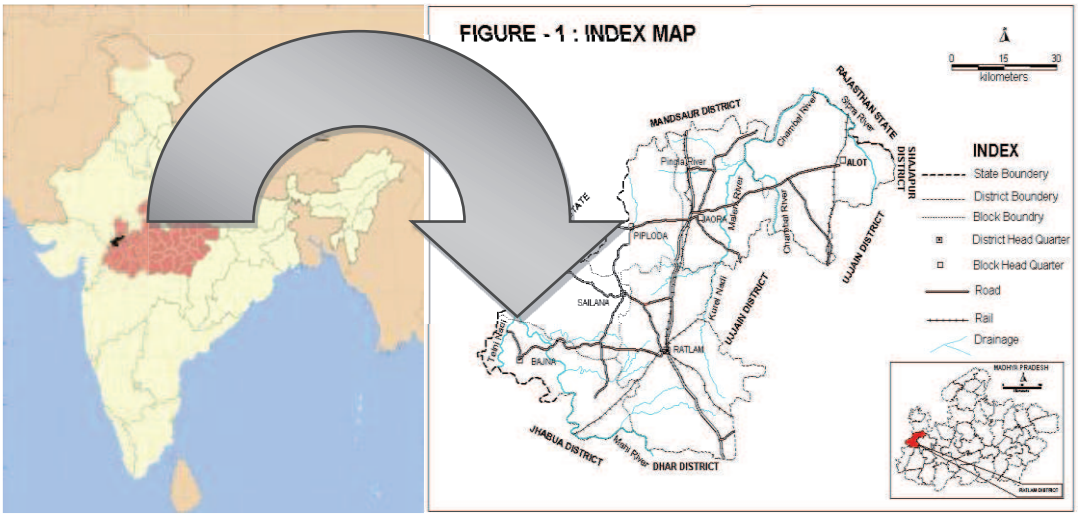

Fig.1. Map showing the location of Ratlam in India.

Table 1:- Water Quality Index (WQI) and status of water quality (WHO, 1985).

Water quality Index Level	Water quality status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very Poor water quality
>100	Unsuitable for drinking

Table 2- Drinking Water Standards and Unit Weights (All values expect pH in mg/L)

S.No.	Parameters	Standards	Recommended agency	Unit Weight
1.	pH	6.5-8.5	ICMR/BIS	0.2190
2.	Total alkalinity	120	ICMR	0.0155
3.	Total Dissolved Solids	500	ICMR/BIS	0.0037
4.	Chlorides	250	ICMR	0.0074
5.	Sulphate	150	ICMR/BIS	0.01236
6.	Calcium	75	ICMR/BIS	0.025
7.	Dissolved Oxygen	5.00	ICMR/BIS	0.3723

Table 3- Physiochemical parameters of different source stations in Ratlam Town between October 2016-January 2017.

S.No	Parameters	StationI (Municipality)	Station II (Tube wells)	Station III (Open wells)
1.	pH	6.2	6.9	7.8
2.	Total alkalinity	78	73	75
3.	Total Dissolved Solids	573	153	345
4.	Chlorides	174	37	110
5.	Sulphate	151	11	32
6.	Calcium	70	72	72
7.	Dissolved Oxygen	6.2	3.5	4
	WQI	96.91	46.95	69.71

Table 4- Calculation of Water Quality Index for Source Station I (Municipality):-

S.No	Parameters	Observed values	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n
1.	pH	6.2	6.5-8.5	0.2190	53.33	11.67
2.	Total alkalinity	78	120	0.0155	65	1.007
3.	TDS	573	500	0.0037	114.6	0.424
4.	Chloride	174	250	0.0074	69.60	0.515
5.	Sulphate	151	150	0.01236	100.67	1.244
6.	Calcium	70	75	0.025	93.33	2.33
7.	DO	6.2	5.00	0.3723	124	46.29
				$\sum W_n=0.655$		$\sum W_nq_n=$ 63.48
	Water Quality Index= 96.91					

Table 5- Calculation of Water Quality Index for Source Station II (Tube Well):-

S.No	Parameters	Observed values	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n
1.	pH	6.9	6.5-8.5	0.2190	6.66	1.459
2.	Total alkalinity	61	120	0.0155	50.83	0.787
3.	TDS	153	500	0.0037	30.6	0.111
4.	Chloride	37	250	0.0074	14.8	0.1095
5.	Sulphate	11	150	0.01236	7.33	0.0905
6.	Calcium	65	75	0.025	86	2.1
7.	DO	3.5	5.00	0.3723	70	26.06
				$\sum W_n=0.655$		$\sum W_n q_n=30.753$
	Water Quality Index= 46.95					

Table 6- Calculation of Water Quality Index for Source Station III (Open well):-

S.No	Parameters	Observed values	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n
1.	pH	7.8	6.5-8.5	0.2190	53.33	11.67
2.	Total alkalinity	75	120	0.0155	62.5	0.968
3.	TDS	345	500	0.0037	69	0.2553
4.	Chloride	110	250	0.0074	44	0.3256
5.	Sulphate	32	150	0.01236	21.33	0.263
6.	Calcium	72	75	0.025	96	2.4
7.	DO	4	5.00	0.3723	80	29.78
				$\sum W_n=0.655$		$\sum W_nq_n=$ 45.66
	Water Quality Index= 69.71					

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