DETERMINATION OF SURFACE WATER QUALITY INDEX OF DHAMOI RESERVOIR IN JHABUA DISTRICT, MADHYA PRADESH, INDIA

RANJANA RAWAT, N.K. DHAKAD

Abstract: The present work is intended to assess the water quality index (WQI) in the surface water of Dhamoi Reservoir in Jhabua in different seasons at different study stations. Three sampling locations were identified as station I, II and III (Centre, Inlet, and outlet) for a period of one year on seasonal basis from June 2013 to May 2014. For calculating the WQI, 11 parameters namely, pH, total alkalinity, TDS, COD, electrical conductivity, chloride, sulphate, phosphate, DO and BOD were considered. The outcome of this study confirmed that most of the water samples were in poor condition (above 80.9) and exceeded standard limits. Results indicated that WQI values of Station I in different seasons were found to be poor ranging from 73.3-80.946, Station II was in poor category (80.946) while station III was found unsuitable for drinking with and 113.280 WQI value. We suggest that water is poor of quality in all study stations and not entirely safe for drinking purpose. So it requires prior treatment before consumption.

Keywords: Jhabua, Madhya Pradesh, Surface water, Water quality index

Introduction: The ever-increasing demand for domestic and irrigation purposes and careless use of water has put its sustainability in danger due to its continuous reduction and deterioration of quality in developing countries including India (Reddy, 2013, Reddy and Baghel, 2013). The environmental conditions of any lake and reservoir system depend upon the it's exposure to various natural and anthropogenic environmental influences (Stribling, L., 1995, Taylor, R.G et al,2013, Yihdego, Y, 2017).Their delicate ecosystem must preserve the state of ecological equilibrium with the existing surroundings particularly from a human induced pollution. On the other hand, in recent times, population growth, agricultural practices and sewage runoff from urban areas have increased nutrient inputs many folds resulting in speed up the process of eutrophication (Nixon, S.W., 1995, Zhang, J., 2016.). The reservoirs and lakes all over India, are in varying degrees of environmental degradation, might be due to encroachments, eutrophication (from domestic and industrial effluents) and silt. Industrial and population growth, agricultural practices and sewage runoff have made the lakes of the study area susceptible to sewage flow, solid waste dumping, etc., in turn exerting pressure on the percolation and infiltration processes responsible for the groundwater recharge (Wilkinson, M.E., et al,2014). For this reason, cyclic examining and assessment of water quality helps to develop management strategies to control surface water pollution (Smucker, N.J. and Detenbeck, N.E., 2014).

Water quality index (WQI) is one of the most effective tools (Mishra and Patel 2001,Ramakrishnaiah, C.R., et al, 2009, Yisa, J. and Jimoh, T., 2010. Mitra and Reddy,2016, Mukherjee et al,2017) to communicate information on the quality of water to the concerned citizens and policy makers.

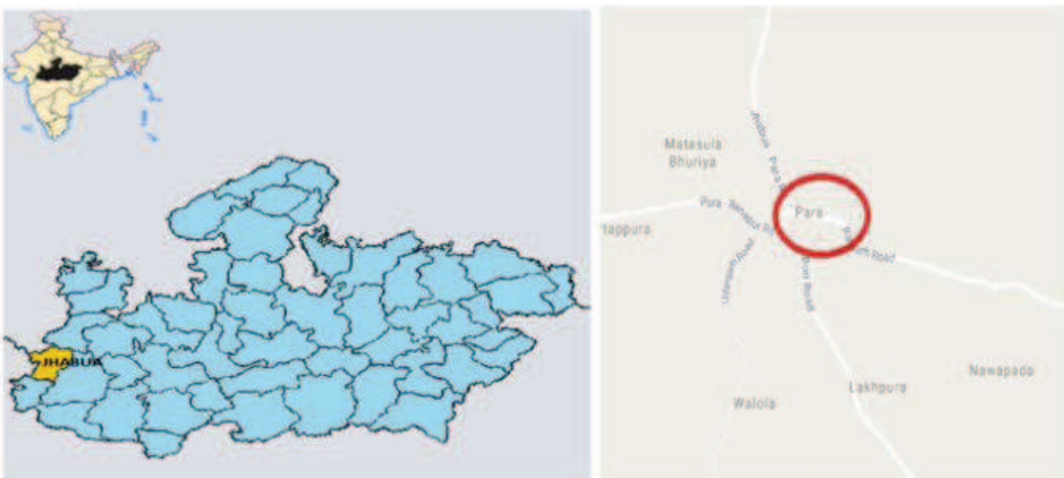

FIG.1. Map showing the sampling locations at Dhamoi Reservoir, Jhabua. M.P

Therefore, the present work has been carried out with a attention to evaluate comparatively the prevailing water quality and potability of Dhamoi Reservoir at different stations and in different seasons by analyzing physico-chemical parameters and by estimating WQI.

Materials and Methods: **Material and Methods: Study area**: The study was carried out at Dhamoi reservoir which is an important water reservoir located about 24km from Jhabua town and 12km away from Para village (Fig.1). It is a man made reservoir and built in 1988-1999.It is about 28.10 meter in height with the catchment area of 61.44sq.km (mpwrd.gov.in). The reservoir is mainly used for drinking, irrigation and fishing purposes. Hence anthropogenic interference is much more to affect the quality of water. The hydro-geochemistry of the study area had carried out to know the possible usage of the Reservoir basin and to plan the same.

The selection of sampling sites was decided by the various uses of water and by their location, relative magnitude and importance. The chance of accidental pollution was also considered for sampling. The water samples were collected from three different points of reservoir.

Study station I: Center point: This is the point represent the general water quality of the reservoir. Human activities are reduced here for bathing and fishing. This station was taken as the reference station (control) owing to the absence of sewage discharge into the reservoir from households.

Study station II: The inlet point: This is the point where the feeder opens in the lake. This station is located at northern part of Para village. Domestic waste is drained into this station. Motor vehicles are constantly washed. Also devotees of Goddess immerse their pantheon (pooja material) directly into the reservoir.

Study station III: The outlets point: This is the place where the overflows and outflow occurs.

Sample collection: Sub surface water samples were collected from three different study stations of reservoir on quarterly basis in triplicate in morning hours between 7:00 to 9:30AM, in one liter plastic bottles, which were previously cleaned with dilute HNO_3 and detergent followed by distilled water. Before sampling, they were again rinsed with sampling water. The closed bottle was dipped in the reservoir at the depth of 0.5 to 0.7 m, and then a bottle was opened inside and was closed again to bring it out at the surface. From the time of sample collection to the time of analysis, many physical, chemical and biochemical reactions would change the quality of the water sample, for that reason to minimize this change the sample were preserved soon after the collection. Water samples were maintained by keeping 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. The water samples were preserved by adding chemical preservatives, lowering the temperature or by the combination of both the method. For analysis of dissolved oxygen content, water samples were fixed immediately after collection. The suitability of the surface water from Dhamoi Reservoir at Jhabua, for drinking, domestic, and irrigation purposes was calculated by comparing the values of different water quality parameters with those of the Bureau of Indian standards (BIS) guideline values for drinking water.

Calculation of WQI: WQI 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 June 2013 to May 2014. A sample of 500 ml of water was collected from each site in plastic cans and analyzed for eight physicochemical parameters. The factors like pH, temperature, Electrical conductivity (EC) and dissolved oxygen (DO) were determined at the sampling site while the parameters like alkalinity, chloride and phosphate were analyzed in the laboratory as per the standard methods of the American Public Health Association (APHA, 1995).The water quality index (WQI) was computed by using the standards of drinking water quality recommended by the Bureau of Indian Standards (BIS, 2003) and the Indian Council of Medical Research (ICMR, 1975). The weightage for parameters is specified according to use. Each one of the water parameters were assigned a weight (wi) based on their supposed effects on primary health and their comparative importance in the overall quality of water for drinking purposes (Table 2). By computing the relative weight (Wi) of each parameter using appropriate equation Table 2 present the weight (wi) and calculated relative weight (Wi) values for each parameter. The weighted average of the parameter will give the WQI of that sample for the desired purpose. The purpose will also select the choice of the parameters. Then after, a standard for maximum and minimum permissible limit is selected and calculated the average of the value.

The WQI has been computed by using the standards of drinking water quality recommended by the Bureau of Indian Standards (BIS, 2003), World Health Organization (WHO, 1985) and Indian Council for Medical Research (ICMR, 1975). The weighted arithmetic index method of Brown et. al., (1972) has been employed for the computation of WQI of the surface water of the Reservoir. Besides, quality rating or sub index (qn) was calculated using the following expression.

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

(Let there be n water quality parameters and quality rating or sub index (qn) 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.)

qn =Quality rating for the n th Water quality parameter

Vn=Estimated value of the n th parameter at a given sampling station.

Sn =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)

Unit weight was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter.

Wn =K/ Sn Wn= unit weight for the n th parameters.

Sn= Standard value for n th parameters

K= Constant for proportionality.

On the whole the Water Quality Index was determined by aggregating the quality rating with the unit weight linearly.

WQI=∑ q n Wn/ ∑Wn

Results and Discussion: Water quality index (WQI) is an important and unique tool to illustrate the overall water quality status. In the present investigation WQI has been calculated for three sites for Dhamoi Reservoir at Jhabua (Western Madhya Pradesh) in three different seasons of the year. The values of various physico-chemical parameters were compared with desirable/permissible limit of ICMR/BIS of drinking water specification (BIS, 2003, ICMR, 1975). The WQI for the water samples of Dhamoi reservoir at Jhabua were ranged 73.3- 80.94 - 113.2.

Results clearly reveal that the water samples of Dhamoi reservoir at Jhabua in different seasons were found to be colorless and neutral. The status of the surface water of the Reservoir is oligotrophic and it is suitable for the human consumption but after proper treatment only. Results also indicate that the pollution load is comparatively high during summer season compared to other seasons.

Results Clear shows the WQI varies with season and segment of the Reservoir. It was found that 76% were in the very poor category in summer, followed by 40.6% in winter and 31% in rainy season. 44.6% of water samples were in the "good" category in rainy and 35.3% were of "poor" quality in winter. None of the samples were found in the "excellent" or "unsuitable for drinking" categories. Water quality was better in winter compared to that in summer or monsoon (Table, 4, 5, 6, 7&8). The average temperature ranged 19.3 in winter and 26.1 in summer. The pH ranged 6.7-8.7, with mean values 6.8 ± 0.39 in monsoon, 8.3 ± 0.33 in summer, and 8.4 ± 0.35 in monsoon. The pH was observed to decline during the monsoon and increase in the winter season. 89% of the mean samples were not exceeding the BIS/ICMR limits and ranged between 6.2-8.6. Electrical conductivity (EC) is a measure of the potential of water to carry an electrical current. This capacity is connected to the total amount of solids dissolved in the water. Hence water with high ions content tends to have higher conductivity, which is an indicator of high solid concentration dissolved in the water (Prerna and Reddy, 2015). The values of water conductivity in the Dhamoi reservoir varied from 310 µs/cm (station I) to 360 µs/cm to in the Station III. The value of conductivity was recorded lowest in Station I and maximum in Station III shows poor quality of water in station III.

The chloride reaches the river from different anthropogenic activities like septic tank effluents and animal feeds. Elevated concentration of chloride can make water distasteful and therefore unsuitable for drinking or livestock watering. The chloride concentration fluctuated in the range of 26-263 mg/l, with mean values 42.0 ± 1.27 at station I, 26.0 ±1.79 in Station II, and 263.0 ± 6.24 in station III. But the concentration of chloride was found to be within permissible limits. DO differ in the range of 5.0-6.9 mg/l. All the parameters in all seasons and in three study stations significantly differed statistically ($P < 0.01$) from the standard values. The water was found to be muddier during the monsoon and summer seasons compared to the winter season which may be due to soil erosion, water discharge, agricultural runoff, etc. In the same way, many other investigators in reported high turbidity in summer and monsoon compared to winter (Reddy and Baghel, 2010, Reddy, 2012a, b, Parmar and Reddy, 2013, Poonia, S.,et al, 2015, Muchandi, S.S et al,2017). The mean values of WQI for all the sampling sites are 80.946 (Station I), 83.049 (Station II) and 133.706 at Station III respectively, which indicates poor quality of water. Most of the samples, showed poor quality of water in summer compared to the winter season as in earlier studies (Poonia, S.,et al, 2015, Muchandi, S.S et al,2017). There is no single site's water quality can be expressed as excellent or unsuitable.

Conclusions: The WQI method is more methodical and facilitates the comparative evaluation of water quality of several sampling sites. The WQI values of current study revealed that the status of water quality is not appropriate for drinking purposes, and therefore prior treatment is required before use. It is advocated that more investigations to be carried out covering more areas and to spread public health education. The outcome of this study is expected to be a supportive tool for the public and for water quality management.

Jhabua is a dominant tribal region of the country. People from in and around of Jhabua are not much aware of sanitation. Hence, sanitary sewage, with a wide variety of dissolved and suspended impurities discharged into the Dhamoi reservoir. Many people dump their garbage into the reservoir hence making water bodies as sink of cans, bottles, plastics, and other household products. Detergents and other synthetic cleaning substances that contain harmful chemicals also dumped into the reservoir. Besides, agriculture is the predominant sector and more than 85% of tribal population depends on it for their live hood.

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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: Seasonal variations of the mean physicochemical parameters of the surface water of Dhamoi Reservoir at Jhabua.

Parameter	ICMR Standard	Unit weight(wn)	Station I			Station II			Station III		
			Rainy	Winter	summer	Rainy	Winter	Summer	Rainy	Winter	Summer
pH	7.74	0.07164	6.75	6.9	7.0	7.8	8.1	8.4	8.2	8.7	8.6
TDS	500	0.00100	490	488	478	587	510	487	586	468	487
TH	200	0.00167	175	287	281	156	142	162	190	187	135
DO	5	0.10030	6.9	7.1	7.4	8.3	8.6	8.8	7	8.7	8.6
BOD	5	0.10030	3.1	2.4	3.4	4.1	3.4	4.2	4.4	3.5	3.8
Chloride	250	0.00200	124	112	101	84	81	95	72	101	117
Total Alkalinity	120	0.00417	108	102	110	75	81	85	51	69	73
COD	20	0.02507	121.2	132	114	89	112	135	124	142	117
Sulphate	200	0.07418	164	185	184	175	212	241	182	154	148
EC	300	0.31	174	185	201	181	201	205	201	212	226

Table.3. Determination of surface water quality index of Dhamoi Reservoir at Station 1.

	Observed Values (Vn)	**Standard Values(Sn)**	**Ideal value**	**Unit Weight (Wn)**	**Quality Rating(Qn)**	**WnQn**
P^H	7.2	6.5 – 8.5	7	0.2188	2.35	0.514
Total Alkalinity	128	120	0	0.0155	91.66	1.42
Total Hardness	254	300	0	0.0062	84.7	0.525
T.D.S.	166	500	0	0.0037	33.2	0.345
COD	33	20	0	-	-	-
EC	347	300	0	0.371	-	--
Chloride	42	250	0	0.0074	16.8	0.124
Sulphate	14	150	0	0.124	9.33	1.157
Phosphate	0.1	0.1	0	0.023	100	23
D.O.	6.9	05	7	0.372	138	51.336
B.O.D.	4.3	05	0	0.372	86	31.99
				$\sum Wn$ = 1.364	562.04	=110.411
		WQI = $\frac{\sum wIqI}{\sum wI}$ =110.411/1.364= 80.946				

Table.4. Determination of surface water quality index of Dhamoi Reservoir at Station 1I.

	Observed Values (Vn)	**Standard Values(Sn)**	**Unit Weight (Wn)**	**Quality Rating(Qn)**	**WnQn**
P^H	8.2	6.5 – 8.5	0.2188	1.171	0.256
Total Alkalinity	157	120	0.0155	130.83	2.028

Total Hardness	132	300	0.0062	44.0	0.2728
T.D.S.	380	500	0.0037	76	0.2812
COD	33	20	3	--	-
EC	389	300	0.371	--	--
Chloride	26	250	0.0074	10.4	0.07696
Sulphate	8	150	0.124	5.3	0.6572
Phosphate	0.5	0.1	0.023	500	11.5
D.O.	6.2	05	0.372	124	46.128
B.O.D.	7	05	0.372	140	52.08
			$\sum Wn=1.364$	661.361	113.280
			WQI $=\frac{\sum wIqI}{\sum wI}$ =113.280/1.364= 83.049		

Table.3. Calculation of water quality index of Dhamoi Reservoir at Station III.

	Observed Values (Vn)	Standard Values(Sn)	Unit Weight (Wn)	Quality Rating(Qn)	WnQn
P^H	7.8	6.5 – 8.5	0.2188	1.1142	0.243
Total Alkalinity	90	120	0.0155	75	1.16
Total Hardness	171	300	0.0062	57	0.3534
T.D.S.	425	500	0.0037	85	0.3145
COD	24	20	3	--	-
EC	314	300	0.371	-	-
Chloride	263	250	0.0074	105.2	0.7784
Sulphate	14	150	0.124	9.33	1.156
Phosphate	0.8	0.1	0.023	800	18.4
D.O.	5	05	0.372	37.2	13.8
B.O.D.	7	05	0.372	140	69.88
			$\sum Wn$ = 1.364	1318.66	182.3753
			WQI $=\frac{\sum wIqI}{\sum wI}$ =	182.3753/1.364=133.706	

Ranjana Rawat, Asst. Professor, PG department of Zoology, Govt.PG College, Jhabua, M.P
N.K. Dhakad, Vice Chancellor, Devi Ahilya Vishwa Vidyalaya, Indore