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Assessment of water quality status of major aquatic bodies of Vindhyan region (M.P.) India

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Abstract
Lakes, the vigorous water filled inland aquatic systems, perform variety of functions like provide potable, irrigation and water for industrial use, sink for waste disposal, fisheries and recreation resource etc. are subject to contamination due to various natural and anthropogenic disturbances and all these turbulences in their water quality can be assessed by calculating WQI to judge the purpose for which the current water can be sagely used for. In the present study, the water quality assessment of Bansagar aquatic body, Govindgarh aquatic body and Ramsagar aquatic body was carried out by assessing water with the help of 10 physico-chemical parameters to calculate the water quality index aquatic body. 4 parameters (DO, BOD, Iron and EC) were found beyond the permissible limits when compared with standards given by ICMR/BIS. WQI results revealed that water quality of each lake is presently in extremely poor condition.

Keywords: Freshwater, lakes, physicochemical parameters, water quality index

Introductions

Lakes are vigorous water filled inland aquatic systems of variable sizes having localized basin, surrounded by land and lack any direct exchange with sea or ocean. These can be shallow or deep, permanent or temporary, filled with fresh or salt water (in arid regions) and have a special eminence among different types of global freshwater resources. World's lakes house four times more water than rivers, hence are very important and crucial natural resource to be taken care of. These water resources contribute 50.01% of all the water present on the Earth's surface (Bhateria and Jain, 2016) [1] and perform variety of roles viz. habitat to diverse flora and fauna, goods and services to mankind like provide potable, irrigation and water for industrial use, sink for waste disposal, fisheries and recreation resource (Kadian and Kadian, 2012) [2], provide food and nutrition, support livelihoods, recharge ground water. Lakes also play a major role in regulating the micro-climate of any urban center (Benjamin *et al.* 1996) [3] hence act as ecological barometers of the health of such places. Freshwater lakes also play a vital role in various natural processes occurring in the environment like hydrological cycle, climate change adaptations, biogeochemical cycle etc. (Ravikumar *et al.* 2013) [4]. Throughout the world lakes are also being used for social and economic benefits as a result of tourism and recreation.

In the current scenario, globally, not only lakes rather all freshwater ecosystems are facing great degradation pressure and threat of eutrophication or extinction because of heavy loads of pollution and contaminations from multiple sources like rapid industrialization, exponentially growing population pressure, fast developing urbanization, modern agricultural practices and other anthropogenic activities (Huttly, 1990; Agarwal *et al.* 2006 and Singh *et al.* 2007) [5-7], saltation, discharge of domestic sewage, immersion of idols and other religious activities (Sonal and Kataria, 2012) [8] and lakes are the worst sufferer because of low surface velocity, long water retention time and isolation from all other terrestrial and aquatic ecosystem. In India large numbers of lakes are considered sacred so religious activities destroy water chemistry and biology and other are facing human neglect (Praveen and Setia, 2017) [9].

Water contamination is becoming the most serious threats to human health. It has been estimated that about 80% of all the diseases in mankind are due to one or another unhealthy aspects of water. Contamination of lakes and other reservoirs is seen as one of the commonly occurring phenomenon in almost all developing nation, especially urban ones, due to demographic expansion coupled with lack of civic amenities results in hitting these natural water reservoirs very hard. Majority of the urban and rural lakes have vanished due to this human neglect (Iscen *et al.* 2008 and Prasanna *et al.* 2011) [10,11] and the others which could sustain this pressure, present non-potable water or are not able to meet human requirements (Zhang *et al.* 2009) [12].

India is facing a severe and critical problem of deterioration of its freshwater bodies throughout its length and breadth due to their continuous and accelerated degradation. In order to prevent these assets from getting vanished a timely information of their water quality status is necessary for successful and effective implement of water quality improvement programs. Water Quality Index (WQI) is one of most effective way to calculate the water quality of a lake or river which is used as an effective tool by any Scientist to evaluate the water status (Kannel *et al.* 2007, Alobaidy *et al.* 2010, Kazmi *et al.* 2013 and Kangabam *et al.* 2017) [13-16]. An extensive study has been done on the Mohan Ram lake and Sharfa dam of Shahdol district (Rana, 2016 and Prajapati, 2016) [17, 18] but very little has been done on the lake of this region especially Vindhyan region. Present work is trying to fill the existing gap to some extent.

Material and Methods

Study location

Bansagar aquatic body (S_1)

Bansagar pond is located in Rewa district 24°32' north latitude and 81°15' east longitude with an elevation 316 meter. Bansagar Colony Pond is constructed near Bansagar Colony, Saman, Tehsil- Huzur, Distt. Rewa (M.P.) area on the Rewa-Sidhi-Shahdol road nearly 0.9 km. away from New Bus Stand, Choona Bhattha, Rewa. The total area of the pond is about 2.5 hect. In which 1.6 hect. Area is used for the fish culture. The width of pond is nearly 1298 feet upstream side and 2287 feet at downstream side and minimum and maximum depth is 10 feet and 20 feet in downstream and upstream side respectively.

Govindgarh aquatic body (S_2)

The Govindgarh lake is one of the unique water body in M.P. and located in south of Rewa district at a distance of 20 km. with a longitude 81°15'0" and latitude 24°20'25". It comes under the Rewa district and in Huzur tehsil. The lake is connected with Rewa-Shahdol and Satna-Sidhi road. The lake was formed by impounding of small nalla originating from Kaimore hill. With a view to storing rain water, the Maharaja of Rewa at that time built a bandh across the nalla to form a tank in 1958.

Ramsagar Aquatic body (S_3)

Ramsagar is situated northeast of Shaba Nadi, and east of Rani talab. Latitude 24.51968° or 24° 31' 11" north, Longitude 81.32508° or 81° 19' 30" east. Elevation 315 metres (1,033 feet).

Sample collection and analysis

The surface water samples were collected in sampling bottles during early hours from different sites for two year's duration (May 2020-21) which were brought to the laboratory for analysis of different physicochemical parameters like pH, Turbidity (NTU), Chloride (ppm), Sulphates (ppm), Iron (ppm) (Fe), Biological Oxygen Demand (ppm) (BOD), Dissolved Oxygen(ppm) (DO), Nitrate (ppm), Electrical Conductivity (µS) (EC) and Total Dissolved Salts (ppm) (TDS). Parameters were analyzed as per standard methods (APHA, 1998) [19].

Statistical Analysis

Water quality index (WQI)

This index is used to check the quality of water that helps in identifying the purpose for which the specific water should be used. In this investigation WQI has been calculated using Weighted Arithmetic Index Method (Brown *et al.* 1972) [20].

$$WQI = \frac{\sum Qn\,Wn}{\sum Wn}$$

Where Qn = Quality rating of nth water quality parameter,

$$Qn = \frac{V_n - V_{io}}{S_n - V_{io}} \times 100$$

Vn = Estimated value of the nth parameter at a given sampling station

Vio = Ideal value of nth parameter (i.e., 7.0 for pH, 14.6 mg/L for DO and 0 for all other parameters)

Sn = Standard permissible value of the nth parameter

Wn = Unit weight for the nth parameters,

$$W_n = \frac{k}{S_n}$$

Sn = Standard permissible value of the nth parameter

k = Constant for proportionality

The calculated WQI of lakes under study were further compared with the standard WQI values (Table no 2) and their water quality status (Chatterjee *et al.* 2002) [21].

Result and Discussion

Physico-chemical analysis: In the present study, the samples from selected three sites showed a wide variation in the water chemistry of the Aquatic body. The comparison with standard values indicated that the water under study is not in a good state of their health. pH is one of the deciding key factor for checking the suitability of water for its utility as it determines the corrosive nature of water. The results show that pH of water was found to vary from slightly acidic to alkaline (7.1- 8.01) but the values of all the sites lie within the permissible standard range. Though pH and turbidity fall within permissible range (6.5-8.5 and 5 NTU respectively) but Fe was found higher and DO much lower, making the body unfit for aquatic biodiversity as well as human use Even to fall in Class-B category. Source of Fe in all the three sites is probably due to unmanned boundaries of S_1 leading to addition of terrestrial dissolved organic matter (DOM) (Kritzberg and Ekstrom, 2012) [22] or the metallic pipe lines pouring water into the S_2 & S_3 sites as also Advocated by others (Arora, 2016) [23]. Lower levels of DO at all the three sites were primarily found to have its correlation with higher algal growth or initial stages of eutrophication (Patidar, 2014) [24].

BOD, a measure of DO that microbes need for the oxidation of all the reduced water that gets added to water body. Its higher levels give a direct measure of amount of organic waste in a particular water body. During present under current investigation were found to show 3-5 (13.49-27.12) times' higher levels of BOD than permissible range (5ppm). The obvious reasons for this high level of BOD were addition of natural organic waste to leaves and other natural vegetation debris, dead and decaying plants and animals, animal waste etc. Similar findings were projected by other workers like (Bhateria and Jain, 2016) [1].

The other parameters like Cl^-, SO_{4-}^-, BOD, NO_{3-}^-, EC and TDS were also found to show wide variations. Some of these were found to exists within the standard permissible limits, like Cl- (250 ppm), SO_4^- (150 ppm) and TDS (500 ppm) while $NO^{- -}$ was found higher than limits at S_3 but within range (45 ppm) at S_1 & S_2. This slight higher value (44.17-53.17) at S_3 is mainly due incorporation of agricultural run-off and animal waste from farm lands from its unmanned Border, As also reported Braham Sarovar (Patidar, 2014) [24] and from Bangalore lakes (Ravikuumar *et al.* 2013) [4].

Even EC et al three sites were also found to exceed the permissible limits (300 ppm) for Class-B water category. Amongst three sites, S_1 was found to have the highest EC (520.23-422.51) due to its most alkaline water (8.35-7.67) while at S_2 it is primarily due to human activities like mass bathing, idol and other "Puja Samgari" immersions, during religious events or even as a matter of routine pilgrim activities and for S_3 it can be associated with comparatively higher levels Fe contents. EC also seems to increases in summers than winter due to evaporation of water. The open expense of water surface of all the sites also contribute towards rapid evaporation leading to higher values of EC (Kashyap, 2016) [25].

National Lake Conservation Plan (NLCP) recommended criteria of Class-B of Designated Best Use (DBU) system [Central Pollution Control Board (CPCB)] as suitable parameters while assessing water quality of Indian lakes (CPCB, 2007 and NLCP, 2008) [26,27]. In the current study both these BOD and DO were found to be in non-recommending range to categorize aquatic body to fit to fall under Class-B. The current investigation has found that though pH of all three sites does fall within permissible range of Class-B water but DO of all site was found much lower while BOD much higher (3-5 times).

It clearly indicates addition of organic waste to this water body.

Table 1: Comparison of parameters of different site of aquatic body with the Indian Standard of Lake Water Quality

S. No.	Parameters	Sites			Class-B of DBU system of CPCB
		S_1	S_2	S_3	
1.	pH	8.01	7.6	7.1	6.5-8.5
2.	DO (ppm)	2.3	2	3.1	5
3.	BOD (ppm)	23.25	24.57	15.6	5

WQI: The WQI has been calculated for each site of aquatic body by using all the ten parameters (Table- 3, 4 and 5). Higher is the value of WQI poorer is the water quality. (Table 2)

Table 2: WQI range and water quality rating (Chatterjee and Raziuddin, 2002) [21]

WQI level	Water quality rating
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unfit

Of the three sites S_1 showed the highest value of WQI (322.8) and S_3 (236.91) the lowest. Though, all the three sites were found to fall in the range of the extremely poor water quality (Chatterjee and Raziuddin, 2002) [21].

Table 3: Water quality index calculation of Bansagar aquatic body (S_1)

S. No.	Parameters	Mean observed value	Standard value	Unit weight (W_n)	Quality rating (Q_n)	QnWn
1.	pH	8.01	6.5-8.5	0.2190	73.33	16.06
2.	Turbidity (NTU)	3.06	5	0.0421	61.2	2.57
3.	Chlorides (ppm)	12.83	2.50	0.0074	5.132	0.0379
4.	Sulphates (ppm)	26.81	150	0.01236	17.82	0.2209
5.	Iron (ppm)	1.67	0.3	0.7022	556.6	390.78
6.	BOD (ppm)	23.25	5	0.3723	465	173.11
7.	DO (ppm)	2.3	5	0.3723	130	48.3
8.	Nitrate (ppm)	26.1	45	0.0412	58	2.38
9.	EC (µs)	471.37	300	0.371	157	58.24
10.	TDS	289.92	500	0.0037	57.98	0.21
				2.143	1582.062	691.90

$$WQI = \frac{691.90}{2.143} = 322.8$$

Table 4: Water quality index calculation of Govindgarh Aquatic body (S_2)

S. No.	Parameters	Mean observed value	Standard value	Unit weight (W_n)	Quality rating (Q_n)	QnWn
1.	pH	7.06	6.5-8.5	0.2190	40	8.76
2.	Turbidity (NTU)	3.01	5	0.0421	62	2.61
3.	Chlorides (ppm)	42.63	2.50	0.0074	17.052	0.126
4.	Sulphates (ppm)	117.34	150	0.01236	78.22	0.966
5.	Iron (ppm)	1.34	0.3	0.7022	433.3	304.2
6.	BOD (ppm)	24.57	5	0.3723	491.4	182.92
7.	DO (ppm)	2	5	0.3723	133.3	49.6
8.	Nitrate (ppm)	23.66	45	0.0412	52.57	2.16
9.	EC (µs)	397.16	300	0.371	132.38	49.11
10.	TDS	244.93	500	0.0037	48.98	0.181
				2.143	1489.2	600.64

$$WQI = \frac{600.64}{2.143} = 280.28$$

Table 5: Water quality index calculation of Ramsagar Aquatic body (S_3)

S. No.	Parameters	Mean observed value	Standard value	Unit weight (W_n)	Quality rating (Q_n)	QnWn
1.	pH	7.1	6.5-8.5	0.2190	6.66	1.46
2.	Turbidity (NTU)	1.5	5	0.0421	30	1.26
3.	Chlorides (ppm)	23.25	2.50	0.0074	9.3	0.068
4.	Sulphates (ppm)	68.67	150	0.01236	45.78	0.565
5.	Iron (ppm)	1.23	0.3	0.7022	400	280.8
6.	BOD (ppm)	15.6	5	0.3723	312	116.15
7.	DO (ppm)	3.1	5	0.3723	121	45.08
8.	Nitrate (ppm)	47.67	45	0.0412	105.93	4.36
9.	EC (µs)	467	300	0.371	155.6	57.75
10.	TDS	187.86	500	0.0037	57.4	0.2112
				2.143	1242.1	507.70

$$WQI = \frac{507.70}{2.143} = 236.91$$

The current status of WQI of each sties under study was found primarily due to higher levels of Fe, BOD, EC, Nitrates and lower levels of DO. This makes the team to understand that none of these sites have water which can be suggested to be used for bathing, swimming of washing (Class-B of CPCB for DBU).

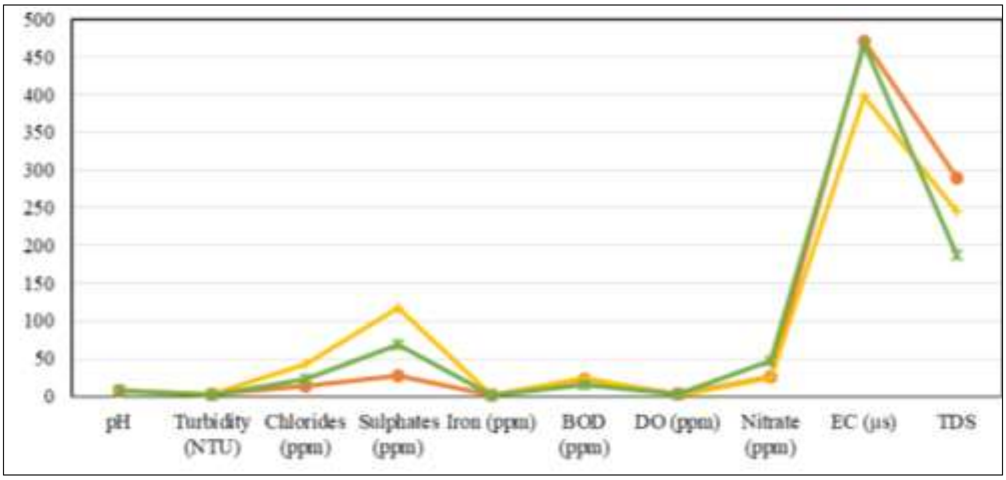

Fig 1: Average water quality index calculation of Bansagar, Govindgarh and Ramsagar Aquatic body

Conclusion

In the present study the WQI of each lake was found above 100 which clearly indicate that their water is unfit and unsuitable for drinking, outdoor bathing and other human uses. The major factors for the depletion of the water quality were found to be human neglect, contamination by human and animal interventions, religious rituals along with unguided tourist activities.

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