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Assessment of Water Quality in Dahod Reservoir using Water Quality Index (WQI)

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ABSTRACT: The aim of this study was to evaluate the quality of surface water in Dahod Reservoir, located in Raisen, Madhya Pradesh, India. Water samples were collected from four different locations during winter and summer seasons in 2021. The samples were tested for various physicochemical parameters, including pH, electrical conductivity, total dissolved solids, total alkalinity, chloride, total hardness, calcium hardness, magnesium hardness, dissolved oxygen, nitrate, and orthophosphate. The analysis was performed based on the standard procedures outlined by APHA (2012) and the Workbook of Limnology. The results were compared with the values or ranges recommended by standard organizations such as WHO and BIS to assess water quality. The findings indicated that some parameters exceeded the acceptable limits, such as total alkalinity, total hardness, calcium hardness, and magnesium hardness. To determine the water quality status of Dahod Reservoir, a water quality index was used. The water quality index was 24.4 for the winter season and 31.3 for the summer season. It was found that the water quality was excellent during the winter season and good during the summer season. The water quality index in both seasons was less than 50, indicating that the water is suitable for drinking, irrigation, and industrial purposes. These results are essential for the future management of water in Dahod Reservoir.

Keywords: Dahod Reservoir, physiochemical parameters, Water quality index.

INTRODUCTION

The planet's most significant freshwater resources are lakes and surface water reservoirs, which offer a multitude of advantages. They provide habitats for aquatic life, particularly fish, which serve as a source of critical protein and a significant share of the planet's biological variety (Qureshimatva *et al*., 2015). They are also utilized for residential and irrigation uses. They provide significant social and economic advantages due to tourism and leisure, and they are significant to people all over the world in terms of culture and aesthetics They are equally crucial in flood control as well (Bhateria and Jain 2016). These water resources make up 50.01% of the total water on Earth's surface (Johnson *et al.,* 2001) and are home to a wide range of plants and animals. However, the world's water reserves have been significantly depleted as a result of the tremendous population growth (Ho *et al.,* 2003). The quality of surface waters is significantly impacted not only by human inputs such as the discharge of industrial and municipal wastes but also by natural processes such as soil erosion and weathering (Bassi *et al.,* 2014). The deterioration of surface water quality not only endangers the aquatic life there but also lowers the quality of subsurface water, which impacts human health (Rashid *et al.,* 2013). Therefore, it becomes essential to regularly assess the physico-chemical and biological properties of these priceless natural resources to monitor their state of health (Venkatesharaju *et al.,* 2010). To evaluate the quality of the water, researchers have put forth and used a wide range of strategies. The Water Quality Index (WQI) is an easy-to-use method for evaluating overall water quality that uses a variety of parameters to compress a large amount of data into a single, usually dimensionless number in a repeatable way (Abbasi and Abbasi 2012). It gives important details on the overall condition of the water quality, which is quite beneficial. This study's objective is to use the water quality index (WQI) to evaluate the Dahod reservoir's water quality status for industrial, agricultural, and drinking uses.

MATERIALS AND METHODS

A. Study area

Dahod reservoir is located at village Dahod in Goharganj Tehsil of District Raisen, M.P. It is an earthen dam and was constructed in 1958. The geographical location is 23°21 N latitude, 77°29 30 E longitude, and 780 meters above mean sea level. Its maximum depth is 9.2 m, and its mean depth is 3.4 m, respectively. A hydropower plant is also located near Dahod reservoir.

B. Sample Collection and analysis

The water samples were collected from four different locations of Dahod Reservoir during the winter and summer seasons in 2021. The water samples were analyzed for physicochemical parameters like pH, electrical conductivity, total dissolved solids, total alkalinity, chloride, total hardness, calcium hardness, magnesium hardness, dissolved oxygen, nitrate, and orthophosphate. The analysis was performed in compliance with the standard operating protocols outlined in the Workbook of Limnology (Adoni *et al.,* 1985 ; APHA, 2012).

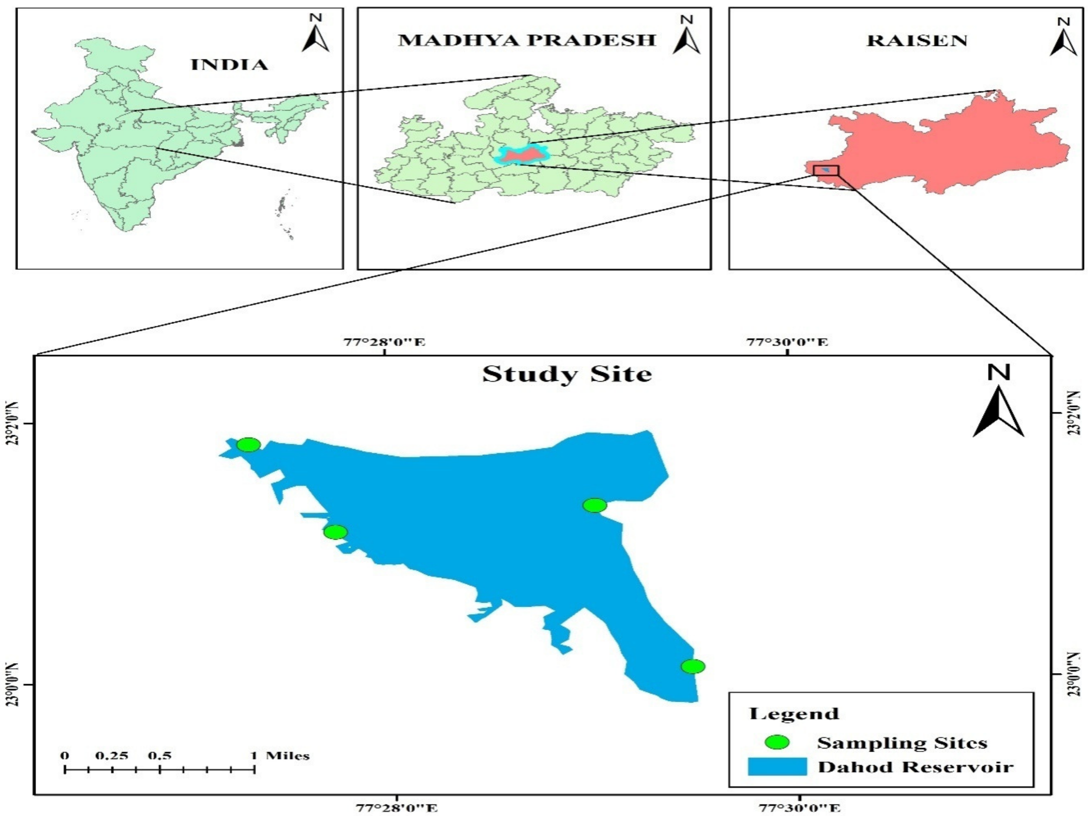

Fig. 1. Showing the study area.

B. Calculation of Water Quality Index (WQI)

The Water Quality Index was calculated using a weighted arithmetic mean method, first proposed by Horton (1965) and then developed by Brown *et al.* (1972). WQI was calculated with 11 parameters (pH, total dissolved solids, conductivity, total alkalinity, chloride, calcium, magnesium, total hardness, dissolved oxygen, nitrate, and orthophosphate) with drinking water to meet the quality standards recommended by the Bureau of Indian Standards (10500:2012). The weighted arithmetic water quality index (WAMWQI) was calculated as follows:

$$WQI = \Sigma QnWn / \Sigma Wn \quad (1)$$

Where

Wn= unit weight for the ***n*th** parameter,

Qn=quality rating (sub-index) of the ***n*th** water quality parameter.

The value of quality rating or sub-index (Qn) was calculated using the equation 2

$$Qn = 100\,[(Vn - Vo/Sn - Vo)] \quad (2)$$

Where,

Vn = concentration of ***n*th** parameter in the analyzed water

Vo= ideal value of ***n*th** parameter in pure water (Ideal value is 0 for all parameters except **pH =7.0** and **DO = 14.6** mg/l)

Sn= recommended standard value of ***n*th** parameter

The unit (**Wn**) of various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters

$$Wn = K/Sn \quad (3)$$

Where,

K=proportional constant,

The value of K has been considered '1′ here and is calculated using the mentioned equation below:

$$K = \frac{1}{\Sigma\left(\frac{1}{si}\right)} \quad (4)$$

RESULTS AND DISCUSSION

A. Physicochemical characteristics

Data on seasonal changes in physicochemical parameters of surface water at four sample stations in the Dahod Reservoir, Raisen (M.P.), have been recorded, and their respective recommended agencies are presented in Table 1.

Table 1: Surface water characteristic and drinking water standards by recommended agencies.

Parameters	Units	Results		Standards	Recommended Agency
		Winter	Summer		
Temperature	°C	22±1.5	28±1.2	—	—
pH		8.5±0.5	8.2±0.7	6.5-8.5	ICMR/BIS
Conductivity	µS/cm	76±3.45	101±3.05	300	ICMR/BIS
TDS	Mg/l	60±2.55	78±3.07	500	WHO
Total Alkalinity	Mg/l	190±5.04	225±4.21	200	ICMR/BIS
Chloride	Mg/l	17.9±1.22	19.9±0.84	250	ICMR/BIS
Total Hardness	Mg/l	340±5.45	420±6.7	200	ICMR/BIS
Calcium Hardness	Mg/l	189±1.34	210±2.13	75	ICMR/BIS
Magnesium Hardness	Mg/l	36.6±1.2	51±1.17	30	ICMR/BIS
Dissolved Oxygen	Mg/l	7.6±0.05	5.6±0.06	5	ICMR/BIS
Nitrate	Mg/l	0.176±0.03	0.147±0.02	45	ICMR/BIS
Orthophosphate	Mg/l	0.058±0.01	0.049±0.01	0.1	WHO

Temperature is an important factor, which regulates the biogeochemical activities in the aquatic environment. It is an influential parameter that directly or indirectly affect a variety of other water quality factors such as pH, dissolved oxygen, and alkalinity (Khaiwal *et al.*, 2003). The mean temperatures of the water samples from the four sampling points for the winter and summer season were, 22±1.5°C and 28±1.2°C respectively (Table 1). These values were acceptable for drinking purposes (WHO, 2017). pH controls biological reactions in the aquatic environment. The mean pH readings were 8.5±0.5 and 8.2±0.7 in the winter and summer seasons, respectively, indicating that the water was alkaline and within the permissible BIS range (6.5-8.5). Electrical conductivity is the ability of water to transport electric current and is a technique of measuring its purity (Murugesan *et al.,* 2006). It also reveals the presence of biological and abiotic pollutants in water (Upadhyay *et al.,* 2012). The mean values of electrical conductivity of water samples in summer and winter seasons were 101±3.05µS/cm and 76±3.45 µS/cm. The EC was within the acceptable limits of ICMR, 1975 (300 µS/cm), indicating that water is suitable for drinking purpose.TDS refers to the dissolved solids in water. Total dissolved solids is an important parameter for assessing water quality. Water samples had mean TDS levels of 60±2.55 Mg/l in winter and 78±3.07 Mg/l in summer, both within the 500 Mg/l threshold. TDS is a good predictor of water quality since it affects the taste, colour, and smell of water. Increased TDS levels render water dangerous for drinking and irrigation, cause reduced photosynthetic capacity, and elevate water temperature (Simeon *et al.,* 2019). The alkalinity of surface water is generally defined by carbonate and hydroxide levels, but it also includes borates, phosphates, silicates, and other bases. Alkalinity is a measure of water's capacity to neutralise a powerful acid (Qureshimatva *et al.,* 2015). The mean value of TA for winter and summer seasons were 190±5.04 mg/l and 225±4.21 mg/l, respectively. The TA value for summer season was above the BI standard (200mg/l). The high alkalinity values of water bodies demonstrate their entropic nature, which is harmful to both the environment and human consumption (Sudarshan *et al.,* 2019). The majority of chlorides in lake water come from sewage and industrial waste disposal (Sirsath *et al.,* 2006). The human body excretes a large amount of chlorides through urine and faeces (Verma *et al.,* 2012). The mean concentrations of chloride in water samples for winter and summer seasons were 17.9±1.22 mg/l and 19.9±0.84 mg/l, respectively. The chloride values were within standards. The dissolved oxygen content of a body of water is the best indicator of its health since it shows the metabolic balance and reflects biological and physical activity in the water (Pradhan *et al.,* 2012). The mean dissolved oxygen values of water were 7.6±0.05 mg/l and 5.6±0.06 mg/l for winter and summer seasons, respectively. The dissolved oxygen decreased in summer season and increased in winter. The term "hardness" is widely used to measure the quality of water supplies. The hardness of water is determined by the presence of calcium and magnesium salts, which are mostly associated with bicarbonate and carbonate (temporary hardness) and with sulphates, chlorides, and other anions of mineral acids (permanent hardness) (Wetzel, 2001). Kannan (1991) classed water based on its hardness ratings in the following manner: 0-60 mg/L is soft; 61-120 mg/L is moderately hard; 121-160 mg/L is hard; and more than 180 mg/L is very hard. The mean hardness values for the winter and summer seasons were 340±5.45 mg/l and 420±6.7 mg/l, respectively. The hardness exceeds BIS norms and is classified as "Very hard."Calcium is the most prevalent ion in fresh water and is vital for shell construction, bone growth, and plant precipitation of lime (Qureshimatva *et al.,* 2015). The mean calcium concentrations were 189±1.34 mg/l and 210±2.13 mg/l for the winter and summer seasons, respectively**.** Magnesium, which is naturally present in surface water, is formed by the weathering of rocks containing magnesium minerals such as biotite, olivine, and augite (Kadam *et al.,* 2021). Magnesium concentrations remain lower than those of calcium (Tulsankar *et al.*, 2020). It is a key micronutrient for algae and macrophytes, and it is a limiting component for phytoplankton's growth (Dijkstra *et al.*, 2019). Magnesium mean levels were 36.6±1.2 mg/l during the winter and 51±1.17 mg/l for the summer, respectively. Nitrates are added to freshwater by the discharge of sewage and industrial wastes, as well as runoff from agricultural fields (Verma *et al.,* 2012). The mean concentration of nitrate in the water samples were 0.176±0.03 mg/l and 0.147±0.02 mg/l for winter and summer, respectively. The nitrate concentration was within the permissible limits of BIS. Phosphate is typically found in low to moderate amounts in natural waterways. The main sources of phosphate are waste water that contains detergents and agricultural runoff that contains fertilizers (Naseema *et al.,* 2013). The mean values of phosphate in the water samples were 0.058±0.01 mg/l and 0.049±0.01 mg/l for winter and summer, respectively, which were below the limits (0.1mg/l).

B. Water Quality Index

The resultant WQI values are reported in Table 2 (winter) and Table 3 (summer). The water quality index values of Dahod reservoir for winter season was 24.4, which indicating excellent water quality (Table 4) while summer season was 31.3, indicating good quality of water (Table 4). The overall WQI for the Dahod reservoir was 27.8; indicating good water quality (Table 4).

Table 2: Calculation of water quality index of winter season.

Sr. No.	Parameters	Observed Value (Va)	Standard Value (Vs)	Unit weight (Wn)	Quality Rating (Qn)	WnQn
1.	pH	7.7	8.5	0.085715	100	4.000038
2.	Conductivity	76	300	0.002429	25.33333333	0.061524
3.	TDS	60	500	0.001457	12	0.017486
4.	Total Alkalinity	190	200	0.003643	95	0.346075
5.	Chloride	17.9	250	0.002914	7.16	0.020866
6.	Total Hardness	340	200	0.003643	170	0.619292
7.	Calcium Hardness	189	75	0.009714	252	2.448023
8.	Magnesium Hardness	36.6	30	0.024286	122	2.962885
9.	Dissolved Oxygen	7.6	5	0.12143	80	9.714378
10.	Nitrate	0.176	45	0.016191	0.391111111	0.006332
11.	Orthophosphate	0.058	0.1	0.728578	5.8	4.225755
				1		
WQI = Σ 24.4 Σ 1						**24.4**

Table 3: Calculation of water quality index of summer season.

Sr. No.	Parameters	Observed Value (Va)	Standard Value (Vs)	Unit weight (Wn)	Quality Rating (Qn)	WnQn
1.	pH	8.2	8.5	0.085715	80	6.857208
2.	Conductivity	101	300	0.002429	33.66666667	0.081763
3.	TDS	78	500	0.001457	15.6	0.022732
4.	Total Alkalinity	225	200	0.003643	112.5	0.409825
5.	Chloride	19.9	250	0.002914	7.96	0.023198
6.	Total Hardness	420	200	0.003643	210	0.765007
7.	Calcium Hardness	210	75	0.009714	280	2.720026
8.	Magnesium Hardness	51	30	0.024286	170	4.128611
9.	Dissolved Oxygen	5.6	5	0.12143	105	12.75012
10.	Nitrate	0.147	45	0.016191	0.326666667	0.005289
11	Orthophosphate	0.049	0.1	0.728578	4.9	3.570034
				1		
WQI = Σ 31.3 Σ 1						**31.3**

Table 4: Water Quality Index (WQI) and its status according to Qureshimatva *et al.* (2015).

WQI Level	Water Quality Status
0-25	Excellent water quality
26-50	Good Water Quality
51-75	Poor quality
76-100	Very Poor quality
≥ 100	Unsuitable for drinking

CONCLUSIONS

The findings from the study were compared to WHO and BIS criteria, and it was found that the majority of parameters in the Dahod reservoir were within acceptable limits during the winter and summer seasons. The water quality of Dahod reservoir was also examined according weighted arithmetic index using 11 physicochemical parameters. The WQI classified the reservoir water as good for aquatic life and fair for drinking and irrigation with overall WQI values of 24.4–31.3 on a scale of 100. The study's findings may be useful in reservoir management for water quality, fisheries, and restoration purposes.

FUTURE SCOPE

The data acquired could potentially constitute baseline and reference point for assessing further changes that might be generated by nature or man in the reservoir.

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Conflict of Interest. None.

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