# ASSESSMENT OF WATER QUALITY INDEX FOR DRINKING PURPOSE: A STUDY OF BHELWA LAKE, DURG, CHHATTISGARH

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## *ABSTRACT*

*The increase in the urban sprawl and human activities in Durg, Chhattisgarh has threatened the freshwater lakes of the city immensely. The water of these fresh water bodies was used for the purpose of drinking, irrigation, and fish farming. Presently there is an urgent need to assess the water quality index of these fresh water bodies to find the suitability for drinking water. This study has been conducted with an objective to assess the water quality index of Bhelwa Lake (a fresh water body) of Durg, Chhattisgarh for drinking water purposes. Thirteen physico-chemical parameters i.e., temperature, transparency, pH, water conductivity, Total hardness, calcium hardness, magnesium hardness, total alkalinity, total dissolved solids, dissolved oxygen, salinity, BOD and COD were calculated in three different seasons (winter, summer and monsoon) between 2019 to 2021 to determine the water quality standards of Bhelwa lake. Then water quality index (WQI) was calculated by using the values of calculated physiochemical parameters and the conclusions were drawn by comparing the water quality parameters with the standards of WHO. It was reported that the noted that the physico-chemical properties across different season show a significant difference ($p \leq 0.05$). The values of water quality index of Bhelwa lake depicted that quality of water varies from poor to very poor as per universal water quality index (U-WQI) of WHO. The water quality of Bhelwa Lake during summer and winter is poor for drinking, however it was found that during the water quality for drinking was very poor during monsoon. ANOVA values report a significant difference ($p \leq 0.05$) among water quality index parameters across different seasons. The change in the water quality parameters across different seasons determine the necessity for adopting protective measures from the pollution by which the quality of water is deteriorated.*

***Keywords:*** *Bhelwa Lake, Physico-chemical parameters, Water Quality Index, Drinking purpose.*

## INTRODUCTION

India is bestowed with a good network of inland fresh water bodies that can fulfill the demand of drinking water. With more than 5,000 big dams now, India is the third-largest country in the world (Pradhan, et.al., 2021). The need to fulfill the rising demands brought on by urbanisation, industry, and contemporary agricultural operations is depleting the existing water resources, and the quality of the water has declined (Misra, 2011; Wu and Tan, 2012; Afroz, et.al., 2014; Raihan and Tuspekova, 2022). Due to the discharge of untreated sewage, industrial effluents, and agricultural runoff, Indian fresh water bodies are getting more and more contaminated. Public health problems are caused by polluted water resources (Jabeen, at.al., 2015; Pal, et.al., 2018; Ayejoto, et.al., 2022), which also alter the balance of aquatic ecosystem. In the current context the rural and urban population is facing a serious fresh water sacristy. Since the rural population wholly and solely depend on the inland fresh water resources, but it has also been evident from the literature that a part urban population also depends on inland fresh water bodies for drinking and domestic uses (Chowdhury, 2010; Rygaard , et.al., 2011; Maniam, et.al., 2022).

The urban fresh water bodies of India are under threat due to urban sprawl and anthropogenic activities. From past few years it has been evident that the fresh water bodies, which are main source of drinking, are getting polluted at an alarming rate. Water quality evaluation has got little attention, despite the fact that water crises and quality are important issues in many countries, particularly in arid and semi-arid regions where water scarcity is prevalent (Chunyan and Xiangyu, 2017). Thus it's essential to gather the information on hydrochemistry of inland fresh water bodies to improve the inland water management practices. For this purpose the assessment of physico-chemical properties would play a pivotal role in determining the water quality index of water bodies.

The World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the Centers for Disease Control (CDC) are the major organisations that have establish permissible limits for physiochemical pollutants in drinking water. When all of the physiochemical and biological characteristics of water are within the criteria, then the water is fit for drinking, but if the values go beyond the limits, then there is a risk to human health (Patil, et.al.,2012). The availability and sustainable management of good quality water is one of the Sustainable Development Goals (SDGs). But given the circumstances of climate change, poverty, population increase, and harmful anthropogenic activities, it has been difficult for policy makers. Consequently, it becomes imperative to keep an eye on the water bodies in terms water quality index (WQI) for drinking water purposes. The most suitable way to assess the water quality of a water body is determining its Water Quality Index (WQI) (Tabrez, et.al., 2022). It assesses the water quality based on a number of physiochemical factors and decides if the water is suitable for drinking or not. Horton in 1965 created this index i.e., WQI for the first time by using 10 water characteristics of water body to determine water quality (Akhtar, et.al., 2021). The formula for calculating this index has since been altered by several experts. Every expert used a distinct

set of criteria to construct the water quality index (WQI). With time the efficiency of calculating water quality index has been increased, but in all methods the physico-chemical properties are required (Pham, 2017).

Durg is a city of Chhattisgarh being a part of Durg-Bhilai urban agglomeration. Durg-Bhilai is the second largest urban area in Chhattisgarh after Raipur. This city has a vast network of inland water bodies. During summer the ground water level of falls and then a section of society uses the inland water bodies (lakes, ponds, and reservoirs) for domestic consumptions. In parallel the urban sprawl and anthropogenic activities are continuously deteriorating the water quality of these inland water bodies. Thus it falls necessary to check the water quality index of these inland water bodies so that it could be made clear that whether these water resources are fit for drinking or not. In this contest the present study has been conducted to assess the water quality index for drinking purpose of Bhelwa lake of Durg, Chhattisgarh. The data of this study will help decision makers in sustainable management of these water resources.

## MATERIAL AND METHODS

***Study area***

Bhelwa Lake is located at Nehru Nagar of Durg district, Chhattisgarh. The lake is located at $21^0$12’07’’ N latitude and $81^0$19’09’’ E longitude at approx 300m above MSL. It’s one of the popular lake of Durg in terms of its location, catchment, and delivery of services. The dam serves as a major source of drinking, cooking, bathing, irrigation and fish farming of the fringe urban area. Thus the continuous monitoring for drinking water quality of this lake is important to determine the level of contamination and suitability of its water for drinking purpose.

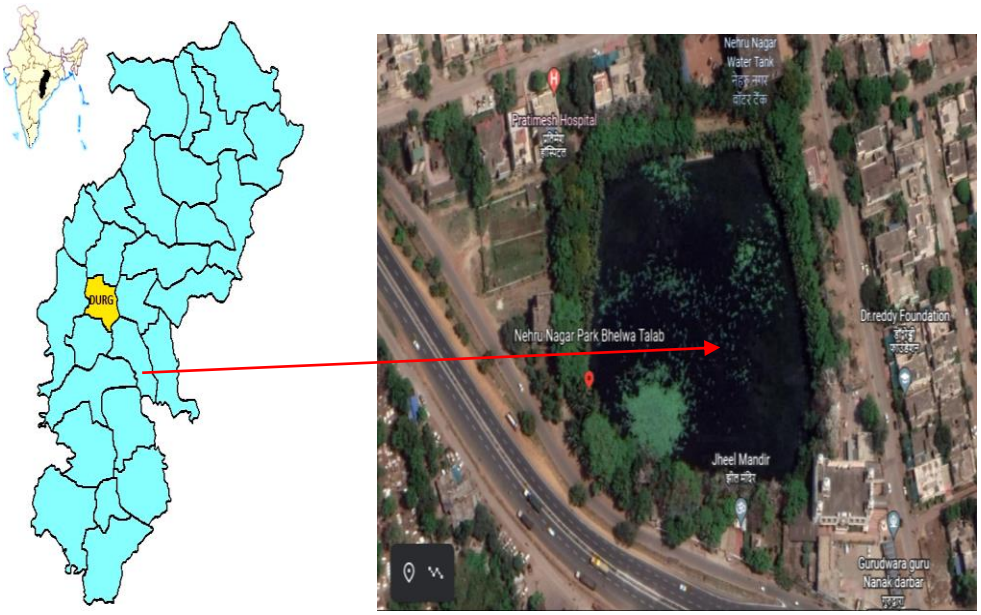


**Fig-1:** Location of Bhelwa Lake of Durg, Chhattisgarh

***Sample collection and sample analysis***

The samples of water from Bhelwa lake were collected for every month of year for two consecutive years (2019-2021) respectively. Water samples were collected from the surface water of the lake and put into sterilized glassware. Thirteen physico-chemical parameters i.e., temperature, transparency, pH, water conductivity, Total hardness, total alkalinity, total dissolved solids, dissolved oxygen, salinity, BOD and COD were studied. Some parameters like water temperature, pH, and transparency were taken on field, where as other physico-chemical parameters were analysed at laboratory by standard methods of APHA(APHA,2005,2012). All the measurements were taken four times and the results were expressed as Mean±SE. Further the whole year was divided into three seasons like summer (Mar-June), monsoon (July-Oct), and winter (Nov-Feb). For each season the average data of four months was used to determine the seasonal variation of physiochemical properties of Bhelwa lake.

***Water Quality Index (WQI)***

To determine the water quality index (WQI) of Bhelwa lake, the calculated physiochemical parameters were used to calculate WQI respectively. It was noted that determining the relative significance of physiochemical parameters (qualitative) in relation to one another is one of the important phases in the calculation of the WQI. Different methods have been developed time to time for determining the WQI of water samples. In the present we followed that, the methods and protocols provided by Imneisi and Aydin (2016) to determine the water quality index of Bhelwa lake. In order to meet the drinking water standards for each season, the computed water quality index (WQI) values of Bhelwa lake were finally categorised into five groups (Table 1).

**Table-1:** Natural Water quality classification as per total score of Water Quality Index (WQI)

| S.No | WQI-Value | Rating of water quality (For drinking) | Grading |
|---|---|---|---|
| 01. | 0-25 | Excellent quality of water | **A** |
| 02. | 26-50 | Good quality of water | **B** |
| 03. | 51-75 | Poor quality of water | **C** |
| 04. | 76-100 | Very poor quality of water | **D** |
| 05 | Above 100 | Unsuitable water for drinking | **E** |

***Data analysis***

For each month and season, the physiochemical analysis findings were expressed as the mean ± standard error (SE) of four replicates. Using SPSS software version 16.5, analysis of variance (ANOVA) was performed on the collected data to determine the significance level ($p \leq 0.05$).

**RESULTS**

The recorded thirteen physiochemical parameters (Temperature ($^0$C), Transparency(cm), pH, Alkalinity (mg/l), Salinity (g/l), Conductivity (µs/cm), Total dissolved solids (mg/l), Calcium Hardness (mg/l), Magnesium Hardness(mg/l), Dissolved Oxygen(mg/l), COD(mg/l), BOD(mg/l) and Total Hardness) for three different seasons in two consecutive years (2019 to 2021) are presented in Table-3. The average water temperature of Bhelwa lake showed a significant variation in three different seasons, with highest water temperature reported in summer season (29.15±0.94) and minimum water temperature was recorded in winter season (20.30±1.05). pH of water of the studied lake does not recorded so much variation and its values remained between 7.00±0.05 to 8.20±0.05. It was observed that the total alkalinity (mg/l) recorded a significant variation ($p \leq 0.05$) in across different seasons. The values of alkalinity were within permissible limits, but were little higher than average values. The total hardness (mg/l) was different between two years .On an average the summer season recorded higher values of total hardness than the winter and monsoon seasons. A significant variation in the total salinity (g/l) was noted across different seasons. The minimum values (04.66±0.09) of salinity were recorded in monsoon. The salinity (g/l) increased significantly from monsoon to summer and reached to its maximum values (05.25±0.05) in summer season.

Water conductivity recorded an increasing trend from monsoon season to summer season during 2019 to 2021 respectively. The minimum values of water conductivity (411.27±12.75µS/cm) were recorded in monsoon and higher values of water conductivity were recorded in summer season. We also observed a significant variation in the average total dissolved salts (TDS) across different seasons. The TDS (mg/l) increased significantly from summer to monsoon season. The highest value of TDS was 425.20±9.58 was recorded in monsoon and lowest TDS values were recorded in summer season (345.85±8.78).

The present investigation showed that the dissolved oxygen record a highly significant seasonal variations ($p \leq 0.05$) during 2019 to 2021. The Maximum value of DO recorded in winter and the minimum value were recorded in monsoon. A significant variation ($p \leq 0.05$) in the chemical oxygen demand (mg/l) across different seasons was recorded in Bhelwa lake. The Maximum value of COD was recorded in monsoon in both dams and the minimum values were recorded in winter respectively. In the present study the BOD values of Bhelwa lake dam during 2019 to 2021 alter significantly ($p \leq 0.05$) across different seasons. The Maximum value of BOD was recorded in summer and the lowest value of BOD was recorded in monsoon.

Table-3 summarises the Bhelwa Lake's water quality index (WQI) for the winter, summer, and monsoon seasons from 2019 to 2021. Bhelwa Lake's water quality index (WQI) values varied significantly ($p \leq 0.05$) throughout the course of three separate seasons. According to the water quality index (WQI) grading, the Bhelwa Lake's drinking water quality ranges from extremely bad to poor quality. The monsoon season was reported to experience the greatest level of water quality degradation. The quality of drinking water also deteriorated throughout the summer because of the intense pressure from nearby people to bathe, wash, and other activities..

## DISCUSSION

In the current scenario with the increase in human population there has been a parallel increase in the demand of fresh water across the globe. The fresh water resources are limited, and the stimulated demand of these resources has brought them under threat. Across different fresh water resources, inland fresh water resources like dams, ponds, lakes, reservoirs etc are facing a major threat in the world. These inland water bodies are used to supply the water needed for drinking, fish farming, agriculture, flood control, and energy production (Kutlu et al., 2020). Anthropogenic activities such as the entry of urban and rural wastewater, livestock and metal factories effluent, and production of pesticides and fertilisers can contaminate water of different inland water bodies (Ozmen et al., 2008; Karadede and Unlu, 2000; Karimi et al., 2020; Masoudinejad et al., 2018). The risk of bioaccumulation and biodiversity loss might be increased as a result of the introduction of pollutants and nutrients into water resources and their accumulation (Başturk, 2019). This pollution of lakes and other inland water bodies has resulted into public health consequences. In the present study water quality index of Bhelwa lake was assessed. Table-2 presents the measured values of the thirteen physiochemical parameters of Bhelwa Lake of Durg Chhattisgarh.

It was observed that the difference between physiochemical properties across different seasons was significant ($p \leq 0.05$), except water pH which show an insignificant difference. Also it was observed that the physiochemical properties show a variation between two consecutive years viz., 2019-2020 to 2020-2021 (Table-2). The WQI of Bhelwa Lake for drinking use was nearly constant i.e., poor, across all seasons, as evidenced. Monsoon, however, has lower drinking water quality than other seasons of the year. similar results were obtained by many authors (Alobaidy et al., 2010; Mooselu et al., 2020; Azadi et al., 2021; Mooselu et al., 2021;). The findings indicate that during the monitoring period, the water quality was not fit for human consumption. One of the reasons for this is that during monsoon excessive runoff from the adjacent area is caught by the lake. This runoff has a mixture of many organic and inorganic pollutants which restrict the suitability of water for drinking (Gawle, et.al., 2021). Therefore, the local government must implement safeguards for drinking water and raise the quality of the water during the water treatment process. The WQI had the greatest value during monsoon, indicating the poorest water quality. Compared to earlier times, the values of variables like COD, pH, and total hardness have altered dramatically. Since the COD level has risen to greater than

30 mg/L, contamination from upstream pollution sources has entered the system. This spike was brought on by an increase in home and industrial wastewater in the lake catchment area. Bhelwa Lake depicts that pollution has entered into the lake. The average values of turbidity, BOD, calcium, and magnesium during the study period were found to be greater than the standard value recommended by the WHO for drinking water. These results are inconsistent with those of Amiri, et.al., (2021) , Anim-Gyampo et al., (2019), and Meher, et.al., (2015). Human health could be at risk due to the low water quality of Bhelwa lake. The study will assist local government in adopting an appropriate strategy for the supply of drinking water in accordance with the norms of Bureau of Indian Standards (2012).

## CONCLUSION

The increase in the urban sprawl and human activities in Durg, Chhattisgarh has threatened the freshwater lakes of the city immensely. This study has been conducted with an objective to assess the water quality index of Bhelwa Lake (a fresh water body) of Durg, Chhattisgarh for drinking water purposes. It was observed that the difference between physiochemical properties across different seasons was significant ($p \leq 0.05$), except water pH which show an insignificant difference. The WQI of Bhelwa Lake for drinking use was nearly constant across all seasons, as evidenced. Monsoon, however, has lower drinking water quality than other seasons of the year. similar results were obtained by many authors. The findings indicate that during the monitoring period, the water quality was not fit for human consumption. The WQI had the greatest value during monsoon, indicating the poorest water quality. Compared to earlier times, the values of variables like COD, pH, and total hardness have altered dramatically. Therefore, the local government must implement safeguards for drinking water and raise the quality of the water during the water treatment process. The data of this study will help decision makers in sustainable management of these water resources.

## CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest

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**Table-2. BHELWA LAKE:** Statistics of analyzed seasonal variation in physiochemical parameters during 2019 to 2021 in Durg, Chhattisgarh. Values are Mean±SE.

| S.NO | Parameters | Standard Values (DP) | *Winter* | | *Summer* | | *Monsoon* | | ANOVA (One way) |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2019-20 | 2020-21 | 2019-20 | 2020-21 | 2019-20 | 2020-21 | |
| 1. | **Temperature ( $^0$C)** | -- | 20.72±1.00 | 20.30±1.05 | 29.15±0.94 | 28.10±1.52 | 26.20±1.12 | 25.95±1.33 | * |
| 2. | **Transparency** | -- | 30.07±1.25 | 32.75±0.94 | 37.02±1.45 | 39.07±1.09 | 25.20±1.25 | 24.75±1.30 | * |
| 3. | **pH** | **7.5** | 07.00±0.05 | 07.10±0.02 | 08.05±0.07 | 08.20±0.05 | 07.50±0.10 | 07.33±0.07 | **NS** |
| 4. | **Alkalinity (mg/l)** | **02-200** | 94.36±3.25 | 105.22±2.98 | 89.56±2.50 | 97.22±3.95 | 60.54±2.27 | 68.26±2.50 | * |
| 5. | **Total Hardness** | **10-500** | 224.31±7.40 | 229.45±5.94 | 252.95±3.75 | 270.38±6.33 | 222.9±4.25 | 240.91±8.29 | ** |
| 6. | **Salinity (g/l)** | **0-50** | 05.05±0.05 | 04.50±0.07 | 05.25±0.05 | 04.90±0.05 | 04.66±0.09 | 05.25±0.05 | * |
| 7. | **Conductivity (µs/cm)** | **0-500** | 578.49±7.98 | 594.28±5.25 | 658.25±6.59 | 687.77±9.80 | 525.64±5.50 | 548.19±6.45 | ** |
| 8. | **Total dissolved solids (mg/l)** | **10-500** | 389.25±7.85 | 375.21±9.68 | 350.37±5.60 | 345.85±8.78 | 425.20±9.58 | 410.98±8.77 | ** |
| 9. | **Calcium Hardness (mg/l)** | **10-75** | 145.36±8.25 | 155.25±9.30 | 163.80±7.25 | 180.27±8.78 | 146.08±4.25 | 157.28±6.65 | * |
| 10. | **Magnesium Hardness(mg/l)** | **10-50** | 78.95±5.25 | 74.20±9.50 | 89.15±4.39 | 90.11±6.78 | 79.88±5.67 | 83.63±8.25 | ** |
| 11. | **Dissolved Oxygen(mg/l)** | **05.00** | 05.26±0.17 | 05.60±0.10 | 03.75±0.05 | 04.25±0.05 | 05.63±0.15 | 05.94±0.19 | * |
| 12. | **COD(mg/l)** | **25.00** | 33.02±1.75 | 30.17±2.05 | 35.23±1.94 | 35.25±2.10 | 27.85±1.98 | 25.69±1.87 | * |
| 13. | **BOD(mg/l)** | **01.00** | 08.19±0.07 | 08.25±0.09 | 09.25±0.07 | 09.75±0.15 | 07.25±0.12 | 06.94±0.08 | **NS** |

The data shown are mean ± SE of four replicates

*****Statistically significant difference at $p \leq 0.05$

******Statistically significant difference at $p \leq 0.01$

**NS**: Not significant DP: Fish Drinking Purpose

**Table-3.** Water Quality index (WQI) of Sampled Dam of Bilaspur, Chhattisgarh across different seasons for drinking purpose during Nov-2019 to Oct- 2021

| S.No | Season | *Water Quality index (WQI)* | | | | Remarks |
|---|---|---|---|---|---|---|
| | | ***2019-2020*** | ***2020-2021*** | **Average Value** | **Grade** | |
| **01** | Winter | 63±2.21 | 61±2.15 | 62.0±1.09 | **C** | Poor water quality is good for Drinking |
| **02** | Summer | 68±3.17 | 67±1.66 | 67.5±2.49 | **C** | Poor quality of water for Drinking |
| **03** | Monsoon | 78±2.85 | 75±3.18 | 76.5±2.94 | **D** | Very poor quality of water for Drinking |
| **04** | **ANOVA** | ***** | ***** | ***** | | *****Statistically significant difference at $p \leq 0.05$ |