

Seasonal and spatial dynamics in physico-chemical characteristics of Chandrakeshar reservoir, Dewas, Madhya Pradesh for suitability of fish and fisheries

Kamlesh Parte¹, Rajendra Chouhan², Vipin Vyas¹ and R.K. Garg³

¹*Department of Zoology and Applied Aquaculture, Barkatullah University, Bhopal 462 026, M. P., India*

²*Govt. Dr Shyama Prasad Mukharjee Science and Commerce College, Bhopal 262 042, M.P., India*

³*Department Biosciences, Barkatullah University, Bhopal 462 026, M.P., India*

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ABSTRACT

The assessment of physico-chemical water quality parameters and their seasonal variations in Chandrakeshar Reservoir, situated in Dewas, Madhya Pradesh, India, provided critical insights into the reservoir's environmental health. The study aimed to evaluate the reservoir's water quality through a comprehensive analysis of various physico-chemical parameters during January, 2021 to December, 2023. Throughout different seasons, the water quality parameters, including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), turbidity, and nutrient levels such as nitrates, phosphates, and ammonia, were examined. These parameters served as indicators of the reservoir's health and its suitability for various purposes like drinking, agriculture, and aquatic life. The study highlighted the seasonal variations in these parameters, acknowledging potential influences such as rainfall, temperature fluctuations, and anthropogenic activities in the catchment area. By monitoring these variations, the impact of human activities, agricultural runoff, and other environmental factors on the water quality of the Chandrakeshar Reservoir was assessed. Understanding these variations was crucial for effective water resource management and the formulation of appropriate conservation strategies. The findings of this assessment served as a foundation for policymakers, environmentalists, and local authorities to implement measures aimed at preserving and improving the water quality of Chandrakeshar Reservoir, ensuring sustainable utilization and safeguarding the ecosystem it supports.

Key words: Tropical reservoir, Water quality parameters, Seasonal variation, Fish Culture.

Introduction

Water quality assessment plays an important part in management and decision-making of water environments, and is the basis of water resources system planning and management (Li *et al.*, 2012; Yang *et al.*, 2020) and also water is the first requirement for the existence of life. The unbridled exploitation of water for irrigation, drinking and industrial purpose

has caused a drastic decline of the important water resources. The reservoir is a semi-artificial natural water body neither like a river nor a lake. The reservoir was originally built for flood control, power generation, farmland irrigation, etc. These reservoirs of freshwater are an important ecosystem, which serves as water reserves for irrigation and consumption but also for recreation and tourism activities. Over the past few years, we have acknowledged a

growing concern with the decreasing of drinking water quality and availability (Johnson *et al.*, 2001, Dudgeon *et al.*, 2006, Setty *et al.*, 2017).

Chandrakeshar reservoir, a man-made reservoir located in the Dewas district of Madhya Pradesh, is known for its significant contribution to the irrigation and drinking water needs of the surrounding villages. Given its importance in sustaining the livelihoods of the local communities, regular assessments of the water quality parameters are crucial in ensuring the health and sustainability of the reservoir. In this regard, a study was conducted to assess the physico-chemical water quality parameters of Chandrakeshar reservoir and understand its seasonal variation. The study also revealed significant seasonal variations in the water quality parameters. During the monsoon season, there was a decrease in pH, temperature, and dissolved oxygen levels, while there was an increase in turbidity and biochemical oxygen demand. This can be attributed to the increased inflow of rainwater and runoff, carrying sediments and organic matter into the reservoir. During the post-monsoon season, there was an improvement in water quality, with a decrease in turbidity, biochemical oxygen demand, and total dissolved solids. However, the summer season saw a significant increase in temperature, electrical conductivity, and total dissolved solids, indicating the concentration of minerals due to evaporation.

Methodology

Study Area

Chandrakeshar reservoir, a tropical reservoir located approximately 20 kilometres from Satwas town in Dewas District, Madhya Pradesh. Its latitude is $22^{\circ}37'00''$ N and longitude are $76^{\circ}2'30''$ E. The Chandrakeshar reservoir, spans the Chandrakeshar River, a tributary of the Narmada and it is situated in between its primary intent was to facilitate irrigation for nearby villages. Additionally, the local populace utilizes its water for drinking purposes and sustains fish culture among the area's fishermen.

Sampling Stations

The water samples collected once a time in every month interval from January, 2021 to December, 2023 in three seasons: Pre monsoon (March-April-May), Post monsoon (September-October) and winter season (November-December-January). Samples

were collected from 5 different sites of the Chandrakeshar reservoir: Site A, which is major landing centre near Jasmatpura; Site B, near 80 chain; Site C is located near overflow of the of the reservoir; Side D considered as near village Hirapur and Site E, which is the middle part of the Chandrakeshar reservoir.

For unstable parameters such as temperature, pH, and dissolved oxygen (DO) were measured at the sampling site. Samples were brought to the laboratory for analysis of other physico-chemical parameters like total dissolved solid, total alkalinity, total hardness, calcium, magnesium, chlorides, and biochemical oxygen demand (BOD). The parameters were compared according to the standard methods described in the literature (APHA, 1998; WHO, 1998; Botkin and EA., 1995).

Analysis of Physico-chemical parameters

Temperature, pH, and dissolved oxygen (DO), being unstable parameters, were measured on-site during sampling. Subsequently, samples were transported to the laboratory of department of Zoology and Applied Aquaculture, Barkartullah University for analysis of additional physico-chemical param-

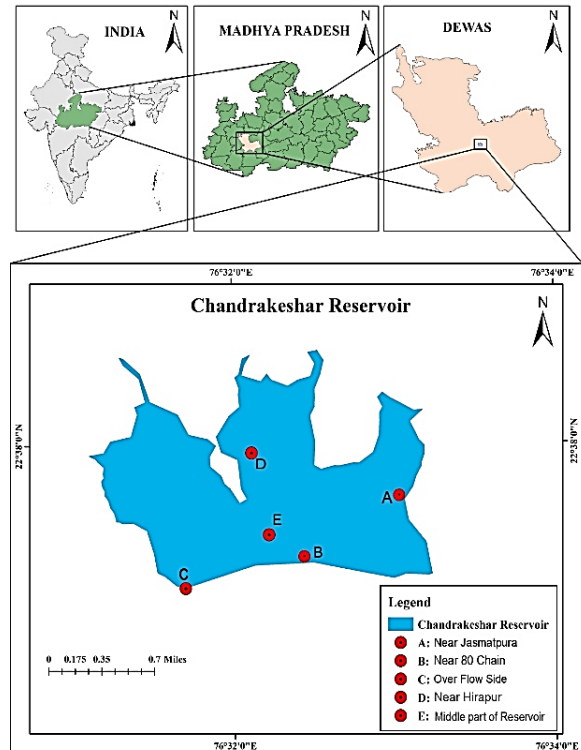


Fig. 1. Map showing study site and sampling station established in Chandrakeshar Reservoir

eters such as free CO₂, alkalinity, total dissolve solids (TDS), nitrate nitrogen and hardness. The comparison of these parameters was conducted following standard methods outlined in the literature (APHA, 1998; WHO, 1998; Botkin and EA., 1995).

Statistical Analysis

In this study, the statistical analysis of physico-chemical parameters in the reservoir was conducted

through the utilization of key descriptive statistics, namely the mean and standard deviation. The mean, or average, provides a central tendency measure, offering insights into the typical values of parameters such as pH, dissolved oxygen, temperature etc. A higher standard deviation suggests greater variability in the observed values, indicating potential fluctuations in the reservoir's physico-chemical profile.

Table 1. Physico-chemical characteristics and its seasonal of Chandrakeshar Reservoir at Site-1 (A) from April, 2021 to January, 2023

| Parameter | 2021-2022 | | | 2022-2023 | | |
|-----------------------------|---------------------------------|----------------------------|-------------------------|---------------------------------|----------------------------|-------------------------|
| | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) |
| Temperature (°C) | 37.83±4.77 | 25.5±1.69 | 18.86±3.86 | 37.63±5.8 | 25.65±2.47 | 17.74±4.41 |
| pH | 9.1±0.43 | 9.25±0.49 | 8.8±0.4 | 8.03±0.56 | 8.35±0.21 | 8.46±0.9 |
| DO (mg/l) | 10.43±0.77 | 9.6±1.69 | 9.76±0.73 | 10.3±1 | 8.9±0.7 | 10.3±1.08 |
| Free CO ₂ (mg/l) | 2.3±0.5 | 2.65±0.21 | 2.7±0.9 | 2.1±0.6 | 2.1±0.42 | 2.23±0.76 |
| Alkalinity (mg/l) | 153.43±18.52 | 132.2±16.12 | 118.63±19.05 | 146.31±9.36 | 133.8±14.7 | 105.39±14.21 |
| TDS (mg/l) | 145.87±30.33 | 109.25±15.48 | 119.43±33.88 | 138.33±19.8 | 109.35±16.35 | 111.03±20.64 |
| Nitrate-Nitrogen | Nil | Nil | Nil | Nil | Nil | Nil |
| Hardness | 165.7±11.96 | 73.3±4.1 | 92.86±15.34 | 149.93±13.87 | 82.95±9.26 | 96.7±17.26 |

Table 2. Physico-chemical characteristics and its seasonal of Chandrakeshar Reservoir at Site-2 (B) from April, 2021 to January, 2023

| Parameter | 2021-2022 | | | 2022-2023 | | |
|-----------------------------|---------------------------------|----------------------------|-------------------------|---------------------------------|----------------------------|-------------------------|
| | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) |
| Temperature (°C) | 37.83±4.76 | 25.3±0.84 | 19.03±4.06 | 37.23±5.25 | 24.4±2.82 | 17.93±4.64 |
| pH | 9.26±0.55 | 9.35±0.35 | 9±0.52 | 8.53±0.66 | 8.8±0.56 | 7.73±0.75 |
| DO (mg/l) | 10.9±1.08 | 10.25±1.2 | 10.1±0.6 | 9.73±0.75 | 9.65±1.06 | 9.73±0.61 |
| Free CO ₂ (mg/l) | 1.96±0.41 | 2.15±0.35 | 2.36±0.41 | 2.16±0.87 | 2.05±0.35 | 2.03±0.3 |
| Alkalinity (mg/l) | 145.86±16.83 | 124.9±8.34 | 133.6±32.55 | 134.46±8.98 | 105.7±18.8 | 119.06±25.77 |
| TDS (mg/l) | 130.86±28.41 | 115.7±52.18 | 119.03±30.39 | 121.1±16.57 | 114.65±59.46 | 116.9±26.42 |
| Nitrate-Nitrogen | Nil | Nil | Nil | Nil | Nil | Nil |
| Hardness | 145.4±18.37 | 97.35±18.17 | 96.56±6.02 | 123.23±8.97 | 103.45±29.76 | 96.56±6.02 |

Table 3. Physico-chemical characteristics and its seasonal of Chandrakeshar Reservoir at Site-3 (C) from April, 2021 to January, 2023

| Parameter | 2021-2022 | | | 2022-2023 | | |
|-----------------------------|---------------------------------|----------------------------|-------------------------|---------------------------------|----------------------------|-------------------------|
| | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) |
| Temperature (°C) | 38.5±4.98 | 24.5±1.83 | 16.2±3.25 | 39.46±4.42 | 23.8±0.56 | 16.4±3.55 |
| pH | 8.23±0.5 | 8.1±0.7 | 8.2±0.2 | 8.76±0.45 | 8.6±0.42 | 8.5±0.42 |
| DO (mg/l) | 11.1±1.17 | 9.65±0.77 | 10.4±0.72 | 10±1.03 | 9.5±0.42 | 10.36±0.87 |
| Free CO ₂ (mg/l) | 2.06±0.15 | 2.5±0.28 | 1.86±0.3 | 2.13±0.37 | 2.2±0.14 | 2.33±0.5 |
| Alkalinity (mg/l) | 131.96±17.04 | 123.4±18.66 | 132.73±26.95 | 123.8±13.95 | 113±13.29 | 121.83±19.58 |
| TDS (mg/l) | 143.53±20.27 | 113.9±17.53 | 123.36±30.28 | 156.16±37.82 | 109.4±18.38 | 118.23±24.43 |
| Nitrate-Nitrogen | Nil | Nil | Nil | Nil | Nil | Nil |
| Hardness | 140.8±16.67 | 66.45±5.58 | 92.86±15.34 | 125.9±17.51 | 108.9±19.09 | 104.66±17.19 |

Results

The tabulated data in Table 1 to 5 outlines the seasonal variations in physico-chemical characteristics observed in the waterbody of Chandrakeshar reservoir. The significance of pH in influencing fish survival is underscored by recorded values ranging from average 7.73 to 8.9, indicative of a highly productive waterbody. Temperature fluctuations were slightly negligible in between all the five selected sights, with registering a peak of 43.6°C in the year 2022 and lowest temperature was 12.4 in January, 2023. Seasonal temperature trends remained largely similar during the study period. In case of dissolve oxygen, reaching a maximum of 12.4 mg/l and minimum 8.3 mg/l in 2021-23. Notably, it showed a highly productive water body it is, while reported a minimum alkalinity of 85.6 mg/l, whether the maximum was 156.8 mg/l. Seasonal fluctuations were observed in TDS levels, indicating dynamic changes in the dissolved solids content of the waterbody. For instance, during the post monsoon season, TDS levels peaked at average 156.16 mg/l, while the lowest

concentration of 109.7 mg/l was recorded during winter season. The recorded TDS values were compared against established water quality standards. The results indicated that the TDS levels in the reservoir water were within the permissible limits set by regulatory authorities, suggesting that the water is generally suitable for various uses, including aquatic life support and recreational activities. Surprisingly, the analysis of nitrate-nitrogen levels in the reservoir waterbody revealed a consistent absence of nitrate throughout the entire study period. The recorded nitrate-nitrogen value remained consistently nil (zero) across all sampling points and throughout different seasons. The mean total hardness concentration over the study period was determined to be in average 165.7 mg/l to 92.86 mg/l. The analysis revealed variations in total hardness concentrations across different sampling points within the reservoir.

Surprisingly, the analysis of nitrate-nitrogen levels in the reservoir waterbody revealed a consistent absence of nitrate throughout the entire study period. The recorded nitrate-nitrogen value remained

Table 4. Physico-chemical characteristics and its seasonal of Chandrakeshar Reservoir at Site-4 (D) from April, 2021 to January, 2023

| Parameter | 2021-2022 | | | 2022-2023 | | |
|-----------------------------|---------------------------------|----------------------------|-------------------------|---------------------------------|----------------------------|-------------------------|
| | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) |
| Temperature (°C) | 37.96±4.86 | 24.25±2.61 | 18.83±5.15 | 37.43±5.5 | 24.8±3.39 | 17.56±5.06 |
| pH | 8.16±0.5 | 7.99.3±0.7 | 8.4±0.2 | 8±0.6 | 8.1±0.42 | 8.23±0.85 |
| DO (mg/l) | 11.1±1.17 | 10.7±0.21 | 10.36±0.6 | 9.33±1 | 8.95±0.49 | 10.36±0.97 |
| Free CO ₂ (mg/l) | 2.13±0.5 | 2.75±0.07 | 1.96±0.8 | 2.16±0.7 | 2.8±0.14 | 1.83±0.41 |
| Alkalinity (mg/l) | 122.46±22.9 | 120.55±22.69 | 121.9±35.5 | 125.73±24.61 | 116.95±19.16 | 114.26±23.89 |
| TDS (mg/l) | 126.23±12.91 | 128.55±2.89 | 132.84±43.77 | 124.76±7.47 | 134±3.39 | 131.65±28.39 |
| Nitrate-Nitrogen | Nil | Nil | Nil | Nil | Nil | Nil |
| Hardness | 132.56±8.77 | 92.9±4.8 | 105.13±17.22 | 131.43±15.2 | 90.6±11.31 | 102.66±23.61 |

Table 5. Physico-chemical characteristics and its seasonal of Chandrakeshar Reservoir at Site-5 (E) from April, 2021 to January, 2023

| Parameter | 2021-2022 | | | 2022-2023 | | |
|-----------------------------|---------------------------------|----------------------------|-------------------------|---------------------------------|----------------------------|-------------------------|
| | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) | Pre-Monsoon (April-May-June) | Post-Monsoon (Sept-Oct) | Winter (Nov-Dec-Jan) |
| Temperature (°C) | 37.96±4.86 | 24.25±2.61 | 18.83±5.15 | 38.36±5 | 24.45±2.75 | 17.33±4.2 |
| pH | 8.46±0.5 | 7.85±0.7 | 8.16±0.2 | 7.86±0.7 | 8.7±0.56 | 8.56±0.65 |
| DO (mg/l) | 11.1±1.17 | 10.7±0.21 | 10.36±0.6 | 9.76±0.73 | 10.7±0.64 | 9.13±0.7 |
| Free CO ₂ (mg/l) | 2.13±0.5 | 2.75±0.07 | 1.96±0.8 | 2.06±0.72 | 2.2±0.56 | 2.26±0.86 |
| Alkalinity (mg/l) | 122.46±22.9 | 120.55±22.69 | 121.9±35.5 | 118.49±27.94 | 107.9±20.5 | 113.2±17.17 |
| TDS (mg/l) | 126.23±12.91 | 128.55±2.89 | 132.84±43.77 | 117.03±16.7 | 125.2±29.98 | 125.93±8.62 |
| Nitrate-Nitrogen | Nil | Nil | Nil | Nil | Nil | Nil |
| Hardness | 132.56±8.77 | 92.9±4.8 | 105.13±17.22 | 127.43±13.93 | 102.2±5.65 | 114.03±23.95 |

consistently nil (zero) across all sampling points and throughout different seasons. The mean total hardness concentration over the study period was determined to be in average 165.7 mg/l to 92.86 mg/l. The analysis revealed variations in total hardness concentrations across different sampling points within the reservoir.

The water quality parameters of Chandrakeshar reservoir were comprehensively analysed and are visually represented in the accompanying bar diagrams. The figures from 1 to 7 depict key indicators such as temperature, pH, DO, Free CO₂, Alkalinity, TDS and Hardness across different sampling points

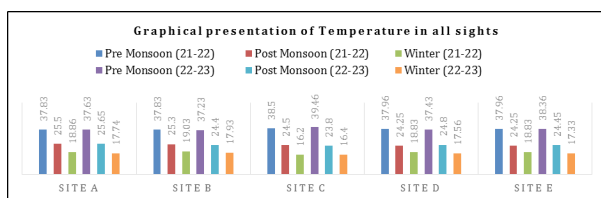


Fig. 2. Seasonal variations in water temperature of Chandrakeshar Reservoir from April, 2021 to January, 2023

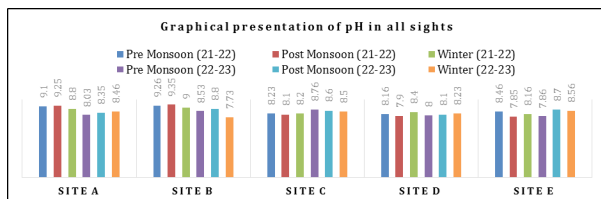


Fig. 3. Seasonal variations in pH of Chandrakeshar Reservoir from April, 2021 to January, 2023

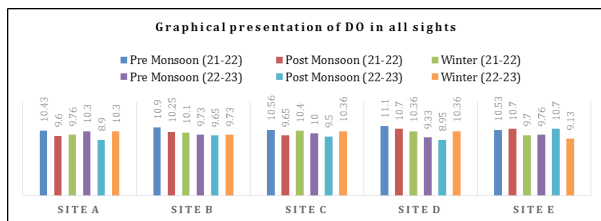


Fig. 4. Seasonal variations in dissolved oxygen of Chandrakeshar Reservoir from April, 2021 to January, 2023

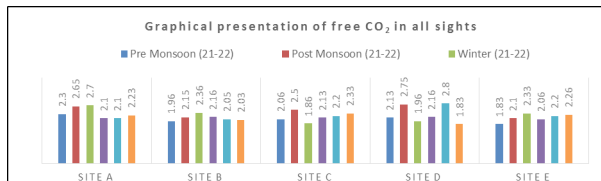


Fig. 5. Seasonal variations in free CO₂ of Chandrakeshar Reservoir from April, 2021 to January, 2023

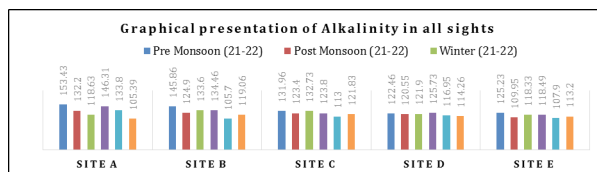


Fig. 6. Seasonal variations in alkalinity of Chandrakeshar Reservoir from April, 2021 to January, 2023

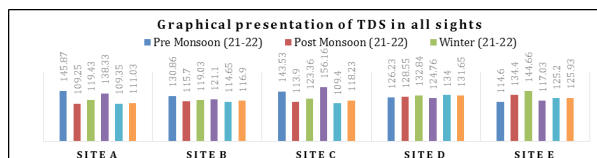


Fig. 7. Seasonal variations in TDS of Chandrakeshar Reservoir from April, 2021 to January, 2023

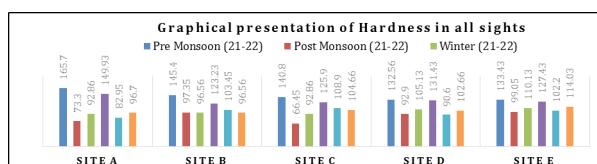


Fig. 8. Seasonal variations in water hardness of Chandrakeshar Reservoir from April, 2021 to January, 2023

and seasons though out the year 2021 to 2023.

Conclusion

In summary, the assessment of Chandrakeshar Reservoir’s physico-chemical water quality parameters revealed significant seasonal variations. The study, covering pH, DO, BOD, COD, TDS, turbidity, and nutrient levels, identified influences such as rainfall and anthropogenic activities. The observed fluctuations, particularly during the monsoon season, highlighted the dynamic nature of the reservoir’s water quality. Despite these variations, the reservoir consistently met water quality standards for various uses, indicating its suitability for irrigation, drinking, and fish culture. The absence of nitrate-nitrogen levels throughout the study period added to the reservoir’s unique characteristics. These findings provide essential insights for local authorities and policymakers, guiding effective water resource management and conservation strategies. The study’s short-term fluctuations underscore the need for continued monitoring to ensure the sustained health and usability of Chandrakeshar Reservoir.

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Conflict of Interest - None

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