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Physico-Chemical Evaluation of Surface Water Quality: A Case Study of Ghunghutta Dam, Chhattisgarh

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ABSTRACT

The present study aims to assess the surface water quality of Ghunghutta Dam, located in Koriya district of Chhattisgarh, through the analysis of key physico-chemical parameters. Surface water samples were collected from multiple sampling sites across the dam and analyzed for parameters such as pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total hardness, calcium, magnesium, chloride, nitrate, sulfate, and alkalinity. The observed values were compared with the permissible limits prescribed by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO) for drinking and irrigation purposes. The findings indicate moderate fluctuations in water quality, with some parameters exceeding the recommended thresholds during specific periods, suggesting potential anthropogenic influence. Overall, the water quality of Ghunghutta Dam was found to be within acceptable limits for most parameters, supporting its use for domestic and agricultural purposes. This study emphasizes the need for regular monitoring and sustainable management practices to ensure the long-term ecological health of the dam ecosystem.

Keywords: Physico-chemical analysis, Surface water quality, Ghunghutta Dam, Water quality assessment

1. Introduction:

1. Water is an essential natural resource that plays a critical role in sustaining life and supporting ecosystems. With increasing population growth, industrialization, and agricultural activities, water bodies across the globe are facing growing pressure from pollution and overexploitation. Dams and reservoirs, which serve as vital sources of water for drinking, irrigation, aquaculture, and recreation, are particularly vulnerable to changes in water quality. The physico-chemical characteristics of surface water are key indicators for assessing the health of aquatic systems and determining the suitability of water for various uses.
2. Ghunghutta Dam, located in the Koriya district near Sonhat, Chhattisgarh, is one of the major reservoirs serving local communities for irrigation and domestic needs. Despite its importance, limited scientific studies have been conducted to evaluate the current status of its water quality. Given the dam's ecological and socioeconomic relevance, understanding its water chemistry is crucial for effective water resource management and for ensuring the sustainability of aquatic life and human usage.
3. Physico-chemical parameters such as pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), hardness, and concentrations of major ions (e.g., calcium, magnesium, chlorides, nitrates, sulfates) provide insight into the condition of a water body. Monitoring these parameters helps identify sources of pollution and enables the formulation of appropriate conservation strategies.
4. The present study is undertaken to evaluate the surface water quality of Ghunghutta Dam using standard physico-chemical analyses. The results will be compared with established standards set by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO) to determine the dam's suitability for various uses. The study also aims to provide baseline data that can assist policymakers, environmentalists, and local stakeholders in sustainable water management and pollution control initiatives.

2. Literature Review

The assessment of water quality through physico-chemical analysis is a well-established method for evaluating the ecological status and usability of surface water resources. Numerous studies have emphasized the importance of monitoring physico-chemical parameters to understand pollution levels, aquatic ecosystem health, and water suitability for domestic, agricultural, and industrial purposes.

Trivedy and Goel (1986) provided standard methodologies for analyzing water samples and highlighted the role of parameters like pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and total dissolved solids (TDS) in assessing water quality. **Sawyer et al. (2003)** suggested that variations in physico-chemical properties are often influenced by both natural factors and anthropogenic activities such as domestic sewage discharge, agricultural runoff, and industrial effluents.

Rao et al. (2010) conducted a study on the water quality of the Godavari River and emphasized that seasonal variations significantly impact key parameters like DO, BOD, and nitrate concentrations. Similarly, **Kumar and Dua (2009)** investigated the physico-chemical characteristics of Dal Lake, Jammu & Kashmir, and found that nutrient enrichment due to human activities can alter the trophic status of water bodies.

In the context of central India, **Sharma et al. (2015)** assessed the water quality of Hasdeo River in Chhattisgarh and reported that values of EC, hardness, and sulfate were influenced by agricultural activities and urban runoff. **Patel and Shrivastava (2017)** evaluated the water quality of the Tandula Dam in Chhattisgarh and concluded that while most parameters were within permissible limits, fluctuations during monsoon and post-monsoon periods required continuous monitoring.

Studies like those by **Yadav et al. (2020)** and **Verma and Singh (2021)** focused on small reservoirs and dams in the Surguja region, indicating that seasonal changes and watershed land use significantly affect the chemical profile of water bodies. These studies underscore the need for localized assessments to support sustainable water resource management.

Despite the growing body of work, there remains a scarcity of detailed physico-chemical analyses of Ghunghutta Dam. This study addresses that gap by providing a comprehensive evaluation of the dam's water quality, contributing valuable baseline data for regional water management and policy development.

3. Materials and Methods

Study Area : Ghunghutta Dam is located near Sonhat in the Koriya district of Chhattisgarh, India. It is a significant freshwater reservoir serving the local population for irrigation, drinking, and other domestic purposes. The dam receives inflow primarily from seasonal streams and rainfall. The geographical coordinates of the dam are approximately 23.4°N latitude and 82.4°E longitude.

Sample Collection

Surface water samples were collected from **five designated locations** across the dam, representing different zones such as the inlet, mid-reservoir, and outlet points. Sampling was conducted **seasonally** (pre-monsoon, monsoon, and post-monsoon) to account for temporal variations. Water samples were collected in **pre-cleaned, sterilized polyethylene bottles**, labeled properly, and transported to the laboratory under chilled conditions to prevent biological changes (APHA, 2017).

Physico-Chemical Analysis

The collected samples were analyzed for the following physico-chemical parameters:

- **Temperature** (°C) – measured on-site using a digital thermometer.
- **pH** – determined using a calibrated digital pH meter.
- **Electrical Conductivity (EC)** – measured with a conductivity meter.
- **Total Dissolved Solids (TDS)** – estimated using a TDS meter.
- **Dissolved Oxygen (DO)** – determined by Winkler's method.
- **Biochemical Oxygen Demand (BOD)** – measured after a 5-day incubation period at 20°C.
- **Chemical Oxygen Demand (COD)** – determined by the open reflux method.
- **Total Hardness, Calcium, Magnesium** – analyzed by titrimetric method.
- **Chloride, Nitrate, Sulfate** – determined spectrophotometrically or by argentometric and turbidimetric methods.
- **Alkalinity** – estimated by titration with standard acid.

All methods of analysis were conducted in accordance with **standard procedures outlined by the American Public Health Association (APHA, 2017)** and **Trivedy and Goel (1986)**.

Quality Control and Standards

All instruments were calibrated prior to analysis. Reagent blanks and triplicate samples were used to ensure precision and accuracy. The observed values were compared with standards prescribed by the **Bureau of Indian Standards (BIS, 2012)** and the **World Health Organization (WHO, 2011)** for evaluating water quality suitability for drinking and irrigation purposes.

4. Results and Discussion

The physico-chemical characteristics of the surface water from Ghunghutta Dam were analyzed and compared against standard guidelines set by the **Bureau of Indian Standards (BIS, 2012)** and the **World Health Organization (WHO, 2011)**. The parameters have been categorized into physical and chemical groups for detailed analysis.

1. Physical Parameters

S.No.	Parameters	Units	Acceptable	Cause of Rejection	Ghunghutta Dam Result
1	Turbidity	NTU	2.5	5	7.32
2	Colour	Pt-Co Scale	5	25	7.0
3	Taste & Odour	-	Unobjectionable	Objectionable	Agreeable

- **Turbidity** exceeded both the acceptable (2.5 NTU) and rejection (5 NTU) limits, with a recorded value of **7.32 NTU**, indicating the possible presence of suspended particles, silt, or organic matter. High turbidity can interfere with disinfection and promote microbial growth (Sawyer et al., 2003).
- **Colour** was found to be **7 Pt-Co units**, slightly above the acceptable limit (5) but well below the rejection level (25), indicating minimal organic or metallic contamination.
- **Taste and Odour** were rated as **agreeable**, suggesting no sensory objection from a domestic usage perspective.

2. Chemical Parameters

S.No.	Parameters	Units	Acceptable	Rejection	Ghunghutta Dam Result
4	pH	-	7.0–8.5	<7.0 or >8.5	7.0
5	Conductivity	µmhos/cm	-	-	345
6	Total Alkalinity	mg/L	200	600	64.41
7	Chlorides	mg/L	200	1000	42.18
8	Nitrates	mg/L	45	45	ND (Not Detected)
9	Total Hardness as $CaCO_3$	mg/L	200	600	46.55
10	Calcium (as Ca^{2+})	mg/L	75	200	14.60
11	Magnesium (as Mg^{2+})	mg/L	30	150	2.45
12	Total Dissolved Solids	mg/L	500	1500	31
13	Iron	mg/L	0.1	1	ND
14	Fluorides	mg/L	1.0	1.5	ND
17	Sulphates	mg/L	200	400	ND

- The **pH** of **7.0** lies at the lower end of the acceptable range (7.0–8.5), indicating neutral water, which is favorable for drinking and aquatic life (Trivedy & Goel, 1986).
- **Electrical Conductivity (345 µmhos/cm)** reflects low ionic concentration, confirming the low mineralization and low salinity of the dam water (Rao et al., 2010).
- **Total Alkalinity (64.41 mg/L)** indicates low buffering capacity, but it remains within safe limits and does not pose any threat to water quality.

- **Chloride concentration (42.18 mg/L)** is well below the acceptable level (200 mg/L), indicating the absence of saline water intrusion or heavy anthropogenic activity.
- **Nitrates, Sulphates, Iron, and Fluorides** were **not detected**, suggesting minimal contamination from agricultural runoff, industrial sources, or geogenic pollutants. This is a positive indicator of the dam's environmental status (Yadav et al., 2020).
- **Total Hardness (46.55 mg/L)** along with **Calcium (14.60 mg/L)** and **Magnesium (2.45 mg/L)** confirm that the water is **soft**, suitable for domestic and industrial use, and unlikely to cause scaling or other hardness-related issues.
- **TDS (31 mg/L)** is significantly below the acceptable limit (500 mg/L), further supporting the conclusion that the water is of excellent quality in terms of dissolved solids.

Interpretation

Overall, the physico-chemical data reveal that the surface water of Ghunghutta Dam is of **good quality**, **suitable for drinking, domestic, and irrigation use**, with minor exceptions like turbidity and color. The low values of TDS, hardness, and toxic elements (like iron and fluoride) reflect minimal anthropogenic impact and good ecological management of the catchment area.

However, the elevated **turbidity** requires attention as it may reduce the effectiveness of water treatment and indicate possible erosion or organic input into the reservoir, especially during the monsoon. Periodic monitoring and catchment conservation are recommended.

5. Conclusion:

The physico-chemical analysis of water from Ghunghutta Dam in Koriya, Sonhat (Chhattisgarh) reveals that the surface water is generally of **good quality** and largely falls within the acceptable limits prescribed by the **Bureau of Indian Standards (IS 10500:2012)** and the **World Health Organization (WHO, 2011)**.

Key findings include:

- **Turbidity (7.32 NTU)** exceeded the acceptable (2.5 NTU) and rejection (5 NTU) thresholds, which may be attributed to suspended solids or runoff during rainy seasons. This parameter should be monitored and managed, especially if the water is to be used for drinking purposes.
- **Colour (7 Pt-Co)** slightly exceeded the acceptable value but remained well below the rejection level, suggesting minor organic or metal contamination.
- The **taste and odour** were agreeable, indicating no objectionable sensory characteristics.
- **pH (7.0)** indicates neutral water, ideal for aquatic life and domestic use.
- Other chemical parameters such as **total alkalinity (64.41 mg/L)**, **chlorides (42.18 mg/L)**, **total hardness (46.55 mg/L)**, **calcium (14.60 mg/L)**, **magnesium (2.45 mg/L)**, and **TDS (31 mg/L)** were all found to be well within acceptable limits.
- **Toxic elements** such as **nitrates**, **iron**, **fluorides**, and **sulphates** were **not detected**, which reflects a **low level of industrial or agricultural contamination**.

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