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Study on Water Quality Dynamics: A Comparative Analysis of Physico-Chemical Parameters of Khadakwasla Dam, Pune

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Abstract

Water quality assessment is essential for the sustainable management and conservation of freshwater resources, particularly in reservoirs that support domestic, agricultural, and ecological needs. The present study investigates the physico-chemical characteristics of water from the front and back regions of Khadakwasla Dam, located near Pune, Maharashtra, India. Water samples were collected during September–October 2025 from two distinct sampling zones representing the inflow (front water) and storage/outflow (back water) regions of the reservoir. The collected samples were analyzed for several important physico-chemical parameters, including colour, odour, temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), turbidity, chloride content, total hardness, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and ammonia using standard analytical methods. The results revealed noticeable spatial variations in water quality between the two sites. The front water region exhibited comparatively better water quality with neutral pH, lower turbidity, and higher dissolved oxygen levels, indicating relatively cleaner and well-aerated conditions. In contrast, the back water region showed higher values of turbidity, chloride, hardness, BOD, COD, and ammonia, suggesting moderate organic and chemical contamination. These variations may be attributed to slower water circulation, accumulation of organic matter, and anthropogenic influences such as agricultural runoff and nearby human activities. Most of the observed parameters remained within the permissible limits recommended by national and international water quality standards, although certain indicators point toward localized deterioration in the back water zone. The study highlights the importance of continuous monitoring and effective management strategies to maintain water quality and ecological balance in the reservoir ecosystem.

Keywords: Khadakwasla Dam, TDS, Hardness, Dissolved oxygen, BOD, COD, Turbidity

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Introduction

Water is one of the most essential natural resources for the survival of living organisms. It supports ecological balance, human health, agriculture and industrial development. Although nearly two-thirds of the Earth's surface is covered by water, only a very small fraction is available as freshwater suitable for human consumption. Most of the water present on Earth occurs in oceans and seas and is saline in nature. Freshwater resources are therefore limited and require careful management and conservation.

Reservoirs and dams play an important role in storing freshwater and supplying it for domestic, agricultural and industrial purposes. They also contribute to irrigation, fisheries, hydroelectric power generation, and flood control. In recent decades rapid urbanization, industrialization, and agricultural expansion have led to increasing pressure on freshwater resources, making continuous monitoring of water quality imperative (Trivedy& Goel,1986).

Khadakwasla Dam is one of the major reservoirs supplying water to Pune City and nearby regions. Due to increasing urban expansion and human activity around the reservoir, there is growing concern regarding the quality of water in the dam. Periodic evaluation of its Physico-chemical characteristics is therefore essential for maintaining the sustainability of this vital water resources. Water quality is generally evaluated using Physico-chemical Parameters such temperature,pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, total dissolved solids (TDS), hardness and nutrient levels. These parameters help determine the suitability of water for drinking, irrigation, aquatic life & other uses. Regular monitoring of these indicators is therefore essential for the sustainable management of freshwater ecosystems. The present study focuses to assess and compare the Physico-chemical Parameters of front and back water in Khadakwasla Dam to evaluate overall water quality and identify possible spatial variations.

Material and Methods

Study Area: Khadakwasla Dam is located approximately 20 km southwest of Pune City in Maharashtra, India, at geographic coordinates around 18°26'N latitude and 73°46'E longitude. The dam is constructed across the Mutha River and forms an important component of the water supply system for Pune City.

The dam plays a vital role in supplying drinking water, supporting irrigation in nearby agricultural lands and maintaining ecological balance in the surrounding region. The Catchment area around the reservoir consists of agricultural land, small settlements and recreational zones. Human activities such as tourism, farming and domestic waste.

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Sampling Sites: Two different locations within the reservoir were selected for the Spatial variation in water quality.

Front Water (Inflow Zone): This sampling sites was located near the inflow region where water enters the reservoir from the upstream river system. This region is influenced by river discharge and may contain suspended sediments and nutrients transported from upstream areas.

Back Water (Near Dam Wall / Outflow Zone): This site was located near the dam wall where water accumulates. This zone represents relatively stagnant water and influenced by waste of human activities and chemical processes.

Sampling Period: Water sample were collected during the months of September and October 2025. This period corresponds to the post – monsoon season when reservoir generally contain significant inflow water and suspended materials from catchment areas.

Sample Collection Method:

Manual water sampling: The water samples were collected manually using clean and sterilized polyethylene bottles. Before sampling, each bottle was thoroughly washed with distilled water to prevent contamination. Samples were collected approximately 10 cm below the water surface and about 5 cm away from the shore to avoid surface impurities.

Each sample bottle was properly labelled with the sampling location and date of collection. After collection, the samples were transported carefully to the laboratory for further analysis. Laboratory analysis was conducted at the Department of Zoology Laboratory at A.K.I's Poona College of Arts, Commerce and Science, Camp, Pune.

- **OBSERVATION TABLE**

Sr. No	Parameters	Front	Back waters	Permissible limits
1.	Colour	Clear	Dusky	True colour units
2.	Odour	No odour	Fishy smell	Unobjectionable/
3.	pH	7.0	8.0	6.5-8.5
4.	Temperature (°C)	19.4°C	22°C	Varies seasonally
5.	DO (mg/L)	4.8 mg/L	2.8 mg/L	6.5-8.5 mg/L
6.	TDS (mg/L)	133.0 mg/L	132.0 mg/L	Upto 500 mg/L

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7.	Turbidity (NTU)	0.2 NTU	2.5 NTU	Less than 5 NTU
8.	Chloride content	53 mg/L	138 mg/L	Upto 250 mg /L
9.	Total hardness (mg/L)	52.0 mg/L	160.0 mg/L	Upto 200 mg/L
10.	BOD (mg/L)	32 mg/L	45 mg /L	<5 (for drinking)
11.	COD (mg/L)	110 mg/L	130 mg/L	<10 (desirable)
12.	Ammonia (mg/L)	0.84 mg/L	1.40 mg/L	Upto 0.5 mg/L

Table 1: Physico-Chemical Parameters of Water sample.

Results

In the present study Physico-chemical parameters of front and back waters of Khadakwasla Dam in Pune district of Maharashtra were analysed .

Colour and odour are simple parameters studied, in which Colouration is a unique property of water on which we can determine the status and quality assessment well as roughly predicted the phytoplankton and zooplankton density . Colour and odour are considered indicator parameters . The volatile compounds produce odour. The odour is qualitatively described as medical (phenolic) and fishy (due to algae), earthy(decaying matter) or chemical (chlorine).

Odour is quality factor influencing acceptability of potable water. The colour and odour for Front waters is clear and no odour present but in Back waters, the colour appears to be dusky and occurrence of fishy smell, which indicates organic pollution or microbial activity in back waters.

pH is a indispensable physical parameter as most of biological process and biochemical reactions are pH dependent. pH is most indispensable in determining the corrosive nature of water, lower the pH value , higher is the corrosive nature of water. The pH is observed in the range from 7.0 (neutral) to 8.0 (slightly alkaline) that is pH for front waters is to be observed as 7.0 which is neutral and for back waters it is observed 8.0 which indicates slightly alkaline backwaters may be due to algal activity or contamination by organic matter.

Temperature of water is important for its effects on the chemistry and biochemical reaction in the organism. It is essential factor in the aerobic environment of the aquatic system, as it determines the succession of pre- dominant of algae, bacteria and other aquatic

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organisms. In the present investigation the temperature observed slightly higher in backwaters i.e 22°C than in front waters it is observed 19.4°C, may be due to reduced flow or sunlight exposure.

Dissolved oxygen is a relative measure of the amount of oxygen which is dissolved or carried in a water body. Dissolved oxygen levels are depending upon the physical, chemical, and biochemical activities prevailing in the water body. Here the observed values are in the range of 2.8 to 4.8 mg/L. Good water should have the dissolved oxygen. 6.5 -8 mg/L, but CPCB also recommends DO concentration of 5mg/L for outdoor bathing in rivers. The DO levels in the back waters of the dam suggests poor aeration and organic pollution leading to oxygen depletion.

The Total Dissolved Solids (TDS) measures all Dissolved substances smaller than 2 microns in water, typically expressed in milligrams per litre(mg/L). High TDS may make water unpalatable, increases corrosion and extremely high or low TDS levels can distrub osmotic balance in aquatic organisms. In the present study, the TDS for front water was 133mg/L and for back waters it was observed as 132mg/L, which is with the limits mentioned in the table according to the measure of BIS.

Total Hardness is the sum of calcium and Magnesium hardness. It is generally caused by calcium and magnesium salts which dissolve from rocks and minerals into water. Water having less than 75mg/L calcium carbonate is termed as soft water. The desirable limit of hardness in drinking water prescribed by ICMR is 120-170 mg/L. For the remaining parameters like hardness, the observed values are 52.0 mg/L and 160 mg/L, which is much higher in backwaters and suggests industrial contaminations.

Chlorides are present in all natural water sources contain chlorides ranging from 100 to 200 mg/L. Here, observed values are in the range of 53 to 138.3 mg/L. The amounts of chloride found in the sample did not exceed the maximum permissible limit i.e 500 mg/L for drinking water prescribed by WHO.

Turbidity is a measure of the light absorbing properties of the water samples. Turbidity is caused by suspended matter, it is caused by clay , slit, finely divided into organic and inorganic contents. Here, it is observed 0.2 NTU for front waters and 2.5 NTU for back waters, which is in the permissible limit.

BOD (Biochemical oxygen demand) is the amount of dissolved oxygen (DO) required by microorganisms to biologically decompose organic matter in water under aerobic conditions, over a specific time and temperature . It indicates the amount of biodegradable organic

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pollution in water . Higher BOD = higher organic pollution= lower water quality.

COD(Chemical oxygen demand) is the amount of oxygen required to chemically oxidize all organic (& some inorganic) matter in water using a strong chemical oxidant. It measures Total oxygen demand, including both biodegradable and non – biodegradable organics and here it indicates strong organic pollution and strong communication for both the water samples.

Ammonia exists in two forms in water:-

- NH4+ (ionized ammonia)- less harmful.
- NH3 (un- ionized ammonia)- highly toxic.

As pH and temperature increases, more NH3 forms high NH3 levels can damage – fish gills , cause stress on death in fish and reducing DO levels, Fueling algal blooms and making water harder and more expensive to treat . According to IS 10500:2021 , the limit for ammonia is 0.5 mg/L and here it is observed, in Front water – still elevated that is 0.84 mg/L but lower than the Back waters which is 1.40 mg/L , that is quite high compared to typical "natural" surface water ammonia levels. Back waters likely posses a risk to aquatic life and this level is above the guidelines.

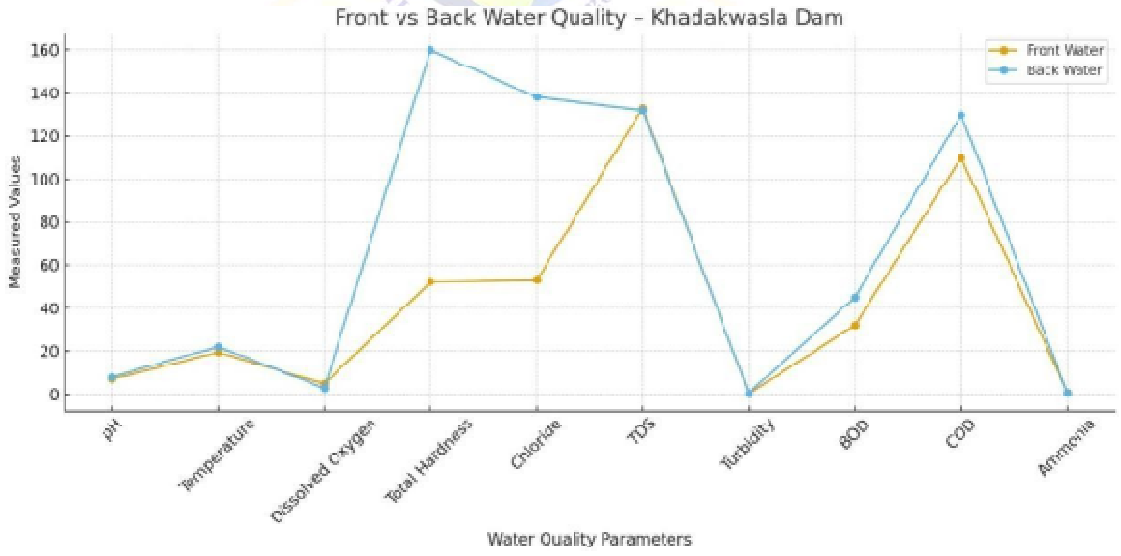

Figure: 1: Comparative Variations of Front and Back Water Parameters .

Discussion

The present study aimed to evaluate the physico-chemical characteristics of the front and

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back waters of Khadakwasla Dam in order to understand the influence of inflow conditions, human activities, and natural processes on water quality. The analyzed parameters and their obtained values were compared with the drinking water standards recommended by BIS and WHO (BIS, 2012; WHO, 2017).

The pH of the front water was recorded as 7.0, while the back waters showed a slightly higher value of 8.0. Both values fall within the desirable range of 6.5–8.5, indicating that the water is slightly alkaline but generally suitable for domestic and irrigation purposes (BIS, 2012; WHO, 2017). Slightly alkaline conditions in reservoir waters are common and may result from increased algal photosynthesis, which removes dissolved carbon dioxide and increases alkalinity (Chapman, 1996; Hem, 1985).

Water temperature ranged from 19.4°C in the front waters to 22°C in the back waters. This slight increase in the back water region may be attributed to relatively stagnant conditions, shallow depth, and greater exposure to sunlight. Temperature plays a crucial role in controlling chemical reactions and biological processes in aquatic systems and also influences dissolved oxygen solubility (Hem, 1985; Trivedy & Goel, 1986).

Turbidity values were recorded as 0.2 NTU in the front water and 2.5 NTU in the back water, which are well within the BIS permissible limit of 5 NTU (BIS, 2012). The slightly higher turbidity observed in the back water region may be due to the accumulation of suspended particles, organic matter, and sediments transported through inflowing water or local runoff (APHA, 1998; Patil et al., 2012).

Total dissolved solids (TDS) values were found to be 133 mg/L in front waters and 132 mg/L in back waters. These values are significantly below the permissible limit of 500 mg/L suggested by WHO and BIS standards (WHO, 2017; BIS, 2012). Lower TDS values generally indicate minimal contamination by dissolved salts and suggest that the water remains suitable for most domestic and agricultural uses .

Dissolved oxygen (DO) levels were recorded as 4.8 mg/L in front waters and 2.8 mg/L in back waters. Ideally, dissolved oxygen concentrations should be around 5 mg/L or higher for maintaining good water quality and supporting aquatic life (WHO, 2017). The comparatively lower DO level in the back waters may indicate mild organic pollution caused by the decomposition of organic matter, slower water circulation, and increased microbial activity (Trivedy & Goel, 1986; Tyagi et al., 2013).

Chloride concentrations ranged from 53 mg/L in the front water to 138 mg/L in the back water, which are within the permissible limit of 250 mg/L prescribed by BIS and WHO (BIS,

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2012; WHO, 2017). However, elevated chloride concentrations in the back waters could suggest contamination from anthropogenic activities such as domestic sewage discharge, agricultural runoff, or human settlements near the reservoir (Patil et al., 2012; Singh et al., 2020).

Total hardness values were recorded as 52 mg/L in the front waters and 160 mg/L in the back waters. Both values fall within the permissible limit of 200 mg/L recommended for drinking water (BIS, 2012). Increased hardness in the back waters may be attributed to the dissolution of calcium and magnesium salts from surrounding rocks and soil, as well as surface runoff entering the reservoir (Hem, 1985; Ramakrishnaiah et al., 2009).

Ammonia concentration is an important indicator of water pollution because elevated ammonia levels are often associated with organic waste decomposition, sewage discharge, and agricultural runoff (APHA, 1998). In the present study, ammonia concentration was higher in the back waters (1.40 mg/L) compared to the front waters (0.84 mg/L). Such elevated levels may adversely affect aquatic organisms and indicate nutrient enrichment within the reservoir ecosystem (Chapman, 1996; Tyagi et al., 2013).

Overall, the results suggest that Khadakwasla Dam water remains within acceptable quality standards; however, localized degradation is noticeable in the back water region. Elevated BOD and COD levels may lead to oxygen depletion and pose risks to aquatic organisms, while increased turbidity can reduce light penetration and affect photosynthetic activity (Tyagi et al., 2013; Kumar & Dua, 2009). Therefore, continuous monitoring and proper management practices are essential to prevent eutrophication and maintain the ecological balance of the reservoir, ensuring that it continues to serve as a reliable source of drinking and irrigation water for Pune and surrounding areas.

Conclusion

The Physico-chemical assessment of Front and Back waters of Khadakwasla Dam provides a comprehensive understanding of its present water quality status. The analyzed parameters generally fall within the BIS (IS 10500:2012) and WHO standards, indicating that the dam water is suitable for domestic, agricultural, aquatic uses with some precautionary measure. The Front waters exhibit better quality with higher DO and lower BOD, COD, and turbidity values. Suggesting relatively cleaner and well aerated condition near the dam well. In contrast, the Back water region showed slightly higher hardness, chloride, BOD and COD levels, indicating mild organic and chemical contamination possibly arising from surface

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runoff, agricultural activities and human interference around the inflow areas. Overall, the study reveals that Khadakwasla Dam water remains within acceptable quality standards through periodic monitoring is essential to track any gradual deterioration. Controlling waste water inflow, and promoting awareness among nearby residents and farmers can help maintain the ecological balance and ensure the dam continues to serve a sustainable source of drinking and irrigation water for the Pune region.

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