

Quarterly Assessment of Sulphate In Relation to TDS And Conductivity for Water Sustainability and Ecosystem Health in Nandan Pahar Pond, Deoghar, Jharkhand, India

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Abstract

Seasonal variation in dissolved substance plays a crucial role in determining freshwater quality, ecosystem health, and sustainability. This study evaluates the quarterly dynamics of sulphate (SO_4^{2-}), total dissolved solids (TDS), and electrical conductivity (EC) in Nandan Pahar Pond, Deoghar, Jharkhand, from July 2024 to April 2025. Observed values show sulphate concentrations of 19.44 mg/L (July), 12.146 mg/L (October), 9.897 mg/L (January), and 13.797 mg/L (April). TDS values ranged from 160 mg/L (July), 152 mg/L (October), 170 mg/L (January), to 260 mg/L (April), while electrical conductivity ranged from 262 μ S/cm (July), 242.2 μ S/cm (October), 270 μ S/cm (January), to 401.7 μ S/cm (April). Results indicate a decline in sulphate during post-monsoon and winter, followed by a pre-summer rise, coinciding with increased TDS and EC. This highlights a strong interrelationship among dissolved ions and suggests seasonal concentration effects due to evaporation and reduced water volume. Although overall values remain within acceptable freshwater limits, rising TDS and EC in pre-summer signal potential water sustainability challenges. Continuous monitoring and management strategies are recommended to ensure long-term ecosystem stability and water quality.

Keywords: *Sulphate, Total Dissolved Solids, Electrical Conductivity, Seasonal variation, Water sustainability, Ecosystem health, Nandan Pahar Pond.*

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1. Introduction

Freshwater ponds serve as essential ecological and socio-economic resources, supporting biodiversity, groundwater recharge, and local livelihoods [Figure 1]. These systems provide habitat for a wide range of aquatic organisms and serve as important water sources for domestic and agricultural use. However, due to their limited size and buffering capacity, they are highly sensitive to seasonal hydrological changes, anthropogenic inputs such as washing, agricultural runoff, and waste disposal, as well as ionic pollution that can gradually alter water chemistry and ecosystem balance. Limnology can be defined as interrelationships of organisms of inland waters as they are affected by their dynamic physical, chemical, and biotic environments [1].

Among dissolved ions, sulphate (SO_4^{2-}) is a key parameter influencing water chemistry, participating in nutrient cycling and affecting biological processes within aquatic systems. Total Dissolved Solids (TDS) represent the overall concentration of dissolved inorganic and organic substances, reflecting the cumulative ionic load of the water body. Electrical Conductivity (EC) acts as an indirect but reliable indicator of ionic concentration and mineralization, as it increases proportionally with the presence of dissolved ions. Monitoring the relationship among sulphate, TDS, and EC is therefore crucial for understanding water sustainability, ecosystem health, and pollution dynamics. These parameters together help in identifying both natural influences, such as mineral weathering and evaporation, and anthropogenic contributions. Seasonal analysis further provides valuable insights into the dynamic nature of pond ecosystems, highlighting the effects of monsoon-driven runoff, dilution during cooler periods, and increased ionic concentration during pre-summer due to evaporation and reduced water volume. Such variations are important indicators of environmental stress and can signal potential long-term changes in water quality.

Figure 1: Google Map view of Nandan pahar pond, Deoghar, Jharkhand, India



This study aims to assess quarterly fluctuations in sulphate and examine its relationship with TDS and EC in Nandan Pahar Pond, Jharkhand, to evaluate potential implications for aquatic ecosystem stability and water resource sustainability.

2. Materials and Methods

2.1. Study Area

Nandan Pahar Pond is located in Deoghar district, Jharkhand, India, and functions as a seasonal freshwater reservoir influenced by monsoon rainfall, winter cooling, and pre-summer evaporation. Sharma et al. (2025) had done a deep study on the heavy metals in this pond [2].

2.2. Sampling Schedule

Water samples were collected quarterly:

- **July 2024** (Monsoon)
- **October 2024** (Post-Monsoon)
- **January 2025** (Winter)
- **April 2025** (Pre-Summer)

2.3. Parameters Analyzed

Different physicochemical parameters has been discussed in Table 1.

Table 1: Process of measurement of various physicochemical parameters:-

Sl No	Parameters	Method follow (APHA, 2017, 23 RD Edition [3])
1	Conductivity $\mu\text{S}/\text{cm}$	2510-B: Conductivity Determination By Laboratory Method
2	TDS (mg/L)	2540-C: Total Dissolved Solids (TDS) By Total Dissolved Solids Dried at 180 °C Method
3	Sulphate (mg/L)	4500-SO ₄ ²⁻ E: Sulfate Determination By Turbidimetric Method

Standard analytical procedures were followed for laboratory estimation and field measurements. Research was conducted at CSIR Institute, Durgapur (Recognized by West Bengal Pollution Control Board).

3. Results

The results have been discussed in Table 2, Figure 2, 3, 4.

Table 2: Quarterly Values of Sulphate, TDS, and EC

Season	Sulphate (mg/L)	TDS (mg/L)	Electrical Conductivity ($\mu\text{S}/\text{cm}$)
Jul-24	19.44	160	262
Oct-24	12.146	152	242.2
Jan-25	9.897	170	270
Apr-25	13.797	260	401.7

4. Discussion

4.1 Seasonal Variation of Sulphate

Sulphate concentration exhibited a clear seasonal pattern, with the highest value recorded during the monsoon (19.44 mg/L), likely due to enhanced surface runoff, soil mineral leaching, and external inputs from surrounding areas. A progressive decline during post-monsoon (12.146 mg/L) and winter (9.897 mg/L) reflects dilution effects, reduced inflow of contaminants, and settling of suspended materials. The subsequent increase in pre-summer (13.797 mg/L) can be attributed to evaporation-driven concentration, reduced water volume, and possible release of sulphate ions from bottom sediments. Additionally, anthropogenic activities such as bathing and washing may also contribute to sulphate presence in the water body.[4]

4.2 Relationship Between Sulphate, TDS, and Electrical Conductivity

A strong positive correlation between Total Dissolved Solids (TDS) and Electrical Conductivity (EC) indicates that EC serves as a reliable indicator of ionic content in the pond water. The peak values of TDS (260 mg/L) and EC (401.7 $\mu\text{S}/\text{cm}$) observed in April coincide with elevated sulphate levels, suggesting seasonal concentration of dissolved salts. This relationship highlights the significant contribution of sulphate to overall ionic load and conductivity. Variations in EC may further be influenced by local factors such as soil composition, agricultural practices, and underlying geological characteristics of the study area.[5]

4.3 Implications for Water Sustainability

Although sulphate concentrations remain within permissible freshwater limits, the marked increase in TDS and EC during the pre-summer season indicates emerging stress on water quality. Elevated ionic concentrations can disrupt aquatic ecosystems by affecting biodiversity, inducing osmotic stress in freshwater organisms, and altering habitat conditions. Furthermore, such changes may reduce the suitability of water for domestic and irrigation purposes. Therefore, continuous seasonal monitoring and effective management strategies are essential to maintain water quality and ensure long-term sustainability of the aquatic system.

4.4. Ecosystem Health Considerations

Moderate sulphate concentrations indicate that there is no immediate risk of toxicity in the pond ecosystem; however, the gradual increase in dissolved solids may have subtle ecological implications. Elevated TDS and EC can influence plankton productivity by altering nutrient availability and light penetration, potentially disturbing the base of the food web. Additionally, higher ionic concentrations may modify benthic habitat conditions, affecting sediment chemistry

and the organisms dwelling within it, and could also impact the survival and physiological functions of fish and macro-invertebrates.

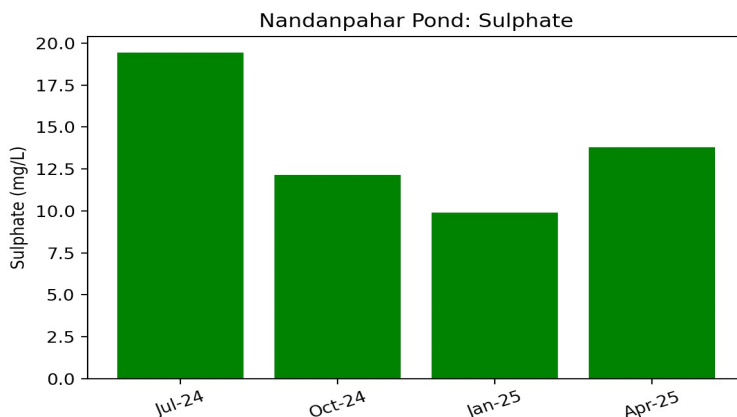


Figure 2: Quarterly variation of Sulphate in Nandan pahar pond, Deoghar, Jharkhand, India.

Despite these concerns, all recorded sulphate levels remain well within WHO and BIS permissible limits, suggesting a currently low level of pollution risk.[6] Seasonally, winter appears to be a relatively stable period with balanced water chemistry, whereas the pre-summer phase reflects increased environmental stress due to evaporation-driven concentration of dissolved ions, making it a more vulnerable period for the aquatic ecosystem.

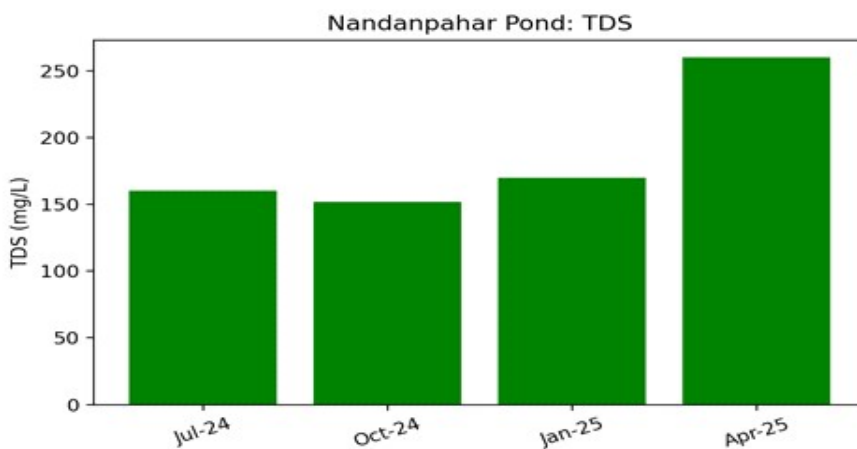


Figure 3. Quarterly variation of TDS in Nandan pahar Pond, Deoghar, Jharkhand, India.

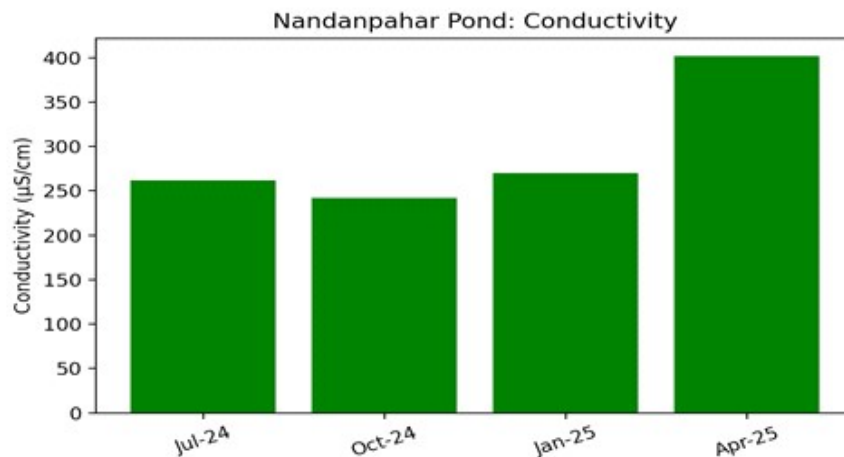


Figure 4: Quarterly variation of Conductivity in Nandan pahar pond, Deoghar, Jharkhand, India.

5. Conclusion

This quarterly assessment demonstrates that sulphate concentration in Nandan Pahar Pond is seasonally dynamic and closely associated with Total Dissolved Solids (TDS) and Electrical Conductivity (EC). Tripathy & Pandey (1990) reported the maximum concentration of TDS and TSS during summer, likely due to reduced inflow and increased evaporation rates.[7] Monsoon runoff contributes additional sulphate from surrounding catchments, while pre-summer evaporation further concentrates dissolved ions, elevating TDS and EC levels. Although the current values remain within permissible limits, the consistent pre-summer rise indicates a gradual accumulation of ionic load, which could affect water quality over time.

This trend highlights the need for proactive management, including continuous seasonal monitoring to detect early changes in water chemistry. Implementing effective runoff control and reducing external pollutant inputs can help limit ionic enrichment. Additionally, adopting sustainable watershed management practices will support long-term ecological balance, ensuring the pond remains resilient to climatic variations and anthropogenic pressures.

6. Recommendations

Effective management of pond water quality requires a combination of monitoring, prevention, and community engagement strategies. Regular seasonal monitoring of sulphate, total dissolved solids (TDS), and electrical conductivity (EC) is essential to track fluctuations in ionic pollution and understand temporal trends. Controlling catchment runoff plays a crucial role in reducing the influx of

both naturally occurring minerals and anthropogenic salts into the pond system. In addition, public awareness programs can help discourage the disposal of domestic and agricultural waste into the water body, thereby limiting pollution at the source. Finally, long-term limnological assessments are necessary to evaluate the impacts of climate variability, such as evaporation and rainfall patterns, on the concentration of dissolved substances, ensuring sustainable water quality management.

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