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# Spatiotemporal Dynamics of BOD and COD as Organic Pollution Indicators in Porsuk Dam Lake, Türkiye

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## Abstract

This study evaluates the spatiotemporal distribution of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) as primary indicators of organic pollution in Porsuk Dam Lake, Türkiye. Monitoring was conducted during the winter and spring seasons of 2025 across multiple stations. Pearson Correlation Index (PCI) was applied to the dataset to identify the relationship between BOD and COD. Results revealed a significant increase in both parameters during the spring, with the highest levels recorded at station P1. This station, located at the inflow of the Porsuk Stream, is subject to intensive domestic and industrial discharges from Kütahya Province. The near-perfect correlation between BOD and COD confirms a shared origin, primarily linked to municipal and agricultural wastewaters. Conversely, a gradual improvement in water quality was observed toward the dam outlet; stations P4 and P5, located near the dam gates, exhibited significantly lower organic loads, consistent with the natural self-purification processes of the reservoir. Ultimately, these findings underscore that organic pollution is driven by anthropogenic activities, particularly concentrated at the river-lake interface.

***Keywords:*** *Porsuk Dam Lake, BOD, COD, Pearson Correlation Index, water quality*

## Introduction

Freshwater degradation remains a critical global environmental challenge, exerting profound consequences on aquatic biodiversity, ecosystem integrity, and public health (Tokatlı et al., 2017; Helvacıoğlu et al., 2025; Haq et al., 2023; Din et al., 2023). As indispensable components of continental water systems, lakes and reservoirs are vital for maintaining ecological balance while supporting essential services such as potable water supply, agricultural irrigation, and fisheries. Nevertheless, the quality of these inland waters is increasingly compromised by anthropogenic stressors. The discharge of untreated municipal effluents, industrial wastes, and nutrient-rich agricultural runoff has led to widespread deterioration in water quality across various geographic regions (Tokatlı, 2019; 2020a; 2020b; Çiçek et al., 2014; Köse et al., 2020; Varol et al., 2022; Ustaoğlu et al., 2022; Yüksel et al., 2024). Such persistent pressures modify the physicochemical characteristics of water bodies, ultimately undermining the resilience and functional capacity of aquatic ecosystems.

A primary concern in the management of freshwater systems is organic enrichment, typically monitored through Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). As fundamental metrics, these parameters quantify the biodegradable organic fraction and the total chemically oxidizable substances, respectively. Evaluating the synergy between BOD and COD is crucial for a holistic assessment of organic pollution and overall ecosystem health. In reservoir environments, elevated levels of these indicators are frequently linked to accelerated nutrient cycling, intense microbial respiration, and subsequent dissolved oxygen depletion, which can trigger severe ecological decline. Consequently, investigating the spatiotemporal fluctuations of these parameters is imperative for pinpointing contamination hotspots, tracing pollutant transport pathways, and assessing how aquatic systems respond to human-induced stress (Muhammad et al., 2024; 2025; Tokatlı et al., 2025).

Within this framework, Porsuk Dam Lake stands out as a socioeconomically vital reservoir on the Porsuk Stream in northwestern Türkiye. Constructed in 1947 and expanded by 1972, this concrete gravity dam (storage capacity: 431 $hm^3$) provides irrigation for 41,020 hectares and supplies 206 $hm^3$ of potable water annually. Geographically, the dam is situated in Eskişehir, while its reservoir body extends into Kütahya, receiving inflows from the Porsuk and Felent Streams that are subject to intensive urbanization and industrial pressures from the Kütahya Plain (Köse et al., 2020). This study aims to evaluate the spatiotemporal distribution of BOD and COD levels to characterize organic contaminant variability and classify water quality according to the Turkish Water Pollution Control Regulation. By integrating seasonal monitoring with statistical analysis, the research clarifies anthropogenic impacts—particularly at the river-lake interface—providing a scientific basis for sustainable water management strategies.

## Materials and Methods

### *Selected locations and sample collection*

The geographic layout of Porsuk Dam Lake and the strategic locations of the sampling stations are illustrated in Figure 1. Fieldwork was conducted during the winter and spring seasons of 2025. Subsurface water samples were collected at a distance of approximately 2.5–3 m from the shoreline using a telescopic sampler and stored in 500 mL high-density polyethylene bottles. Following collection, all samples were immediately preserved at 4 °C in chilled containers, adhering to APHA (2017) protocols, and transported to the laboratories at Trakya University for further physicochemical analysis.


Figure 1. Porsuk Dam Lake and selected sampling stations

### *BOD – COD analysis*

Biochemical Oxygen Demand (BOD) was determined following the 5-day incubation protocol ($BOD_5$) utilizing the Hach BOD Trak II respirometric system. This method quantifies the oxygen consumption of microorganisms during the biological degradation of organic matter. Chemical Oxygen Demand (COD) was measured via the dichromate digestion method using a Hach DR3900 spectrophotometer, providing a comprehensive quantification of total oxidizable substances. All analytical procedures were executed in strict adherence to APHA (1998) standard methods. To verify the accuracy and precision of the dataset, rigorous quality control measures, including blank samples and replicate analyses, were systematically applied.

## Results and Discussion

The spatiotemporal fluctuations of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) concentrations recorded throughout the study period are illustrated in Figures 2 and 3, respectively. These graphical representations facilitate a comprehensive visualization of the spatial heterogeneity and comparative seasonal trends observed across the Porsuk Dam Lake monitoring stations. When evaluated according to the Turkish Surface Water Quality Regulation (TSWQR, 2021), the results revealed a concerning degree of organic pollution, particularly concentrated at the inflow zone. At station P1, BOD concentrations were recorded at 12.7 mg/L in winter and surged to 22.0 mg/L in spring, representing a dramatic 73.23% increase. These levels far exceed the threshold for 4th class water quality (>20 mg/L) in spring, reflecting a severe biodegradable organic load. Similarly, COD concentrations at P1 showed markedly elevated levels, increasing from 29.2 mg/L in winter to 44.9 mg/L in spring—a percent exchange of 53.77%. While the remaining stations (P2–P5) generally maintained 1st class (<4 mg/L for BOD; <25 mg/L for COD) or 2nd class categories, the persistent high values at P1 identify the river-lake interface as a critical pollution hotspot.

The marked seasonal increase at P1 suggests an intensified influx of municipal and industrial effluents from the Kütahya region, likely exacerbated by seasonal runoff and increased flow rates that mobilize contaminants from the catchment area. Conversely, the transition from high concentrations at P1 to significantly lower values toward the dam outlet—where BOD reached 2.5 mg/L and COD dropped to 14.8 mg/L at P5—underscores the reservoir's robust capacity for natural self-purification and attenuation through sedimentation and dilution processes. These elevated levels of BOD and COD serve as critical precursors to the acceleration of eutrophication, a process where excessive organic enrichment stimulates algal blooms, ultimately leading to oxygen depletion and profound disruptions in the aquatic food web. In Porsuk Dam Lake, these concentrations are intrinsically linked to external terrestrial inputs, including agricultural runoff and the discharge of untreated or partially treated wastewaters. Agricultural activities in the Kütahya Plain introduce significant organic matter via fertilizers and animal waste, while domestic and industrial effluents further intensify the chemical load (Mutlu et al., 2021a; 2021b; Tokatlı et al., 2023; 2024).

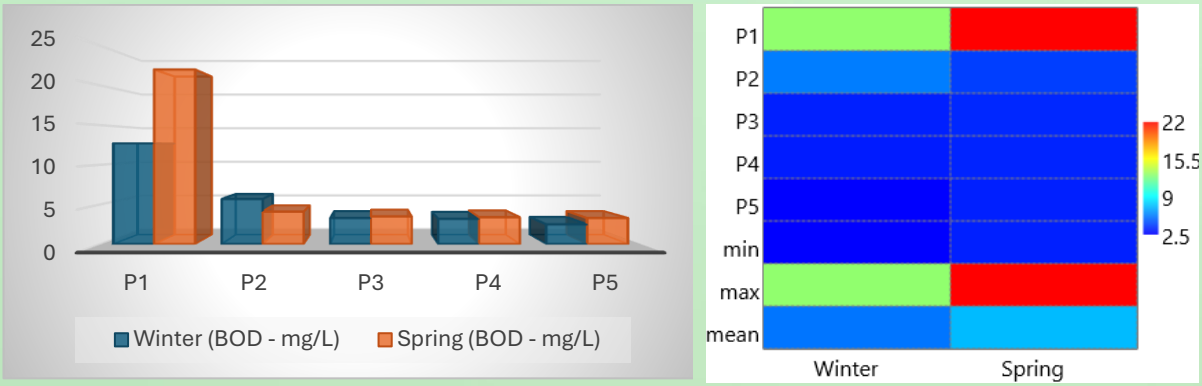


Figure 2. Spatio – temporal BOD distributions on the Porsuk Dam Lake

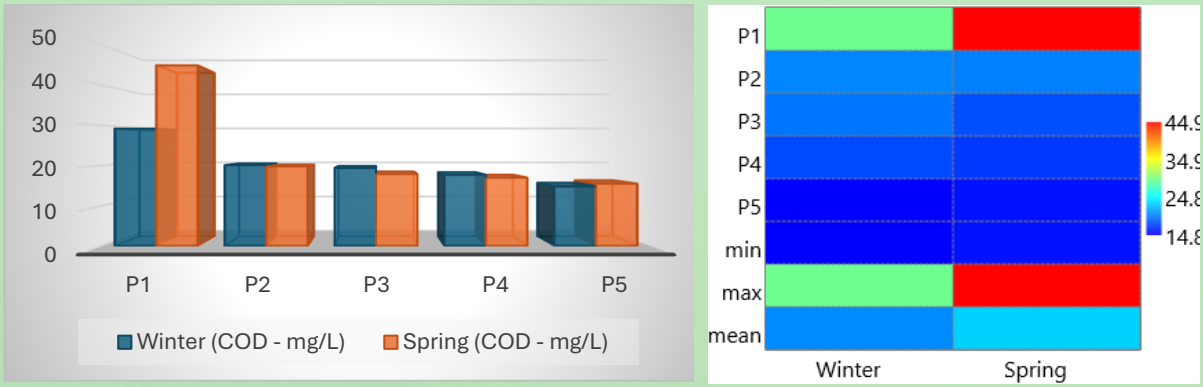


Figure 3. Spatio – temporal COD distributions on the Porsuk Dam Lake

These cumulative pressures enhance microbial respiration, thereby escalating oxygen consumption and potentially inducing hypoxic conditions that jeopardize aquatic biodiversity. The near-perfect correlation between BOD and COD data further confirms a shared anthropogenic origin for these pollutants. While the main body of the reservoir (P3–P5) currently maintains a relatively good ecological status, the extreme organic burden at the inflow zone highlights a significant vulnerability to ongoing degradation. Overall, the findings underscore that organic pollution is strongly influenced by human activities, especially domestic, industrial, and agricultural inputs at the river inflow zone. Persistent monitoring and the implementation of advanced wastewater treatment strategies are essential to mitigate these anthropogenic pressures and ensure the long-term ecological resilience of this vital water resource.

## Conclusions

This study highlights a clear spatiotemporal gradient in Porsuk Dam Lake, where severe organic pollution at the Porsuk Stream inflow (P1) progressively diminishes toward the dam outlet (P4–P5). The significant surge in BOD and COD levels during the spring, reaching 4th class water quality at the inflow, underscores the intensified impact of municipal, industrial, and agricultural discharges from the Kütahya region. While the near-perfect correlation between these parameters confirms a shared anthropogenic origin, the sharp decline in organic loads toward the downstream sections demonstrates the reservoir's robust natural self-purification capacity. Although

the main water body maintains relatively good ecological status, the extreme organic burden at the inflow necessitates urgent management interventions. Ultimately, implementing advanced wastewater treatment and continuous monitoring within the catchment area is imperative to mitigate eutrophication risks and ensure the long-term sustainability of this vital freshwater resource for irrigation and potable use.

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