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Comparative Limnological Characterization and Environmental Risk Assessment of Two Strategic Wetland Ecosystems in the Marmara Basin

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Abstract

The protected wetlands situated within the Marmara Basin represent indispensable ecosystems for regional biodiversity and critical migratory corridors. Despite their high conservation status, these shallow lake systems are increasingly vulnerable to surrounding industrial, agricultural, and domestic stressors. This research focuses on a comparative limnological evaluation of Manyas and Uluabat Lakes to quantify the extent of anthropogenic degradation. During a systematic monitoring campaign in the winter of 2025, water samples were analyzed for a comprehensive suite of parameters, including physicochemical variables (pH, EC, TDS, salinity, turbidity, SS) and organic/inorganic indicators (DO, O_2 saturation, NO_2-N, PO_4-P, and COD). The analytical results revealed distinct hydrochemical signatures for each system; Uluabat Lake was characterized by a more alkaline nature and superior dissolved oxygen levels, whereas Manyas Lake exhibited a profound organic pollution burden. These findings suggest that Manyas Lake is subject to more intensive allochthonous organic inputs and physical disturbances. This study underscores the necessity of implementing site-specific restoration protocols and integrated basin management to safeguard the ecological functionality of these vital aquatic habitats against escalating environmental pressures.

Keywords: *Wetland Management, Hydrochemistry, Manyas Lake, Uluabat Lake, Comparative Limnology, Marmara Basin*

Introduction

In the past century, industrial activities, agricultural practices, and the excessive exploitation of natural resources have significantly contributed to environmental degradation, adversely impacting all components of our biosphere. Freshwater contamination profoundly affects aquatic life, disrupting natural ecosystems and causing numerous ecological and health issues, including biodiversity loss (Mia et al., 2023; Tokatlı et al., 2023; Yüksel et al., 2025; Muhammad et al., 2024; 2025). Excessive contaminants, particularly nutrients from agricultural runoff and wastewater, induce algal blooms, especially in lentic ecosystems (Atıcı et al., 2018; Jannat et al., 2022; Mutlu et al., 2023; Tokatlı et al., 2024; Din et al., 2024). These pollutants accumulate in aquatic organisms, bioaccumulating toxins that ascend the food chain, potentially affecting larger predators and humans (Howarth et al., 2011; Borrell et al., 2019; Tokatlı and Varol, 2021; Ustaoğlu et al., 2022; Yazman et al., 2024). Parameters such as oxygenation, turbidity, salinity, and nitrogen-phosphorus compounds are crucial for the functioning of aquatic ecosystems; however, their imbalanced concentrations can lead to significant challenges (Isiuku and Enyoh, 2020; Varol et al., 2022; Varol and Tokatlı, 2023; 2024).

Manyas Lake is situated in the Bandırma region of western Türkiye. This nutrient-rich freshwater lake, with an average depth of 3 meters, is fed by groundwater and four streams, making extensive marshes and reed beds. It is a crucial habitat for breeding and wintering waterbirds, including the vulnerable Dalmatian pelican, and is also a Ramsar site. Uluabat Lake is a shallow freshwater lake with a surface area that fluctuates between 135 and 160 km², depending on water levels, and a maximum depth of 3 meters. It receives water from the Mustafakemalpaşa River and drains into the Marmara Sea via the Susurluk River. The lake is designated as a Ramsar Wetland of International Importance, supporting extensive white water lily beds and significant populations of endangered pygmy cormorants. Both lakes are threatened by substantial pollution from agricultural runoff, domestic and industrial discharges, and waste from poultry farms and slaughterhouses. Pollutants such as nitrogenous and phosphorous compounds, low dissolved oxygen levels and salinization significantly degrade water quality and threaten the biodiversity of these lakes. Therefore, it is crucial to implement urgent measures to mitigate pollution and protect these essential ecosystems (https:// www.livinglakes.org/; https:// www.marmara.gov.tr/; Tokatlı et al., 2025). This study undertook a comparative hydrochemical assessment of the water quality in Manyas Lake (ML) and Uluabat Lake (UL).

Materials and Methods

Selected locations and water collection

Figure 1 shows the map of the investigated lakes and the selected sampling locations. Water samples were gathered during the winter of 2025. Subsurface samples were collected using a telescopic water sampler, approximately 2.5 to 3 meters from the shore, and stored in 500 mL polyethylene bottles at 4°C (APHA, 2017). These samples were then transported to Trakya University for further chemical analysis.

Chemical analysis

Electrical Conductivity (EC), Total Dissolved Solids (TDS), salinity, Dissolved Oxygen (DO), O_2 saturation, pH, and turbidity were measured on-site in the field (APHA, 1998, 2017) using a multiparameter device (Hach Lange – HQ40D) and a turbidimeter (Hach Lange – 2100Q). In the laboratory, Suspended Solids (SS), nitrite nitrogen (NO_2-N), phosphate phosphorus (PO_4-P), and Chemical Oxygen Demand (COD) levels were determined in filtered samples (using a 0.45 µm cellulose nitrate filter) (APHA, 1998) with a colorimeter (Hach Lange – DR890) and a spectrophotometer (Hach Lange – DR3900).

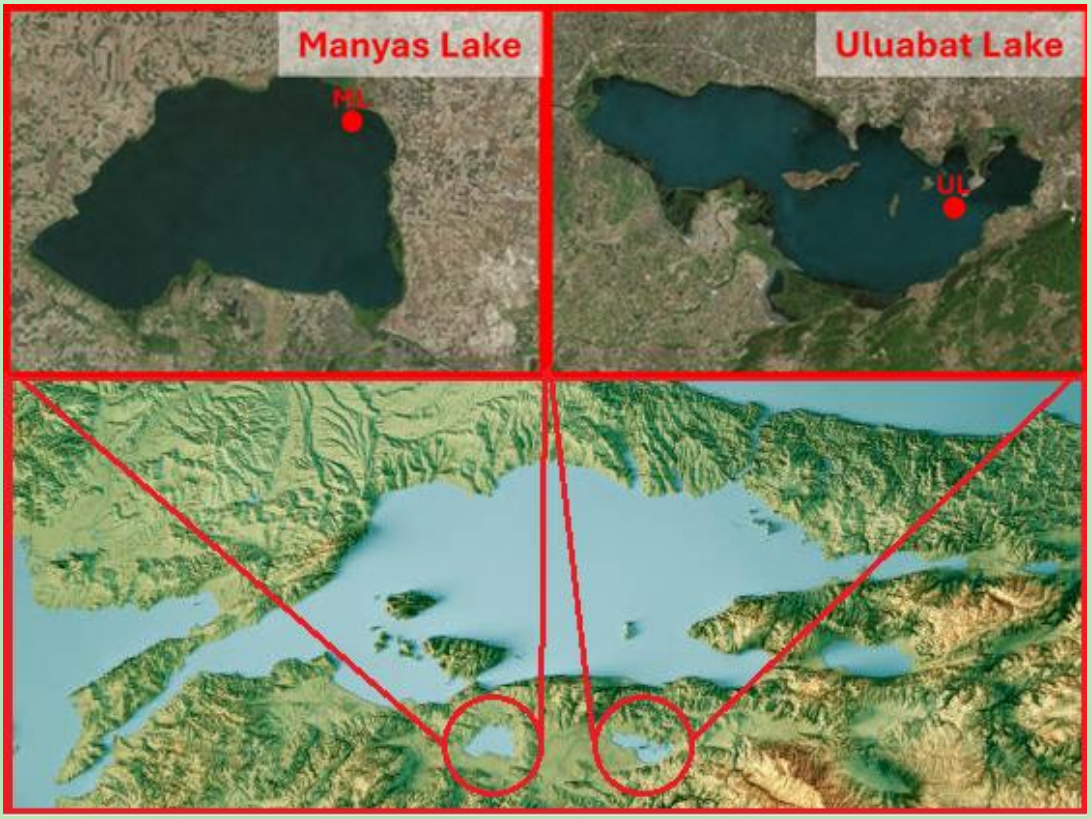

Figure 1. Study area and selected stations

Results and Discussion

The data for measured water quality parameters of UL and ML are given in Figure 2. Results showed that the water of UL (pH: 8.46) exhibited a more alkaline character than ML (pH: 7.80). Also, oxygen content of UL (DO: 9.82 mg/L; O_2 saturation: 110.1 %) is higher than those in ML (DO: 8.76 mg/L; O_2 saturation: 98.1 %). Although salinity parameters were slightly higher in UL (EC: 518 µS/cm; TDS: 251 mg/L; salinity: 0.25 ‰) than those in ML (EC: 472 µS/cm; TDS: 228 mg/L; salinity: 0.23 ‰), water of ML exhibited significantly elevated levels of organic pollution (NO_2-N: 0.021 mg/L; PO_4-P: 0.401 mg/L) compared to water of UL (NO_2-N: 0.001 mg/L; PO_4-P: 0.091 mg/L). In addition, the turbidity, SS and COD values detected in water of ML (turbidity: 29.1 NTU; SS: 59 mg/L; COD: 49.5 mg/L) were recorded as 12, 4 and 3 times higher than detected in water of UL (turbidity: 2.36 NTU; and SS: 14 mg/L; COD: 15.6 mg/L), respectively.

The investigated lacustrine habitats have 1st class water quality (wq) in terms of pH (6–9) DO (> 8 mg/L) values, while they have 2nd class wq in terms of EC (400–1000 µS/cm) values (TSWQR, 2021). The water of UL was classified as 1st class wq based NO_2-N (< 0.01 mg/L) and COD (< 15 mg/L) values and 2nd class wq based PO_4-P (0.05 – 0.16 mg/L) values, while ML was classified as 2nd class wq based NO_2-N (0.01 – 0.06 mg/L) and COD (25 – 50 mg/L) values and 3rd class wq based PO_4-P (> 0.16 mg/L) values (TSWQR, 2021).

Figure 2. Limnologic variables detected in water of UL and ML

Conclusions

In this research, water qualities of Uluabat Lake (UL) and Manyas Lake (ML) two of significant Ramsar lakes of Türkiye were investigated. In conclusion, the water quality of UL is superior to that of ML. The water in UL is more alkaline, has higher oxygen content, and shows lower levels of organic pollution. Additionally, UL's water has lower turbidity, suspended solids, and chemical oxygen demand values. These data indicate that UL's water quality is cleaner and healthier compared to ML. To improve the water quality of ML, it is essential to reduce organic pollution through stricter regulations and monitoring, enhance wastewater treatment facilities for better contaminant removal, promote sustainable agricultural practices to minimize fertilizer and pesticide use, establish vegetative buffer zones to filter pollutants, and raise public awareness about water conservation and pollution prevention.

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