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Spatiotemporal Dynamics of Li, Mn, Ni, and Ba Concentrations in Sediments of Lotic Habitats in the Gelibolu Peninsula, Türkiye

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Abstract

Sediments, rich in various toxic and essential elements, play a crucial role in freshwater habitats. While some elements are necessary for living organisms, prolonged and large-scale exposure to them—similar to non-essential toxic elements—can be harmful. The Gelibolu Peninsula, situated in the northwestern part of Anatolia, holds significant agricultural, industrial, and touristic potential due to its fertile lands, strategic location, and rich natural resources. This study was carried out to determine the spatiotemporal variations of lithium (Li), manganese (Mn), nickel (Ni) and Barium (Ba) levels in sediments of the riverine ecosystems located in the Gelibolu Peninsula. Three riverine ecosystems were selected for the study, and sediment samples were collected during both the dry and wet seasons of 2022–2023 to assess seasonal variations. According to the results of this research, the annually average concentrations of investigated elements in sediments of the riverine ecosystems located in the Gelibolu Peninsula were found in the order of Mn (708 mg/kg) > Ba (52 mg/kg) > Ni (22 mg/kg) > Li (15 mg/kg). While no significant seasonal differences were detected in Mn, Ni and Ba accumulations, it was recorded that the average Li values in the sediments increased approximately 4 times during the wet season.

Keywords: *Gelibolu Peninsula, Creeks, Sediment quality*

Introduction

The presence of certain elements in the environment is essential for sustaining life, as they contribute to the growth and development of all living organisms. However, when these elements, including manganese, accumulate in excessive concentrations, they can negatively impact ecosystems, much like toxic elements such as lithium, nickel, and barium. Therefore, ensuring that toxic elements remain below critical limits and that essential elements are present in balanced amounts within aquatic habitats is crucial for environmental preservation (Haq et al., 2023; Haque et al., 2023; Muhammad et al., 2025). Freshwater sediments act as major carriers of pollutants in aquatic ecosystems and offer valuable insights into environmental conditions (Muhammad et al., 2024; Yüksel et al., 2024; Tokatlı et al., 2025). Thus, examining the elemental composition of surface sediments is fundamental for assessing and monitoring ecological health (Varol et al., 2022; Ustaoğlu et al., 2022; Köse et al., 2023).

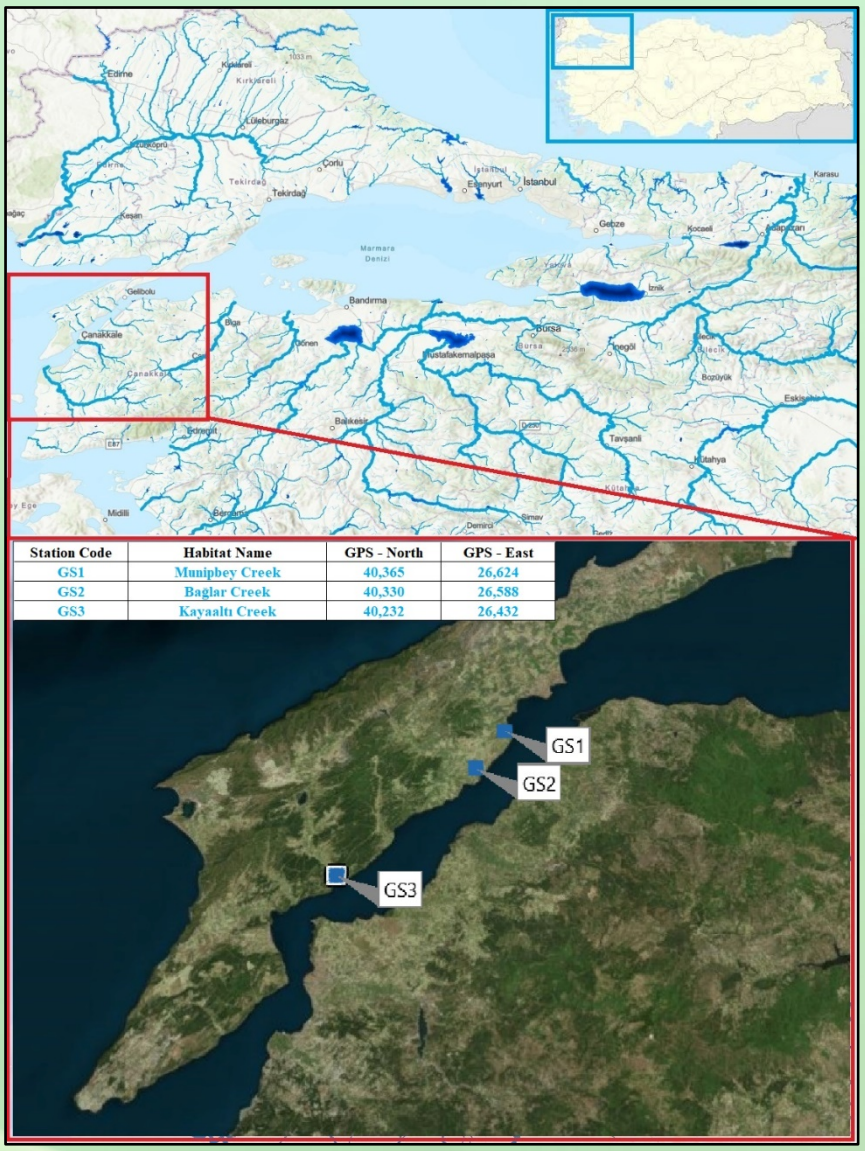
The Gelibolu Peninsula, located in the northwestern region of Anatolia, offers considerable agricultural, industrial, and touristic potential, owing to its strategic geographical position, fertile lands, and abundant historical and natural resources. Positioned in the southern part of East Thrace, the European region of Türkiye, with the Aegean Sea to the west and the Çanakkale Strait to the east, the peninsula benefits from a favourable climate and productive soils that support a diverse array of agricultural activities. These include the cultivation of various crops, fruits, and vegetables, which contribute substantially to both local and national economies. The region's agriculture-based economy is further strengthened by the development of numerous industrial facilities that engage in agriculture-based production. Additionally, the Gelibolu Peninsula has a well-established fishing industry, with many fish canning facilities operating in the area. The presence of developing industrial zones, along with the region's historical significance, scenic coastal landscapes, and cultural heritage, also make it a prominent tourism destination, attracting visitors interested in both historical exploration and nature-based experiences (Anonymous, 2021; Tokatlı et al., 2023; 2024; Varol and Tokatlı, 2024; https://www.biga.bel.tr/; https://www.gelibolu.bel.tr/; http://www.biga.gov.tr/; http://www.gelibolu.gov.tr/).

Due to these characteristics of Gelibolu Peninsula, investigating sediment quality is crucial for both human and ecosystem health. In this research, accumulations and spatiotemporal distributions of lithium (Li), manganese (Mn), nickel (Ni) and Barium (Ba) in sediments of the riverine habitats of Gelibolu Peninsula were investigated.

Materials and Methods

Research area and sample collection

Three fluvial habitats were selected across the Biga Peninsula (Figure 1). Surface sediment samples were then collected during the dry (late summer) and wet (late winter) seasons of 2022–2023 using a Hydrobios branded Ekman Grab (EPA, 2001a).



Station Code	Habitat Name	GPS - North	GPS - East
GS1	Munipbey Creek	40,365	26,624
GS2	Baglar Creek	40,330	26,588
GS3	Kayaaltı Creek	40,232	26,432

Figure 1. Research area and selected sampling stations

Macro – micro element analysis

To quantify the concentrations of lithium (Li), manganese (Mn), nickel (Ni), and barium (Ba) in the sediment samples, each sample was first dried for 3 hours at 105°C. A 0.25g aliquot of each dried sample was then placed into a CEM Mars Xpress microwave digestion system. To initiate the digestion process, a mixture of acids ($HClO_4$ and HNO_3 in a 1:3 ratio) was added to the reactors (Pyrex). The samples were subsequently subjected to mineralization by heating at 200°C for 30 minutes. After the mineralization process, the samples were filtered through a 0.45 µm cellulose nitrate filter. The filtrates were then diluted to a final volume of 100 ml with ultrapure water. The elemental concentrations in the samples were measured using an Agilent 7700 ICP-MS system, performing triple readings for each sample. The analysis was conducted at the central laboratory of Trakya University (Edirne, Turkey), which is accredited under TS EN / ISO IEC 17025 (EPA, 1998; 2001b).

Results and Discussion

The variations of measured lithium (Li), manganese (Mn), nickel (Ni) and Barium (Ba) concentrations in sediments of riverine habitats located in Gelibolu Peninsula are given in Figure 2. Significant spatial and temporal differences in accumulations of investigated elements were recorded. Average data of the Li, Mn, Ni and Ba levels in sediments of straits basins components in dry and wet seasons as follows respectively: 5 – 19 mg/kg for Li; 571 – 523 mg/kg for Mn; 21 – 15 mg/kg for Ni; and 23 – 26 mg/kg for Ba. Also, according to the results of this research, the annually average concentrations of investigated elements were found in the order of Mn (708 mg/kg) > Ba (52 mg/kg) > Ni (22 mg/kg) > Li (15 mg/kg).

The geological composition of watersheds plays a crucial role in shaping the sediment chemistry of aquatic ecosystems, often leading to an increase in both essential and toxic element concentrations beyond their natural baselines (Çiçek et al., 2013; 2014; Tokatlı and Helvacıoğlu, 2020; Tokatlı and İslam, 2022; Mia et al., 2023; Mutlu et al., 2023). Elevated macro element concentrations in aquatic habitats are widely recognized as indicators of anthropogenic influence and can have detrimental effects on natural ecosystems (Köse et al., 2023; Tokatlı et al., 2023; Din et al., 2023). Therefore, the relatively high macro element levels observed in sediments at specific locations are likely a consequence of both underlying geological formations and human activities within these regions.

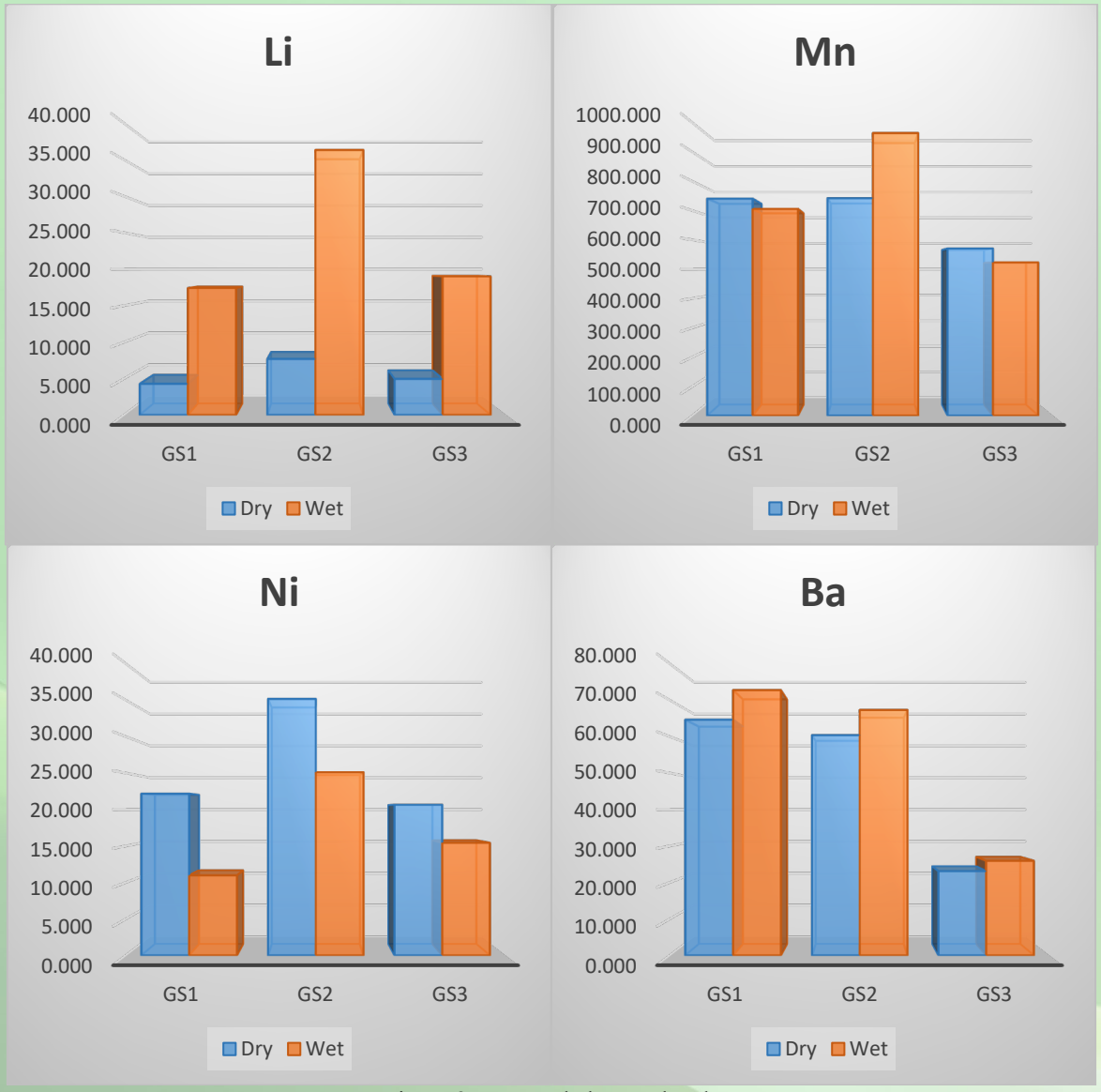


Figure 2. Detected element levels

Conclusions

The findings of this study reveal notable spatial and temporal variations in the concentrations of lithium (Li), manganese (Mn), nickel (Ni), and barium (Ba) in the sediments of riverine habitats in the Gelibolu Peninsula. These differences, observed between the dry and wet seasons, suggest that seasonal fluctuations, such as changes in rainfall, water flow, and sediment transport, significantly influence the distribution and accumulation of these elements. The concentrations of Mn, Ba, Ni, and Li were found to vary across the seasons, with manganese exhibiting the highest concentrations. Specifically, Mn levels ranged from 571 mg/kg in the dry season to 523 mg/kg in the wet season, indicating a relatively high and stable presence in the sediments throughout the year. In contrast, lithium had the lowest concentrations, ranging from 5 to 19 mg/kg. The average concentration levels for the elements in the sediments were found in the following order: Mn > Ba > Ni > Li. This pattern reflects the relative abundance of these elements in the environment and suggests that manganese plays a dominant role in the sediment chemistry of the Gelibolu Peninsula. The findings highlight the need for further research to explore the environmental factors influencing these variations and their potential implications for the local ecosystem and water quality management.

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