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

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Abstract

Sediments, which contain a wealth of various toxic and essential elements, play a very important role in our freshwater habitats. Although some elements are essential and needed by living things, it is known that long-term and large-scale exposure to them can be harmful, just like non-essential toxic elements. The Biga Peninsula, situated in the northwestern region of Anatolia, possesses significant agricultural, industrial, and touristic potential. 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 Biga Peninsula. Five 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 Biga Peninsula were found in the order of Mn (1076 mg/kg) > Ba (93 mg/kg) > Ni (21 mg/kg) > Li (14 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 8 times during the wet season.

Keywords: *Biga Peninsula, Creeks, Sediment quality*

Introduction

Essential elements, such as manganese, are crucial nutrients that play a vital role in the healthy growth and development of all living organisms. However, excessive concentrations of these elements can have detrimental effects on the environment, similar to toxic elements like lithium, nickel, and barium. Therefore, maintaining toxic elements below threshold levels and ensuring a balanced presence of essential elements in aquatic habitats are critical for environmental protection (Haq et al., 2023; Haque et al., 2023; Muhammad et al., 2025). Freshwater sediments serve as key transporters of various pollutants within aquatic ecosystems and provide essential environmental data (Muhammad et al., 2024; Yüksel et al., 2024; Tokatlı et al., 2025). Consequently, analysing the elemental composition of surface sediments is of great importance for understanding and monitoring ecological health (Varol et al., 2022; Ustaoğlu et al., 2022; Köse et al., 2023).

The Biga Peninsula, situated in the northwestern part of Anatolia, possesses considerable agricultural, industrial, and touristic potential due to its fertile soils, strategic geographic location, and abundant natural resources. The peninsula forms part of the eastern connection between Anatolia and Rumelia, divided by the Çanakkale Strait. The region's favourable climate and productive soil support diverse agricultural activities, including the cultivation of various crops, fruits, and vegetables, which substantially contribute to both local and national economies. Agriculture plays a dominant role in the local economy, with the development of agricultural activities leading to the establishment of numerous industrial facilities engaged in agriculture-based production. Additionally, the presence of developing industrial zones and manufacturing sectors fosters economic growth, providing employment opportunities and enhancing regional trade. Furthermore, the peninsula's historical heritage, scenic landscapes, and coastal attractions make it an appealing destination for tourism, drawing visitors with an interest in cultural, historical, 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 Biga 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 Biga Peninsula were investigated.

Materials and Methods

Research area and sample collection

Five 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).

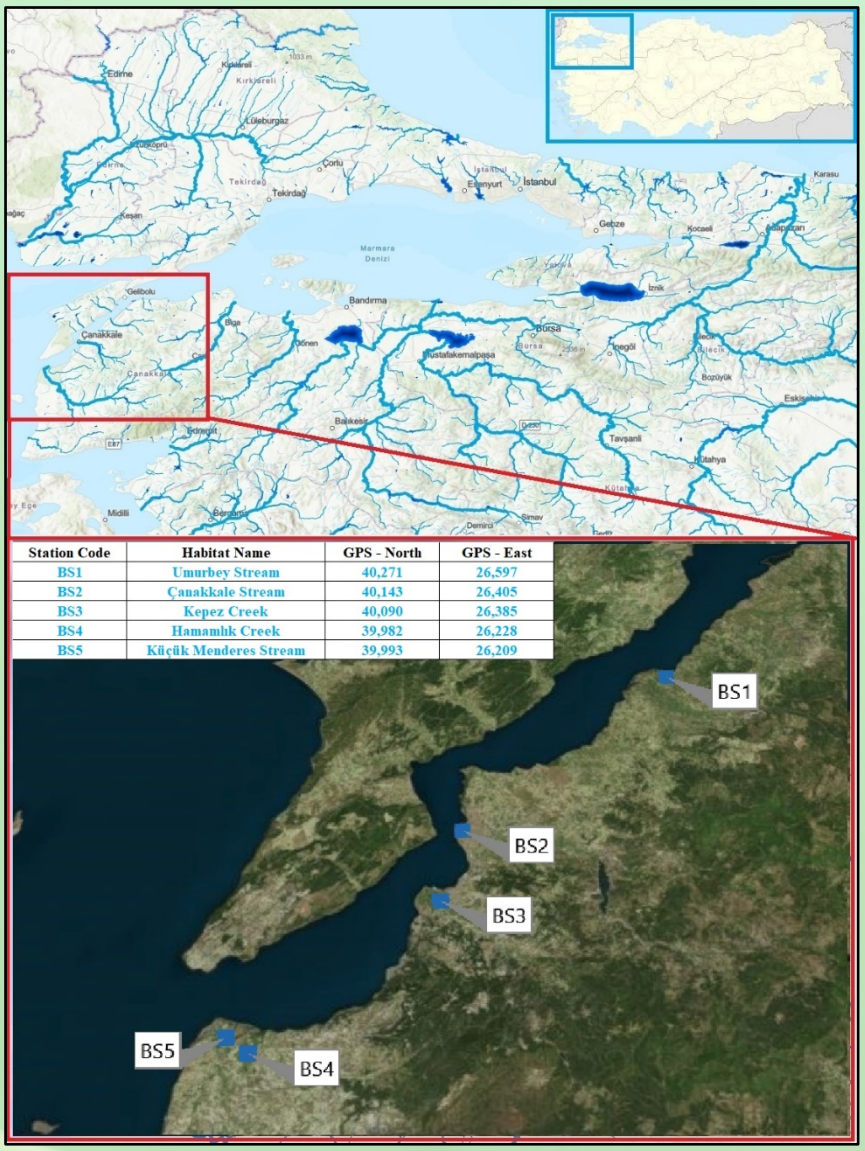

Figure 1. Research area and selected sampling stations

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 Biga 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: 2 – 14 mg/kg for Li; 1389 – 2357 mg/kg for Mn; 13 – 18 mg/kg for Ni; and 85 –151 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 (1076 mg/kg) > Ba (93 mg/kg) > Ni (21 mg/kg) > Li (14 mg/kg).

The geological characteristics of watersheds can significantly influence the sediment chemistry of aquatic ecosystems, potentially leading to an increase in both essential and toxic element concentrations beyond natural thresholds (Çiçek et al., 2013; 2014; Tokatlı and Helvacıoğlu, 2020; Tokatlı and İslam, 2022; Mia et al., 2023; Mutlu et al., 2023). Elevated concentrations of macro elements in aquatic environments serve as indicators of anthropogenic activities and may pose a threat to natural ecosystems (Köse et al., 2023; Tokatlı et al., 2023; Din et al., 2023). Consequently, the relatively high macro element contents detected in sediments at certain locations are likely attributable to the geological composition of the region and human-induced influences.

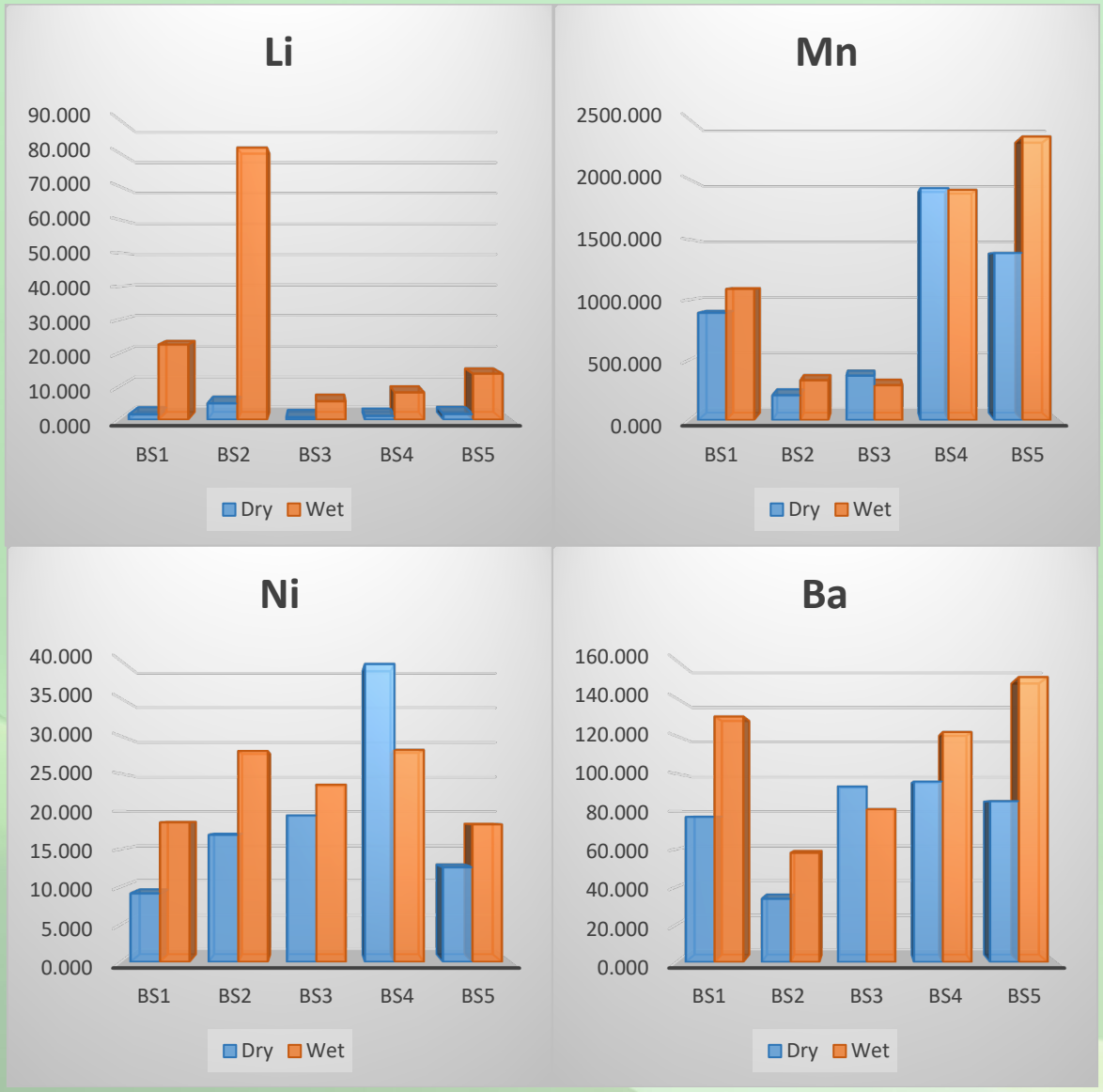

Figure 2. Detected element levels

Conclusions

The results of this study indicate significant spatial and temporal variations in the concentrations of lithium (Li), manganese (Mn), nickel (Ni), and barium (Ba) in the sediments of riverine habitats located in the Biga Peninsula. The observed differences between dry and wet seasons suggest that seasonal factors, such as rainfall and runoff, may influence the distribution and accumulation of these elements in sediments. The average concentrations of Mn, Ba, Ni, and Li were found to vary significantly, with Mn exhibiting the highest levels across both seasons. Specifically, Mn concentrations ranged from 1389 mg/kg in the dry season to 2357 mg/kg in the wet season, highlighting its dominant presence in the sediments of these riverine habitats. Conversely, lithium, with a range of 2 to 14 mg/kg, exhibited the lowest concentrations. The order of average concentrations—Mn > Ba > Ni > Li—reflects the relative abundance of these elements in the environment and emphasizes the importance of manganese in this context. These findings suggest that while some elements, such as Mn and Ba, are more prevalent in the sediment, other elements like Li and Ni may be influenced by different environmental processes or sources. Further research is needed to understand the underlying mechanisms driving these variations and to assess the potential impacts on the local ecosystem.

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