Statistical Evaluation of Some Micro Elements (Li, Mn, Ni and Ba) Accumulated in Sediments of Turkish Straits Watersheds

Cem Tokatlı[1*], Memet Varol[2]

[1]Trakya University, Edirne / Türkiye
[2]Malatya Turgut Özal University, Malatya / Türkiye

Abstract

Çanakkale and İstanbul Straits are known as the Turkish Straits and they are two of the most significant international marine habitats located in the north-western Türkiye. There are many fluvial and lacustrine components in the watersheds of both these straits. As many aquatic habitats, they are expose to a significant pollution stress. This study was carried out to evaluate the lithium, manganese, nickel and barium accumulations in sediments of Çanakkale and İstanbul Straits Basins components from a statistical perspective. Eleven fluvial and four lacustrine ecosystems were defined in the watersheds and sediment samples were collected in dry and wet seasons of 2022 – 2023. Pearson Correlation Index (PCI), Principal Component Analysis (PCA) and Cluster Analysis (CA) were applied to data to categorize the investigated habitats and define the sources of investigated micro elements. According to the results of applied PCI, statistically significant positive correlations were determined among the investigated parameters. According to the results of applied PCA, two factors named as "Agricultural – Domestic factor (F1)" and "Industrial factor (F2)" explained 83% of the total variance. According to the results of applied CA, two clusters, named as "Relatively less contaminated zone (C1)" and "Relatively more contaminated zone (C2)", were formed.

Keywords: Çanakkale and İstanbul Straits, Micro elements, Statistical evaluation

Introduction

Multivariate statistical techniques play a crucial role in managing and understanding water resources. They are beneficial in validating spatiotemporal differences induced by geogenic and anthropic causes associated to seasonally change, these approaches have been frequently employed to define and evaluate surface stream water – sediment quality. They also help in assessing the risk levels of various pollutants, enabling targeted interventions to mitigate potential health hazards (Köse et al., 2014; 2018; Tokatlı, 2014; 2020).

Multivariate techniques like Principal Component Analysis (PCA) help to simplify complex datasets by reducing their dimensionality. Also, techniques such as Cluster Analysis (CA) is used to identify patterns and group similar water – sediment quality samples and used to classify the investigated locations in terms of their similar characteristics (Çiçek et al., 2013; 2017; Tokatlı et al., 2014; Tokatlı and Helvacıoğlu, 2020).

Freshwater sediments act as transporters of numbers of pollutants in aquatic ecosystems and provide valuable environmental information (Mutlu, 2021; Yüksel et al., 2024; Varol and Tokatlı, 2024). Therefore, analysing the elemental contents in surface sediments is crucial (Varol et al., 2022; Ustaoğlu et al., 2022; Tokatlı and İslam, 2022).

İstanbul and Çanakkale straits that are known as Turkish Straits are two of the most significant international marine habitats located in the north – western Türkiye. There are many fluvial and lacustrine components in the watersheds of both these straits and as many aquatic habitats, they are expose to a significant pollution stress (Tokatlı et al., 2023; 2024; Varol and Tokatlı, 2024). In this research, sediment qualities of Turkish Straits Watersheds were evaluated from a statistical perspective.

Material and Method

Fifteen locations were selected on the watersheds of Turkish Straits (Figure 1). Then surface sediment samples were collected in the wet (end of winter) and dry (end of summer) seasons of 2022 – 2023 by using an Ekman Grab (Hydrobios) according to the standard protocol (EPA, 2001a).

For determination of lithium (Li), manganese (Mn), nickel (Ni) and Barium (Ba) concentrations in sediments of İstanbul and Çanakkale straits watersheds, EPA methods (1998; 2001b) were applied. Accumulations of elements in sediments were measured by using an ICP – MS device (Agilent 7700) in the Thrace University (Edirne/Türkiye).

Pearson Correlation Index was applied to data by using the OriginPro Lab, Principal Component Analysis was applied to data by using the SPSS and Cluster Analysis was applied to data by using the PAST.
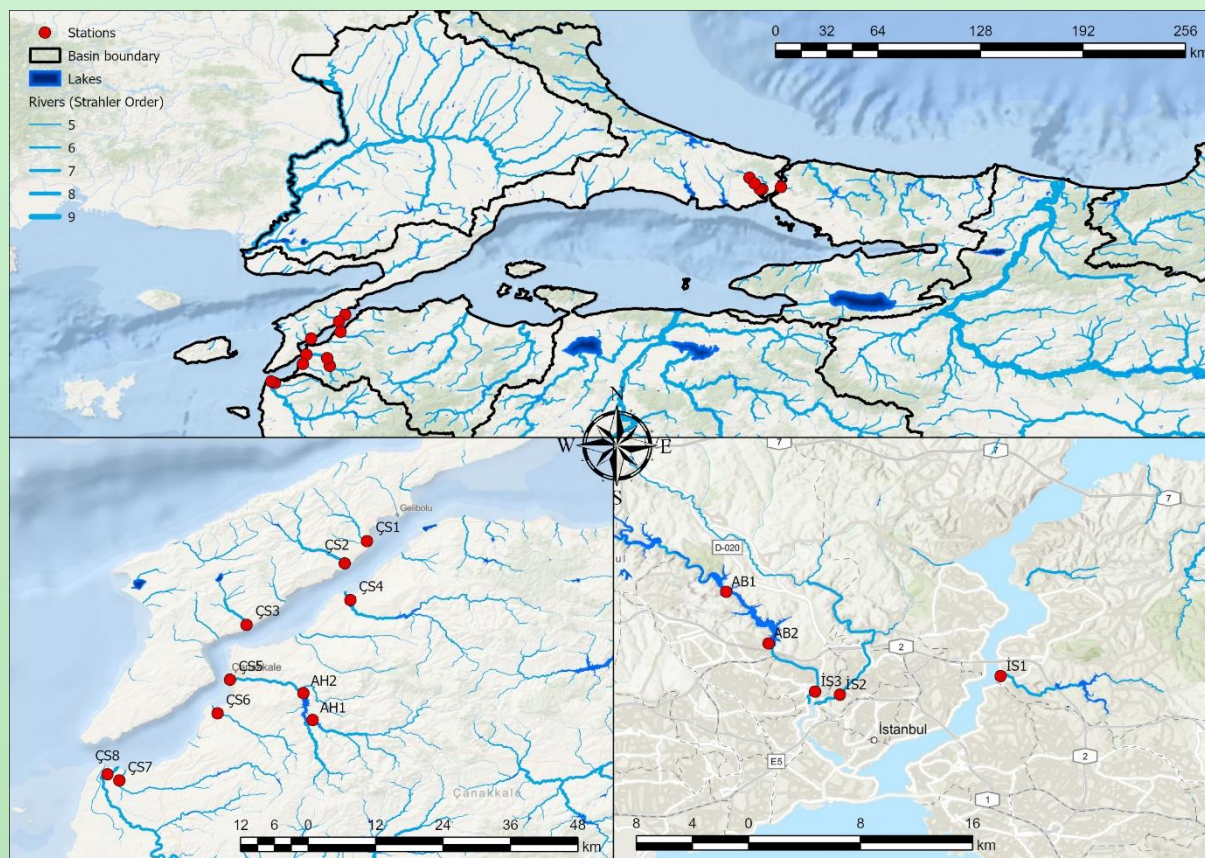
Figure 1. Study area and selected stations

Results and Discussion

The PCI was used to identify the significant relations among the lithium (Li), manganese (Mn), nickel (Ni) and Barium (Ba) contents in sediments of Turkish Straits Watershed. The recorded relations among the investigated elements with the correlation coefficients are shown in Figure 2. According to the results of applied PCI, significant positive correlations were recorded between the variables of Mn – Ni and Ba at the $p<0.01$ significance levels and Ni – Ba at the $p<0.05$ significance levels. The PCA was used to determine the effective factors on the sediment qualities of the Turkish Straits Watershed. The eigenvalues and the component plot with the rotated component matrix data are shown in Figure 3. As a result of applied PCA, 2 factors named as "Agricultural – Domestic factor (F1)" and "Industrial factor (F2)" explained 83% of the total variance. The CA was used to present the groups – clusters of similar sediment quality characteristics among the investigated locations on the Turkish Straits Watershed. The diagram of CA and the similarity coefficients of locations are shown in Figure 4. As a result of CA, 2 clusters, named as "Relatively less contaminated zone (C1) and "Relatively more contaminated zone (C2)", were formed.

It is clearly known that geological structures of the basins and the anthropogenic activities conducted around the regions may alter the macro and micro element concentrations in freshwater sediments (Köse et al., 2023; Haque et al., 2023; Din et al., 2023; Mutlu et al., 2023).

According to the PCA results applied in our study, it is known that lithium in the F2 factor called "Industrial Factor" is widely used in industrial activities (Tokatlı et al., 2021; 2024; Varol and Tokatlı, 2022). It is also known that nickel, manganese and barium in the F1 factor called "Agricultural – Domestic Factor" are abundantly found in domestic waste, agricultural fertilizers and pesticides (Mia et al., 2023; Tokatlı et al., 2023).

As a result of applied CA, fluvial components of the Turkish Straits Watershed were formed a separate cluster, which was named as "Relatively More Contaminated Zone", while the lacustrine components were formed a separate cluster, which was named as "Relatively Less Contaminated Zone". Since fluvial components generally pass through residential areas, they are more exposed to domestic, agricultural and industrial pollutants than lacustrine components. Therefore, these regions are considered to form a separate cluster as "Relatively More Contaminated Zone" in our study.
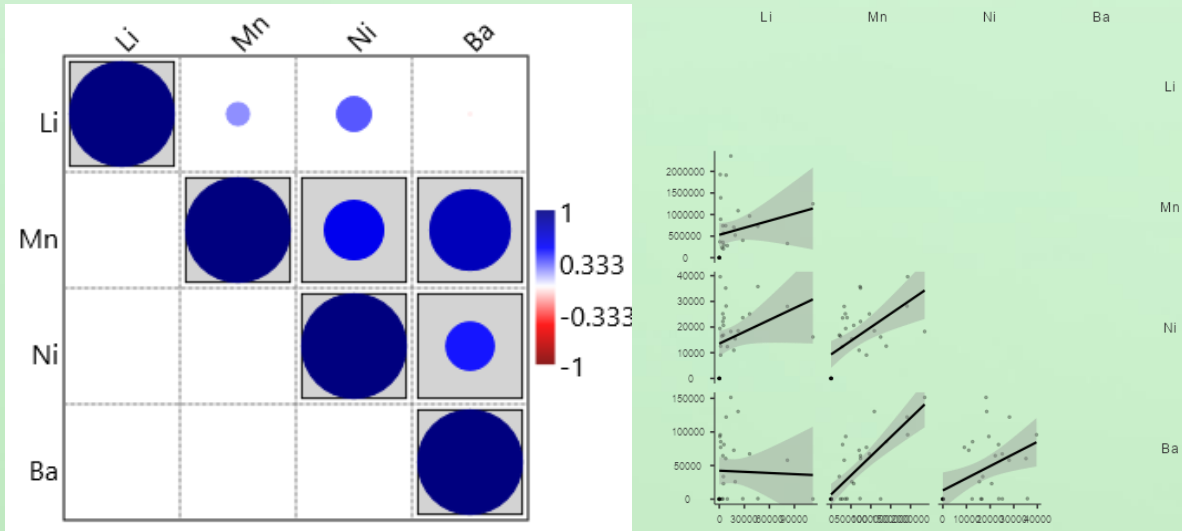
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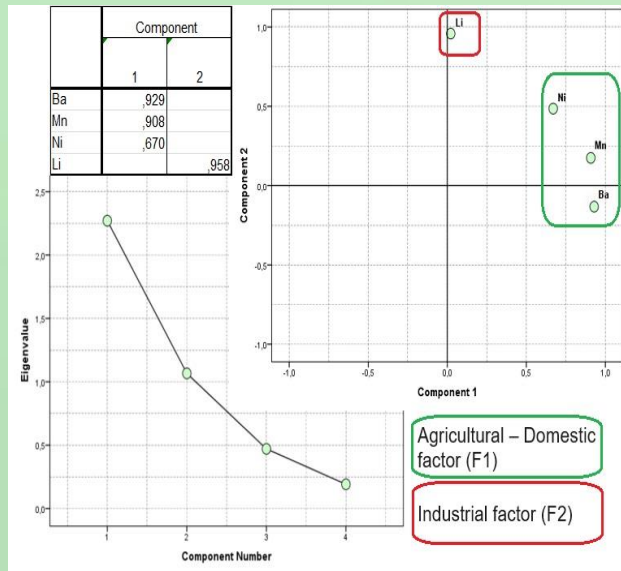Figure 2. Results of PCI (left) and the regression diagrams (right)
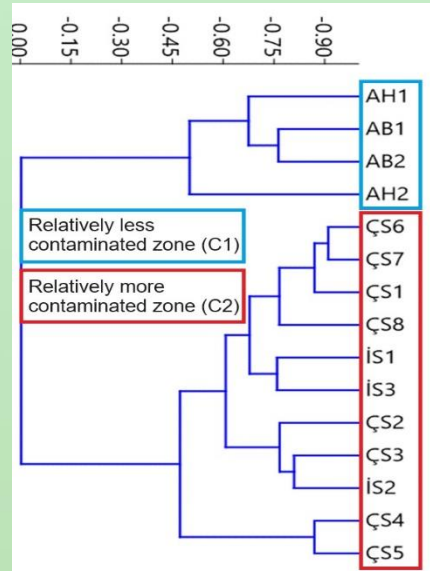

Figure 3. Results of PCA

Figure 4. Results of CA

Conclusions

In this research, Pearson Correlation Index (PCI), Principle Component Analysis (PCA) and Cluster Analysis (CA) were used to evaluate the surface sediment quality of Turkish Straits Watershed. According to the results of applied PCI, statistically significant positive correlations were determined among the investigated variables, according to the results of applied PCA, 2 factors explained 83% of the total variance (agricultural – domestic factor – F1 and industrial factor – F2) and according to the results of applied CA, 2 statistically significant clusters were formed (relatively less contaminated zone – C1 and relatively more contaminated zone – C2. The data from the current study also reflect the importance and necessity of using multistatistical techiques and reflect that researchers can gain a more comprehensive understanding of freshwater quality.

Acknowledgements

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