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MONITORING AND CHARACTERIZATION OF MACROPLASTIC DEBRIS IN FRESHWATER LAKE: A CASE STUDY FROM SERA LAKE, TRABZON, TURKIYE

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Abstract. Plastic pollution is an increasing concern for freshwater ecosystems, yet much of the existing research still focuses on marine environments. In particular, macroplastics known as plastic items larger than 5 cm is poses significant risks to freshwater habitats by affecting water quality, endangering wildlife, and diminishing recreational and aesthetic value. This study explores the presence and characteristics of macroplastic litter in Sera Lake, a small but ecologically and socially important freshwater body located in Trabzon, in the Southeastern part of Türkiye's Black Sea region. Despite being a popular destination for tourism and recreation, Sera Lake has received limited attention in terms of plastic pollution study. To assess the extent of macroplastic contamination, we conducted field surveys four times a year during Autumn, Winter, Spring and Summer in 2024, applying an adapted methodology based on the Guidance on Monitoring Marine Litter in the European Seas following the Marine Strategy Framework Directive (MSFD) Technical Group on Marine Litter developed by the European Union. The MSFD protocol, although originally designed for marine environments, offers a structured and harmonized approach for monitoring. litter, including categorization and quantification of plastic litter items. During the surveys, litter was recorded across selected shoreline transects, then classified by usage type and estimated material composition. Visual observations and spatial assessments were also carried out to help identify likely sources of plastic input, including tourism-related activities, urban runoff, and informal waste dumping. Our findings revealed a clear presence of macroplastic pollution throughout the lake, with the highest abundance recorded in Summer 2024. Station 2, located at the center of the lake and experiencing the highest visitor traffic, showed the greatest level of pollution, with a total of 4,997 items over the year. Notably, this station also recorded 1,874 items during the summer alone, the highest seasonal count across all locations. Across all stations and seasons, a total of 18,349 macroplastic items were documented, with an average of 1,149 items per survey. The most commonly found items were single-use plastics, especially cigarette butts, followed by lollipop and ice cream sticks, plastic straws, and plastic bags. Larger plastic fragments and construction-related waste were also observed, suggesting broader waste management issues in the surrounding area.These results highlight an urgent need for better waste management practices and increased public awareness, especially in tourism-heavy areas like Sera Lake. This study provides a baseline for future monitoring

efforts and can support local policymakers and environmental planners in developing targeted strategies to reduce plastic input into freshwater systems.
Keywords: Macroplastic, Solid waste, Pollution, Inland Water, Sera Lake, Black Sea

1. INTRODUCTION

Plastic have become an indispensable part of modern life, revolutionizing industries, healthcare, packaging and transportation (Jiang et al., 2022). However, the environmental cost of plastic production has become a major concern worldwide (Nayanathara Thathsarani Pilapitiya & Ratnayake, 2024). There is growing evidence that plastic pollution in inland freshwater system, particularly macroplastic pollution in lakes and rivers (Özşeker et al., 2022). Inland aquatic ecosystems are not only crucial ecological reservoirs but also vital sources of freshwater, biodiversity, food, recreation, and cultural services (Birnie-Gauvin et al., 2023). Understanding the dynamics, impact and management of macroplastic pollution in these systems is critical for ensuring the sustainability of both ecosystems and the human communities that rely on them.

Macroplastic refer to plastic items larger than 5 cm, including bottles, bags, containers, caps, packaging materials, and other visibly discarded plastic items (Thushari & Senevirathna, 2020). These materials are highly persistent, often buoyant, and can accumulate in natural environments for decades (Nayanathara Thathsarani Pilapitiya & Ratnayake, 2024). These pollutants can enter freshwater bodies through multiple pathways such as urban and agricultural run-off, direct littering, stormwater discharges, wastewater overflows, and recreational activities. Lakes and rivers often act as both sinks and conduits for macroplastic debris, accumulating waste in shorelines, sediment beds, or water columns while also transporting it downstream to larger water bodies such as estuaries and seas (Müller et al., 2020). While much of the scientific focus has been directed toward marine environments, recent studies have emphasized the need to investigate plastic litter in freshwater systems, where rivers and lakes act both as sinks and pathways for plastic transport to the ocean (Erüz et al., 2023). Freshwater lakes with limited outflow can become concentrated hotspots for macroplastic accumulation. Inland plastic pollution is now recognized as a distinct problem with unique dynamics and consequences. The physical confinement, human proximity, and biological sensitivity of freshwater environments make them especially vulnerable to plastic pollution (Blettler et al., 2018). Hence, it is vital to approach inland macroplastic pollution not just as a pathway to ocean plastic, but as a critical environmental issue.

Inland lakes and rivers are biodiversity hotspots that support a wide range of flora and fauna, many of which be endemic and highly sensitive to environmental disturbances. Macroplastic debris poses multiple ecological risks to aquatic organisms. One of the most visible impacts is entanglement, where fish, birds, turtles and mammals become trapped in plastic items (Roman et al., 2022). Organisms may mistake plastic for food, leading to digestive blockages, malnutrition, or exposure to toxic chemical additives (Garcês & Pires, 2024). Furthermore, macroplastic can alter habitats by smothering benthic environments, reducing light penetration, or physically disrupting spawning and feeding grounds. They may also serve as vectors for invasive species, pathogens, as floating plastics can provide hard substrates for organisms to colonize and travel across regions (García-Gómez et al., 2021). The breakdown of microplastics through photodegradation, mechanical abrasion, and biofouling further complicates ecological impacts, creating a cascading problem of chemical and particle pollution that infiltrates food webs (Amobonye et al., 2021). Study in marine systems has already established how plastic debris can disrupt trophic dynamics and ecosystem functioning. Similar process is likely occurring in freshwater system, although they remain poorly documented. Given the ecological importance of inland lakes and rivers especially in regions with high biodiversity or endangered species, research on macroplastic impacts is urgently needed to inform conservation strategies.

Beyond ecological concerns, macroplastic pollution has serious implications for human well-being. Many inland lakes are integral to local economies, providing water for drinking, agriculture,

aquaculture, industry, and hydropower. Pollution of these water bodies can compromise water quality and increase the cost of water treatment. Moreover, plastic litter is visually offensive and can degrade the recreational and aesthetic value of lakes used for tourism, swimming, fishing, and cultural events (Ribeiro et al., 2022). In regions where lakes form the backbone of rural economies, this can lead to economic losses, and social tensions. In developing countries, where waste management infrastructure is often inadequate, lakes may serve as informal dumping grounds for plastic waste, compounding environmental justice issues and affecting vulnerable populations disproportionately(Matavos-Aramyan, 2024). Furthermore, the presence of macroplastic in freshwater environments may be a sign of broader systemic issues related to urban planning, waste governance and societal consumption patterns. Therefore, studying macroplastic pollutions is not just about cleaning lakes but understanding and addressing because that intersect with urbanization, equity and sustainability.

Despite the growing recognition of plastic pollution as a global issue, there are substantial gaps in the scientific understanding of macroplastic dynamic in inland aquatic ecosystems. Given the urgency and complexity of the problem, there is a strong scientific and policy imperative to conduct research on macroplastic pollution in inland aquatic ecosystems. Such research serves several vital functions. First, it provides baseline data that can guide environmental assessments, identify vulnerable areas and prioritize resource allocation. Second, it enables the development of evidence-based interventions ranging from infrastructure improvements to behavioral change campaigns and regulatory frameworks. Moreover, research plays a key role in supporting international environmental commitments, such as the United Nation Sustainable Development Goals (SDGs) particularly SDG 6 (Clean Water and Sanitation), SDG 14 (Life Below Water) and SDG 15 (Life on Land).

Sera Lake, located in Trabzon in the southeastern Black Sea region of Türkiye, is a small natural lake with growing ecological and recreational significance. It receives hydrological inputs from nearby urban areas and is frequently visited by locals and tourists alike. Despite its importance, little is known about the extent of plastic pollution in the lake. Given the increasing human pressure in the region, there is a pressing need to assess the current status of macroplastic litter in and around the lake to inform effective environmental management and policy responses.

This study aims to provide the first systematic assessment of macroplastic litter in Sera Lake, using a methodology adapted from the Marine Strategy Framework Directive (MSFD) of the European Union. Although originally developed for marine settings, the MSFD protocol offers a standardized approach to litter monitoring that can be applied to inland waters with appropriate modifications. The specific objectives of this study are to: (i) quantify the abundance of macroplastic litter in selected zones of Sera Lake, (ii) classify the items by type and potential source, and (iii) explore spatial patterns of litter distribution in relation to human activities. The results of this study are expected to support future monitoring efforts and contribute to the development of integrated litter management strategies for freshwater bodies in the region.

2. METHODS

This study was conducted in 2024 at Sera Lake, a naturally formed lake located approximately 1.2 km inland from the Black Sea coast in Trabzon, northeastern Türkiye. The lake covers a surface area of 160 hectares and reaches a maximum depth of 25 meters. It was formed by a landslide that created a natural barrier, obstructing the downstream flow of water. Sera Lake is primarily fed by Sera Creek and several small streams, with flow rates ranging seasonally between 50 and 350 liters per second (Mete & Bayram, 2024). The lake's water levels are influenced by seasonal rainfall and runoff. Sera Lake supports diverse aquatic life, including various fish, amphibians, and plant species, making it a vital habitat that contributes to regional biodiversity. Surrounded by lush vegetation and scenic landscapes, it also serves as an important natural reserve and a popular tourist destination. Activities such as boating, fishing, and picnicking attract both locals and visitors, thanks to the lake’s accessibility from Trabzon city center.

Given its unique natural characteristics and the pressures of human activity, especially tourism, Sera Lake provides an ideal case for assessing solid waste pollution dynamics in freshwater ecosystems. Sampling was conducted seasonally, allowing for a comprehensive evaluation of temporal variations in pollution levels across different seasons. In this study, four sampling stations were designated in Sera Lake area based on solid waste density and key contributor factors. The selection criteria included river inflows and outflows, recreational and tourism zones, ensuring a comprehensive representation of pollution hotspots within study area. The station coded S1-S4 represents the Sera Lake (Figure 1).

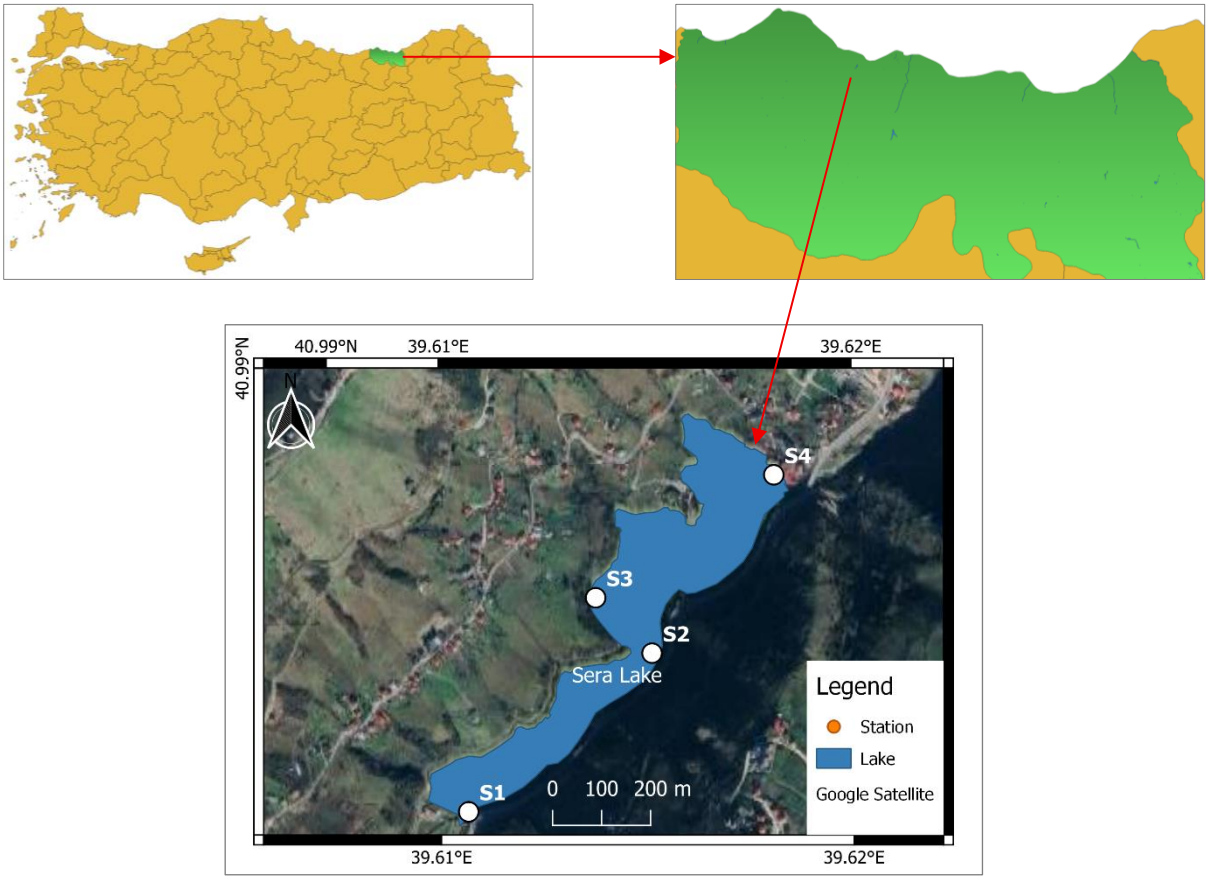

Figure 1. Study areas in Sera Lake, Trabzon

Solid waste items on the coast at each station were collected from areas of 50-100 m2, depending on the local waste density. The items smaller than 2.5 cm were generally excluded from the analysis due to their high degree of deformation and the difficulty in accurately classifying them. The collected solid waste items were countered to determine the quantity per unit. The density of solid waste items was calculated using the following formula:

$$D = \frac{N}{a}$$

Where D is the density of solid waste items (items/m2), N is the total number of collected solid waste items in a station, a is the total surface area of the stations in m2.

Waste items were categorized according to the Guidance on the Monitoring of Marine Litter in European Seas which classify plastic materials into 109 items (MSFD TG ML, 2023). After counting and classification, all collected solid waste was properly disposed of in the nearest waste containers. The flowchart methodology of the study is given in Figure 2. The sampling map was created using QGIS to visualize the surveyed areas.

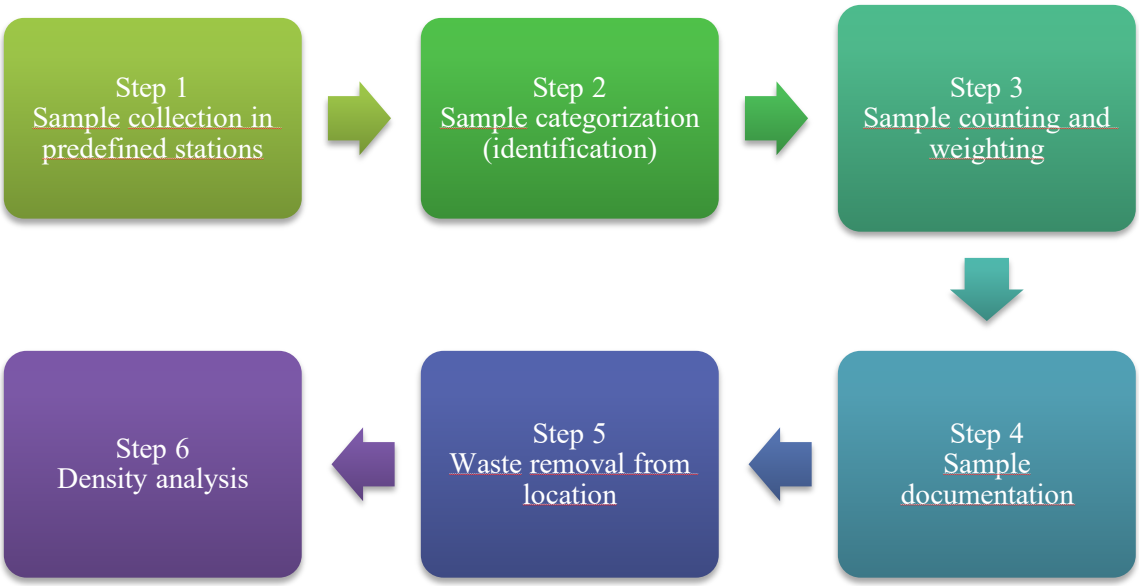

Figure 2. Macroplastic litter sampling collection flowchart

3. RESULTS AND DISCUSSIONS

During the 2024 sampling period, a total of 18,389 solid waste items were collected from Sera Lake, with field surveys covering four distinct seasons across four monitoring stations. The overall average litter density was 11.5 items/m^2 highlight a notable degree of macroplastic pollution within this freshwater ecosystem. Seasonal and spatial variation was evident, underscoring the influence of temporal human pressures and localized land-use dynamics on macroplastic accumulation. Seasonal pattern revealed an increase in plastic debris during summer months, when 6,869 items were recorded, in contrast to a significantly lower count of 2,464 items in winter. This nearly threefold increase reflects heightened anthropogenic activity, particularly li

nked to tourism and recreational use of the lake during warmer weather. The seasonal disparity is consistent with previous studies indicating increased plastic inputs to aquatic systems during peak tourist seasons, where improper disposal and insufficient waste management are common.

Among the four monitoring stations, Stations 2 exhibited the highest total litter accumulation, with 4,997 items, while Station 1 recorded the lowest with 3,787 items (Figure 3). Stations 2 proximity to urban access points, recreational areas likely explain its elevated litter levels. This spatial distribution provide understanding that macroplastic accumulatio is strongly tied to patterns of human use, accessibility, and shoreline infrastructure. Macroplastic concentration was particularly elevated at Station 2 during summer, reaching a peak value of 18.7 items/m2, followed by Station 3 at 18.3 items/m2 and Station 4 at 17.3 items/m2. In contrast, Station 1 situated in a relatively secluded area, consistently exhibited the lowest macroplastic densities, peaking at of 14.4 items/m2 in summer. These findings suggest that Station 2, located in a central, high-traffic area of the lake, is particularly vulnerable to plastic pollution. Across all stations, macroplastic concentrations were lowest in winter and peaked during summer, consistent with increased anthropogenic pressures during the tourist season.

Across all stations, Station 2 maintained the highest mean macroplastic abundance, ranging from 10.6 items/m2 in winter to 18.7 items/m2 in summer. Station 3 and 4 followed similar seasonal trends, with values increasing from 10 and 10.2 items/m2 in winter to 18.7 and 17.3 items/m2 in

summer, respectively. Station 1, situated in a relatively less trafficked area, showed the least seasonal variation, ranging from 8.1 to 14.4 items/m2 (Figure 3). The seasonal trend was consistent across all stations: macroplastic abundance increased progressively from winter to summer, with notable rises during spring and peaking in summer. This pattern suggests a strong influence of seasonal tourism and recreational activities on macroplastic input to the lake. In contrast, the lowest abundance levels observed during winter likely reflect reduced human activity and potential hydrodynamic effects on macroplastic deposition.

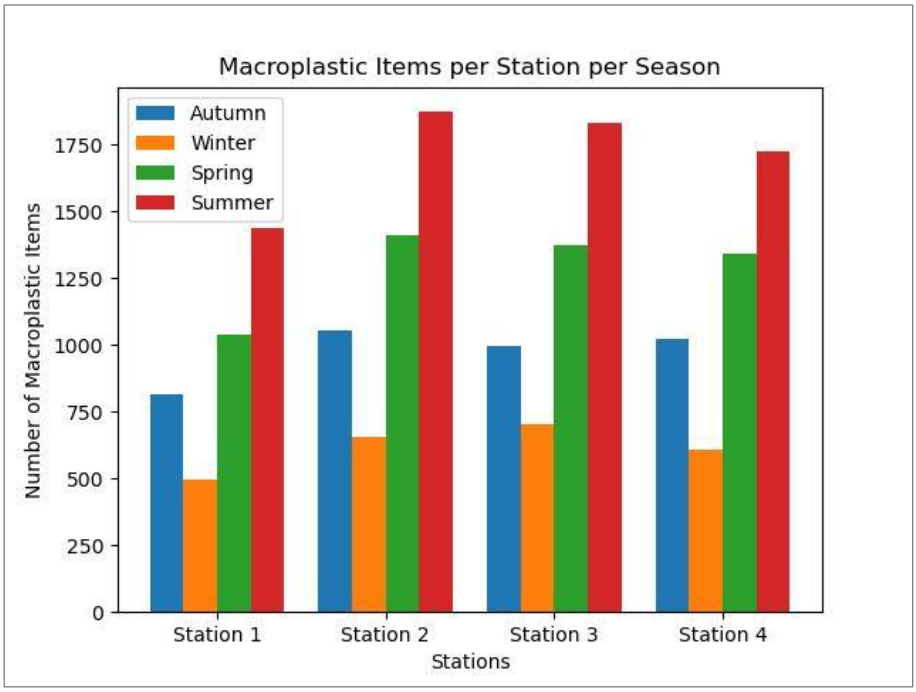

Figure 3. Seasonal variation in macroplastic abundance across four seasons in four stations in Sera Lake

The analysis of macroplastic debris in Sera Lake revealed a diverse composition of plastic item types, with 109 sub categories exhibiting average abundances above 20 items (Figure 4). Among there, severai single-use plastic (SUPs) items dominated the debris profile, reflecting modern consumption patterns and behavioral waste disposal tendencies around the lake. The most abundant item type was single-use plastic (SUP) tobacco products with filters (J27, cigarette butts with filters), with an average of 47.6 items, indicating widespread smoking activity around the lake. This was followed by SUP plastic cups/lids chemicals, detergents (J22) at 41.6 items and SUP plastic stirrers (J230) at 39.6 items.

Other frequently encountered macroplastic items included SUP plastic drink bottles ≤0.5 litter (J7) at 37.1 items, SUP plastic straws (J231) at 35.7 items, SUP cups and lids of hard plastic (J227) at 32.2 items and SUP plastic wet wipes (J237) at 31.9 items. The abundance of SUP plastic rings from bottle caps/lids (J24) was also notable, averaging 30.4 items. Fragments of larger plastic objects were common, particularly fragments of foamed polystyrene 2.5 cm ≤ X ≤ 50 cm (J82) at 33.4 items, plastic construction waste (J89) at 25.9 items, and fragments of non-foamed plastic 2.5 ≤ X ≤ 50 cm (J79) at 11.8 items. Additionally, SUP plastic shopping/carrier/grocery bags (J3) and SUP plastic crips packet/sweet wrappers (J30) were frequently encountered. These findings reflect the prevalence of on-the-go consumption, single-use convenience culture, and inadequate disposal behavior in the area. The use of small packaging, disposable utensils, and cleaning products indicates significant day-use activities by locals and visitors.

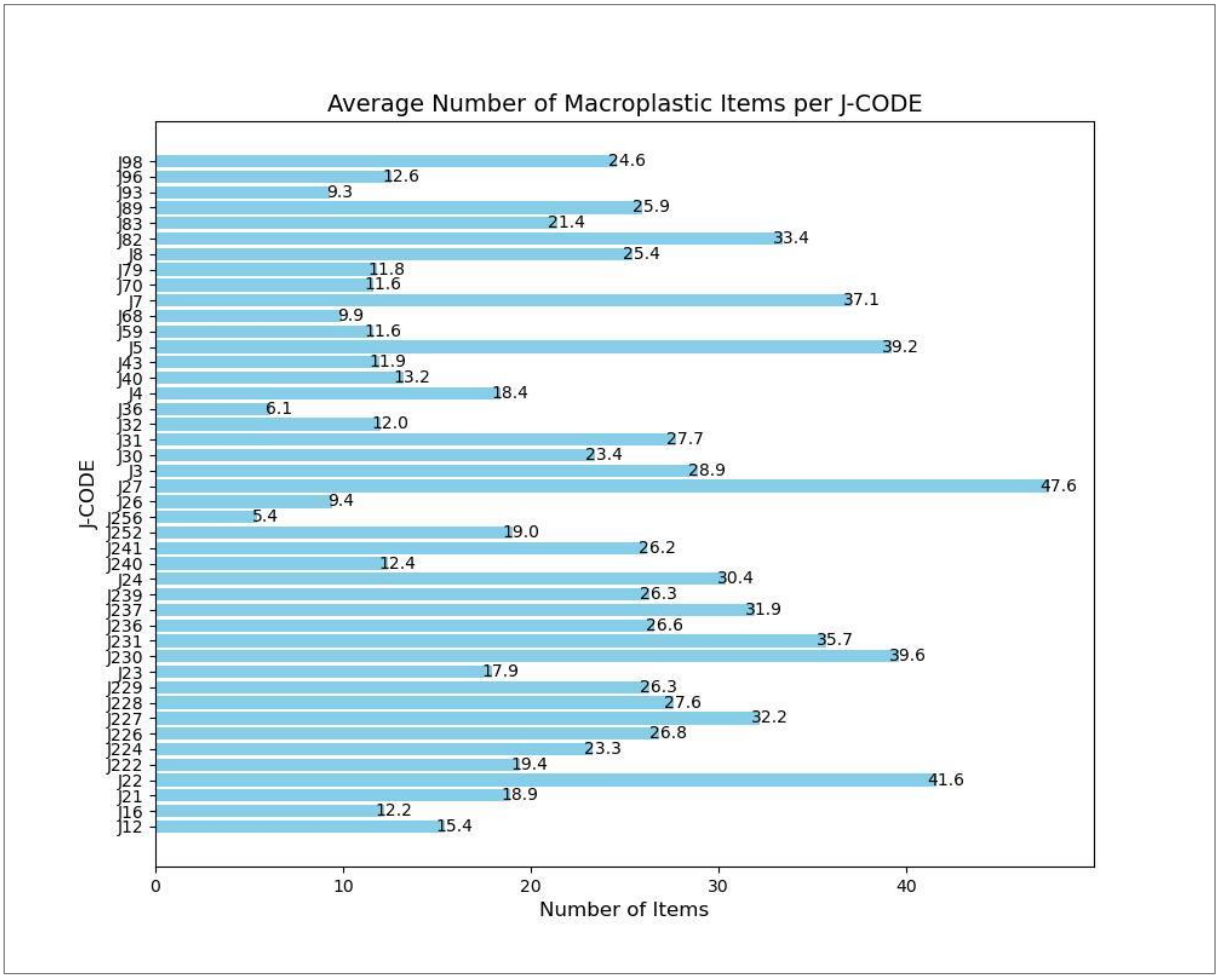

Figure 4. Average abundance of macroplastic debris types in Sera Lake, classified based on the European Union J-Code system. Only categories with an average of more than 20 items are shown.

The seasonal variation in macroplastic pollution in lakes, which higher during summer and lower during winter, can be attributed to several factors, including human activities, meteorological conditions and hydrological changes. These factors influence the distribution and concentration of macroplastics in freshwater environments, as evidenced by studies conducted in various lakes worldwide. Increased recreational activities during summer months lead to the higher macroplastic pollutions. For instance, tourism and recreational use of beaches and lakes contribute significantly to plastic waste, as observed in the South Aegean Sea, where summer activities resulted in higher plastic concentrations. In contrast, during winter, reduced human activity leads to lower plastic pollution levels, as fewer people visit these areas, resulting in less littering ad waste generation (Şener & Yabanlı, 2023). Wind and wave action can transport plastic from land to water bodies. Also, seasonal changes in weather patterns, such as increased rainfall in certain regions, can also influence plastic transport and deposition in lakes (Binelli et al., 2024). Seasonal variations in water flow and lake levels can affect plastic concentrations (Malla-Pradhan et al., 2022). For example, during rainy seasons, increased water flow can dilute plastic concentrations, while in dry flow can lead to higher concentrations. The interplay of human activities, meteorological conditions, and hydrological changes significantly influences plastic pollution levels in lakes, necessitating comprehensive monitoring and management strategies to address these environmental challenges.

The dominance of single-use plastics (SUPs), such as cigarette butts, caps and lids, stirrers and straws, drink bottles, and plastic packaging underscores the significant impact of tourism and recreational activities as primary sources of macroplastic pollution in the lake. The presence of construction-related debris and fragmented plastics also suggests broader inputs from urban run-off and informal waste dumping within the catchment area. These findings highlight the urgent need for targeted waste management strategies, particularly during peak tourist seasons, and the importance

of public awareness campaigns to reduce littering and promote sustainable practices around freshwater ecosystems.

The seasonal and spatial distribution of macroplastic debris in Sera Lake not only reflects direct human influence but also points to the lack of effective waste management and environmental awareness, particularly during peak tourism months. The data reveal a strong correlation between human activity intensity and macroplastic density, indicating that behavioral interventions, improved public waste facilities and targeted policy enforcement could significantly mitigate the problem. Previously used for agriculture and fisheries, the area has been significantly transformed to accommodate infrastructure and amenities supporting the growth of local tourism. As a result, tourism-related developments have played a major role in reshaping the landscape and shifting the region's economic focus. Additionally, increased human activity in the area has contributed to the generation of solid waste within the tourism zone (Mete & Bayram, 2024).

From a policy perspective, these findings can inform both local lake management and contribute to national-level obligations under the Marine Strategy Framework Directive (MSFD) and other international conventions such as the UN Sustainable Development Goals (SDG 6, 14, and 15). The identification of dominant items types (e.g. cigarette butts, plastic drink containers, straws) also, provides a foundation for the development of extended producer responsibility measures and plastic-use reduction strategies in the upstream market. Moreover, the data from Sera Lake demonstrate how inland freshwater ecosystems function as early indicators of plastic pollution trends before materials enter downstream rivers network and coastal areas. In this context, macroplastic monitoring in lakes serves as a critical early-warning and mitigation opportunity for broader marine litter management. Integrating inland water monitoring with existing marine frameworks could enhance catchment-wide pollution prevention.

The observed macroplastic patterns at Sera Lake underscores the need for integrated waste management approaches that span across sectors: tourism, urban planning, environmental protection, and community engagement (Eruz & Ozseker, 2017; Terzi & Seyhan, 2017). Addressing lake plastic pollution will require improved public infrastructure, enhance law enforcement and anti-littering campaigns, strategic clean-up operations targeting hotspots. Promotion of sustainable tourism practices and development of citizens science and education programs.

While this study offers important insights into microplastic pollution in Sera Lake, there were several challenges and constraints should be considered when interpreting the results. First, the adaptation of the marine-focused MSFD protocol to a freshwater environment many not fully account for lake-specific dynamics although it is widely used for inland water ecosystem waste pollution analysis (Özşeker et al., 2025). Second, seasonal sampling may have missed short-term pollution events. Additionally, the exclusion of plastic 2.5 cm and the focus on shoreline litter likely resulted in an underestimation of total plastic pollution. Future studies would benefit from more frequent sampling, expanded spatial coverage, and integration of hydrological data. Even with this limitation, these findings provide a useful snapshot of plastic pollution in Sera Lake.

4. CONCLUSIONS

This study provides a systematic assessment of macroplastic pollution in Sera Lake, a small yet socio-ecologically significant freshwater system in the Black Sea region of Türkiye. The results demonstrate that macroplastic debris is widespread across the lake's shoreline, with a total of 18,349 items recorded over four seasons' surveys in 2024. The highest accumulation was observed during summer season, particularly at Station 2 where the area is subject to the highest tourist activity. This indicating a strong correlation between anthropogenic pressure and litter abundance. The dominance of single-use plastics, especially cigarette butts, confectionery sticks, straws, and plastic bags highlight inadequate waste management and public awareness as primary drivers of pollution. The presence of larger plastic fragments and construction-related waste further points to systematic deficiencies in waste handling practices in the lake's catchment area.

These findings underscore the urgent need to address both point and diffuse sources of plastic pollution in freshwater systems, particularly in high-use recreational areas. We recommend the development of an integrated waste management strategy for the Sera Lake basin, incorporating stricter controls on illegal dumping improved litter collection infrastructure and seasonal waste management reinforcement during peak tourist periods. Public education campaigns targeting visitors and local communities should be prioritized to reduce littering behavior. Furthermore, the adaptation of macroplastic debris monitoring protocols proved effective in the freshwater context, providing a useful framework for ongoing surveillance. Continued long-term monitoring is essential to evaluate the effectiveness of mitigation measures and to better understand the ecological impacts of macroplastic accumulation on aquatic habitats and biota within Sera Lake.

REFERENCES

Amobonye, A., Bhagwat, P., Raveendran, S., Singh, S., & Pillai, S. (2021). Environmental Impacts of Microplastics and Nanoplastics: A Current Overview. *Frontiers in Microbiology*, *12*, 768297. https://doi.org/10.3389/FMICB.2021.768297/XML

Binelli, A., Magni, S., Della Torre, C., Sbarberi, R., Cremonesi, C., & Galafassi, S. (2024). Monthly variability of floating plastic contamination in Lake Maggiore (Northern Italy). *Science of The Total Environment*, *919*, 170740–170740. https://doi.org/10.1016/J.SCITOTENV.2024.170740

Birnie-Gauvin, K., Lynch, A. J., Franklin, P. A., Reid, A. J., Landsman, S. J., Tickner, D., Dalton, J., Aarestrup, K., & Cooke, S. J. (2023). The RACE for freshwater biodiversity: Essential actions to create the social context for meaningful conservation. *Conservation Science and Practice*, *5*(4), e12911. https://doi.org/10.1111/CSP2.12911;JOURNAL:JOURNAL:25784854;WGROUP:STRING:PUBLICATION

Blettler, M. C. M., Abrial, E., Khan, F. R., Sivri, N., & Espinola, L. A. (2018). Freshwater plastic pollution: Recognizing research biases and identifying knowledge gaps. *Water Research*, *143*, 416–424. https://doi.org/10.1016/J.WATRES.2018.06.015

Eruz, C., & Ozseker, K. (2017). Land Based Litter Pollution on the shores of South Eastern Black Sea coastal cities. *Fresenius Environmental Bulletin*, *26*, 3839–3844. https://www.researchgate.net/profile/Figen-Kayhan-2/publication/316667590_THE_SUBLETHAL_DISRUPTING_EFFECTS_OF_FLUOXETINE-HCl_FLX_ON_CATALASE_CAT_ACTIVITY_AND_MALONDIALDEHYDE_MDA_LEVELS_IN_ZEBRAFISH_DANIO_RERIO/links/5af57f4d4585157136caedfe/THE-SUBLETHAL-DISRUPTING-EFFECTS-OF-FLUOXETINE-HCl-FLX-ON-CATALASE-CAT-ACTIVITY-AND-MALONDIALDEHYDE-MDA-LEVELS-IN-ZEBRAFISH-DANIO-RERIO.pdf#page=115

Erüz, C., Terzi, Y., Ismail, N. P., Özşeker, K., Başkan, N., & Karakoç, F. T. (2023). From Source to Sink: A Comparative Study of Streamside and Beach Litter in the Black Sea. *Waste Management*, *161*, 1–9. https://doi.org/10.1016/J.WASMAN.2023.02.025

Garcês, A., & Pires, I. (2024). The Detrimental Impacts of Plastic Pollution on Wildlife. *Research in Ecology*, *6*(2), 42–46. https://doi.org/10.30564/RE.V6I2.6294

García-Gómez, J. C., Garrigós, M., & Garrigós, J. (2021). Plastic as a Vector of Dispersion for Marine Species With Invasive Potential. A Review. *Frontiers in Ecology and Evolution*, *9*, 629756. https://doi.org/10.3389/FEVO.2021.629756/XML

Jiang, D. H., Satoh, T., Tung, S. H., & Kuo, C. C. (2022). Sustainable Alternatives to Nondegradable Medical Plastics. *ACS Sustainable Chemistry and Engineering*, *10*(15), 4792–4806. https://doi.org/10.1021/ACSSUSCHEMENG.2C00160/ASSET/IMAGES/MEDIUM/SC2C00160_0006.GIF

Malla-Pradhan, R., Suwunwong, T., Phoungthong, K., Joshi, T. P., & Pradhan, B. L. (2022). Microplastic pollution in urban Lake Phewa, Nepal: the first report on abundance and composition in surface water of lake in different seasons. *Environmental Science and Pollution Research*, *29*(26), 39928–39936. https://doi.org/10.1007/S11356-021-18301-9

Matavos-Aramyan, S. (2024). Addressing the microplastic crisis: A multifaceted approach to removal and regulation. *Environmental Advances*, *17*, 100579. https://doi.org/10.1016/J.ENVADV.2024.100579

Mete, B., & Bayram, A. (2024). Effects of sediment-storage dams on suspended sediment transport in the Sera Lake Watershed, northeast Turkey. *Environmental Earth Sciences*, *83*(8), 1–12. https://doi.org/10.1007/S12665-024-11572-8/TABLES/3

MSFD TG ML. (2023). *Guidance on Monitoring of Marine Litter in European Seas - Update of the guidance on Monitoring of Marine Litter for the Marine Strategy Framework Directive*. https://doi.org/10.2760/59137

Müller, A., Österlund, H., Marsalek, J., & Viklander, M. (2020). The pollution conveyed by urban runoff: A review of sources. *Science of The Total Environment*, *709*, 136125. https://doi.org/10.1016/J.SCITOTENV.2019.136125

Nayanathara Thathsarani Pilapitiya, P. G. C., & Ratnayake, A. S. (2024). The world of plastic waste: A review. *Cleaner Materials*, *11*, 100220. https://doi.org/10.1016/J.CLEMA.2024.100220

Özşeker, K., Terzi, Y., & Erüz, C. (2022). Solid waste composition and COVID-19-induced changes in an inland water ecosystem in Turkey. *Environmental Science and Pollution Research International*, *29*(36), 54596–54605. https://doi.org/10.1007/S11356-022-19750-6

Özşeker, K., Terzi, Y., & Seyhan, K. (2025). Long-term monitoring (2022–2024) of solid waste pollution in inland water ecosystems of Türkiye: Spatial and temporal dynamics. *Waste Management*, *201*, 114807. https://doi.org/10.1016/J.WASMAN.2025.114807

Ribeiro, V. V., Lopes, T. C., Amaral dos Santos Pinto, M., Póvoa, A. A., Corrêa, V. R., De-la-Torre, G. E., Dobaradaran, S., Green, D. S., Szklo, A. S., & Castro, Í. B. (2022). Cigarette butts in two urban areas from Brazil: Links among environmental impacts, demography and market. *Environmental Research*, *213*, 113730. https://doi.org/10.1016/J.ENVRES.2022.113730

Roman, L., Hardesty, B. D., & Schuyler, Q. (2022). A systematic review and risk matrix of plastic litter impacts on aquatic wildlife: A case study of the Mekong and Ganges River Basins. *Science of The Total Environment*, *843*, 156858. https://doi.org/10.1016/J.SCITOTENV.2022.156858

Şener, İ., & Yabanlı, M. (2023). Macro- and microplastic abundance from recreational beaches along the South Aegean Sea (Türkiye). *Marine Pollution Bulletin*, *194*. https://doi.org/10.1016/J.MARPOLBUL.2023.115329

Terzi, Y., & Seyhan, K. (2017). Seasonal and Spatial Variations of Marine Litter on the South-eastern Black Sea Coast. *Marine Pollution Bulletin*, *120*(1–2), 154–158. https://doi.org/10.1016/j.marpolbul.2017.04.041

Thushari, G. G. N., & Senevirathna, J. D. M. (2020). Plastic pollution in the marine environment. *Heliyon*, *6*(8), e04709. https://doi.org/10.1016/J.HELIYON.2020.E04709