Microplastics in sandy beaches of Thermaikos Gulf: quantification and spatial distribution

S. Apostolides[1], S. Galinou-Mitsoudi[1], C.A. Papadimitriou[2*]

[1]International Hellenic University, Department of Environmental Engineering, 57400 Thessaloniki, Greece

[2]Agricultural University of Athens, Faculty of Crop Science, Laboratory of Ecology and Environmental Science, 11855 Athens, Greece

*corresponding author: C.A. Papadimitriou
e-mail: cpapadim@aua.gr

Abstract This study looks into microplastic pollution along the coast of the Thermaic Gulf. Samples were collected from eight locations and analyzed for their amount, size, shape, and where they were found. The highest levels appeared in tourist-heavy areas, while fibers were more common in places with fishing activity. Most microplastics were found in the midlittoral zone, likely due to how water moves and deposits them. The results point to tourism as a major source of pollution and highlight the need for regular monitoring and better measures to protect the marine environment.

Keywords: Microplastics, Microplastic pollution, Beach sediments, Thermaic Gulf

1. Introduction

Plastics play an essential role in our daily lives but also pose a potential risk to both human health and the environment (Piperagkas et al. 2019).10% of plastics produced enter the oceans and constitute 80- 85% marine litter (Coyle R. et al 2020). One result of plastic pollution is an emerging threat of microplastics. Microplastics are plastic particles less than 5mm in diameter (Huang & Xu, 2022). Beaches are the most likely locations of plastic degradation within the marine environment as conditions are conducive to high rates of photodegradation (Coyle R. et al 2020). Assessing the ecological impact of microplastics is a key goal of the EU Marine Strategy Framework Directive (MSFD 2008/56/EC). This includes studying their sources, sinks and distribution processes in ecosystems.

2. Materials and Methods

Beach sediment samples were collected from 8 sampling sites of the (Fig.1) using a cylindrical core sampler. Site characteristics, usage and activities are detailed in Table 1. Three replicate samples were obtained from the midlittoral and supralittoral zone of each sampling site. Samples were dried, and sieved into two size fractions: SMPs (<1 mm) and LMPs (1–5 mm). LMPs were counted visually, while SMPs were extracted using saturated NaCl solution, filtered, and examined under a stereomicroscope.

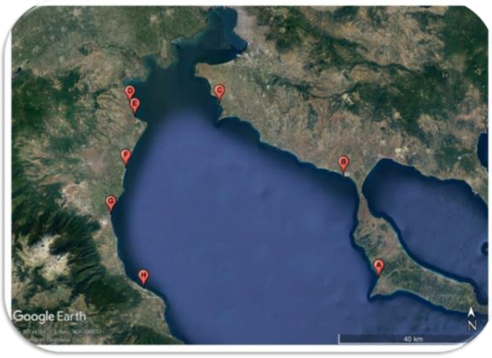

Figure 1. Map of study area and sampling sites

Table 1. Sampling sites and characteristics.

Station	Name of the area	Characteristics
A	Fourka Beach	Intense tourism, intense fishing, fishing port
B	Nea Moudania	Intense tourism, intense fishing, fishing and tourist port
C	Epanomi	Intense tourism, intense fishing, fishing port
D	Makrigialos	Mildly tourism, intense fishing, fishing port, mussel farming
E	Alikes	Mildly tourism, intense fishing, fishing port, mussel farming
F	Katerini Beach	Intense tourism, intense fishing, fishing port
G	Gritsa	Intense tourism, mildly fishing, fishing port, mussel farming
H	Neoi Poroi	Intense tourism

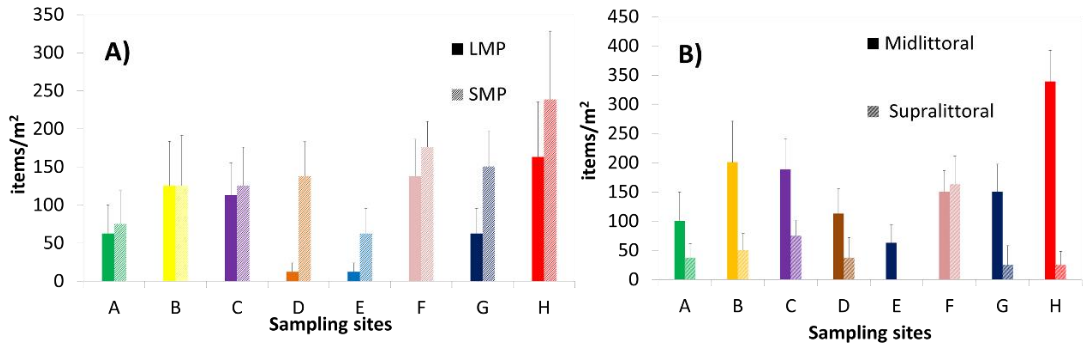

Figure2. (A) Concentration of LMPs and SMPs (items/m2) per sampling site. (B) Concentration in Midlittoral and Supralittoral (items/m2) per sampling site

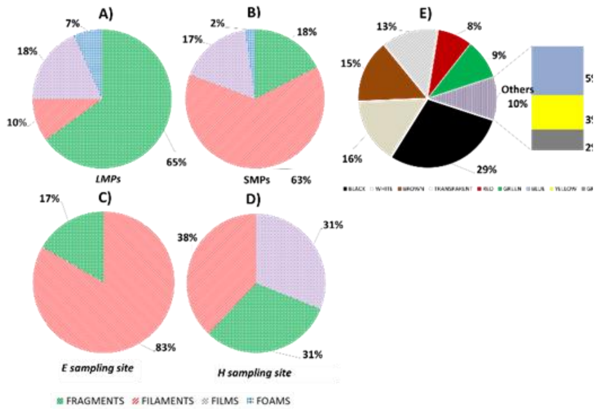

Figure 3. (A) Shape characteristics of SMPs. (B) Shape characteristics of LMPs. (C) Shape characteristics at E sampling site. (D) Shape characteristics at H sampling site. (E) Colour characteristic

3. Results and Discussion

Concentrations and Spatial Distribution

Microplastic concentrations ranged from 12.56 to 163.32 items/m² for LMPs and from 62.81 to 238.7 items/m² for SMPs, with the highest levels recorded at tourist-heavy sites (stations H and F) (Fig. 2). This supports previous studies identifying tourism as a major source of beach plastic pollution (Wilson & Verlis, 2017). The predominance of smaller particles (SMPs) suggests long-term degradation processes. Notably, 75% of the total microplastics were found in the midlittoral zone, consistent with literature showing that coastal hydrodynamic forces drive and retain plastics along shorelines.

Shape and Color of Microplastics

Fragments were the dominant shape among LMPs, while filaments prevailed in SMPs (Fig. 3). At site H, where tourism is high, a notable presence of films—mainly from degraded plastic bags—was observed (Coyle et al., 2020; Piperagkas et al., 2019). At sites D and E, characterized by fishing and mussel farming, filaments were most common, especially in the midlittoral zone, suggesting input from fishing gear such as nets and ropes (Xue et al., 2020). Color analysis revealed black as the most frequent, followed by white, brown, and transparent. Black plastics, widely used but rarely recycled due to sorting limitations, are prone to environmental leakage (Huang & Xu, 2022). Color transformations, particularly from white to brown, may indicate prolonged exposure and photodegradation (Jeon et al., 2023).

References

[1] Coyle R., Hardiman G., O' Driscoll K. (2020). Microplastics in the marine environment: A review of their sources, distribution processes, uptake and exchange in ecosystems, Case Studies in Chemical and Environmental Engineering 100010.

[2] Huang Z., Hu B., Wang H. (2022). Analytical methods for microplastics in the environment: a review. Environmental Chemistry Letters 21:383–401.

[3] Jeon, S., Jeon, J. H., Jeon, J., Kim, G., Lee, S., Kim, S., Maruthupandy, M., Lee, K., Yang, S. I. Cho, W.-S. (2023). Size- and oxidative potential-dependent toxicity of environmentally relevant expanded polystyrene styrofoam microplastics to macrophages, Journal of Hazardous Materials, 459, 132295

[5] Piperagkas O., Papageorgiou N., Karakassis I. (2019). Qualitative and quantitative assessment of microplastics in three sandy Mediterranean beaches, including different methodological approaches, Estuarine, Coastal and Shelf Science, 219: 169-175.

[6] Wilson S. P. & Verlis K. (2017). The ugly face of tourism: Marine debris pollution linked to visitation in the southern Great Barrier Reef, Australia. Marine Pollution Bulletin , 117(1-2): 239–246.

[7] Xue B., Zhang L., Li R., Wang Y., Guo J., Yu K., & Wang S. (2020). Underestimated microplastic pollution derived from fishery activities and “hidden” in deep sediment, Environmental Science & Technology, 54, 2210-2217.equilibrium study, *Journal of Hazardous Materials*, **193**, 27-36. Cheremisinoff P.N. (1995), Handbook of Water and Wastewater Treatment Technology, Marcel Dekker Inc., New York.