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Microplastics in the Estuarine Area of the Pineios River: Seasonal Trends and Variability

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Abstract. This study examines the concentration and distribution of microplastics in the estuary area of the Pineios River. The results show a clear seasonal pattern, with much higher microplastic levels during the summer. The difference in the shape distribution between sediment and water samples shows that human activities and the physical and chemical properties of microplastics affect where they end up in the environment.

Keywords: Microplastics; Pineios River; Estuarine pollution; sediments samples; water samples;

1. Introduction

Rivers and estuaries serve as key pathways for the transport of microplastics to the world's oceans [1]. The ability of estuarine systems to trap significant amounts of microplastics has been consistently documented in related studies [1]. The Pineios River flows into the NW Aegean Sea and is influenced by various anthropogenic activities, including intensive agriculture involving agrochemical use, overexploitation of groundwater, deforestation, soil erosion, semi-industrial operations (such as olive mills and slaughterhouses), hydromorphological modifications (e.g., dams and channelization), and the discharge of treated urban wastewater from the cities of Larissa and Trikala. Furthermore, Storm Daniel, which impacted the Thessaly region from September 4 to 8, 2023, with precipitation levels ranging from 200 to 650 mm, exerted considerable pressure on the river system, exacerbating pollutant mobilization and sediment transport. Under these circumstances, the Pineios River constitutes a representative case study for examining the cumulative impacts of human activities on microplastic pollution in fluvial and marine ecosystems, with particular emphasis on the Aegean Sea and the broader Mediterranean region.

2. Materials and Methods

Monthly sediment and surface water samples were collected from the Pineios River estuary (Fig. 1) between May 2024 and March 2025.

Sediment samples were obtained using a 15 cm core sampler, dried, and sieved into two size fractions: small microplastics (<1 mm) and large microplastics (1–5 mm). Large microplastic particles were separated and counted visually. To isolate smaller microplastics, the sediment fraction <1 mm was treated with a saturated NaCl solution, filtered (20 µm), and examined under a stereomicroscope (10× magnification).

Surface water was collected ~4 m offshore at ~30 cm depth using 1.5 L glass bottles. Samples were sieved (>1 mm), filtered, and analyzed microscopically. A thermal needle was used to confirm that the item was plastic and not organic material.

Figure 1. Estuarine Area of Pineios River – sampling area

3. Results

The concentrations of microplastics in the Pinios River mouth sediments and water throughout the sampling period are presented in Figure 2. The percentage of microplastics by shape in sediment and water samples are presented in Figure 3.

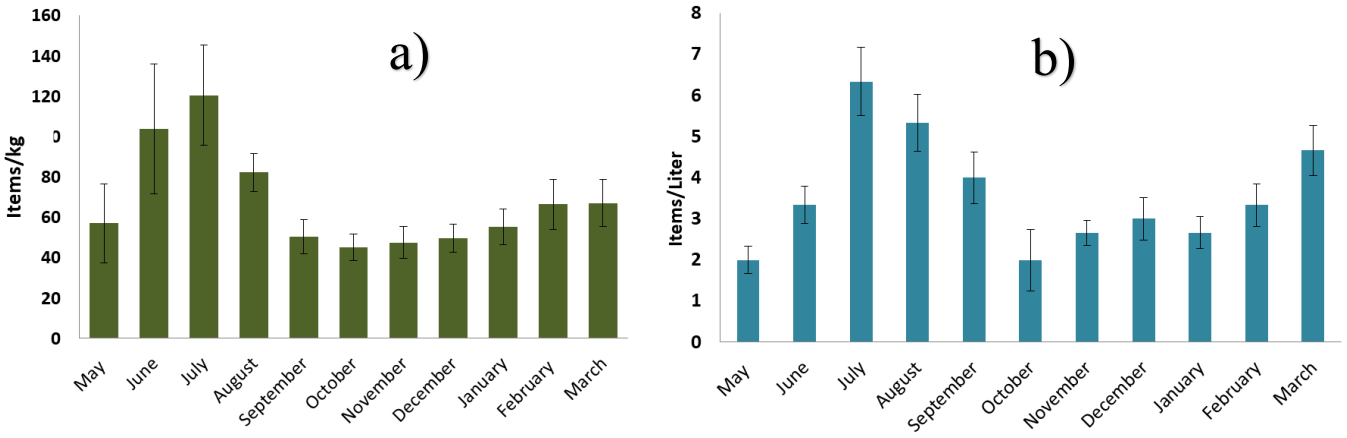

Figure 2. Concertation of microplastics **a)** in sediment samples (Items per kilogram of dry weight) **b)** in water samples (Items per Liter) -bars represent standard error.

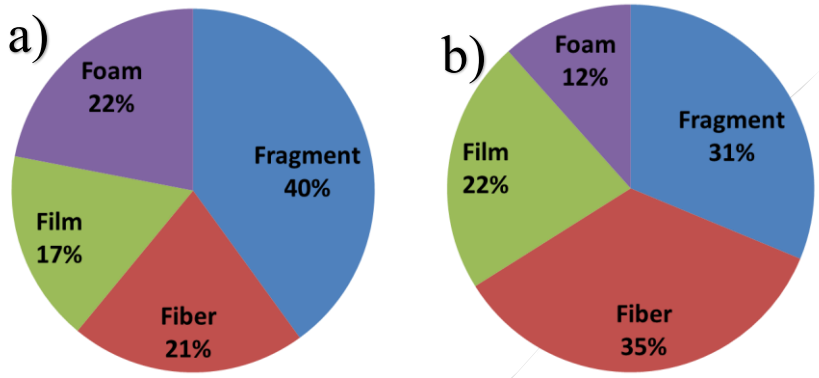

Figure 3. Percentage concentration of microplastics by shape a) in sediment samples b) in water samples

Microplastic concentrations in both soil and water samples show an increasing trend in late spring and during the summer months, with a peak in July. At that time, the highest values were recorded, reaching 120,38 ±27,75 items/kg (mean±SD) of dry weight in soil and 6,33 ±0,83 items/liter (mean±SD) in water (Fig. 3). The observed increase in microplastics during the summer months may be attributed to the reduced freshwater discharge, which limits dilution and removal processes, in combination with elevated temperatures that promote photooxidation and thermal degradation of larger plastic items into microplastics, thereby increasing particle numbers [2] (not necessarily mass, but abundance and density).

The different distribution of microplastic shapes in sediment and water is a common pattern and has been reported in several studies on rivers and estuaries [2,3]. The high number of fragments may be related to the fact that they usually have higher density and tend to sink and gather in the sediment [4]. On the other hand, fibers stay floating for longer because of their small size and low density [5], so they are more often found in the water.

The results from the Pineios River are in line with international studies, highlighting the need for targeted actions to reduce microplastic sources, depending on the most common type and origin.

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