The spatiotemporal distribution and polymer composition of microplastics in the Ishmi River in Albania

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Abstract

In recent years, research on microplastics in rivers has undergone rapid expansion, resulting in the revelation of widespread contamination and the subsequent emergence of concerns regarding ecological and human health impacts. A multitude of studies have confirmed the presence of microplastics in European rivers, with microplastic density demonstrating seasonal variations. The reported concentrations of microplastic in surface waters vary considerably, ranging from as low as 0.03 particles per cubic meter up to extreme values of nearly 187,000 particles/m^3. The presence of microplastic pollution in Albania's freshwater systems represents a novel and growing concern. Albania has not yet established a comprehensive river estuary cleaning system, incorporating automated stations or permanent structures. Current initiatives are predominantly pilot investments from voluntary and non-governmental organizations. The objective of this study is to investigate the spatiotemporal distribution and polymer composition of microplastics in the Ishmi River, which drains the Tirana-Fushe Kruja region with a delta into the Adriatic Sea.

Surface water samples were collected at six stations along the Ishmi River in a two-time sampling calendar, September 2024 and March 2025. It is noteworthy that microplastic levels exhibited an increase at four of the six stations between 2024 and 2025, with the highest concentration (~4 particles/m^3) being recorded at a mid-river station situated in proximity to urban areas in 2025. Polymer analysis revealed a diverse mix of plastics; polyethylene, polypropylene and copolymers fragments, film and synthetic fibers were commonly identified using Micro-Fourier-transform infrared spectroscopy (FTIR) spectroscopy. These results indicate that microplastic pollution in Ishmi River is significant and appears to have worsened over time, likely driven by urban runoff and inadequate waste management. The findings emphasize the necessity for ongoing monitoring of Albanian rivers and the implementation of mitigation measures, such as enhanced waste management and wastewater treatment, to minimize plastic inputs. A comprehensive reduction in land-based plastic pollution will contribute to the preservation of riverine and coastal ecosystems downstream.

- **Key words**: microplastics, spatiotemporal distribution, polymer, river water, waste management.

Introduction

Over the last decade, microplastic pollution has transitioned from a niche research topic to a global environmental priority. Microplastics originate from the breakdown of larger plastic debris or direct sources such as personal care products and synthetic clothing fibers. Once in aquatic environments, they are persistent, easily transported, and capable of absorbing harmful pollutants. Their presence poses risks not only to aquatic organisms but also to human populations through the food chain and water resources. European rivers have been shown to carry significant microplastic loads, but data availability and monitoring consistency vary widely by country. In Albania, the issue of microplastic pollution in freshwater systems is still poorly understood and undocumented in national environmental policy. The Ishmi River, which drains a large portion of the Tirana-Fushë Kruja basin—an area experiencing rapid urban growth and industrial development—is particularly vulnerable to anthropogenic pressures. The absence of wastewater treatment infrastructure and organized waste collection in specific areas likely contributes to increasing plastic loads. This study was designed to assess the extent of microplastic contamination in the Ishmi River through a dual temporal lens. It explores both seasonal dynamics and the types of plastic polymers present, offering a foundational dataset for future environmental management strategies in Albania. However, data on microplastics in Albanian river systems are sparse. The Ishmi River, which drains the densely populated Tirana region and flows into the Adriatic, represents a critical case study for freshwater plastic pollution. This river receives inputs from urban runoff, untreated wastewater, and informal waste dumping, making it susceptible to plastic contamination. This study aims to evaluate the spatiotemporal distribution and polymer composition of microplastics in the Ishmi River. We present results from two sampling campaigns (late summer 2024 and spring 2025) at six stations along the river, capturing both spatial variation and seasonal change in microplastic abundance. Using FT-IR Lumos II Microscope by Bruker we also identify the types of polymers and pieces (such as fragments, films, particle and fibers) present to infer possible sources. By comparing our findings with regional and global studies, we provide context on the severity of microplastic pollution in the Ishmi River and discuss implications for environmental management. This work provides the first detailed baseline on microplastics in an Albanian river, addressing a knowledge gap and informing future monitoring and mitigation efforts.

Material and Methode

Sampling was conducted twice: once in September 2024 (dry season) and again in March 2025 (wet season), to account for seasonal variations in runoff, waste discharge, and river flow.

Surface water samples were collected using a fine-manta net (mesh size <300 μm), allowing for the capture of small microplastic particles, during one hour of river flow. The filtered material was transferred to pre-cleaned glass containers and stored for laboratory analysis. In the lab, samples were visually inspected under a stereomicroscope to isolate suspected plastic fragments. These fragments were categorized by shape (e.g., fragments, films, fibers) and then analyzed using Micro-FTIR to identify polymer types. Microplastic separation is a critical step for accurate and reliable analysis, contributing to a deeper understanding of microplastic pollution in aquatic environments.

Samples may be subjected to separation for three main reasons:

a) Separation helps concentrate microplastics from a larger volume of water, making it easier to detect and analyze them accurately.
b) Separation removes other organic and inorganic materials present in the sample.
c) Concentrating microplastics through separation allows for a clearer view under a microscope, aiding in proper identification and classification of microplastics.

- Microplastic particles can be separated from matrices with higher densities by flotation with saturated salt solutions of high density.
- To avoid the influence of organic matter in the water sample, 30% H2O2 was added into the glass bottle containing water sample, placed in a constant temperature magnetic plate, and vibrated at the frequency of 100 r/min at 60 °C for 24h. After the supernatant was taken and mixed with NaCl was placet again in a constant temperature magnetic plate for 12h.
- To minimize the sample volume for more efficient results, all the sample content was thrown in a separatory funnel and left for 24 hours. After decantation of big particles and separation of densities only 1/5 of water column (surface part) were filtered by vacuum pump through 2,2 μm filter paper. Before analysis, the filter papers were put in the oven and dried at 30 °C for 24-48 h.

Results and discussion

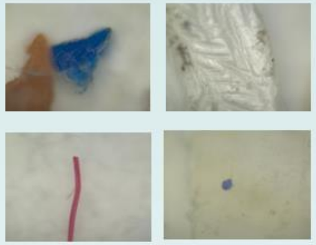

Figure 1: Images of different shape of MP(fragment, film, fiber, particle)

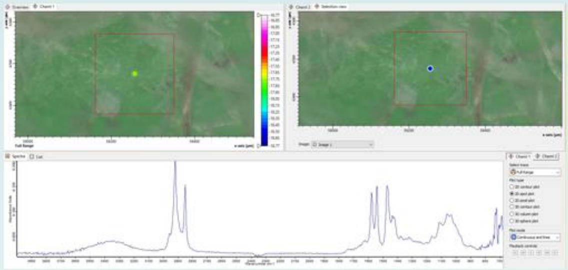

Figure 2: Image of FT-IR Lumos II Microscope by Bruker spectra

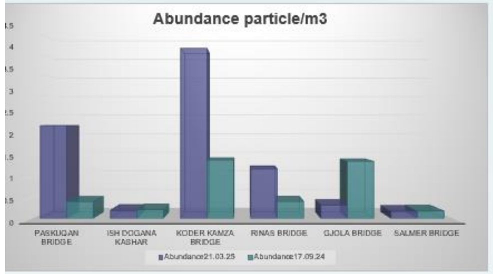

Figure 3: Abundance of MP(particle/m3) in March2025 vs September2024 in six different stations of Ishmi River

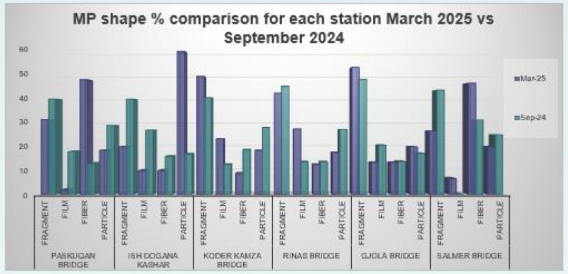

Figure 4: MP shape % comparison for each station March 2025 vs September 2024

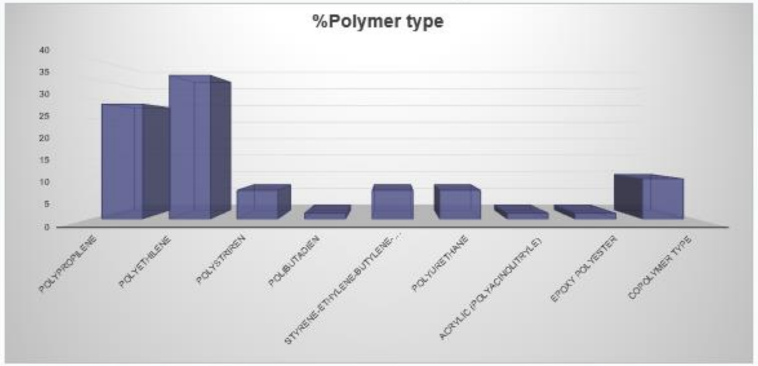

Figure 5: % of MP polymer type detected in all the samples

Microplastics were detected at all six sampling stations during both field campaigns, confirming the widespread presence of plastic pollution in the Ishmi River. Between the two sampling periods, microplastic concentrations increased in three of the six stations, particularly those located downstream of urban areas and near industrial discharge points.

The highest concentration recorded was approximately 4 particles/m³ in March 2025 at a midstream station adjacent to dense residential zones and informal waste dumps. In contrast, stations that are in non-urban areas showed lower concentrations, suggesting that local human activity is a key driver of microplastic loading.

In terms of physical characteristics, the most common types of microplastics observed were:

Fragments: likely derived from broken plastic containers and packaging.

Films: often originating from plastic bags and agricultural mulch.

Fibers: consistent with synthetic textiles and possibly washing machine effluents.

Polymer analysis revealed that polyethylene (PE) was the most prevalent material, followed by polypropylene (PP) and copolymers type. These materials are commonly used in household and industrial packaging, indicating terrestrial runoff as a dominant source of microplastic entry into the river.

The observed increase in microplastic concentration over time and downstream highlights several important patterns. Firstly, urbanization and improper solid waste disposal appear to be primary contributors to microplastic contamination. The absence of a functional waste separation or river filtering system means that much of the plastic waste produced in the Tirana region likely ends up in nearby waterways.

Secondly, the seasonal variation—higher concentrations in spring—may be linked to increased precipitation and surface runoff, which transports accumulated waste from land into the river.

The Ishmi River is considered the most polluted river in Albania. During sampling with manta net, a high presence of sludge and various types of pollutants was observed. Due to this, it is suspected that some microplastic particles may have been lost during laboratory sieving, as they might have adhered to larger debris and were not fully separated.

The diversity of polymers and particle forms suggests multiple and diffuse sources of pollution, including household waste, industrial byproducts, and textile fibers. The predominance of PE and PP is consistent with global patterns and indicates packaging materials as a major contributor.

These findings raise significant concerns regarding long-term environmental and health impacts, especially considering the Ishmi River's connection to the Adriatic Sea and the risk of marine ecosystem contamination.

Conclusion

This study presents one of the first comprehensive analyses of microplastic pollution in an Albanian river system. The data clearly show that microplastics are present throughout the Ishmi River with a average concentration of 1,56 particles/m^3 .

The non-uniform increase in microplastic concentrations may result from a combination of localized pollution sources, riverbed characteristics, varying land use, and hydrological dynamics. Further investigation is needed to quantify the contribution of each factor particularly.

There is an urgent need for Albania to develop a national monitoring framework for microplastic pollution, coupled with investments in wastewater treatment, solid waste management, and public awareness campaigns. Only through coordinated action can the impacts on freshwater and marine environments be mitigated.

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The manta net used in this study was custom-designed by the authors based on established methodologies in the literature. It proved effective and reliable during the sampling process, enabling the successful collection of microplastic samples from the river.