

Microplastic analysis in urban areas and their impact on quality of life

Angelica-Nicoleta Gaman^{1*}, Alexandru Simion¹, and Sorin Simion¹

¹ National Institute for Research and Development in Mine Safety and Protection to Explosion – INSEMEX Petroșani, Romania

Abstract. Plastic pollution is a major threat to both biodiversity and human health. Due to its high environmental persistence, concern has grown in recent years regarding the effects of microplastic pollution on ecosystems and its potential long-term impact on human well-being. Advancing research into the identification of microplastics in freshwater systems is a crucial step toward addressing this environmental challenge. However, a significant global issue remains: the lack of standardized methods for the qualitative and quantitative analysis of microplastics in environmental samples. This study focuses on the identification and quantification of microplastics in two tributaries of the Jiul River, located in western Romania. Sampling was conducted at two monitoring sites, with Fourier-transform infrared spectroscopy (FTIR) combined with infrared microscopy used to generate reliable, high-resolution data. The microplastics analysed (particles <5 mm) were classified by size and polymer type. Results showed microplastics present at only one of the two sites—specifically, at the confluence of the Maleia stream with the eastern Jiul River. Most particles measured between 25 and 50 μm and were primarily composed of PET, LDPE, and HDPE polymers. PET was the most frequently detected, highlighting the need for targeted.

1 Introduction

Plastic pollution in natural environments has received significant attention from academia, citizens and policy makers in recent years due to its potential negative impact on ecosystems, economy and human health [1,2]. In urban areas, the concentration of microplastics is increased because of heavy traffic, industrial activities and use of plastic products.

Europe is addressing this issue through a series of measures aimed at contributing to the circular economy and reducing waste. It is therefore proposed that all plastic packaging should be recyclable or reusable by 2030, and that the consumption of single-use plastics should be reduced and that the deliberate use of microplastics should be restricted [3,4].

Microplastics (MP) are plastic particles smaller than 5 mm; they can be primary and manufactured for commercial use, such as cosmetics or textile microfibers, or secondary, resulting from the breakdown of macro plastics, over time [5].

* Corresponding author: angela.gaman@insemex.ro

Microplastics mainly include plastics such as polyethylene, polystyrene and polypropylene. Due to their small size and non-degradable nature, microplastics accumulate in aquatic organisms. The food chain is the main route through which humans are exposed to microplastics [6]. In addition, microplastics have been reported in foods such as sea salt, beer, bottled water [1] and honey, and this represents yet another route through which humans are exposed [6,7]. Scientists have also detected microplastics in human tissues and organs, and the implications of these findings for human health are highly subjective [8]. Thus, multiple efforts have been made to monitor plastics and microplastics to understand the transport and types of plastics in urban areas [2], river systems [5,9] and oceans [10,11]. The determination of (micro)(nano)plastics in the environment, in various areas, is critically necessary, especially in surface waters (rivers), in order to identify the pathways through which they enter the environment and, as much as possible, the time intervals involved. This is essential for quantifying their size and presence so that the situation can be managed by local authorities to protect both environmental and public health. Less attention has been paid recently to the effects of plastics in freshwater systems, despite the fact that rivers are the dominant source of plastic pollution in the oceans, therefore it is reasonable to assume that the potential effects are identical to the plastic debris found in the marine environment. As a result, plastic pollution is also ubiquitous in surface waters, not only in seas and oceans, but rivers in smaller urban areas are still not sufficiently researched to detect plastic presence or abundance.

There are studies conducted on the territory of Romania in the waters of the Danube by the Mai Mult Verde Association and Global Water Partnership Romania, which is the most extensive study of this kind conducted in our country, to date, and which demonstrated that the Romanian sector of the Danube transports annually, on average, 48.5 tons of microplastic and 48 tons of macro plastic [9].

Given the durability of microplastics in the environment and their potential hazards found in freshwater systems, as well as numerous studies [2,12,13] highlighting the urgent need for monitoring, prevention, and new policies, this study aims to determine their presence in the East Jiul hydrographic system in Romania and to identify the best indicator for locating other potential areas of contamination. To achieve this, the first step in our research was to identify households near tributaries of the Jiul River, as well as their points of confluence with the main river.

1.1 Description of the area of interest for sampling

Among all the streams collected by the Jiul River, the most important tributaries are the Jiet and Maleia streams.

The selection of locations for sampling took into account the household activities that are located near the two streams with the aim of identifying pollution sources of the East Jiul River. Thus, the water sampling was carried out at the confluence of the Maleia and Jiet streams with the East Jiul River, which is part of the Jiul River basin (fig.1)

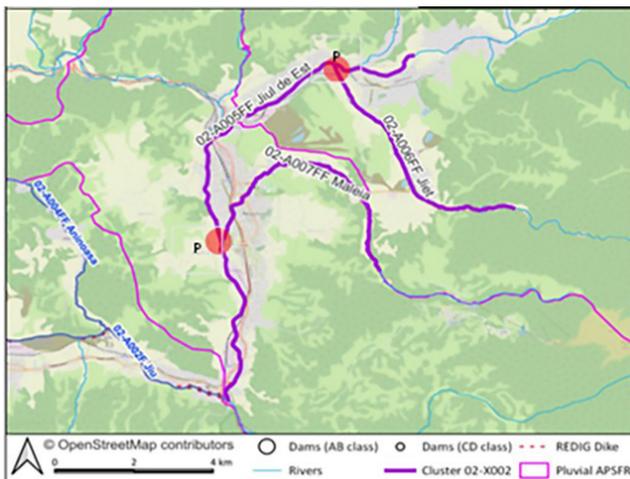


Fig. 1. Confluence of Maleia and Jiet streams with the East Jiul River [14] - Map of sampling sites

2 Methods and materials

Detection of microplastics in water requires a combination of physical, chemical and spectroscopic methods for an accurate analysis. The choice of method depends on desired sensitivity, type of sample and available resources, even though, at present, there are no internationally harmonized working standards.

Microplastics in surface water samples can be qualitatively determined by several techniques, namely: Fourier Transform Infrared Spectroscopy (FTIR) for the analysis of plastic and polymer material types, Infrared Microscopy (IR) coupled with FTIR, Raman Spectrometry or Thermogravimetric Analysis, Advanced Scanning Electron Microscope (SEM). All of these techniques can provide valuable results, with greater or lesser precision, regarding the analysis of microplastics in water samples.

The National Institute for Research and Development -INCD INSEMEX Petrosani, through the Environmental Protection Laboratory, has an Infrared Microscope (AIMsight) coupled with a Fourier Transform Spectrophotometer (FTIR) that was used to identify the presence of microplastics in the tributaries of the East Jiul River, to characterize and quantify them in order to assess their impact on the quality of life.

The infrared microscope (AIMsight) has a T2SL detector cooled with liquid nitrogen. The measurable wavenumber range of the microscope is from 5,000 to 700 cm^{-1} , having an SN ratio of 30,000:1, which is the highest in its class, offering the possibility of obtaining satisfactory spectra in a short time. AIMsight is equipped with a rich range of functions that can analyse particles in detail, being equipped with a Wide Field camera for wide-field observation, high-speed mapping with imaging presentation, with the possibility of visual observation and simultaneous measurement of particle size and shape $< 100 \mu\text{m}$. The data are obtained using LabSolutions software (Shimadzu), and for precise qualitative analysis, the microscope uses the NIST spectrum library and Shimadzu custom libraries (polymers, copolymers, synthetic fibres, resins, plasticizers, etc.).

2.1 Sample collection and preparation

Water samples were collected during a campaign in March 2025 using a telescopic rod water sampler, from the two streams (Maleia and Jiet) approximately 1km away from the confluence with the East Jiul River. The sampling was carried out from the upper layer of the

water column (the first 10 cm – 20 cm). The samples were transferred into 1L glass containers, previously decontaminated in the laboratory with ultrapure water, and subsequently, in the field, with sample water. From each location, 2 litres of water were sampled, being labelled with the name of the sampling site.



Fig. 2. Water sampling Maleia stream



Fig. 3. Water sampling Jiet stream

Analysing the research and studies carried out to date, using two online publication databases: SCOPUS and Web of Science regarding the chemical reagents used for the separation of samples from the water matrix, it was found that the technique applied is similar in several studies [10, 15]:

- Using a 1:1 mixture of 10M KOH solution and 30% H₂O₂ to remove natural organic residues. This pretreatment is usually followed by density separation or filtration. Thus, the samples were left to digest under agitation for 5 days, and then they were neutralized using formic acid and separated from denser suspensions using a saline solution of ZnCl₂, 60%.

The samples collected from the Maleia River and the East Jiul River (upstream of the confluence with the Maleia River) were portioned into representative 100 mL samples and transferred into individual pre-cleaned Berzelius beakers (Fig.4). The organic matter was digested using 15 mL of 10 M potassium hydroxide (KOH) solution and 15 mL of hydrogen peroxide (H₂O₂, 30%), following the methodologies described by literature. After an agitation period of 5–7 days, the samples were neutralized with 5.8 mL of formic acid. During the chemical treatment, the glass beakers were covered with Parafilm to prevent contamination with airborne microplastics.

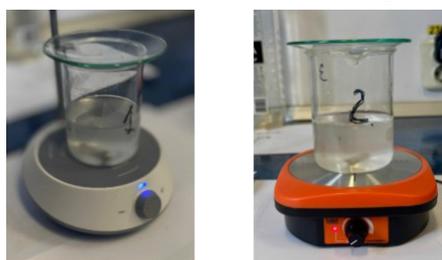


Fig. 4. Agitation of samples



Fig. 5. Isolation of microplastic particles

The isolation of microplastic particles was performed using a separatory funnel (Fig.6), into which 50 ml of potassium formate (CHKO₂) solution with a density of 3.6 g/mL was added, so that the final sample reached a final density of 1.6 g/m L. This density is appropriate, since most types of plastic have lower densities and, therefore, plastic microparticles float in the solution.

After approximately 3–4 days, filtration (Fig.7) was performed under pressure (Merck Millipore, EZ-Fit) using gold-blown polycarbonate filters (Fig. 6) (Sterlitech, PCTG, diameter: 47 mm, pore size: 0.8 μm). The filters were subsequently stored in individual aluminium cassettes and covered for protection (Fig. 8).



Fig. 6. PCTG filters



Fig. 7. Water sample filtration



Fig. 8. Aluminium cassettes

3 Results and discussion

3.1. Particle analysis by FTIR spectroscopy with integrated microscope (μ -FTIR)

After the isolation of microplastic particles by chemical digestion, densiometric separation and filtration, the next essential step was their identification and compositional characterization. Initially, the particles were examined by optical analysis, using visual identification under the microscope (Fig. 9) to select fragments suspected of being microplastics. The analysis of particles retained on the gold-blown polycarbonate filters was performed using a Shimadzu AIMSight microscope, coupled to an IRTracer-100 FTIR spectrometer, in reflection mode. The choice of this analysis mode was justified by the compatibility with the metallized substrate of the filters and the efficiency in identifying small microplastic particles, similar to the approaches applied for synthetic samples subjected to mechanical and thermal degradation.

The filters were carefully handled using sterile metal tweezers and placed directly on the microscope analysis platform in a controlled environment to prevent contamination. For each particle of interest (Fig. 10), spectroscopic analysis was performed on a $50 \times 50 \mu\text{m}$ aperture, with 160 scans per analysis point, in the spectral range $4000\text{--}800 \text{ cm}^{-1}$, at a resolution of 4 cm^{-1} .

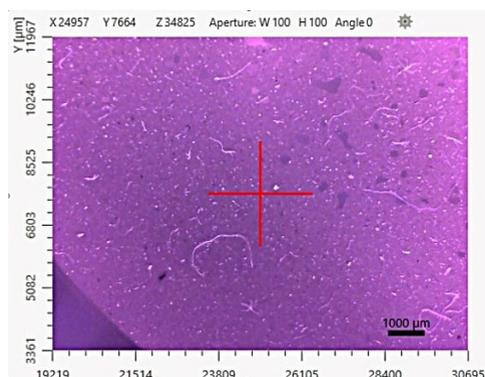


Fig. 9. Optical visualization of microparticles

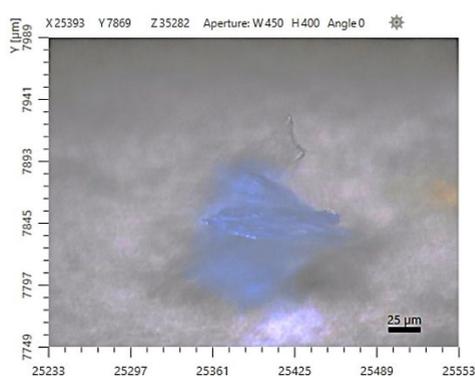


Fig. 10. Analysis of microparticles of interest

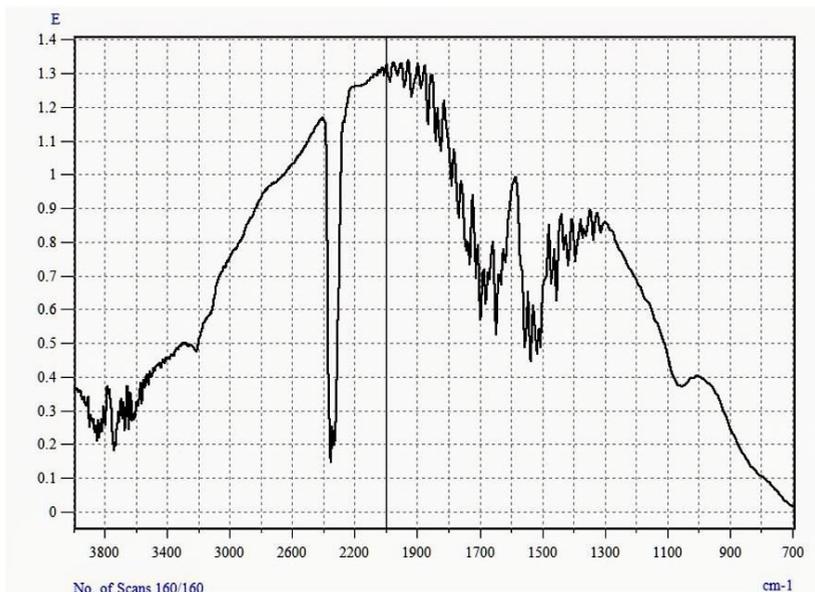


Fig. 11. Reference spectrum of the PCTG filter

For the qualitative identification of microplastics collected on PCTG filters, the samples were analysed using an FTIR microscope. The reference spectrum (Fig. 11) was previously recorded using an unpolluted portion of the PCTG filter or a gold-coated reflection window, and subsequently the spectra of the particles of interest (Fig. 12) were obtained by automatic correction to the reference spectrum. The spectra were collected using the Happ-Genzel correction to ensure the accuracy of the measurements and the elimination of background interferences.

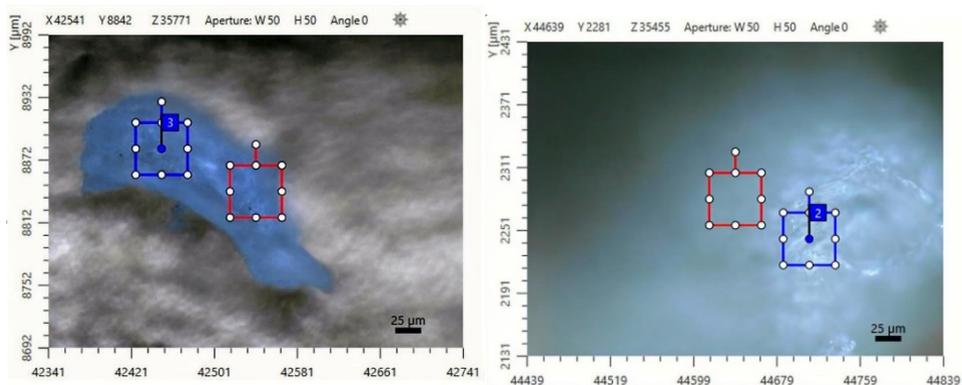


Fig. 12. Optical visualization of microparticles

Qualitative identification and polymer composition was performed by comparing the experimental spectra with the spectra (Fig. 13) from the NIST library, Shimadzu custom libraries (polymers, copolymers, synthetic fibres, resins, plasticizers, etc.) and Shimadzu

libraries specifically developed for mechanically and thermally degraded plastics. A match was considered valid for a correlation index (Hit Quality Index) greater than 0.7.

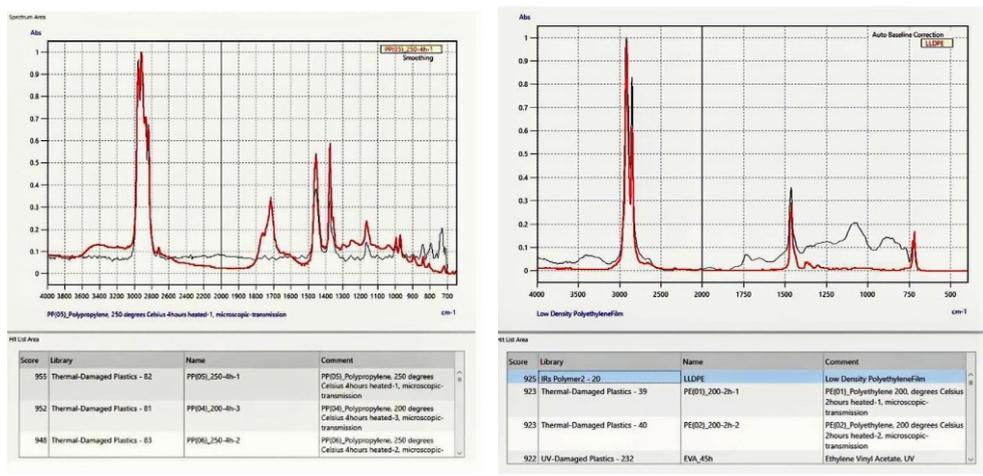


Fig. 13. Optical visualization of microparticles

The identified microparticles that did not obtain conclusive spectra and did not have a correlation index higher than 0.7, were excluded from the final analysis.

Hydrometeorological parameters measured during sampling, such as water temperature, pH, dissolved oxygen and current velocity, revealed significant fluctuations that may influence the behaviour of microplastics in river beds. For example, variability in current velocity and water temperature can affect both the transport of microplastic particles and their degree of suspension in the water column, and pH influences the solubility and chemical interactions of microplastics with other substances in the environment. These fluctuations must be taken into account in simulation models of microplastic dynamics, in order to obtain accurate and relevant results for water quality management.

The analysis of microplastics in the Maleia River revealed a predominance of particles in the 25-50 μm range, with a significant number of PET, LDPE and HDPE particles. In this size range, approximately 7 particles were observed for each 25-50 μm group. PET was the most common, followed by LDPE and HDPE. These particles were the most common in water and sediment samples, suggesting diversified pollution sources, which include both industrial activities and the use of plastic products in the area. In the case of the East Jiul River, the distribution of microplastic particles was more uniform across the size ranges. The most common sizes were 250-500 μm and 50-100 μm , with a significant amount of PET, LDPE and PVC particles. For example, approximately 2-3 particles were observed for the 250-500 μm size ranges, most of which were PET and PVC. LDPE and HDPE particles were also evenly distributed in the 10-25 μm and 50-100 μm ranges, with a number of approximately 1-2 particles in these categories. This distribution suggests a different behaviour of microplastics in the East Jiul River compared to the Maleia River, possibly influenced by the different hydrodynamic regime and sedimentological conditions.

Regarding the analysis of samples taken from the Jiet River, no plastic microparticles were identified, suggesting that, in the respective area, microplastic pollution is either extremely low or non-existent, at least at the sampling point selected for this research. This can be explained by the predominant nature of microscale agricultural activities in the area, which usually do not generate a significant amount of plastic microparticles compared to other types of industrial activities.

4 Conclusions

This case study was carried out at the confluence of the Maleia and Jiet streams with the East Jiul River, taking into account the household activities located near these tributaries in order to identify potential sources of pollution affecting the Jiul River. The methodology applied for sampling and analysis was scientifically validated, and the use of chemical extraction, filtration, and density separation techniques ensured the efficient isolation of microplastics from the samples.

Monitoring, prevention, and reduction of plastic and microplastic pollution should be prioritized across all environments—urban, rural, and global. Unfortunately, current monitoring efforts vary significantly, with a greater focus placed on large urban areas, major rivers, and oceans. However, addressing aquatic plastic pollution at all scales is essential for the protection of ecosystems and for raising public awareness to fight plastic pollution.

Urban areas are significant sources of microplastics, and their monitoring and management must become a strategic priority. Effective collaboration between local authorities, researchers, and the public is vital to mitigate the impacts of this largely invisible form of pollution.

This study highlights the importance of implementing standardized methods for monitoring microplastics, which would enable accurate assessment of pollution levels and support the development of more effective environmental protection measures.

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