University of Belgrade, Technical Faculty in Bor

29th International Conference Ecological Truth & Environmental Research

EcoTER'22

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Prof. Dr Snežana Šerbula

21-24 June 2022, Hotel Sunce, Sokobanja, Serbia

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MICROPLASTIC OCCURRENCE IN URBAN AND SUBURBAN SOILS OF BOR, EASTERN SERBIA

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Abstract

Microplastics (MPs) are a newly acknowledged, pervasive pollutants found even in distant Earth areas and represent a matter of global concern. This study inspects, for the first time, microplastic content in terrestrial environments in the city of Bor, known as one of the most polluted industrial cities in Serbia. Soils from the park in the II kilometer and the periphery of the Bor (Brezonik settlement) were collected and analyzed. Plastic particle extraction from the soil matrix was performed using the flotation method based on density separation. MP content differed significantly between the two sites. Urban soil contained around 3800 items kg^{-1}, while suburban held 600 particles per kilogram. The outstandingly high difference likely originates from the distinction in the anthropogenic activity levels of the two localities. There was no notable difference in appearance. All extracted items were white to transparent fragments. The morphological shape of plastic particles indicated defragmentation as a governing origin source. Future investigations should be concentrated on the MPs' correlation with other contaminants, namely heavy metals, and the eventual recognition of MP`s role as the metal pollution vector in the investigated area.

Keywords: enviroment, soil, microplastic, isolation

INTRODUCTION

Plastic waste has been internationally recognized as one of the massive environmental pollutants for decades already. However, the discovery of microscale plastic fragments, ubiquitous in almost all ecosystem components originating from plastic degradation, has recently made this contaminant an important ecological focal point for researchers. Plastic particles smaller than 5 mm, measuring the longest dimension, represent microplastics (MPs) [1]. MPs origins are categorized into primary (microbeads) and secondary sources. Microbeads are plastics originally produced micro-sized. Secondary-sourced plastics undergo various degradation processes - chemical (corrosion, high temperatures exposure, photooxidation), mechanical (wave action, abrasion, erosion), and biodegradation (microbial activity), leading to fragmentation into MPs [2]. Due to the persistence and durability of MPs, after ending up in the environment, it remains there indefinitely. Even remote areas, such as Mount Everest, Antarctica, and the Arctic, were found to contain microplastic debris [3,4]. According to the degradation level, plastics are involved in all ecosystem compartments – atmosphere, aquatic and terrestrial systems, and even in biota, just as various chemical elements. Additional hazard occurs with MPs associated with other toxic chemicals. Owing to sorption capacity for heavy metals, hydrophobic organic contaminants (HOC), and biological pollutants MPs act as a vector for multiple contaminants [5]. The majority of them are bioaccumulative and harmful to humans and the environment.

Microplastic pollution has substantially increased and become omnipresent in marine environments, making up about 80–85% of marine litter [6]. The existence and abundance of MPs in ocean waters are mainly a consequence of land activities, closely associated with transportation pathways in which rivers play a principal role. MPs in freshwater bodies impair water quality, and hence require high-level monitoring, as well. The entering of MPs into the food web was demonstrated by ingested particles detected in a wide range of organisms. Once it enters the food chain, it can cause tissue and organ dysfunction and disrupt metabolic processes, causing injuries or even death [7,8].

Additionally, microplastics are extensively detected in terrestrial environments, as soils are considered sinks for MPs. Occurrence in soils originates from various sources, such as tire wear, municipal solid waste, wastewater treatment plants, soil amendments (biosolids and composts), plastic mulching films, materials used in greenhouses, etc. [9]. Transport of MPs through soil systems may lead to uptake by terrestrial species causing severe biochemical consequences and groundwater contamination. Published literature on particle detections in soils has significantly expanded in the past decade. Several methods of MPs isolation from soil samples have been developed so far, of which flotation based on density separation is currently regarded as the most reliable [10]. However, many modifications of this method are currently in use, trying to optimize extraction conditions for various complex soil matrices. Thus, a modified density separation method was used in our research.

The aims of this study were: 1) determining the presence of microplastic particles in urban and suburban soils from Bor, 2) quantification of particles and determination of their differences between the soil types, and 3) identification of potential sources of MPs in both sampling locations.

MATERIALS AND METHODS

Study area and sample collection

The study area was located in the city of Bor, in eastern Serbia. The first sampling point was in Brezonik, the suburban area of the Bor city, while the location of the urban soil sampling was a city park in the II kilometer. Soils were collected using stainless steel shovels. About 1 kg of the composite formed from five subsamples, was taken from each site. After sampling at the first site, the shovel was cleaned and washed. To avoid contamination, all afterward manipulations and storage were performed without potential contact with plastic materials.

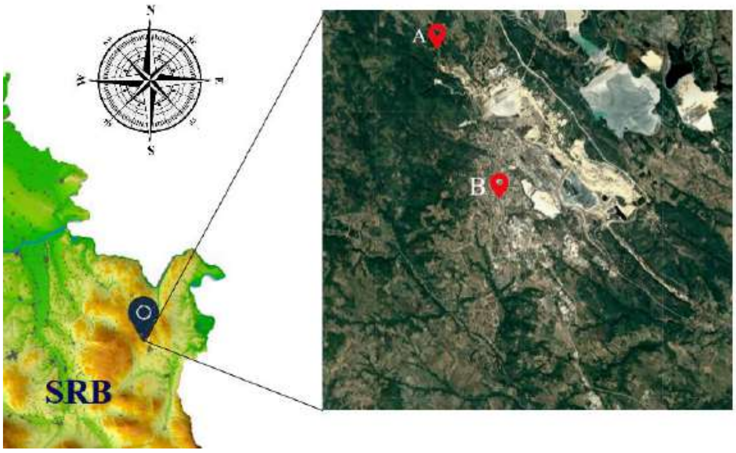

Figure 1 *Map of eastern Serbia and Bor with marked sampling points*

MPs extraction and observation

Soil samples were air-dried for two weeks and sieved through a 2 mm sieve. Soils were additionally dried in the heating oven at 60˚C to a constant weight, and then 5 g was measured for the analysis. Microplastic particles were extracted by the flotation method based on Zhou *et al*. (2019) [11]. Soils were covered with 60 ml of saturated NaCl solution with a density of 1.2 g cm^{-1} and left overnight. Around 30 ml of supernatant, was taken from the top with a glass dropper. The suspension containing MP and OM particles was filtered through stainless steel filter with a porosity of 20 µm. The filter was left in a 30% H_2O_2 solution in an ultrasonic bath for 10 min and rinsed thoroughly afterward. The suspension stood at 60˚C for 24h in order to digest the OM and filtered it through a steel filter. Observation and MPs counting was done using a polarizing microscope (Carl Zeiss Jena Pol-U).

RESULTS AND DISCUSSION

The average abundances of MPs in 5 g of soils from Amfi park and Brezonik were 19 and 3 MPs, respectively, i.e., 3800 items kg^{-1} and 600 items kg^{-1}, respectively.

Table 1 *Abundance and size distribution of MPs detected in soils*

Sample	Location	Sublocation	MPs kg^{-1}	MPs per 5 g of soil	Diameter (µm)				
					< 50	≈ 50	50–100	≈ 100	> 100
BOA	Bor	Citypark on II kilometer	3800	19	400	800	1000	800	800
BOB	Bor	Brezonik	600	3	-	400	200	-	-

"–" - no observed particles

MPs found in BOA were generally uniform regarding particle size distribution. Only 10% accounted for particles smaller than 50 µm, while the majority of them were between 50 and 100 µm in diameter. Knowing that the filter mesh size was 20 µm, the small-scale plastic pieces were in a size range of 20–50 microns. The proportion of 20% of MP debris was close to 50 µm, or 100 µm, and above 100 µm (Figure 2). Considering medium (50–100 µm) and larger (≥ 100 µm) particle size distribution is consistent with the results of previous studies, demonstrating MPs quantity increment with decreasing the particles size [12]. On the other hand, small plastic debris (≤ 50 µm) was less abundant than the medium-sized. Furthermore, the number of MPs around 50 microns was twice higher compared to the smaller ones. Some authors found dominance of MPs higher than 100 µm among detected particles [13,14]. Filters used during the extraction were not the limiting factor as the pore size was 2 µm and 7 µm, respectively.

Table 2 *MPs abundance, dominant size, shape and colors in investigated urban soils*

Location	MPs abundance (n kg^{-1})	Dominant size (%)	Dominant shape (%)	Dominant color (%)	Ref.
Baoding City, China	Not characterised	< 15 µm (49%)	Not characterised	Not characterised	[12]
Ahvaz metropolis, Iran	100–3135	100–250 µm (33%)	Fibers (70%)	White/transparent (52%)	[13]
City of Amsterdam, The Netherlands	4825 on average	190–400 µm (47%)	Not characterised	Not characterised	[14]
Beijing, China	22001.67 on average	< 500 µm (88.06%)	Not characterised	White/transparent	[15]
Shihezi City, China	287–3227	20–500 µm (64.8%)	Fibers (69.9%)	Black (36.7%)	[16]

The shape and color of the particles were consistent. All MPs were white to transparent colored. The only morphotype occurring was a fragment.

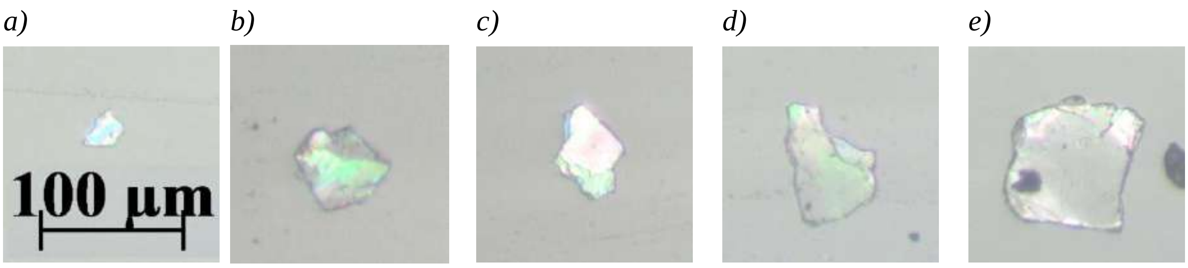

Figure 2 *MPs found in BOA a) < 50 µm; b) ≈ 50 µm; c) 50–100 µm; d) ≈ 100 µm; e) < 100 µm*

MPs detected in BOB were dominantly smaller-sized, i.e., around 50 µm in diameter or slightly larger (Figure 3). Particles were white and transparent fragments, without significant differences in their appearance from the ones found in BOA.

a) *b)*

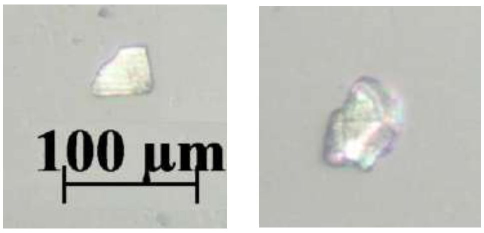

Figure 3 *MPs found in BOB a) ≈ 50 µm; b) 50–100 µm*

Although MPs abundance could be underestimated due to lower NaCl density than usually used $ZnCl_2$, it was generally accordant with the number of particles detected in recent studies in city areas in different countries, such as Ahvaz metropolis, Iran, Shihezi City, China, or Amsterdam, The Netherlands (Table 2), so as MPs color [15]. Contrary to these findings, revealing fibers as the most representative morphotype [16], MPs extraction from soils in Bor demonstrated that fragments are the only particle shape present. Detected MPs were possibly derived from the macroplastic disintegration. A closure of parking places, crowded sidewalks, resting places, and following anthropogenic activity likely affect outstandingly increased MPs abundance in BOA. Hence, MPs mostly originate from the weathered macroplastic pieces of frequently used products with plastic wrapping. The second sampling site is outside the urban city area, consequently considered less polluted with microplastic, due to the less frequent anthropogenic activity. MPs could also be transferred via long-distance migration, rainfalls, and aerial transport.

CONCLUSION

For the first time, microplastic presence was inspected in the soils of the city of Bor, known for its pollution with heavy metals due to high-level mining activities. Two sampling sites, urban and suburban, were selected for the examination. MPs detected in both locations were white to transparent fragments. A significant difference in the number of MPs between the two sites was noticed. Soil from the city park on II kilometer contained 6-fold more plastic particles than soils from Brezonik, which is likely affected by the excess overload of the consumed plastics, deemed to be one of the prevailing anthropogenic sources of MPs accumulation in urban environments. The future investigations will be focused on establishing if MPs act as vectors for other pollutants, i.e., finding the potential relation between heavy metals content and MPs' presence in the soils.

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