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CHARACTERISTICS OF MICROPLASTIC FROM SURFACE ROADSIDE SOIL IN SELECTED AREAS OF MON STATE, MYANMAR

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Abstract

In many nations, the widespread use of plastics represents an important environmental risk. The pollution caused by microplastics (MP) in soil settings is not well understood, yet. In this work, MP quantity and polymer type in roadside soil from Mawlamyine, Mudon, and Kyaikmaraw in Mon State were characterized. Soil samples were also separated by using density separation and the floating portions were collected. Under a microscope, the extracted microscopic fragments from the soil samples were analyzed, and then they were identified using FT IR. The concentrations of MP in roadside soils collected from Mawlamyine, Mudon, and Kyaikmaraw were 238 pieces/kg (dry weight) (n = 143), 147 pieces/kg (n = 47), and 150 pieces/kg (n = 42), respectively. Significant relationships between the total amount of MP in roadside soils and daily vehicle traffic were found in Mudon and Kyaikmaraw. The higher concentrations of MP in Mawlamyine compared to other collected areas may be due to the city's high population and traffic density. The analysis of soil samples showed that polyethylene and polypropylene were dominant, all of which are commonly used plastics. These findings indicate a relationship between MP profiles in roadside soil and differences in economics and populations.

Keywords: microplastics, microscope, roadside soil, polyethene, polypropylene, density separation

Introduction

There is increasing anxiety about the effects of microplastics (MP; plastics less than 5 mm in size), which have been found in the environment (Cole *et al*., 2011). They are a widespread environmental contaminant that can be found in soil, water, and the air. Plastics are utilized in a variety of industrial applications, including packaging, construction, vehicles, textiles, electrical materials, agriculture, household goods, and products for health and safety. About 8.3 billion tons of plastic have been produced worldwide in the last 65 years, and 60% of that quantity is considered to have been dumped into the ocean (Geyer *et al*., 2017). MP come in a variety of sizes and forms, including microbeads, fibres, fragments, film foam pellets, and filaments, to name a few (Wright and Kelley 2017). MPs are separated into primary and secondary MPs depending on where they came from. The characteristics of primary and secondary MP, such as colour, surface morphology, size, crystallinity, and density, alter as a result of continuous degradation. According to Rouillon *et al*. (2016), these changes may have an effect on their chemical and physical processes as well as on their environment and other life forms.

Globally, MP has been discovered in sources of soil, water, and air as well as in salt, beer, marine life, and, most recently, packaged drinking water (Schymanski *et al*., 2015). According to Wright and Kelley (2017), MP exposure may accumulate and deposit in human tissue and body parts, change the immune system, or result in various clinical issues. Worldwide reports of MP contamination and plastic waste have been reported. Road dust from Asian nations and considerable MP contamination in open dumping site soils have been the subject of recent

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investigations (Tun *et al*., 2022; Mon and Nakata, 2020). These findings imply that MPs in roadside soil may represent a significant terrestrial source in different nations. Additionally, Mon and Nakata (2020) reported the presence of microplastics in cosmetics sourced from Myanmar, but little is known about the distribution and dispersion of MPs in environmental matrices, such as road dust. The amount and distribution of MPs in roadside soil samples collected in different parts of Mon State were the focus of this study. Analysis was done on the various kinds of MP polymer and their probable sources in the environment.

Materials and Methods

Study Area

289,388 people live in Mawlamyine's urban area, compared to 197,703 in Mudon and 195,810 in Kyaikmaraw. A high car density is the effect of such a dense population. The entire study region is highly urbanized, has a high level of traffic, and has the largest quantity of land used for paving, building, and road surfaces. The historic center district, which has a lot of urban activity and frequent vehicular traffic, is at the center of the area under study.

Sample Collection

In November 2021, 30 roadside soil samples from Mon State's Mawlamyine (n = 15), Mudon (n = 8), and Kyaikmaraw (n = 7) districts were collected (Figure 1). By population density, Mawlamyine is the fourth-largest city in Myanmar. 30 urban and rural locations were used to collect soil samples from the side of the road. Using a clean brush and dustpan, all roadside soil samples were collected from the edge of a road and stored at -20 °C until examination.

(a) **(b)** **(c)**

Figure 1. (a) Sampling sites of the Mawlamyine Township (b) Mudon Township (c) Kyaikmaraw Township

Determination of Physicochemical Properties of Roadside Soil

The bulk density and moisture content of the soil samples collected from the side of the road were determined using the AOAC method (AOAC, 2002). The sample's pH was measured using a pH meter according to the conventional method.

Abundance and Polymer Identification

A method developed (Ken and Nakata, 2020) was used to determine MP abundances and polymer types in the roadside soil samples. Roadside soil samples weighing 40g were first strained using stainless steel sieves with a 1 mm screen. The sieved soil samples were exposed to 30 % hydrogen peroxide for three days at room temperature in a glass beaker covered with an aluminium sheet to study the decomposition of organic materials. The recovered soil samples were dried in an oven at 50 °C with a nylon filter with a 100 μm screen. Gravity separation was used to extract the microplastic from the dried samples. In beakers, the samples were exposed to a three-hour treatment of a 60 % sodium iodide (NaI) solution (1.8 g/cm^3). The NaI solution's floating solids were removed and filtered using a nylon filter, and the residues were then dried. For reuse, the NaI solution was filtered. With the use of tweezers, each MP candidate was removed from the filter and placed into a tiny plastic bag for examination under a microscope and with an FT IR spectrometer.

A stereo microscope (S9, LEICA, Germany) was used to obtain photographs of the potential microplastic candidates. The polymer type of each piece was then determined by attenuated total reflectance (ATR) FT IR (IR Affinity 1S, Shimadzu, Japan) analysis. Before sample analysis, background spectra were examined, and isopropyl alcohol (IPA) was used to clean the instrument detector. The types of plastics were identified by comparing sample spectra with those of a reference library database, and the FT IR wavenumber employed ranged from 600 to 4000 cm^{-1}. A 75 % or better match to the reference library was required for microplastic polymer identification to pass quality standards. Due to sample handling constraints, smaller MP fibres (maximum diameter of 100–300 μm) and rubber microplastics, such as styrene–butadiene rubber (SBR), were not examined in this work.

Results and Discussion

Aspect of Physicochemical Properties of Roadside Soil

The physicochemical characteristics of roadside soil samples from the Mon State region are shown in Table 1. pH, moisture, and bulk density are measurement parameters. In the Mawlamyine region, roadside soil samples collected at different points had a pH value in the range of 6.2-7.8, whereas those collected in the Mudon and Kyaikmaraw regions had a pH value in the range of 7.4-8.5. It could be classified as an alkaline soil type. Mawlamyine Township's roadside soil was determined to have a mo2isture level of 2-4.5 %. Additionally, it was found that the moisture content in Mudon Township was 2.5-4 % and Kyaikmaraw Township was 2-4 %. All roadside soil samples were found to have a bulk density of between 0.779 and 1.374 g/mL. The highest bulk density was notedp in M-1 and D-5, and the highest pH values in D-2, R-5 and R-6. The Ayethayar market (M-8) and the Myineyadana market (M-9) were found to have the highest moisture percentage in soil sample. As a result, all the physical properties of the roadside soil samples exhibited acceptable values.

Table 1. Some Physicochemical Properties of Roadside Soil Samples

Sampling sites	Sample ID	pH	Moisture (%)	Bulk Density (g mL^{-1})
Mawlamyine (n=15)				
railway station	M-1	7.8	3.00	1.291
bus station	M-2	7.6	3.50	1.252
downtown 1	M-3	7.7	2.00	1.000
downtown 2	M-4	6.6	4.00	0.779
no.1 market	M-5	6.8	3.50	1.008
Strand road	M-6	6.7	2.00	1.271
downtown 3	M-7	6.7	2.50	0.974
ayethayar market	M-8	6.2	4.50	0.963
myineyadana market	M-9	6.6	4.50	1.013
thanlwin market	M-10	6.3	3.00	0.798
hospital	M-11	6.2	4.00	1.268
university	M-12	7.2	3.50	1.200
air port	M-13	6.5	3.00	1.255
technology university	M-14	6.5	2.00	1.000
highway	M-15	6.8	3.50	1.008
Mudon (n=8)				
highway	D-1	7.8	2.50	1.250
gateway	D-2	8.5	3.50	1.000
downtown	D-3	8.3	4.00	1.271
shwehintar market	D-4	7.5	3.00	1.268
police station	D-5	8.3	4.00	1.374
myoma market	D-6	7.4	3.50	1.317
hospital	D-7	7.8	2.50	1.078
high school	D-8	7.5	2.50	1.035
Kyaikmaraw (n=7)				
police station	R-1	8.1	4.00	1.039
gateway	R-2	7.8	3.50	0.881
hospital	R-3	7.6	2.50	1.278
downtown	R-4	8.2	2.50	0.836
high school	R-5	8.5	3.50	1.268
myoma market	R-6	8.5	2.00	1.031
highway	R-7	8.1	2.50	0.807

Abundance of Microplastics in Surface Roadside Soil

In 30 surface roadside soil samples collected from the selected area of Mon State, microplastics (MP) were found. Microplastics were present in roadside soil samples in Mawlamyine at 238 ± 137 pieces/kg dry wt., Mudon at 147 ± 90 pieces/kg dry wt., and Kyaikmaraw at 150 ± 164 pieces/kg dry wt. (Table 2). The findings on microplastic concentration are in line with data on population, industrial activity, and traffic volume compiled by other researchers (Yukioka *et al*., 2020). With measured quantities of 150, 200, 250, and 275 pieces/kg dry weight, respectively, in D-3, D-4, D-6, and D-7 in Mudon, the abundance of microplastics was highest there (Table 2). High levels of vehicle traffic were present at these places, and D-3, D-4, and D-6 were close to commercial businesses in Mudon's downtown. The highest concentration of microplastic in roadside soils in Kyaikmaraw was found at R-6 (400 pieces/kg dry weight), followed by R-4 (375 pieces/kg dry weight). These sites are found in Kyaikmaraw's market and downtown areas. More roadside soil microplastics are present in Mawlamyine samples than in Mudon and Kyaikmaraw samples. Mawlamyine is Myanmar's fourth-largest city according to population density. This shows that there is a significant amount of microplastic contamination in the soil along the roads due to increased traffic brought on by Mawlamyine's densely populated area. The roadside soil in front of Thanlwin Market (M-10; 375 pieces/kg dry weight) had the highest concentration of microplastics, followed by No. 1 Market (M-5; 525 pieces/kg dry weight) and Railway Station (M-1; 425 pieces/kg dry weight). More than 200 pieces/kg dry wt. of microplastics were found in most Mawlamyine sample sites. These results show that microplastics are the dominant component in surface roadside soils.

Polymer Composition of Roadside Soil Microplastics

The different kinds of polymers in the microplastics isolated from roadside soils in samples collected in Mudon, Kyaikmaraw, and Mawlamyine were identified. The identification of microplastics in the surface roadside soil was carried out using FTTR. To assess the validity of different detection modes in FTIR, a confirmatory test was conducted using known standard polymers; polyethylene (PE), prolypropylene (PP), polyurethane (PU), and polyethylene terephthalate (PET) (Figure 2). Following polypropylene (PP; 32 %), poly (diallyl phthalate) (PDAP; 7 %), and polyvinyl chloride (PVC; 4 %), which made up the bulk of the microplastics in Mudon (55 % of the total; n = 47), the subsequent order was polyethene (PE), which made up the majority of them (Figure 3). PE and PP were abundant in D-1, D-3, D-6 and D-7 (Table 2). PE was found in 7 of the 8 sampling areas, with the largest amounts occurring at sites with significant activity in the market area, D-4, D-5, and D-6 (Table 1). Additionally, PVC and PET were found in samples from Mudon's D-2 and D-3 (Table 2), this might have been caused by the damaged wire insulating layer of electrical equipment (Chai *et al*., 2020).

Similar profile was also found in roadside soil sample from Kyaikmaraw, where PE (56%), PP (10%), PDAP (29%) and PVC (5%) (Figure 3). Every sampling site in Kyaikmaraw revealed PE, with site R-6 having the highest concentration (Table 2). PP was found in the roadside soil sample from site R-5 and R-6. Along with PDAP found at R-2, R-4, and R-5 (Table 3), they could be caused by the breakdown of urban building materials, their fragmentation, and their subsequent integration into roadside soil (Tun *et al*., 2023).

Table 2. Summary of Abundance and Polymer Types of MPs in Roadside Soils Collected from Mon State

Sample	Sample weight analyzed (g dry)	Abundance of MPs (pieces/ g dry wt.)	Abundance of MPs (pieces/kg dry wt.)	Number of Polymer types (pieces/g)						
				PE	PP	PS	PET	PVC	PDAP	PU
Mawlamyine (*n*=15)										
M-1	40	17	425	13	3				1	
M-2	40	14	350	10	4					
M-3	40	6	150						1	5
M-4	40	6	150	3						3
M-5	40	21	525	13	5	1	1		1	
M-6	40	12	300	4	8					
M-7	40	6	150	4	2					
M-8	40	8	200	2	4			1	1	
M-9	40	14	350	10	4					
M-10	40	15	375	6	8		1			
M-11	40	4	100		3		1			
M-12	40	5	125	2					3	
M-13	40	6	150	6						
M-14	40	3	75		3					
M-15	40	6	150	2	3				1	
			238							
Mudon (n=8)										
D-1	40	4	100	2	2					
D-2	40	2	50				1	1		
D-3	40	6	150	2	3			1		
D-4	40	8	200	6					2	
D-5	40	5	125	5						
D-6	40	10	250	6	3				1	
D-7	40	11	275	4	7					
D-8	40	1	25	1						
			147							
Kyaitmaraw (n=7)										
R-1	40	1	25	1						
R-2	40	2	50	1					1	
R-3	40	2	50	2						
R-4	40	15	375	3				2	10	
R-5	40	4	100	1	2				1	
R-6	40	16	400	14	2					
R-7	40	2	50	2						
			150							

PE: polyethene, PP: polypropylene, PS: polystyrene, PET: polyethene terephthalates; PVC: polyvinyl chloride; PDAP: poly-diallyl phthalate; PU: polyurethane

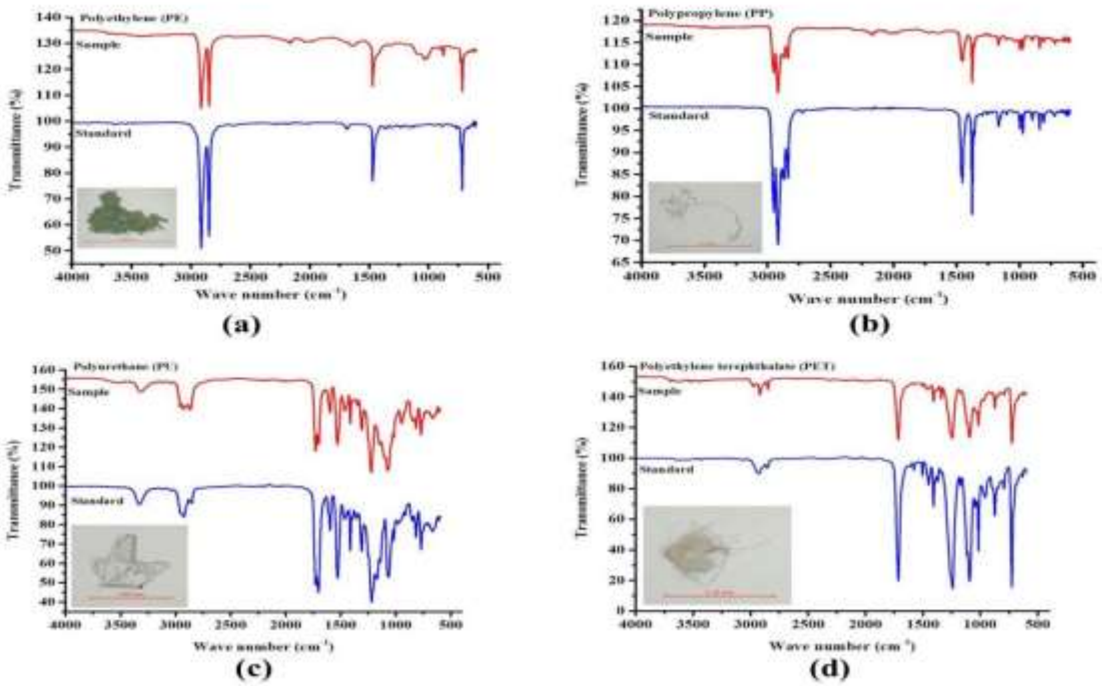

Figure 2. FT IR spectra of extracted microplastics from collected roadside soils in Mon State with reference library (a) polyethylene (PE) (b) polypropylene (PP) (c) polyurethane (PU) and (d) polyethylene terephthalate (PET)

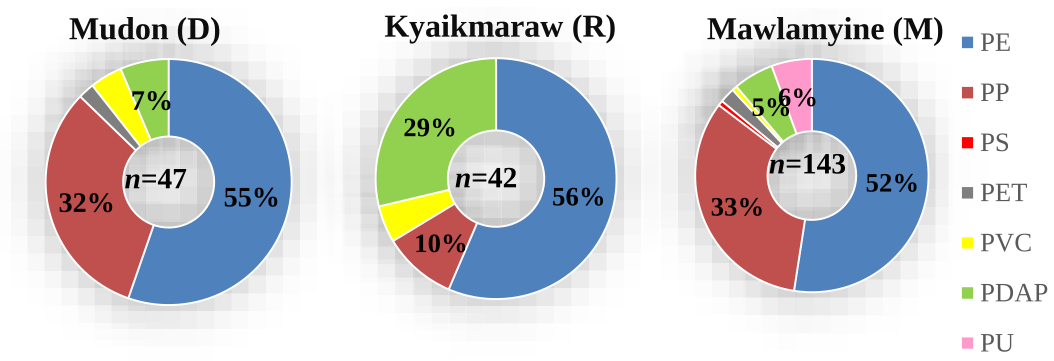

Figure 3. Pie chart diagrams of polymer compositions of microplastic in roadside soil samples from Mawlamyine, Mudon and Kyaikmaraw Townships

PE (n = 143) formed the majority of the MPs in Mawlamyine, accounting up 52 % of the total, followed by PP (33 %), polyurethane (PU; 6 %), and poly (diallyl phthalate; PDAP, 5 %). The M-5 sample, which was collected from an area close to a market, included large amounts of PE and PP, whereas PE and PP, which are typically found in home goods, were the main polymers found in Mawlamyine, Mudon, and Kyaikmaraw. According to Mon *et al*. (2022), PE and PP made up the majority of the MPs found in road dust collected from Myanmar, which may indicate that containers and packaging are probable sources of MPs.

Polymer Colour, Shape, and Size of Roadside Soil Microplastics

In Mawlamyine, an examination of the colour of the MP revealed that white or transparent was predominant (45 % of all the MP; *n* = 143), followed by red (26 %), green (16 %), and blue (10 %), in that order (Figure 4). The majority of MPs (30 %; *n* = 47) in Mudon were red, whereas the majority (55 %; *n* = 42) in Kyaikmaraw were blue. In Mawlamyine, Mudon, and Kyaikmaraw, the percentages of white or translucent MP were 45 %, 21 %, and 10 %, respectively (Figure 4).

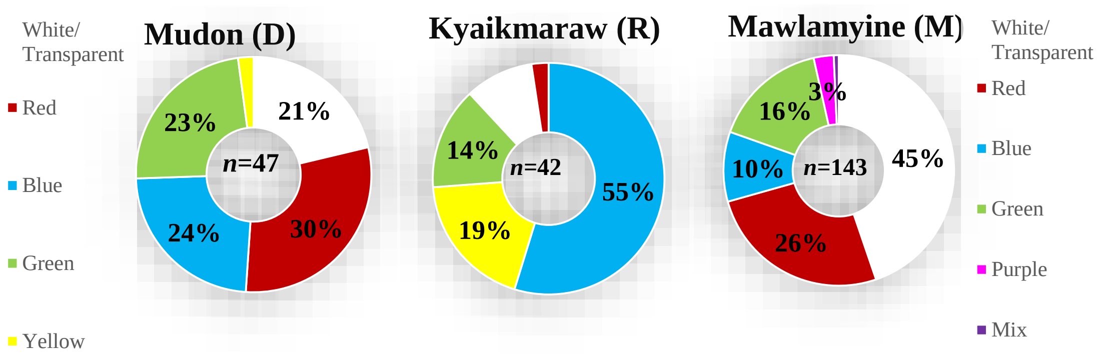

Figure 4. Pie chart diagrams of the colour of microplastic in roadside soil samples from Mawlamyine, Mudon and Kyaikmaraw Townships

Three types of MP shapes were identified: pieces, films or sheets, and lines or threads. In Mawlamyin (67 % of the total MP; *n* = 143), Mudon (91 %; *n* = 47), and Kyaikmaraw (90 %; *n* = 42), the majority of MP pieces were fragments (Figure 5).

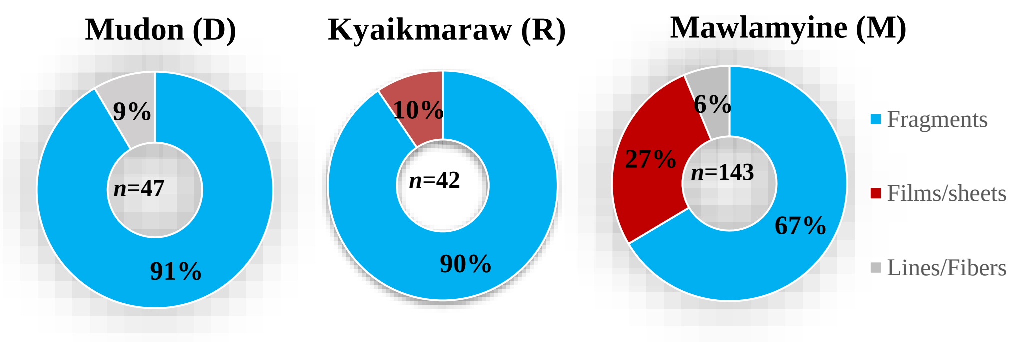

Figure 5. Pie chart diagrams of the shape of microplastic in roadside soil samples from Mawlamyine, Mudon and Kyaikmaraw Townships

Seven categories were used to categorize the size distribution of MP: 500, 500-1,000, 1,000-1,500, 1,500-2,000, 2,000-2,500, 2,500-3,000, and > 3,000 μm. For all MP in Mudon and 1000-1500 μm (33 %) in Kyaikmaraw, the most prominent distribution was 1000-1500 μm (26 %) (Figure 6). In Mawlamyine, the predominant distribution was >3,000 μm (38 %; *n*=143).

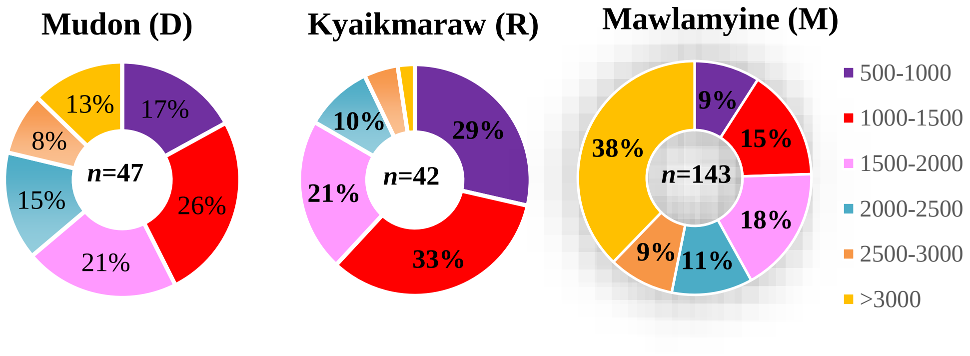

Figure 6. Pie chart diagrams of the size of microplastic in roadside soil samples from Mawlamyine, Mudon and Kyaikmaraw Townships

Conclusion

In this research, surface roadside soil samples were collected from thirty sites in Mon State, and microplastics were frequently detected. When the findings of this investigation and the literature are compared, significant levels of microplastic contamination are revealed. The highest MP abundances were detected in Mawlamyine (525 pieces/kg), Mudon (275 pieces/kg), and Kyaikmaraw (400 pieces/kg) in Mon State. Microplastic pollution of roadside soil was greater in Mawlamyine, which has the largest population and highest traffic density of all areas sampled in this study. PE and PP were the two main plastic polymers in the MPs found in the soils along the sides of the roadways, suggesting that consumer goods and road paints may be possible sources of MPs in the road dust. MPs concentrations in roadside soil were slightly correlated with population size, suggesting that human activities are a major source of MPs in roadside soils. This study showed that polyethylene plastics are the dominant component of microplastics in roadside soils. Because of this, research on microplastic contamination should be accelerated, and public awareness of the problem should be raised daily, leading to a greener environment.

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