J. Myanmar Acad. Arts Sci. 2026 **Vol. XXIII. No.1A**

AN ENVIRONMENTAL STUDY ON MICROPLASTICS AND HEAVY METAL POLLUTION IN KALAY CITY'S ROADSIDE SOILS*

Mang Sial Thang[1], Mya Thandar Aung [2], Ye Myint Aung [3]

Abstract

Microplastics (MPs) are pollutants a growing environmental concern, particularly in soils, where their impacts on ecosystems and human health at risks. This study examines roadside soil contamination in Kalay Township, Sagaing Region, focusing on MPs and heavy metals. Ten soil samples were collected in 2021, and SEM-EDX analysis revealed varying concentrations of silicon, iron, and calcium. AAS confirmed calcium, iron, and potassium presence, with concentrations up to 57.40 ppm. Polyethylene (PE) was the most prevalent type of microplastic (66 %), followed by polypropylene (PP) (30 %), with an average of 92 pieces/Kg of dry soil. MPs primarily appeared as fragments (96 %), ranging between 1000-1500 µm in size. MPs can adsorb potentially toxic elements (PTEs), facilitating their movement in soil and increasing human health risks. This combined contamination poses significant dangers, leading to bioaccumulation of toxic metals, potentially causing organ damage and developmental disorders. The study emphasizes the urgent need for policy interventions, advocating for circular economy strategies and the 3R approach (reduce, reuse, and recycle) as critical measures to combat soil pollution and protect public health.

Keywords: Microplastic contamination, Heavy metals, Roadside soils

Introduction

Microplastics (MPs) and heavy metal contamination are emerging environmental issues that present serious risks to both ecosystems and human health. MPs, defined as plastic particles smaller than 5 mm, have been increasingly recognized as persistent pollutants in various environments, including marine ecosystems, freshwater bodies, and terrestrial soils (Thompson *et al.,* 2004). Roadside soils, particularly, are vulnerable to contamination from vehicle emissions, tire wear, improper waste disposal, and industrial activities, leading to the accumulation of both MPs and potentially toxic elements (PTEs) such as heavy metals (Kane *et al.,* 2020). In Kalay Township, located in the Sagaing Region of Myanmar, increased urbanization and traffic density have contributed to the heightened presence of these pollutants in roadside soils.

MPs can act as vectors for other soil contaminants, especially heavy metals, by facilitating their adsorption and transport in the environment (Wang *et al*., 2020). This adsorption occurs primarily through electrostatic attraction and surface complexation, which increases the mobility of PTEs like lead (Pb), cadmium (Cd), and chromium (Cr) in the soil (Tang *et al.,* 2019). Such complexes can be taken up by plants and enter the food chain, raising concerns about human health impacts through the consumption of contaminated crops. Previous research has shown that MPs not only increase the availability of heavy metals in soils but also enhance their transfer to plants, posing a significant threat to both environmental and food safety (Peng *et al.,* 2017).

In Kalay Township, the combination of MPs and heavy metals in roadside soils presents a heightened risk of human exposure. Potential exposure routes include inhalation, dermal contact, and ingestion of contaminated food products (Zhang *et al.,* 2018). Chronic exposure to heavy metals such as lead and cadmium has been linked to serious health issues, including neurological damage, respiratory diseases, and an increased risk of cancer (Jarup, 2003). Moreover, the

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* Third Prize (2024)
[1] Department of Chemistry, University of Yangon
[2] Department of Chemistry, University of Yangon
[3] Department of Chemistry, University of Yangon

ingestion of MPs can lead to gastrointestinal issues, oxidative stress, and further complications due to the toxic substances they carry (Wright and Kelly, 2017).

In response to the growing concern about the environmental and health risks posed by microplastics (MPs) and heavy metal contamination, this study focuses on assessing the contamination levels in roadside soils of Kalay Township. By analyzing the concentrations and interactions between MPs and heavy metals, this research aims to provide a clearer understanding of the environmental and health implications, while advocating for policy interventions and better waste management practices to mitigate the contamination.

Materials and Methods

Sample Collection

In 2021, ten roadside soil samples were collected from various locations in Kalay Township, Sagaing Region. The sampling sites included Lanson Road (K-1), Kalay University (K-2), Bogyoke Road (K-3), Downtown (K-4), Kalay Market (K-5), Bus Station (K-6), Myopat Road (K-7), Myothi Market (K-8), Pinlong Road (K-9), and Tahan Market (K-10). Soil samples were collected using a clean wooden brush and dustpan to prevent contamination, and the collected soils were passed through a 5 mm mesh sieve to remove larger particles. The sieved samples were then stored in airtight containers for further investigation.

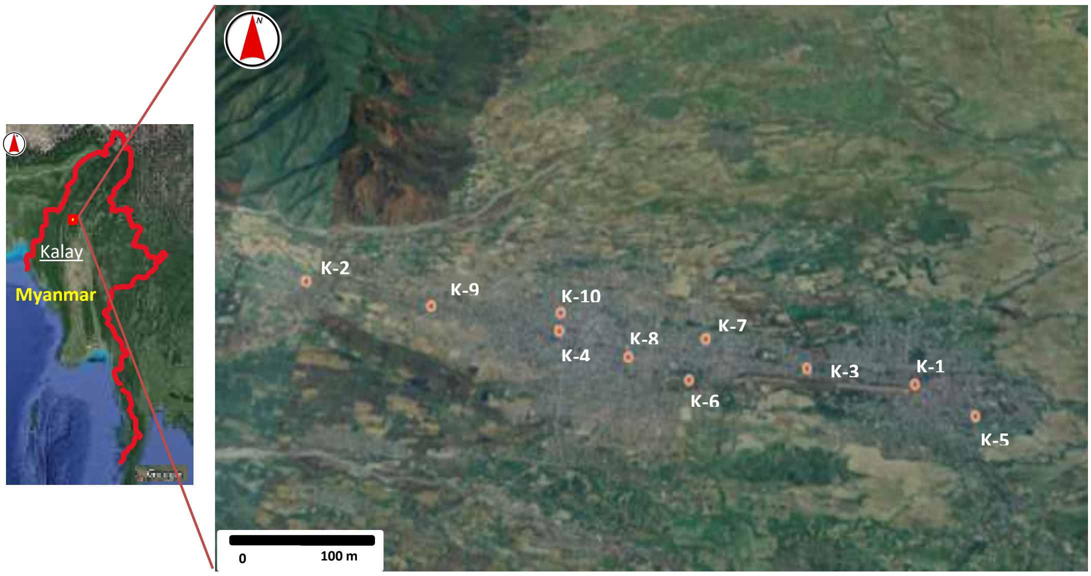


Figure 1. Ten sampling sites of roadside soil samples from Kalay Township

Preparation of Soil Samples

A 500 g portion of each soil sample was air-dried at room temperature for three days. To avoid contamination, sieving was conducted under controlled laboratory conditions. After air-drying, 50 g of each sample was placed into a 1 mm sieve, and any particles larger than 1 mm were discarded. The samples were stored in airtight containers and kept in the laboratory for further analysis.

Preparation of a 60 % Saturated Sodium Iodide Solution

Sodium iodide (300 g) was weighed and transferred into a 500 mL beaker. To this, 200 mL of distilled water was added slowly while stirring with a glass rod until the NaI was fully dissolved.

Fourier Transform Infrared Spectroscopy (FT IR)

Extracted microplastics and fragments were examined by a microscope and identify the type of sample by FT IR spectroscopy. This study was made at the Nakata Laboratory, Kumamoto University, Japan. This technique was employed to identify and characterize microplastic polymers in the soil samples by comparing the spectra with reference libraries.

Atomic Absorption Spectroscopy (AAS)

AAS was used to measure the concentrations of metals such as calcium (Ca), iron (Fe), and potassium (K) in the soil samples.

Energy-Dispersive X-ray Fluorescence (EDXRF)

EDXRF analysis was conducted to determine the elemental composition of the soil samples, including the presence of potentially toxic elements (PTEs).

Results and Discussion

Identification of MPs by FT IR Spectroscopy

The identification of microplastics (MPs) in 8 out of 10 locations in Kalay Township highlights an alarming spread of polymer particles across varied environments. Among the types of polymers analyzed, polyethylene (PE) was the most frequently detected, appearing in the majority of the samples. This finding is consistent with the global plastic consumption pattern, where PE's versatility and low manufacturing cost make it a predominant player in the market. The prominence of PE in roadside soils can be attributed to its widespread use in packaging, bags, and other disposable products that are often improperly discarded and subject to environmental degradation.

All MP candidates that match 75 % or more with the reference libraries, including the Aldrich Standard, were examined, while those matching less than 75 % were discarded. The FI IR spectra of standared microplastics and microplastics detcted in roadside soil samples were shown in Table 1 and Figure 2.

The variation in MP (microplastic) levels across locations suggests influences such as waste management efficiency, traffic, and environmental awareness. Tahan Market and Downtown show moderate MP levels, likely due to increased human activity and plastic usage. In contrast, lower MP counts at Myopat Road and Kalay University may point to reduced pollution sources or better waste management.

Table 1. Polymer Types Detected of MPs in Roadside Soils Collected from Kalay Township

No.	Location	Sample ID	Sample weight analyzed (g dry)	PE	PET	PP	PS	Total
1	Lan Son Road	K-1	50	10		3	1	14
2	Tahan Market	K-2	50	3		2		5
3	Bogyoke Road	K-3	50	9		5		14
4	Downtown	K-5	50	3		2		5
5	Bus Station	K-6	50	3		1		4
6	Myopat Road	K-7	50	1		1		2
7	Myothi Market	K-8	50		1			1
8	Kalay University	K-10	50	1				1

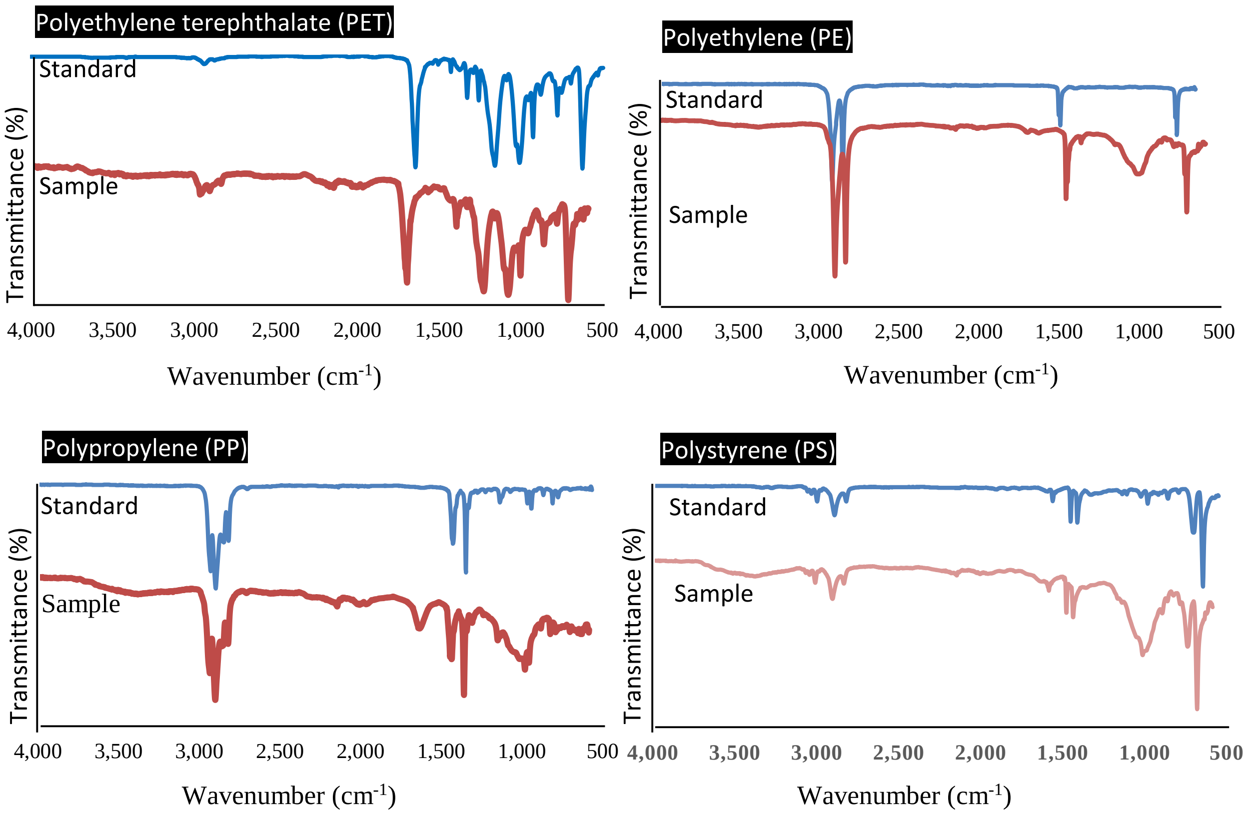


Figure 2. FT IR spectra of microplastics detected in the collected roadside soil samples from Kalay Township

Polymer Type, Shape, Color and Size of MPs in Roadside Soilsx

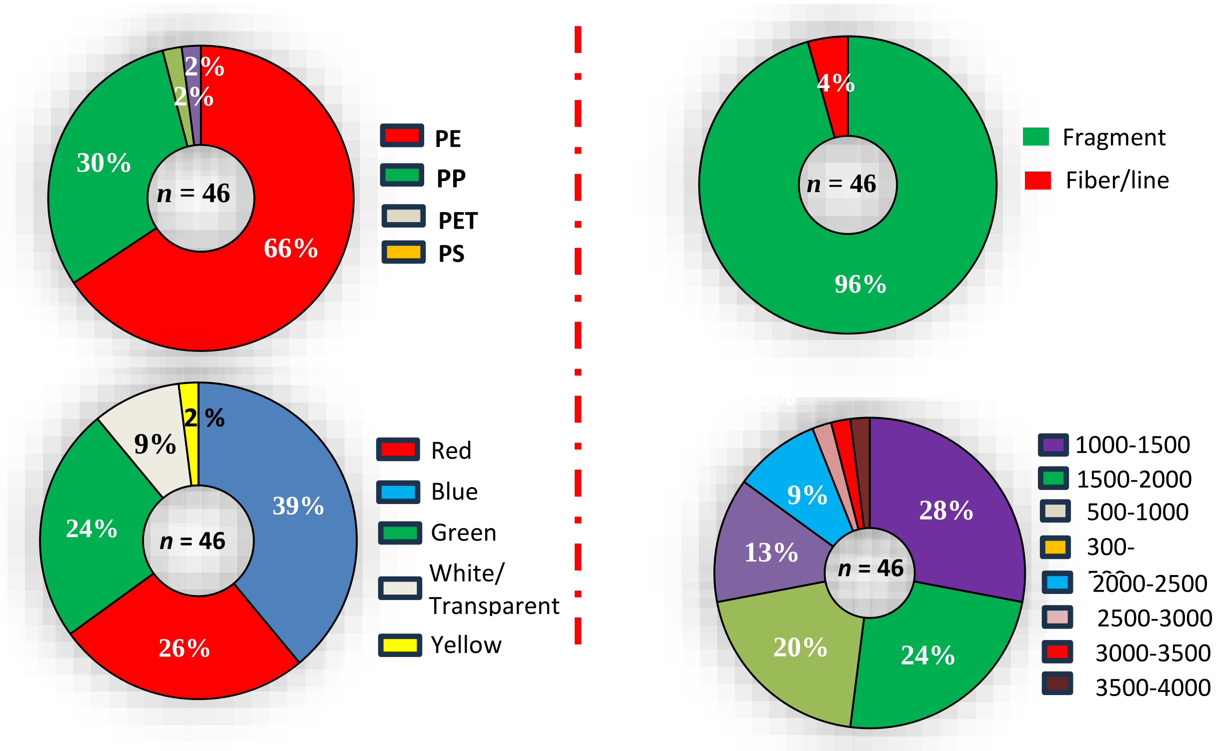
The analysis of microplastics (MPs) in roadside soils provided important insights into their polymer type, shape, color, and size distribution, offering clues about their origins and environmental impact (Figure 3).

MPs were mainly fragments (96 %), with fibers/lines making up 4 %. The dominance of fragments likely results from the breakdown of larger plastic items like packaging and bags, degraded by environmental factors such as UV radiation and physical wear.

Blue was the most common MP color (39 %), followed by red (26 %), green (24 %), white/transparent (9 %), and yellow (2 %). The dominance of blue and red suggests these colors are widely used in plastic products like bags and containers, helping trace MP origins to specific industries.

MPs were grouped into eight size categories, with 1000-1500 µm being the most common (28 %), followed by 1500-2000 µm (24 %) and 500-1000 µm (20 %). Around 90 % of the MPs were smaller than 1 mm, likely due to the fragmentation of larger plastics and input from smaller plastic products, consistent with previous studies of roadside soils.

The findings emphasize the need for better waste management and increased public awareness of plastic pollution, highlighting the urgent environmental challenge of microplastics and the importance of targeted mitigation efforts.



PP= Polypropylene, PE= Polyethylene, PET= Polyethylene terephthalate, PS= Polystyrene

Figure 3. Pie chart of polymer type, shape, color and size of MPs in Kalay Township

Comparison of Microplastic Distribution by Location

The highest concentrations of microplastics were found at Lan Son Road (K-1) and Bogyoke Road (K-3), each with 14 particles, primarily polyethylene (PE). In contrast, Myothi Market (K-8) and Kalay University (K-10) had the lowest contamination, with just one particle each PET at Myothi Market and PE at Kalay University, as shown in Figure 4. This suggest that microplastic distribution varies significantly due to local human activities and waste management practices.

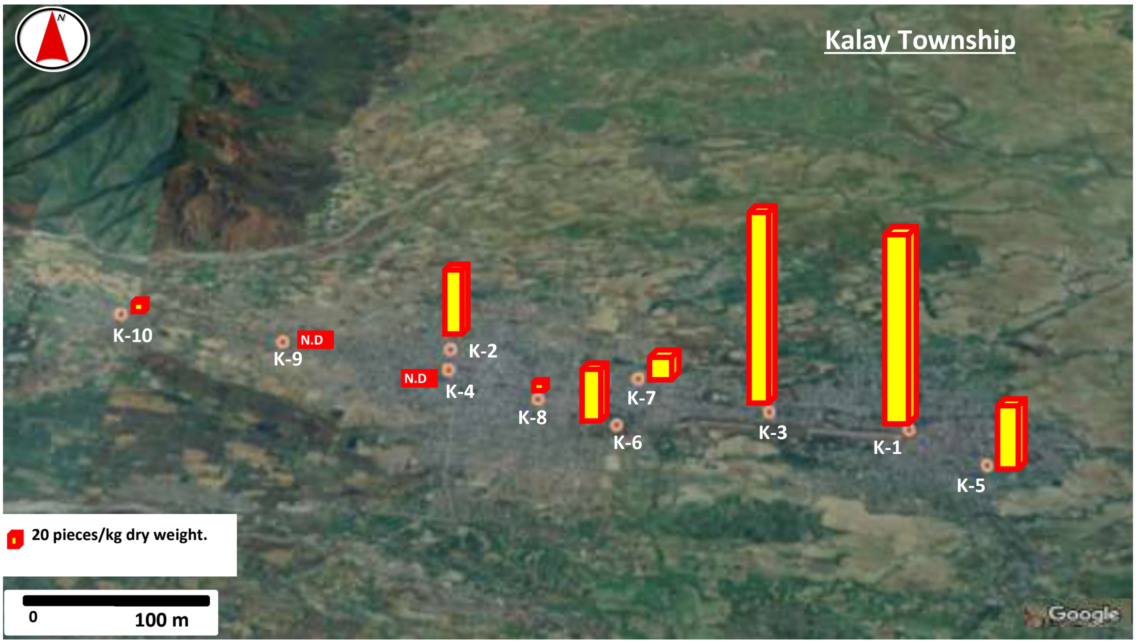


Figure 4. Distribution of microplastics in roadside soil samples from Kalay Township

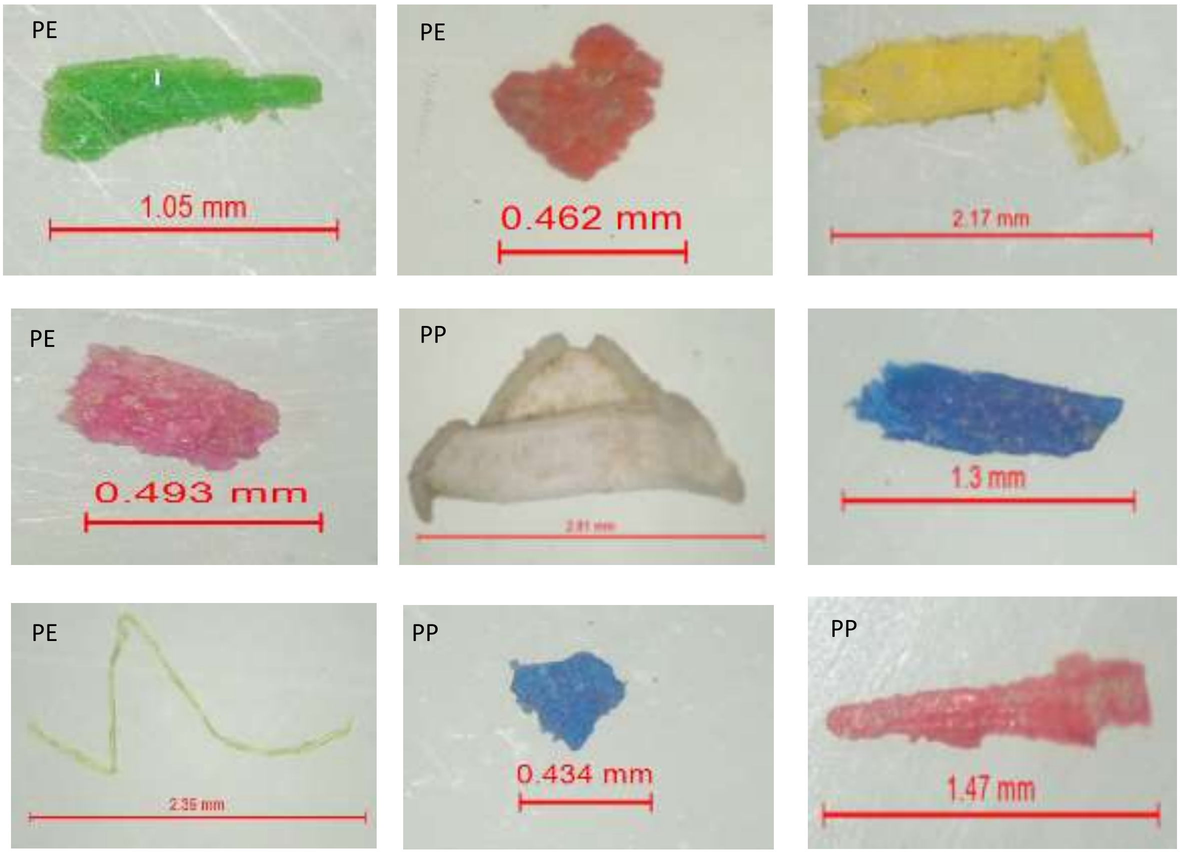


Figure 5. Some detected microplastics in the collected roadside soil samples

Elemental Abundances and Soil Quality

The analysis of the soil samples from Kalay Township reveals a consistent presence of major elements like silicon, iron, calcium, and potassium, with trace elements such as barium, manganese, and chromium present in smaller quantities. The high carbon and hydrogen content points to substantial organic matter, while the AAS data supports the findings from EDXRF regarding the distribution of calcium, iron, and potassium. This data provides a comprehensive understanding of the soil composition, which is essential for agricultural and environmental assessments in the region, as shown in Table (2).

Table 2. EDXRF Result Data of Soil Samples (Site 2, 4, 6, 8 and 10) in Kalay Township

Elements	Relative Aboundance (%)				
	Site-2	Site-4	Site-6	Site-8	Site-10
Silicon (Si)	4.175	1.546	2.265	-	3.086
Iron (Fe)	0.525	0.419	0.634	0.245	0.411
Calcium (Ca)	0.136	0.224	0.088	0.088	0.141
Potassium (K)	0.219	0.128	0.199	0.074	0.121
Titanium (Ti)	0.066	0.038	0.051	0.025	0.036
Barium (Ba)	0.018	-	-	-	0.011
Manganese (Mn)	0.012	0.007	0.017	0.004	0.006
Chromium (Cr)	-	0.003	0.006	0.003	0.007
Strontium (Sr)	0.002	0.001	0.001	0.001	0.001
Zinc (Zn)	0.002	0.001	0.002	0.001	0.001
Zirconium (Zr)	-	0.002	0.003	-	-
Nickel (Ni)	0.001	-	0.002	0.001	-
Silver (Ag)	-	-	0.004	0.003	-
Copper (Cu)	0.001	0.001	0.001	-	-
Yttrium (Y)	0.001	-	-	-	-
Vanadium (V)	-	0.002	-	-	-
Rubidium (Rb)	0.000	-	-	0.000	0.001
Carbon Hydrogen	94.843	97.628	96.710	99.552	96.176

Table 3. Some Element Contents (Ca, Fe and K) Present in Roadside Soil Samples by AAS

Sample	Content (ppm)		
	Ca	Fe	K
K-2	35.17 $\pm$ 0.292	12.09 $\pm$ 0.013	4.194 $\pm$ 0.005
K-4	57.40 $\pm$ 0.490	12.31 $\pm$ 0.021	2.782 $\pm$ 0.020
K-6	11.06 $\pm$ 0.143	12.39 $\pm$ 0.002	3.083 $\pm$ 0.030
K-8	35.40 $\pm$ 0.289	12.37 $\pm$ 0.007	2.494 $\pm$ 0.038
K-10	48.57 $\pm$ 0.697	12.52 $\pm$ 0.008	2.417 $\pm$ 0.020

As shown in Table (3), the analysis of calcium (Ca), iron (Fe), and potassium (K) levels in roadside soils reveals significant differences that may reflect soil quality variations due to natural or human influences. High calcium (Ca) levels could be linked to limestone or anthropogenic sources like road salts, while the consistent Fe suggests its natural abundance and crucial role in soil and plant health. Variations in K indicate soil or agricultural differences, given its importance for plant growth.

The elemental soil composition has implications for human health, with calcium (Ca) and potassium (K) being vital for bone strength and cardiovascular health. Soils enrich crop nutritional quality, but excessive Fe could pose risks if it contaminates water sources. Additionally, soil elements' interaction with microplastics may release toxic compounds, posing further health risks through the food chain or water contamination.

Conclusion

The investigation about the microplastics particularly due to polyestere (PE) and heavy metal contamination on roadside soils of Kalay Township reveals significant environmental and health concerns because of their spread across varied environment. The prevalent microplastics, primarily polyethylene, and consistently detected heavy metals indicate serious roadside pollution linked to human activities. These contaminants threaten soil quality, water resources, and food security, potentially leading to toxic bioaccumulation in the food chain. To protect both the ecosystem and human health in Kalay Township, it is essential to implement stricter pollution controls, improve public awareness, and enforce stronger regulations on plastic use and waste management.

Acknowledgements

The authors would like to thank the Department of Higher Education, Ministry of Education, Yangon, Myanmar. We would like to express our sincere thanks to Dr Tin Maung Tun (Rector) and Dr Khin Chit Chit, Dr Cho Cho, and Dr Thidar Aye (Pro-Rectors), University of Yangon. Our warmest thanks are also extended to Professor Dr Ni Ni Than, Head of the Department of Chemistry, University of Yangon, for her kind encouragement, and permission to submit this research paper and gave many helpful suggestions.

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