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Morphochemical Composition of Soil Microplastics in Lampung Landfill Using Microscopy and FTIR Spectroscopy Method

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Abstract

Background: *Plastic debris smaller than 5 mm is categorized as microplastic, a pollutant with persistent characteristics that often contains toxic or carcinogenic compounds. These particles can infiltrate soil systems, migrate into the food chain, and ultimately threaten both environmental integrity and human health. This research focuses on identifying the types and quantifying the abundance of microplastics in soils collected from three final disposal sites in Lampung Province, Indonesia.* **Methodology:** *Sampling at three landfill points was carried out purposive sampling method, with microplastics sample analyzed through visual inspection by microscopy and polymer composition confirmed using Fourier Transform Infrared (FTIR) Spectroscopy Method.* **Findings:** *Landfill sites B1 and C1 exhibited the highest abundance of microplastics, reaching 195 particles per kilogram of soil. The particles displayed morphological diversity, including fragments, fibers, and films, with fragments representing the predominant category. The color distribution was largely transparent, black, and brown, while the detected particle sizes ranged from 2.12 to 110.25 µm. Polymer analysis revealed the presence of polyethylene (PE), polyamide, and polystyrene, alongside particles suspected to be polyethylene terephthalate (PET). These findings indicate that physical and chemical degradation processes accelerate the breakdown of plastics into smaller fragments, thereby contributing to elevated microplastic levels in landfill soils.* **Contribution:** *The outcomes of this research, derived from visual microscopy and FTIR Spectroscopy-based identification of microplastics in Lampung landfill soils, The findings offer essential data for the development of monitoring frameworks and risk assessment strategies related to soil and environmental risks in the region.*

Keywords: *Contaminated Soil; Garbagel; Microplastics; Landfill; Plastic Waste*

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INTRODUCTION

Due to the increasing amount of plastic waste, plastic use has now become a global issue. Plastic is widely consumed because it is practical and inexpensive. The amount of plastic waste produced is predicted to increase fourfold by 2050 due to the number of people worldwide who use plastic for their daily needs (Suaria et al., 2016). However, because plastic waste is difficult to decompose in nature, it is now recognized as a global environmental pollution problem (Amaral-Zettler et al., 2015). Plastic waste and microplastics have become a matter of international concern in recent decades. Plastic is widely used in every aspect of daily life, from household appliances to food packaging.

However, excessive plastic use and poor waste management have led to a global increase in plastic waste (Putra et al., 2019). Human daily activities cause plastic to spread widely in terrestrial environments. In industrial zones, plastic is found between 0.03 % and 6.7 % in road surface soil (Fuller & Gautam, 2016). On the soil surface, ultraviolet radiation and high temperatures can break down plastic into microplastics (MP). Then, through the movement of soil organisms and human activities, microplastics (MP) are transferred to deeper soil layers (Horton et al., 2017). On the New England coast of North America, microplastics were first discovered in the 1970s. Plastic that has broken down into small pieces measuring 0.3 – 5 mm is called microplastic (Dehaut et al., 2016).

Microplastics originate from plastic waste in homes, businesses, markets, and landfills that degrade in nature. Microplastics can enter landfill soil through various channels. First, domestic and industrial waste containing plastic can cause microplastics to accumulate in landfills (Pratiwi et al., 2024). Once this waste decomposes naturally or through waste decomposition processes, microplastics can be released and seep into the soil layers of the landfill. Additionally, environmental conditions around landfills, such as soil activity and rainfall levels, can also contribute to microplastic accumulation. Due to high temperatures, ultraviolet radiation, and oxygen present in the landfill, plastic can break down into microplastics within 20 years (Wojnowska-Baryła, 2022).

As carriers of chemicals, microplastics contain hazardous or toxic chemicals and can cause physical damage. Human exposure to microplastics and nanoplastics can occur through inhalation, consumption, and/or skin contact. The three main ways they enter the human body are through inhalation, consumption of contaminated food and beverages, and skin contact. Some microplastic polymers, such as polyethylene, polyethylene terephthalate, and low-density polyethylene, have been shown to cause health problems in laboratory animal studies. Nanoplastics and microplastics pose a high risk of chronic toxicity, such as cardiovascular toxicity, hepatotoxicity, neurotoxicity, and genotoxicity.

Human exposure to microplastics may pose risks of oxidative stress, cytotoxicity, neurotoxicity, and immune system disruption, and microplastics are distributed throughout the human body via the bloodstream. Tests conducted on polyethylene terephthalate microplastics using laboratory animals showed that microplastics can cause weight loss, cysts, intestinal obstruction, damage, and death in 40% of individuals; another study showed that administration of low-density polyethylene microplastics resulted in the presence of microplastic particles in the blood of laboratory animals, with higher levels of microplastic particles in the blood leading to increased expression of malondialdehyde and 8-OHdG metabolites in hippocampal neurons, the results indicating damage to hippocampal neuronal membranes and deoxyribonucleic acid. If microplastics are found in the placenta of a pregnant woman, it can cause issues with metabolism and reproductive processes. Recent studies show that polyethylene, polypropylene, and polymerized styrene form microplastics in human bloodstreams, and other research indicates that microplastics are found in human lungs through inhalation.

Microplastics are most commonly found in the lower regions of the lungs. Microplastics that contaminate humans can enter organs through the bloodstream. Polystyrene microplastics entering the bloodstream can cause hemolysis and, at high concentrations, can cause inflammation. Thus, the toxic effects of microplastics on human health still need to be studied. If exposed regularly and in large quantities, microplastics can cause toxicity issues, both acute and chronic, recent research focuses on identifying the types of microplastics as a basis for searching for effective microbes in their biodegradation.

This identification is essential not only to develop environmentally friendly decomposition methods, but also to enrich soil biota to support healthier ecosystems. Field research has shown a diversity of microplastics, such as fragments, fibers, films, foam, and pellets. Case studies at several landfills in Lampung – for example, Bakung Landfill, Karang Rejo Landfill, and Bumi Ayu Landfill – reveal that the presence of microplastics is increasingly disrupting the environmental balance. These landfills are overloaded due to suboptimal management, which also causes air, soil, and water pollution. This condition endangers not only the environment but also the health of local communities through the potential entry of microplastic particles into the food chain.

Final Processing Sites (TPA) are final disposal sites for various types of waste, including plastic waste, which are now experiencing overload conditions, especially in Lampung province (Serly et al., 2013). Microplastics derived from this plastic waste have been identified in the landfill environment and its surroundings through various methods, such as microscopic analysis and FT-IR spectrophotometry. Research at the Piyungan Bantul Landfill revealed that the highest abundance of microplastics is found in Zone 3, with a variety of shapes that include fragments, fibers, films, foam, and pellets, as well as various colors. FT-IR analysis in the study identified 26 polymers, with the closest choices being Tencel, Cellopha, Ramie, Cotton, and Polyacetylene, which are derived from fragment, fiber, and film microplastics (Utami et al., 2021).

Studies on agricultural land around the Piyungan Yogyakarta Landfill using the grab sampling method and density separation (using NaCl and $ZnCl_2$ solutions) showed variations in microplastic abundance between locomotives, with the dominance of film, fragment, and fiber forms. Another study on coastal sediments on the coast of North Sangatta District found that the identified microplastics consisted of films, fibers, foam, and fragments. The data showed the highest average abundance at station 1, indicating potential contamination of marine life and health risks through the food chain 2021 In addition, research on groundwater around the

Talang Gulo Landfill, Jambi, with tests using stereo microscopes, identified microplastics based on size, color, and shape (filaments, fibers, and fragments) with abundances of up to 370 particles/liter (Dewi et al., 2025).

Overall, From some of these studies, it can be concluded that microplastics generally consist of fibers, fragments, and films. This information not only provides an overview of the distribution and characteristics of microplastics, but also provides an important basis for further research, especially in the development of a Biodegradation strategy using effective microbes, to reduce the impact of microplastic pollution in a sustainable manner. An improved understanding of microplastic characteristics and spatial patterns within landfill environments serves as the basis for exploring microbial-mediated biodegradation strategies. These findings are expected to contribute to sustainable approaches in plastic waste management, with significant implications for pollution mitigation, public health, and ecosystem preservation.

METHOD

This study was conducted from January to March 2025 and lasted for three months. Figures 1, 2, and 3 show the sampling locations at the Karangrejo, Bakung, and Bumi Ayu landfills. Samples were taken from 0 to 5 cm depths, and a purposive sampling method was used for each landfill. Laboratory analysis was conducted at the Raden Intan State Islamic University in Lampung. The samples were obtained with sterile shovels, transferred into ziplock plastic bags, properly labeled, and kept in a cooler prior to laboratory analysis.

Procedure Research

The amount of microplastics found in soil samples from the studied landfills is described in this study through the use of descriptive quantitative techniques and field research methods. Microplastics contained in the soil are the population in this study. The research consisted of several main stages. Initially, the soil samples were dried at 70 °C for 24 hours to eliminate moisture content. Subsequently, the samples were treated with a saturated sodium chloride solution (35.7 %) and stirred using a magnetic stirrer for one hour to enable density separation, followed by 24 hours of settling. The organic matter was removed by applying the water peroxide oxidation (WPO) method with 30 % H_2O_2, stirred for 24 hours at 65 °C. Finally, microplastics were isolated from the samples using Whatman filter paper mounted on an Erlenmeyer flask.

Microscopy and Fourier Transform Infrared Spectroscopy (FTIR) of Microplastics

Using 2 methods were used to perform the analysis stage. The number, shape, and color of microplastics in the sample were identified using a 10x magnification stereo microscope. This analysis can help understand the presence, type, and abundance of microplastics in each zone of the three landfills. Description: Presence and Abundance of Microplastics:

a. Presence of Microplastics (Dry Soil Weight Particles) = Number of Microplastics in Soil (Particles) Dry Soil Weight (Gram).

b. Calculation of Percentage of Type and Color: Percentage (%) = Number of Particles of Type or Color (Particles) Total Number of Particles of Type and Color (Particles).

Data analysis

Data analysis on the type and color of microplastics was conducted by counting the number and percentage of each type. Data analysis using FTIR equipment involves measuring infrared intensity on samples that were previously observed on filter paper. Infrared intensity is measured at wavelengths read by the FTIR device. FTIR wavelength readings can include molecular structure and how the sample resembles chemical functional groups. After the FTIR analysis is complete, the next step is to process the data. Based on the sample codes that have been tested, the processed data is then presented in tables and graphs. In this data processing, information about the color, type, and shape of microplastics in the soil at the Bakung, Bumi Ayu, and Karangrejo landfills is combined with data from FTIR readings for chemical compounds, types, and colors to provide a more complete picture of the microplastic contamination at these locations. In this study, data was collected through direct observation of sample conditions in the field and documentation from various sources, including literature, research journals, and other relevant documents such as Xu et al., (2020); Yang et al., (2021); Sun et al., (2021). This research method was intended to obtain accurate information about the amount of microplastics and their properties contained in the soil at the landfill site.

RESULT AND DISCUSSION

Fragmentation of plastic waste within landfill soils detected represent the degradation products of plastic waste accumulated in the landfill soil. As illustrated in Figure 4, sampling points B1 and C1 exhibited the highest abundances, each reaching 195 particles/kg, attributed to their direct exposure to environmental stressors, including UV light and temperature variation. Conversely, reduced quantities were found at A3 (169 particles/kg), B3 (185 particles/kg), and B2 (186 particles/kg).

Significant differences in microplastic particle counts were evident between locations. Sites A2, B1, and C1 exhibited the highest levels, nearing 195 particles, while the lowest abundance was detected at A3 with around 169 particles. Intermediate abundances, ranging between 180 to 192 particles, were identified at A1, B2, B3, C2, and C3. These spatial variations are likely influenced by varying degrees of anthropogenic activity within the landfill environment.

Additionally, environmental factors such as sunlight exposure, humidity, and water flow also influence the rate of plastic degradation; conditions that promote degradation break down plastic more quickly, increasing microplastic particle counts. In locations with better waste management or those farther from pollution sources, the number of collected particles tends to be lower. Therefore, differences in the number of microplastic particles at each location reflect differences in waste sources,

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environmental conditions, and the effectiveness of waste management at those locations.

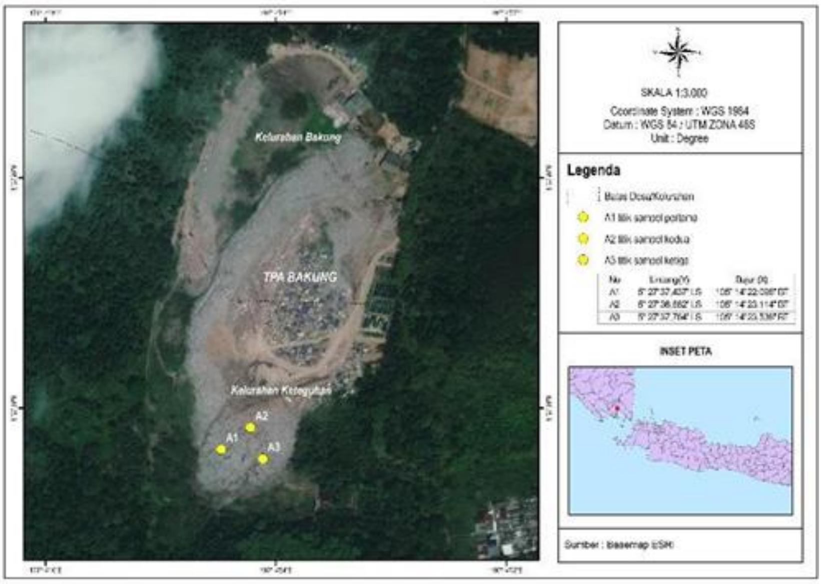

Figure 1. Sampling Locations A1, A2, A3 at the Bakung Landfill
A1 (Y) 5°27’37,437” Southern latitude, (X) 105°14’22,098” East longitude
A2 (Y) 5°27’36,682” Southern latitude, (X) 105°14’23,114” East longitude
A3 (Y) 5°27’37,764” Southern latitude, (X) 105°14’23,538” East longitude

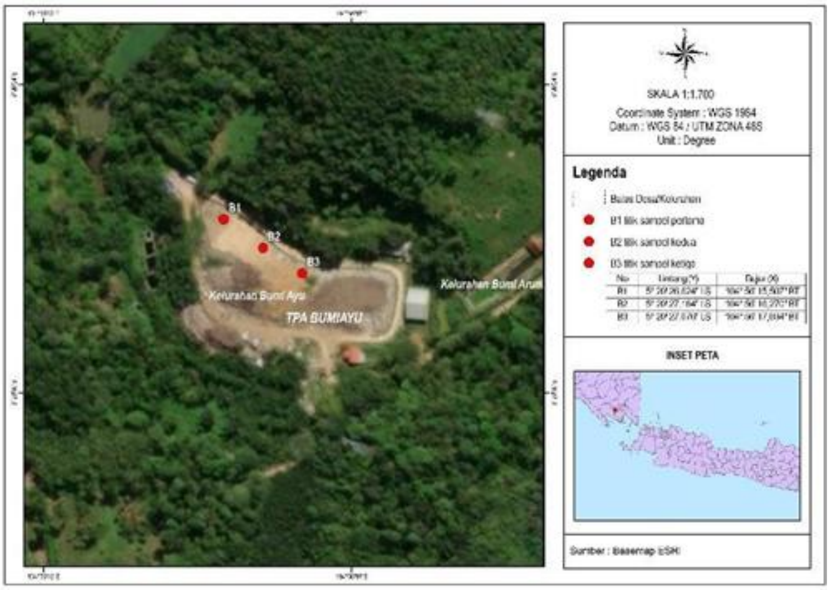

Figure 2. Sampling Locations C1, C2, C3 at the Bumi Ayu Landfill
B1 (Y) 5°20’26,624” Southern latitude, (X) 104°56’15,507” East longitude
B2 (Y) 5°20’27,184” Southern latitude, (X) 104°56’16,270” East longitude
B3 (Y) 5°20’27,676” Southern latitude, (X) 104°56’17,034” East longitude

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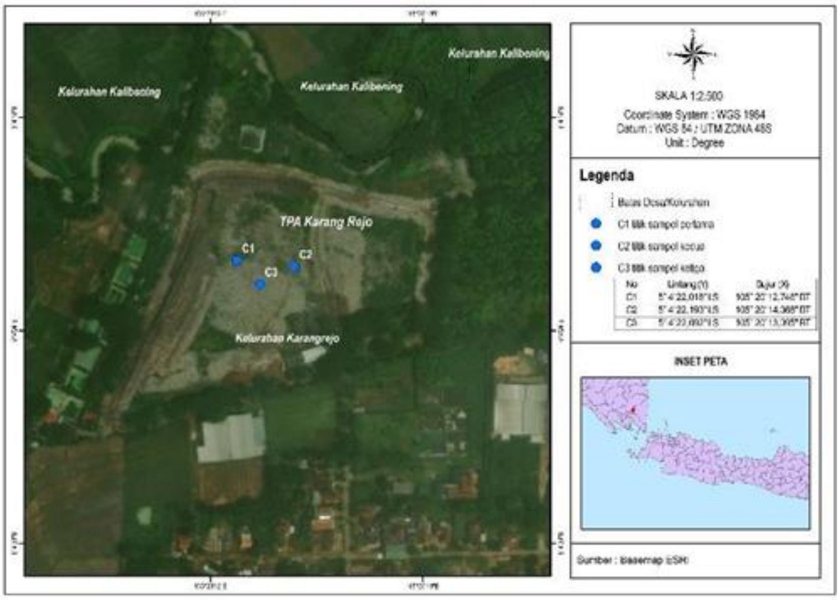


Figure 3. Sampling Locations B1, B2, B3 at the Karangrejo Landfill
C1 (Y) 5°4'22,018" Southern latitude, (X)105°20'12,746" East longitude
C2 (Y) 5°4'22,193" Southern latitude, (X)105°20'14,368" East longitude
C3 (Y) 5°4'22,692" Southern latitude, (X)105°20'13,395" East longitude

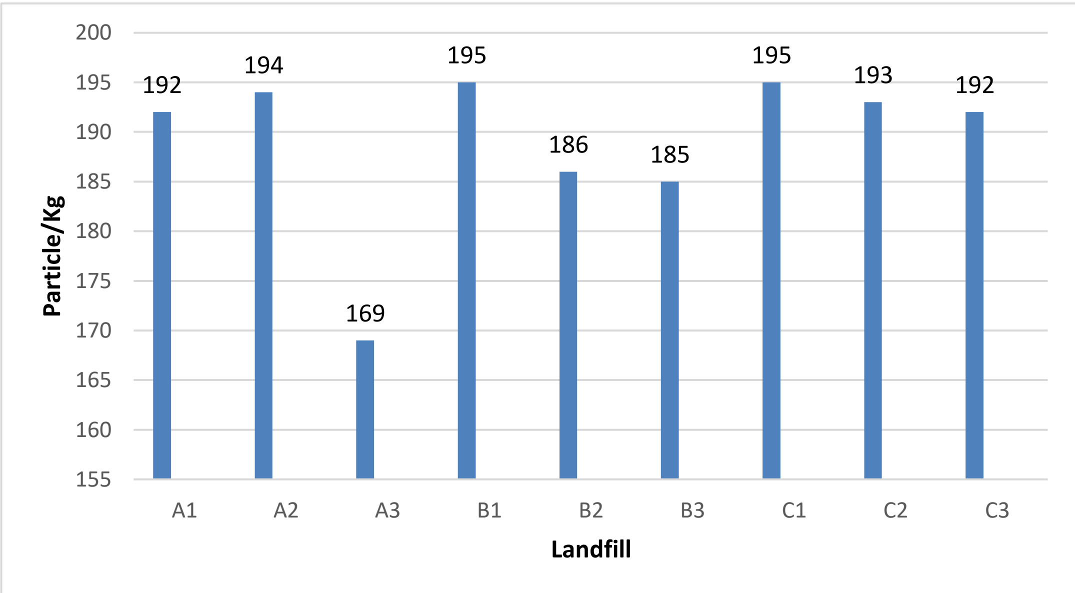
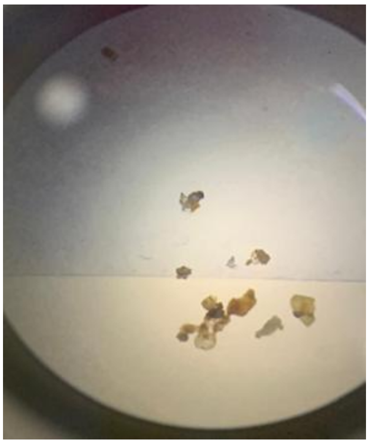


Figure 4. The Microplastic Particles found in the soil of Bakung, Bumi Ayu and Karang Rejo landfills

Examination of soil samples from Bakung, Bumi Ayu, and Karangrejo landfills identified three distinct types of microplastics—fragments, fibers, and films (Figure 5). Fragments were found to be the most prevalent form at all sites. In line with Fiore et al., (2022) Fragments are a type of microplastic formed from larger objects, characterized by darker colors and a fibrous or thin texture. Zhang et al., (2020a) Microplastic fragments are microplastic particles formed from broken ropes, plastic beverage bottles, glass shards, gallon containers, mica, broken pipes, and other debris fragments. And Zhang et al., (2020b) added Fibers are elongated plastic fibers formed from the breakdown of monofilament debris from ships and ropes. The primary type of microplastic fiber has the characteristic of resembling fishing nets or ropes and emits a bright blue light when exposed to ultraviolet light. This type of microplastic film typically originates from the degradation of shopping bags, food packaging such as candy wrappers and snack food packaging, agricultural plastic mulch, and everyday plastic stickers or labels.



A. Fragment

B. Fiber

C. Film

Figure 5. Microplastic Particle Shapes, on 10 x10 magnification
(Code A: Fragment, Code B: Fiber, and Code C: film)

The highest total amount of microplastics in the form of fragments was found at points B1 (160 particles/kg) and c3 (160 particles/kg). Cordova et al., (2019) statement that Microplastics in the form of fragments indicate that the source of the pollutants is human activity, Tanaka & Takada (2016) as fragments are pieces of plastic products with strong plastic polymers, such as beverage bottles and plastic gallons. Meanwhile, the highest total microplastic fiber type at point A1 (34 particles/kg) and B2 (35 particles/kg) originated from the fragmentation of monofilaments. Zhou et al., (2018) describe monofilaments (single fibers) usually from fishing nets, plastic ropes, and synthetic fabrics or clothing fibers. The highest concentration of film-type microplastics was found at point A1 (6 particles/kg) and

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A2 (7 particles/kg). Cole (2011) Film-shaped microplastics are likely produced from the fragmentation of plastic bags, low-density plastic packaging or Low Density Polyethylene (LDPE), which is used as a coating for chemical tanks, general packaging plastic, and gas and water pipes.

The particle sizes of microplastics found in the landfill soil samples vary widely, as shown in Table 1. Microplastics in the form of fibers are always elongated, reaching up to 214.53 µm in sediments and 259.06 µm in seawater, which this result in line with the findings of Khuyen et al., (2021). The data in Table 1 shows that the smallest microplastic fragment measures 2.12 µm, while the largest is a fiber measuring 110.25 µm. The size of microplastics is influenced by the duration of the microplastic fragmentation process within soil sediments. Hebner & Jones (2020) Smaller microplastics indicate a longer fragmentation process, where plastic articles break down into smaller sizes.

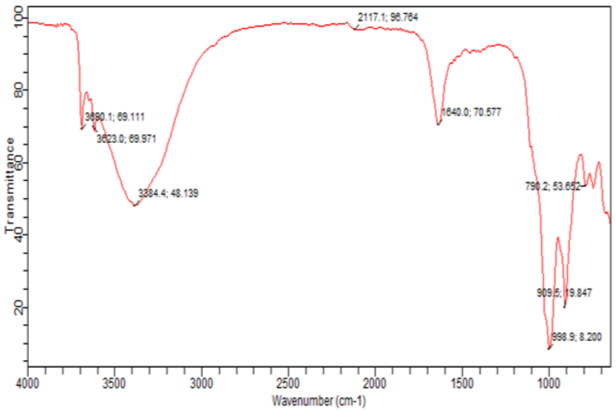
The microplastics identified in soil samples from the three landfill sites exhibited three dominant color variations—black, brown, and transparent. Among these, black and brown particles were consistently the most abundant. According to Syakti et al., (2019), observing the color of microplastics can help identify the source of contamination. The coloration or transparency of microplastics increases the likelihood of ingestion by marine organisms, as these particles can visually resemble their natural food sources (Prata et al., 2020; Ugwu et al., 2021).

Table 1. Shape and Size of Microplastics in Landfill Soil Samples (Bakung, Bumi ayu, and Karang Rejo)

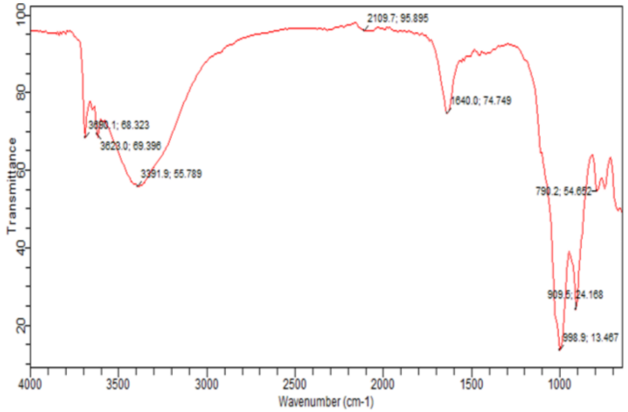
Sample of Landfill Land	Shape	Size range (µm)
Bakung; Bumi ayu; Karengrejo	Fragment	2.12 - 45.95
	Fiber	5.32 - 110.25
	Film	3.78 - 38.45

Table 2. FTIR wave analysis of Bakung A1 location

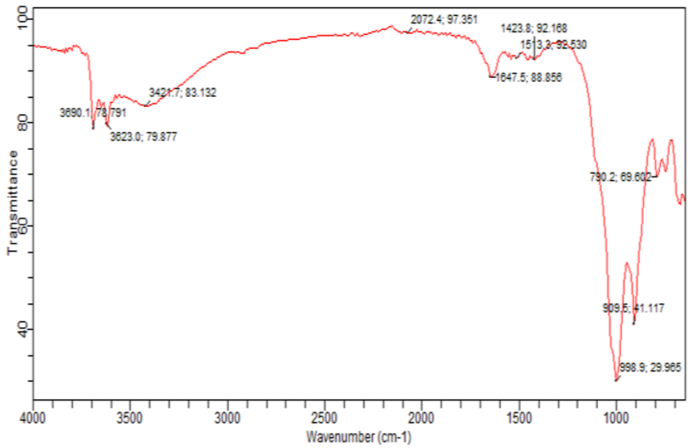
Number of Waves (cm^{-1})	Identified Functional Groups	Interpretation of Descriptions	Polymer Types
1640	C=O stretching (karbonil)	Carbonyl groups of esters or amides	polyamide
998.9	C-O stretching	Normal vibrations in polymer structures	polystyrene
909.6	Aromatic C-H out of plane bending	Structure of aromatic rings (benzene)	polystyrene
790.2	Aromatic C-H out of plane bending	Aromatic structure as well (characteristic of aromatic polymers such as PET or PS)	polystyrene



TPA BAKUNG A1

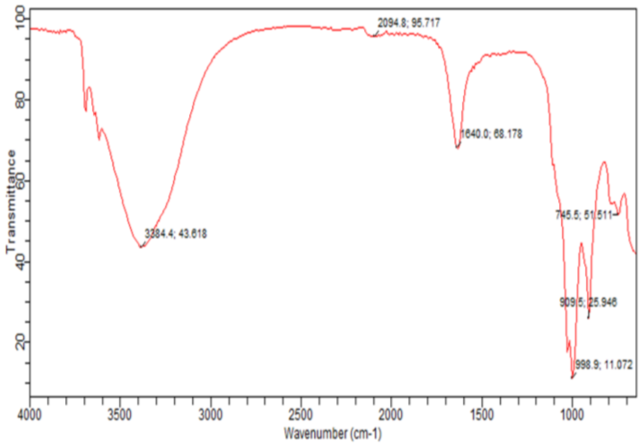


TPA BAKUNG A2

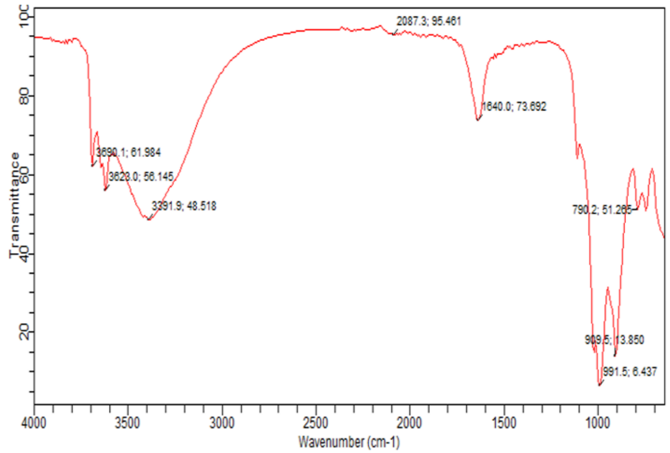


TPA BAKUNG A3

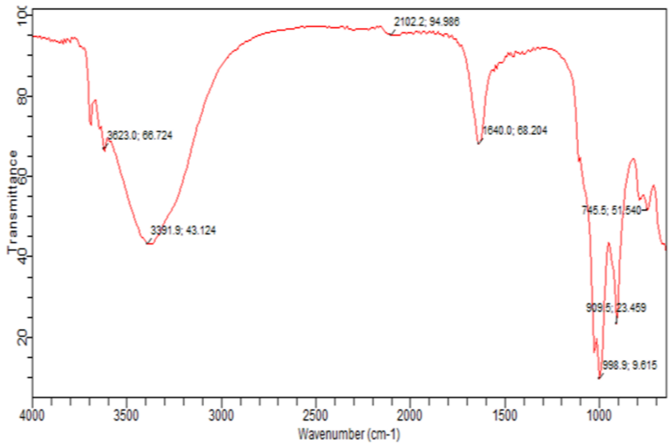
Figure 6. FTIR spectrum at 3 sample site of TPA Bakung landfill



TPA METRO B1

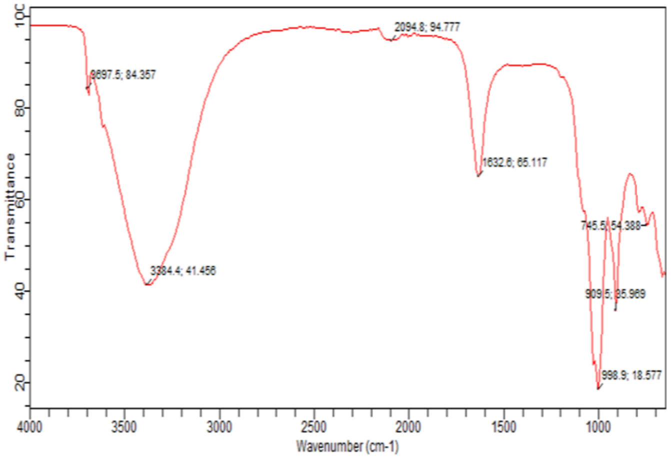


TPA METRO B2

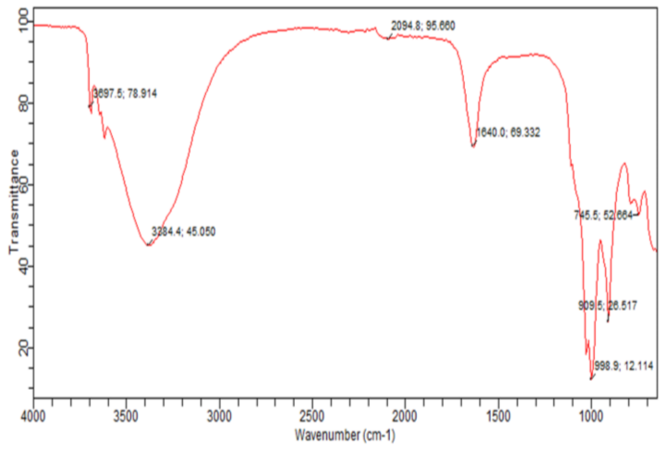


TPA METRO B3

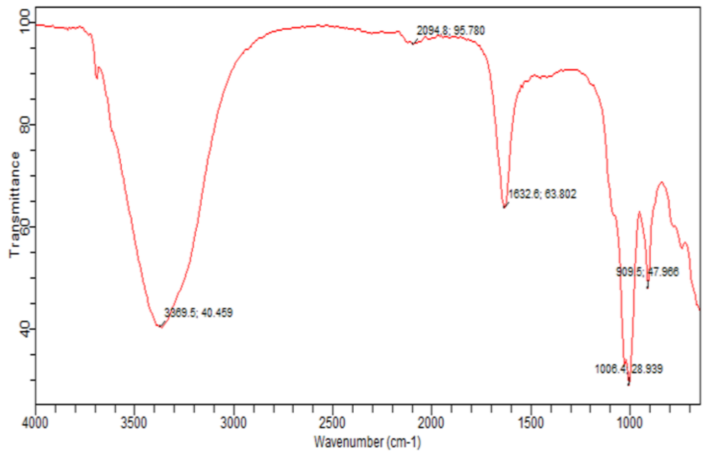
Figure 7. FTIR spectrum at 3 sample site of TPA Metro Landfill



TPA BUMIAYU C1



TPA BUMIAYU C2



TPA BUMIAYU C3

Figure 8. FTIR spectrum at 3 sample site of TPA Bumiayu Landfill

Based on table 2, the results of FTIR analysis of Bakung A1 landfill samples found, the peak absorption was found at 3680.1 cm^{-1}, 3623 cm^{-1}, 3384.4 cm^{-1}, 2117.1 cm^{-1}, 1640 cm^{-1}, 998.9 cm^{-1}, 909.6 cm^{-1}, and 790.2 cm^{-1}. These peaks indicate the presence of functional groups O-H, C=O (carbonyl), C-O, and aromatic structures. Based on this spectral pattern, the most likely type of microplastic to be identified is Polyethylene Terephthalate (PET). Wave numbers of 3680.1 cm^{-1} - 3300 cm^{-1} indicate the presence of a -OH (hydroxyl) functional group in alcohol. This functional group often appears in microplastics that are degraded by the environment, such as particles derived from plastic degradation.

A wave number of 2117.1 cm^{-1}- 2000 cm^{-1} indicates the presence of a triple bond (C≡C or C≡N) functional group in organic compounds. This number of waves is typical for vibrations at a carbon-carbon (C≡C) or carbon-nitrogen (C≡N) triple bond. Meanwhile, the types of microplastics that may come from these compounds are primary or secondary microplastics that come from the degradation of organic compounds containing the triple bond.

Table 3. FTIR wave analysis of Bakung A2 location

Number of Waves (cm^{-1})	Identified Functional Groups	Interpretation of Descriptions	Polymer Types
1640	C=O stretching (karbonil)	Carbonyl groups of esters or amides	Polyamide
998.9	C-O stretching	Normal vibrations in polymer structures	Polystyrene
909.6	Aromatic C-H out of plane bending	Structure of aromatic rings (benzene)	Polystyrene
790.2	Aromatic C-H out of plane bending	Aromatic structure as well (characteristic of aromatic polymers such as PET or PS)	Polystyrene

Table 4. FTIR wave analysis of Bakung A3 location

Number of Waves (cm^{-1})	Identified Functional Groups	Interpretation of Descriptions	Polymer Types
1647.5	C=O stretching (karbonil)	Carbonyl groups of esters or amides	Polyamide
1423.8	C-H	CH_2 Bend	Polietilena (PE)
998.9	C-O stretching	Normal vibrations in polymer	Polystyrene

		structures	
909.6	Aromatic C-H out of plane bending	Structure of aromatic rings (benzene)	Polystyrene
790.2	Aromatic C-H out of plane bending	Aromatic structure as well (characteristic of aromatic polymers such as PET or PS)	Polystyrene

Table 5. FTIR wave analysis of Metro B1 location

Number of Waves (cm⁻¹)	**Identified Functional Groups**	**Interpretation of Descriptions**	**Polymer Types**
1640	C=O stretching (karbonil)	Carbonyl groups of esters or amides	polyamide
998.9	C-O stretching	Normal vibrations in polymer structures	polystyrene
908.5	Aromatic C-H out of plane bending	Structure of aromatic rings (benzene)	polystyrene
745.5	Aromatic C-H out of plane bending	Aromatic structure as well (characteristic of aromatic polymers such as PET or PS)	polystyrene

Table 6. FTIR wave analysis of Metro B2 location

Number of Waves (cm^{-1})	**Identified Functional Groups**	**Interpretation of Descriptions**	**Polymer Types**
1640	C=O stretching (karbonil, amida)	If it is related to plastics, it is usually from carbonyl groups (e.g. PET, Nylon)	polyamide
991	C-H bending atau C-O stretching	Generally the vibration of carbon bonds in polymer structures	polystyrene
809 & 790.2	Aromatic C-H out of plane bending	Indicates aromatic structure (benzene ring)	polystyrene

From the results of the above functional group, the strong indication that (1) There is O-H (hydroxyl), which can come from water (because it is from landfill soil + NaCl is saturated). (2) There is C=O (carbonyl) at 1640 cm⁻¹ — this is usually an ester or amide in the polymer structure. (3) There are aromatic vibrations (809 and 790 cm⁻¹) - aromatic ring structures like in PET. (4) The most likely microplastics detected are: -PET (Polyethylene Terephthalate) → due to: o Has an ester group (C=O). o Has an aromatic structure (benzene ring). Additional details, The presence of a peak of 2087 cm⁻¹ may indicate a slight contaminant from the soil or environment, rather than from the main plastic.

Table 7. FTIR wave analysis of Metro B3 location

Number of Waves (cm^{-1})	Identified Functional Groups	Interpretation of Descriptions	Polymer Types
1640	C=O stretching (karbonil, amida)	If it is related to plastics, it is usually from carbonyl groups (e.g. PET, Nylon)	polyamide
991	C-H bending atau C-O stretching	Generally the vibration of carbon bonds in polymer structures	polystyrene
809 & 790.2	Aromatic C-H out of plane bending	Indicates aromatic structure (benzene ring)	polystyrene

Table 8. FTIR wave analysis of Bumiayu C3 location

Number of Waves (cm^{-1})	Identified Functional Groups	Interpretation of Descriptions	Polymer Types
1632.6	C=O stretching (karbonil)	Ester (characteristic of PET)	polyamide
1006.4	C-O stretching	Ester structure in polymers	polystyrene
909.5	Aromatic C-H bending	Aromatic structure (benzene)	polystyrene

Based on FTIR spectrum analysis of Bumiayu C3 landfill samples, absorption peaks were detected at 3369.5 cm^{-1}, 2094.8 cm^{-1}, 1632.6 cm^{-1}, 1006.4 cm^{-1}, and 909.5 cm^{-1}. These peaks indicate the presence of functional groups O-H, C=O (carbonyl), C-O, and aromatic structures. This spectral pattern is very much in line with the characteristics of Polyethylene Terephthalate (PET) polymers. Therefore, it can be concluded that the type of microplastic identified in the sample is PET.

Table 9. FTIR wave analysis of Bumiayu C2 location

Number of Waves (cm^{-1})	Identified Functional Groups	Interpretation of Descriptions	Polymer Types
1640	C=O stretching (karbonil)	Carbonyl groups of esters or amides	polyamide
998.9	C-O stretching	Normal vibrations in polymer structures	polystyrene
908.5	Aromatic C-H out of plane bending	Structure of aromatic rings (benzene)	polystyrene
745.5	Aromatic C-H out of plane bending	Aromatic structure as well (characteristic of aromatic polymers such as PET or PS)	polystyrene

Table 10. FTIR wave analysis of Bumiayu C1 location

Number of Waves (cm^{-1})	Identified Functional Groups	Interpretation of Descriptions	Polymer Types
1632.6	C=O stretching (karbonil)	Carbonyl groups of esters or amides	polyamide
998.9	C-O stretching	Normal vibrations in polymer structures	polystyrene
908.5	Aromatic C-H out of plane bending	Structure of aromatic rings (benzene)	polystyrene
745.5	Aromatic C-H out of plane bending	Aromatic structure as well (characteristic of aromatic polymers such as PET or PS)	polystyrene

Table 11. Conclusion of FTIR analysis with References Pavia et al., (2015); Silverstein et al., (2014); Socrates (2001); Prata et al., (2019); Araujo et al., (2018); Hidalgo-Ruz et al., (2012)

Name	Main Function Groups	The Most Suitable Polymer Types	Scientific Reasons
TPA Bakung A1	O-H, C=O, C-O, Aromatik C-H	PET	There are esters (C=O & C-O) and aromatic structures
TPA	O-H, C=O, C-O,	PET	There are esters (C=O & C-

Name	Main Function Groups	The Most Suitable Polymer Types	Scientific Reasons
Bakung A2	Aromatik C-H		O) and aromatic structures
TPA Bakung A3	O-H, C=O, C-O, Aromatik C-H, CH_2 bend	PET, kemungkinan Poliamida minor	There is a possibility that N-H (O-H is strong), and C=O amide
TPA Metro B1	O-H, C=O, C-O, Aromatik C-H	PET	The spectral characteristics of PET are stronger than PS or polyamide
TPA Metro B2	O-H, C=O, C-O, Aromatik C-H	PET	The distinctive crest of esters and aromatics is clearly visible
TPA Metro B3	O-H, C=O, C-O, Aromatik C-H	PET, kemungkinan Poliamida minor	B2-like spectrum
TPA Bumiayu C3	O-H, C=O, C-O, Aromatik C-H	PET	All tops match the characteristics of PET
TPA Bumiayu C2	O-H, C=O, C-O, Aromatik C-H	PET	Doesn't fully support PS
TPA Bumiayu C1	O-H, C=O, C-O, Aromatik C-H	PET	Very similar to C2 and C3

Microplastic characteristics, including shape and color, provide insights into degradation pathways (Khuyen et al., 2021). Soil-mediated fragmentation generates micro- to nanoscale particles that are less detectable yet more hazardous. These transformations influence soil structure by modifying density, porosity, and moisture-gas retention, ultimately affecting plant development. Additionally, degradation facilitates the leaching of hazardous additives such as phthalates, BPA, and heavy metals into soil systems, where they may infiltrate the food chain. Microplastics also act as substrates or pathogen carriers for soil microbes, disrupting ecological balance. The smaller the particles, the greater their likelihood of uptake by invertebrates and plants, intensifying bioaccumulation risks. Sunlight exposure weakens polymers, causing brittleness and fragmentation (Crawford & Quinn, 2017), while UV-induced discoloration frequently produces translucent fragments (Kunz et al., 2020; Crawford & Quinn, 2017).

CONCLUSION

The diversity of microplastic characteristics includes fibers, fragments, and films, with colors ranging from black, brown, and transparent. Their size range is 2.12 – 110.25 µm, with the most common plastic types being polyethylene (PE), polyamide, and polystyrene, with PET being the closest polymer. This indicates that microplastic pollution sources originate from various human products and activities. The highest abundance was found at sampling points b1 and c1 (195 particles/kg), which are the final disposal sites at the Karangrejo and Bumiayu landfills. The findings of this research contribute to a better understanding of microplastic pollution in landfill environments, highlighting the need for improved waste management practices and policies to mitigate the impact of microplastics on the ecosystem and human health.

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