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Microplastic Detection in the Blood of Female Waste Workers at Landfill Site

Amalia Putri Kurniawati✉, Marshanda Rachma Maulida, Muhammad Alvin Alvianto
Universitas Negeri Malang

Keywords

Microplastics in blood; Waste pickers; Fragments; Environmental exposure; Informal workers

Abstract

Microplastics constitute an emerging environmental health concern, as their presence has been confirmed in human blood, with potential implications for adverse health outcomes, particularly among occupationally exposed populations. This study was conducted to identify the presence of fragment-type microplastics in human blood and to observe their relationship with individual characteristics (age, length of employment, and type of work) in a group of female waste picker. A total of 24 blood samples were analyzed using the blood smear method and observed under a binocular light microscope. The results showed that all samples contained microplastic fragments. Statistical analysis using the chi-square test on variables such as age, length of employment, and type of work did not show a significant association with the presence of microplastics. Stricter monitoring and control of plastic exposure in landfill environments are needed, along with occupational health protection for vulnerable waste pickers. Additionally, further research using more advanced chemical analysis methods and a larger sample size is important to strengthen the findings and identify potential long-term health risks.

INTRODUCTION

The use of plastic has become a daily necessity for humans in the modern era. The issue of plastic waste has become a global challenge faced by all countries. Based on data from the National Waste Management Information System (SIPSN), Indonesia contributes 6.9 million tons of plastic waste, or around 19.71% of the total waste generated in Indonesia in 2024 (Alvionita, 2025).

Although this is an environmental challenge, this condition actually opens up job opportunities for local residents as waste pickers. The high volume of waste is also utilized by some women, especially those from low-income backgrounds, to earn additional income (Tatambihe et al., 2017). Low education, limited skills, and unstable husbands' incomes are the main reasons women choose this job as a way to help meet their families' needs (Kauntu & Suraya, 2018).

However, behind these opportunities, the issue of waste, especially plastic, also poses a health threat. Plastic can produce microplastics, small particles measuring <5 mm, and nanoplastics, small particles measuring <1 μm (Kye et al., 2023; Sutanhaji et al., 2021), with variations in shape depending on the source. Indonesia is listed as one of the countries with the highest number of microplastic fragments (Allen et al., 2022). Microplastics can enter the human body through three main routes of exposure, namely skin contact, inhalation through breathing, and consumption through the digestive tract (Cox et al., 2019; Leslie et al., 2022). These particles can accumulate in the food chain, be absorbed by plants from contaminated soil, and enter the body through the consumption of plant products (Xu et al., 2024).

Microplastic exposure is also influenced by consumption patterns, age, and body mass index (BMI); older age and high BMI correlate with microplastic accumulation, including in cancerous

✉ amalia.putri.2206126@students.um.ac.id, Malang, East Java

tissue (Leslie et al., 2022). Women are considered a more vulnerable group because they have a more complex hormonal system and physiological structure than men (Teleayo, 2023), which makes women more susceptible to the effects of microplastic exposure. Microplastic exposure has been linked to disorders of the female reproductive system, including ovarian dysfunction, decreased fertility, hormonal imbalances, and potential harm to embryo development and offspring health (Inam, 2025).

Based on research conducted by Pironti et al. (2023) it was found that there are microplastics in human urine, which are likely carried from the bloodstream. Then, recent research by Leonard et al. (2024) conducted a study that detected the presence of microplastics in human blood. Of the 20 samples tested, 18 samples (90%) were found to contain 24 types of microplastic polymers. The most common type of polymer found in blood samples was PE (Leonard et al., 2024; Li et al., 2025). In the bloodstream itself, microplastics in the blood can enter the organs (Sincihu, 2022), and can trigger toxic reactions such as hemolysis, thrombosis, and inhibition of the blood clotting process (Wu et al., 2023). This study on microplastics in blood focuses on female waste workers, examining the significance of the relationship between age, length of employment, and type of task with the findings of microplastics in the respondents' blood. The limitations of research related to the spread of microplastics in the bloodstream of waste workers also prompted researchers to conduct this study.

RESEARCH METHODOLOGY

The study was carried out during June–July 2025. The research population consisted of all female waste workers at landfill area who met the inclusion criteria, including willingness to participate as respondents and having worked for at least one year. From the total eligible population, 90% were selected as samples, resulting in 24 individuals included in the study. The independent variables (X) examined were age, length of employment, and type of work. Age was categorized into young adults (20–39 years), adults (40–59 years), and elderly (60–74 years). Length of employment was grouped based on years of service, while type of work included sorting, burning, and transporting waste. The dependent variable (Y) was the presence of fragment-type microplastics in the blood.

Two milliliters of blood was collected from each respondent and processed using a blood smear method. The samples were observed under a binocular light microscope to identify microplastic particles based on their shape, color, and optical properties. Primary data were collected through structured questionnaires to explore demographic and occupational information, as well as through laboratory analysis for microplastic detection. Data were analyzed using SPSS software, with descriptive analysis to describe respondent characteristics, and chi-square tests to determine the relationship between age, length of employment, and type of task with the presence of microplastics in the blood.

RESULTS AND DISCUSSION

This study was conducted with a total of 24 respondents. The study focused on identifying the presence of microplastics in the blood and testing the relationship between characteristic factors, including age, duration of work, and type of task, with microplastic findings. The data were presented systematically to describe the distribution of respondent characteristics, followed by the results of statistical tests on the variables studied, which are written in Table 1.

Based on Table 1, the majority of workers are in the adult age group (40–59 years) with 15 people or 62.5%. The young adult age group (20–39 years) consists of 5 people (20.83%), while the elderly group (60–74 years) consists of 4 people (16.67%). This shows that most respondents are in

Table 1
Respondent Characteristics

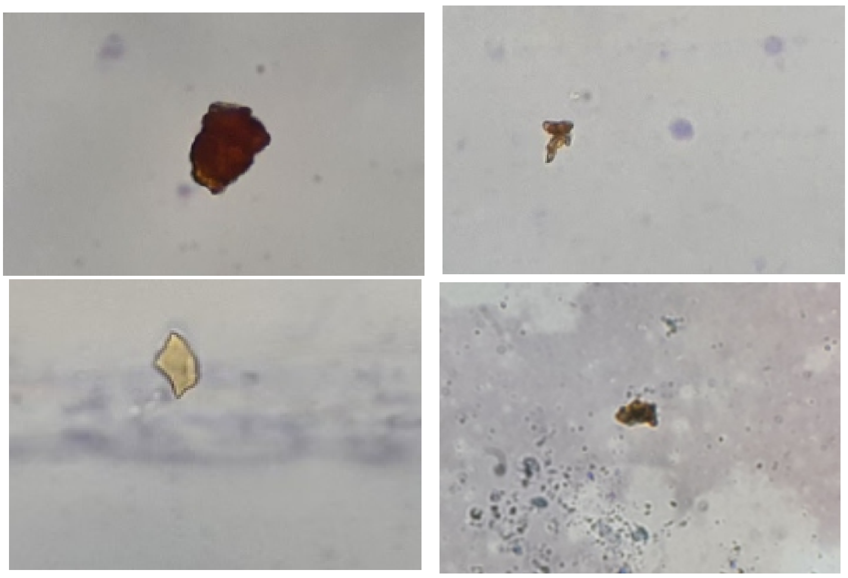
Variab le	Category	n	%
Age	Young Adult (20-39)	5	20,83
	Adult (40-59)	15	62,5
	Elderly (60-74)	4	16,67
Length of Employment	<10 years	8	33,33
	10 years - 20 years	9	37,5
	> 20 years	7	29,16
Jobdesc	Picker	14	58,3
	Sorter	10	41,67

Source: Processed Primary Data, 2025

their middle productive age. In terms of length of service, respondents with 10 to 20 years of service are the most numerous, numbering 9 people (37.5%). Furthermore, 8 people (33.33%) had less than 10 years of work experience, and 7 people (29.16%) had worked for more than 20 years. These findings indicate that most respondents had long-term work experience in this field. Based on the type of work at their workplace, 14 people (58.3%) worked as waste pickers, while 10 people (41.67%) worked as sorters.

Microscopic observations of blood samples from all respondents showed that 24 samples from 24 respondents (100%) contained foreign particles in the form of microplastics. A total of 108 microplastic particles were found in the 24 samples, with an average abundance of 2.25 particles/ml, dominated by 78 fragments (76.47%). In addition, there were also filament-type microplastics, numbering 21 (20.59%), and granules, numbering 3 (2.94%). These particles had striking color variations, such as blue, red, green, and yellow, and did not exhibit any distinctive biological characteristics. All respondents were recorded as belonging to a group with indications of microplastic exposure.

To determine the relationship between respondent characteristics and



Source: Processed Primary Data, (2025)
Figure 1
Microplastics Found in Blood

Table 2
Microplastic Fragments in the Body

Variab le	None		Present		P-value
	n	%	n	%	
Age					
Young Adult	0	0,00	5	100,00	>0,05 (0,731)
Adult	1	6,67	14	93,33	
Elderly	0	0,00	4	100,00	
Length of Employment					
<10 years	0	0,00	8	100,00	>0,05 (0,282)
10-20 years	0	0,00	9	100,00	
>20 years	1	14,29	6	85,71	
Job Title					
Picker	0	0,00	14	100,00	>0,05 (0,227)
Sorter	1	10,00	9	90,00	

Source: Processed Primary Data, 2025

microplastic exposure levels, a Chi-square test was conducted on variables such as age, length of employment, and workplace duties in relation to the findings of fragment-type microplastics. The results of the Chi-square test are presented in Table 2, which shows whether there is a significant relationship between each factor and the presence of fragment-type microplastics in the respondents' blood.

Based on the results of the chi-square test between the independent variables (age, length of employment, and workplace duties) and the dependent variable (microplastic fragments), it was found that the independent variables as a whole were not related to the dependent variable and were declared statistically insignificant because the p-value was >0.05.

Respondent Age

In terms of age, all respondents in the young adult (100%), adult (93.33%), and elderly (100%) groups showed the presence of microplastics in their bodies. Although there were slight differences in the figures for the adult group, statistical tests showed a p-value of 0.731 (>0.05), which means that there was no significant difference between age groups in terms of the presence of microplastics. This reflects exposure to microplastics is evenly distributed across all age groups.

These findings are consistent with Leonard et al. (2024) who detected microplastics in human blood in 18 out of 20 samples (90%), with no significant difference in age, indicating that exposure to microplastics can occur evenly across all age groups, regardless of young or old age. This reinforces the assumption that microplastic exposure is a widespread phenomenon that is not specific to certain demographic groups and also shows that individuals from various age categories, ranging from children to the elderly, have the potential to be exposed to micro-plastics through various common exposure pathways, such as consumption of contaminated food, drinking water from plastic packaging or contaminated water distribution systems, and inhaling air containing suspended microplastic particles (Pironti et al., 2023).

According to Enyoh et al. (2020) the use of personal care products (face wash, body wash, toothpaste, and body scrub), seafood, plants, skin contact with soil, water, or particles in the air, as well as particles falling from open food, and inhalation can also cause humans to be exposed to microplastic pollution (Nawab et al., 2024). Microplastics also have the potential to be excreted by the body through the excretory system, so the accumulation of microplastic particles is not entirely determined by the duration of exposure or microplastic exposure.

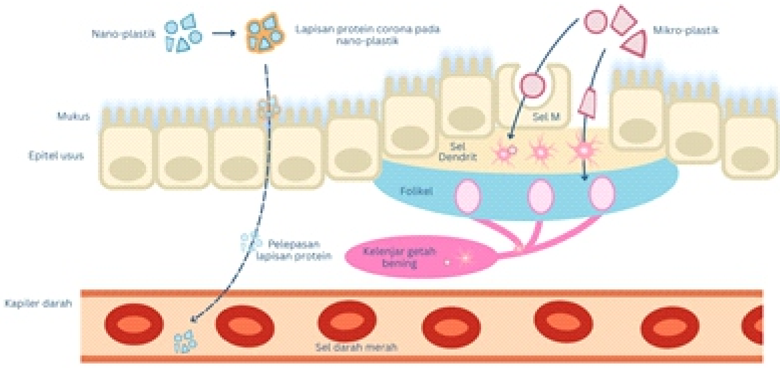
Types of Work Tasks

Both waste pickers and sorters showed high levels of microplastic exposure (100% and 90%), indicating that both types of work carry a high risk of microplastic exposure, but this difference is not significant (p-value > 0.227). This shows that even though waste pickers have more direct contact with plastic, it does not mean that their risk of microplastic exposure is significantly higher than that of sorters.

Differences in job types at the workplace do indeed result in variations in physical exposure to plastic waste, but these results indicate that the work environment in general is evenly contaminated with microplastics, so that both sorters and collectors experience intense contact with the same sources of contamination. In practice, waste pickers who work directly in the field tend to be more exposed to plastic in its whole form or as fragments due to weather, friction, and transportation activities. Meanwhile, sorters who work in semi-enclosed areas or in warehouses, although not in direct contact, are still at high risk because they repeatedly come into contact with used and dusty plastic, as well as in workspaces with poor air circulation.

Research by Prata et al. (2020) states that exposure to microplastics does not only occur in open environments such as in the air, but also high exposure in closed environments filled with plastic dust from packaging, synthetic textiles and industrial materials. This fine dust contains microplastic particles that can be easily inhaled by workers, especially if they do not use personal protective equipment (PPE) such as masks. Research by Hernandez et al. (2017) also states that repetitive activities with plastic materials can increase the risk of microplastics entering the body through inhalation and dermal routes, especially if workers do not practice optimal hand and tool hygiene.

Microplastics can be absorbed by the body through the digestive tract, especially in the small intestine. These particles must pass through several layers of biological barriers before entering the bloodstream, starting with the intestinal mucus, which acts as the first line of defense. Particles smaller than 500 nm are more likely to penetrate the mucus layer, especially if they are neutral or slightly negative in charge (van Wijngaarden et al., 2025). Microplastics (<5 mm) enter through two main mechanisms: paracellular transport, which is through the gaps between intestinal epithelial cells (tight junctions), which can widen when there is a disruption in the integrity of the intestinal barrier, allowing particles up to 2 μm in size to pass through (Delon et al., 2022). In addition, microplastics can also be absorbed by immune cells (M cells) located in Peyer's patches and are capable of capturing particles measuring 1–5 μm



Source: Processed Secondary Data, (2025)

Figure 2

Microplastics entering the bloodstream

through transcytosis and transporting them to the immune cells below (Geppner et al., 2025).

Meanwhile, nanoplastics (<1 μm) undergo an initial stage of opsonization, namely coating by proteins (protein corona) to enable them to pass through the protective mucus layer (Mamun et al., 2023). After that, the particles are absorbed by enterocytes through the transcytosis mechanism, including endocytosis and exocytosis. Endocytosis involves the formation of vesicles to carry particles into the cell, which are then released again through exocytosis into the subepithelial tissue, until they enter the capillary blood vessels (Sheth et al., 2021). In inflammatory conditions, such as intestinal disorders, intestinal barrier permeability and immune cell activity may increase, allowing for the absorption of larger amounts of microplastics and nanoplastics (Agrawal et al., 2024).

Microplastics and nanoplastics that enter the bloodstream can damage blood vessels and blood cells. These particles can cause inflammation, damage blood vessel walls, and trigger blood clotting, all of which increase the risk of high blood pressure and heart problems (Christodoulides et al., 2023). Additionally, MP and NP can damage red blood cells (erythrocytes), causing cell rupture (hemolysis), attaching to blood vessel walls, and triggering oxidative stress that damages cells from within (Agrawal et al., 2024; Remigante et al., 2024).

CONCLUSION

This study found that blood samples from female waste pickers contained microplastics in the form of fragments, filaments, and granules, indicating that microplastic exposure is no longer limited to the environment. Although statistical analysis did not show a significant relationship between age, length of employment, and type of work with the presence of microplastics in the blood, the finding that all respondents were identified as containing fragment-type microplastics indicates a high and consistent level of environmental exposure, which is likely to be the main factor for the presence of these particles in the body. The presence of microplastics in the blood raises important questions about the long-term impact on health. Although very small and invisible to the naked eye, these particles have the potential to cause major health impacts, ranging from circulatory system disorders to systemic effects on vital organs. Therefore, further steps are needed in the form of broader research, taking into account other individual factors that may play a role in microplastic absorption. This knowledge will be an important basis for prevention efforts, risk assessment and monitoring, protection of vulnerable workers, and waste management policies.

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