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# Analysis of the Abundance, Types, and Shapes of Microplastics in Ambient Air Associated with Transportation Activities Using Passive Sampling in Pekanbaru City

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**ABSTRACT**

Rapid urbanization and increasing transportation intensity have raised concerns regarding airborne microplastic pollution, particularly through road dust resuspension. Owing to their low density and aerodynamic properties, microplastic particles can become airborne and contribute to inhalation exposure. This study investigated the abundance, morphology, and polymer composition of airborne microplastics associated with transportation activities in Pekanbaru City, Indonesia. Sampling was conducted at sites representing arterial, collector, and local roads, in addition to a control location without transportation activity. Traffic volume was quantified through traffic counting, while airborne microplastics were collected using passive sampling over a 28-day period with weekly analysis. Polymer identification was performed using Differential Scanning Calorimetry (DSC). The results of this study indicated a clear relationship between traffic intensity and microplastic abundance in ambient air. The highest microplastic concentration was observed on arterial roads (0.251 particles/m³), followed by collector roads (0.172 particles/m³), local roads (0.119 particles/m³), and the control site (0.015 particles/m³). Pearson correlation analysis revealed a strong positive association between traffic volume and microplastic abundance ($r = 0.787$; $R^2 = 0.619$; $p < 0.05$). Fibers constituted the dominant morphology (70.05%), followed by fragments (22.84%) and films (7.12%). Identified polymers included polyvinyl chloride (PVC), polycarbonate (PC), and polyamide (PA). These findings demonstrate that transportation activities are a significant source of airborne microplastics in urban environments and may contribute to inhalation exposure.

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## INTRODUCTION

Pekanbaru City as the capital of Riau Province is experiencing rapid development, characterized by comparatively high rates of urbanization, migration, and population expansion (Gu et al., 2021). In 2024, the population of Pekanbaru City was 1.167 million with an annual growth rate of 3.23% (Statistics Pekanbaru, 2025). This population growth directly contributes to the increase in the number of private vehicles in the region (Waleed & Marizwan, 2024). The number of active motorized vehicles in Riau Province in 2022 was 4,216,014 units, increasing by 7.35% to 4,526,046 units in 2023 (Statistics Pekanbaru, 2025).

The transportation sector is a major contributor to microplastic emissions into the air. Increased traffic volume is directly proportional to the intensity of microplastic release into the atmosphere (Mierzyńska et al., 2024). These microplastic particles tend to accumulate on road surfaces as part of road dust, but their low density ensures they are easily suspended and

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dispersed into the air by vehicle activity (Kaydi et al., 2024). These airborne microplastics can originate from synthetic clothing, tires, domestic uses, industrial operations, road dust, macro plastic waste, and 3D printing (O'Brien et al., 2023)

Several studies have been conducted, including one by Lestari et al., (2023) that 2.78 grams of microplastics were found in a 50-gram dust sample at the sampling location with the highest traffic volume. In Asaluyeh, Iran, 900 microplastic particles were also detected in road dust per 15-gram sample, these particles have oxidative activity that could potentially cause biological effects (Abbasi et al., 2019). This is consistent with the research by Brahney et al., 2020) reported that the accumulate microplastic particles was above 1000 metric tons annually in the central and southern western United States.

Plastic materials entering the environment as plastic waste can undergo physical, chemical, and biological processes that degrade into microplastics and nano plastics (Belioka & Achilias, 2024). Microplastics are defined as small plastic particles, ranging from 1 micrometer to 5 millimeters (Cole et al., 2011); (Ryan, 2015); (Pant & Valapa, 2023). These microplastic particles can act as particulate pollutants in the air and divided into main and secondary microplastics according to their source (Noorimotlagh et al., 2024). Primary microplastics include microparticles intentionally produced for use in personal care products, plastic pellets, and resins used as raw materials for larger-scale plastic production. Meanwhile, secondary microplastics originate from fragments resulting from degradation, such as road surface wear, vehicle tire abrasion, and fibers released from washing synthetic clothing (Peries et al., 2024).

The accumulation of microplastics in the environment poses a risk to human and animal health because their extremely small particle size allows them to spread widely (Matavos-Aramyan, 2024). They act as vectors for various environmental toxins, such as heavy metals and persistent organic pollutants (Xayachak et al., 2024). Humans can be exposed to microplastics through skin contact, food consumption, and inhalation of air from both indoor and outdoor environments (Y. Lee et al., 2023). This exposure has the potential to cause various negative health impacts, such as inflammation, lung tissue damage, and oxidative stress (Saha & Saha, 2024). Reporting particle concentrations in particles/m$^3$ allows direct estimation of human inhalation exposure, as this unit reflects the number of particles contained in the volume of air inhaled during respiration (Geng et al., 2023).

Existing research on microplastics has mostly focused on aquatic environments, but recent studies are expanding to terrestrial settings such as soil and air, and human health (Ricciardi et al., 2021). Research on microplastics in the air in Indonesia is starting to be carried out extensively, one of which is regarding the microplastic content in the city of Jakarta (Purwiyanto et al., 2022). Of the total 168 studies on microplastics in Indonesia (Lee, 2023), only 15 studies discussed the topic of airborne microplastics (Lestari et al., 2025). However, there is limited research on microplastics in the ambient air in Indonesia, due to air sampling test equipment is relatively expensive compared to others (Alam & Rachmawati, 2020). The objectives of this study were to analyze the abundance of microplastics, identify the types and kinds of microplastic polymers in airborne dust samples from arterial, collector, and local roads, and the relationship between traffic volume and microplastic abundance at the study site was also analyzed.

## MATERIALS & METHODS

### *Passive Sampler procedures and Sample Preparation*

The equipment used in this study was a passive air sampler. The principle of this device is to collect airborne dust. Air sampling has employed passive sampling all around the world and is useful for tracking both temporal and geographical trends (Lai et al., 2019). The device is a 1.2 m–high passive sampler equipped with a 25 cm diameter collection funnel, which is connected to the collection bottle via a rubber tube. On the top of the device is covered with an iron sieve with a filter size of 20 mesh (0.841 mm).

To ensure data reliability, duplicate passive samplers were installed at each sampling point. Each collection bottle was filled with 1 L of $CuCO_4$ solution, sealed, and placed at the designated location with the lid opened. After exposure, the collection bottles were closed and retrieved. The collected samples were visually inspected and manually cleaned to remove extraneous materials such as leaves, insects, and other debris. The samples were subsequently sieved, and the filtrates were collected for further processing. The filtrates were transferred into beakers, followed by the addition of 100 mL of 30% NaCl solution. The mixtures were homogenized by stirring and allowed to settle for 24 h. The addition of NaCl aimed to increase solution density, thereby facilitating the separation of microplastic particles from organic matter. Subsequently, 2.5 mL of 30% $H_2O_2$ solution was added to each sample, stirred for 5 min, and left to react for 48 h to oxidize residual organic compounds (Tang et al., 2021). The treated samples were then filtered using a vacuum filtration system. The retained residues were dried in an oven at 60 °C for 24 hours. Finally, the dried samples were examined under an optical microscope at 10× magnification to identify and classify the microplastic types present.

Microplastic sample collection was carried out for 28 days, with testing carried out every 7 days. Microplastic abundance was then calculated, and a Differential Scanning Calorimetry (DSC) test was performed to determine the type of plastic polymer.

*Research Location*

The locations coordinates of the sampling locations in Table 1 below.

The study area is located in one of the most densely populated regions of Pekanbaru City and is situated near the entrance to the toll road, representing an area with substantial traffic activity. Location 1 is an arterial road used by many vehicles, both between cities and between provinces, contain many shophouses selling various goods and daily necessities, educational areas, hotels, places of worship, hospitals, banks, and shopping centers. The physical condition of the road

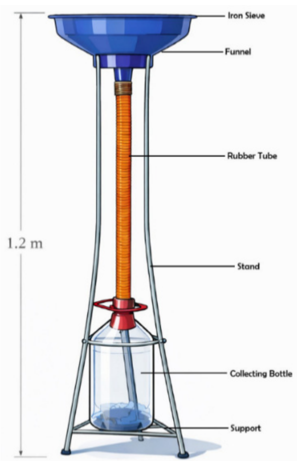


**Fig. 1.** Passive Sampling Device

**Table 1.** Coordinate of Sampling Locations

| Code | Street Name | Road function | Coordinate |
|---|---|---|---|
| Location 1 | HR. Soebrantas | Arterial | 0°27'51.2"N 101°23'05.8"E |
| Location 2 | Garuda Sakti | Collector | 0°28'19.0"N 101°22'01.4"E |
| Location 3 | Merak Sakti | Local | 0°28'03.4"N 101°23'18.0"E |
| Location 4 | - | Without traffic | 0°28'35.8"N 101°22'28.5"E |


image source : https://www.google.com/maps.

**Fig. 2.** Sampling Location Points

generally consists of two lanes in two directions separated by a road median. Location 2 is a collector road, there are many shops, and there are several piles of garbage on the roadside where the garbage is still burned by local residents. The physical condition of Garuda Sakti Street consists of two lanes in two directions without a fixed median. Meanwhile, location 3 is a local road consisting of residential areas where there is also community activity of burning garbage and not too much transportation activity. It has a relatively narrow road width, ranging from 4 to 6 meters and there is no road median. Location 4 as the control location was located in a residential yard, far from main roads and with minimal human activity. This location was chosen to demonstrate the influence of transportation on the abundance of microplastics in the air.

All sites were situated within a ±3 km radius to reduce potential meteorological variability. Therefore, these meteorological parameters were not measured, as the primary focus of the study was to compare differences based on road classification.

*Traffic Counting*

Data on the number and type of vehicles passing along the research area was collected simultaneously. The method used was recording during peak hours and followed by a manual count with video cameras installed at each measurement point. Counting was performed by reviewing the recordings after recording. This was done to minimize errors when counting directly at the research location.Traffic counting was conducted daily during peak traffic hours from 4:00 PM to 7:00 PM. The collected data were converted into daily vehicle counts and subsequently aggregated to obtain weekly vehicle totals. This procedure was repeated for the following week. Vehicles are differentiated based on their type, namely heavy vehicles, light vehicles and motorbikes which are converted into the number of Vehicles per Passenger Car Unit (PCU).

*Identification of Microplastics by Differential Scanning Calorimetry (DSC)*

Microplastic particles previously identified under an optical microscope were subjected to Differential Scanning Calorimetry (DSC) analysis for polymer identification. Because DSC requires sufficient sample mass to obtain measurable thermal transitions, individual particles were not analyzed separately. Instead, particles were pooled by sampling site and week to obtain adequate polymer mass. The pooled material from 16 sample yielded a total mass of ± 10 gram. DSC equipment used is PerkinElmer – DSC 4000, working at a pressure of 4 bar, nitrogen purge of 50 mL/min, temperature range is 30°C to 300°C, and the heating rate is 10°C/min. The instrument was calibrated for temperature and enthalpy prior to analysis using an indium standard (melting temperature 156.6°C; ΔH = 28.45 J/g). Calibration ensured temperature accuracy within ±0.5°C.

Polymer identification was based on comparison between observed melting temperatures (Tm) and reference melting ranges reported in polymer handbooks and literature databases, which is (Cafe, 2007), (Lewandowski & Skórczewska, 2022), and (Ahmad et al., 2020).

While DSC provides valuable information regarding polymer thermal behavior, including melting temperature and crystallinity, it does not provide direct molecular fingerprint identification. Spectroscopic methods such as Fourier Transform Infrared Spectroscopy (FTIR) and Raman spectroscopy are generally considered more definitive for polymer identification (De Frond et al., 2023). However, due to equipment availability constraints, these techniques were not applied in the present study. Therefore, polymer identification in this research is based on thermal transition analysis supported by reference melting data

*Data processing and correlation analysis*

The abundance of microplastics can be calculated using the following formula (Rodrigues et al., 2020).

$$K = \frac{n}{v}$$

Description:
K = Abundance of microplastics in the sample (particles/liter)
n = Number of microplastic particles (particles)
v = Sample volume (liters)

The correlation analysis method used is the Pearson Product Moment Correlation Test uses the SPSS program. The sample size used in the correlation analysis was 16 pairs of observations, consisting of 4 sampling locations and 4 sampling weeks. Normality test was carried out by testing the normality of the data using the nonparametric One-Sample Kolmogorov-Smirnov method and calculating the correlation coefficient (r) and significance (p-value), which were then interpreted to see the strength and meaning of the relationship between variables.

## RESULTS AND DISCUSSION

*Traffic Volume*

Data on the number of vehicles counted at the research location converted to passenger car units in Table 2

Based on the table presented, it can be seen that there are significant differences in the number of vehicles on the three road sections observed during the four weeks of data collection. These three road sections have different characteristics and functions that affect the traffic volume on each road. Location 1 has the highest number of vehicles compared to the other two road sections. In line with the function of HR. Soebrantas Street, an arterial road, is supported by a wider road width and more complex traffic infrastructure (Hafeez, 2024).

Meanwhile, the number of vehicles on location 2 is at a medium level and has experienced slight fluctuations, starting at 169,227 vehicles in week 1, increasing to 172,653 vehicles in

**Table 2.** Number of Vehicles per Week

| Road Function | Week | Number of Vehicles (PCU/week) |
|---|---|---|
| Artery (Location 1) | 1 | 331,602 |
| | 2 | 332,060 |
| | 3 | 329,238 |
| | 4 | 318,191 |
| Collector (Location 2) | 1 | 169,227 |
| | 2 | 172,653 |
| | 3 | 179,480 |
| | 4 | 172,253 |
| Local (Location 3) | 1 | 13.790 |
| | 2 | 13.688 |
| | 3 | 12.171 |
| | 4 | 12.114 |

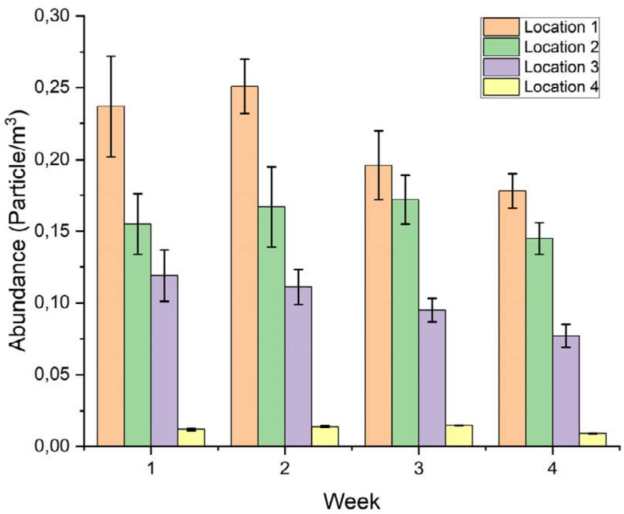


**Fig. 3.** Abundance of Microplastics at Each Location

week 2, then increasing again to 179,480 vehicles in week 3, before declining to 172,253 vehicles in week 4. Location 2 reflects its function as a collector road as a secondary roads, serving medium-distance travel connecting primary and secondary areas (Kurniawan et al., 2024). Location 3 has the lowest number of vehicles among the three roads observed. In week 1, the number of vehicles recorded was 13,790 in the first week then significant decrease where the total number of vehicles dropped 12,114 vehicles in week 4. This gradual decline indicates a downward trend in traffic volume. As a local road, this section only serves internal mobility within neighborhoods (Wirahaji et al., 2023) such as housing or campus areas, so the traffic volume is lower and dominated by private vehicles and motorcycles.

*Microplastic Abundance*

The abundance of microplastics observed in this study in dust samples found at each sampling location. Figure 3 shows that microplastic abundance decreases from location 1 to location 4. Location 1, a major arterial road, showed the highest average total microplastic abundance of all locations, at 0.251 ± 0,004 particles/m$^3$. The high microplastic abundance at location 1 is due to the high volume of vehicles that transport microplastics into the air. These results align with research conducted by Syafei et al., (2019) in Surabaya, where the highest microplastic abundance was found in locations with high traffic volumes compared to locations with low traffic volumes. Location 2 which functions as a collector road, the highest microplastic abundance was at week 3, at 0.172 ± 0,002 particles/m$^3$, which is still lower than location 1. At Location 3, a local road representing a residential area, the highest abundance of microplastics was lower than on Location 1 and Location 2, at 0.119 ± 0,004 particles/ m$^3$. This result is much higher than that reported by Wati et al., (2025). However, the difference may be attributed to the shorter sampling duration used in that study, which was limited to 6 hours, potentially resulting in lower particle accumulation compared to this study. Based on research conducted by (Myat et al., 2024) on air microplastics on roadsides and residential areas in Southern Thailand, microplastic abundance was found to be higher in roadside samples compared to in residential samples.

The lowest microplastic abundance was found at location 4, the control point in this study, where there was no transportation activity. The lowest abundance of microplastics at the control location at week 4 was 0.009 particles/m$^3$. The low abundance of microplastics at the control point indicates that human activity and vehicle traffic other than industrial activity are the main factors contributing to airborne microplastics (Yang et al., 2022). Microplastic particles tend to accumulate on road surfaces as part of road dust. However, their low density can cause these microplastics to become suspended in the air, particularly due to vehicle activity (Jannah et al., 2024).

Sampling was conducted from May to June 2025, corresponding to the transitional period between the rainy and dry seasons in Indonesia. Seasonal conditions during this period may have influenced atmospheric microplastic concentrations, particularly through variations in precipitation, humidity, and wind patterns (Uogintė et al., 2022). Consequently, the findings of this study should be interpreted within this seasonal context, as microplastic abundance and distribution may differ if sampling is conducted during the peak rainy or dry season.

The reported percentages of microplastic shapes (fiber, fragment, and film) represent the proportion of visually counted particles relative to the total number of particles identified in each sample. Procedural blank correction was not performed in this study. The absence of procedural blank correction represents a limitation in this study.

Other limitation is on the method used; passive sampling has inherent limitations that may affect the interpretation of airborne microplastic data. Because passive methods rely on gravitational settling, they introduce particle-size selection bias, preferentially collecting larger and denser particles while underestimating finer aerosolized particles that remain suspended. Additionally, passive samplers do not measure a defined air volume, so the method may therefore underestimate fine aerosolized microplastics.

*Microplastic Shape*

Based on research conducted on the abundance of microplastics in dust samples, several shape of microplastics were identified: fragments, fibers, and films.

Based on Figure 4 above, the highest abundance of microplastics in the dust samples was found in the fiber shape, with 1368 particles representing 70.05%. This was followed by the fragment shape, with 446 particles representing 22.84%, and the film shape, with 139 particles representing only 7.12%. The results of this study in line with the results of Toha et al., (2024), where the largest form of microplastic is fiber, followed by fragments and the smallest is film.

*Fiber-shaped Microplastics*

Fiber was the most common shape of microplastic found, accounting for 70.05% of the total abundance. A similar finding was found in a study by Wati et al., (2025) on the abundance of

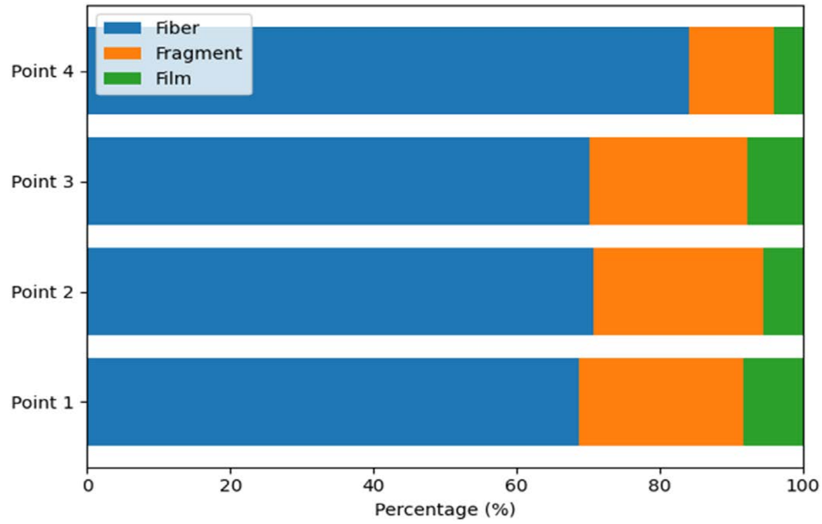


**Fig 4.** Abundance of Microplastics Based on Shape

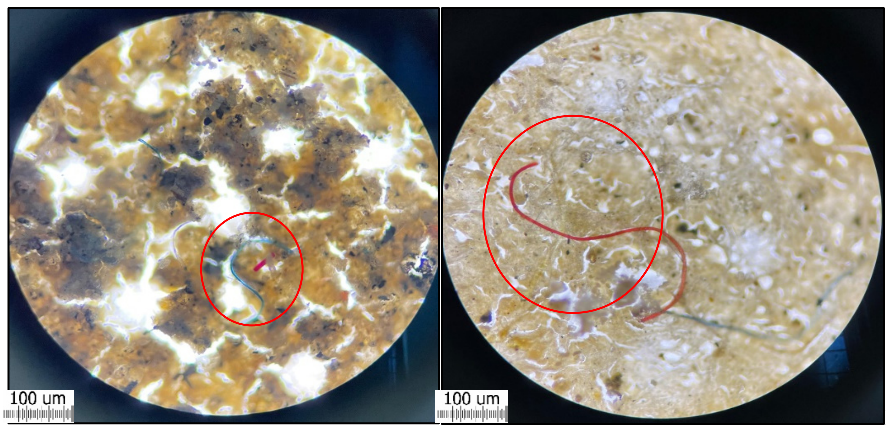


**Fig. 5.** Fiber Microplastics

microplastics in the air on urban roads in Gresik City. In that study, fiber-shaped microplastics were the most common form, accounting for 80% of the total abundance of microplastics found. A picture of fiber-shaped microplastics can be seen in the following figure.

Figure 5 shows that the fiber-shaped microplastics found are long, thin, brightly colored, and resemble threads. This aligns with Cledera-Castro et al., (2024) who stated that fibers are thread-like, ranging in length from 5 mm and typically come in contrasting colors such as red, blue, yellow, and others. The primary source of fiber-shaped microplastics in the air comes from synthetic textiles such as clothing, carpets, and curtains, which release microplastic fibers due to friction and washing (Rutgers et al., 2022). In residential areas, fiber-shaped microplastics can also be found in ropes, fabrics, paranets, plastic sacks, and other materials (Jahandari, 2023).

*Fragments-shaped Microplastics*

Fragments were also one of the microplastic shape found at each study location. This microplastic fragment shape was the most abundant microplastic after fibers in this study, accounting for 22.84% of the total microplastic. The microplastic fragments found in this study resemble flakes or irregular pieces. The characteristics of the microplastic fragments found in this study are similar to those described by Indriyasari et al., (2024), namely, they are blue

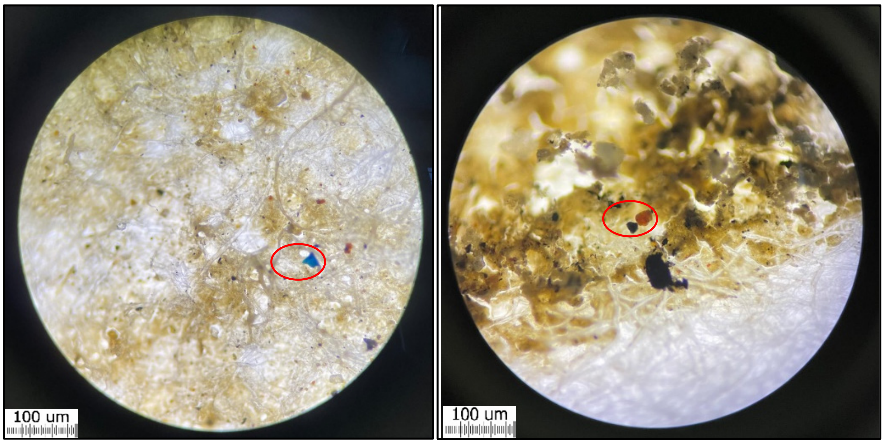


**Fig. 6.** Microplastic Fragments

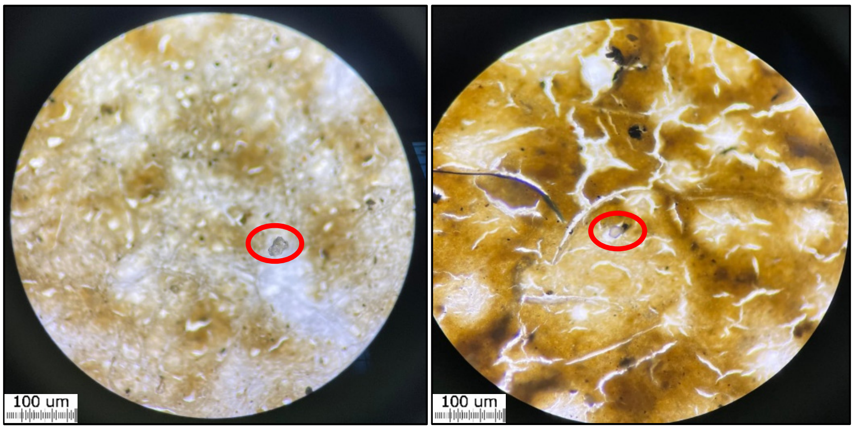


**Fig. 7.** Film-shaped microplastics

in color and irregular in shape, appearing harder and slightly stiffer. Microplastic fragments originate from the fragmentation of macro-waste and generally come from pieces of jars, gallon jugs, hard plastic, small pieces of PVC pipe, and small pieces of beverage bottles from daily human activities (Priyambada et al., 2023). The tendency for fragmentation is caused by UV light, physical erosion by wave energy, oxidation, and the effects of microorganisms (Salsabila et al., 2023).

*Film-shaped Microplastics*

In this study, film-shape of microplastic found with an abundance of 7.12% in samples which was quite low.

Figure 7 shows that film-shaped microplastics resemble thin sheets. This is consistent with Borriello et al., (2023), who stated that films are thin, flexible sheets of plastic that originate from and have low density. The presence of film-shaped microplastics is thought to be due to the waste generation site being located in a residential area, where most residents frequently use plastic bags and food wrappers, which degrade into film-shaped microplastics (Ziani et al., 2023). The generation of film-shaped microplastics is typically influenced by people's habits and behaviors regarding the use of single-use plastic bags and other plastic-based materials (Ghosh et al., 2023).

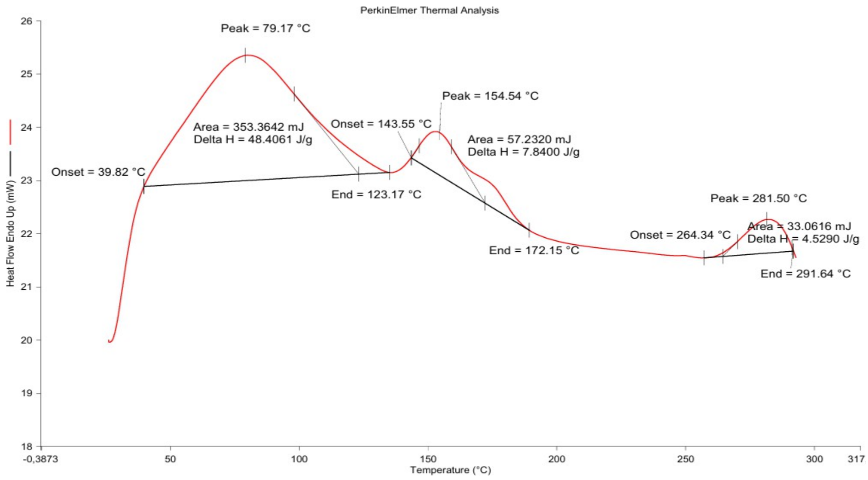


**Fig. 8.** Thermogram of DSC Test Results on Samples

*Types of Microplastic Polymers Based on Differential Scanning Calorimetry (DSC)*

In this study, DSC testing was carried out to determine the plastic polymers contained in microplastic particles.

Based on Figure 8, DSC testing results on the samples showed that the polymer melting points (Tm) were 79.17°C, 154.54°C, and 281.50°C. Compared to Cafe, (2007), the types of microplastic polymers identified with these melting points were polyvinyl chloride (PVC) with a variety of melting points of 75-100°C. Polycarbonate (PC) with a melting point range of 140-150°C, and polyamide (PA), with a melting point range of 160-275°C.

PVC is often used to make doors and windows, clean water and waste pipes, electrical cable protectors, medical devices, and others (Lewandowski & Skórczewska, 2022). In the environment, PVC is commonly found in various plastic products, such as beverage bottles, food containers, plastic tubs, and even children's toys (Mnyango & Hlangothi, 2024).

PC is a type of plastic widely used by the public. Polycarbonate is known to contain the compound Bisphenol A (BPA), or 2,2-bis (4-hydroxyphenyl) propane (Idowu et al., 2022). BPA is a chemical compound produced on a large scale in industry and commonly used as a raw material in the manufacture of polycarbonate plastic and epoxy resin (Wang et al., 2022). Various food and beverage containers, both disposable and reusable, are generally made from polycarbonate. This BPA content has the potential to be released and mixed with packaged food and beverages. BPA is also a compound that can cause various diseases, such as cancer (Sulistiyani et al., 2025).

Another type of polymer found in this study is polyamide (PA). Polyamide is frequently used in the textile, carpet, shoe, rope, and synthetic fabric (nylon) industries (Ahmad et al., 2020). In the atmospheric context, polyamide is found as microplastic fibers formed by mechanical degradation, e.g. abrasion of fabric, clothing, or nylon tires (Zhong et al., 2024). This aligns with research by Tanjil et al., (2025) in a textile industrial area in Dhaka City, Bangladesh, which showed that polyester and polyamide fibers dominated microplastic deposition in the air around the factory. The results of DSC tests conducted on the test samples also align with microscopic identification results, which revealed that the most common type of microplastic found was fiber, a type typically derived from textile or clothing fibers.

The presence of microplastics with the polymer types Polyvinyl Chloride (PVC), Polycarbonate (PC), and Polyamide (PA) identified in the samples indicates that the study area is contaminated by microplastics. Microplastics found contain toxic additives such as bisphenol

**Table 3.** Results of the Correlation Test Between Microplastic Abundance and Traffic Volume

| Parameter | Normality Test | Correlation Value (r) | Significance Value (α) | Conclusion |
|---|---|---|---|---|
| Limit | p > α 0,05 | r = 0,001- 1,000 | sig.< 0,05 | |
| Traffic Volume | 0,200 | 0,787 | 0,002 | H1 is accepted, H0 is rejected |

Description:
H1 = There is a significant effect of traffic volume on microplastic abundance at each location.
H0 = There is no significant effect of traffic volume on microplastic abundance at each location.

A (BPA), when suspended in the air could be inhaled by humans and enter the respiratory tract, which in the long term can trigger various health problems (Shahsavani et al., 2025).

*Correlation Between Traffic Volume and Microplastic Abundance*

To determine the relationship between traffic volume and microplastic abundance, a correlation analysis was conducted. The results of the correlation test between traffic volume and microplastic abundance are shown in Table 3. below.

Based on statistical tests, traffic volume data was normally distributed with a p value of 0.200 > α 0.05. Furthermore, a correlation test obtained a correlation value (r) between traffic volume and microplastic abundance of 0.787, and $R^2$ is 0,619. Significance value of 0.002 α < 0.05 and a positive direction. This indicates a strong correlation between traffic volume and microplastic abundance at each study location. An $R^2$ value of 0.619 means that 61.9% of the variation in microplastic abundance is contributed by traffic volume, while the remaining 38.1% is influenced by other variables. Microplastic particles deposited on road surfaces can become suspended in the atmosphere due to wind gusts from passing vehicles, particularly in areas with high daily traffic (Khodabakhshloo et al., 2023). This is supported by a study by Evangeliou et al.,(2020), which showed that heavy traffic not only creates new microplastics but also remobilizes particles already present on road surfaces into the air.

## CONCLUSION

Based on the study that has been undertaken, it is concluded that the highest abundance of microplastics is on arterial roads (0.251 particles/$m^3$), collector roads (0.172 particles/$m^3$), local roads (0.119 particles/$m^3$), and control points without transportation activity (0.015 particles/$m^3$). The results of microplastic identification obtained from this study are in the form of fragments of 22.84%, fiber form of 70.05%, and film form of 7.12%. The types of microplastic polymers found are Polyvinyl Chloride (PVC), Polycarbonate (PC) and Polyamide (PA). The results of the correlation test show that traffic volume is significantly correlated with the abundance of microplastics in each study location, with a correlation coefficient (r) value of 0.787. This findings suggest that traffic-related activities are an important source of airborne microplastics in urban environments. For future research recommended the use of active volumetric air sampling would allow direct comparison with other studies. Size-fractionated analysis is needed to better characterize fine and respirable microplastic fractions that may pose greater health risks. Advanced chemical identification techniques such as Fourier Transform Infrared Spectroscopy (FTIR) and Raman spectroscopy should be applied to improve polymer identification accuracy and reduce misclassification. In addition, deposition modeling could help estimate transport pathways, settling behavior, and potential exposure levels

## GRANT SUPPORT DETAILS

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## CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript.

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