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Evaluation of Deposited Atmospheric Microplastic Characteristic within Malaysia Cities Airshed

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The abundance of plastic pollution is a global issue posing a threat to all living things. The breakdown of plastic between 1 to 5,000 μm in size, known as microplastic (MPs), has commonly been found in all regions as an emerging environmental pollutant in recent years. Presence of MPs in the ambient air poses hazard to the environment and health as it can also carry other pollutant. Preliminary research has found that the MPs contamination in the air would give health effect such as lung inflammation and increase the risk of infertility and cancer. To date, the atmospheric MPs deposition in Malaysia is still unknown. In this regard, this research aims to evaluate the presence and characteristics of MPs in Malaysia. The deposition of atmospheric MPs sample was collected in Kuala Lumpur due to the high number of traffic activities and populations and the rural area, which is in Timah Tasoh, Perlis. The physical characteristics of MPs were categorized by shape, colours, and size using a stereo-zoom microscope. The most common MPs shapes and colours were fiber and black, respectively. The atmospheric MPs found a range between 50–5,000 μm in size. With increased worries about its effects on living species, MPs pollution is predicted to worsen during the ensuing decades. This data will provide a holistic picture of the MPs significant primary discoveries, knowledge gaps, and future challenges in comprehending this emerging contaminant.

1. Introduction

Synthetic polymeric organic materials, such as plastics, are used frequently because of their exceptional adaptability and inexpensive price (Facciolà et al., 2021). Every year, the global manufacturing of plastic increases by 3 % with a 359×10^6 t worldwide production each year (Verla et al., 2019). Asia is the largest producer of plastic, producing 183×10^6 t (51 % of the total) (Facciolà et al., 2021). According to US Environmental Protection Agency, an astonishing 91 % of plastic does not actually get recycled (US EPA, n.d.). This means that only about 9 % of the plastic is recycled.

MPs have moved into every crevice on earth (Huang et al., 2021). MP are small plastic particles that measure less than 5 mm in size consisting of synthetic compounds(Narmadha et al., 2020). It is occurred after human put trash on the ground and in the ocean where the plastic part synegrate by heat, wind and waves bit by bit into even smaller part (Huang et al., 2021). This shredded plastic waste particle is known as secondary MPs while primary MPs are from the microbeads utilised in personal care products and pellet used in plastic manufacturing (Gerdes et al., 2019).

The major source of MP in atmosphere is from textiles fibers (domestic washing machine, industrial laundries), tyre abrasion & rubber crumb from road networks and spillage in pre-production plastic pellets (Park and Park, 2021). Plastic is made for packaging, plastics bag, cups, toys, cars part, synthetic clothing, electric home & appliances and also plastic bottles where it is an artificial made material which is why it is technically synthetic compound. It is mostly made of crude oil, natural gas or coal and naturally not biodegradable like the other

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composite material (Wright et al., 2020). Study on the ecotoxicity of the MPs shown the root growth inhibition of selected plantation after the exposure (Roupcova et al., 2022).

The transfer of substances from the atmosphere onto the earth's surface is known as atmospheric deposition. Both dry and wet deposition contribute to the formation of atmospheric fallout as a whole (Klein and Fischer, 2019a). Wet deposition includes all types of precipitation, whereas dry deposition is the gravitational sedimentation of solid particles and gases that settle to the surface in between precipitation occurrences.

The type, size, shape, and colour of MP are important factors that determine their fate in the environment and in biota (Rochman et al., 2019). Plastic fragments and particles as an increasing environmental contaminant and pollutant have become a significant concern in recent decades as a result of the hazards they pose to biota (Chen et al., 2020). Plastic deteriorates or disintegrates into smaller plastic particles due to physical and chemical factors like mechanical abrasion, weathering, UV radiation, and microbial activity (Yan et al., 2019). Numerous studies have documented the dispersion of MP in various compartments (i.e., water, sediment, and biota) to date (Sarijan et al., 2021). Nonetheless, the investigation on atmospheric MP deposition is still scarce compared to water and sediment fields (Park and Park, 2021).

This paper provides an overview of the development and current state of knowledge in atmospheric MP deposition pollution to have the better understanding the characteristic and the sampler used in the deposited atmospheric MP. Abundance, size, shape, colour and the polymer type are the characteristic that taking into consideration for the deposited atmospheric MP which have been reported for urban, sub-urban and rural areas (Yukioka et al., 2020).

2. Methodology

2.1 Sampling locations

Deposited MPs were collected from Universiti Teknologi Malaysia, Kuala Lumpur (UTMKL) and Timah Tasoh, Perlis (as shown in Figure 1) from December 2021 to March 2022 with total 18 samples for each location. The sampling in KL were presented as high population area while Timah Tasoh are dam location with no activities were conducted there that act as background sampling. Commonly, there are two types of sampling used in atmospheric MP deposited which is dry and wet deposition sampling and dust sampling which they are known as passive collector. In this study, dry and wet deposition sampling type were used that are known as dust deposited gauge. The sample were collected in passive sampler through a glass funnel in glass bottle at 1.5 m height above ground average height of human exposure to inhale (Liu et al., 2019a). After each collection, the samples in each glass bottle were transported and kept individually for further laboratory analysis. The funnel and bottle were rinsed with ultrapure water in order to extract all particles. All samples were then wrapped with aluminium foil to prevent contamination from airborne plastic particles and were stored until the next step of processing.

Figure 1: Sampling location in UTMKLand Timah Tasoh

2.2 Digestion of organic matter

The samples were then filtered on MCE filter paper (47 mm, 0.22 μm). Leftover samples from the bottle were rinse three times using filtered water. Finally, the top unit's sides were then filled with filtered water, which was used to effectively remove any particles that had adhered to them. In order to remove any organic substances that had adsorb onto the surface of the MPs, the filter was transferred to a beaker and were treated with 35 mL of hydrogen peroxide solution (H_2O_2, R&M, 30 %) then left for a day in a fume hood until formation stopped. After that the sample were vacuum filtered onto 47 mm diameter of MCE filters. The filters placed directly to a glass petri dish and covered with aluminium foil with tiny hole and stored in desiccator to dry for at least 24 h before further observation.

2.3 Identification of MPs particle

The collected sample was visually examined using a digital microscope to identify the amount and physical form of MPs. The MPs counted manually where the dry filter paper placed under microscope for visual observation and then classified according to the group of shape, size and colour. The shape, size and colour were observed using a Leica EZ4W stereomicroscope. Hot needle test was done to verify that the sample counted is MPs. Any structure portray to the organic material were identified and excluded during the analysis. Category of particle shape (fiber/line, fragment, film, foam, bead/pellet) was evaluated during the process. Additionally, mesoplastics, or particles larger than 5 mm, and nanoplastics, or those smaller than 1 µm, were not examined in this study.

2.4 Contamination precaution

All tools and glassware were triple washed with ultrapure water (PURELAB® Flex, Elga) before use to prevent plastic contamination. Usage of plastic containers were avoided during the sampling and analysis. Aluminium foil were used to wrapped all the samples to prevent the contamination. Cotton lab coats were worn in the laboratories and during conducting the sample procedures. This is the standard precautions were made to prevent the contamination of samples by airborne particles.

3. Result and discussion

In this study, MPs were detected in both locations shown in Figure 2. The size range derived from this study and previous research indicates that the result falls within the acceptable range. In this investigation, the average size of the MPs collected is between 50-5,000 m, which is acceptable. The size of MPs can be affected by several factors, including their origin, their chemical composition, their physical properties, and their exposure to environmental conditions such as sunlight, wind, and water.

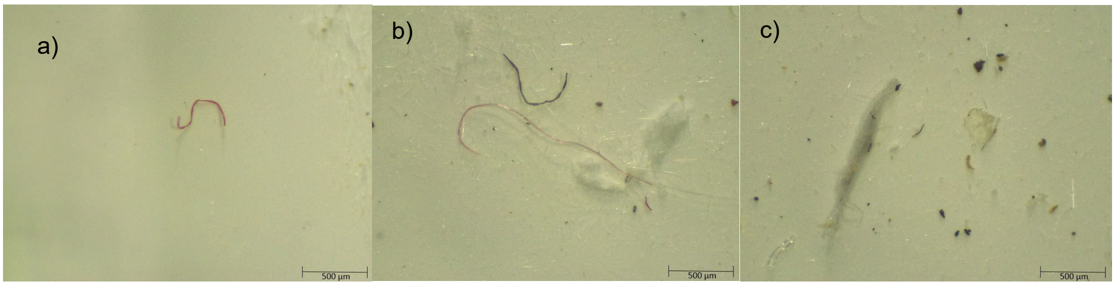

Figure 2: The stereomicroscope image of microplastic with (a) fiber shape (b) long fiber shape and (c) fragment shape

The abundance of atmospheric MPs varied considerably between studied regions among the 18 samples as shown in Figure 3. The highest abundance in UTMKL and Timah Tasoh were 582 ± 55 and 983 ± 146 particles/m²/d. Despite Timah Tasoh acted as background sampling and less populated area compared to UTMKL, the result shown that Timah Tasoh has higher number abundance of MPs compared to UTMKL area. This probably because of the area is in open spaces and not obstructed by any buildings which allows the light and small MPs particles to be dispersed by wind more easily than UTMKL. Tall buildings can cause turbulence in the air which can affect the air currents and the movement of MPs. Additionally, tall buildings can act as impediment that prevent MPs from travelling in certain directions. Weather also can affect the amount and distribution of MPs in the atmosphere. For instance, wind can transport and disseminate MPs throughout the atmosphere. Additionally, rain can wash MPs out of the atmosphere and into the environment, where they can be absorbed into bodies of water and land. Furthermore, high temperatures can cause MPs to break down into smaller pieces, creating even smaller MPs that can be transported through the atmosphere more easily.

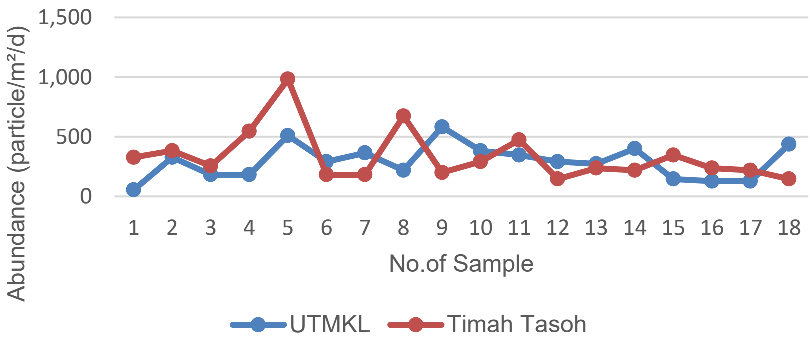

Figure 3: Comparison of the MPs abundance collected in this study

MPs are frequently described as spheres, beads, pellets, foam, fibers, pieces, films, and flakes (Akanyange et al., 2021). In this study, the particles observed under stereomicroscope are shown in Figure 4 are classified as fibers, fragments and films that are only found with fiber were dominant shaped (>80 %) with total 480 particles in both sampling locations. Timah tasoh has the highest percentage in fiber compared to UTMKL Previous research in Dongguan, Shanghai, and Paris similarly found that fiber was the most prevalent shape (>60 %) (Liu et al., 2019b). Fiber is a type of MPs that is typically made of polyester, nylon, rayon, or acrylic. It is commonly used in clothing and other textiles, as well as in mattresses, furniture, and car interiors. Fiber MPs can enter the atmosphere through the breakdown of larger plastic items or through intentional release from textiles. Studies indicate that laundry washing and drying is a significant source of fiber polymers in the environment (Dris et al., 2016). Film and fragment can be found in atmospheric MPs because it is a lightweight material that can become airborne and travel long distances. It is also resistant to degradation and can remain in the environment for long periods of time.

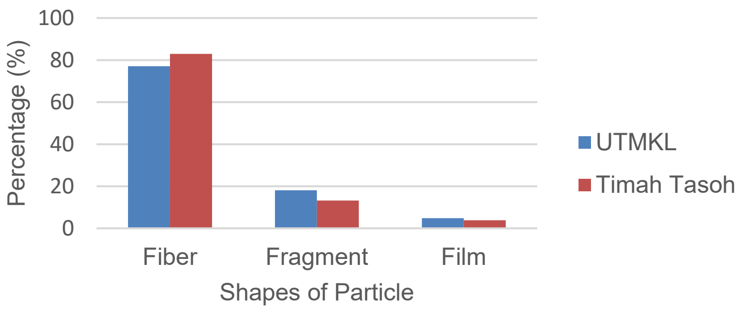

Figure 4: Comparison of the type of MPs shape collected in this study

MPs' colour has no effect on their environmental impact, but it can be utilised to identify their source. For instance, brightly coloured MPs are frequently linked with consumer goods, but dull grey MPs are frequently connected with vehicle tires. Figure 5 depicts the distribution of various hues of MPs. In this study, the collected MPs are found by colour as follows: transparent/white, black, red, blue, green, brown, yellow, and orange. Transparent/white and black were the most abundant (>30 %) for both locations. However, in Timah Tasoh transparent/white has the highest percentage while in UTMKL black is more dominant. Red, blue, green, brown, yellow and orange MPs are rather few. From this study, orange colour is only found in UTMKL with smallest number. Black colour is found in atmospheric MPs due to the presence of carbon-based compounds, such as polyethylene, polypropylene, and polystyrene. MPs in the atmosphere has a transparent colour due to the fact that the particles are so small that they are able to absorb and scatter sunlight, making them appear transparent. Discoloration of MPs can occur during weathering and sample preparation (especially with oxidative digestion such as H_2O_2), which should be considered when reporting and interpreting data that may be the result of this phenomenon. Total number of transparent/white MPs in the sample is higher (Rochman et al., 2019). Colour is helpful for identifying probable sources of plastic debris and contaminations during sampling (Hartmann et al., 2019).

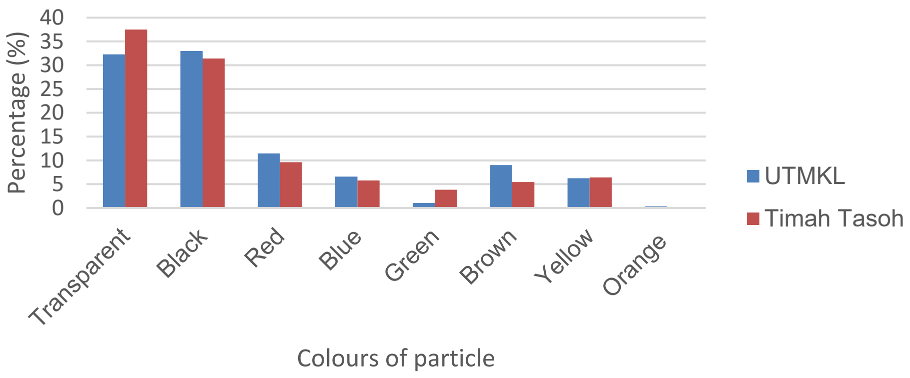

Figure 5: Colour comparison of MPs in this study

4. Conclusions

The present study has shown that atmospheric MPs in the atmosphere in urban area of Kuala Lumpur contain no more than 600 particles/m²/d while in rural area of Timah Tasoh contain no more than 1,000 particles/m²/d with range between 50–5,000 μm in size. Based on the analysis, deposited samples from both places are contaminated with MPs, with Timah Tasoh having the highest concentration. The use of a microscope allows for the classification of the physical characteristic into a number of categories, including size, shape, and colour in the context of this investigation. The fibre shape and black colour are the ones that are most frequently found, and this conforms to the findings of other studies. This work constitutes the baseline database for monitoring MPs contamination in Peninsular Malaysia's urban and rural areas. Current study on air MPs is in its infancy, resulting in scant data on abundance and characterization, particularly for Malaysia. The findings also demonstrated the significance of regulating plastics materials and implementing a recycling programme in order to avoid the growth of this hazard to the environment, particularly in the atmosphere, according to new MPs research. Moreover, due to many purchases are made online across the world during the pandemic Covid-19, more plastic is being use for wrapping, this could lead to many plastics' consumption hence more MP would be generate in the future. In addition, the findings may give a foundation for gaining insight into the source, associated impact of this pollutant on the ecosystem, and potential impact of MPs intake on human health.

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