Atmospheric Microplastic Deposition and Suspension in Kuala Lumpur

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ABSTRACT

The primary sources of microplastics (MP) in the atmosphere include textile fibers, tire abrasion, rubber fragments from road networks, and spills in plastic production. Malaysia's high plastic usage is expected to result in higher concentrations of MP in densely populated cities. The research is conducted at Universiti Teknologi Malaysia Kuala Lumpur, using a dust deposition gauge to collect atmospheric MP. Control samples will be used for comparison. Malaysia has the highest per capita plastic packaging usage among six Asian nations. The sampling methods include active sampling with a pump sampler system and passive sampling with a glass container. The samples will be analyzed using a digital microscope. Fibers are the most common shape of air microplastics, likely originating from fabric. Different colors have been reported for microplastics, which can aid in visual assessment. The deposition rate for fibre and non fibrous MP are 3.408×103 MP/m^2/day and 0.046×103 MP/m^2/day respectively. The suspension rate for fibre and non fibrous MP are 1.254 MP/m^3 and 0.005 MP/m^3 respectively. The most abundant colour found in UTM KL was transparent, followed by black. Also, other colours visually identified includes blue, green, yellow, and red.

Keywords: Atmospheric microplastic, micropastic deposition, microplastic suspension.

1. INTRODUCTION

The term "plastic" refers to a variety of carbon-, hydrogen-, oxygen-, nitrogen-, chlorine-, and sulfur-based substances. Plastics are primarily made from natural resources such as cellulose, coal, natural gas, and petroleum oil [1]. Microplastics (MP) are small synthetic compound-filled plastic that are smaller than 5 mm in size [2]–[4]. MP has gotten into every crease and crevice on earth [5]–[7].

The primary sources of MP in the atmosphere include textile fibres (home washing machines, industrial laundries), tyre abrasion and rubber fragment from road networks, and spills in pre-production plastic pellets [8]. Since plastic is an artificially created substance that is used for packaging, plastic bags, cups, toys, automotive parts, synthetic apparel, electric home appliances, and plastic bottles, it is officially a synthetic compound. It is mostly made of coal, natural gas, or crude oil and isn't biodegradable like other composite materials [8], [9]. Toxins and pathogens are drawn to the surface of MP. Animals on land and in the water mistake plastic particles for small animals, which they subsequently eat. The polluting plastic particle eventually makes its way to our plate and then into our bodies through the food chain [10]. MP has been found in even our drinking water and food, but no harm has yet been proven [8].

Malaysia's yearly per capita usage of plastic packaging, at 16.78 kg per person, placed Malaysia first among the six Asian nations studied in recent research by the World Wide Fund for Nature [11]. While Jambeck *et al.*, said that Malaysia produced 0.94 million tonnes of improperly disposed plastic garbage, it is possible that 0.14 to 0.37 million tonnes of that amount poured into the oceans based on a prediction that may be biased [12]. Although there are very few studies

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concentrating on the distribution of MP in ambient air, a number of studies have found that MP are available in the atmosphere [13].

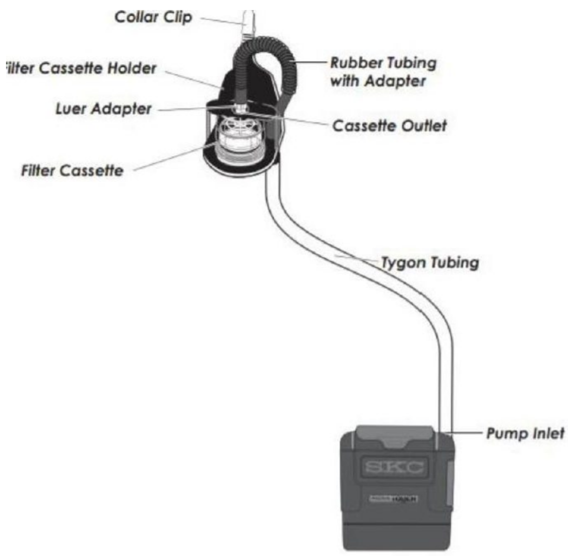
Most research in Malaysia is focusing into MP distribution in water and soils. As a result, it is anticipated that the presence of MP in a growing nation like Malaysia will be on par with or higher than that of other regions of the world. Due to Malaysia's rising plastic usage, it is anticipated that the concentration of MP in the fallout of densely populated cities will be significantly higher than the composition of MP seen in most studies. However, because of the particle's aerodynamic size and density, this quantity of MP may be considerably lower in suspended air particles.

2. EXPERIMENTAL PROCEDURE

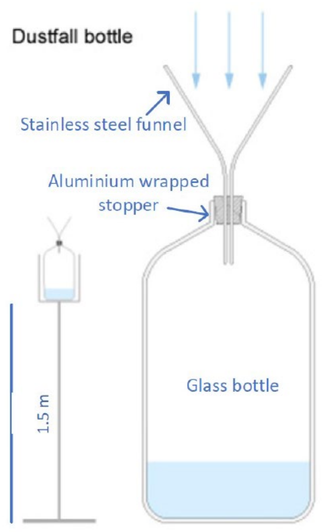
This study will concentrate on gathering atmospheric deposition data. Two separate sample techniques, active sampling, and passive sampling will be used to gather the atmospheric fallout. There might be variations between the outcomes of active and passive sampling techniques, thus this research will study and compare the difference in outcomes between these two different techniques.

The active sampling method is based on a pump sampler system at the rate 8L/min while the passive sampling method collects dry or wet ambient sediment in a glass container through an aluminium funnel. For active sampling, the sampling point was on a rooftop of a double storey building in UTM KL, while the sampling point for passive sampling is 1.5m above ground.

The dust deposition gauge, a sampling tool made of a stainless-steel funnel linked to an amber glass container to prevent contamination or contact with plastics, will be used to collect deposited atmospheric MP (DAMP) at each location. The identical process will be followed in every site to guarantee the accuracy and reliability of the results. Figure 1 depicts the configuration of the sampling apparatus.



(a)



(b)

Figure 1. Sampling equipment and setup (a) Sampling train for Suspended atmospheric MP (SAMP), (b) Deposited atmospheric MP (DAMP) sampling setup.

To prevent sample contamination owing to resuspended dust on the ground during heavy rains, the height of the collector's opening area must be at least 1.5 meters above ground. A sampling head unit (pre-loaded with MCE Filter, 37 mm in diameter) connected to a sampling pump (SKC AirChek XR5000) will be utilized as an active sampler to collect suspended atmospheric MP (SAMP).

2.1. Samples Pre-Treatment: Volume Reduction for DAMP

The bulk of the atmospheric MP samples that are obtained will include both dry and/or wet depositions. For all DAMP samples at all locations, the volume reduction approach provided by [11] will be used. To guarantee that samples are correctly separated from rainwater (wet precipitation), pre-treatment (volume reduction) will be applied to the DAMP samples that have been collected. The same tools are used to collect samples when it is not raining. Pre-treatment involves vacuuming filtration via MCE filters to reduce sample volume. SAMP samples will not go through the same pre-treatment as DAMP. SAMP samples will be directly deposited onto the filter surface by the suction of the pump.

To eliminate organic material that adheres to the MPs' surface through adsorption, the samples will go through digestion. Pre-filtered 30% hydrogen peroxide (H_2O_2) will be used for the digestion process for 24 hours [14]. The amount of organic matter in the samples will determine how much H_2O_2 is required [6]. The volume of 30% H_2O_2 utilized according to some researcher is 100mL [6], [15]. Physical density separation of the sample will be done by pouring the mixture of sample and H_2O_2 into the glass ampoule decanter, and then wait for the mixture to settle around 3 minutes and next, decant out 10mL of the mixture which contain denser non plastic particle.

2.2. Visual and Physical Classification

The simplest and commonly used identification method is the visual inspection. The method of visual identification is suitable for rapidly counting many microplastics [8]. The sample will be analysed by visual observation using digital microscope to see the quantity and physical form of microplastic in the collected sample. The microplastic counted manually and then classified due to the group of shape, size, and colour. The shape, size and colour will be observed by LEICA Stereomicroscope. The dry filter paper will be placed under microscope for visual observation.

Different units can be used to quantify the deposition rate, such as mass per unit area or number of particles per unit area over a given period of time as shown in Equation 1 [9]. the sampling area is 0.0134 m^2.

$$Deposition\ Rate\ (MP/m^2/day) = \frac{Count\ of\ MP}{Area\ of\ surface \times Day} \quad (1)$$

For suspended atmospheric MP research, the flow rate of sampling pump, Q being pumped in sampling area is at 8L/min, with 24 hours of sampling duration. Hence, the Equation 2 is commonly used to calculate the volume of fluid (liquid or gas) that passes through a particular point in a system within the time frame of research [9]. Therefore, the Equation 2 shows that it is particularly useful to quantify the volume of fluid flowing through a system [16]. Which resulting the answer of the volume of fluid, V that has flowed or will flow through the Leland Legacy Sampling Pump is 11.52 m^3. Hence, value of V from Equation 2 can be used to calculate the Suspension Rate (MP/m^3) by dividing the total count of MP present during suspension of pump on sampling duration, as shown in Equation 3 [17].

$$V = Qt \quad (2)$$

$$Suspension\ Rate\ (MP/m^3) = \frac{Count\ of\ MP}{Volume} \quad (3)$$

3. RESULTS AND DISCUSSION

3.1. Deposition and Suspension Rate of Atmospheric Microplastic

Figure 2 and 3 below demonstrates the deposition and suspension rate of atmospheric microplastic at Universiti Teknologi Malaysia Kuala Lumpur.

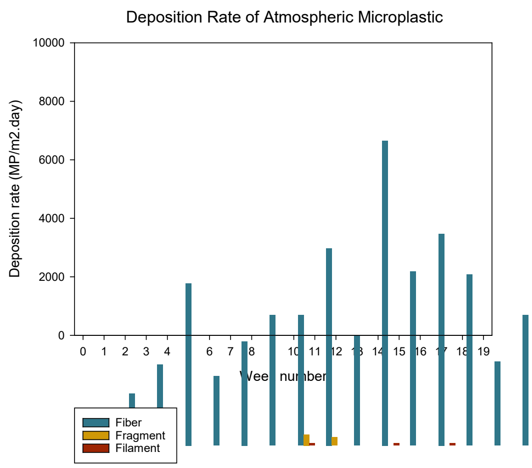


Figure 2. Deposition rate of atmospheric microplastic.

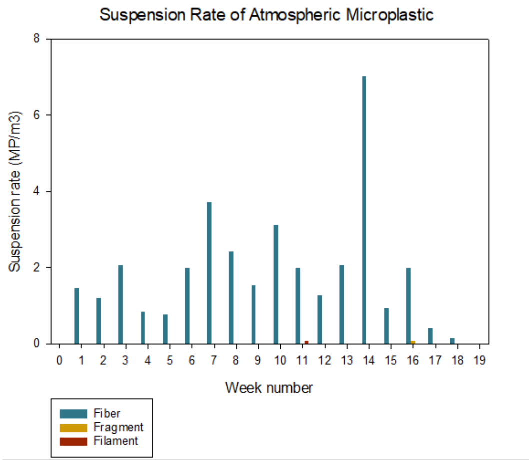


Figure 3. Suspension rate of atmospheric microplastic.

From both figures, fibres shows the most significant value compared to fragment and filament. The samples were taken between 30th June 2022 to 19th October 2022 which was during southwest monsoon. Many Asian nations' air quality is mostly determined by the monsoon season [18]. Pollutant levels are significantly influenced by meteorological variables such as wind speed, rainfall, temperature, relative humidity, and the physical scale of the city [19], [20]. Numerous research [21]–[24] showed that the southwest monsoon, which is a relatively dry season, is when the PM^{10} levels were mostly high. As a result, the amount of air microplastic deposited during the Southwest monsoon may be significant. The deposition rate for fibre and non fibrous MP are 3.408×10^3 $MP/m^2/day$ and 0.046×10^3 $MP/m^2/day$ respectively. The suspension rate for fibre and non fibrous MP are 1.254 MP/m^3 and 0.005 MP/m^3 respectively. According to previous investigations, fibre and fragment are the most typical shapes of air microplastics deposited, with fibre being present over the whole study region. While pieces are believed to have originated from disposable plastics through fragmentation, fibres are thought to have originated from fabric, such as clothing and textiles [25]. This suggests why fibre are the most frequent shapes discovered in the study.

3.2. Colour of Atmospheric Microplastic

Several colours have been reported for microplastics, including red, orange, yellow, brown, tan, off-white, white, grey, blue, and green [5]. Based on Figure 4, the most abundant colour found was transparent followed by black. Also, other colours visually identified includes blue, green, yellow, and red. Red, yellow, brown, white, grey, blue, green, translucent, pink, and purple microplastics have been documented [26]–[29]. According to Verla et al., the colour of plastics shows the state of their decomposition [30]. Colour analysis is thought to be less important than spectral or chemical identification of these microplastics due to the predominantly small particle size and frequently significant weathering of these particles [8]. However, colour can be helpful in the initial visual assessment of microplastics in atmospheric samples.

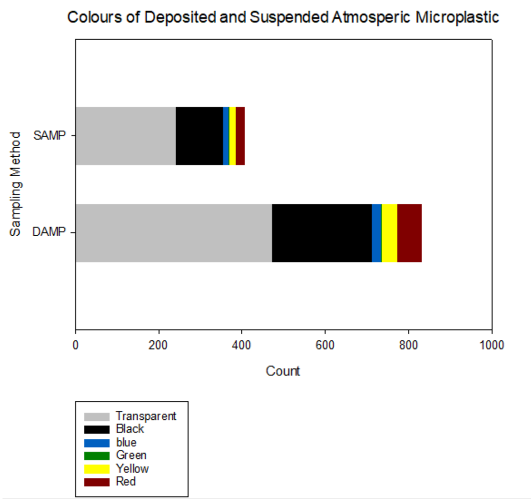


Figure 4. Colours of atmospheric microplastic.

4. CONCLUSION

It is expected that the level of microplastic concentration in the fallout of densely populated cities in Malaysia can be much higher than average composition of microplastic in most research due to the increasing consumption of plastics in the country. It is estimated that the non-fibrous shape of microplastic (possibly fragments and/or films) could be dominant in Malaysian air- shed since Malaysia consumes much plastics packaging. The deposition rate for fibre and non fibrous MP are 3.408×10^3 MP/m^2/day and 0.046×10^3 MP/m^2/day respectively. The suspension rate for fibre and non fibrous MP are 1.254 MP/m^3 and 0.005 MP/m^3 respectively. The most abundant colour found in UTM KL was transparent, followed by black. Also, other colours visually identified includes blue, green, yellow, and red.

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