Relationship of Suspended Atmospheric Microplastics and Meteorological Parameters in Universiti Teknologi Malaysia, Kuala Lumpur

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Abstract. Microplastic has been an interesting topic since years ago, but majority only focus on the relation between microplastics and ocean or aquatic life, therefore, the information regarding the suspended atmospheric microplastics (SAMPs) is still limited to date. Microplastics are small particles within the size of 1µm-5mm and composes of different elements. Be it marine life or airborne pathways, microplastic has become one of the major concerns among environmental researchers around the world and microplastic pollution can be expected to stay for a very long time, as plastics production keep increasing, year by year. In this regard, this study evaluates the physical characteristics of atmospheric microplastics and the relationship between its emission and meteorological data. The atmospheric microplastics were collected using a High-Volume Sampler in which the sampler was placed on a rooftop at Universiti Teknologi Malaysia for three months. The physical characteristics of microplastics were categorized by shape, colors and size using spectro-microscopy microscope. The correlation between the characteristics with environmental parameters such as rainfall, wind speed, mean temperature, and relative humidity were then evaluated. The estimated daily intake of microplastic were also determined at different human development. The atmospheric microplastics found are in the range between 300µm–5000µm, which is similar to literature. There is no correlation that can be found between the atmospheric microplastics and the meteorological data, probably due to the low number of samplings. The estimation of daily abundance of microplastics were found to be high for infants.

1. Introduction

The topic of microplastic has been an interesting topic since years ago but that majority only focusing on the relation between microplastics and ocean or aquatic life, therefore, the information regarding the suspended atmospheric microplastics (SAMPs) still limited to date [1–3]. With how the microplastics is related with the aquatic, the recent studies may only pressure in the passive of microplastics, while this research was using an active sampler to collect suspended atmospheric microplastic. Plastic was released into the environment as a result of waste mismanagement and unauthorized dumping, and because of its extended environmental lifetime, plastic is easily collected in numerous environmental matrices [2].

Since microplastics through airborne is related towards the environmental effects greatly, meteorological parameters are playing a role as important pathway in transferring the polluted

microplastics around the environment. Therefore, we can find and correlate between identifications of microplastics that are collected and the environmental variables.

Tiny particles of microplastics are easily transport through air and to be breath which there is possibility to risk the human health [4]. In a recent study, humans are expected to breathe in approximately 26-130 microplastics every day due to the prevalence of airborne microplastics in our atmosphere [4]. When people breathe, they take in not only air but also probably all of the other particles hanging in the air. In this regard, this study aims to investigate the physical characteristics of SAMPs, to determine the relationships of SAMPs abundances with meteorological parameters, and to estimate the daily abundances of microplastics intake (EDI) of the SAMPs.

2. Methodology

2.1 Sampling & Organic Matter Removal

A total of 8 samples (n=8) were obtained from UTM Kuala Lumpur campus for10 weeks between January to March 2022. A High-Volume Sampler (SIBATA HV-1000R) with quartz fiber filter were used to sample the atmospheric microplastics for 24 hours for each of the sample. During the sampling, a simple rain gauge was used to record the amount of precipitating rain. A weather station located in the same area were also used to record the wind speed and relative humidity during the sampling. After the sampling, all samples were covered in an aluminum tray with aluminum foil wrap to protect from contamination. The weight of the filter was measured by using an analytical balance. The filter was then soaked in a 150 ml 30% hydrogen peroxide for 24 hours under a fume hood to remove the organic matter.

Figure 1. Overview and detailed views of the sampling area.

2.2 Physical Characterization

The sample that has been dried from previous step were analyzed by using a stereo-microscope (Nikon SMZ-745T) to obtained the microplastics count and the physical characteristics of shape, size, and color.

2.3 Estimation of Expected Daily Abundance of Microplastics Intake (EDI)

The EDI for four (4) group of humans which are infant, toddler, teenager and adult were estimated using Equation 1 which was adopted from previous study.

$$EDI\ (particles/kg.day) = C.m/BW \qquad \text{Eq. 1}$$

Where:

C = concentration of microplastic (particles/g)
m = ingestion rate (g/day)
BW = average body weight of various age group (kg)

3. Result & Discussion

3.1. Physical characteristics of microplastics

Figure 2 shows the comparison of the microplastics abundances and size range that is obtained from this study and from the literature, which indicate that the finding is within the acceptable range. In this study, the size of microplastics collected are between 300µm – 5000µm in average which is acceptable. The microplastics abundances found from this study are not more than 2000 particles/m^2.day which is similar to the other two studies [5,6]. This is probably due to the targeted sample is the suspended atmospheric microplastics and the type of sampler that are being used is the active sampler. While for studies on deposited air microplastics used passive sampler or vacuum cleaner [7,8]. Vacuum cleaner can collect much more dust than the ones in the air. Hence, the result obtained for the passive sampler is relatively high.

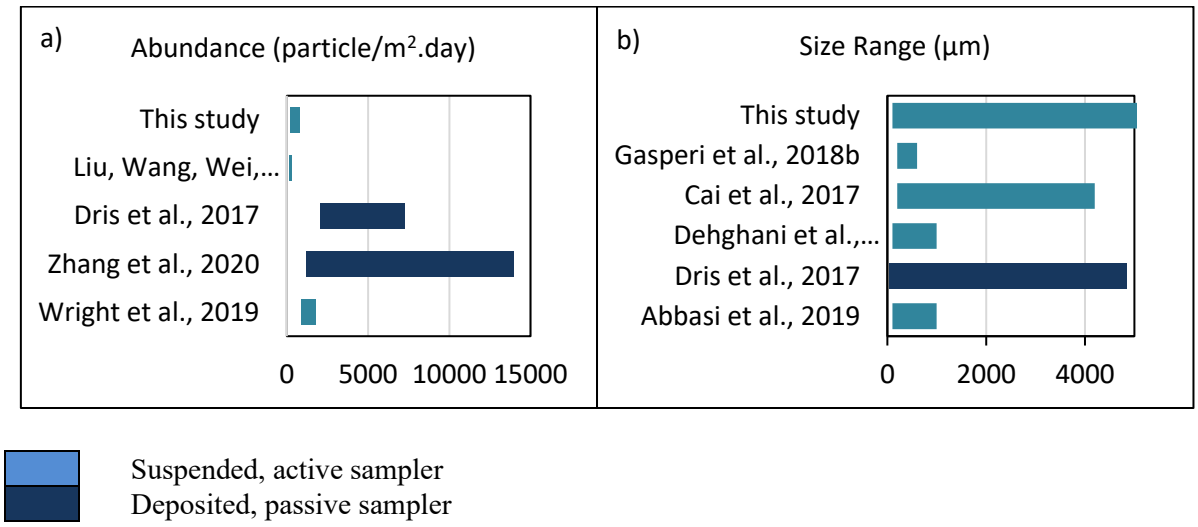

Figure 2. Comparison of the microplastics abundance and size range collected in this study with literatures

With respect to the size of microplastic, the range of microplastics size in this study is above the range of other studies [7]. Differ from what has been experimented and collected from this study, most of the studies that related to the air microplastic sampling are in a smaller range size of microplastics and this probably happened due to several factors which included the location of the sampling. This study was conducted in an urban area of Kuala Lumpur with an addition of building development and construction surrounding the area of sampling which may be the result of large size of microplastics.

The particles observed from the stereomicroscope are shown in Figure 3 are classified as fibers and fragments with fiber-shaped is mostly collected at about 92% in total. Laundry washing and drying has been demonstrated to be a major source of fibrous polymers in the environment in studies [7,9].

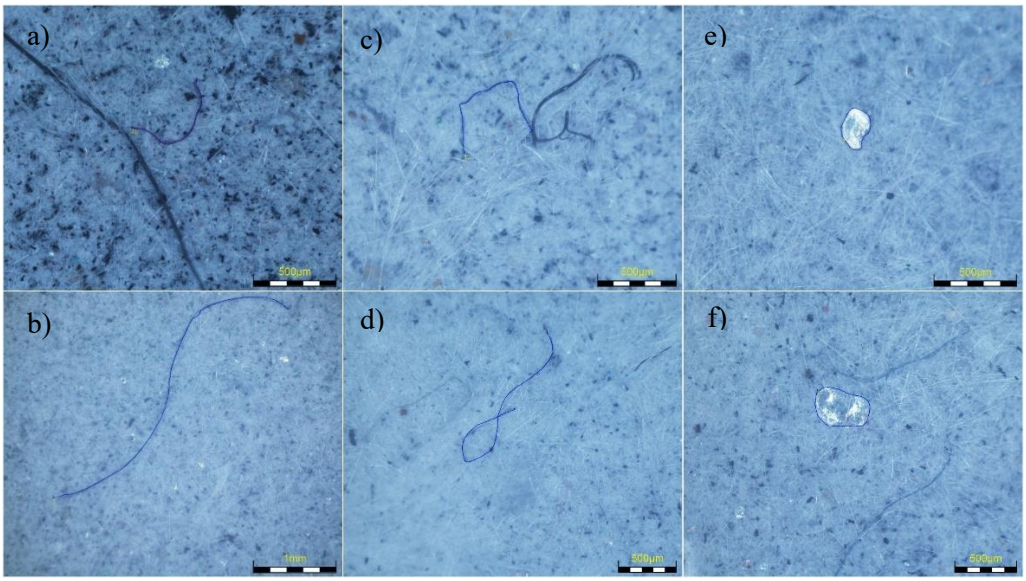

Figure 3. The stereo-microscope image of microplastic. **a-d** fiber shape, **e** and **f** fragment shaped of microplastics collected from this study.

The main concern with fibrous microplastics is that they have the potential for long-range transportation. Since the sampling site is about at the busiest city of Malaysia, the commercial and high population of residence may contribute to the numbers of fibers collected in this research and this case may affected the presence of fragment as well. Whether the location is indoor or outdoor, suspended or deposited, the fibrous microplastics could still be a major shape found since the sources of fibers are literally surrounding everywhere.

In this study, the microplastics collected are classified in several colors such as black, white, red, blue, orange, and yellow. The identification is observed by using a microscope and the total count of microplastics in this study can be seen in Figure 4 below where black color is the most collected at over 50%. Although there is no strong justification on the correlation of microplastics abundance with the various of colors collected, it is to be found that by comparing with previous studies, the black color seems to be the most found among the microplastics collected. This is probably because of the high use of black color in several industries such as black plastics for agriculture, clothes, shoes, etc.

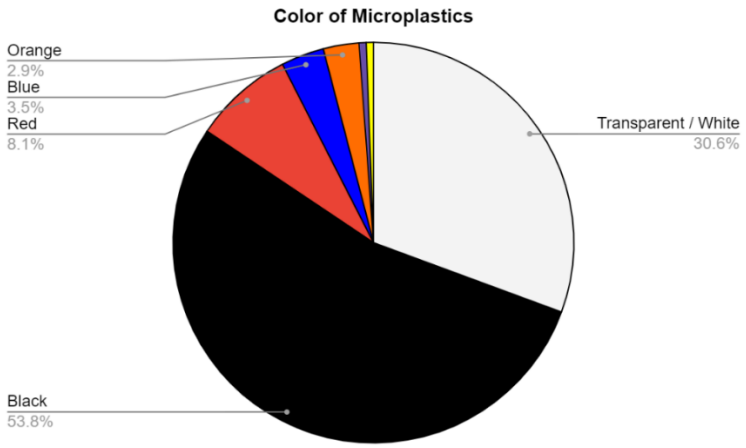

Figure 4. Accumulation of different colors collected of microplastics.

3.2. Meteorological parameters and SAMPs abundance correlation

The meteorological parameters we correlate with are rainfall, windspeed, relative humidity, and mean temperature. Generally, the amount of rainfall appears to have a significant impact on the fallout flux. In fact, dry conditions or periods of little cumulative rainfall produced especially small fibers.

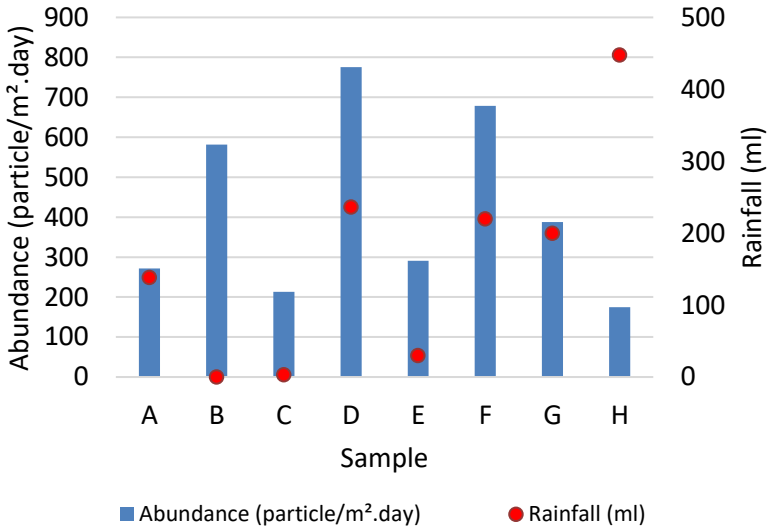

Figure 5. Correlation between microplastics abundance and rainfall

At the lowest abundance of microplastic collected, Sample H, the amount of rainfall on that day was the highest compared to the others. This indicates that, heavy rain gives less sources of microplastics and is influenced by human activities [10]. Besides, the abundance of microplastics may be significantly affected by hydrodynamics flow of rainfall where sampler used in this study was only able to collect dry air despite the high-volume used.

Microplastics pollution is travelling vast distances via the wind which may be the reason why in certain places on earth found a sheer amount of microplastics pollution that should be somewhere far away from the site [11]. With the large amount of plastics production and plastics waste at the near place of site sampling may contribute to the existence of microplastics and this probably can be seen if the analysis is focusing on the wind direction instead of windspeed.

By theory, precipitation increased with both increasing wind speed and was accelerated by high relative humidity during dry periods. Low abundance of microplastics in Sample H was found at high relative humidity, a little over 80%, compared to the highest abundance found in Sample D at 85% relative humidity. However, a study by [12]the obtained data showed an increase average in humidity promote the abundance of microplastics. This unfortunately cannot be proved by this study and need to be further analyzed depending on the windspeed and other meteorological parameters that may affect to the humidity and abundance of microplastics.

A study reviewed by [13], pollutant records in snow have been successfully utilized to quantify the flow from air deposition because of its low temperature and isolation from human activity. From the results, the highest abundance found in Sample D was collected when the day has low mean temperature at 27°C compared to the others. This may because of the amount clothes human wearing during the low temperature. These parameters may correlate to each other and other factors as well such as wind direction. Therefore, more studies and further research are needed in finding these correlations specifically for meteorological parameters and the abundance of microplastics.

3.3. Daily abundance of microplastic intake (EDI)

Figure 6 shows the average EDI for infant, toddler, teenager and adult which indicate a high average EDI for infant. The trend of relationship between average EDI and stage of human stage can be clearly analyzed where the estimated intake of microplastics is decreasing as the age in older. The infant may be the most vulnerable since the amount of ingestion rate is almost the same as adult despite of the average weight. Humans may consume 74,000–121,000 particles per year, or 0.1–5 g of MPs up to 1 mm in size, on average, globally [14]. Adults are thought to absorb between 39,000 and 52,000 microplastic particles annually, according to research [15]. While infants receiving formula from plastic bottles may receive up to 4 million particles each day, or 1.5 billion particles annually [16]. Although there is a lot of room for variance in these estimates, they are probably low because of the methodological and data constraints.

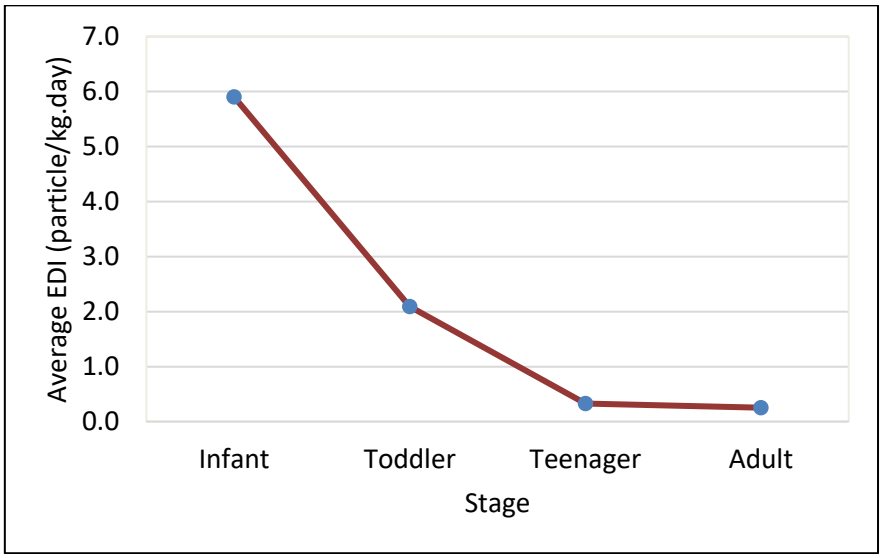

Figure 6. Relationship between average EDI and human stage

4. Conclusion and recommendation

Suspended atmospheric microplastic are potentially significant contaminants in the urban settings that are been received little consideration. The present study has shown that atmospheric microplastic in the atmosphere in urban area of Kuala Lumpur contain no more than 2000 particles/m^2.day. The physical characteristics can be identified by using a microscope by several classes which for this study are size, shape, and color. Fiber shape and black color is the most common found and it is complied with other study. The abundance of microplastics per day is calculated to correlate with meteorological parameters such as rainfall, windspeed, relative humidity, and the mean temperature. Although this study cannot prove the trend between meteorological parameters and the abundance of microplastics, more research can be done and correlated each other to see the effect and factors that may be affecting the existence of microplastics in the air. Microplastics may be the most harmful towards the infants compared to the adults. However, it must not be avoided for the adults to aware how microplastic pollution is as hazardous as the plastic generation is still increasing as the year increase.

As for recommendation, it is recommended to record any existence of possible polymers especially when using a high-volume active sampler. Besides, it is necessary to record for any possible and doable weight measurement to get a more accurate data for microplastics concentration and abundance. Current atmospheric microplastics research is in the early stage, therefore, seems that there is an insufficient amount of comparable data can be done.

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