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Wet and Dry Deposition of Microplastics in Thailand: Asian Institute of Technology Campus

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Abstract

In this study, wet and dry deposition of microplastics in an outdoor environment, and dry deposition of microplastics in an indoor environment in AIT were studied. The rainwater samples and outdoor air sample were collected at the open area of EEM research station, and the indoor air samples were collected in the location of student dormitory Room X-29A. The US-330 automatic precipitation sampler was used to collect rainwater samples and the surface area 0.0314 m^2 stainless steel bowls were used to collect the outdoor and indoor air samples. Microplastics identification techniques involved wet sieving, first transfer sieve solids, digestion, density separation, second transfer sieve solids, stereomicroscopic examination, and FTIR analysis. The deposition of microplastics in rainwater was 1994±1030 number/m^2/week. Among them, 93 % were in fiber shape, 6 % were in fragment shape, and 1 %, were in film shape. The study showed that 80 % of the microplastics were in white color, brown color 12 %, blue color 5 %, green, yellow, and red color had approximately 1% each. The deposition of microplastics in the outdoor air was 1392±987 numbers/m^2/week. Among them, 94 % were in fiber shape, and 6 % were in fragment shape. Color of microplastics in the outdoor air were observed that 84 % of the microplastics were in white color, brown color 9 %, blue color 5 %, red color and yellow color had 1 % each respectively. The weekly averaged deposition of microplastics in outdoor environment (Wet + Dry) was 3451±1539 number/m^2/week. The deposition of microplastics in the indoor air was 2619±1,289 numbers/m^2/week. Among them, 96 % were in fiber shape, and 4 % were in fragment shape. Color of microplastics in the indoor air was observed that 94 % were in white color, brown color 3 %, green color 2 %, and blue color 1% respectively. Fibers were the dominant shape of microplastics in this study, which might come from clothes and textiles. Most polymer types found in this study were PP, PU, PET, PE, and Cellophane. PP might come from consumer products, bottle lids, food tubs, automotive products, and textiles. PU might come from cleaning products, cushion materials, and PET might come from fibers for clothing, plastic bags, plastic film, plastics bottle. Cellophane might come from tapes, photographic film, clothes. White color was the dominant color of the microplastics in this study. White color has been ascribed as PE and it might come from plastic bags, plastic film, and plastic bottles.

Keywords: dry deposition, wet deposition, primary microplastics, secondary microplastics, indoor microplastics, outdoor microplastics

ထိုင်းနိုင်ငံ AIT Campus အတွင်း မိုးရေနှင့် လေထုတွင် မိုက်ခရိုပလတ်စတစ်ပါဝင်မှုကို ဆန်းစစ်ခြင်း

ကျော်ဇင်လတ်၊ လက်ထောက်ညွှန်ကြားရေးမှူး
ပတ်ဝန်းကျင်ထိန်းသိမ်းရေးဦးစီးဌာန

စာတမ်းအကျဉ်း

စာတမ်းပြုစုနိုင်ရေးအတွက် AIT campus အတွင်း မိုးရေတွင်ပါဝင်သော မိုက်ခရိုပလတ်စတစ်၊ ပြင်ပလေထုတွင်ပါဝင်သော မိုက်ခရိုပလတ်စတစ်၊ ပြင်ပပတ်ဝန်းကျင်တွင် ပါဝင်သော မိုက်ခရိုပလတ်စတစ်နှင့် အခန်းတွင်းလေထုတွင်ပါဝင်သော မိုက်ခရိုပလတ်စတစ်တို့ကို လေ့လာဆန်းစစ်ခဲ့ပါသည်။ ပြင်ပပတ်ဝန်းကျင်အတွက် နမူနာပစ္စည်း ကောက်ယူမည့်နေရာအား AIT ၏ သုတေသနဌာနအား ရွေးချယ်ခဲ့ပြီး အခန်းတွင်း ပတ်ဝန်းကျင်အတွက် နမူနာပစ္စည်းကောက်ယူ မည့်နေရာအား ကျောင်းသားအဆောင် X၊ အခန်း 29 Aအား ရွေးချယ်ခဲ့ပါသည်။ မိုးရေတွင် ပါဝင်သော မိုက်ခရိုပလတ်စတစ်အား ဆန်းစစ်ရန်အတွက် နမူနာပစ္စည်း ကောက်ယူရာတွင် US 330 Automatic precipitation sampler အား အသုံးပြုခဲ့ပြီး ပြင်ပလေထုနှင့်အခန်းတွင်း လေထုတွင် ပါဝင်သော မိုက်ခရိုပလတ်စတစ်အား ဆန်းစစ်ရန်အတွက် နမူနာပစ္စည်း ကောက်ယူရာတွင် 0.0314 m^2 ဧရိယာရှိသော စတီးခွက်အား အသုံးပြု၍ ကောက်ယူခဲ့ပါသည်။ မိုက်ခရိုပလတ်စတစ် ဆန်းစစ်ခြင်း ဓာတ်ခွဲမှုနည်းစဉ်များအနေဖြင့် စစ်ထုတ်ခြင်း၊ Organic ပစ္စည်းများအား ချေဖျက်ခြင်း၊ Inorganic ပစ္စည်းများအား အလေးချိန်အလိုက် ခွဲထုတ်ခြင်း၊ မိုက်ခရိုစကုတ်အား အသုံးပြု ၍ မိုက်ခရိုပလတ်စတစ်များ၏ အရွယ်အစား၊ ပုံသဏ္ဍာန်နှင့် အရောင်အသွေးတို့အား ခွဲခြားခြင်းနှင့် Polymer အမျိုးအစားကို ဆန်းစစ်နိုင်ရန်အတွက် Fourier-Transform Infrared Spectroscopy analysis (FTIR analysis)အား ဆက်လက်ဆောင်ရွက်ခဲ့ပါသည်။ FTIR analysis အရတွေ့ရှိရသော Polymer အမျိုးအစားအပေါ် အခြေခံ၍ မိုက်ခရိုပလတ်စတစ်ထွက်ရှိရာ အရင်းအမြစ်များအား ဆန်းစစ်ဆောင်ရွက်ခဲ့ပါသည်။ လေ့လာတွေ့ရှိချက်အရ မိုးရေတွင်ပါဝင်သော မိုက်ခရိုပလတ်စတစ်အနေဖြင့် တစ်ပတ်လျှင် ပျမ်းမျှ 1994 numbers/m^2 တွေ့ရှိရပါသည်။Polymer အမျိုးအစားများ အနေဖြင့် Prolypropolyne(PP) ပါဝင်မှု 29%၊ Polyurethane (PU)ပါဝင်မှု 14%၊ Polyethylene Terephalate(PET) ပါဝင်မှု 29 % ၊ Poly (ethylacrylate) ပါဝင်မှု 14%နှင့် PBA ပါဝင်မှု14% ဖြစ်ကြောင်းတွေ့ရှိရပါသည်။ ပြင်ပလေထုတွင်ပါဝင်သော မိုက်ခရိုပလတ်စတစ်အနေဖြင့် တစ်ပတ်လျှင်ပျမ်းမျှ 1392 numbers/m^2

တွေ့ရှိရပါသည်။ Polymer အမျိုးအစားများ အနေဖြင့် Prolypropolyne(PP) ပါဝင်မှု30% ၊ Polyurethane (PU) ပါဝင်မှု 20% ၊ Polyethylene Terephalate (PET) ပါဝင်မှု 20% ၊ Poly (ethylacrylate) ပါဝင်မှု 20% နှင့် Cellophane ပါဝင်မှု 14% ဖြစ်ကြောင်း ဆန်းစစ်တွေ့ရှိရပါသည်။ ပြင်ပပတ်ဝန်းကျင်တွင် တွေ့ရှိရသော မိုက်ခရိုပလတ်စတစ်အနေဖြင့် တစ်ပတ်လျှင်ပျမ်းမျှ 3451 numbers/m^2 တွေ့ရှိရပါသည်။ အခန်းတွင်း လေထုတွင်ပါဝင်သော မိုက်ခရိုပလတ်စတစ်(Dry deposition) အနေဖြင့် တစ်ပတ်လျှင်ပျမ်းမျှ 2619 numbers /m^2 တွေ့ရှိ ရပြီး ဓာတုပစ္စည်း ပါဝင်မှုအနေဖြင့် Polyethylene Terephthalate (PET) ပါဝင်မှုအများဆုံး ဖြစ်ကြောင်းတွေ့ရှိရပါသည်။ ယခုလေ့လာ ဆန်းစစ်ချက်တွင် ရုပ်ပိုင်းဆိုင်ရာ တွေ့ရှိချက်အရ မိုက်ခရို ပလတ်စတစ်အများစုမှာ Fiber ပုံသဏ္ဍာန်ဖြစ်ပြီး အဖြူရောင်ရှိသော မိုက်ခရိုပလတ်စတစ်များကို ရာခိုင်နှုန်းအများဆုံး တွေ့ရှိရပါသည်။ Fiber ပုံသဏ္ဍာန်ရှိသော မိုက်ခရိုပလတ်စတစ်များမှာ အများအားဖြင့် အဝတ်အထည်နှင့် ချည်ထည်များ၊ အဝတ်လျှော်လုပ်ငန်းစဉ်များမှ အများဆုံးထွက်ရှိနိုင်ကြောင်း လေ့လာသုံးသပ်ရပါသည်။ အဖြူရောင်ရှိသော မိုက်ခရိုပလတ်စတစ်များမှာ အများအားဖြင့် Polyethylene (PP) ဟု သတ်မှတ်နိုင်ပြီး ပလတ်စတစ်အိတ်များ၊ ပလတ်စတစ် ဖလင်ပြားများ၊ ပလတ်စတစ်ဗူးများ ပြိုကွဲပျက်စီးရာမှ ဖြစ်ပေါ်လာကြောင်း လေ့လာသုံးသပ်ရပါသည်။ လေ့လာတွေ့ရှိချက်အရ Propolyne(PP)၊ Polyurethane(PU)၊ Polyethylene Terephthalate (PET)၊ Polyethylene(PE)တို့အား အများဆုံး တွေ့ရှိရပြီး အဆိုပါ Polymer အမျိုးအစားများ အနေဖြင့် လူသုံးပစ္စည်းများ၊ အစားအသောက် ထည့်သည့်ဗူးခွံများ၊ ဖော့ဗူးများ၊ အထည်အလိပ်များ၊ အဝတ်လျှော်လုပ်ငန်းစဉ်များ၊ သန့်ရှင်းရေးသုံး ပစ္စည်းများ၊ ပလတ်စတစ်အိတ်များ၊ ပလတ်စတစ်ဖလင် ပြားများနှင့် ပလတ်စတစ်ဗူးများ ပြိုကွဲပျက်စီးရာမှ ဖြစ်ပေါ်လာကြောင်း လေ့လာသုံးသပ်ရပါသည်။

Wet and Dry Deposition of Microplastics in Thailand: Asian Institute of Technology Campus

1. Introduction

Plastics are organic materials with a lightweight, hygienic and resistant material which can be moulded in a variety of ways and utilized in a wide range of applications. The plastics production will continue increase due to the lower price, easily molded, lightweight, and reliable properties. Since the 1950s, the growth in the plastic production has largely outpaced that of any other material, with a global shift from the production of durable plastics to single-use plastics. The production of plastic is largely reliant on fossil hydrocarbons. Fossil hydrocarbons are non-renewable resources.

Most of the plastics are not biodegradable, but instead photodegradable, and they slowly break down into small fragments known as microplastics. Microplastics (size <5 mm) are small pieces of synthetic polymers, derived from a number of sources, including disintegration of larger plastics via physical and biological degradation, applications of personal care products, laundering of synthetic textiles, and industrial processing of plastics (Shruti et al., 2021). The sources of microplastics originated mainly from numerous products and from extensive local human activities. An increase in plastic production and usage, illegal trash disposal, and poor management are assumed to be the important sources of the release of plastic materials into the environment (Lares et al., 2018).

Microplastics can be classified into two types, primary microplastics, and secondary microplastics (Piñon-colin et al., 2020). Primary microplastics are those made in a small size for a specific use, such as virgin resin pellets used in molding processes, sandblasting, and cosmetic products. Primary microplastics have been reported in every type of urban water source, including rainwater, drinking water, wastewater treatment plant (WWTP) and in effluents, sludge, stormwater, and the atmosphere. Secondary microplastics are those resulting from fragmentation or environmental degradation of plastic waste, such as wrapping and packages, bags, and the fibers shed during the laundering of synthetic fabrics.

Microplastic occurring in the environment are identified by physical characterization and chemical components (Zhang et al., 2020). The physical identification of microplastics is usually observed through shapes, sizes, and colors. Microplastics in the environment appear in a wide diversity of shapes. such as fibers, spheres, films, beads, pellets, foam, fragments, and flake. The shapes of microplastic can represent the source, degradation, and residence time of microplastic in the environment (Zhang et al., 2020c). Microplastics encompass a broad range of sizes, which are typically considered to be 1 μm to 5 mm in length (Zhang et al., 2020a). Microplastics have been reported in a range color, including yellow, brown, tan, red, orange, white, green, grey, blue, and so on. The chemical component is the basic criteria of polymer identification such as PE from firm plastic bags, PS from packaging, and PP & PET from polyester fiber (Plastic Europe, 2018; Allen et al., 2019).

Microplastics can enter animal and human bodies by different methods, such as inhalation, ingestion. Toxicity of the microplastics can be caused by the additives they contain, the plastic polymers themselves, or by other pollutants adsorbed on the microplastics. Studies have shown that microplastics are ubiquitous in the environment, and have negative impacts on aquatic and terrestrial organisms (Baeza et al., 2018; Jin et al., 2019; White et., 2018).

An abundance of microplastics in the atmosphere has not been studied as much as the abundances of microplastics in other media, such as water, sediment. To study the microplastics in the air, two methods have been used: active and passive sampling methods. Active samplers are done by drawing in sampling of known volumes of air over specific periods (Hayward et al., 2010). Passive samplers provide an information of the quantity of microplastic falling onto the surface and in rainwater (Zhang et al., 2020). This study monitored the microplastics in the atmosphere in different locations in Asian Institute of Technology (AIT) by using the passive sampling methods.

2. Objectives of the Study

The objectives of the study are:

1) To assess the current situation of microplastic deposition in indoor and outdoor environment in AIT campus.
2) To provide suggestions on the sources of deposited microplastics in AIT campus.

3. The Overview of Methodology Framework

This study was conducted to identify the amount and polymer type of wet and dry deposition of microplastics in AIT. An automotive precipitation sampler US 330 was used to collect samples for the wet deposition of microplastic in an outdoor environment in AIT, and the stainless-steel bowl with the surface area of 0.0314 m^2 was used to collect for the dry deposition of microplastic in an outdoor and indoor environment in AIT. After sampling, microplastics contained in the samples were extracted for subsequent quantification and identification. The microplastics with the ranges in size from 5 mm (5000 microns) to 0.044 mm (44 microns) were identified. Techniques involved extracting microplastics from other unwanted materials mainly included wet sieving, first transfer sieve solids, wet peroxide oxidation (WPO)/digestion, density separation, second transfer sieve solids, and the visual inspection under a stereomicroscope. Finally, FTIR analysis was carried out to identify the polymer type and the source of microplastics. The figure shows the overview methodology framework of the study.

3.1 Study Area and Sampling Plan

Rainwater samples were collected during September 2021 to October 2021 at the open area of Environmental Engineering and Management (EEM) research station. An automotive precipitation sampler US 330 was used to collect the rainwater samples. For the dry deposition of microplastics in an outdoor environment in AIT, the outdoor air samples were collected at the open area of EEM research station at AIT from September 2021 to January 2022. For the dry deposition of microplastics in an indoor environment in AIT, the indoor air samples from student dormitory X-Room 29A were collected from October 2021 to November 2021. The stainless-steel bowl with the surface area of 0.0314 m^2 was used to collect to collect the air samples. Table 1 shows the microplastics sampling plan of the study.

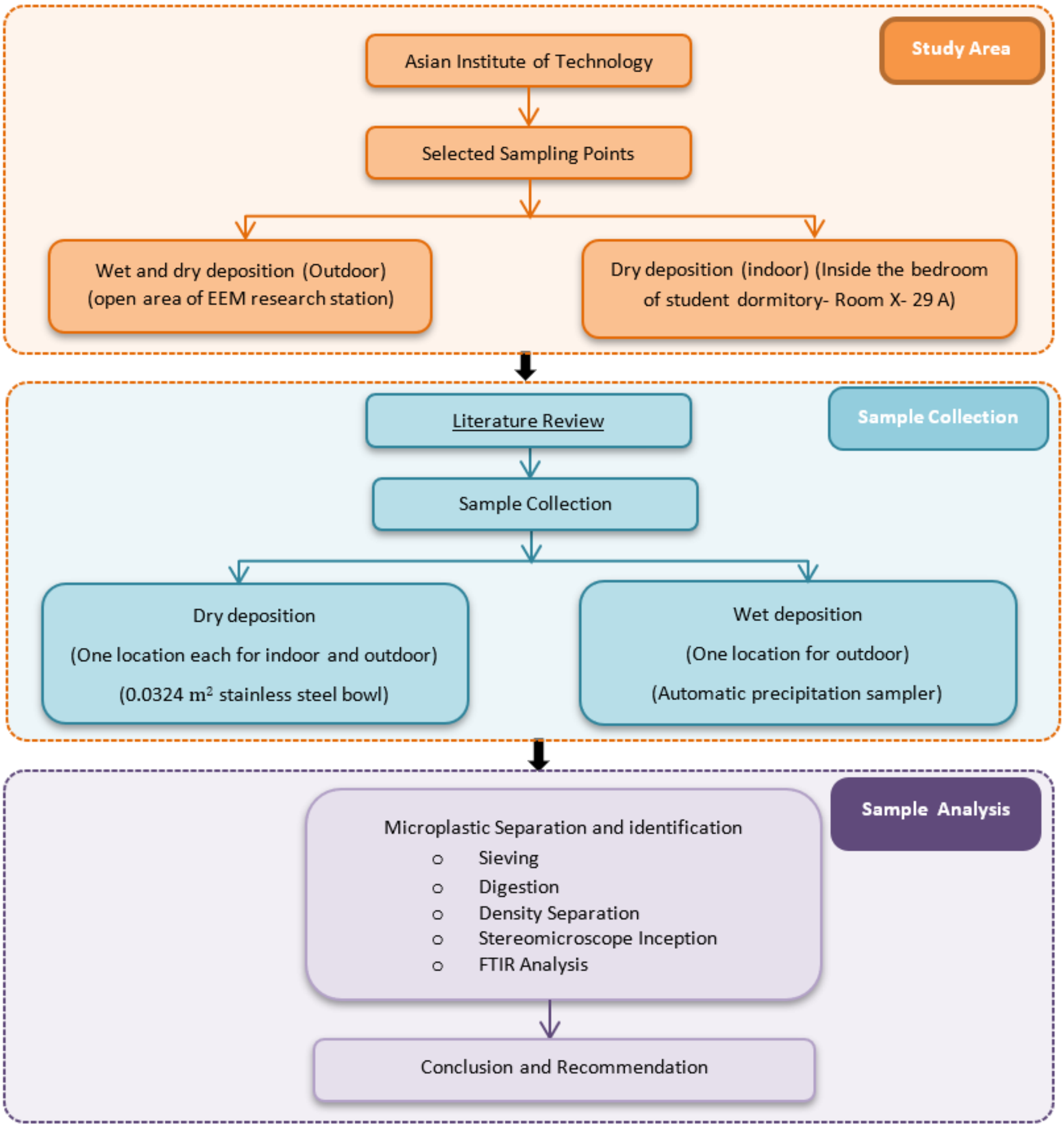

Figure 1: The overview of methodology framework

Table 1 Microplastics Sampling Plan

	Sampling Locations	Condition	No. of Samples	Sampling Period
1	Open area of EEM research station	Outdoor (Wet)	8	September 2021 to October 2021
2	Open area of EEM research station	Outdoor (Dry)	20	September 2021 to January 2022
3	Inside the bed room of student dormitory- Room-X-29A	Indoor (Dry)	8	October 2021 to November 2021

4. Results and Discussion

In this study, wet and dry deposition of microplastics in an outdoor environment in AIT, and dry deposition of microplastics in an indoor environment in AIT were studied. To monitor the wet and dry deposition of microplastics in an outdoor environment in AIT, rainwater samples and outdoor air samples were collected at the open are of the EEM research station. For dry deposition of microplastics in an indoor environment in AIT, indoor air samples were collected inside the bed room of student dormitory, room X-29A.

4.1 Wet Deposition of Microplastics in an Outdoor Environment

The deposition of microplastics in rainwater was 1994±1030 number/m2 /week. Among them, 93 % were in fiber shape, 6 % were in fragment shape, and 1 %, were in film shape. The study showed that 80 % of the microplastics were in white color, followed by brown color 12 %, blue color 5 %, green, yellow, and red color had the same share approximately 1% each. The size of microplastics ranged from 121.31 µm to 4990.79 µm.

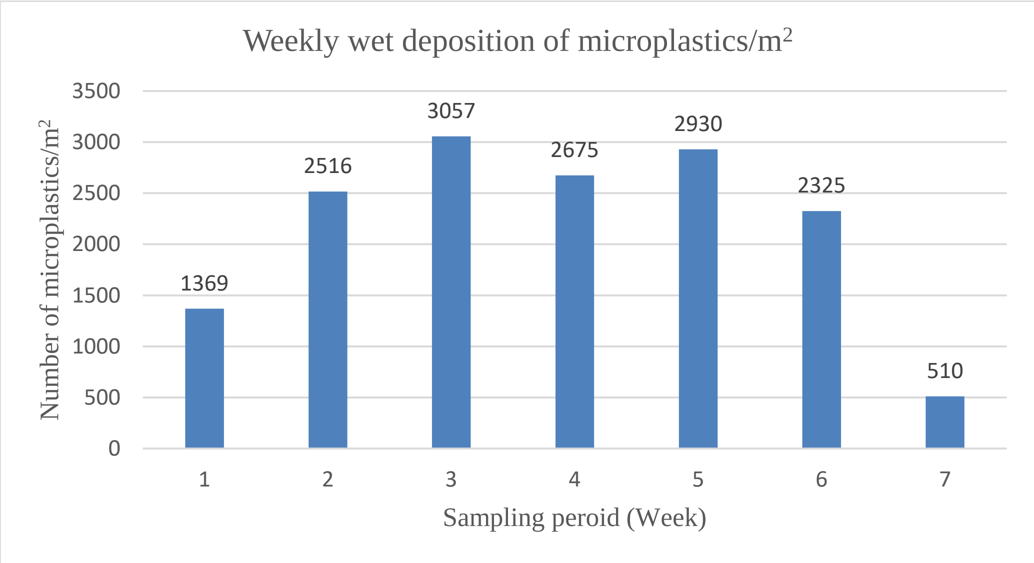

Figure 2: Weekly wet deposition of microplastics in rainwater

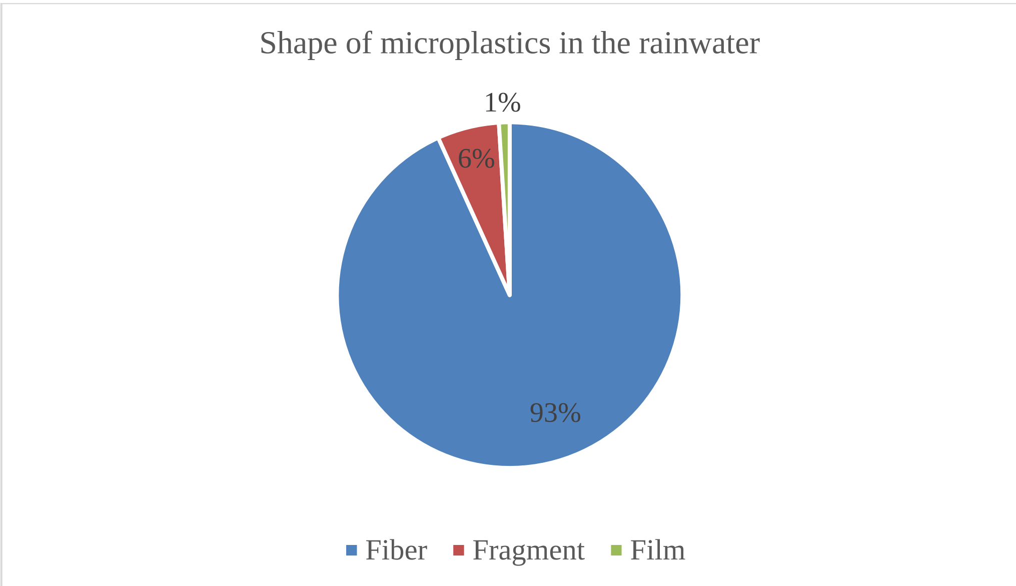

Figure 3: Percentage of different shapes of microplastics in the rainwater

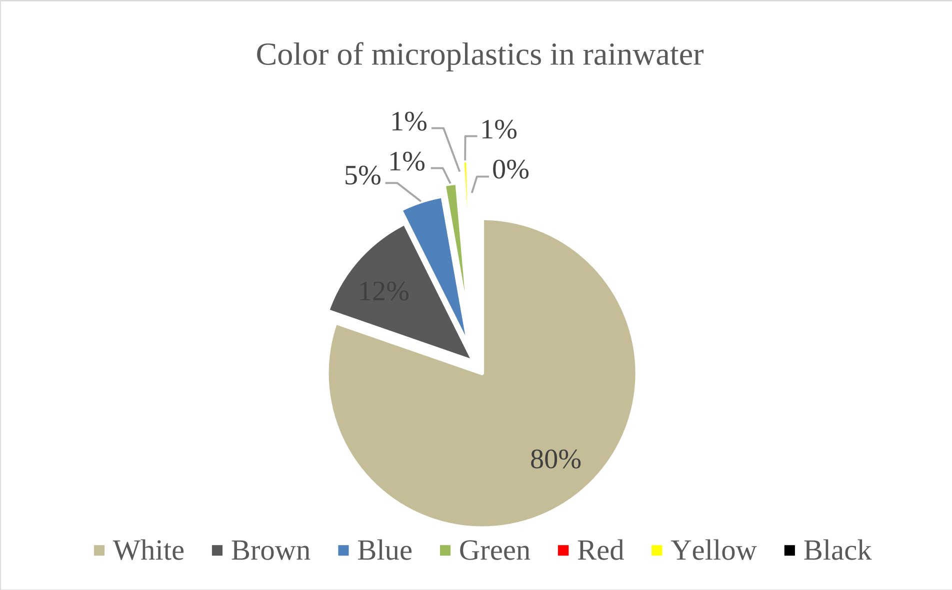

Figure 4: Percentage of different colors of microplastics in the rainwater

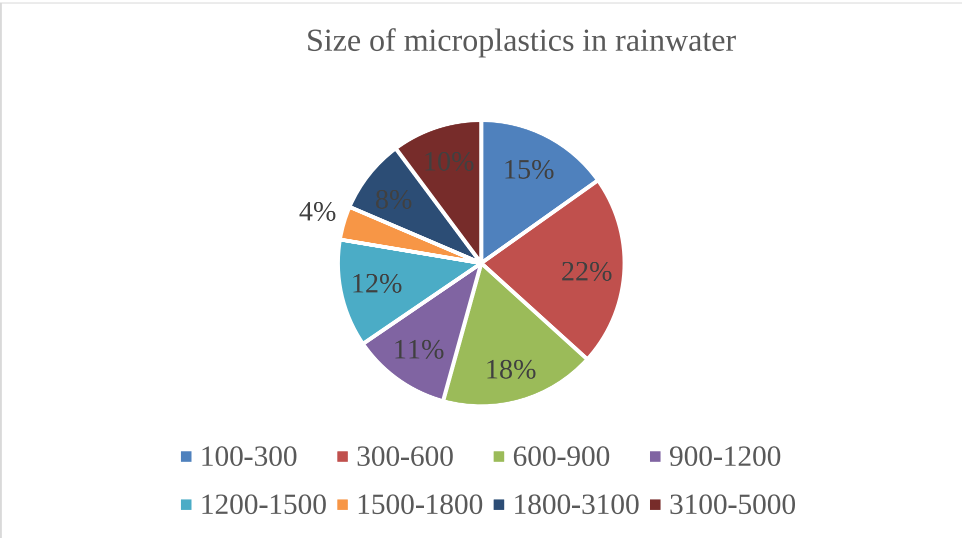

Figure 5: Percentage of different sizes of microplastics in the rainwater

4.2 Dry Deposition of Microplastics in an Outdoor Environment

The deposition of microplastics in the outdoor air was 1392±987 numbers/m2 /week. Among them, 94 % were in fiber shape, and 6 % were in fragment shape. Color of microplastics in the outdoor air were observed that 84 % of the microplastics were in white color, followed by brown color 9 %, blue color 5 %, red color and yellow color had the same share 1 % each respectively. The size of microplastics ranged from 132.11 µm to 4541.64µm.

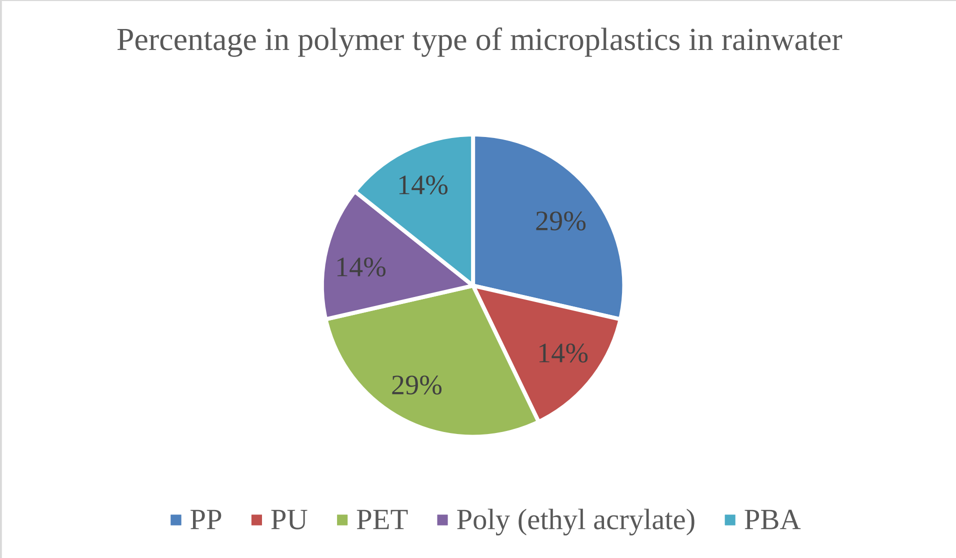

Figure 6: Percentage of Polymer types of microplastics in rainwater

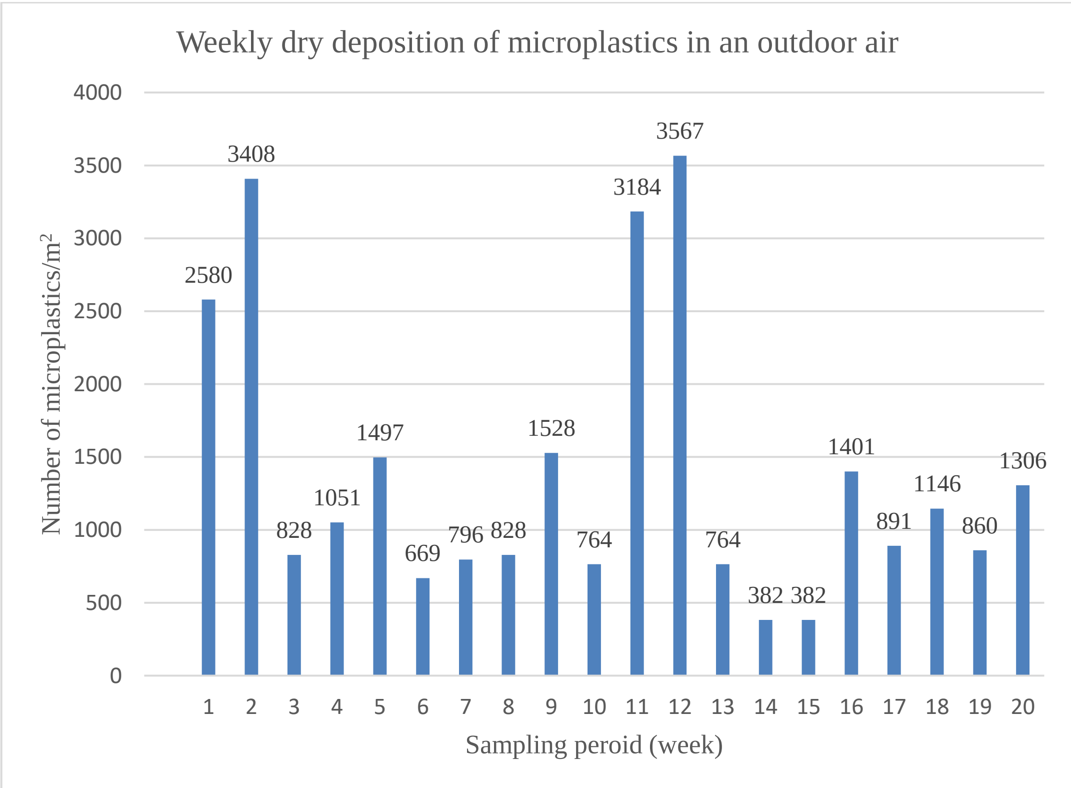

Figure 7: Weekly dry deposition of microplastics in outdoor air

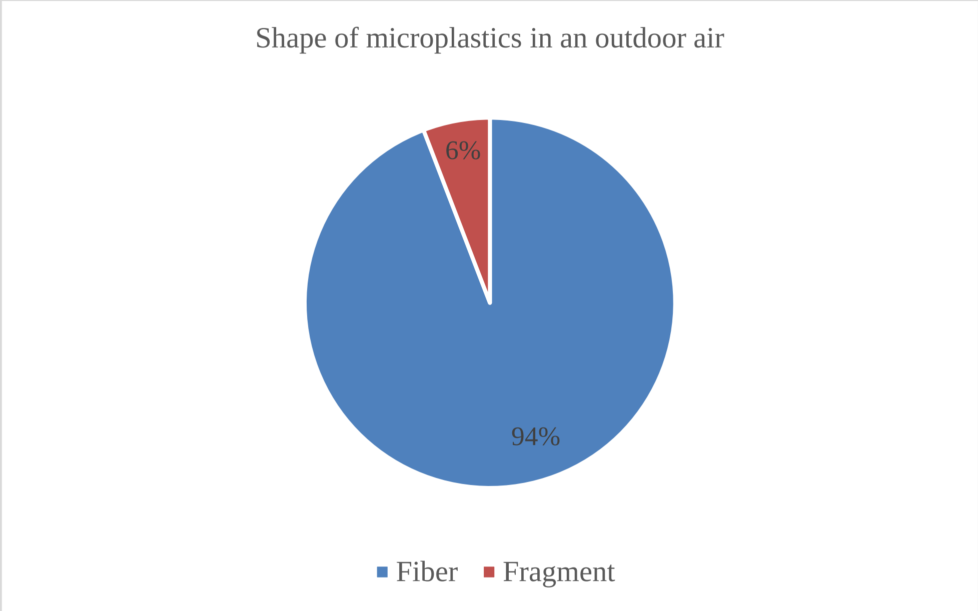

Figure 8: Percentage in different shapes of microplastics in an outdoor air

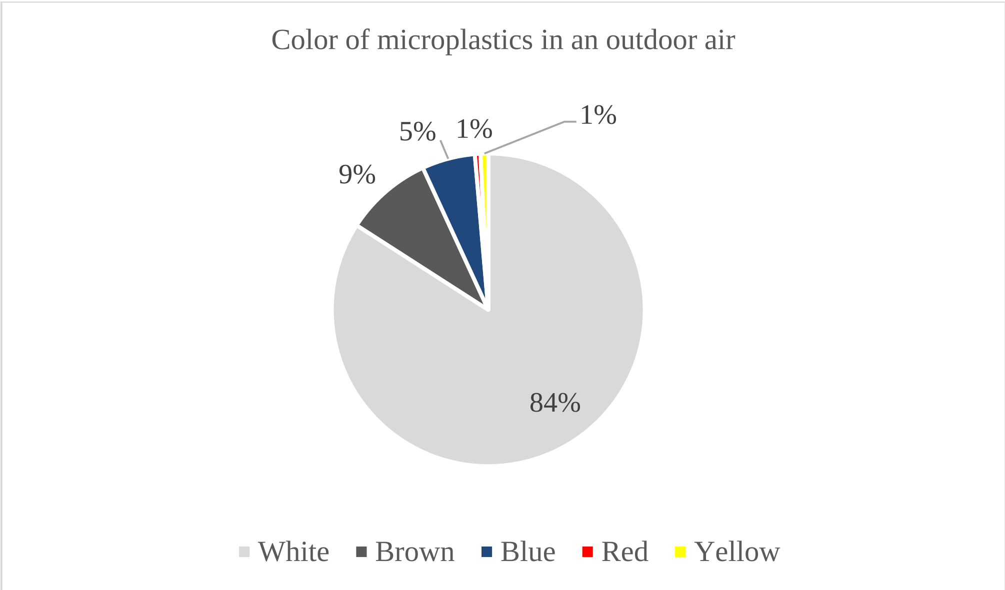

Figure 9: Percentage in different colors of microplastics in an outdoor air

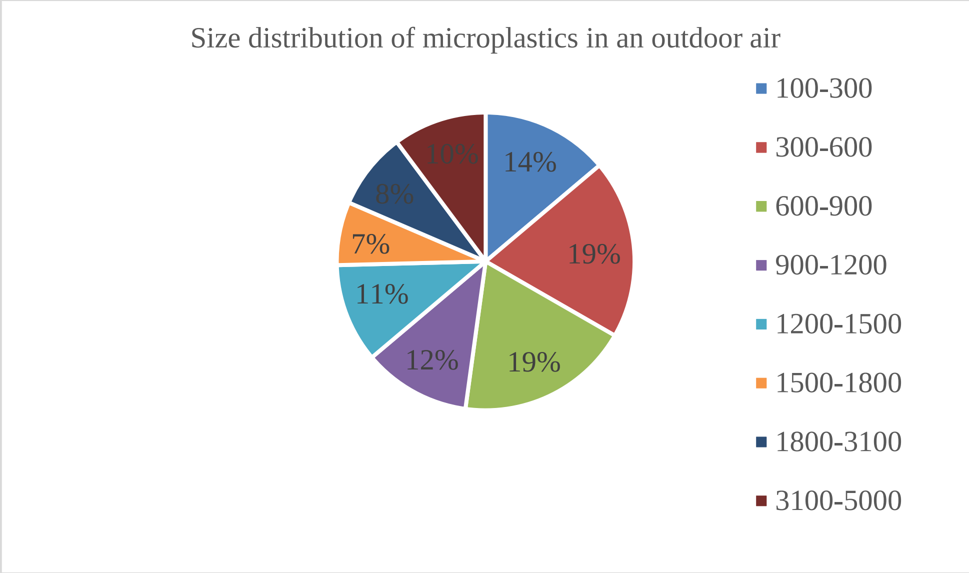

Figure 10: Size distribution of microplastics in dry deposition in an outdoor air

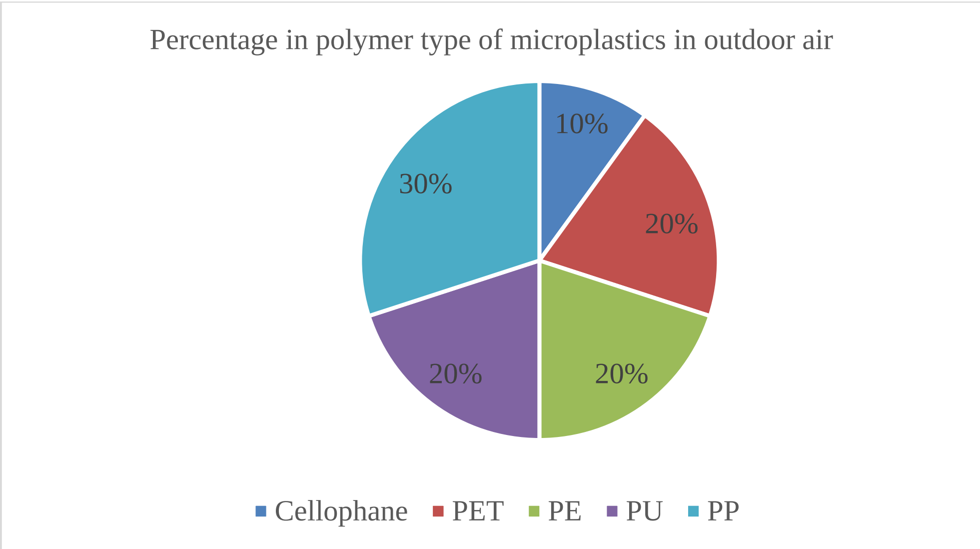

Figure 11: Percentage of polymer types of microplastics in an outdoor air

4.3 The Deposition of Microplastics in an Outdoor Environment

The deposition microplastics in an outdoor environment was considered the combination of microplastics deposition in rainwater and outdoor air during 6th September 2021 to 1st November 2021. The weekly averaged deposition of microplastics was 3451±1539 number/m2 /week when the total rainfall, averaged temperature and averaged relative humidity was 69.8 ± 48 mm, 29.81±2.2 ºC, and 91.2±2.75%, respectively.

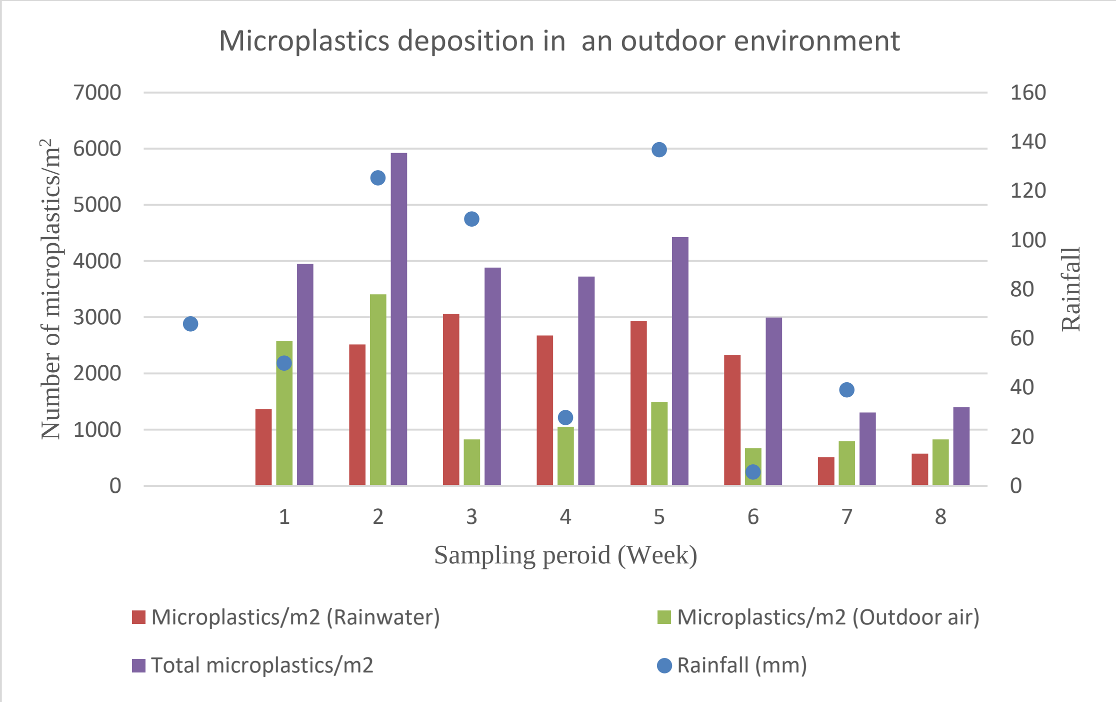

Figure 12: Microplastics deposition in an outdoor environment

4.4 Dry Deposition of Microplastics in an Indoor Environment

The dry deposition of microplastics in an indoor air was 2619 ±1289 numbers/ m^2/week. The weekly temperature averaged was 27.81 ± 0.52 ºC while the weekly averaged relative humidity was 27.81±0.52ºC, respectively. The dry deposition of microplastics in an indoor environment in AIT are summarized in Table 4.14.

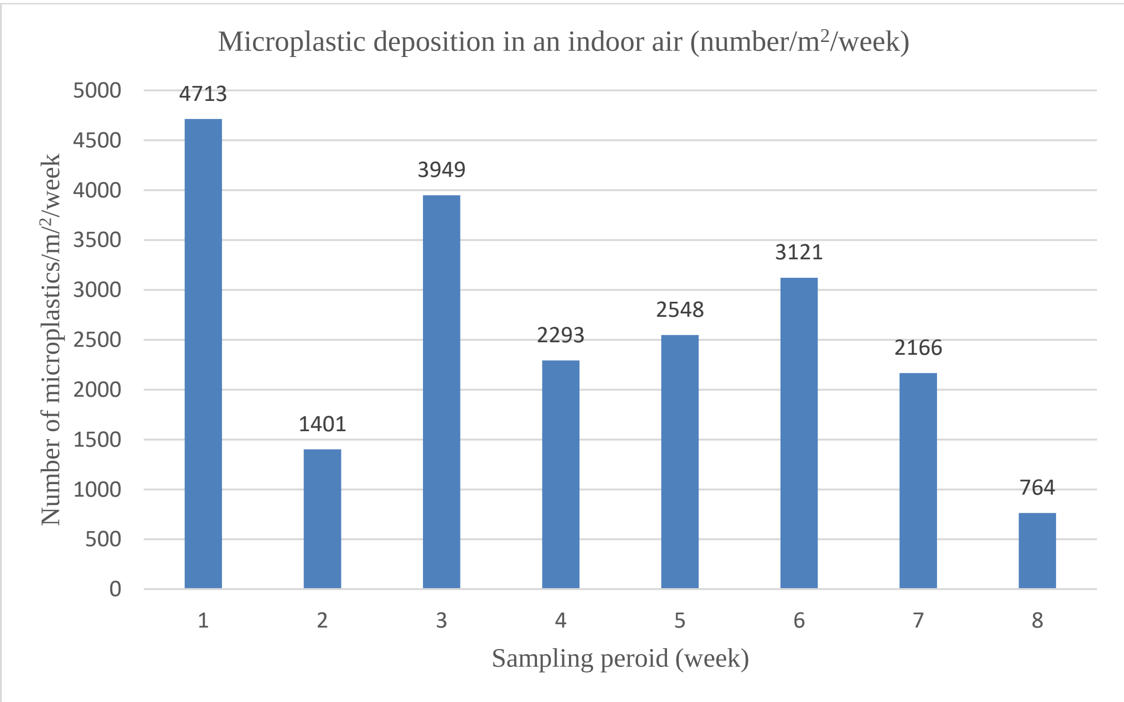

Figure 13: Weekly dry deposition of microplastics in an indoor air

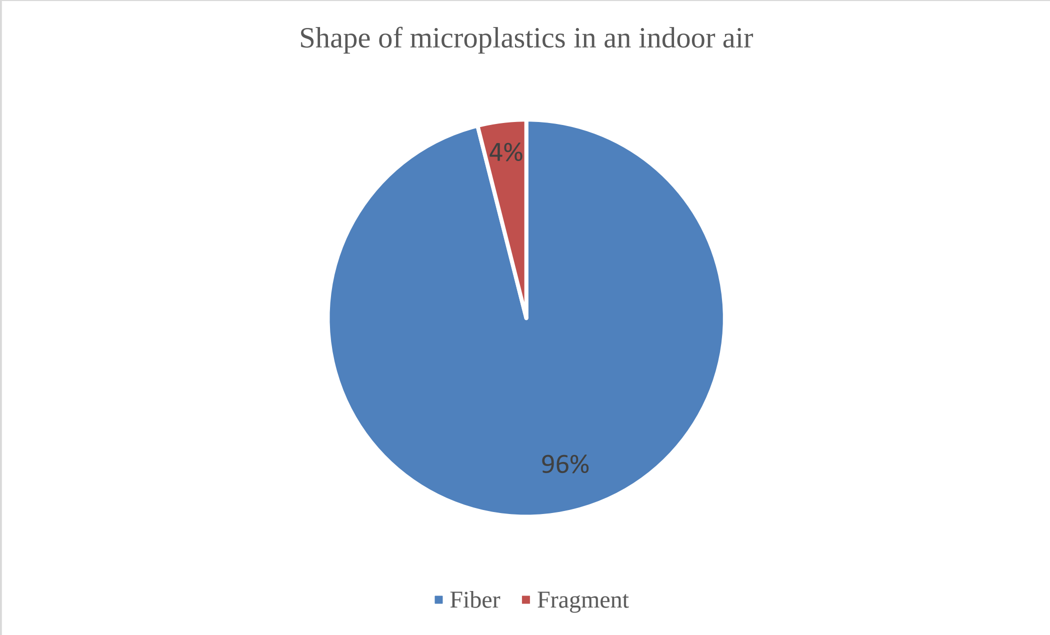

Figure 14: Percentage in different shapes of microplastics in an indoor air

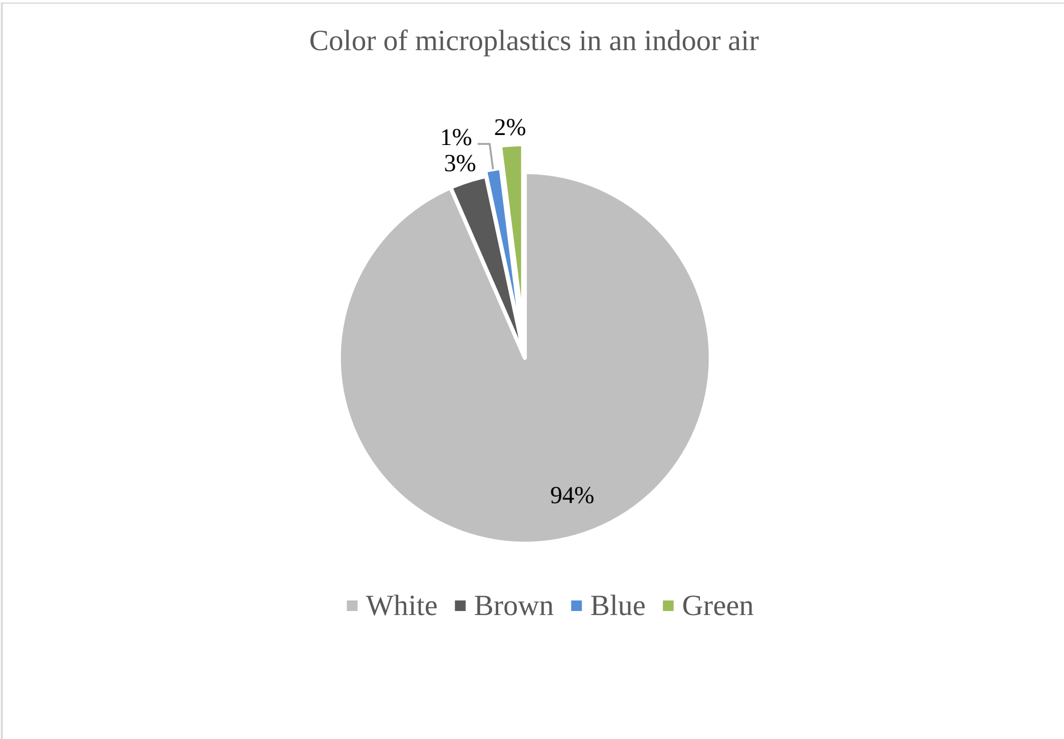

Figure 15: Percentage of different colors of microplastics in an indoor air

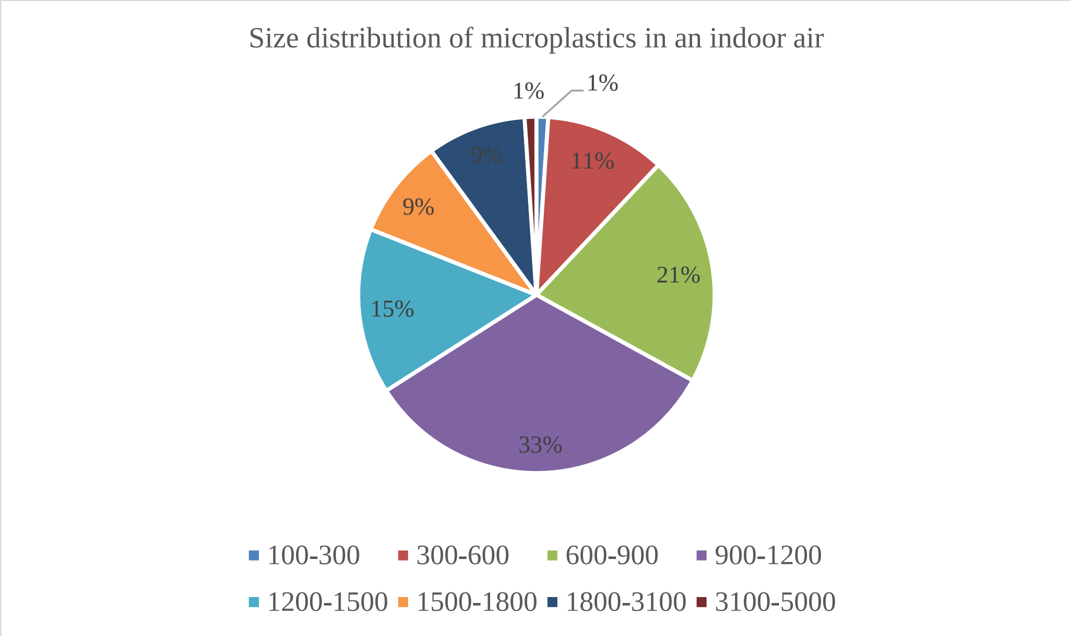

Figure 16: Percentage size distribution of dry deposition of MPs in an indoor air

4.5 Source of Microplastics

Source of microplastics could be judged based on the morphologic characterizations and the polymer type of microplastics. In this study, to identify the morphologic characterizations of microplastics, the visual inspection under a 40X magnification stereomicroscope in which the microplastics deposit on the petri dish surface were inspected, counted, and characterized for shape, colors, and size.

Diverse shapes of microplastics particularly fiber and fragment were found, and fiber was the dominant shape of microplastics in this study. The sources of fibers, which were normally released from clothes and textiles, and it was likely mainly coming from the synthetic textile (clothing, upholstery, or carpet). White color was the dominant color of the microplastics in this study. White color has been ascribed as polyethylene (PE) (Zhang et al., 2020c) and PE might come from plastic bags, plastic film, bottle, etc.. However, the color of a plastic particle cannot easily be used to deduce the type or origin.

Most polymer types found in this study were Polypropylene (PP), polyurethane (PU), Polyethylene terephthalate (PET), Polyethylene (PE), and Cellophane. The sources of PP might come from consumer products, bottle lids, food tubs, automotive products, and textiles, etc. Polyurethane (PU) might come from cleaning products, cushion materials, etc., and Polyethylene terephthalate (PET) might come from fibers for clothing, plastic bags, plastic film, plastics bottle, etc. The sources of Cellophane might come from tapes, photographic film, clothes, etc., and Polyethylene (PE) might come from plastic bags, plastic film, bottle, etc.

5. Conclusions

The deposition of microplastics in rainwater was 1994±1030 number/m^2/week. Among them, 93 % were in fiber shape, 6 % were in fragment shape, and 1 %, were in film shape. The study showed that 80 % of the microplastics were in white color, followed by brown color 12 %, blue color 5 %, green, yellow, and red color had the same share approximately 1% each. The size of microplastics ranged from 121.31 µm to 4990.79 µm.

The deposition of microplastics in the outdoor air was 1392±987 numbers/m^2/week. Among them, 94 % were in fiber shape, and 6 % were in fragment shape. Color of microplastics in the outdoor air were observed that 84 % of the microplastics were in white color, followed by brown color 9 %, blue color 5 %, red color and yellow color had the same share 1 % each respectively. The size of microplastics ranged from 132.11 µm to 4541.64µm.

The deposition microplastics in an outdoor environment was considered the combination of microplastics deposition in rainwater and outdoor air during 6th September 2021 to 1st November 2021. The weekly averaged deposition of microplastics was 3451±1539 number/m^2/week when the total rainfall, averaged temperature and averaged relative humidity was 69.8 ± 48 mm, 29.81±2.2 ºC, and 91.2±2.75%, respectively.

The deposition of microplastics in the indoor air was 2619±1,289 numbers/m^2/week. Among them, 96 % were in fiber shape, and 4 % were in fragment shape Color of microplastics in the outdoor air were observed that 94 % of the microplastics were in white color, followed by brown color 3 %, green color 2 %, and blue color 1% respectively. The sizes of microplastics detected in the indoor air ranged from 197.06 µm to 4679.21µm.

Fibers were the dominant shape of microplastics in this study, which might come from clothes and textiles. Most polymer types found in this study were PP, PU, PET, PE, and Cellophane. PP might come from consumer products, bottle lids, food tubs, automotive products, and textiles. PU might come from cleaning products, cushion materials, and PET might come from fibers for clothing, plastic bags, plastic film, plastics bottle. Cellophane might come from tapes, photographic film, clothes. White color was the dominant color of the microplastics in this study. White color has been ascribed as PE and it might come from plastic bags, plastic film, and plastic bottles.

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