Microplastic characteristics in several land covers in Banda Aceh and Aceh Besar

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Abstract. Plastic is one of the materials that is often used by people who are difficult to decompose. The decomposed plastic will become several parts which are termed macro plastic and micro plastic. Plastic will accumulate in soil and water can release chemicals that will endanger plant health. The purpose of this paper is to identify the accumulation of microplastics in several land covers. The research started with sampling on land cover at Mini Sport center Universitas Syiah Kuala (Gelanggang Park), Experimental Farm of Faculty of Agriculture, Urban Forest, Community Park (Tahura), and Edge of cross road (sibreh). Each replicate was sampled amount to 30 top soil samples (0-5 cm) and 30 subsoil samples (5-20 cm). Total soil samples per location point were 6 samples. The stages carried out were starting from drying the sample, separating the sediment, removing the organic material, separating the solid and identifying microplastic. Results found that the most dominant type of microplastics found at each sample point is the Fragment type of microplastics with 164 particles. Then fiber type microplastics with a particle count of 103 particles. While the least found is the type of microplastic film with a particle count of 92 particles. At Gelanggang Park, we found a high abundance of Film species and a moderate abundance of Fiber species. The Urban Forest had a low abundance of all particle types. The most common colour appearing in the data are Brown and Grey, with a total of 210 and 73 respectively. The colours dominate compared to other colour across locations and layers, there are differences in the number of colours between the Lower and Upper layers at each site.

1. Introduction

The use of plastics is increasingly becoming a necessity that has received attention from agricultural experts in recent years. Agricultural plastics are generally single-use and can remain in the environment long after their use and turn into microplastics. Microplastics are small plastic particles less than 5 millimeters in size and are commonly found in soil and water. Their widespread and long-term use, coupled with a lack of systematic collection and sustainable management, leads to their accumulation in soil and aquatic environments [1].

KLHK data cited by [2] stated that in 2008, the amount of plastic waste in Indonesia had reached 280,500 tons/day. The average use of plastic bags reaches 700 bags/person/year. [3] stated that in Europe and North America, it is estimated that ± 63,000 - 430,000 and 44,000 - 300,000 tons of microplastics are annually poured into agricultural land through liquid application (sludge).

Microplastics can absorb nutrients and chemicals from the environment, which can alter the nutrient composition of the soil. In some cases, this can lead to nutrient imbalances that can affect plant growth and development. In addition, microplastics can release harmful chemicals as they decompose, which can

negatively impact plant health and plant nutrient uptake. In the soil, these microplastic particles can also accumulate to form walls that can limit the ability of plant roots to access nutrients in the soil.

The number of microplastics in agricultural soil according to the results of research by [4] shows that there are 3 types of microplastics, namely film, fragments, and fibers. In aquatic environments, microplastics can also accumulate nutrients and other chemicals, which can affect the growth and development of aquatic organisms. For example, microplastics have been shown to interfere with the feeding and nutrient uptake of zooplankton, which are an important food source for many marine organisms. Overall, the presence of microplastics can significantly impact the availability and uptake of nutrients in terrestrial and aquatic ecosystems.

Several previous studies have shown that soil amendments, one of which is biochar, may have the potential to affect microplastics in soil, as the interactions between biochar, microplastics, and soil biota are complex and depend on a variety of factors, including the type of biochar, application rate, and soil properties. Biochar is a porous, carbon-rich material produced by heating organic matter in the absence of oxygen. Biochar has been shown to have the potential to reduce the negative impact of microplastics in soil. Therefore, the aim of this study was to identify the accumulation of microplastics in several land covers such as agricultural land, sports playground, urban forest, and botanical forest park. And look at the microplastic contamination in the land cover areas.

2. Materials and method

The research started with sampling on land cover which located in Mini Sport center area (Gelanggang Park), Experimental Farm of Faculty of Agriculture, Urban Forest, Community Park (Tahura), and Edge of cross road (sibreh (Figure 1).

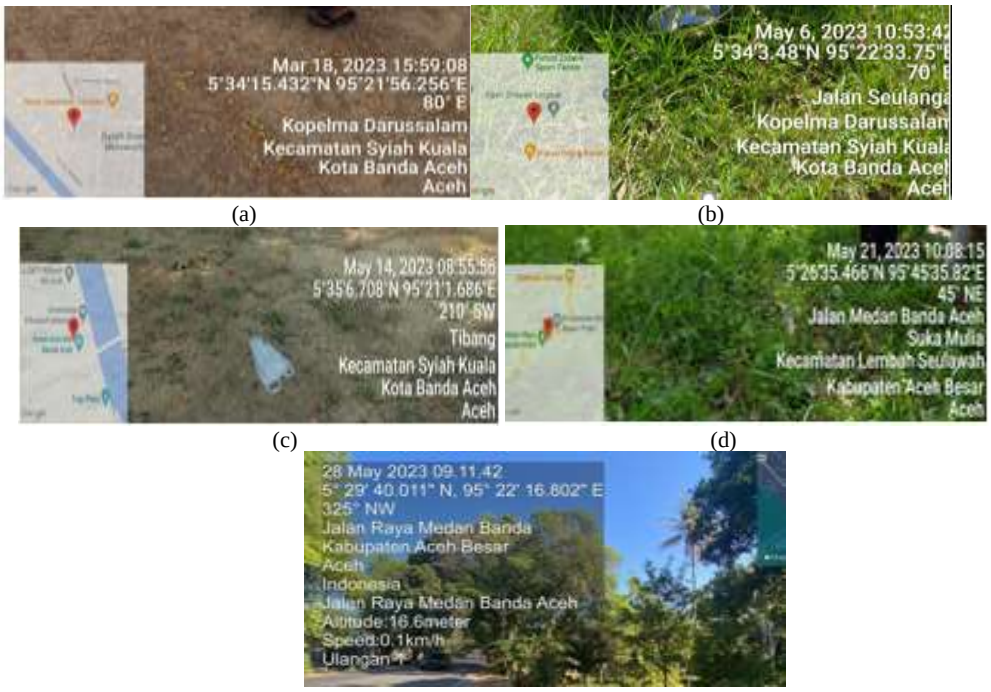

Figure 1. Sampling location of the study on (a) mini sport center area, (b) Experimental farm Faculty of Agriculture, (c) Urban forest, (d) Community Park (Tahura), (e) Edge of cross road (Sibreh)

Research sampling on land cover was carried out according to purposive sampling design, namely: L1 = Mini sport center area (Gelanggang Park), L2 = Experimental farm of Faculty of Agriculture, L3 = Urban forest, L4 = Community Park (Tahura), L5 = Edge of cross road (Sibreh). Each research location was made 3 replicates. Each replicate took 30 top soil samples (0-5 cm) and 30 subsoil samples (5-20 cm). The 30 soil samples then composited into one so that each replicate would produce 2 samples. Total soil samples per location point were 6 samples. The sampling site was given in Figure 2.

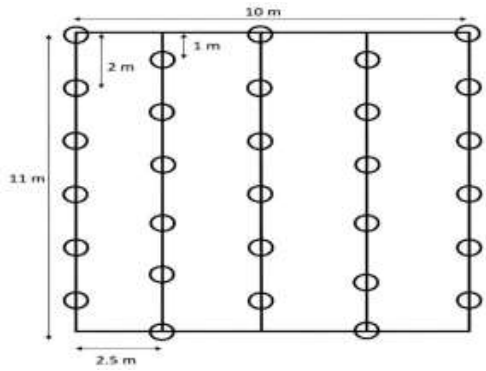

Figure 2. Soil Microplastic Sampling Plan

Each point of observation location for sampling measured land area 10 x 11, plots divided by 4 with a width of 2.5 m; soil samples were taken 6 samples of each vertical line with a distance of 2 m. Resulting in a total of 30 sample points. Then drilling was done using a 15mm diameter drill. Soil samples were taken at a depth of 0 - 5 cm, and secondly at a depth of 5 - 20 cm. Then put in a paper bag and then wrapped in aluminum foil to avoid contamination. soil samples were stored in the oven with a maximum temperature of 45 degrees Celsius and remains inside until observation was conducted.

The stages of microplastic analysis for sediments analysis, namely: (1) Drying sediment samples with an oven at 40 ° C for 24 hours (until the sediment is completely dry). (2) Sediment samples were crushed until smooth, then filtered using a 2 mm mesh sieve. Filtering is done to reduce the volume of sediment and sort out macro sediments. (3) Weighing 10 g of sediment using digital scales. (4) Mixing dry sediment samples (10g) with 30% H_2O_2 solution (120 ml) was allowed to stand until there was no further reaction (5) Destruction of organic material was done by adding 50 ml Na_2CO_3 solution and stirring using a magnetic stirrer for 15 minutes. (6) The sample was centrifuged at 9000 rpm for 20 minutes. (7) The supernatant was filtered with whatman paper size Ø 47 mm. (8) Observing microplastics using a binocular microscope with 4x and 10x magnification to observe the abundance of microplastics including type, color and size [5]

3. Results and discussion

3.1 Plastic Type Identification

Plastic type

Microplastics come in various types and forms, varying in terms of size, shape, color, composition, density and other properties [6]. The type and amount of microplastics based on the form found at the sample location, there are three types of microplastic forms obtained, namely Fiber, Film and Fragments [7]. The most dominant type of microplastics found at each sample point is the Fragment type of microplastics with 164 particles. Then fiber type microplastics with a particle count of 103 particles. While the least found is the type of microplastic film with a particle count of 92 particles (Table 1).

Table 1. Recapitulation of Microplastic Identification Results

Location	Layer	Type			Particle Count	
		Fiber	Film	Fragments		
Gelanggang Park	0 - 5 cm	3	4	3	10	80
	5-20 cm	4	53	13	70	
Experimental Farm	0 - 5 cm	83	5	-	88	118
	5-20 cm	1	27	2	30	
Urban Forest	0 - 5 cm	3	-	4	7	59
	Above	2	-	50	52	
Tahura	5-20 cm	4	-	20	24	32
	5-20 cm	2	2	4	8	
Edge of cross road (Sibreh)	0 - 5 cm	-	-	5	5	70
	5-20 cm	1	1	63	65	

The location where the most microplastic particles found was at the Experimental Station equal to 118 particles. The subsoil of Experimental Farm site has the highest number of particles; 83 fibers, 5 films, and 0 fragments, totaling 88 particles. While in the upper layer the number of particles decreases to 1 for fiber, 27 for films, and 2 for fragments, bringing the total to 30 particles. The number of plastic particles in the upper layer tends to be more than the lower layer at each location. It is an indication that the presence of more particle sources was found more in the upper layer. The types of microplastic; fibers, films, and fragments were given in Figure 3.

Fiber type microplastics have the characteristic of being shaped like fibers or like fishing nets, in general fiber type microplastics are easy to find. This is due to its use as a basic material in the manufacture of clothing, clothing fibers, fishing nets, and in the manufacture of household appliances. Film type microplastics are characterized by being shaped like sheets or plastic fragments, generally used for making plastic bags or plastic packaging. Fragment type microplastics are characterized by the form of fragments produced from waste such as bottles, jars, mica folders, and small pieces that come from pipes [8]. The plastic degradation process is caused by UV radiation which triggers oxidative degradation of the polymer. During the degradation stage, plastic waste has characteristics such as discolors, becoming softer and easily destroyed over time. Other mechanical influences include wind, sea waves, animal bites and human activities which can destroy plastic into fragments [9].

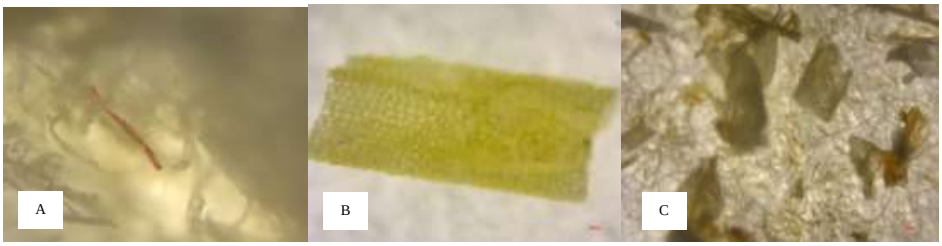

Figure 3. Fiber Particles (a), Films (b), Fragments (c)

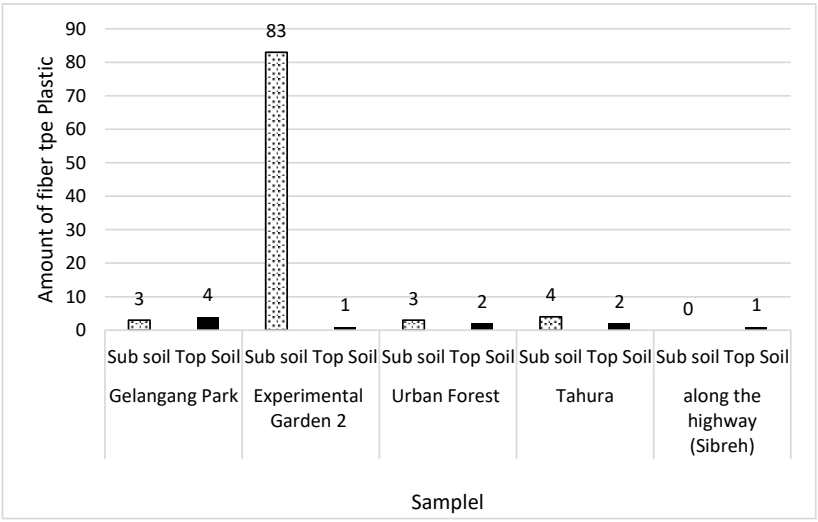

Figure 4. Number of Microplastics of Fiber Type

Figure 4 shows that microplastic fibers were seen in almost every site, with varying amounts. Experimental farm site had the highest number of microplastic fiber particles in the bottom layer (83 particles). Although microplastic fibers were also present in other sites, the amount tended to be lower compared to these sites.

The amount of film microplastics varied greatly. It was seen in Gelanggang Park, film microplastics had a significant number of particles (53 particles) in the upper layer, while in Experimental farm site, there were very few particles (5 particles) in the lower layer (Figure 5). In some sites, especially in the upper layer, the number of microplastic particles of the Fragment type appears to be quite high. For example, at Gelanggang Park (upper layer) and Site 5 (upper layer), there were 13 and 63 fragments, respectively (Figure 6).

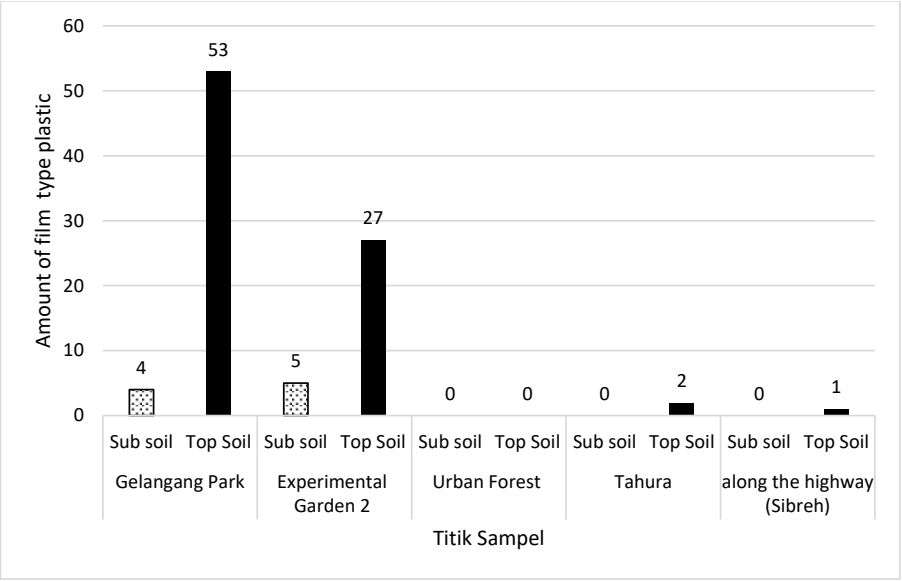

Figure 5. Microplastic counts of film types

If we compare the total number of particles across locations, Experimental Park has the highest number of microplastic particles, followed by Gelanggang Park, edge of cross road, Urban Forest, and finally Tahura. The Data showed that apparently fiber-type microplastics and film-type microplastics are more prevalent than fragment-type microplastics. This may indicate that these environments have been exposed to larger amounts of fiber or film material compared to larger and possibly more diverse fragments.

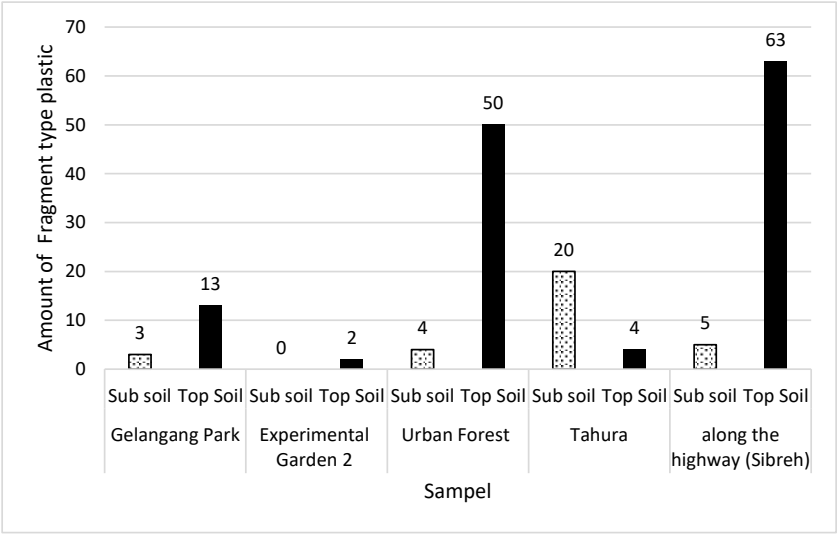

Figure 6. Number of Fragment-type microplastics

From the available data, it appears that fiber-type microplastics and film-type microplastics are more common than fragment-type microplastics. This may be indicated that these environments have been exposed to larger amounts of fiber or film material compared to larger and possibly more diverse fragments. High levels of fiber microplastics are thought to originate from household waste, and textile fiber degradation [10].

Significant differences between the upper and lower layers in some locations might be caused by environmental factors such as wind, water flow, or human activities that all affect the distribution of particles in the air. The upper layer tends to capture smaller particles that may be carried by the wind. This is because the molecular weight of microplastics allows them to settle in sediments [11].

Abundance

The abundance of plastic particle types at sampling locations varies. This is due to environmental conditions, human activities, and other factors that affect particle distribution. The abundance of microplastics is expressed as (Particles/kg). Fiber types have different abundances at each location. Experimental farm had the highest abundance with 8400 particles/kg, while the Urban Forest had the lowest abundance with only 500 particles/kg.

Film-type microplastics also had varying abundances. Gelanggang Park had the highest abundance with 5700 particles/kg, while the Urban Forest had an abundance of 0 particles/kg, which may indicate a lack of this particle type at the site.

Fragment-type microplastics had significant variation in abundance between sites. The Urban Forest had the highest abundance of 5,400 particles/kg, while Experimental Farm and edge of cross road (Sibreh) had low abundances of 200 and 6,800 particles/kg, respectively (Figure 7).

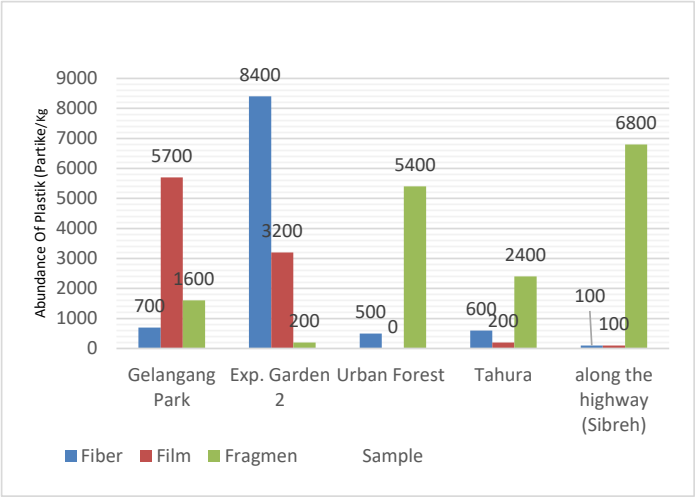

Figure 7. Abundance of microplastic species

Gelanggang Park has a high abundance of Film species and a moderate abundance of Fiber species. The Urban Forest had a low abundance of all particle types. Experiment Station 2 had a high abundance of Fiber and Fragment species, while the roadside (Sibreh) had a high abundance of Fragment species. Tahura had a low abundance of all particle types, except Fiber.

Fiber microplastics had significant variations in abundance across sites. Films tended to be more common at Gelanggang Park and Experimental Farm than at other sites. Fragments had the most variation in abundance and tended to be more abundant in the Urban Forest and Roadside (Sibreh).

Variations in particle abundance between sites can indicate differences in environmental conditions in each place, such as land use patterns, human activities, and natural factors. Variations in particle abundance can provide clues about the environmental quality of different locations. Sites with high particle abundance may face pollution or environmental degradation issues that need to be addressed. Based on [12] The main factor in transporting microplastic particles is water currents, where microplastics will accumulate more in sediment if the current is weak.

Differences in particle type abundance can give an indication of the environmental impact of different types of activities. For example, the high abundance of Fragments in the Urban Forest may indicate activities that cause particle fragments, such as the abundance of fallen branches. Variability in particle abundance at each site may be attributed to the different human activities carried out in the area. For example, the high abundance of Fragments at edge of cross road (Sibreh) may be related to construction activities or vehicle traffic. These factors cause the yield and type of microplastics to vary between stations. In addition to particle degradation and erosion, anthropogenic activities may affect the type and yield of microplastics in an area [13].

The distribution of microplastics affects its dominance in sediments, where the distribution of fiber microplastics itself can be influenced by the presence of human activities around the environment that experience the degradation process or sources of waste originating from human activities that enter the river to settle, and accumulate in sediments. Human activity waste can be in the form of leftover clothing threads

from washing clothes and plastic ropes that have undergone a degradation process [14]. Microplastics deposited at the bottom of the sediment are influenced by gravitational forces and the magnitude of the plastic density is higher than the density of water. This causes the plastic to sink and accumulate in sediment [15].

Research by [16] shows that there is no relationship between the abundance of microplastics and the organic material content in sediment, which is only 1.55%. Even though based on [17], microplastics have the potential to absorb and release persistent organic compounds.

Microplastic Color

The colors of microplastics found in the five sample points are clear, blue, red, yellow, black, brown, and gray. The number of colors in each location and layer varies as shown in Table 2. The colors of microplastics found at the five sample points are clear, blue, red, yellow, black, brown and gray. The number of colors at each location and layer varies. There are locations that have more colors than others, such as the Urban Forest in the Upper layer with a total of 20 different colors.

Table 2. Color of Microplastics in Some Locations

Location	Layer	Color						
		Clear	**Blue**	**Red**	**Yellow**	**Black**	**Chocolate**	**Gray**
Par of Gelanggang	0-5 cm	1	2	1	0	4	2	0
	5-20 cm	2	0	0	1	0	47	20
Experimental Farm	0-5 cm	2	2	0	0	7	72	5
	5-20 cm	0	0	1	0	8	20	1
Urban Forest	0-5 cm	0	0	0	1	2	2	2
	5-20 cm	2	0	0	3	1	13	33
Community Forest (Tahura)	0-5 cm	2	1	0	0	10	10	1
	5-20 cm	2	0	1	0	3	1	1
Edge of cross road (Sibreh)	0-5 cm	3	0	0	0	1	1	0
	5-20 cm	0	0	0	0	13	42	10

Each location and layer has a different color distribution. For example, Gelanggang Park in the lower layer has a significant amount of Black and Brown colors, while Gelanggang park in the Upper layer has a dominant amount of clear and brown colors. This color distribution can reflect the environmental conditions at each location and layer.

The most common colors appearing in the data are Brown and Grey, with a total of 210 and 73 respectively. This shows that these colors dominate compared to other colors across locations and layers. There are differences in the number of colors between the lower and upper layers at each site. For example, at experimental Farm (the Lower layer), the color Brown appeared 72 times, while in the Upper layer it appeared only 20 times. This shows the variation that may occur between the two layers.

Overall, the results of this study indicate that the presence of microplastics in soil is not only limited to the top soil layer, but also detected at sub soil depths. The chemical impact of microplastics on soil at both depths has significant ecological implications. Therefore, further research is needed to better understand the impacts and consequences of microplastic interactions with soil and to find appropriate solutions to address the problem of microplastics in the soil environment.

In recent years, many studies have shown the detrimental impact of microplastics on the biosphere [15]. Microplastics can lead to reduce nutrient uptake and growth in organisms such as fish, shrimp and shellfish. This can impact the entire food chain, as these organisms are an important food source for larger predators. Overall, the negative impact of microplastics on nutrient uptake highlights the urgent need for better waste management practices and efforts to reduce plastic pollution in the environment. Overall, the exact mechanism for how microplastics affect nutrient uptake in plants is still under research, but it is clear that microplastics can negatively impact soil health and plant growth, which in turn can affect nutrient uptake. Microplastics have the potential to affect nutrient uptake in a variety of ways, both for plants and the animals that eat them. So it is clear that microplastics have the potential to affect nutrient uptake in plants by reducing the availability of nutrients in the soil. In plants, microplastics can physically block or impede nutrient uptake by occupying root surface areas, which can inhibit the uptake of essential nutrients such as nitrogen, phosphorus and potassium. In addition, microplastics can also release toxic chemicals as they decompose,

which can harm plant growth and affect nutrient uptake.

4. Conclusions

The location where the most microplastic particles were found was the Experiment 2 garden location, namely 118 particles. The most dominant type of microplastics found at each sample point is the Fragment type of microplastics with 164 particles. Then fiber type microplastics with a particle count of 103 particles. While the least found is the type of microplastic film with a particle count of 92 particles. Gelanggang Park has a high abundance of Film species and a moderate abundance of Fiber species. The chemical impact of microplastics on soil at both these depths holds substantial ecological implications. Consequently, further investigation is imperative to better comprehend the ramifications and consequences of the interaction between microplastics and soil. Finding appropriate solutions to address the issue of microplastics in the soil environment also remains a crucial focus.

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