UNIVERSITI PUTRA MALAYSIA

OCCURRENCE OF MICROPLASTIC ON SURFACE SOIL FROM SELECTED ORGANIC FARMS (SELANGOR, MALAYSIA)

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BY

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Thesis submitted in fulfilment of the requirement for the degree of Bachelor of Science in Environmental and Occupational Health with Honours from the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia

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ABSTRACT

OCCURRENCE OF MICROPLASTIC ON SURFACE SOIL FROM SELECTED ORGANIC FARMS (SELANGOR, MALAYSIA)

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Introduction: Organic farms are defined as those that do not use pesticides, fertilisers, genetically modified organisms, antibiotics, or growth hormones. However, it is unknown whether organic farms are truly safe due to the presence of numerous other factors such as microplastics (MPs) pollution in organic agricultural soil. Numerous investigations conducted worldwide have revealed contamination of agricultural soil with MPs. MPs are prevalent on surface soil and can have a harmful influence on human and environmental health. However, there are inadequate evidence on the prevalence of MPs on Malaysian organic farms, as this topic is rarely researched. **Objectives:** This study aims to determine the occurrence of MPs, characterized MPs properties (size, colour shape and polymer type) and conclude the suitability of organic agricultural soil from selected organic farms in Selangor, Malaysia. **Methodology:** A total of 26 samples were taken from three (3) different types of areas: Disturbed surface soil (areas that still undergoing agriculture activities and areas that do not undergo agriculture activities yet) and undisturbed surface soil were collected from chosen organic farms in Selangor, Malaysia. MPs were extracted from surface soil samples using density separation technique via zinc chloride solution. Microscopic imaging and Fourier-transform infrared spectroscopy (FTIR) were used to identify the extracted particles' morphological properties (size, colour, shape and polymer composition). **Result and Discussion:** The retrieved particles from all surface soil samples examined varied between four and sixty-four particles per sampling location. MARDI (175 particles) > MISA (168 particles) > Shri Swanabhairavar Enterprise (155 particles) > TPU UPM (93 particles). The majority of the particles collected from surface soil were fragmented and irregular in shape, with a mixture of colourful (black, red, blue, green, brown) and colourless particles. The predominant plastic polymer discovered in the recovered particles from surface soil was acrylonitrile butadiene styrene (ABS), followed by polyvinyl chloride, polystyrene, nylon, and nitrile. These polymers imply that the particles came from agriculture tools operated at the sites. **Conclusion:** MPs were detected in surface soil from selected organic farms in Selangor, Malaysia. These organic farms need to control plastics usage in organic agriculture. Additional research is needed to better understand how agricultural operations may affect the buildup of MPs in organic farm soils.

Keywords: microplastics, organic farm, agriculture, surface soil

ABSTRAK

KEJADIAN MIKROPLASTIK PADA PERMUKAAN TANAH DARI LADANG ORGANIK TERPILIH (SELANGOR, MALAYSIA)

MUHAMMAD AIMAN FAHIM BIN ISHAK HISHAM

Pengenalan: Ladang organik dikenali sebagai ladang yang tidak menggunakan racun serangga, baja, organisma yang diubah suai secara genetik, antibiotik atau hormon pertumbuhan tetapi ia masih tidak diketahui sama ada ladang organik adalah betul-betul selamat, kerana terdapat banyak faktor lain seperti pencemaran mikroplastik (MP) yang boleh berlaku dalam tanah ladang organik. Tanah pertanian dilaporkan telah tercemar dengan MP dengan bilangan yang banyak di kalangan pengajian yang dilakukan di seluruh dunia. Kejadian MP yang meluas di permukaan tanah mampu memberi kesan buruk kepada kesihatan manusia dan kesihatan persekitaran. Namun, terdapat sedikit data tentang kejadian MP di ladang organik dari Malaysia memandangkan isu ini jarang dikaji. **Objektif:** Kajian ini dapat menentukan kejadian MP, bercirikan ciri-ciri mikroplastik (saiz, warna, bentuk dan jenis polimer) dan menyimpulkan kesesuaian tanah ladang organik dari ladang organik terpilih di Selangor, Malaysia. **Metodologi:** Sebanyak 28 sampel yang terdiri daripada tiga (3) jenis kawasan: Kawasan permukaan tanah terganggu (kawasan pertanian yang sedang berlaku dan Kawasan pertanian yang akan berlaku) dan kawasan permukaan tanah yang tidak terganggu telah dikumpul dari ladang organik di Selangor, Malaysia. Sampel permukaan tanah disaring untuk mengesan kehadiran MP dengan menggunakan teknik pemisahan ketumpatan menggunakan larutan zink klorida. Partikel yang diekstrak diperiksa melalui pengimejan mikroskopik dan spektroskopi inframerah transformasi Fourier (FTIR) untuk mengenalpasti jumlah dan ciri morfologi mereka (bentuk, warna dan komposisi polimer). **Keputusan dan Perbincangan:** Partikel yang diekstrak dari semua spesies yang disaring adalah antara 4 dan 64 partikel per kawasan persampelan. Pengumpulan partikel paling tinggi dikesan dalam MARDI (175 partikel) > MISA (168 partikel) > Shri Swanabhairavar Enterprise (155 partikel) > TPU UPM (93 partikel). Partikel yang diekstrak dari permukaan tanah sebahagian besar dalam bentuk serpihan dan tidak mempunyai bentuk yang seragam, dengan campuran berwarna dan tidak berwarna. Akrilonitril butadiene stirena (ABS) ialah jenis polimer primer dan diikuti oleh polivinil klorida, polisterin, nilon dan nitril merupakan polimer plastik yang dikesan di antara partikel yang diekstrak dari permukaan tanah, menunjukkan bahawa partikel itu berkemungkinan berasal dari barang pertanian yang digunakan di ladang organik. **Kesimpulan:** Mikroplastik dikesan dalam permukaan tanah ladang organik dari Selangor, Malaysia. Ladang-ladang tersebut perlu mengawal penggunaan barangan plastik dalam pertanian organik. Tambahan pula, penyelidikan lebih lanjut diperlukan untuk memahami dengan lebih baik bagaimana aktiviti pertanian mempengaruhi pengumpulan MP dalam permukaan tanah ladang organik.

Kata kunci: mikroplastik, ladang organik, pertanian, permukaan tanah

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LIST OF ABBREVATIONS

DOAM	Department of Agriculture Malaysia
FAO	Food and Agriculture Organization of the United Nation
FTIR	Fourier-Transform Infrared Spectroscopy
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
MARDI	Malaysian Agricultural Research and Development Institute
MISA	Malaysian Institute of Sustainable Agriculture
MPs	Microplastics
NY	Nylon
HDPE	High-density polyethylene
LDPE	Low-density polyethylene
PE	Polyethylene
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
TPU UPM	Taman Pertanian Universiti, Universiti Putra Malaysia
UPM	Universiti Putra Malaysia
UV	Ultraviolet
$ZnCl_2$	Zinc chloride

CHAPTER 1
INTRODUCTION

1.1 Study background

Microplastics (MPs) are small plastic particles less than five millimetres in length that have been found in the environment as a result of plastic pollution (Rogers, 2020). MPs vary in terms of size, shape, colour, and density, and are frequently classified as primary or secondary based on their source (FAO, 2017). Primary MPs are defined as plastic particles less than five millimetres in length that have been intentionally generated for industrial and commercial purposes, such as plastic pellets used in industrial manufacturing, microbeads used in cosmetics and personal care products, and plastic fibers shed from clothing or other textiles, such as nets (GESAMP, 2015). Secondary MPs, on the other hand, are microscopic particles formed during the breakdown of larger plastic items such as plastic bags, water bottles, and fishing equipment (GESAMP, 2015). Wind abrasion, UV radiation exposure, temperature, and ocean waves are the most common external factors that contribute to secondary MPs degeneration (National Geographic Society, 2019).

Organic farming covers a total area of 2003.02 hectares in Malaysia (Department of Agriculture Malaysia, 2018), as indicated in Table 1.1. There are 54 organic vegetable farms. There are several varieties of organic vegetable farms, including those that grow chillies, cabbages, spinach, and carrots. Organic fruits such as durian, papaya, banana, and jackfruit have been cultivated on Malaysian organic farms. In Kedah, there are three organic paddy farms. The mushroom and herb farms account for the majority of organic farms in Malaysia (114). According to DOAM in April 2018, Malaysia had 211 farms certified as myOrganic. The number of farms certified as myOrganic in each state is shown in Table 1.2.

Table 1.1: The area of organic farming in Malaysia (Department of Agriculture, 2018)

	No of farm	Area (ha)
Fruit	40	335.21
Vegetable	54	144.81
Paddy	3	118.46
Others	114	1404.54
Total	211	2003.02

Table 1.2: The Number of Farms with myOrganic Certification in Each State (Department of Agriculture Malaysia, 2018)

State	No. of farm
Perlis	0
Kedah	16
Pulau Pinang	14
Perak	12
Selangor	30
Negeri Sembilan	13
Melaka	2
Johor	37
Pahang	46
Terengganu	6
Kelantan	8
Sabah	20
Sarawak	6
Labuan	1
Total	211

The expanding use of plastics in agriculture has benefitted farmers in raising crop output and enhancing food quality. Not only do plastics allow for year-round vegetable and fruit growing, but these produces are often of greater quality than those grown in open fields. According to Blanco et al., (2018), agriculture utilises a variety of plastics, including polyolefins, polyethylene (PE), polypropylene (PP), high density polyethylene (HDPE) and low-density polyethylene (LDPE). Most of plastic material that has been use in agricultural activities are mulching film, plastic net, bucket and hose (Liu et al., 2018) (Figure 1.1).

Figure 1.1: Mulching film and plastic net in organic farms.

1.2 Problem Statement

1.3

Since the mid-twentieth century, there has been widespread and steadily increasing use of plastic films in agriculture (Table 1.1). (Scarascia-Mugnozza, et al., 2012). Using plastic materials in agricultural fields is said to have many benefits, including higher yields, earlier harvests, less herbicide and pesticide use, frost protection, and water conservation. Plastic also plays an important role in preserving, transporting, packaging, and selling agro-food products (Jiang et al., 2004; Zhang et al., 2001). Plastic materials are widely used in European agriculture because they aid in the improvement of both quality and quantity of output. Their use is quickly expanding, particularly in specific agricultural applications such as covering greenhouses, tunnels, and low tunnels, all of which are gaining favour in certain Mediterranean nations such as Italy, Spain, and France (Scarascia-Mugnozza, et al., 2012).

Table 1.3 - Applications of plastic in agriculture (Scarascia-Mugnozza, et al., 2012)

Protected cultivation films: • Greenhouse and tunnel • Low tunnel • Mulching • Nursery films • Direct covering • Covering vineyards and orchards	**Nets:** • Anti-hail • Anti-bird • Wind breaking • Shading **Piping, irrigation /drainage:** • Water reservoir • Channel lining • Irrigation tapes and pipes • Drainage pipes • Micro irrigation • Drippers	**Packaging:** • Fertilizer sacks • Agrochemical cans • Containers • Tanks for liquid storage **Other:** • Silage films • Fumigation films • Bale twines • Bale wraps • Nursery pots • Strings and ropes

Globally, research on the presence of MPs in agricultural soil is extensive, particularly in China (Ding et al., 2020; Zhang et al., 2021; Zhu et al., 2019). Those studies discovered that MPs were present in agricultural soils. MPs concentrations in soil varied between 1430 and 3410 items/kg (Ding et al., 2020).

In Malaysia, the studies regarding agricultural soils are more focusing on pollutants which are pesticides and fertilisers (Zulkefli et al., 2011, Farina, Y et al., 2018, Li Yee Lim et al., 2019, Yang Farina et al., 2017, S. Norela et al., 2013). For example, Yang Farina et al., (2017) stated that the presence and distribution of organochlorine pesticides (OCPs), organophosphate pesticides (OPPs), and pyrethroid pesticides (PYRs) residues in leafy vegetables were analyzed using gas chromatography-electron capture detector in conjunction with soil samples.

1.4 Study Justification

1.5

This study will be able to provide quantitative information of prevalence of MPs on organic farms and its suitability of soil is critical for organic farming. This study will be able to give information on the necessity for MPs monitoring in organic agriculture soil.

1.4 Research Question

i. Is there any occurrence of microplastic in organic agricultural soil from selected organic farms in Selangor, Malaysia?

ii. What is the characteristics of microplastics properties (colour, size, shape, polymer type) in organic agricultural soil?

iii. Is the soil from organic agricultural soil is suitable for organic farming?

1.5 Research Objectives

1.5.1 General Objective

To provide understanding of microplastic pollution in selected organic agricultural soil.

1.5.2 Specific Objectives

i. To determine the occurrence of microplastic in organic agricultural soil.

ii. To characterize microplastic properties (size, colour shape, polymer type) in organic agricultural soil

iii. To conclude the suitability of organic agricultural soil.

1.6 Research Hypothesis

The hypothesis tested was shown below in null form:

1. There will be microplastic occur in organic agricultural soil

1.7 Definition

1.7.1 Conceptual Definition

i) Microplastics (MPs)

MPs are tiny plastic particles with a length of less than 5 mm that naturally occur in the environment as a result of plastic pollution. MPs are present in a variety of products, including cosmetics, synthetic clothing, and plastic bags and bottles. Numerous of these items are rapidly absorbed into the environment via waste (Rogers, K., 2020).

ii) Organic Farm

Organic farming is an agricultural technique that relies on environmentally friendly pest management methods and biological fertiliser obtained mostly from animal and plant wastes, as well as a nitrogen-fixing cover crop (Adamchak R., 2008).

1.7.2 Operational Definition

i) Microplastic (MPs)

The parameters of MPs detected in the surface soil of a selected organic farm were determined in terms of their colour, size, form, and polymer type. These attributes were determined by utilising the separation method, the Olympus CHK Compound Microscope for size, shape, and colour identification, and Fourier Transform Infrared Spectrometry (FTIR) for polymer composition identification.

ii) Organic Farm

Three distinct types of surface soil were chosen: soil that had not been disturbed by agricultural activities, land that was ready to begin agricultural activities, and soil where planting was currently occurring.

1.8 Conceptual Framework

Figure 1.3 shows the conceptual framework for this study. The independent variable (IV) is organic farm, while the dependent variable (DV) is the microplastic.

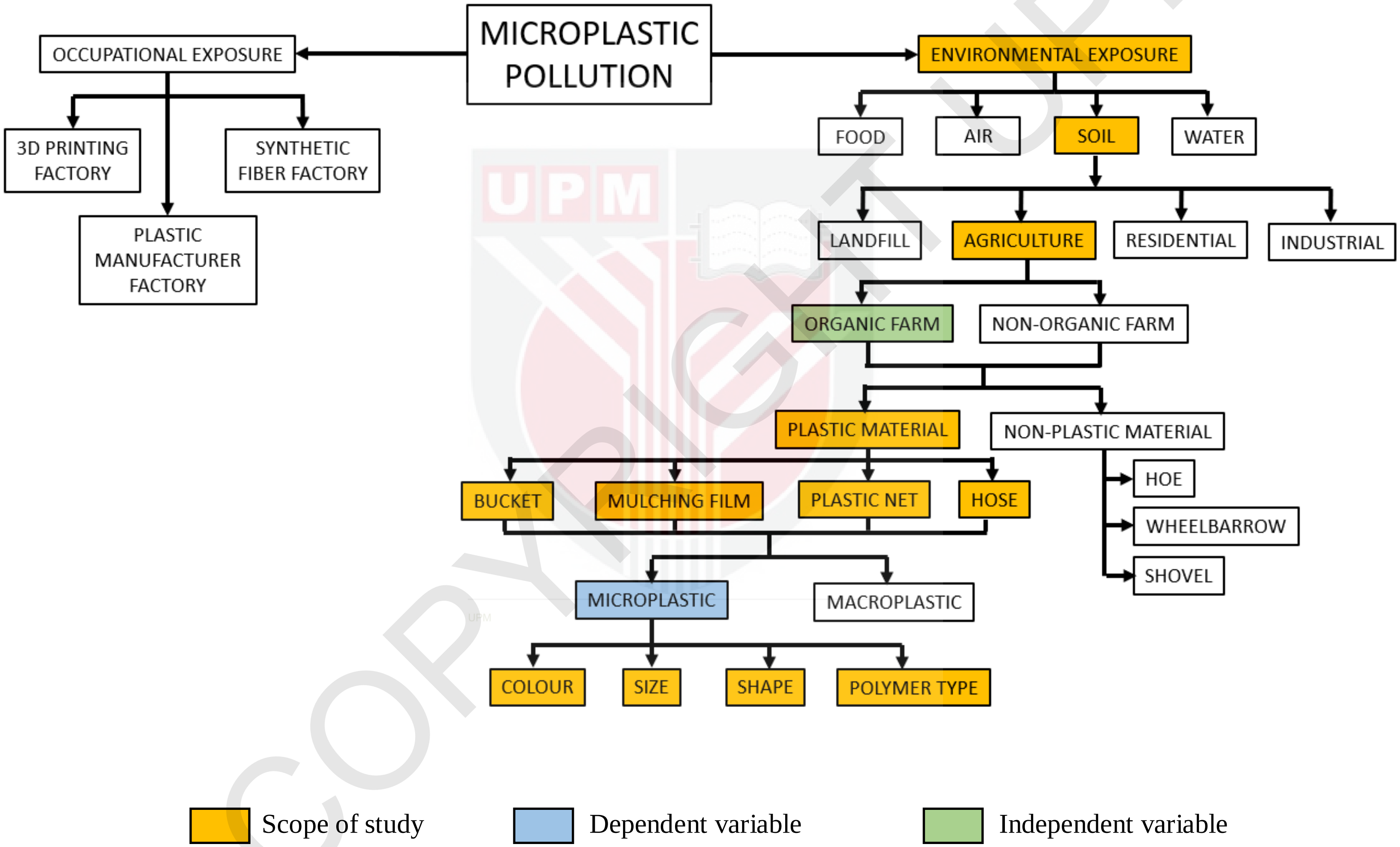


Figure 1.2: Conceptual Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Occurrence of Microplastic in Agricultural Farm

According to Ding et al., (2020), all sampling sites in Shaanxi Province contained four distinct types of MPs. Fiber particles were abundant in all soil samples tested and accounted for 49% of the total MPs concentrations in each sample (L.Ding et al., 2020). Previously, it was believed that irrigation with wastewater and the use of sewage sludge were the principal sources of fibers in agricultural soil (Scheurer and Bigalke, 2018). Additionally, all samples contained film and fragments. These films and shards might have developed as a result of agricultural plastic wastes such as agricultural instruments, plastic packing materials, woven plastic bags, and plastic seed sacks decomposing. S. Feng, et al (2021) stated that, among the 35 sample locations in the Shanghai suburbs, the highest MP abundance (260 items/kg in shallow soil and 193.3 items/kg in deep soil) was found at a site with a plastic mulching time of more than 15 years made of plastic debris that is difficult to blow away by wind. As a result, the accumulation of plastic mulch waste over time contributed to the area's high MPs abundance.

Agriculture area	Microplastic size	Colour	Shape	Plastic polymer	Sources
Wuhan, China (Chen et al., 2020)	• 0.5 - 1 mm (13%) • 0.2-0.5 mm (9%) • 1.0-3.0 mm (7%)	• Red • black • green • blue • brown • transparent.	• Microbeads • Fibers • Fragments • Foams	• Polyamide (PA) (32.5%) • polypropylene (PP) (28.8%) • polystyrene (PS) (16.9%) • polyethylene (PE) (4.2%) • polyvinyl chloride (PVC) (1.9%)	The quantity of MPs in various places may be influenced by a variety of factors, including farming, fertilisation, and sampling locations. Additionally, the sources of pollution and the composition of plastics contribute to the spread of MPs contamination. Numerous businesses, such as car washes and building materials stores, are located near suburban road sample locations and may dump plastic trash and discharge wastewater containing MPs into vegetable farmlands.
Shaanxi Province, China (Ding et al., 2020)	• 0–0.49 mm • 0.5–1 mm • 1–2 mm • 2–5 mm	-	• Film • Fiber • Fragment • pellet	• polystyrene (PS) • polyethylene (PE) • polypropylene (PP) • high-density polyethylene (HDPE) • polyvinyl chloride (PVC) • polyethylene terephthalate (PET)	Composting agricultural plastic wastes, including agricultural instruments, plastic packaging materials, weaved bags, and seed sacks

Qinghai-Tibet Plateau. China (Feng et al., 2021)	• >1mm (11%), 0.5-1mm • (27%), 0.1-0.5 mm (32%), • 50mm-100µm (13%) • <50µm (17%)	• transparent (65.43%) • white (17.65%) • black (11.37%) • other colors (10.59%) • blue (4.31%)	• fragments (27.45%) • fibers (20.58%) • foams (7.35%) • spherules (3.92%)	• polypropylene (PP) • polyethylene (PE) • polystyrene (PS) • polyamide/nylon (PA) • polyethylene terephthalate • polycarbonate • polyvinyl chloride.	Materials made of plastic, such as greenhouses, plastic mulching, and fertiliser bags. The high concentration of pieces and fibres in the samples might be explained by rivers being irrigated with residential effluent.
Northern Germany (Harms et al., 2021)	-	• black (63%) • while (18%) • brown (6%) • grey (4%) • transparent (4%) • red (2%) • yellow (2%) • green (1%) • orange • blue (<1%)	• 61% were foil • 28% were fragments • 10% were platelets • (1%) were polymer fibers.	• Polyethylene (87%) • polypropylene (4%) • nylon (3%), polyamide (3%) • polyvinylidene fluoride (PVDF) • poly diallyl phthalate (PDAP) • polymethyl methacrylate (PMMA) • poly terephthalate (PET)	Pesticides, nets, silage and mulching films, greenhouse and fertiliser bags are all packaged in this manner.

				• polyvinyl formal (PVF), poly (1.4-ButyleneAdipate) • polyvinyl acetate (PVA) • polyvinyl stearate (PVS)	
Shanghai, China (Liu et al., 2018)	• <1mm (50%) 1-3mm (35%) • 3-5mm (10%) • >5mm (5%)	• Black • Blue • Green • Red • Transparent.	• Fibers (53.33%) • fragment (37.58%) • film (6.67%) • pellet (2.12%)	• Polypropylene (50.51%) • polyethylene (43.43%) • polyester (6.06%)	Formation of microplastics were formed through agriculture activity such as plough 1-2 times per year and the usage of mulching film

Table 2.1: Summary of studies reporting the occurrence of microplastics in agricultural farms.

2.2 Microplastic Formation in Agriculture Activities.

By and large, traditional plastic materials are quite durable. Plastics are expected to survive hundreds, if not, thousands of years, depending on their properties and the surrounding environmental circumstances. Although occurring at a snail's pace, environmental weathering continues to destroy plastics, resulting in changes in polymer properties due to abiotic processes. The general degradation mechanisms of plastic are depicted in Figures 2.1. Degradation of plastics refers to the alteration of a material's physical or chemical properties caused by abiotic elements such as sunlight, rain, and mechanical forces (Svedin, 2020; Zhang et al., 2021).

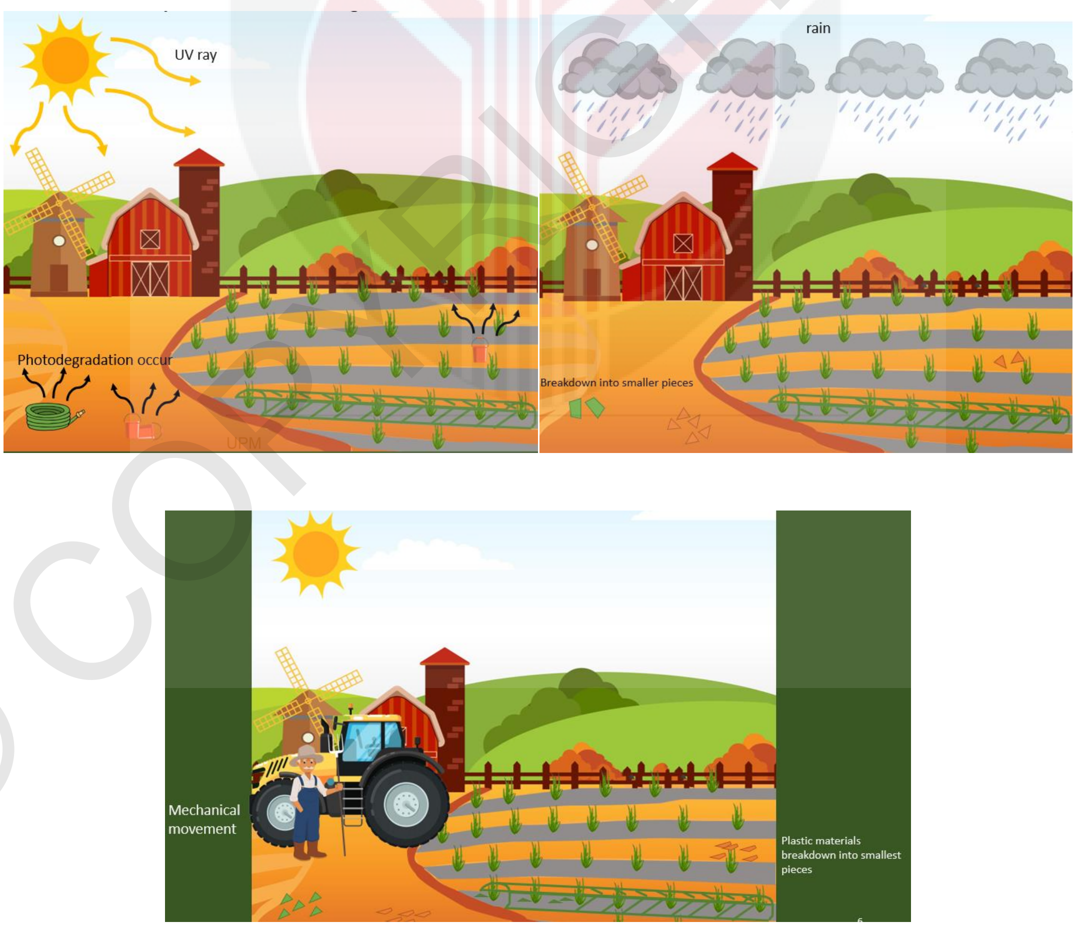


Figure 2.1: How Microplastic is Formed in Agriculture Farms

2.2.1 Sunlight

As previously stated, photo-degradation refers to degradation that happens as a result of exposure to light. It was commonly anticipated that producing photodegradable mulch films with precisely regulated lifetimes would be crucial for minimising the risks associated with plastic (Farooq Shah., 2020). Numerous types of plastic, including the most often used PE, PP, and PVC, can deteriorate when exposed to light. The majority of these polymers are vulnerable to light, particularly UV radiations. For example, photodegradation of PE occurs when UV light with a wavelength of 290–330 mm is absorbed by carbonyl and hydroperoxide groups found on PE chains. It is possible for it to occur anaerobically (through chain scission or cross-linking) or aerobically (by photooxidation) (Yousif and Haddad, 2013). Photo-degradation is one of the most advanced degradation processes which occur as a result of abiotic influences in the natural environment. Indeed, abiotic oxidation occurs first, followed by biodegradation (Yang et al., 2015).

According to Daglen and Tyler (2010), the commencement of photodegradable plastic deterioration should be rather predictable and adjustable, given the polymers are typically employed in a variety of applications with varying life requirements. Additionally, the photodegradable plastic's rapid and complete disintegration after usage is an ideal attribute. Mechanical characteristics and molecular weight of photodegradable plastics can be drastically altered upon deterioration, while the plastic's aesthetic appearance remains unchanged. It hinted that such a feature is necessary since the plastic can be hazardous in certain circumstances.

2.2.2 Rain

The annual average rainfall is 2,420 mm for Peninsular Malaysia, 2,630 mm for Sabah and 3,830 mm for Sarawak (Ahmad et al., 2017). However, certain regions of the country receive far more annual precipitation than others. This is because Malaysia's seasonal variance is mostly controlled by the northeast and southwest monsoons. Malaysia receives rains on a daily basis, which makes it much simpler to generate MPs, as the water droplet will collide with all the plastic components, further breaking them down into tiny bits.

2.2.3 Mechanical forces

Mechanical forces are the breakdown of plastics because of external forces acting on them (Zhang et al., 2021). External forces can occur in the environment as a result of plastics clashing and abrading against rocks and sands as a result of wind, as well as people, lorries, and tractors stepping on the plastic. External forces have a different influence depending on the mechanical properties of the plastics. Elongation during break, alternatively referred to as fracture strain, indicates a plastic product's capacity to withstand shape changes without forming cracks. For various plastics, elongation at break ranges between 1% and around 900 percent (Crawford and Quinn 2017). Plastics with a low elongation at break are more prone to fragment when subjected to external tensile pressures. Continuing to stress plastics results in polymer chain scission. Mechanical forces are primarily responsible for tyre wear, brake wear, and road wear particle formation (Wagner et al., 2018). The interactions of a tyre and a road surface, as well as a brake pad and a brake disc, generate frictional forces that directly shred rubber particles from the surface. During driving, tyre treads are continuously stressed, and the rubber is compressed into a bulge, resulting in persistent stretching and material fatigue.

2.3 Plastic Usage in Organic Farm

The increasing use of plastic in modern agriculture is jeopardizing the ecosystem's general sustainability, as leftover plastic wastes remain in terrestrial setting (Farooq Shah., 2020). As a result, critical components of crop production (such as crops and soil), as well as human beings, are very sensitive to the plastic pollution threat. To this, the widespread use of plastic tools as mulching film, plastic net and bucket are significant components.

Manzano et al. (2019) stated that mulching is a practise that entails covering the soil around newly planted cultivations with a layer that protects seedlings and young plants. Mulching helps to increase soil temperature at the root level by reducing water evaporation and heat loss via radiation and convection, as well as weed development and subsequent chemical usage (Manzano et al., 2019). Nowadays, mulching is accomplished by the use of thin plastic films that are transparent or opaque, white or black, or coloured, and have a thickness of 20–50 mm. These films are mechanically spread on the soil. Due to the great quality of the products and the inexpensive cost of the operation, it is one of the most often employed agricultural techniques (Scarascia-Mugnozza, et al., 2012).

Mulching with transparent large films has also been used in a number of European countries for soil solarization, in order to achieve a partial sterilisation of the agricultural soil prior to planting, due to the high temperatures generated in well-watered and mulched soil during the summer season by the high solar radiation, which are capable of eradicating the major soil-borne pathogens and devitalizing weed seeds (Manzano et al., 2019). Solarization of soil is frequently combined with other disinfection strategies, such as green manure containing biocide plants, to improve soil quality. A novel mulching technique involves spraying a biodegradable foamy liquid over the soil.

Plastic nets (Figure 2.2) are extensively employed in a variety of agricultural applications, including protection from hail, wind, snow, and heavy rainfall in fruit and ornamental farming, as well as shade nets for greenhouse applications throughout the summer, reducing the interior microclimate (Maraveas, 2020). Furthermore, nets are widely used to protect against virus-vectoring insects and birds, as well as for tiny fruit picking and post-harvest operations (cut flower gathering and fruit drying) (Chrysanthos Maraveas., 2020). Additionally, nets are utilised to provide shade for mushroom beds and cow breeding shelters.

It is critical to assess the shading effect of used nets because it can be considered a positive effect when the net covering system is used to reduce incoming solar radiation, but it can have negative consequences when used in other applications, such as anti-hail, by altering the microenvironment, particularly the interior brightness and air temperature (FAO, 2021).

Different net types are defined structurally by their thread types, fabrics, the shape and dimension of fibers and meshing, as well as their physical properties such as weight, colour, shading factor, durability, porosity, and air permeability, as well as their mechanical properties such as stress, strength at break, and elongation (FAO, 2021). The most frequently used raw material for agricultural nets is high density polyethylene (HDPE), while polypropylene (PP) is also used as a raw material for nets, but more frequently for the manufacture of nonwoven layers.

According to FAO, (2021), plastic buckets (Figure 2.2) are constructed of polypropylene (PP), a food-grade plastic. However, containers constructed of a food-grade variant of high-density polyethylene can also be used (HDPE). While HDPE is occasionally less expensive, PP is better resistant to temperature variations. This bucket is ideal for shipping and storing produce (or other food-grade products), and lids are available. Additionally, the bucket is frequently used to transport fruits and vegetables and even to store organic fertiliser.

Other produced plastics are used to make irrigation and drainage pipes and tapes, decorative plant and flower pots, nursery containers, soilless culture substrate, strings, bags, and containers, as well as agrochemicals. Plastic films are also used to make silage, package agricultural products, transport them, store them, and sell them (FAO, 2021).

Figure 2.2: Mulching film (a), plastic net (b) and plastic bucket (c) used in organic farms

CHAPTER 3

METHODOLOGY

3.1 Study Area

Four organic farms were selected by referring to Malaysia database which is from Department of Agriculture of Malaysia and was recommended by a lecturer from Faculty of Agriculture UPM. Malaysian Agricultural Research and Development Institute (MARDI), Malaysian Institute of Sustainable Agriculture (MISA), Shri Swarnabhairavar Enterprise, and Taman Pertanian Universiti, Universiti Putra Malaysia (TPU UPM) are amongst the organic farms that have agreed to participate in this study. These organic farms are located around Selangor (Figure 3.1).

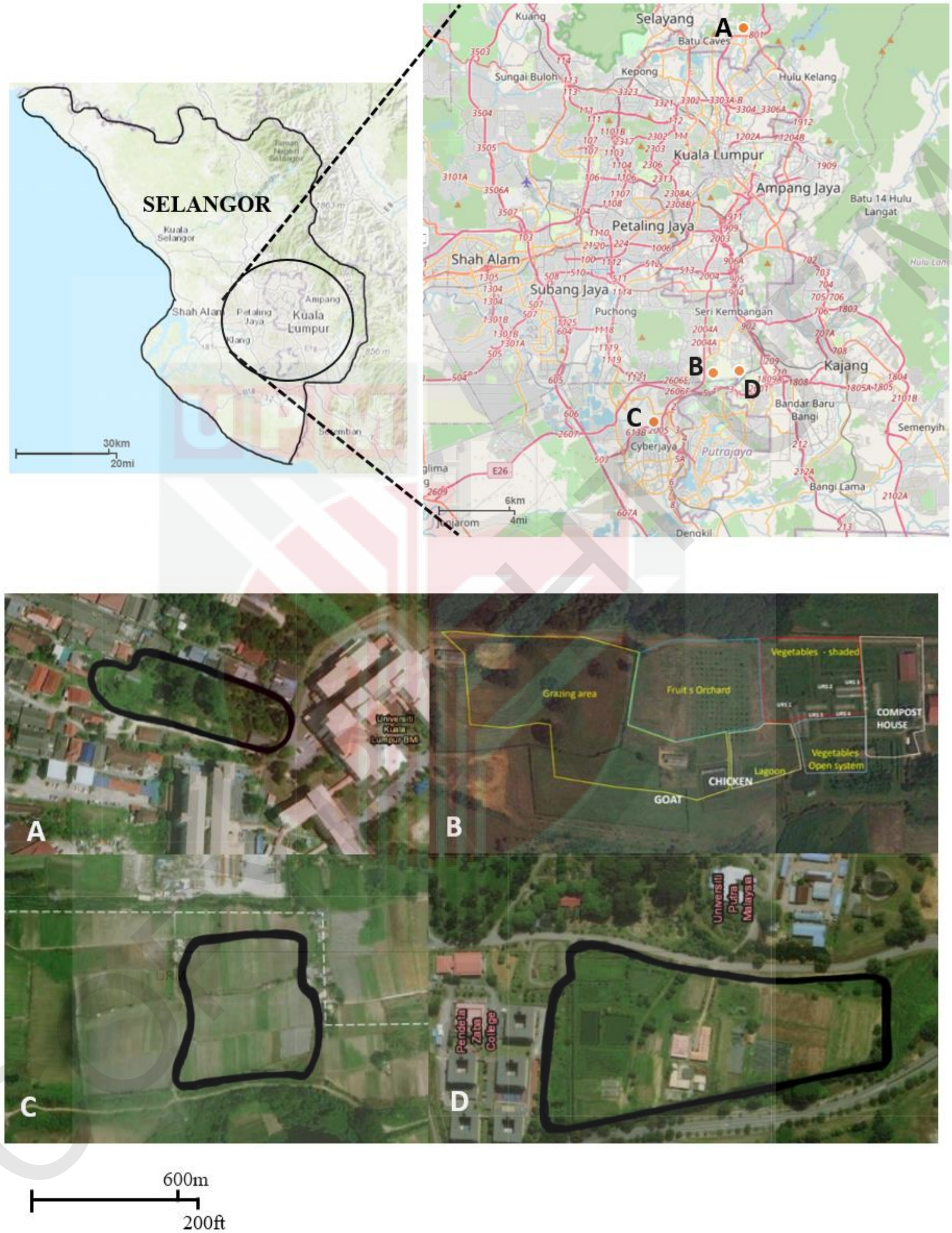


Figure 3.1: Selected organic farms in Selangor: (A) MISA, (B) MARDI, (C) Shri Swanabhairavar Enterprise and (D) TPU UPM

3.1.1 Malaysian Institute of Sustainable Agriculture (MISA)

Malaysian Institute of Sustainable Agriculture (MISA) is a 0.2 hectare farm located in Gombak, Selangor. MISA grows a variety of plants, including spinach, ulam raja, and mustard green. According to observation, this farm has made extensive use of plastic such as plastic net, bucket, and hose.

Figure 3.2: Plastic usage in MISA farm.

3.1.2 Malaysian Agricultural Research and Development Institute (MARDI)

Malaysian Agricultural Research and Development Institute (MARDI) is a seven-hectare farm located in Serdang, Selangor. MARDI grows a variety of plants, including chilli, tomato, potato, and cabbage. According to observation, this farm has made extensive use of plastic. Plastic net, mulching sheet, bucket, and hose made of plastic as shown in the Figure 3.3. Additionally, plastic trimmer line has been discovered on the farm, which may contribute to the formation of MP.

Figure 3.3: Plastic usage in MARDI farm.

3.1.3 Shri Swarnabhairavar Enterprise

Shri Swarnabhairavar Enterprise is a two-hectare farm located in Cyberjaya, Selangor. Shri Swarnabhairavar Enterprise grows a variety of plants, Spinach, kale and ladies finger. According to observation, this farm has made extensive use of plastic such as mulching sheet, plastic bucket, plastic hose and plastic net as shown in the Figure 3.4. Additionally, small pieces of plastics has been discovered on the farm, which may contribute to the formation of MP.

Figure 3.4: Plastic usage in Shri Swanabhairavar Enterprise farm.

3.1.4 Taman Pertanian Universiti, Universiti Putra Malaysia (TPU UPM)

Taman Pertanian Universiti, Universiti Putra Malaysia (TPU UPM) is a two-hector farm located in Serdang, Selangor. TPU UPM grows a variety of plants, including Kale, spinach, chilli and corn. According to observation, this farm has made extensive use of plastic. Plastic net, plastic bucket, and plastic made of plastic as shown in the Figure 3.5.

Figure 3.5: Plastic usage in TPU UPM farm.

3.2 Soil Sampling

Surface soil samples (20 cm) have been collected randomly from each selected agriculture area. Four types of areas were chosen and they are these sampling areas (disturbed and undisturbed surface soil). The surface soil sample was collected using a gardening scoop and then placed and wrapped in clean A4 papers. The soil samples were air-dried for 2 days before further analysis.

Figure 3.6: Soil sampling from Shri Swanabhairavar Enterprise and MARDI.

3.3 Soil Microplastic Homogenization

The dried soil samples were sieved with a 2 mm stainless sieve. Soil samples were homogenized using a pestle and mortar (Zhang et al., 2021). The mixture of soils and MPs were sieved again with a 2 mm metal mesh (Zhang et al., 2021).. A total of 100g of homogenized soil sample was selected for MPs extraction.

Figure 3.7: Soil sample was homogenized using pestle and mortar

Figure 3.8: Homogenized soil sample was sieved

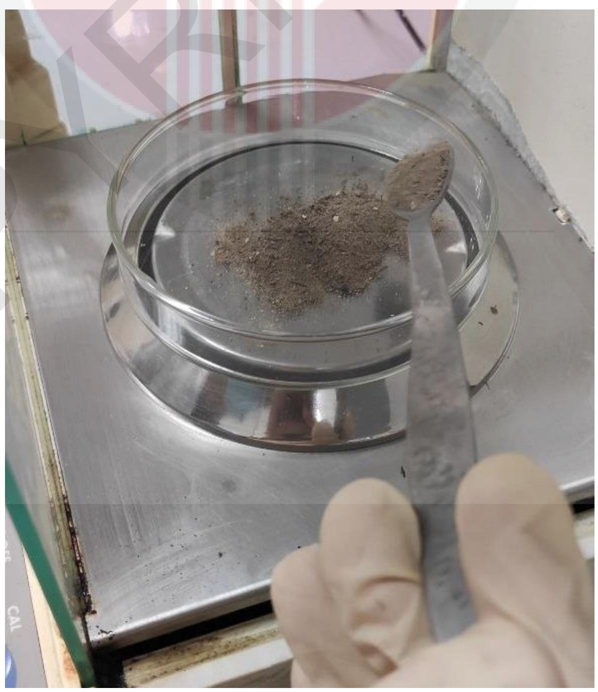


Figure 3.9: Soil sample was weighed to a 100 gram

3.4 Density Separation

The method of density separation (using saturated ZnCl2 (1.7 gcm3) was used to separate MPs from soil, as reported in (Li et al. (2019) and Missawi et al (2020). Zinc chloride solution ($ZnCl_2$) was used in this research because the density of zinc chloride solution is 1.7 gcm^{-3} which can suspend a greater amount of MPs which typically are range between 0.9–1.6 g cm^{-3} (Thomas, et al., 2020). A total of 100 gram of soil sample was added into a conical flask. Then 250 mL of $ZnCl_2$ was added in the same conical flask. The conical flask then mixed and swirled for two minutes. The mixture was then kept for 24 hours. These steps were repeated for all the soil samples.

The suspended material was inspected for visible MPs. If any MPs is found, it will be photographed and stored in a petri dish. After filtering the mixture, the suspended material on the filter paper will be air-dried in the laboratory prior to being observed under a microscope.

3.5 Identification and Characterization

For microplastics identification and characterization had been done by used the Olympus CHK Compound Microscope and Thermo Scientific Nicolet 6700 FTIR Spectrometer. The Olympus CHK Compound Microscope was used to identify the particles (size, colour, and form) in each sample, while the Thermo Scientific Nicolet 6700 FTIR Spectrometer was used to classify the particles (polymer type) (Zhang et al., 2021).

3.6 Data Analysis

Table 3.1 below shows the data analysis that were used in this study. Only descriptive analysis was used for analyzing MPs data in selected organic farms.

Specific Objectives	Data Analysis
To determine occurrence of microplastic in agriculture soil	-
To characterize microplastic properties (colour, size and shape) in agriculture soil	Descriptive analysis
To conclude the suitability of organic agriculture soil	-

Table 3.1: Data analysis for analyzing MPs data in selected organic farms

CHAPTER 4
RESULTS

4.1 Occurrence of Microplastic in Organic Agriculture Soil.

A total of 26 extracted surface soil samples was observed under the Olympus CHK Compound Microscope with a magnification of 4x. Figure S1 (refer Appendix 3) shows the images of some extracted particles from freshwater aquaculture samples. Table 4.1 summarizes the result of particles extracted from surface soil samples.

Table 4.1: The particles extracted from surface soil samples.

Organic Farm	**Sample**	**Number of particles (particle/g)**	**Shape**	**Colour**
A	S1F1	0.39	Irregular	Black
	S1F2	0.64	Line	Transparent
	S2F1	0.21	Fiber	Red
	S2F2	0.21	Film	Green
	S3F1	0.12	Fragment	
	S3F2	0.18		
B	S1F1	0.17		
	S1F2	0.21		Black
	S2F1	0.15	Irregular	Transparent
	S2F2	0.15	Fiber	Red
	S3F1	0.19	Film	Green
	S3F2	0.35	Fragment	Blue
	S4F1	0.25		Brown
	S4F2	0.21		

C	S1F1	0.26	Irregular	Black
	S1F2	0.19	Line	Transparent
	S2F1	0.29	Fiber	Red
	S2F2	0.26	Film	Green
	S3F1	0.20	Fragment	Blue
	S3F2	0.35	Film	Brown
D	S1F1	0.80	Irregular	Black
	S1F2	0.40	Line	Transparent
	S2F1	0.21	Fiber	Red
	S2F2	0.26	Film	Blue
	S3F1	0.19	Fragment	Brown
	S3F2	0.15	Film	

Based on the data, the amount ranged from 0.4 particle/g – 64 particle/g. The highest number of particles was found in the S1F2 of organic farm A (0.64 particle/g). The least particles were detected in the S1F2 of organic farm C (0.40 particle/g).

4.2 Size, Colour, Shape and Polymer Types of Microplastics Particles on Surface Soil in Organic Agriculture Soil.

4.2.1 Size of MPs Particles on Surface Soil in Organic Agriculture Soil.

Table 4.2 to 4.5 shows the size distribution of MP particles. Additionally, the majority of MPs detected in this study were composed primarily of tiny particles (1 mm – 13 μm).

Table 4.2: Size of MPs in organic farm A-D

Organic Farm	Sample	Mean (μm)	Standard Deviation	Minimum (μm)	Maximum (μm)
A	S1F1	158.712	165.118	16.73	838.428
	S1F2	230.471	200.013	16.73	1029.628
	S2F1	397.46	318.587	91.584	1443.861
	S2F2	313.399	204.713	43.689	725.329
	S3F1	356.666	359.008	30.293	1363.85
	S3F2	238.772	282.544	33.46	1129.654
B	S1F1	178.619	141.659	40.416	630.345
	S1F2	209.094	227.096	47.319	992.469
	S2F1	266.054	152.272	90.068	569.64
	S2F2	290.709	221.655	77.233	846.93
	S3F1	340.58	213.85	106.415	912.341
	S3F2	200.239	217.652	36.603	1335.656
	S4F1	282.728	294.966	21.42	1442.068
	S4F2	283.015	197.709	21.4221.42	714.25
C	S1F1	106.805	77.789	24.98	299.067
	S1F2	225.784	228.183	15.447	751.993
	S2F1	282.796	215.03	17.136	839.169
	S2F2	213.979	238.189	27.432	908.147
	S3F1	275.051	239.782	34.539	1019.309
	S3F2	289.357	229.431	27.095	1019.309
D	S1F1	226.811	276.371	59.517	688.554
	S1F2	168.355	80.367	107.102	280.437
	S2F1	394.563	263.406	52.294	926.801
	S2F2	373.759	283.659	13.547	1223.43
	S3F1	236.531	124.797	80.034	527.97
	S3F2	339.315	299.699	57.637	1049.953

4.2.2 Colour of MPs Particles on Surface Soil in Organic Agriculture Soil.

Six types of colour (black, transparent, red, blue, green and brown) were identified in these extracted particles. The total number of particles based on detected colours are shown in Table 4.3 (refer Appendix 1). The black colour is accounted for the dominant shape of the particle extracted, followed by transparent, red, brown, blue and green, as shown in Figure 4.1 – Figure 4.4.

Table 4.3: The total number of particles extracted from surface soil samples by colour

Organic Farm	Number of particles	Shape	Number of particles
A	175	Irregular	50
		Line	2
		Fiber	37
		Film	9
		Fragment	77
B	168	Irregular	32
		Line	12
		Fiber	40
		Film	4
		Fragment	80
C	155	Irregular	43
		Line	16
		Fiber	45
		Film	3
		Fragment	48
D	93	Irregular	27
		Line	7
		Fiber	27
		Film	1
		Fragment	31

Figure 4.1: The proportion of colour among particles extracted from surface soil samples of organic farm A

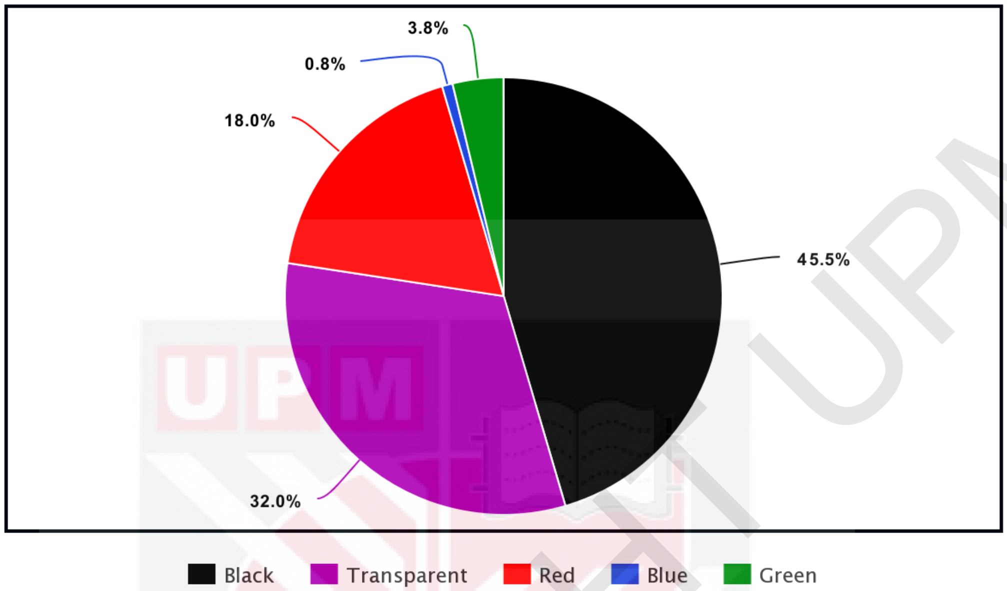


Figure 4.2: The proportion of colour among particles extracted from surface soil samples of organic farm B

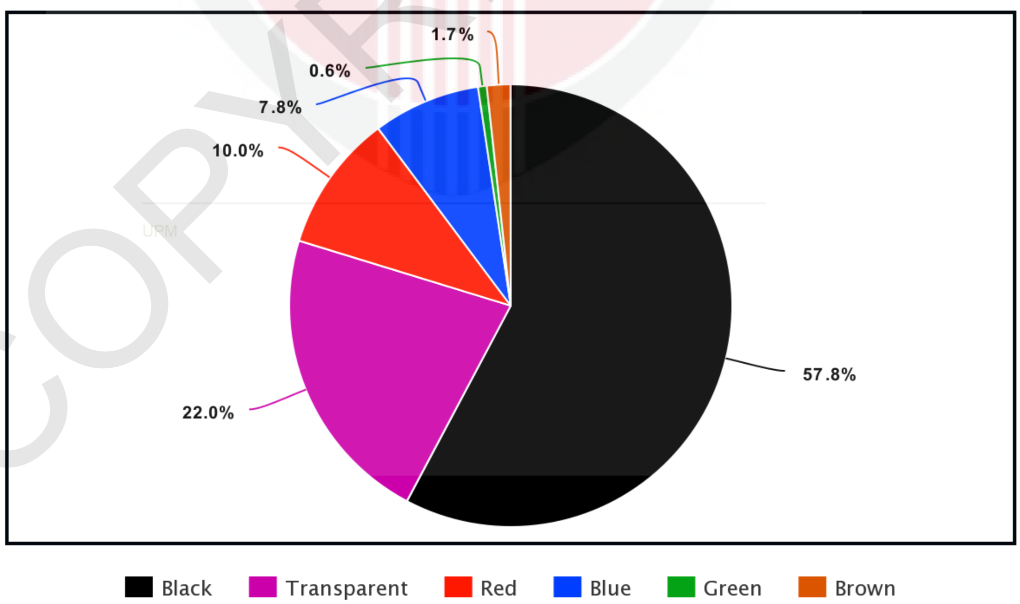


Figure 4.3: The proportion of colour among particles extracted from surface soil samples of organic farm C

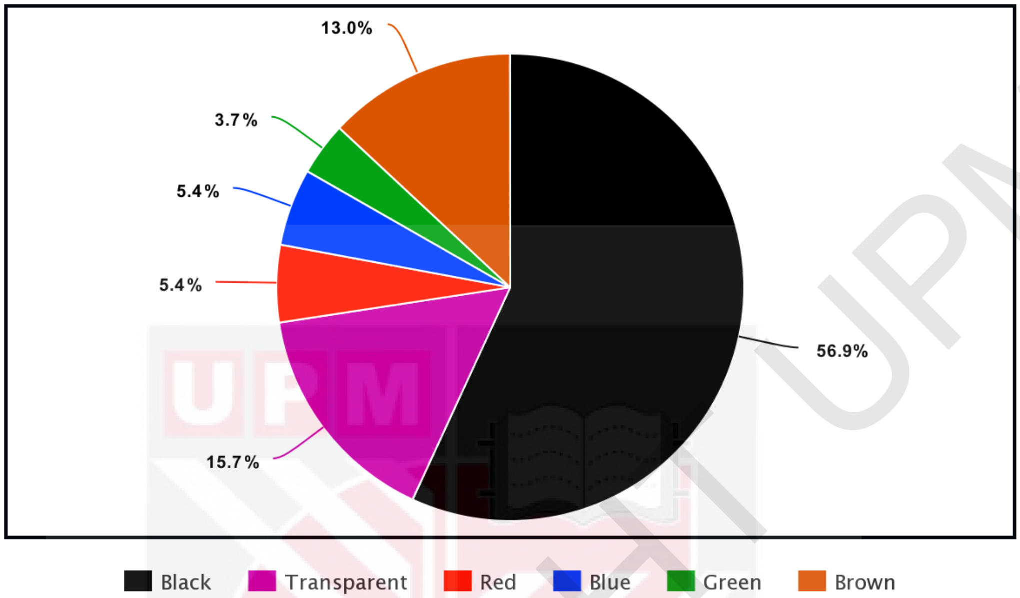
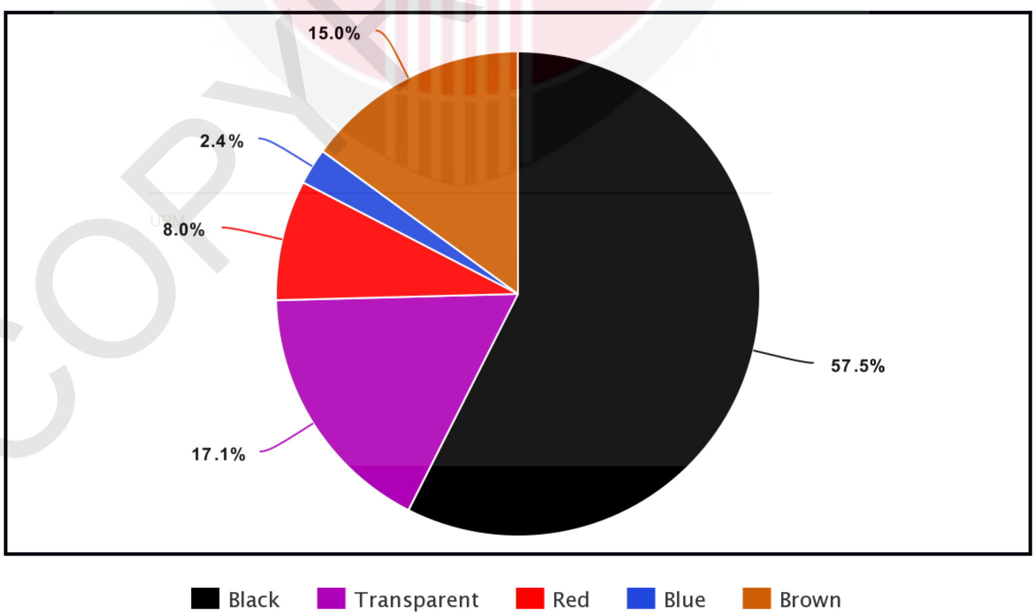


Figure 4.4: The proportion of colour among particles extracted from surface soil samples of organic farm D



4.2.3 Shape of MPs Particles on Surface Soil in Organic Agriculture Soil.

Five types of shape (fragment, fiber, line, film and irregular) were identified in these extracted particles. The total number of particles based on detected shapes are shown in Table 4.4. Fragment has the highest number of particles (41%) while line has the lowest number of particles while film has the lowest number of particles (3%) for four organic farms, as shown in Figure 4.5 – Figure 4.8.

Table S2: The total number of particles extracted from surface soil samples by shape

Organic Farm	Number of particles	Shape	Number of particles
A	175	Irregular	50
		Line	2
		Fiber	37
		Film	9
		Fragment	77
B	168	Irregular	32
		Line	12
		Fiber	40
		Film	4
		Fragment	80
C	155	Irregular	43
		Line	16
		Fiber	45
		Film	3
		Fragment	48
D	93	Irregular	27
		Line	7
		Fiber	27
		Film	1
		Fragment	31

Figure 4.5: The proportion of shapes among particles extracted from surface soil samples from organic farm A

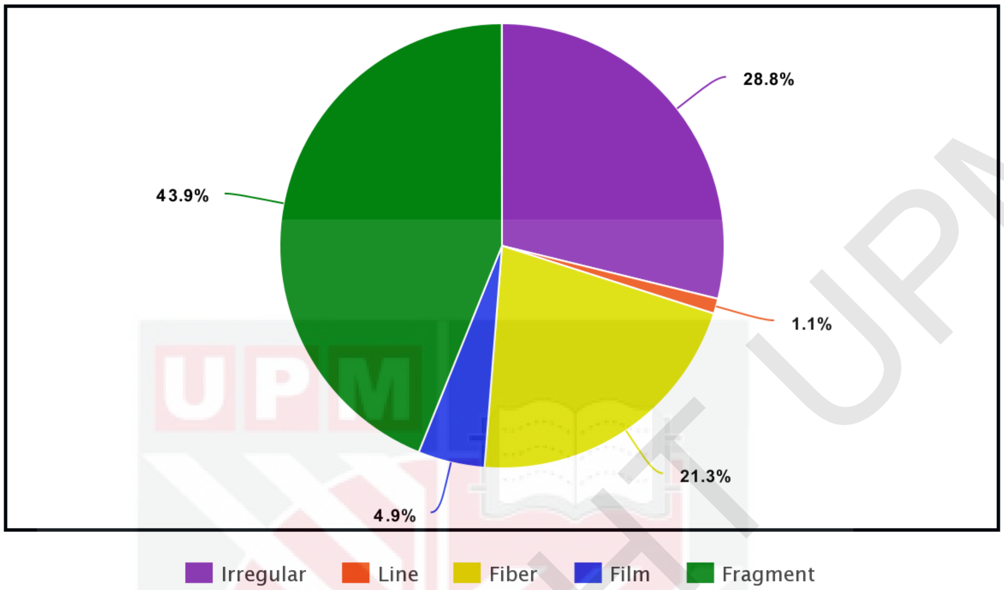


Figure 4.6: The proportion of shapes among particles extracted from surface soil samples from organic farm B

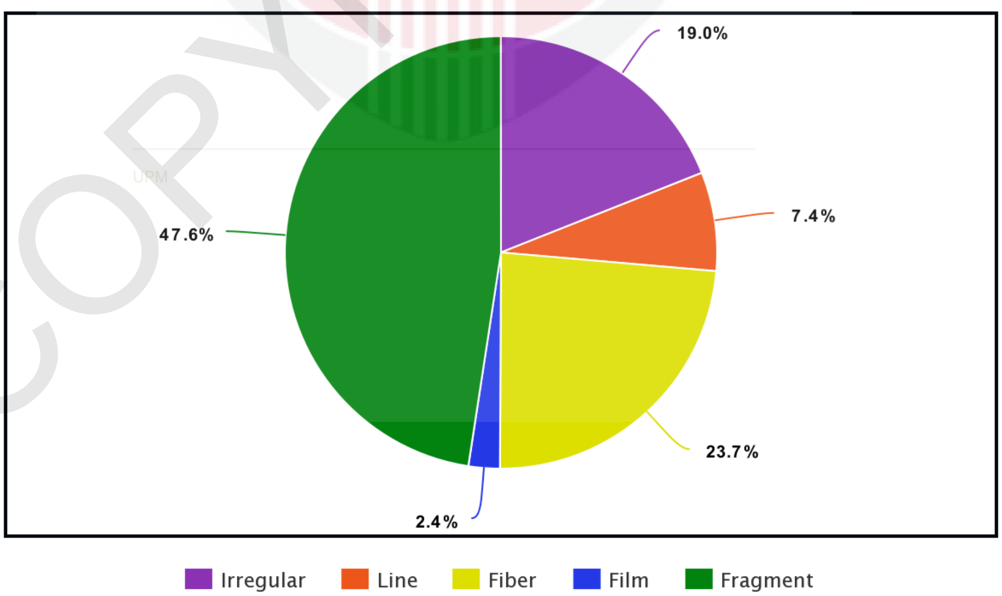


Figure 4.7: The proportion of shapes among particles extracted from surface soil samples from organic farm C

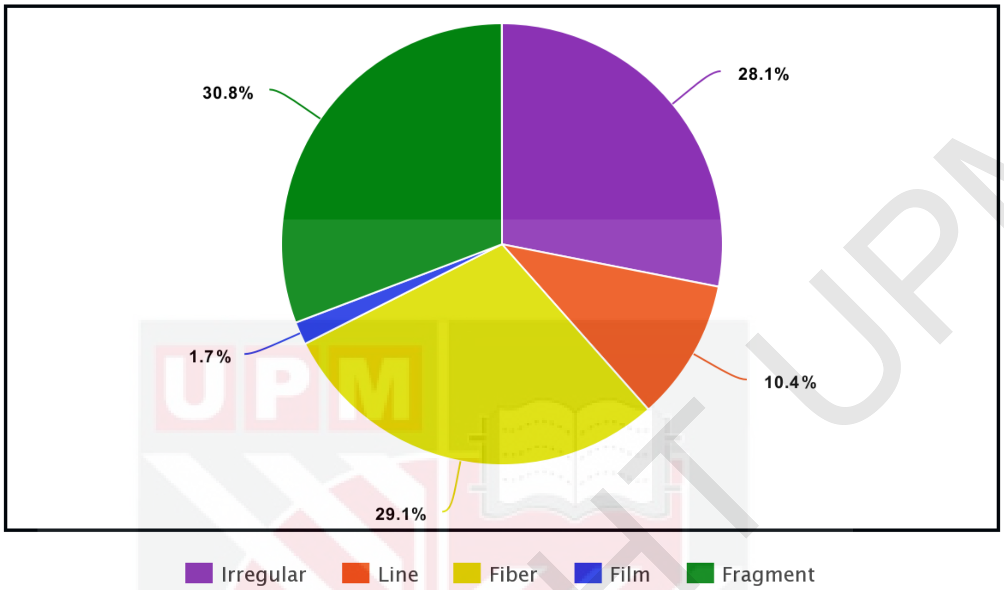
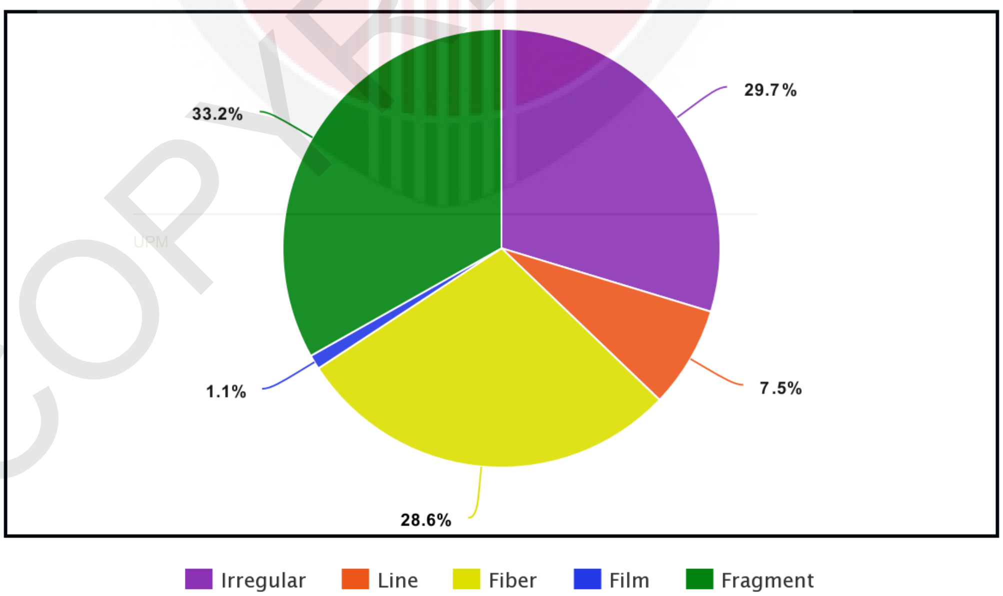


Figure 4.8: The proportion of shapes among particles extracted from surface soil samples from organic farm D



4.2.4 Polymer Type of Microplastics Particles on Surface Soil in Organic Agriculture Soil.

Eight samples of surface soil were chosen visually, and the polymers of extracted particles were evaluated by FTIR spectrometry. The findings of FTIR spectrometry on particles isolated from surface soil samples are shown in Table 4.6.

Sample	Organic Farm	Polymer composition of extracted particles
S1F1	A	ABS
S1F2		Nylon
S1F1	B	Polystyrene
S1F2		ABS
S2F1	C	PVC
S3F2		ABS
S2F1	D	PVC
S3F1		Nitrile

Table 4.3: The polymer composition of extracted particles in selected surface soil samples from four organic farms

Five distinct types of polymers with varying chemical compositions have been identified. The FTIR and microscopic images of extracted particles in the samples with their polymer types are shown in Figure 4.9 to Figure 4.16. Acrylonitrile butadiene styrene (ABS) was the primary plastic polymer, followed by polyvinyl chloride (PVC), polystyrene (PS), nylon (NY), and nitrile.

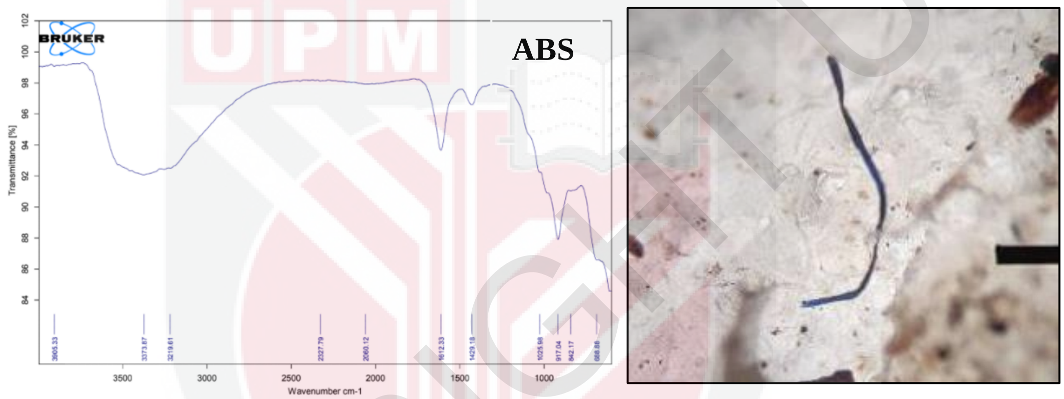


Figure 4.9: FTIR and microscopic images of extracted particles in sample S1F1 Organic Farm A

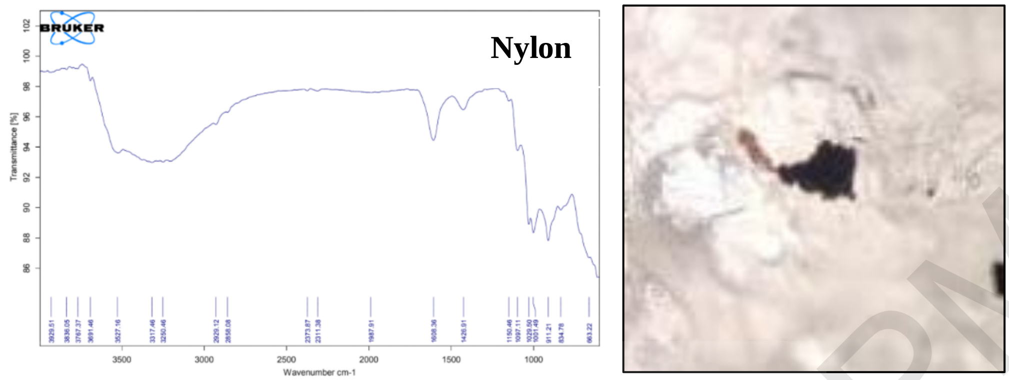


Figure 4.10: FTIR and microscopic images of extracted particles in sample S1F2 Organic Farm A

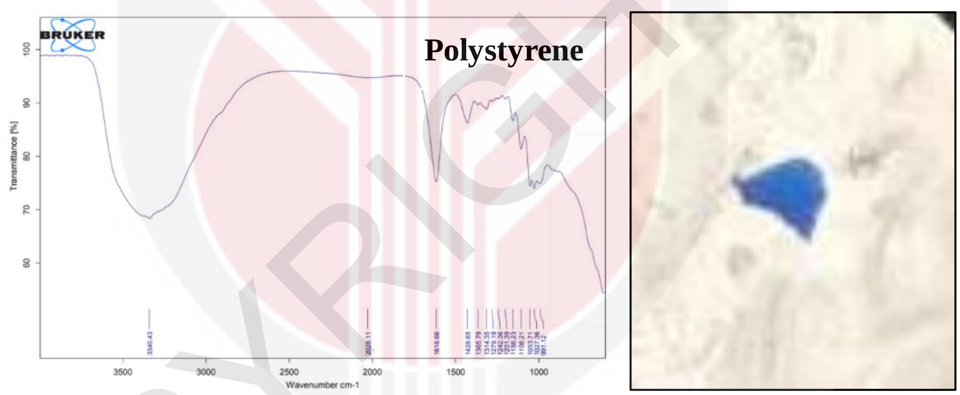


Figure 4.11: FTIR and microscopic images of extracted particles in sample S1F1 Organic Farm B

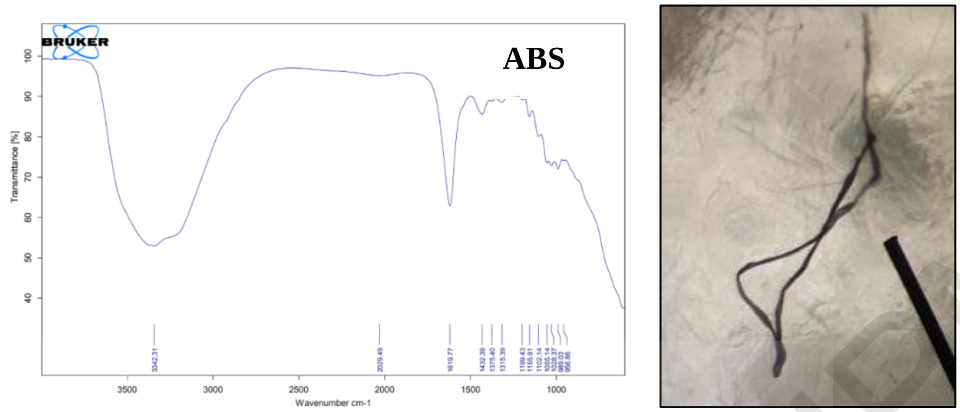


Figure 4.12: FTIR and microscopic images of extracted particles in sample S1F2 Organic Farm B

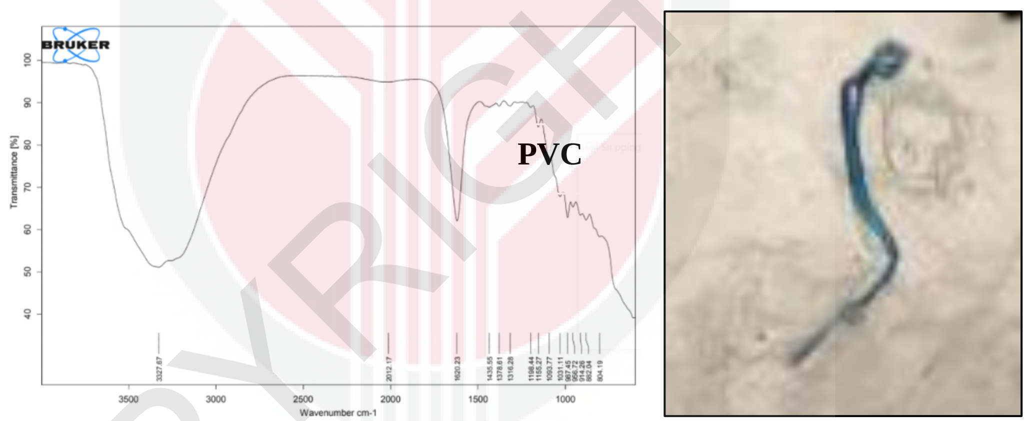


Figure 4.13: FTIR and microscopic images of extracted particles in sample S2F1 Organic Farm C

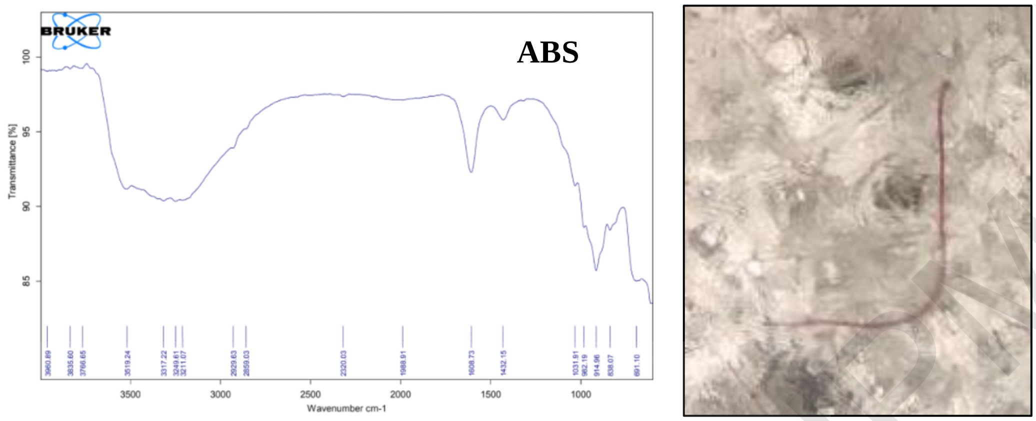


Figure 4.14: FTIR and microscopic images of extracted particles in sample S3F2 Organic Farm C

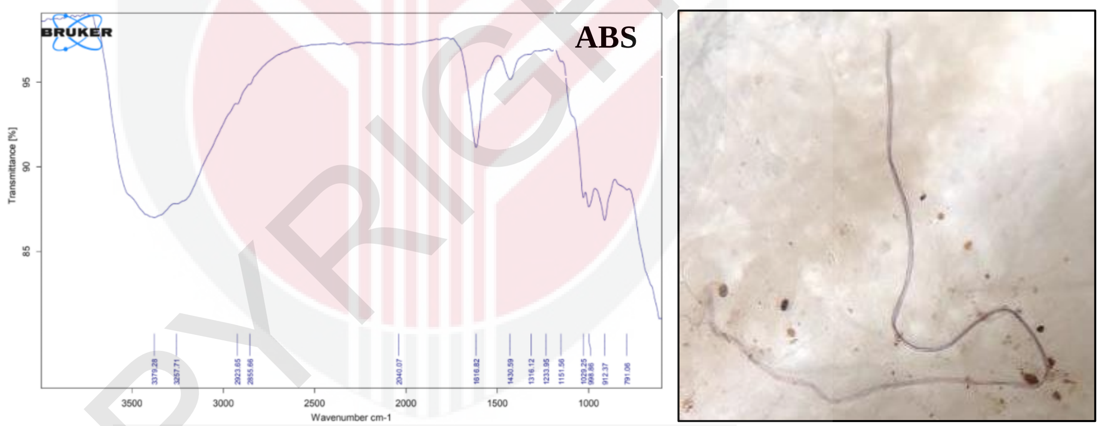


Figure 4.15: FTIR and microscopic images of extracted particles in sample S2F1 Organic Farm D

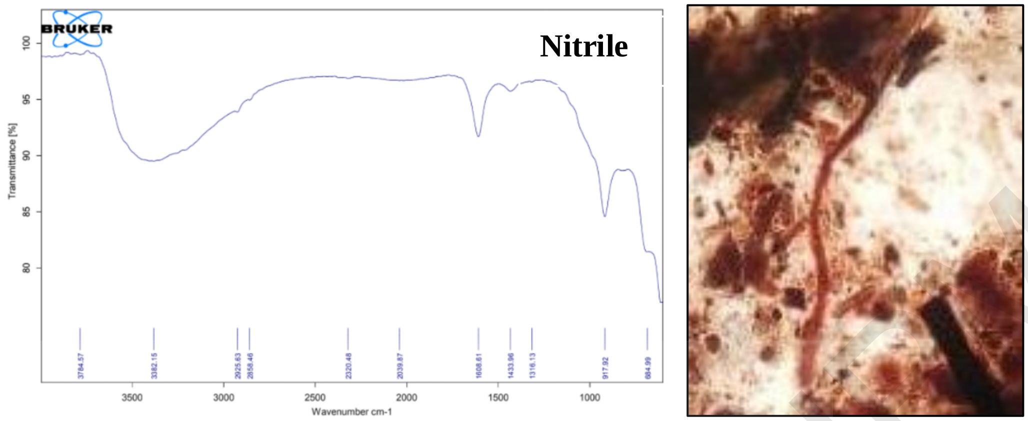


Figure 4.16: FTIR and microscopic images of extracted particles in sample S3F1 Organic Farm D

4.3 Conclude the Suitability of Organic Agricultural Soil.

All sample points used in this study are unsuitable for organic farming. This is because the MPs particles were detected on the surface soil from all of the sampling points. Additionally, the undisturbed soil contains MPs that should not be present. According to the FAO (2019), plastics contain toxic chemicals and transmit them into surface soil. This demonstrates that, while organic farming is free of chemical-based pesticides and fertilisers, there are alternative chemical sources that can be introduced to the organic farm's plants (Chen et al., 2020).

Although organic farms claim to use no pesticides, fertilisers, genetically modified organisms, antibiotics, or growth hormones (Seufert et al., 2017), it is still unknown whether organic farms are truly safe, as there are numerous other factors, such as MP pollution, that can compromise the organic agricultural soil's safety.

CHAPTER 5

DISCUSSION

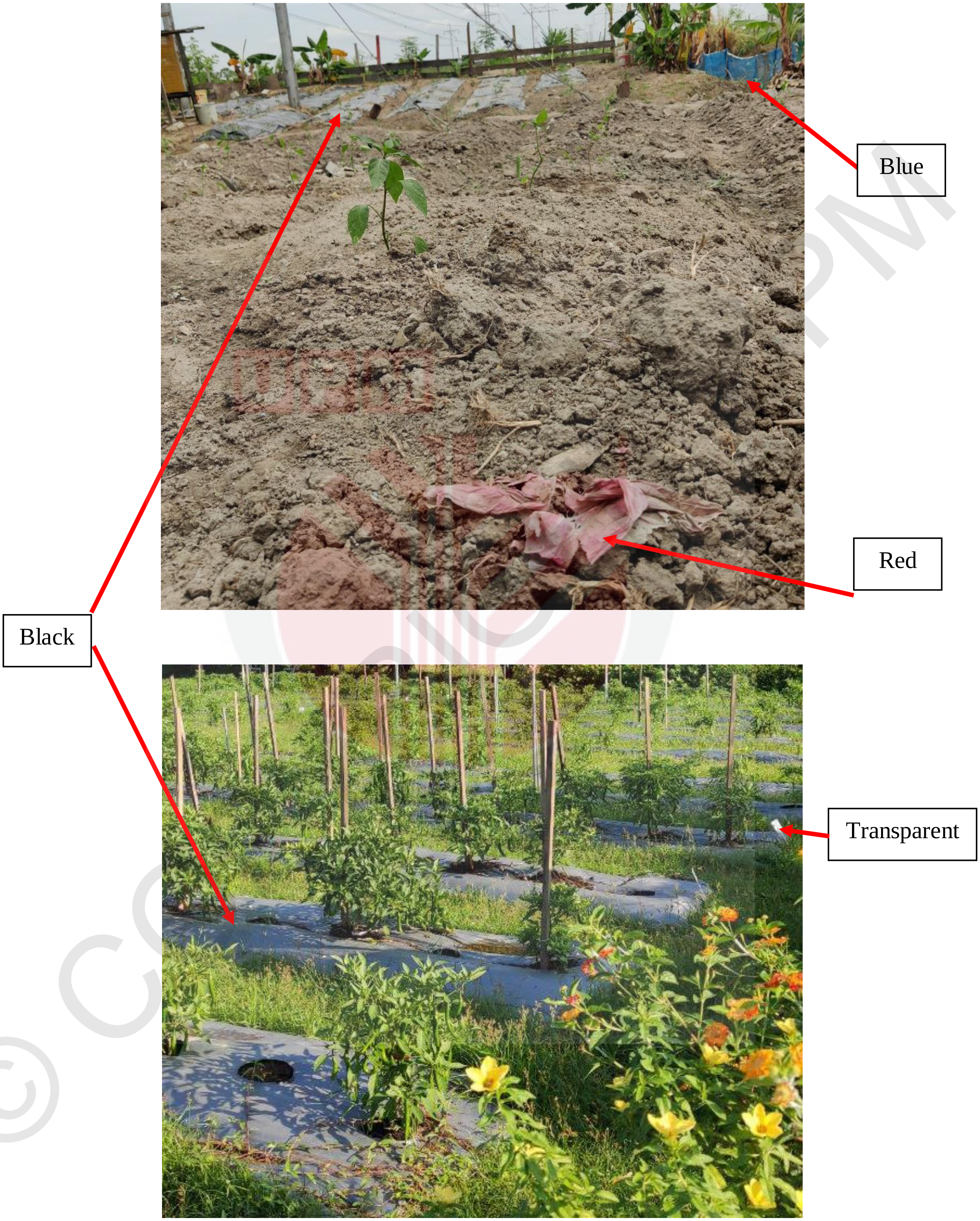
5.1 Size of MPs Particles on Surface Soil in Organic Agriculture Soil.

The average size of MPs on surface soil were 13.447 μm and 1443.861 μm, respectively, as indicated in Table 4.2 and Table 4.5, while organic farms A and D had an overall greater MP size. MPs studies conducted worldwide have identified sizes ranging from 50 μm to 20 μm in length (Boughattas et al., 2021; Castro et al., 2016; Frias et al., 2014). This study discovered the smallest dimension of MPs to be 50 μm. This figure is most likely due to fragmentation caused by mechanical operations during the sample procedure (Boughattas et al., 2021).

The size that is less than 1 mm was the most prevalent in all sample locations (Table 4.2 - 4.5). Choi et al. (2020) and Wang et al. (2020) likewise discovered the highest abundance of MPs with a diameter of less than 1 mm. According to Bergmann et al. (2015), this might be a result of the fragmentation of larger plastic trash, indicating a secondary source, or it could be the result of plastic microparticles entering the environment, indicating a primary source.

5.2 Colour of MPs Particles on Surface Soil in Organic Agriculture Soil.

There are several possible sources of particles in the organic farm site, as shown in Figure 5.1. The black coloured particles in surface soil samples could originate from plastic bucket and mulching film which were use during agricultural activities. Most of the sampling point were using mulching films. Plastic buckets have many colours such as black, transparent, blue and red which can contribute most colours in the surface soil samples (Chen et al., 2020).


Blue
Red
Black
Transparent

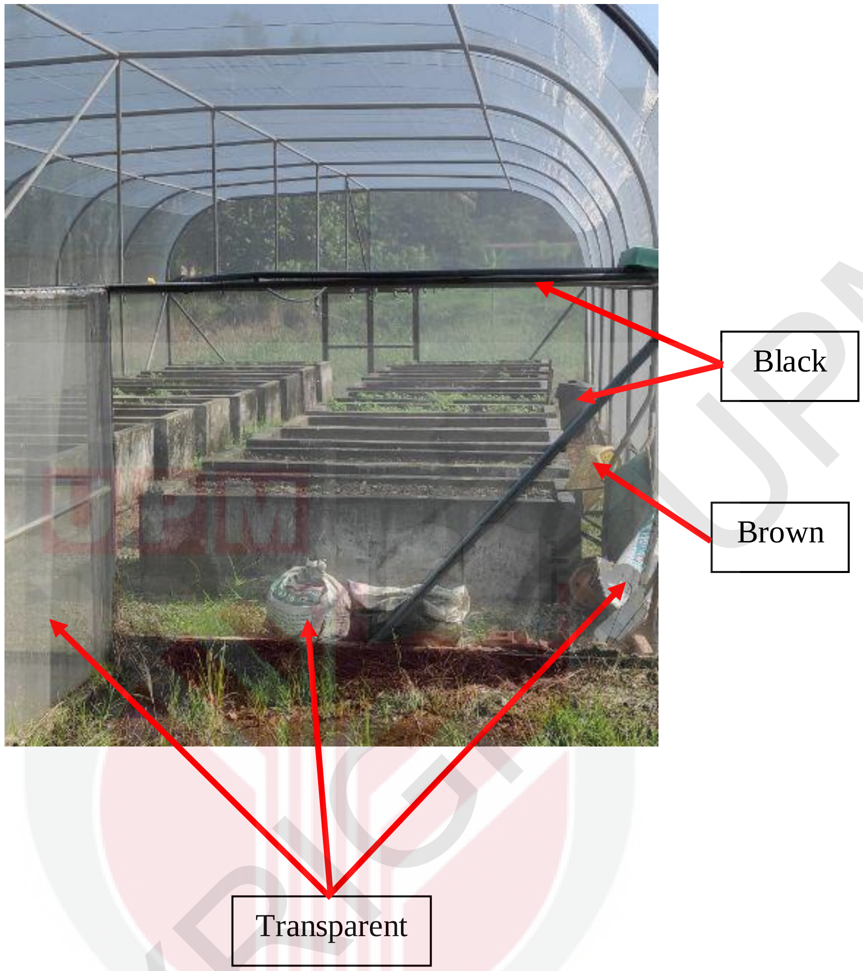


Figure 5.1: The possible sources of particles extracted from soil surface samples

5.3 Shape of MPs Particles on Surface Soil in Organic Agriculture Soil.

The fibers and lines in surface soil samples could originate from plastic net used to protect the crops from pests and strong wind. Besides, the plastic bucket could be the primary source of fragments in the sites, which the farmers always use to put agriculture tools when they are doing agriculture works. Another possible source of particles in surface soil is the usage of mulching film. Deterioration of plastic mulching film over time could lead to the accumulation of particles in the surface soil. As shown in Figure 5.2, some part and color of the mulching film were already degraded. These fibers, films, and fragments may be derived from agricultural plastic wastes, including agricultural equipment, plastic packaging materials, plastic greenhouses, and plastic seed sacks (Ding et al., 2020; Feng et al., 2021; Liu et al. 2018).

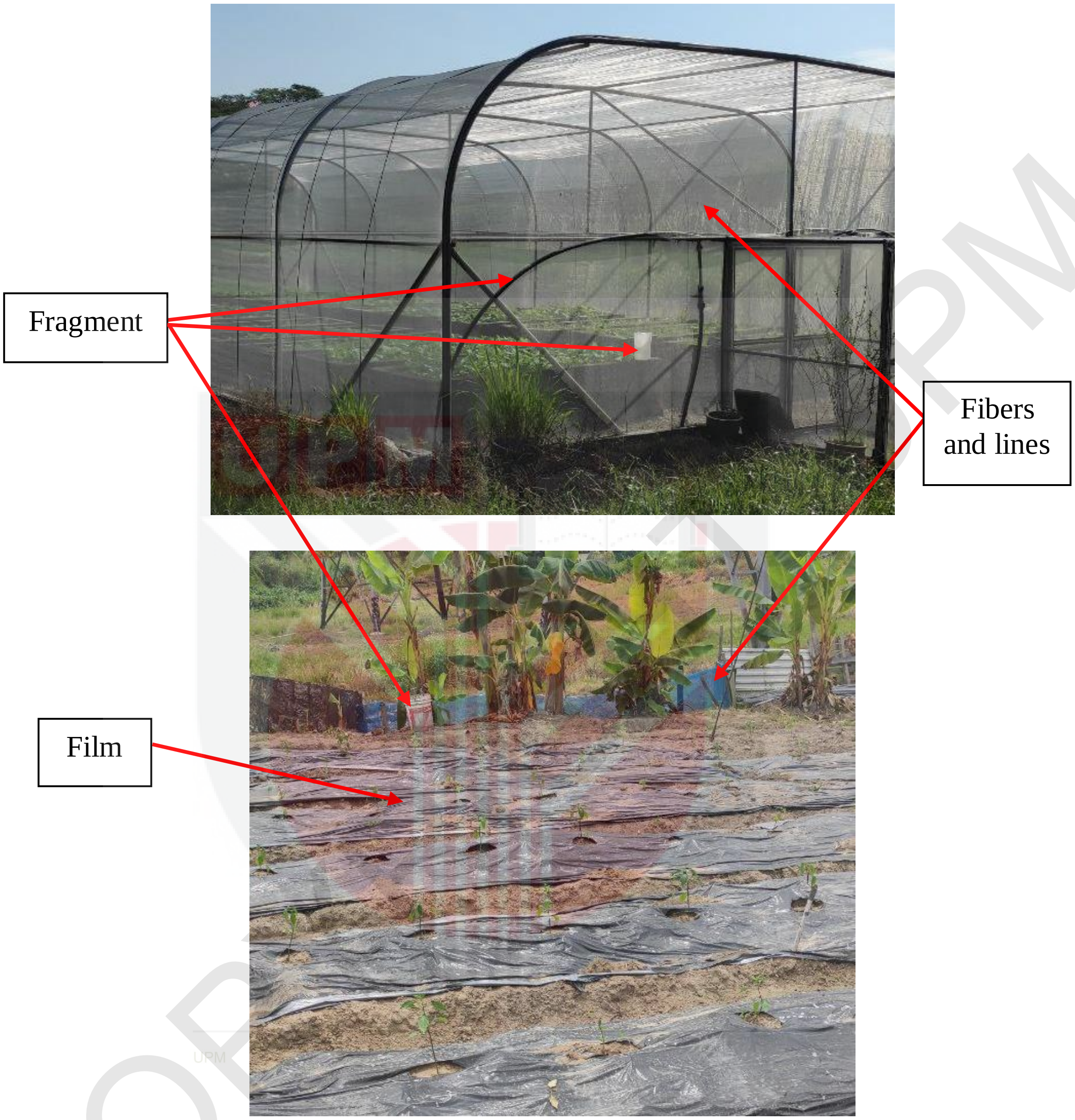


Figure 5.2: The possible sources of particles extracted from soil surface samples

5.4 Polymer Type of Microplastics Particles on Surface Soil in Organic Agriculture Soil.

This study found acrylonitrile butadiene styrene (ABS), followed by polyvinyl chloride (PVC), polystyrene (PS), nylon (NY), and nitrile on surface soil from four selected organic farms.

These results correspond with those of (Ding et al.,2020; Piehl et al.,2018; Corradini et al.,2021), who detected PS throughout their evaluations of German, Chilean, and Chinese farms, respectively. PS particles are frequently present in irregular shapes, and packaging residues may be a source of MPs. The fragment was constituted of ABS, PVC, and NY particles, and its primary source may have been mulching film, woven bags, packing materials, and irrigation hose tubing (Ding et al., 2020; Peng et al., 2020). Along with conventional polymers used in agriculture for greenhouses and mulches, such as ABS, PVC, and PE, crop quality has been improved (Scarascia-Mugnozza, et al., 2012; Biron, 2016; Jat et al., 2021). Thus, agricultural activities have a significant influence on MP contamination.

S3F2 from organic farm C and S3F1 from organic farm D were found to have MPs. These two sampling locations should be free of MPs, as they are in undisturbed soils. However, photographs acquired during the sampling of the presence of plastics at the sampling locations, are as seen in Figure 5.3.

Figure 5.3: Presents of plastics on undisturbed soil from organic farm C and D

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, abundance number of particles has been detected on surface soil from selected organic farms in Selangor, Malaysia, which comprised of organic farm A (175 particles), organic farm B (168 particles), organic farm C (155 particles) and organic farm D (93 particles). The length of the MPs particles extracted are from 1 mm – 13 µm. Six types of colour (black, transparent, red, blue, green and brown) were identified in these extracted particles. The black particles were mostly observed in all samples. On the other hand, the shape of fragment is accounted for the dominant shape among the particles extracted from surface soil samples, followed by irregular, fiber, line and film. Acrylonitrile butadiene styrene (ABS) followed by polyvinyl chloride, polystyrene, nylon and nitrile. The surface soil from four organic farms which were considered for this study are unsuitable for organic agricultural soil since they can also have a deleterious influence on human and environmental health. This is because MPs particles have been discovered in every sample of soil surface.

6.2 Recommendations

This study recommends core soil to be taken from organic farm. Many studies used core soil in the research because MPs are more abundant in core soil than in surface soil, owing to the fact that MPs will continue to sink deeper into the soil as time passes (Ding et al., 2020; Feng et al., 2021; Liu et al. 2018). Aside from that, this study provides baseline data of MPs pollution on surface soil from organic farms. Hence, further investigation is needed to understand better on how surface soil / agriculture activities could influence MPs accumulation in sites and MPs on surface soil from organic farms.

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APPENDICES

APPENDIX 1: Microscopic images of particles extracted from soil samples

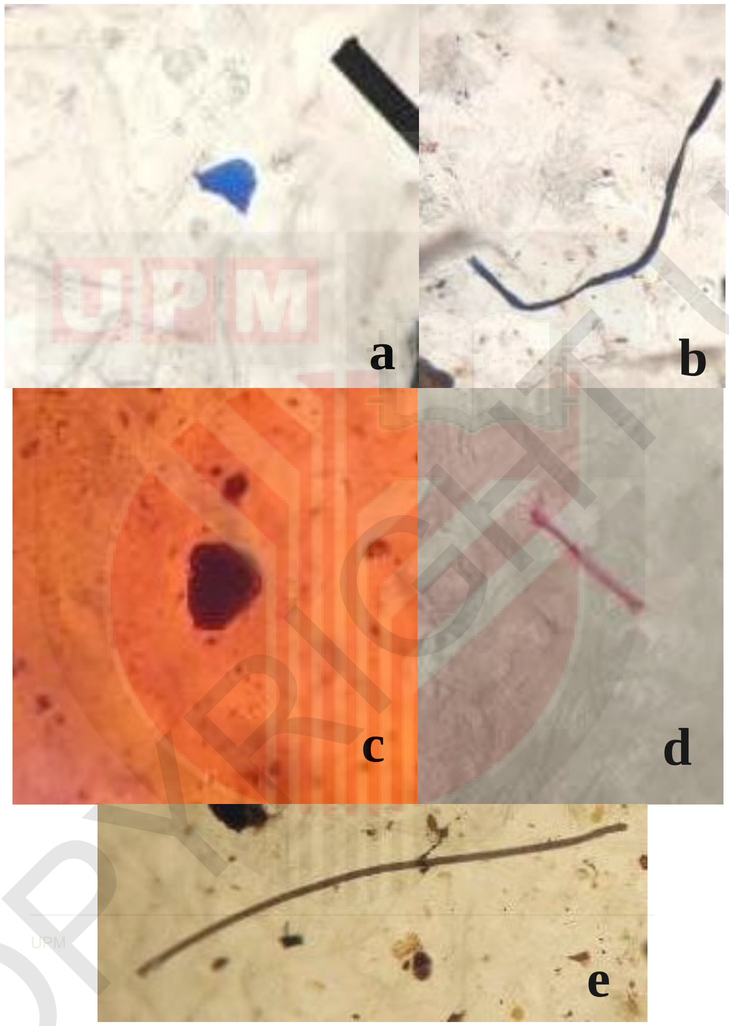

Figure S1: Microscope images of particles extracted from surface soil samples: (a) fragment, (b) fiber, (c) irregular, (d) line, (e) fiber