UNIVERSITI PUTRA MALAYSIA

MICROPLASTIC POLLUTION IN COASTAL WATERS FROM SELECTED BEACH IN KUALA LANGAT (MALAYSIA) COASTLINE

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BY

SITI SHALIHAH BINTI SULONG

Thesis submitted in fulfilment of the requirement for the degree of Bachelor Sciences (Environment and Occupational Health) from Faculty of Medicine and Health Sciences, University Putra Malaysia

ACKNOWLEDGMENTS

First and foremost, I want to express my gratitude to Allah s.w.t for providing me with the strength and patience to complete my thesis and final year project. Without His blessing, I would be incapable of starting or doing anything.

I would like to convey my heartfelt appreciation to my supervisor, Associate Professor Dr. Sarva Mangala Praveena, for her priceless guidance, time, encouragement and financial support from the start of the final year project (FYP) until the end. It was a great experience to work under her supervision, and I respect and thank her for sharing expertise throughout the research and thesis writing processes.

I also would like to say special thanks to Dr. Sharifah Norkhadijah for the wise words she gave me when I was on my edge. She acted like a sister to me, guiding me to choose the right choice. I am forever thankful to her for this second opportunity.

Following that, I would like to extend my gratitude to the Laboratory of Environmental Health at the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, for allowing me to use the equipment there and facilitating all laboratory activities.

Additionally, I would like to express my heartfelt gratitude to my adoring family who have always believed in my ability to complete my final year project. Apart from that, I'd like to express my gratitude to my FYP classmates and close friends, particularly Wahida, Emilia, Mas, Haninah, Aisyah, Haziqah, Aina, Aiman Farzana and Eleeda for the emotional support and assistance I received throughout this research.

Finally, I want to express my gratitude to everyone who assisted me, whether directly or indirectly, during the process of completing this project report and earning my bachelo's degree. May Allah reward the good deeds performed as a result of being a part of this effort.

ABSTRACT

MICROPLASTIC POLLUTION IN COASTAL WATERS FROM SELECTED BEACH IN KUALA LANGAT (MALAYSIA) COASTLINE

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Introduction: The plastic debris often degrades when exposed to various environmental elements like sunlight, water, and wind, it usually disintegrates into small plastic particles known as microplastics (Sherrington et. al., 2017). **Objective**: The distribution and abundance of microplastics in the Kuala Langat coastline are able to be studied by analyzing the morphology of the microplastics presence in the selected beaches along Kuala Langat coastline and also by comparing the microplastics occurrence in coastal water between the selected beaches. **Method**: Beach water samples were collected from five selected beaches (Tanjung Rhu beach, Kelanang beach, Morib beach, Batu Laut beach and Cunang beach) by using Schott glass bottles. Four replicate samples for each of the sampling points were collected and extracted by using vacuum-filtered through a 0.45μm pore size of Nitrocellulose filter. Stereo microscopes (Motic SMZ-168) were used for optical analysis and photography. **Result:** The study found that there was a high abundance of extended particles from Tanjung Rhu beach (2434.34 μm) while a short particle was found in Cunang (1270.02 μm). There were six main types of colors (white, red, black, brown, transparents and blue) that were mainly found in beach water samples of selected beaches. All of the beaches except for Cunang had the highest in transparents colour while in Cunang, white tended to be the highest. Overall, the highest percentage of colour type found was transparents (39.98%) followed by white colour (35.2%), black (13.1%), brown (11.78%), red (7.04%) and the lowest was blue (4.16%). Meanwhile, five types of shape were identified in the beach water samples (fibre, fragment, film, foam and pellet). Overall, the shapes that were mostly identified in all of the selected beaches are fragments (41.46%) followed by fiber (30.56%), pellet (14.4%), film (7.04%) and the lowest is foam (6.56%). The One Way ANOVA was used to assess the association between microplastics size among the selected beaches. One Way ANOVA test was not statistically significant, showing that the particle size of microplastics from the selected beaches were not influenced by the type of activities of the beach area, $F(4,23)=1.742$, $p=0.773$. This was because the size of microplastics were influenced by the difference of degradation rate in each of the beaches, the distance between the microplastics sources to its final destination and the size of the plastics before they degrade. **Conclusion**: This study results provide an important baseline reference on microplastics pollution from beach water samples in Kuala Langat coastline. The morphology of the microplastics also indicate the human activity that causes the source of the microplastics such as littering, fishing activities and tourism.

Keywords: Beach water, Microplastics, Pollution, Kuala Langat

ABSTRAK

PENCEMARAN MIKROPLASTIK DI AIR PANTAI DARI PANTAI TERPILIH DI PANTAI KUALA LANGAT (MALAYSIA)

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Pengenalan: Serpihan plastik sering merosot apabila terdedah kepada pelbagai unsur persekitaran seperti cahaya matahari, air dan angin, ia biasanya hancur menjadi zarah plastik kecil yang dikenali sebagai mikroplastik (Sherrington et. al., 2017). **Objektif:** Taburan dan kelimpahan mikroplastik di pinggir pantai Kuala Langat dapat dikaji dengan menganalisis morfologi kehadiran mikroplastik di pantai terpilih sepanjang pantai Kuala Langat dan juga dengan membandingkan kejadian mikroplastik di perairan pantai antara pantai yang dipilih. **Kaedah:** Sampel air pantai telah diambil dari lima pantai terpilih (pantai Tanjung Rhu, pantai Kelanang, pantai Morib, pantai Batu Laut dan pantai Cunang) dengan menggunakan botol kaca Schott. Empat sampel replika untuk setiap titik persampelan telah dikumpul dan kemudian ia diekstrak dengan menggunakan penapisan vakum melalui penapis Nitroselulosa bersaiz 0.45µm. Penggunaan mikroskop stereo (Motic SMZ-168) digunakan untuk analisis optik dan fotografi. **Keputusan:** Kajian mendapati terdapat kelimpahan zarah lanjutan yang tinggi dari pantai Tanjung Rhu (2434.34 µm) manakala zarah pendek ditemui di Cunang (1270.02 µm). Terdapat enam jenis warna utama (putih, merah, hitam, coklat, lutsinar dan biru) yang kebanyakannya ditemui dalam sampel air pantai pantai terpilih. Semua pantai kecuali Cunang mempunyai warna trasparents yang paling tinggi manakala di Cunang, putih cenderung menjadi yang tertinggi. Secara keseluruhan, peratusan tertinggi bagi jenis warna yang ditemui ialah lutsinar (39.98%) diikuti oleh warna putih (35.2%), hitam (13.1%), coklat (11.78%), merah (7.04%) dan yang terendah ialah biru (4.16%). . Sementara itu, lima jenis bentuk dikenal pasti dalam sampel air pantai (gentian, serpihan, filem, buih dan pelet). Secara keseluruhannya, bentuk yang kebanyakannya dikenal pasti di semua pantai terpilih ialah serpihan (41.46%) diikuti oleh gentian (30.56%), pelet (14.4%), filem (7.04%) dan yang paling rendah ialah buih (6.56%). ANOVA Sehala digunakan untuk menilai perkaitan antara saiz mikroplastik di antara pantai yang dipilih. Ujian ANOVA Sehala tidak signifikan secara statistik, menunjukkan saiz zarah mikroplastik dari pantai terpilih tidak dipengaruhi oleh jenis aktiviti kawasan pantai, $F(4,23)=1.742$, $p=0.773$. Ini kerana saiz mikroplastik dipengaruhi oleh perbezaan kadar degradasi di setiap pantai, jarak antara sumber mikroplastik ke destinasi akhir dan saiz plastik sebelum ia terdegradasi. **Kesimpulan:** Hasil kajian ini memberi rujukan asas yang penting terhadap pencemaran mikroplastik daripada sampel air pantai di persisiran pantai Kuala Langat. Morfologi mikroplastik juga menunjukkan aktiviti manusia yang menyebabkan sumber mikroplastik seperti membuang sampah, aktiviti memancing dan pelancongan.

Kata kunci: Air pantai, Mikroplastik, Pencemaran, Kuala Langat

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LIST OF ABBREVIATION

MPs	Microplastics
PE	Polyethylene
PP	Polypropylene
PET	Polyethylene terephthalate
PVC	Polyvinylchloride
PS	Polystyrene
PA-12	Polyamide 12
PAA	Polyacrylic acid
EVA	Ethyl Vinyl Acetate
PL	Polyester
PTFE	Polyetrafluoroethylene
PMMA	Polymethylmethacrylate
PVAC	Polyvinyl acetate

CHAPTER 1

INTRODUCTION

1.1 Background of the study

According to world plastics production data, the production of plastics in 2019 almost reached 370 million tonnes worldwide where half of the total production of plastics is from Asia while 19% are from Europe (D'ambrieres, 2019; PlasticEurope Market Research Group (PEMRG, 2019). A total of 36% of the plastics worldwide are used as packaging and nearly 32% of the plastic used for packaging globally seeps into the environment. Only 2% of materials are recycled, and only 14% of them are recycled in a form that allows for continuous recycling into other goods (*The New Plastics Economy: Rethinking the Future of Plastics*, 2016). Rapid economic development has greatly increased the usage of plastic, particularly for consumer goods packaging, in Southeast Asia and China while 40% of plastics are used for packaging in Europe (Plastic Soup Foundation, 2022). Unfortunately, regional waste management systems in Asia have lagged behind. A report shows that only around half of the trash gets collected, for instance, in China and Thailand, and only 15% of it is safely disposed of in Malaysia and the Philippines (*Waste Atlas - Interactive Map with Visualized Waste Management Data*, 2012). The Ocean Conservancy has long conducted item-by-item waste audits. Glass bottles, aluminium cans, and rope, which had previously dominated the list, were replaced by plastics for the first time in 2017 in the top ten items that were recovered. The list also includes food wrappers, bottles, bottle caps, shopping bags, and cigarette butts (with plastic filters) (Parker, 2018).

Plastic pollution is well known to be a threat to the marine environment. According to estimates, 8 million tonnes of plastic waste enter our seas each year, and if this trend continues, by 2050 there will be more plastic than fish in all of the world's waterways (M Fava Fava, 2022). Wildlife is directly impacted by plastic pollution because it kills tens of thousands of seabirds and sea turtles every year by suffocating them with plastic bags, fishing nets, and other debris. The consumption of microplastics by fish and other species endangers their lives as well as that of people (Raunek, 2019). According to a recent study, marine turtles who consume just 14 bits of plastic are at an elevated risk of dying. The young are particularly vulnerable because they like to consume anything they feel like, unlike their elders, and because they drift with the currents much like plastic they tend to eat anything that floats along with them too (Wilcox et al., 2018). Up to a million seabirds per year are killed by plastic garbage. Similar to sea turtles, when seabirds consume plastic, it occupies space in their stomachs and can occasionally result in malnutrition. Numerous seabirds are discovered deceased with this material still in their stomachs. Scientists predict that by 2050, 99 percent of all seabird species would have consumed plastic, up from the current estimate of 60 percent (Reddy, 2018). It is proven that the plastic waste released to the ocean had caused major plastic pollution in the beach environment.

The plastic debris often degrades when exposed to various environmental elements like sunlight, water, and wind, it usually disintegrates into small plastic particles known as microplastics (1-5000 m) (5 mm) and nanoplastics (<1 m)

(Sherrington et. al., 2017). When ultraviolet light from the sun supplies the activation energy necessary to activate the incorporation of oxygen atoms into the polymer, the process of photodegradation, which leads to thermo-oxidative degradation, begins. As a result, the plastic becomes brittle and shatters into ever-tinier fragments with the help of mechanical disintegration, or the wave itself, until the polymer chains have a sufficiently low molecular weight to be digested by microorganisms, or biodegradation. The carbon in the polymer chains is subsequently either transformed by these bacteria into carbon dioxide or incorporated into proteins. To totally decompose plastic, however, can take 50 or more years due to how slowly the entire process moves. As a result, this greatly increased the amount of microplastic pollution in the ocean, which finally stranded on the beach (Gewert et. al., 2015). Currently, the ocean contains between 50 and 75 trillion trillion bits of plastic and microplastics (Stanton, 2021). The quantity of microplastics and the fraction of creatures that can consume them both rise as fragment size falls. Risks may be increased by particles smaller than 20 microns (m). Consumption, metabolism, reproduction, and behavior can all be negatively impacted by exposure (Hale et al., 2020).

1.2 Problem Statement

Beaches along Kuala Langat coastal area of Selangor, Malaysia are the top famous beaches in Malaysia (Tourism Selangor, 2021). Morib Beach is ranked as one of the top visited by tourists from the year of 2019 to 2020 (DOSM, 2020). According to Khong (2013), the amount of plastic waste collected at Morib Beach was the highest compared to any beaches. There's also a group of volunteers, My Clean Beach (2019) who also states that the total trash collected in the Banting beach area was 208.5kg with 12% of it being plastic waste. This states that, although plastic waste is a major problem on Morib beach, however limited studies have been conducted to understand the impacts of plastics waste including microplastics in these beach environments.

Microplastics is a serious matter to the beach environment worldwide, moreover, according to statistics, Malaysia was the eighth-worst polluter of plastic in the world in 2021, and it consumes the most plastic in Asia at a rate of 62 kg per person per year (Santodomingo et al., 2021). Yet so far microplastics pollution in beach environments, specifically on beach water samples, are only studied by Wan Khalik et al. (2018) in Kuala Nerus and Kuantan, Port Dickson and Lukut by Zainuddin et al. (2022), and Kuah, Langkawi & Seberang Perai, Pulau Pinang by Najihah et al. (2020). Despite being popular tourism destinations yet there is still no information about microplastics pollution study along Kuala Langat coastline especially in the beach environment.

1.3 Study justification

The aim of this research is to provide information on the microplastics pollution in the beach environment especially along Kuala Langat coastal area, Selangor Malaysia. As we all know, different activities will contribute to different types of microplastics' polymer type. Thus, this study will offer information on microplastics' characteristics from different types of human activities, particularly on the microplastics' size, color, and shape.

Moreover, this study will also be able to identify the possible sources of microplastics pollution by comparing the microplastics obtained from each of the locations and also by observing human activities around the sampling area. In addition, this study might be able to contribute to reducing the statistics of microplastics pollution in beach environments in the future.

1.4 Research Question

This study aims to address several research issues, including the following:

I. Is there any occurrence of microplastics in coastal water from the selected beaches along Kuala Langat coastline and what is the characteristic presence?

II. What is the difference of microplastics occurrence in coastal water between the selected beaches along Kuala Langat coastline?

1.5 Research Objective

1.5.1 General objective

- To provide understanding on microplastics occurrence in coastal water from selected beaches along Kuala Langat coastline.

1.5.2 Specific objective

- To analyze the presence and characteristics (size,color,shape) of microplastics in coastal water from selected beaches along Kuala Langat coastline.

- To compare the microplastics occurrence in coastal water between the selected beaches along Kuala Langat coastline.

1.6 Research Hypothesis

There will be microplastics occurrence in the beach water samples of beaches along Kuala Langat coastal area.

1.7 Definition

1.7.1 Conceptual Definition

- Microplastics

  Microplastics are tiny plastic flecks that are smaller than 5 millimeters (0.2 inches) in size. This definition frequently includes nanoscale (< 1 μm) plastic particles (Rogers, 2022).

- Coastal area

  A narrow continental shelf, gently sloping seaward to a continental slope, and a somewhat abrupt drop to the deep ocean are characteristic features of coastal waters. The water circulation is also influenced by how close coastal water is to land. The presence of density-driven motions in the vicinity of freshwater inflows affects the nearshore circulation (GEMET, 2021).

- Beach water

A complex mixture of 96.5 percent water, 2.5 percent salts, and smaller amounts of other components, such as particles, dissolved inorganic and organic compounds, and a few atmospheric gasses, makes up seawater (Mackenzie, 2022).

1.7.2 Operational Definition

- Microplastic

The technique used for this study to extract microplastics is by using filter separation through a 47 mm diameter nitrocellulose membrane with 0.45 µm pore size using a circulating water multi-purpose vacuum pump (Zheng et. al., 2019).

- Beach Water

Beach water is collected by using glass bottles (Khalik et al., 2018). The samples can be filtered directly on board. (Dai et al., 2018).

- Coastal Area

For the classification of coastal zones, remote sensing using passive and active sensors has proven to be an effective method. Thematic Mapper (TM) (Landsat 5), Enhanced Thematic Mapper Plus (ETM+) (Landsat 7), High Resolution

Visible (HRV) (SPOT 3), High Resolution Visible and Infrared (HRVIR) (SPOT 4), and High Resolution Geometric (HRG) (Spot 5) sensors are examples of optical sensors. The new Chinese Gaofen (GF-1, -2, and -4) sensors are synthetic aperture radar (SAR) sensors (Li et al., 2018).

1.8 Conceptual Framework

Figure 1.1 shows all the variables that are included in this study. This study will focus on analyzing microplastics in beach water. This study will emphasize on beach water, along the Kuala Langat coastal area. This study will focus on the upper shoreface part in order to determine the microplastics that are as near as possible to the shore. According to a study, the number of microplastics found deposited on the upper beach is high (Constant et. al., 2019). The microplastics will be observed in terms of color, size and shape and the potential human activities that cause the sources of microplastics in the beach environment.

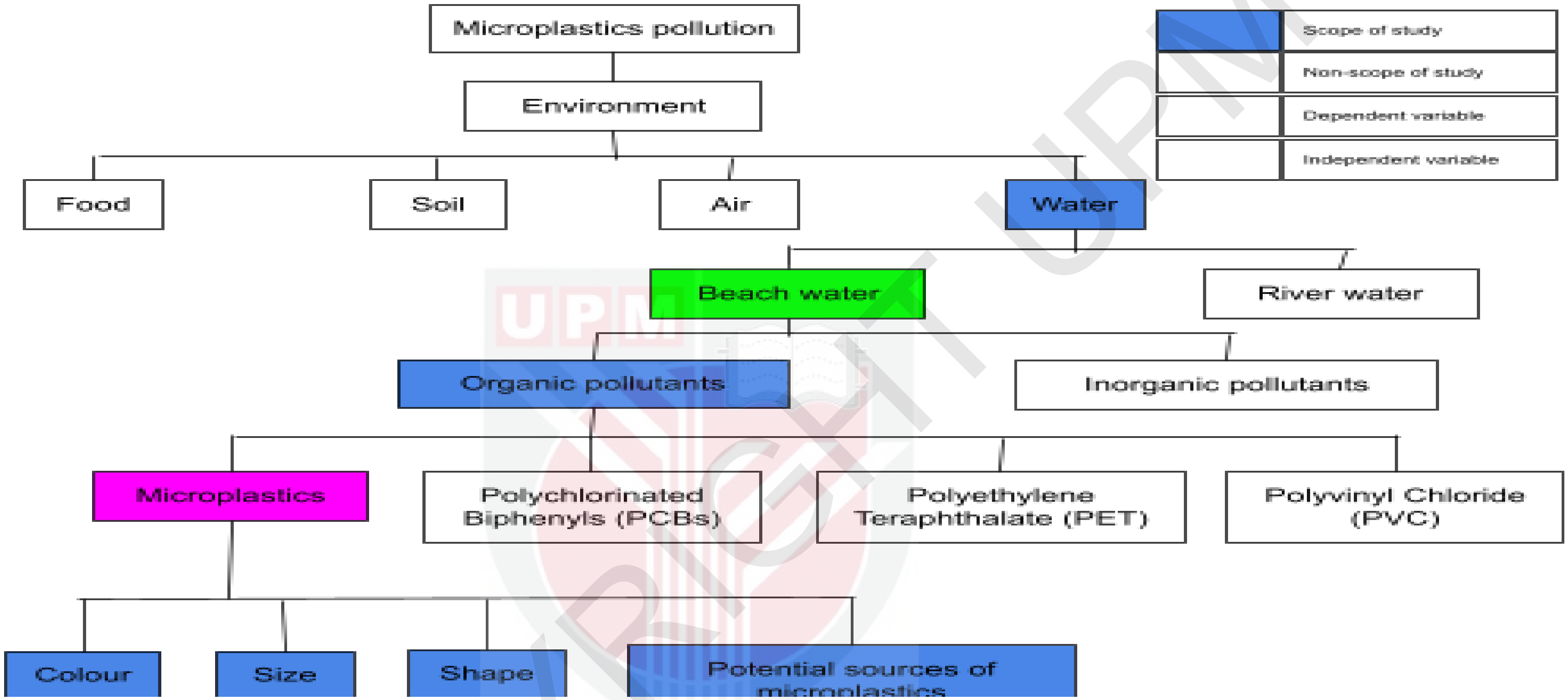

Figure 1.1 Conceptual Framework of this study involving microplastics in beach water

CHAPTER 2

LITERATURE REVIEW

Plastics are synthetic polymer compounds with numerous additional chemicals added for improved performance. The majority of plastics are produced using petrochemicals, which have a high molecular weight and plasticity (Costa et. al., 2016). Microplastics pollution has been a major problem worldwide, caused by plastic pollution. The use of products is primarily responsible for 28% of releases of plastics to the ocean and 49% of releases that result from product maintenance. Road runoff (66%) and wastewater treatment (25%) systems, as well as wind transfer (7%), are the three main routes where these plastics enter the ocean (IUCN, 2017). Microplastics are officially described as plastics with a diameter of less than five millimeters, which is smaller than the typical pearl used in jewelry (Stanley, 2017).

Microplastics can be found in two types which are primary and secondary microplastics (US, 2015). Primary microplastics are tiny plastic particles that are made to be small sizes and later used in so many ways and one of them is to manufacture macroplastics such as bottled water. Primary microplastics can also be produced as a result of production-related spills, use-related degradation of plastic products such tyre abrasion, paint and coating flaking, and washing or wearing synthetic clothing (EEA, 2022). According to a study, personal care cosmetic products (PCCPs) have been the main contributor of primary microplastics to the ocean other than plastic pellets (Cheung and Fok, 2017). Every year, 3 million tonnes of primary microplastics are discharged into the environment, in addition to 5.3 million tonnes of bigger plastic items that are primarily made of improperly managed waste and litter and eventually degrade to form secondary microplastics (UNEP, 2018). Secondary microplastics are defined as small fragments of plastic material that have broken apart and weathered into pieces (UNEP, 2018). Another source of secondary microplastics that are released into the ocean directly is discarded fishing nets, which are thought to total roughly 500,000 tonnes annually worldwide (Boucher and Friot, 2017; UNEP, 2018). As shown in figure 1.2, the degradation usually started with photodegradation followed by thermal-degradation. The integration of oxygen atoms into the polymer takes place when ultraviolet radiation from the sun supplies the activation energy needed to start the process. The result of this is that the plastic becomes brittle and shatters into ever-tinier fragments with the help of mechanical disintegration, which is the wave itself, until the polymer chains have a sufficiently low molecular weight to be digested by microorganisms, or biodegradation. The carbon in the polymer chains is subsequently either transformed by these bacteria into carbon dioxide or incorporated into proteins (Gewert et. al., 2015).

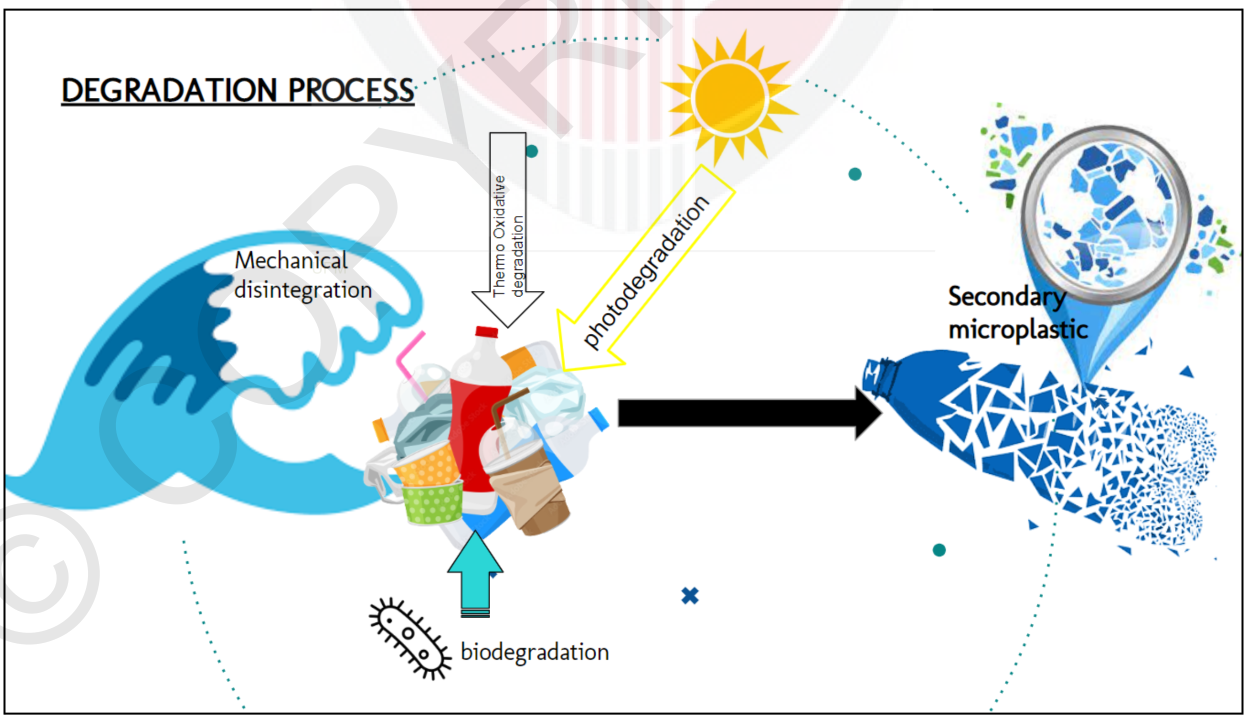

Figure: 2.0 Degradation process of plastics (Gewert, 2015)

2.2 Factors associated with microplastics formation in beach environments

Microplastics are formed from the breakdown of macroplastics with the aid of external forces. Factors that are associated with microplastics formation in beach environments are sun (UV), presence of oxygen and mechanical forces (Andrady et al., 2022; Abdelbary, 2014).

2.2.1 Sun

The primary cause of plastic aging is thought to be sunlight exposure (Ultraviolet (UV) exposure), which tends to trigger polymer chain reactions and chain scission, causing plastic to fragment into microplastics (Andrady et al., 2022). Color changes in plastic polymers are typically brought on by photoaging. Contrarily, as different coloured plastics absorb light of different wavelengths and energies, the colour of plastics as a whole will also have a substantial impact on how much sunlight is absorbed (Zhao et. al., 2022). When exposed to UV light, plastic garbage in saltwater degrades and dissolves into organic molecules considerably more quickly than anticipated (Zhu et. al., 2020). UV light, such as that from the Sun, weakens plastic by causing the bonds keeping the polymer together to disintegrate (Zhande, 2015). As a result of photooxidative degradation brought on by UV light, polymer chains are broken, free radicals are produced, and the molecular weight is decreased. Over time, this process degrades the mechanical qualities of the material, rendering it worthless.

2.2.2 Oxygen

Degradation and fragmentation are more sluggish in aphotic and low-oxygen settings in mid-water or sediment (GESAMP, 2015). This is because oxygen is used for freeing the radical from the polymers during the photo-oxidation process (Shi et. al., 2022). Oxygen is used during the propagation steps polymer photo-oxidation degradation process (Smith el. al., 2018; Shi et.

al., 2022). With the aid of light irradiation from the sun, the polymers are able to form environmentally persistent free radicals which later generate reactive oxygen species (ROS). The release of ROS allowed microplastics to function as photosensitizers to accelerate the photo-transformation of pollutants (Shi et. al., 2022) which produces microplastics. Aerobic degradation needs oxygen in order to degrade larger compounds to smaller compounds where the oxygen is used as electron receptors (Zeenat et al., 2021).

2.2.3 Mechanical forces

The plastic debris often discolors and develops surface characteristics during advanced stages of breakdown, weakening and becoming brittle (embrittle) over time as a result. The extremely degraded, embrittled plastics can be broken into pieces by any mechanical force (such as wind, waves, animal bites, and human activities) (GESAMP, 2015). Mechanical stress applied on the plastic increases the microplastics particles released in the environment (Winkler et. al., 2019). Surface delamination is the main mechanism by which microplastic particles are created in the early stages of degradation, and it is a reasonably speedy process in salt marshes where plastic trash is degraded (Weinstein et. al., 2016).

2.3 Microplastics pollution in beach water

Plastic can be degraded in a few different ways, where usually it starts with photodegradation then followed by the other mechanisms which are thermal-degradation, mechanical degradation and biodegradation. Since the polymer characteristic is persistent, thus the complete biodegradation is expected to take decades to happen (Worm et. al., 2017). After being broken up, these plastic fragments are making their way toward marine bodies as pellets, fibres, and granules. Microplastics are found everywhere and have been identified in aquatic environments, ocean sediments, and deep-sea sediments in the most polar parts of the Arctic and Antarctic (Wright and Kelly, 2017) causing massive microplastics pollution. Due to their small size, microplastics are frequently consumed by marine species, which is harmful to their health and raises the worrying issue of the transmission of these toxic microplastics to higher trophic levels (Chatterjee and Sharma, 2019). Different coastal activities are thought to be responsible for the release of about 8.8 kg/capita/year of macroplastics and 0.18 kg/capita/year of microplastics into marine bodies (Van-Wijnen et al., 2019).

A study in China proved that most of the microplastics found in the bay area is from fishing and also waste being left out from tourists (Wei et al., 2022). Currently, textiles, personal care items, tyre dust, and pellets all leak microplastics into the oceans on an annual basis, amounting to an estimated 1.3 million metric tonnes. By 2040, the amount of microplastic pollution entering the ocean from these sources will reach three million metric tonnes annually under the status quo. By 2040, seven million metric tonnes of terrestrial pollution from these four sources of microplastics are anticipated. The amount of microplastics released into the environment is much more than the amount that is burned or dumped in sanitary landfills (Tiseo, 2021). This had a direct effect on the microplastic pollution in the beach water.

2.4 Occurrence of microplastics in beach water

Table 2.4 below summarizes earlier investigations that were carried out in the seawater area and provides information on the size, color, shape, and types of polymers of the microplastics. Additionally, it offers any available studies' potential sources of microplastics emission.

Table 2.4 Summary of earlier investigations reporting the occurrence of microplastics in beach water

Continent	Study area	Size	Color	Shape	Plastic polymers found	Sources	Reference
Africa	Kingston Harbour, Jamaica	1-2.5 mm	Transparent (35%) Non-transparents (27%) White (19%) Black (10%)	Fragments(86.08) Fibres (12.68%) Foam (0.92%) Beads (0.31%)	PE (78%) PP (22%)	-	Rose and Webber (2019)
	Cape town, South Africa	-	-	-	Polyethylene (PE) (85.7%) Polyethylene terephthalate (PET) (71.4%) polyvinylchlorid	Rinse-off cosmetics, automobile tyres, lubricant in injection moulding and	Vilakati et al. (2020)

					e (PVC) (57.1%) Polystyrene (PS) & Polyamide 12 (PA-12) (42.9%) Polyacrylic acid (PAA) & Ethyl Vinyl Acetate (EVA) (28.6%)	pressing of ceramic powders	
	Port of Durban, Durban Bay Estuary, east coast, South	200 µm–500 µm	-	-	PE (47%) PET (16%) PS (9%)	Laundry, Personal care products from drain. High port activity (traffic, container &	Whyte et al. (2021)

	Africa					container loading)	
Antartica	East antarctica Ross-Sea	5.0-7.8 mm	-	Fragments (72%) Fibers (13%)	PE & PP (57.1%) Polyester (PL) (28.6%) Polyetrafluoroethylene (PTFE) (5.7%) Polymethylmethacrylate (PMMA) (5.7%) Polyamide (PA) (2.9%)	Laundry, Ship traffic, research activities and wastewater treatment plant	Cincinelli et al (2017)
	Peninsula	1-74	White (47%)	Fragment (51.3%)	Polyurethane	Paint particles	Lacerda et al.

	Antartica	mm	Black (23%) Blue, brown and green (7%) Red (5%) Yellow (1%)	Line (42.3%) Sphere (6.4%)	(35%) Polyamide (25%) Polyethylene (21%) Polystyrene (11%) Polypropylene (8%)	from ship (red and green), fishing activities, research activities and tourism	(2019).
	Antarctica seawater	2.0-2.5 mm	Transparents (77.2%) Blue (6.3%) Black (5.4%) White (3.3%) Red (2.8%) Yellow (1.8%)	Fiber (98.9%) Flake (0.6%) Film (0.3%)	PP (33.1%) PET (28.7%) PE (22.8%) PS (5.1%) PA (2.9%) PVC (1.5%)	Wastewater discharge	Zhang et al. (2022)

Asia	Rayong coast, Thailand	100-500 µm	Blue-green (40%) Transparents (23%) Black (14%) Red purple (12%) Yellow-brown (7%) White (4%)	Fibers (80%) Fragments (19%) Foams (0.3%)	PE (73%) PP (17%) PS (10%)	Fisheries, laundry	Prarat and Hongsawat, (2022)
	Chabahar Bay, Gulf of Oman (Makran Coast)	500-1000 µm	White, blue & red (72%) Transparents (13%)	Fibers (32.7%) Fragments (26.7%) Paint flake (25.8%) Pellets (14.87%)	Polyethylene (46%) Polypropylene (23%) Polystyrene (11%)	Laundry clothes, Cosmetics, secondary plastics, boats color and vessel	Aliabad et al (2019)

					(PE n PS packaging)	cleaning Fishing activities Tourism (Daryabozorg beach)	
	Jiaozhou Bay, China	1-1.99 mm	Black (40.63%) Blue (43.75%)	Fiber (77.14%)	Polyethylene terephthalate (PET) (56.25%) (PP) (34.38%) (PE) (3.13%) (PA) (3.13) Polyvinyl acetate (PVAC) (3.11%)	Fishing, Laundry	Zheng et al. (2019)

	Ma'an Archipelago, Shengsi, China	500-1000 µm	Blue (62.2%) Transparents (11.2%) Red (10.2%)	Fibers (70%) Film (8.9%) Fragments (21.1 %)	PE-PP (21.9%) PP (18.8 %) PE (18.8%) PS (9.4%) PA (6.3%)	Fishing activity Domestic waste (fishing village)	Zhang et al. (2020)
	Kuala Nerus, Terengganu & Kuantan, Pahang	-	Grey (59.9%) Black (28.9%) Brown (9.6%) Blue (5.5%)	Fragments (76.2%) Filaments (23.76%)	PS Polyester Polyamide Polyvinyl chloride polyethylene	Local human activities (not specifies)	W.M Khalik et al. (2018)
	Northwest Coast Peninsular, Malaysia	330 µm to 1 mm	White (Langkawi, 50%; Pulau Pinang, 52.34%)	Fragments (Langkawi, 39%; Pulau Pinang, 62%)	-	Recreational activity & tourism (Chenang beach	Najihah et al. (2020)

				Filament (Langkawi, 13%; Pulau Pinang, 20%)		is nearby, Kuah Jetty (main focal point of Langkawi)) Fishing activity Marine transportation	
Europe	Portuguese West coast	1-2 mm	-	Fragment (51%) Foam (22%) Film (19%) Fiber (4%) Bead (3%) Filament (2%)	PE (66.42%) PP (18.11%)	Fishing harbor Tourism Industrial Marine traffic	Rodrigues et al. (2020)
	Sweden	-	Black Blue	Fibers (27%)	PE (65%) PP (21%)	Fishing	Schonlau et al. (2020)

	Tuscany, Italy	1-2.5 mm	-	Fragments (81%) Fibers (13%)	PE (>66%) PP (28%) PS (5%)	-	Baini et al. (2018)

2.4.1 Africa

Study on Kingston Harbour, Jamaica shows the most size for microplastics found are range from 1 to 2.5 mm, this is because stations at Gallows Point and Refuge Cay, two of the Kingston Harbour's most seriously polluted mangrove wooded areas by huge anthropogenic trash, it is also recorded that the maximum amount of microplastics identified between 0.335 mm and 5 mm. Other than that, the colour that are mostly found in the study are transparents (35%), then opaque (27%), followed by white and black. The study stated that most of the fragments found is transparents. Fragments are the most abundant shape found in the study with 86.08% followed by fibers (12.68%), foam and beads. This proves that the majority of the microplastic pollution in Kingston Harbour comes from secondary sources, specifically from the weathering and fragmentation of meso- and macroplastics. As for the polymers, Polyethylene (PE) is the highest abundance (78%) found in the study, followed by Polypropylene (PP) (22%). The study states that the high amount of PE might not come from the harbour yet it might come from the control station, which was notable for having microplastic contamination. The outflow current might move the plastics into the harbour area. Therefore, the Caribbean Sea's currents are more likely to have an impact on microplastic concentrations by moving debris from nearby bays or land masses.

The study in Cape town, South Africa focuses on the types of polymer found in microplastics in seawater. This study stated that the most polymer type found in the study is Polyethylene (PE) with 85.7%, followed by Polyethylene terepthalate (PET) (71.4%), polyvinylchloride (PVC) (57.1%), Polystyrene (PS) & Polyamide 12 (PA-12) (42.9%), Polyacrylic acid (PAA) & Ethyl Vinyl Acetate (EVA) (28.6%). The study identifies the source of the microplastics are from the rinse of cosmetics from the drain, due to the high number of PE that used to be found in the cosmetics. It is also said that the automobile tyres lubricant in injection moulding and pressing of ceramic powders also contributes to the PAA and EVA in the findings. There's no info on the shape, colour and size of the microplastics.

Study on the Port of Durban, Durban Bay Estuary east coast, South Africa showed that the highest abundance of size of the microplastics found in the study area is 200 µm–500 µm. The polymer types that are highly found in the study are PE (47%), PET (16%) and PS (9%). The high amount of PE and PET found in the study area are from the laundry activity nearby the area and also from personal care products that are from the drain. There's also high port activity such as traffic, container and container loading which contribute to the number of PS.

2.4.2 Antartica

A study in the east antarctica Ross-Sea shows that the highest size found in the area is ranging from 5.0 to 7.8 mm and most of it are in fragment shape (72%), followed by fibers (13%). Numerous factors, including proximity to the wastewater treatment plant, ship traffic, research operations in the coastal area, transit via ocean currents, and others, may contribute to the variety of the MPs during the sample cruises. The polymer types that are found to be the highest in the study are PE & PP (57.1%) followed by PL (28.6%) and other polymers also found in the study such as PTFE, PMMA and PA. When they reach a water front or become polluted, as in this instance, with algae and diatoms that increase their density, low density polymers, like PP and PE, may likewise be immersed in the top 10 metres of water. When they enter the sea through high flow rates or due to turbulence, high density MPs, including PL and PA, can be present in lesser quantities and briefly suspended within the water column, which explains the reason why PE and PP is found to be abundant in the study.

Moreover, another study in Peninsula Antartica shows that the most size found in the study is ranging from 1-74 mm, where the longest microplastics found in line shape and concluded to be from the fishing rope. Fragments (51.3%) tend to be the highest number to be found in the study, followed by line (42.3%) and sphere (6.4%). Polymer types found in the study are mostly Polyurethane (35%) where mostly are fragments, followed by PA (25%) which are composed in line shape. PE (21%), PS (11%) and PP (8%) are also found in the study. Paint particles are found in this study and are found in 7 colours (red, green, yellow, blue, orange, gray and white). It is also detected that the polyurethane is composed of the paint fragments and is proved to be sourced from the ship. The study also states that some of the microplastics are sources from fishing activities, research activities and also tourism activities.

Other study in Antartica seawater shows different abundances of microplastics which are fibers (98.9%) yet most of the studies in Antartica found fragments as highest shape found. The study states that the source of the high fibers found might come from the wastewater discharge nearby. Other than that, the size of microplastics found are mostly a bit bigger than other microplastics found in Antartica seawater which are ranging from 2.0-2.5 mm. Colours found to be highest in the study are transparents (77.2%) and followed by blue (6.3%), black (5.4%), white (3.3%), red (2.8%), yellow (1.8%). Weathering can cause discoloration of plastics and this might contribute to the high number of transparents colors in the study.

2.4.3 Asia

A study had been conducted at the Rayong coast, Thailand and the study shows that mostly microplastics found are in 100-500 μm and the highest shape found was fibers (80%) followed by fragments (19%) and foams (0.3%). The polymer types found are mostly PE (73%)

followed by PP (17%) and PS (10%). It is also stated that the blue-green (40%) coloured which most found in the study are mostly from fibers and are made of PE and it is proved that it was sourced from fishing line also nets since the community's activities are mostly fisheries. Other than fishing activities, laundry was also detected to be part of the reason why fibers are highly found in that area.

In Chabahar Bay, Gulf of Oman (Makran Coast) study about microplastics also found that fibers (32.7%) are highly found in the study area, followed by fragments (26.7%), paint flake (25.8%) and pellets (14.87%). Overall, it was discovered that many of the fibres in marine settings close to cities were land-based and may have come from effluent from washing garments. Microplastics' shape is thought to be a clue as to where they came from. In cosmetics like toothpaste, cleaning gel, and body soaps, pellet, microbeads, and granola are the three main types of microplastic that can be discovered. Also known as secondary microplastics, fibre and fragments created by the breakdown of plastic waste. It may be concluded that the majority of the microplastics in Chabahar Bay are secondary microplastics because fibre and fragments made up 59.4% of all the microplastic samples that were collected. In this investigation, it was discovered that boat colour and vessel cleaning were the primary contributors to the creation of paint flakes. The scale of these contaminants has a significant impact on the possible impact of microplastics on the ecosystem biota. Due to their hydrophobic characteristics, organic pollutants adsorb on the surface of microplastics. It was discovered that as the size of microplastics shrank, so did their ability to adsorb organic pollutants. This might be the result of the increased surface area and also explains why the sizes found in the study are mostly around 500-1000 µm. White, blue & red (72%), Transparents (13%) are the colors found in the study. The two hues that were most frequently discovered in samples that contained paint flakes were blue and white. It made sense because the majority of the fishing boats in Chabahar Bay were blue and white. Most of the fibres were blue, red, and white. The majority of the fragments were white as well. Polyethylene (46%) was found to be the highest among other polymer types followed by polypropylene, polystyrene and plystryene. The breakdown of both land- and sea-based hard polymers produced polyethylene, which is mostly employed in the packaging industry. Fibers made of polyethylene, polypropylene, and polystyrene are often used as microplastics in textiles. Additionally, microplastic fragments made from these polymers are mostly employed in consumer goods including plastic bottles, bags, and films. Fishing nets and ropes are made of polyvinyl alcohol. Polypropylene is used most frequently in pipes, carpets, and rugs because of its special chemical and physical characteristics. Additionally utilized in packing is polystyrene. This concludes that the fishing activities and tourism activities actually contribute to the number of microplastics.

A study in Jiazhou Bay, China found 5 polymer types in the seawater samples where polyethylene terephthalate (PET, 56.25%), polypropylene (PP, 34.38%), polyethylene (PE, 3.13%), polyamide (PA, 3.13%) and polyvinyl acetate (PVAC, 3.11%). PET is found high in packaging, also fiber for carpet, and tote bags which is why laundry might be the source of microplastics in the area. Other than that, PE is mostly used to manufacture fishing nets that is why fishing activity is also one of the sources of microplastics. The highest size found in the seawater samples are between 1.0-1.99 mm. Fiber (77.14%) is the most abundant shape in the study. Black (40.63%) and blue (43.75%) are the highest number of colours in the study. This is because most of the fiber is in black and blue.

Study that had been done around the Ma'an Archipelago, Shengsi, China found that the highest size of microplastics around the area are 500-1000 μm. Fibers (70%) are the most abundant microplastics in the surface water, followed by fragments (21.1%) and film (8.9%). 5 Polymer types are found in the study which include PE-PP (21.9%), PP (18.8 %), PE (18.8%), PS (9.4%), and PA (6.3%). As for the colour, blue (62.2%) dominate the microplastics colour, followed by transparents (11.2%) and red (10.2%). The study agreed that the source for the microplastics are mostly from fishing gears and the high number of fibers are mostly from the domestic waste as near the study area is the fishing village. Also, according to the study, the fibers made from fishing ropes have a different type of polymer than those made from sewage effluent. PE, PA, and PP are commonly the primary polymers of micro-fibers from fishing nets and ropes.

2.4.4 Europe

A study done in the Portuguese West coast shows that the abundance size of microplastics in the area is 1-2 mm. There is no data on the colour of the microplastics but the highest number of microplastics' shapes are found as fragments (51%), followed by foam (22%), film (19%), fiber (4%), bead (3%), and filament (2%). PE (66.42%) and PP (18.11%) are the polymer types found in the study. The source of the microplastics are stated to be from fishing harbors nearby, tourism,industrial, and marine traffic.

Microplastics study in Sweden shows a bit different in shapes found the highest which are fibers (27%), there's no other data about other shapes found. The colour are also stated that there are only 2 colour which are black and blue. The polymer types found are PE (65%) and PP (21%) which clearly shows that the source of the microplastics are from fishing activity. There's no data about the size of the microplastics.

Tuscany, Italy microplastics study shows that the highest number of microplastics are found to be in the size ranging from 1 to 2.5 mm. Microplastics are found to be in fragments (81%) shape the highest followed by fibers (13%). The polymer types found in the study are PE (>66%) as the highest, followed by PP (28%) and PS (5%). There's no sources stated in the study.

2.5 Microplastics study in Malaysia in beach water

Table 2.5 summarizes the microplastics study in Malaysia that were carried out in the seawater samples and provides information on the size, colour, shape and the types of polymers of the microplastics.

Table 2.5 Summary of microplastics study in seawater samples in Malaysia

Study Area	Size	Colour	Shape	Plastic Polymer types	Sources	Reference
Kuala Nerus and Kuantan Port	5000 µm	Black, blue, brown, grey, red, orange, yellow, and transparent	Fragments (76.2%) Filaments (23.76%)	Polyester (PL), polystyrene (PS), polyamide (PA), polyvinyl chloride (PVC), and polyethylene (PE)	Fishing activities, tourism, personal care products, and multi-cargo ports	Khalik et al. (2018)
Port Dickson and Lukut	200-3000 µm	Transparent, black, and red	Fibers (61%) Pellets (16%) Fragments (16%) Sphere (5%)	Polyester (PL), polyethylene (PE), polystyrene (PS), and Cellophane,	Fishing activities and tourism	Zainuddin et al. (2022)
Terengganu Estuary	100-3617 µm	Transparent, black, red, and blue	Fibres (80.8%) Fragments	polyethylene (PE), and polypropylene (PP)	Industrial activities, tourism, fishing activities,	Daoud et al. (2021)

			(18.6%) Pellets (0.17%)		boat manufacturing, and recreation	
Kuah, Langkawi & Seberang Perai, Pulau Pinang	1000-3000 µm	Red, transparent, black, blue, grey, yellow, and green	Fragments (Langkawi, 39%; Pulau Pinang, 62%) Filament (Langkawi, 13%; Pulau Pinang, 20%)	Polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), and polystyrene (PS)	Tourism activities, Industrial activities to produce electronics and personal care products	Najihah et al. (2020)

Microplastics study in Kuala Nerus and Kuantan, Malaysia shows different than the other in terms of the most shape found in the area which is fragments (76.2%) and followed by filaments (23.76%). The polymer types found in the study is not specified but it is listed down to be 5 polymer types found in it which are polystyrene, polyester, polyamide, polyvinyl chloride and polyethylene. The source of the microplastics are also not discussed further which the study states generally that the microplastics are from the local human activity.

Another microplastics study in Malaysia is done in Langkawi and Pulau Pinang. The study had discovered that the highest concentration of size of microplastics in the study area are 330 µm to 1 mm. Number of fragments (Langkawi, 39%; Pulau Pinang, 62%) found in the study area are considered to be the highest compared to filament (Langkawi, 13%; Pulau Pinang, 20%) shape. The microplastics are mostly coloured white (Langkawi, 50%; Pulau Pinang, 52.34%) the others are multicolored. There is no identification of polymer types in this study. The source is concluded to be from Chenang Beach which is nearby, also Kuah Jetty which is known as the main focal point in Langkawi. Thus, the microplastics are mostly from recreational activity and also tourism, other than fishing activity and also marine transportation.

Most of the microplastics studied in seawater samples in Malaysia, come from the same sources which are fishing and tourism activities. Other than that, the sources are coming from boat manufacturing, personal care products, and multi cargo ports. Studies in Port Dickson, Lukut and Terengganu show that the highest number of microplastics found are fibres (Terengganu (80%); Port Dickson and Lukut (61%)) while in Kuala Nerus, Kuantan Port, (76.2%) Kuah, Langkawi (39%) and Seberang Perai, Pulau Pinang (62%) have fragments as the most abundance microplastics in the study area. The Port Dickson shoreline region showed a greater abundance of fibres. The high levels of tourism in Port Dickson, particularly along the beach and fishing, show that human activity directly caused fibres from these sources to end up in the marine ecosystems (Zainuddin et al., 2022). It is hypothesised that the increased abundance is caused by large quantities of contaminants from various human activities. The most frequently found microplastic in seawater was fibres made of various polymers, specifically polyamide, polyethylene, and polypropylene. These fibres may have come from secondary microplastics, which are reflective of the diverse activities taking place in the estuary, including dining establishments, tourism, fishing, the seafood processing industry, and maritime traffic (Daoud et al., 2021). As for Kuala Nerus, Kuantan Port, Langkawi and Seberang Perai, there is no specific evidence that prove the source of the microplastics but it is mention on Langkawi and Seberang Perai study that the sampling area is near to attraction site and the microplastics found in that area are high than any other site (Najihah et al., 2020).

CHAPTER 3

METHODOLOGY

3.1 Study Area

Tanjung Rhu beach, Kelanang beach, Morib beach, Batu Laut beach and Cunang beach were located along the Kuala Langat coastline. It was located on the south-west side of peninsular Malaysia and tends to be a tourism destination due to its beautiful beaches. It was also one of the main attractions in Selangor. Other than that, there were also native villages near the beaches which caused a lot of human activities happening in the area for example fishing activities. Beach water samples were collected from five beaches along Kuala Langat coastline, the region with high possibility of tourist attraction in the province. All of the beaches selected are known to be a tourist attraction with various other human activities going around. Tanjung Rhu Beach and Morib Beach are found to be the most prone to be complained about for the trash left by the tourists or visitors of the beach (Beach Cleanup, 2019; Abu, 2022). Other than a tourism area, Batu Laut Beach is also known as a sailing center training. Meanwhile, Cunang Beach is the only beach that is adjacent to an aboriginal people's village where their most activity is fisheries. So the expected microplastics obtained should be from the net line, and also the fishing line.

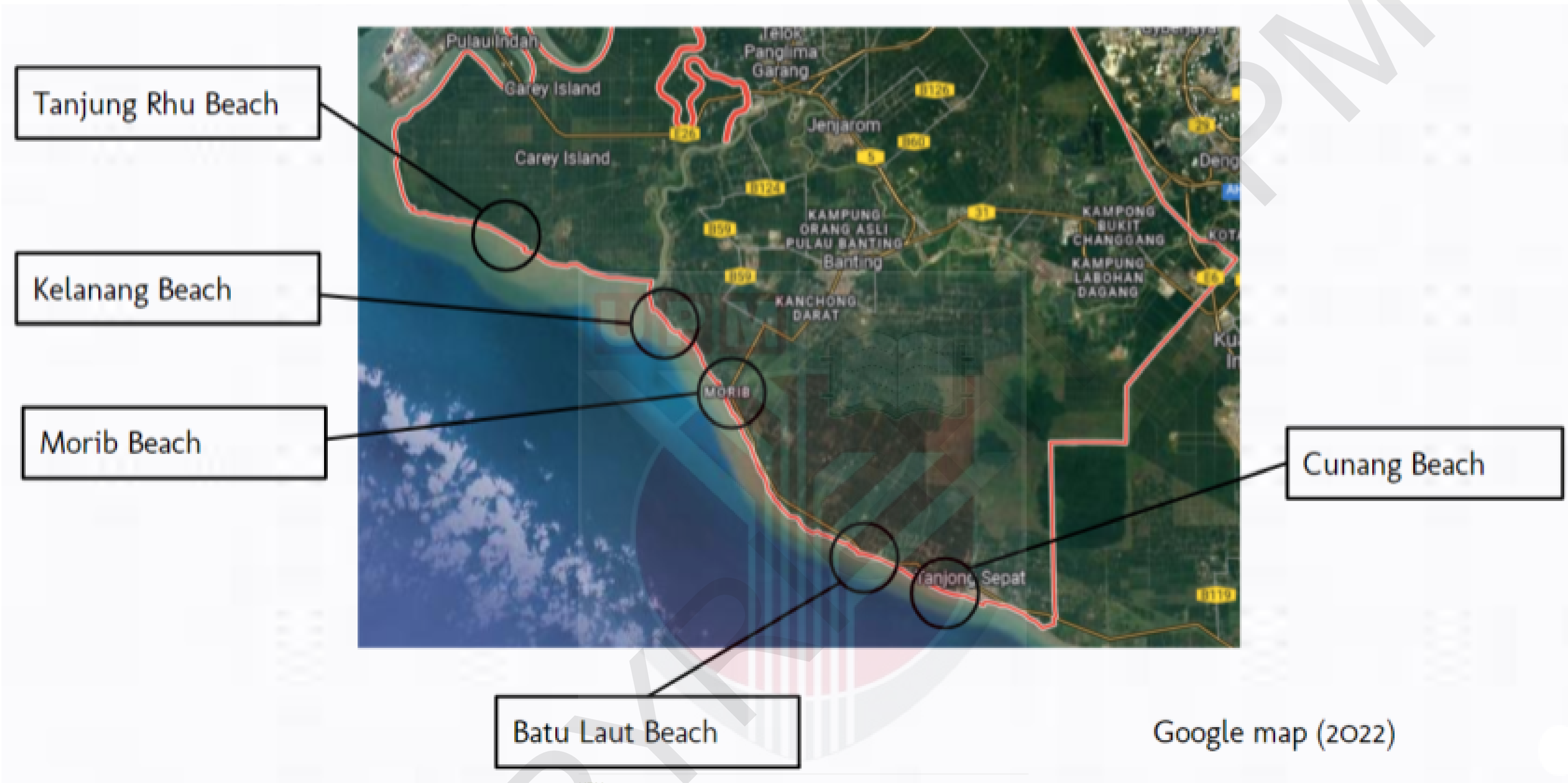

Figure 3.1 The selected beach along Kuala Langat Coastline (Google Map, 2022)

3.2 Beach water sampling

In this study, simple random sampling was selected where the sampling location was 500m between the sampling location. In each of the beaches, there were different numbers of sampling locations due to the length of the beach itself. The sites were selected based on their proximity to sources of pollution. Figure 3.1, 3.2, 3.3, 3.4 and 3.5 shows the geographic locations of our sampling sites (n = 28). Beach water sample was done linearly along the shoreline manually by hand. We collected the samples by using Schott bottle glass from each of the selected beaches. 500 ml of beach water sample was needed for a replicate (Prata et al., 2020), thus 2L of beach water was achieved from each sampling point. The glass Schott bottle was rinsed with beach water and then submerged just below the surface. The bottle glass was then tightly secured with a lid while holding it still underwater to fully achieve the volume of samples needed.

Figure 3.21 Tanjung Rhu Beach, Pulau Carey

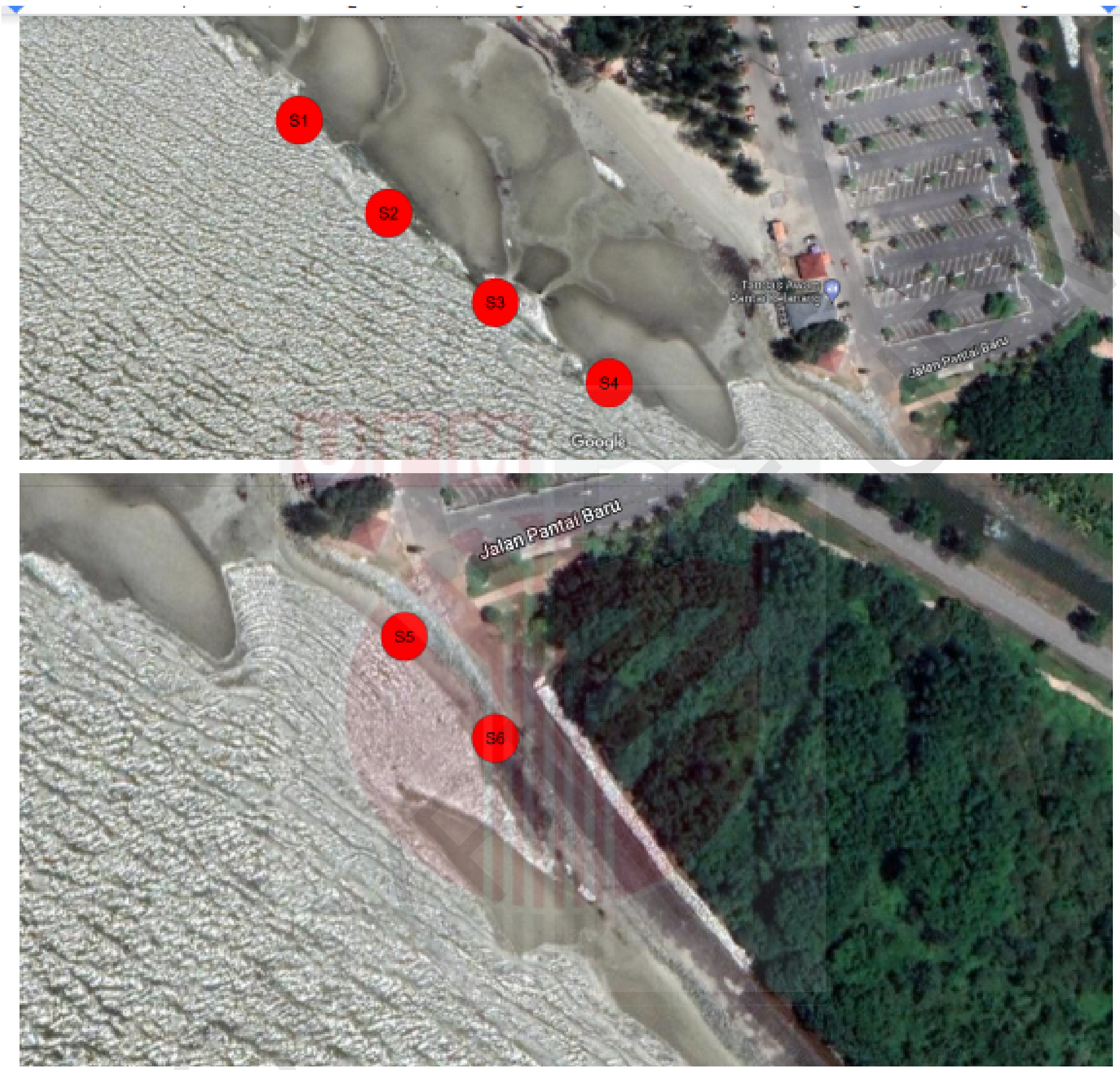

Figure 3.22 Kenang Beach

Figure 3.23 Morib Beach

Figure 3.24 Batu Laut Beach

Figure 3.25 Cunang Beach

3.3 Sample preparation

The beach water samples were collected during high tide causing some of the sediments to be collected too. Thus, the beach water samples were left for a night for sedimentation. This would ease the process of vacuum-filtration and also helps in achieving a clear image of microplastics during identification.

3.4 Microplastics analysis on beach water

The beach water sample was vacuum-filtered through a 0.45µm pore size of Nitrocellulose filter. This is because 0.45µm size filter pore size is the smallest size to vacuum-filter separate microplastics from beach water samples. The filtration was done per replication (500mL). After every filtration of a sampling point, the filtration apparatus were all rinsed with deionised water to avoid mixing of samples. The filter paper was then put on a petri dish, where it was left dried for a night. The petri dishes were arranged in a closed glass cabinet where it was cleaned beforehand to avoid any dust from the surrounding area contaminating the samples as it might cause disturbance during the observation of samples under microscope.

3.5 Identification & characterization

The identification of microplastic particles on the filters were optically analyzed and photographed using a stereo microscope (Motic SMZ-168), at magnification power 5.0X to locate possible microplastics. The identification of microplastics was according to the physical features of the particles by identifying the shape, color and size of microplastics. The criteria of a shape was categorized into fiber (fibrous plastic strands), fragments (hard, uneven shape), pellets (hard, sphere shaped), film (thin, 2D plastic films) and foam (soft and flimsy material) (Hidalgo-Ruz et al. 2012). There have been reports of red, orange, yellow, brown, tan, off-white, white, grey, blue, and green microplastics among others (Murray and Ormeci, 2020; Rochman et al., 2019). When reporting and interpreting results, it is important to take into account that microplastic discolouration can happen during weathering (Allen et al, 2020).

3.6 Data Analysis

Table 3.6 shows the data analysis used to analyze each of the specific objectives. In order to determine the normality and homogeneity of the data was determined by using the Shapiro Wilk test. Skewness, kurtosis, Shapiro-Wikl statistics all supported the assumption of normality for each of the three conditions yet the Levene's statistic was significant at $\alpha=0.05$, ($F=5.623, Sig=0.003$) the assumption of homogeneity of variance has been violated. One way-ANOVA test was used to determine the comparison of microplastics occurrence in coastal water among the selected beaches along Kuala Langat (Malaysia) coastline.

Table 3.6 Data analysis for each specific objectives

Objective	**Data with normally distribution**
To **analyze** the presence and characteristics (size,color,shape) of microplastics in coastal water from selected beaches along Kuala Langat coastline	Descriptive statistic
To **compare** the microplastics occurrence in coastal water between the selected beaches along Kuala Langat coastline	One way- ANOVA test ● Skewness, kurtosis, Shapiro-Wikl statistics all supported the assumption of normality for each of the three conditions yet the Levene's statistic was

	significant at $\alpha=0.05$, ($F=5.623$, $Sig=0.003$) the assumption of homogeneity of variance has been violated.

CHAPTER 4

RESULTS

4.1 Identification of the microplastics extracted from the beach water of selected beaches along Kuala Langat coastline.

4.1.1 Microplastics size in beach water of selected beaches along Kuala Langat coastline.

In this study, particle size ranging from 94.97 µm to 10617.95 µm was detected in the beach water sample from the selected beaches of Kuala Langat coastlines. The highest abundance of the longest microplastics was identified from Tanjung Rhu beach (3519.92 µm) while the shortest particles was found in Kelanang (749.4 µm). Table 4.1 shows the mean for each of the selected beaches along Kuala Langat coastline.

Table 4.1 The size of microplastics extracted from all samples

Beach	Sample	Mean (µm)	Standard Deviation (µm)	Minimum (µm)	Maximum (µm)	Mean for each beach (µm)
Tanjung Rhu	A1	1348.75	1620.56	195.55	6313.11	2434.34
	A2	3519.92	622.16	2189.51	5875.86	
Kelanang	B1	1336.98	803.1	144.68	3666.46	1513.29
	B2	1880.34	1914.67	209.79	9879.17	
	B3	1714.3	1254.18	163.39	5479.84	
	B4	749.4	707.14	100.6	2512.16	
	B5	1987.95	1980.08	173.85	6622.26	
	B6	1410.74	1460.98	127.41	6825.89	
Morib	C1	2443.19	2278.13	134.3	8787.54	1557.33
	C2	2037.4	1468.67	263.86	5746.58	
	C3	919.6	695.11	306.26	2911.01	
	C4	1492.38	2105.5	229.5	10604.7	
	C5	1436.45	1666.34	132.95	7663.36	
	C6	1014.96	753.99	276.55	2927.2	

Batu Laut	D1	1299.96	1214.08	180.19	5784.53	1518.52
	D2	1730.53	1711.49	246.91	7182.53	
	D3	1237.64	1451.83	205.44	7507.16	
	D4	1915.32	2030.3	348.67	7707.96	
	D5	1488.3	1133.63	153.13	5320.58	
	D6	1942.38	2310.05	163.39	10617.95	
	D7	1441.72	1669.36	169.88	8236.57	
	D8	1092.28	1185.56	169.88	6656.49	
Cunang	E1	1010.61	780.27	228.71	3219.36	1270.02
	E2	1301.95	1542.51	198.3	7463.83	
	E3	1615.3	1677.88	198.3	6121.64	
	E4	1931.25	1905.37	193.69	7057.07	
	E5	964.53	1258.33	94.97	5714.22	
	E6	796.46	636.31	163.39	3302.93	

The shortest microplastics particle was from Cunang beach (1270.02 µm), and the longest came from Tanjung Rhu beach (2434.34 µm). The size of microplastics gets smaller more often in a place with more human activities going around. Cunang beach is adjacent to an aboriginal village whose activities are mostly fisheries. The average length of microplastics found among the selected beaches are ranging from 1510 µm to 1560 µm.

4.2.2 Microplastics color in beach water of selected beaches along Kuala Langat Coastline.

Six main types of colors (white, red, black, brown, transparents and blue) of microplastics were mainly found in the beach water among selected beaches along Kuala Langat coastline. In Tanjung Aru Beach, the highest number of colour types found was transparents

(35.2%) and the lowest number of colour identified was blue (1.1%). Kelanang Beach has transparents as the highest number of colors identified too and the lowest was blue (1.3%). Next, Morib beach also has the transparents (48.1%) as the highest colour found in the beach water and blue (7.9%) as the lowest number of colour identified. Transparents (43.8%) colour is the highest number identified in Batu Laut beach and the lowest would be blue (5.2%). Lastly for Cunang beach, white (58.82%) colour seems to be the highest number found too and the lowest would be brown (3.92%).

It is concluded that transparents (39.98%) is the highest number of microplastics colour found in the selected beach water along Kuala Langat coastline, followed by white colour (35.2%), black (13.1%), brown (11.78%), red (7.04%) and the lowest is blue (4.16%).

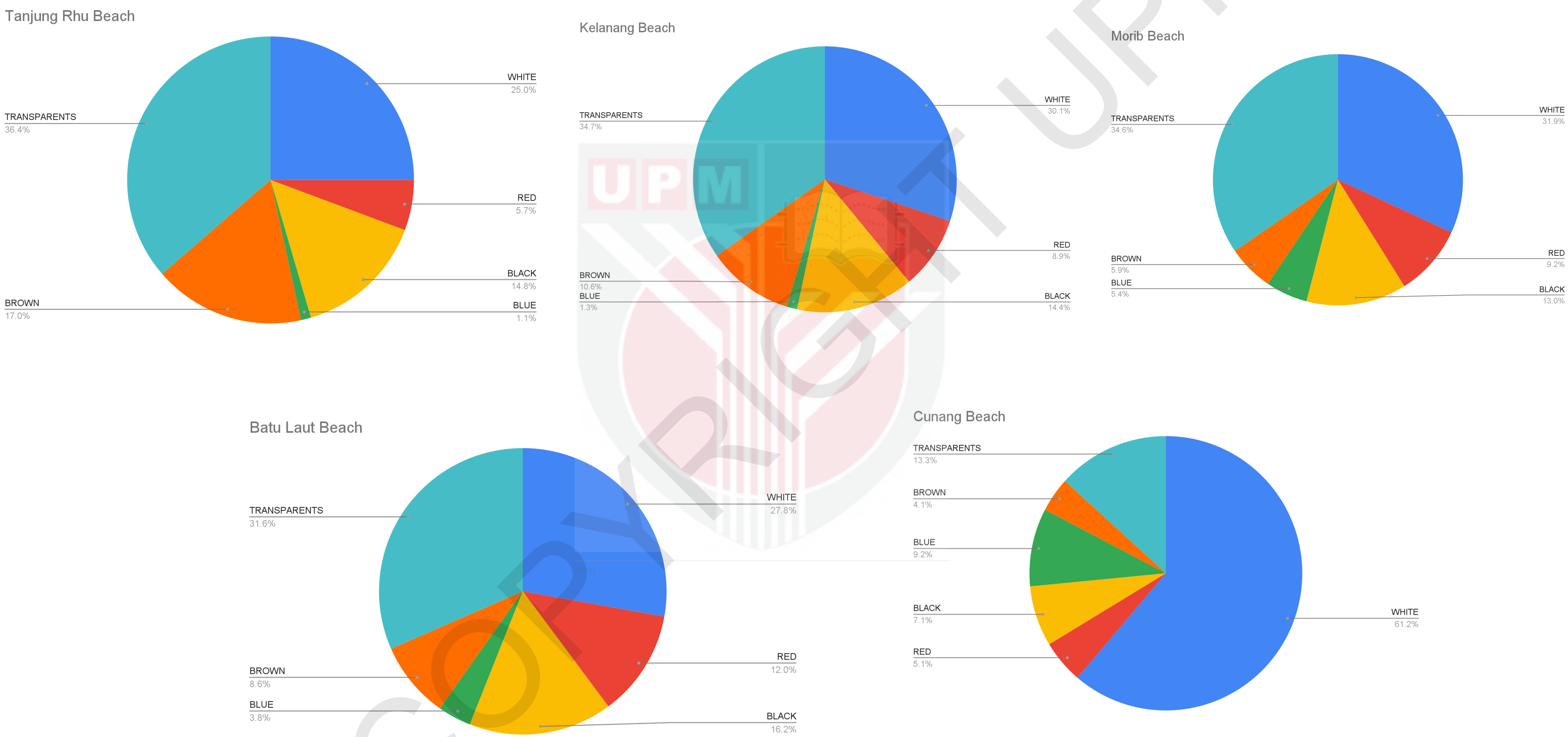

Figure 4.1: The proportion of colour among particles extracted from beach water samples

4.2.3 Microplastics shape in the selected beach along Kuala Langat Coastline

Five types of shape (fibre, fragment, film, foam and pellet) were found in these extracted particles. In Tanjung Rhu beach, fragment (40.7%) is dominantly identified in the samples and the lowest number of shape found in the sample is foam (3.3%). As same as Tanjung Rhu beach, Kelanang beach also found fragment (44.3%) shape to be the highest yet shape with the lowest number found is film (6.3%). As for Morib beach, fiber (39.6%) seems to be the highest percentage found in the beach water and the lowest is film (3.6%). Fragments were found to be the highest in Batu Laut beach (48.2%) and also Cunang (35%) but foam (3.7%) to be the lowest in Batu Laut beach and film (2.5%) is the lowest number of microplastics shapes found in Cunang beach.

In concussion, shapes that were mostly identified in all of the selected beaches are fragments (41.46%) followed by fiber (30.56%), pellet (14.4%), film (7.04%) and the lowest is foam (6.56%).

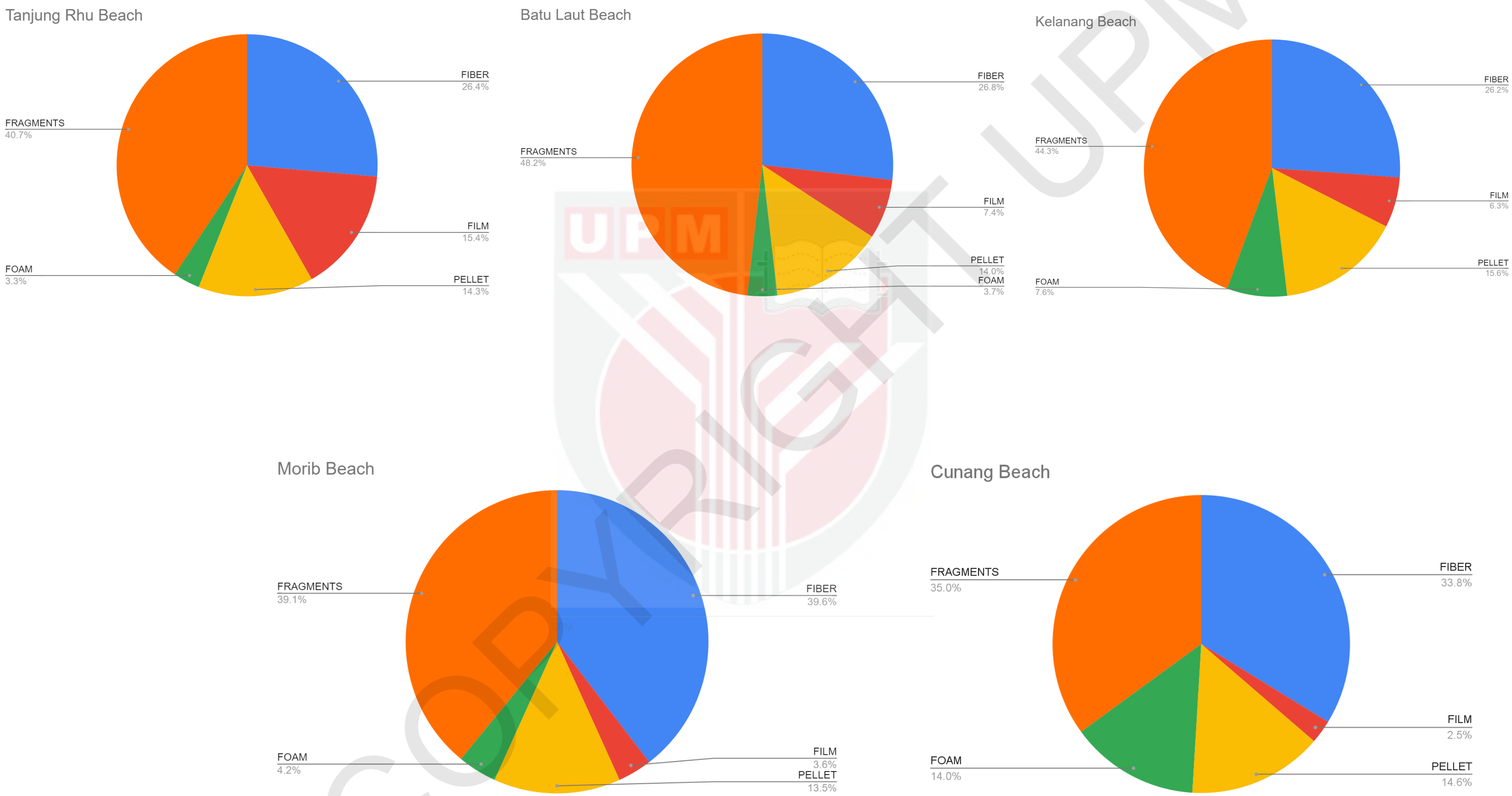

Figure 4.2 The proportion of shapes among particles extracted from each beach water samples of selected beach

4.3 The association between Microplastics occurrence in beach water between the selected beaches along Kuala Langat coastline

Table 4.3 shows ANOVA test results that assess the association between microplastics size among the selected beaches. A one-way analysis of variance (ANOVA) between groups was performed to determine whether there is an effect of human activity on the beach towards microplastics size in beach water. After Levene's statistics were run, it is indicated that the assumption of homogeneity of variance has been violated. Thus, in order to avoid the probability of falsely rejecting the null hypothesis, the Welch test had been used to assess the association between the types of activities of the beach area and size of the microplastics. ANOVA test was not statistically significant, showing that the particle size of microplastics from the selected beaches were not influenced by the type of activities of the beach area, $F(4,23)=1.742$, $p=0.773$.

Table 4.3 ANOVA test to assess the association between microplastics size among the selected beaches

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2046666.664	4	511666.666	1.742	0.175
Within Groups	6757011.996	23	293783.130		
	9903678.660	27			

Robust Test of Equality of Means

	Statistic	df1	df2	Sig.
Welch	0.446	4	5.536	0.773

a. Asymptotically F distributed

** p is significant when <0.05*

CHAPTER 5

DISCUSSION

5.1 Characteristics of microplastics extracted from the beach water sample of selected beaches along Kuala Langat coastline

5.1.1 Size

It was found that the particle size identified in this study is ranging from 94.97 µm to 10617.95 µm and the abundance of longest microplastics was found in Tanjung Rhu beach (2434.34 µm) while the shortest was found in Cunang (1270.02 µm). In studies of microscopic microplastics, it is crucial to take into account the pathways by which plastic waste degrades, the environmental fate at the µm-scale from their source to their final destination (Ter Halle et. al., 2017). Since the selected beaches were in the same coastlines, there was a possibility that the microplastics might have migrated from the first beach (Tanjung Rhu beach) to Cunang beach due to the tidal regime, windiness and water flow of the beach. Larger particles are physically faster and more stable to float at similar particle shapes and polymer densities, so the general decrease in small microplastics size with increasing distance from the coast is caused by vertical sorting mechanisms under various environmental conditions (floatability affected by salinity, wind, and waves) and processes like biofouling and interaction with lower trophic levels (González-Ortegón et al., 2022).

5.1.2 Colour

Most likely the transparents colour originated from the fishing activities commonly visible in the area, in which colorless plastic fishing lines and nylon nets serve as the primary fishing tools. Single use clear food packaging were often seen littered around in the beach area, explaining the number of percentage of transparents colour tends to be highest in the majority of the beach. Other than that, the exposure to sunlight is thought to be the main factor in the aging of plastics, as it has the tendency to trigger chain reactions and chain scission in polymers, which breaks down plastic into microplastics. Color changes in plastic polymers are typically brought on by photoaging (Zhao et al., 2022). In a study that revealed faded fibers (usually red and blue), some of which are even almost transparent after fading (Di & Wang, 2018). The highest number of white coloured in Cunang was due to the aging process in the meantime of its migration from Tanjung Rhu beach to Cunang beach. Long-term solar exposure causes plastics to gradually become lighter in colour (discoloration or whitening), and then more weathering causes them to turn from white to yellow or amber (yellowing and tanning, respectively). In general, the colour gets lighter as the weathering process goes on longer. As a result, the colour variations may, to some extent, reflect the stages of deterioration of plastic debris and may even be used as proxies for the duration of such debris's exposure to the environment (Marti et al., 2020).

5.1.3 Shape

The shape found in this study could be categorized into 5 main shapes which were fibers, film, fragments, pellets and foam (Figure 5.1). Microplastics' morphology may be related to the sources of their emissions (primary or secondary microplastics). The results were the same as research that had been done in Kuala Nerus and Kuantan Port (Khalik et al., 2018) and Kuah, Langkawi and Seberang Perai, Pulau Pinang (Najihah et al., 2020) where both researchers state that the microplastics were sources from tourism activities, fishing activities and personal care products.

Fragments and fibers were the most abundant of shapes that were produced during the opening of a food packaging (Sobhani et al., 2020). Basic shapes including pellets, granules, and spheres are discharged directly as primary microplastics. Others are primarily brought on by the breakdown of plastic products made of fibres and unidentified forms (secondary source). Their basic shape or distortion brought on by erosion, solar radiation, or biological degradation may be found in coastal locations. Sometimes, because of erosion or the attachment of organisms, the surface morphologies of plastic can change substantially during cracking (Imhoff et al., 2013). Thus, surface morphologies vary depending on the environment, the plastic's physical and chemical characteristics, and other environmental conditions.

Microplastics abundance and type all depends on the human activities on the beach itself (Kaviarasan et al., 2022). All of the selected beaches tend to have the same human activities since the region selected was a tourism destination. Food packaging such as plastic bags and confectionery packaging was found to be abundant in the sampling area of all of the beaches. The highest abundance of shapes that were found in all of the sampling locations were the same fragments and also fibers which indicate that the fragments came from the breakdown of food packaging of the tourism activities and the fibers were from the fishing activities. During the collection of beach water samples, some fishing activities were done in the area (refer supplementary materials). The selected beaches along the Kuala Langat coastline were also influenced by windiness, tidal regime and water flow of the beach, aiding the movement of microplastics to be spread from the first beach to the last beach which was Cunang beach (Du et al., 2021; Lusher, 2015). Thus, the study on effect on marine dynamics on microplastics migration along Kuala Langat coastline should be conducted which will give better insight of the fate of microplastics in the environment.

Figure 5.1 Shape of microplastics identified in the selected beaches in beach water samples

5.2 The association between Microplastics occurrence in beach water between the selected beaches along Kuala Langat coastline.

Based on the result of One Way ANOVA, the size of microplastics found are not significantly different for each beach. This means that the size of microplastics were not influenced by the beaches. The reason is because each of the beaches have a different degradation rate which explains why the size of the microplastics on each of the beaches were different. Other than that, the duration of exposure to the UV light from the sun was also one of the factors to the degradation of plastics. The bigger the surface area exposed to the UV, the faster the degradation rate of a plastic. The exposed surfaces were where degradation mostly happens, we assume that the degradation rate is proportional to surface area and that the rate constant k has dimensions of kg $s^{-1}m^{-2}$ (Chamas el. al., 2020). This concludes that the larger the surface area of macroplastics are exposed to the factors of degradation (sunlight, temperature, etc), the faster the degradation rate happens which produces smaller size of microplastics.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, this study provides an understanding of microplastics pollution in the selected beaches in Kuala Langat coastline based on its morphology such as size, shape and colour. The size of particles have been identified in the beach water samples of the selected beaches along Kuala Langat coastline, comprised of Tanjung Rhu beach (2434.34 μm), Kelanang beach (1513.29 μm), Morib beach (1557.33 μm), Batu Laut beach (1518.52 μm) and Cunang beach (1270.02 μm) where the most extended particles detected were from Tanjung Rhu beach and the shortest to be from Cunang beach. Transparents (39.98%) colors were found to be abundant in most of the of the selected beaches, meanwhile Cunang beach has white color as the highest number identified. The highest number of particles extracted from the beach water samples were fragments (41.46%) and the lowest tended to be the foam particles (6.56%). ANOVA data found no significant difference between the size of particles and the beaches selected which indicate that the activities that were carried out by humans in the sampling area, does not influence the size of the microplastics. Factors that affect the size of the microplastics were the difference of degradation rate in each of the beaches, the distance between the microplastics sources to its final destination and the size of the plastics before they degrade. The physical characteristics of the microplastics found in the selected beaches indicated that the particles originated from a variety of sources of activities such as littering, fishing activities and also tourism.

6.2 Recommendations

This research gives information on the prevalence of microplastics pollution in the beach environment. Preventive and control approaches need to be taken to minimize and reduce microplastics in the beach environments. The preventive approach may consist of several ways, such as educational programmes to raise the public awareness by promoting the already existing campaign that were carried out by some of the Non-Government Organization (NGO) so that the public won't depend on the NGO themself. The cleanliness of the beach is everyone's responsibility. Other than that, by promoting alternative usage of plastics such as biodegradable plastics and reusable food packaging (Tupperware) will also help in reducing the microplastics pollution especially during family gathering or tourism activities in the beach. In addition, comprehensive and effective policies need to be established towards the tourism industry. The waste management on the beach area needs to be monitored and frequently provide a better waste collection dumpster around the beach.

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APPENDICES

1) Beach water sampling

Figure 1: Collecting beach water sample

2) Macroplastics spotted in the sampling location

Figure 2 Fishing net stuck to a tree indicating fishing activities in the area

Figure 3 Fishing activities in the sampling area

Figure 4 Fishing net identified in the beach water

Figure 5 Plastic bags shown floating in the beach water

Figure 6 Plastics bottle, bottle cap and confectionary packaging were identified during the data collection