# DETERMINATION OF MICROPLASTICS IN SEDIMENT IN KELANTAN AND PATTANI BAY

By

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## DECLARATION

I declare that this thesis entitled "Determination of Microplastics in Sediment in Kelantan and Pattani Bay" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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**Determination of Microplastics in Sediment in Kelantan and Pattani, Bay**


## ABSTRACT

Marine plastic pollution has arise in the last few decades due to both an increase in consumerism and an increase in the number of plastics used in the daily production of the products that human use. In general, microplastics are classified as plastic particles that are broken into less than 5 mm in size. There are many studies have been reported in the occurrence and impacts of the microplastics in marine environments in other country but less investigation has been carried out in Malaysia and Thailand. Therefore, the purpose of this study is to determine the microplastics presents in sediment in Kelantan and Pattani Bay. Sediment samples were collected from Sri Tujuh Beach, Tumpat and Talo Kapo Beach, Pattani Bay in between May and July 2019. Microplastics were isolated from sediment samples using wet peroxide oxidation (WPO) followed by density separation. Microplastics were sorted visually according to their shapes and colors after being examined under photographed microscope. A total of 52 pieces of microplastics were identified and the most abundant particle found in this study was threadlike shape. Fourier Transform Infrared (FTIR) spectroscopy has been used to identify functional groups in the composition of microplastics. This study shows that degraded of large plastic materials to microplastics due to some factors such as weathering can impact abundance of microplastics in both places, as these locations are well known for fishing activities, industrial areas and also as tourism area.

**Mengenal Pasti Kehadiran Plastik Mikro dalam Sedimen di Teluk Pattani dan Kelantan**

## ABSTRAK

Pencemaran plastik di persekitaran laut telah meningkat dalam beberapa dekad yang lalu kerana faktor peningkatan dalam kepenggunaan dan peningkatan dalam jumlah plastik yang digunakan dalam pengeluaran produk kegunaan harian manusia. Secara umumnya, plastik mikro dikelaskan sebagai zarah plastik yang sudah mengecil kepada ukuran saiz yang lebih kecil daripada 5mm. Terdapat banyak kajian yang telah dilaporkan dalam kehadiran dan impak plastik mikro di banyak persekitran laut di negara lain tetapi kurang kajian dilakukan di Malaysia dan Thailand. Oleh itu, tujuan kajian ini adalah untuk mengenal pasti kehadiran plastik mikro dalam sedimen di Teluk Pattani dan Kelantan. Sampel sedimen telah diambil dari Pantai Sri Tujuh, Tumpat dan Pantai Talo Kapo, Teluk Pattani dari bulan Mei hingga Julai, 2019. Plastik mikro telah diasingkan daripada sampel sedimen menggunakan analisis peroksida pengoksidaan basah (WPO) diikuti oleh pemisahan ketumpatan. Plastik mikro telah diklasifikasikan mengikut bentuk dan warna mereka selepas di periksa di bawah mikroskop tangkap gambar. Sebanyak 52 keping plastik mikro telah dikenal pasti dan zarah yang paling banyak dijumpai di dalam kajian ini adalah berbentuk benang. Fourier Transform Infrared (FTIR) spektroskopi telah digunakan untuk mengenal pasti kumpulan berfungsi dalam komposisi plastik mikro. Kajian ini menunjukkan bahawa pengecilan ukuran plastik menjadi plastik mikro disebabkan oleh beberapa faktor seperti luluhawa yang boleh mempengaruhi kuantiti plastik mikro yang hadir di kedua-dua tempat. Ini adalah kerana lokasi tersebut terkenal dengan aktiviti memancing, kawasan perindustrian dan juga kawasan pelancongan.

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| | |
|---|---|
| POPs | Persistent Organic Pollutants |
| FTIR | Fourier Transform Infrared |
| WPO | Wet Peroxide Oxidation |
| UV | Ultraviolet |
| HDPE | High Density Polyethylene |
| PS | Polystyrene |
| PP | Polypropylene |
| PE | Polyethylene |
| PCBs | Polychlorinated Biphenyls |
| PAHs | Polycyclic Aromatic Hydrocarbons |
| LDPE | Low Density Polyethylene |
| PVC | Polyvinyl Chloride |
| PUR | Polyurethane |
| PET | Polyethylene Terephthalate |
| PA | Polyamide |
| Teflon | Polytetrafluoroethene |
| PBDEs | Flame Retardants |
| Fe (II) | Iron (II) |
| $G/CM^{-3}$ | Grams per cubic centimetre |
| KG | Kilogram |
| µm | Micrometre |
| mm | Millimetre |
| mL | Millilitre |
| G | Gram |
| g/mol | Gram/Moles |
| M | Molar |

**LIST OF SYMBOLS**

| | |
|---|---|
| °C | Degree Celcius |
| % | Percentage |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Marine debris is a globally recognised environmental issue of increasing concern. Marine ecosystems worldwide are affected by human-made waste, most of which is plastic (Noaa, 2013). Plastic is a major contributor to ocean pollution where a study was published in 2017 estimated between 1.15 to 2.41 million tonnes of plastic enters the oceans via rivers annually, with peak months being between May and October (Griffin & Wilkins, 2019). The top 20 contributing rivers, which according to the report are mostly found in Asia, contribute around 67% of all plastics flowing into the ocean from rivers around the world (Griffin & Wilkins, 2019). The demand for plastic has increased dramatically over the last 70 years. According to Plastic Ocean, 300 million tons of plastic is produced globally every year.

Every year, the amount of plastic waste keep increasing on the environment due to half of that plastic is used for disposable items that will only be used once and also improper management which end up causes more of these discarded plastics waste can be found in the sea. This event is called as plastic pollution. Based on Charles Moore, plastic pollution can be defined as the accumulation of plastic waste or debris, in the environment which giving negatively impacts towards all living things and their habitat. Plastic pollution firstly occurs on land where mostly of these items are single-use items, which are used once and then throw. Properties plastic itself had made them end up become one of the environmental pollution where the plastics will be lasts forever in the environment.

The word of plastic comes from Greek “plassein”, which brings means of mold or shape. The invention of plastic is begin when first synthetic polymer was invented by John Wesley Hyatt, in 1869, where the invention of plastic was as to provide a substitute for the ivory. As years pass by, the plastic has been produced in variety types which more versatile, lightweight, flexible, moisture resistant, strong and inexpensive where it encouraging people around the world to consume in large amount. After all, products that are manufacture from plastic materials tend to be long-lived waste in the environment due to its high durability and slowly degrade.

Over production or consuming of plastics used and improper waste management could lead to chronic problem in plastic pollution. Environmentalists have exposed for a long time that plastic as a long-lasting pollutant that does not fully break down or degrade, in other terms, not biodegradable. The lifespan of plastic commonly up to 450 years and degrade to small particles. From larger pieces, the plastic can be degraded into the smaller form such as microbeads. Plastic can be broken down from larger pieces into smaller pieces’ form like microbeads.

Based on Barnes, Galgani, Thompson, & Barlaz (2009), plastics that are available in the environment has various of sizes and range in between metres to micrometres. Microplastic is the smallest form (less than 5 mm) of plastic litter which that present in the environment and they can categorise into two which are primary microplastics and secondary microplastics. Primary microplastic is plastic that originally manufacture in smaller form such as pellets. Through transportation of rivers, discharge from treatment plant, wind and surface run-off due to heavily rainfall, this primary microplastics end up can be found in the ocean (Directive, 2013).

Meanwhile, secondary microplastics can be defined as larger debris or plastics that undergo fragmentation or photo-degradation process and break down into smaller particles. (Thompson et al., 2009; Directive, 2013). The abundance of microplastics in aquatic environment could lead to negative impacts on environment especially in seabed which higher chances of benthic organisms ingest the microplastics that was mistaking them as food. Other than that, exposure of carcinogenicity is higher because of the accumulation of the microplastics in sediment which the occurrence of microplastics in sediment is more longer than in the water bodies and tend to photo-degradation. The study about the composition and polymer origins of microplastics is necessary in order to identify the impacts of microplastics towards environmental.

## 1.2 Problem Statement

About 300 million tons of plastic has been produced a year by plastic industry (Griffin & Wilkins, 2019). Due to its flexibility, lightweight and sustainable, this plastic has been popular among the consumerism and manufacturer. Only nine percents of this plastic waste gets recycled while the others, has become waste as stated by Griffin & Wilkins (2019). Instead, the plastic was disposed in improperly ways such as thrown away from the car window, dropped them on the ground accidentally and did not picking up back and the mostly consumers always do is thrown into the full rubbish bin and when the garbage truck time to collect the plastic waste remains sat on that places and begin the environmental pollution. Indeed, it becomes common in this world when the environment is littered by the plastic.

The plastic waste generated on land ends up received by the ocean since the location of terrestrial is nearly to the ocean. Every year, they are many plastic which is up to million tonnes that being end up in the world's oceans and main reason are discarding of plastic waste in improperly ways. It published in 2014 where the amount of near-surface plastic debris in the world's oceans was examined through the oceanographic study and estimated about 5.25 trillion individual plastics that floating nears the surface. Only 1 percent that stayed in the surface and the rest is sinks to the ocean floor.

In the late 1960s, a scientist that carried out the study of plankton has noticed the plastic pollution events and till today, the oceans and beaches receive the most concerns in reducing the plastic pollution. The fact is there are floating plastic waste cover the fourty percent of the world's oceans as they shown in five subtropical gyres. The marked of plastic waste problem is the Great Pacific Garbage Patch that has been described as Texas floating in the pacific oceans as it is from accumulation of plastic waste.

In the marine environment, this plastic pollution has been kills about 1 million of seabirds and 100,000 marine mammals each year in directly ways such as entanglement and stuck in larger plastic waste such as fishing gear and also kill through ingestion, by mistaking them for food. Recently, studies have found that all kinds of aquatic species easily ingest the plastic bits and debris due their morphology that attract the attention of the organisms.

Plastic properties do not biodegrade but they disintegrate into smaller particles that organisms especially fish to ingest it. When the fish has being fishing up by fishermen then sold to the customer and eaten as well by the customer, the micoplastics end up in human body through the ingestion of fish that contains the mircoplastics. Other than that, the plastics can acts as carriers of various toxins such as additives that have been degraded and accumulate persistent organic pollutant (POPs) which are toxin may cause of great health problems to humans. Plastic debris could also accumulate metals from the surrounding environment.

The study of microplastics in sediment in Malaysia and Thailand is very limited where only several papers reviewed about this research. In this case, the research of microplastics has been chosen in sediment in seafloor which there is positive correlation between the amount of the microplastics in the sediment and the ingestion of the microplastics by the aquatic organisms.

## 1.3 Objectives

a) To determine the presence of miroplastics in sediment at Kelantan Bay, Malaysia and Pattani Bay, Thailand.
b) To identify the composition and polymer origin of microplastics in sediment by using Fourier ransforms infrared spectroscopy (FTIR).

## 1.4 Scope of Study

In this study, sediment in seafloor has been chosen to analyse the microplastics presence in the marine environment. The microscopy exam and FTIR analysis has been used to observe the classification of size, shape of the microplastics, colour and the composition of the microplastics that presence in the sediment. There are some methods that are used to extract the microplastics from the sediment sample. In this research, Wet Peroxide Oxidation (WPO) and density separation has been used to extract the microplastics from the sediment sample.

**1.5 Significant of Study**

Plastic waste can degrade through the photo-degradation processs, where polymer of the plastic was merge by the oxygen atoms that gains the energy from the ultraviolet (UV) light from the sun. The plastic then becomes crumbling and degrade into smaller particles. Insufficient of light, oxygen and temperature is low in the seafloor where the temperature in seafloor is much cooler than the water in the surface might cause this process take longer time.

When the plastic fragments over exposed for a longer time, microplastics result which in long term or maybe in short term can give bad impact towards marine ecosystems and the study about the occurrence of microplastics in sediment is needed. Through this research, the microplastics presents in the sediment have been determined. The composition and the polymer origins of the microplastics also has been analysed through this research.

# CHAPTER 2

# LITERATURE REVIEW

The wide distribution of plastic has increasing the amount of plastic debris in environment that raised global concerns into environment. According to PlasticsEurope (2015), around 300 million tonnes of plastic produce annually. 10 percent of plastic fragments being end up in marine environment due to excessive of usage, demanding in production of plastic product, and poor management of the waste (Cole *et al*., 2011). Hence, this plastic debris might be causes of reducing the quality of water environment due to the impacts towards environment such as biodiversity loss and at the same time can be threat hazards to public health (Thompson *et al*., 2009; Gall & Thompson, 2015).

## 2.1 Characterisation of Microplastics

There a various types of microplastics with different sizes, shapes and origins due to the diversity of sources. Their presents and impacts towards environment can be determined through their characteristics. Since there are various types, sizes, shapes and colours of microplastics, the marine organisms and seabirds can easily mistake the microplastics as their food (Hidalgo-Ruz, Gutow, Thompson, & Thiel, 2012).

### 2.1.1 Types of Microplastics

Microplastics can be found in many types such as plastics pellets, fragments, filaments, films, foam, granules, and styrofoam. Different types of microplastics can give different impacts towards environment. For example, plastic pellets that mainly can be found near to plastic-processing plant.

Plastic pellets can be defined as raw materials that are melted and form to create plastic products. Plastic pellet can be form to various shapes and colours. During their residence at sea, the changes of plastic pellets properties such as buoyancy and density might be happen due to the bio-fouling, and weathering (Andrady, Hamid, Hu, & Torikai, 1998; Morét-Ferguson *et al*., 2010). For example, due to the longer time of exposed to the aquatic environment, the specific density of plastics pellets such as high density polyethylene (HDPE) decreased from 0.85 to 0.81 g $cm^{-3}$ and for polystyrene (PS) declined from 1.41 to 1.24 g $cm^{-3}$ (Morét-Ferguson *et al*., 2010).

Fragments have many different of types and various origins. These plastic types have been defined as "weathered, irregularly shaped and sized de-gradational chunks of plastic", with sharp, broken edges (Gregory, 1978; Shaw & Day, 1994). Fragments mostly came from many sources such as fishing nets and raw material from industrial. For example such as from industry of ship breaking or polymer fragments from the oxo-biodegradable plastic (Doyle, Watson, Bowlin, & Sheavly, 2011; Reddy, Shaik Basha, Adimurthy, & Ramachandraiah, 2006; Brine & Thompson, 2010).

Fiber are significant land-based input source of microplastics which originally from fabrics, for example, through clothing washing (Browne *et al*., 2011;

Napper & Thompson, 2016). Additional sources of microfibers are fishing tools such as nets, ropes and monofilaments and also used in aquaculture farms. A high proportion of fibers, made of polymers that are denser than the body of water, were found in sub-tide sediments, indicating their elimination from surface water by sinking.

Other several types of microplastics are microbeads that mainly founds in cleansers, mostly facial cleanser and low density of fibers of polyester that freely or escaped to the oceans from wastewater plants (Browne *et al.*, 2011).

### 2.1.2 Shape of Microplastics

Microplastics had different shapes, ranging from circular to spherical and long-fine fibres. Pellets types of plastics can be found in tablet-like, oval, cylindrical, spherical, and disk shapes, usually spherical while for the plastic fragments is depends on the period time of over exposed to the marine environment and the process of fragmentation (Abu-Hilal & Al-Najjar, 2009). Sharp edges signify either the beginning of entering the sea or the recent break-up of larger parts, while the smooth edges are made of older fragments, which remain continuously polished by other particles or sediments (Doyle *et al.*,2011).

Larger particles more to lengthen and irregular surfaces, while the particles that small in size were more to circular shapes (Gilfillan, Ohman, Doyle, & Watson, 2009). Most over time, the particles continue to degrade into small particles (Doyle *et al.*, 2011). Visible crack on the plastic surface likely because of degradation and erosion of the surface of the particles caused by certain factors such as biological breakdown, photo-degradation, chemical weathering, or physical forces and end up producing various types of particle shapes (Anthony L. Andrady, 2011; Shaw & Day, 1994). Based on Shim, Hong, & Eo (2018), microplastic shape can affect floating, sinking and transportation behaviour. Furthermore, the shape of the microplastics may have an effect on the ingestion and the removal rate of microplastics by aquatic organisms.

### 2.1.3 Colour of Microplastics

Colour can further break down where microplastics are distributed among abundant massive of other waste or debris. Particles that has bright coloured and eye-catching types of has higher possibility to identify as microplastics while the particles that has dull colours are simply unnoticed hence high capability on attract the marine organisms (Hidalgo-Ruz *et al.*, 2012).

In the classification of the chemical composition in the most common samples, the colours are one of the classification of microplastics that need to be studied in advance (Abu-Hilal & Al-Najjar, 2009). Mostly polypropylene (PP) has transparent and clear coloured while for white plastic pellets have been pointed to polyethylene (PE). According to the Shiber (1987), Polyethylene (PE) that have low density own the opaque colours and for ethyl vinyl acetate more onto pellets that has clear and particularly transparent (Shiber, 1987).

Colour is one of the index to measures the residence time at the sea, photo-degradation and weathering event (Anthony L. Andrady, Pegram, & Song, 1993; Ogata *et al.*, 2009; Turner & Holmes, 2011). Based on the article by Endo (2005), amounts of PCBs is higher in discoloured PE pellets rather than non-discoloured because process of discoloration (yellowing) indicate a longer time of exposure to seawater where the chance of polymers become oxidized is higher. For polystyrene (PS) and PP has composed of black colour and aged pellets that presented various types of adsorbed pollutants such as PAHs and PCBs (Frias, Sobral, & Ferreira, 2010).

### 2.1.4 Polymer Origin of Microplastics

Different types of polymers were created due to the demand of various types of plastic products. According to Plastics Europe (2016), “Big Six” resins which is polypropylene(PP), high-and low-density polyethylene (HDPE and LDPE), polyvinyl chloride (PVC), polyurethane (PUR), polyethylene terephthalate (PET), and polystyrene (PS) are the usually plastics that reported in marine environment (Browne *et al*., 2010). Based on the global production and worldwide used, polymers of polyethylene (PE) and PP that dominantly found in all environmental section (Lenz *et al*., 2015; Antunes *et al*., 2013; Gesamp, 2016).

Each different of polymers have a different densities (Hidalgo-Ruz *et al*., 2012). This chemical structure of polymers can be assumed as they can give an impact has they have tested in both isolated differently and in mixtures that has complex solution. However, the geographical event must be considered as it is may affects the structure of polymers. For example, dominantly polyester is fibers collected in sea but due to local activities it might be originally nylon.

## 2.2 Sources of Microplastics

According to Pettipas *et al* (2016), it is significant in identifying the source of the microplastic in reducing the impacts of microplastics towards environment especially. The categories of microplastics can be into two which is the first one is primary and second one is secondary. Bergmann *et al.*, (2015) stated that the sources of microplastics can be classified into two, land-based such as micro-beads and litter and sea-based such as fishing nets and buoys.

Microplastics could be manufactured from the degradation of larger plastic litter and breakdown to small particles of plastic. The origins of microplastics can be from the abroad harbours, production of industrial sites, textile manufacturing, sewage treatment plants and human activities such as dumping and urban runoff (Dubaish & Liebezeit, 2013; Salvador Cesa *et al*., 2017). Different sources can produce different types of particles (Horton, Svendsen, Williams, Spurgeon, & Lahive, 2017). As stated by Yu *et al*., (2016), even the various colours of microplastics verified that they are many different sources of microplastics. The microplastics derived from synthetic and could be enriched with organic substances is approved due to presence of colour microplastics.

Based on morphology, microplastics are classified into two which is primary, where the microplastics manufactured in small size and secondary microplastics is microplastics that extract from larger plastics. In the other meaning, based on the shape and surface texture of microplastics, they can be classified into two categories, primary or secondary. For example primary microplastics consist of smooth edges or texture and symmetrical shape (Estahbanati & Fahrenfeld, 2016).

Primary microplastics is the best described as microplastics that original manufacturing with size less than 5 mm and commonly can be found in the medicines, textiles industries and personal care products especially facial cleansers and body scrubs (Cole *et al*., 2011; Bergmann *et al*., 2015). These primary microplastics came from the activities of plastic production and it spilled enter the near water-bodies such as rivers and it might be escaped through the treatments screen in water treatment plants (Gall & Thompson, 2015).

Secondary microplastics are originated from the degradation of larger plastic waste that undergo through mechanical forces such as thermo-degradation, photolysis, thermo-oxidation and biodegradation processes (Zhao, Zhu, & Li, 2015). Secondary microplastics dominantly found in resin pellets industries, items of household and other of plastic litter (Eerkes-Medrano, Thompson, & Aldridge, 2015).

The increase production of plastic from different sources could lead into increasing of plastic debris that abundance in waters and lead into continual transformation of secondary microplastics (Cole *et al*., 2011). There will be high possibility where the microplastics will break-down into nanoplastics and it may cause high risks into environment. Due to the wide variety of sources and routes, it cause the secondary microplastics difficult to identify (Stolte, Forster, Gerdts, & Schubert, 2015). In fact, the understanding about the sources and pathways of microplastics is needed to prevent the pollution of our environment (Bergmann *et al*., 2015).

## 2.3 Occurrence of Microplastics in Sediment

The study on presence of microplastics in sediment is very limited where only 22 papers reviewed that main focusing the microplastics in sediment. The distributions of microplastics in marine environment such as sediments, open waters and organisms is become widely concerns (Ivar Do Sul & Costa, 2014). The occurrence of microplastics in sediments was mainly associated to density of the microplastics. The approximate of plastic particles density was determined by the type of polymer used and the process of manufacturing that involved. For example, polystyrene (PS) foam has the lowest density, 0.05 $g/cm^{-3}$ while polytetrafluoroethylene (Teflon) has the highest density with 2.1-2.3 $g/cm^{-3}$ (Rodríguez-Seijo & Pereira, 2017).

Microplastics that have low density than seawater will float on the surface of the seawater. As reported by Wright et al. (2013b), polyethylene (PE) will floating in the surface of seawater due to its lower density (0.91-0.94 $g/cm^{-3}$) than the seawater and this type of plastic will be ingest by planktivorous or filter feeders while the high-density plastics like polyvinyl chloride (PVC) (1.35-1.39 $g/cm^{-3}$) will tend to sink into sediment and be uptake by detritivores or benthic organism.

According to several studies (WWF, 2018), 80 percent of plastic in our ocean is from land sources and it can come to our ocean in three major ways such as dump plastic in the bin, throwing and at last the products going down to the drain. Once in the ocean, plastic stays in the surface level of the water bodies for certain period of times, breaks down into tiny pieces and then travels to other trophic level of the water bodies such as middle level and finally to the bottom level while Valeria and her research team has stated that, the condition of high specific density plastics in an open ocean is they will directly sink and accumulate in sediments.

## 2.4 Microplastics in Malaysia

Research about microplastics in Malaysia is very limited where there is only several paper reviewed about the microplastics. One of the papers reviewed is mainly focussing on occurrence of microplastics in sediment. This research has been done in December 2017 at Skudai and Tebrau River, Johor (Sarijan, Azman, Said, Andu, & Zon, 2018). Both of the rivers were stated as most known contaminated by plenty of trash river in Peninsular Malaysia.

Based on research, the result showed that the occurrence of microplastics in sediment in both rivers is positively where the average concentrations in Skudai is 200 ± 80 and Tebrau River, 680 ± 140 particles per kg and the dominant size (1000 to 5000 μm) was detected in both rivers which can cause the rate of ingestion by aquatic life especially fish is high (Sarijan *et al.*, 2018).

Film is the most abundant types of mciroplastics that have been detected in Skudai and Tebrau River and mostly they are coloured particles. The dominant coloured was found in Tebrau River is Blue while in Skudai River is yellow and white are mostly can be seen. Due to the ingestion of plastic particles by aquatic organisms is increase because of mistaking them for food since it has bright coloured, it is significant on evaluate the various colour of microplastics in the environment. Possibility on reducing of growth rate, hatchability and physical injury of aquatic organisms is higher due to the ingestion incident.

## 2.5 Microplastics in Thailand

Meanwhile in Thailand, the research has been done at Kalim, Tri Trang, and Patong Beach, Phuket Province, southern of Thailand during the period of maximum low tides in November, 2018 (Akkajit, Thongnonghin, Sriraksa, & Pumsri, 2019). The result based on all plastic-debris sizes (macro, meso and micro) found at three selected beaches showed that Patong Beach has the highest concentration (items $m^{-2}$ quadrat) compared to Kalim and Tri Trang Beaches. The occurrence of microplastic debris (items $m^{-2}$ quadrate areas) in Patong Beach was widespread and spatially variable with a range of 7 to 35 $m^{-2}$ quadrats. On the other hand, the abundance of microplastic debris in Kalim and Tri Trang Beaches ranged from 2-13 and 1-14 items $m^{-2}$ square areas, respectively.

Concentrations of all plastic sizes at Patong Beach are higher than at any other beach due to the high rate of tourist activity at this main tourist destination. Discarded plastic waste from tourist activities was a significant source of microplastics. Through this study, fibers, other, and sheets types of microplastics were detected in the sample. Fibers predominated in the micro-plastic components of the samples, especially in Tri Trang (5-15 items) Patong (115 items) and Kalim (6-11 items). The highest number of all three types of microplastics was found at Patong Beach, which coincided with the highest tourist activity rate. Fibers are produced primarily from broken protective boards, ropes and personal care products. Based on Browne *et al.*, (2011), a large proportion of microplastic fibers contained in the marine environment can derive from wastewater as a result of the washing of clothing made from synthetic materials such as polyester or nylon.

In this research, microplastic debris was classified into 7 color categories which are white / transparent, yellow / orange, pink / red, green, blue, purple, and black / brown / grey. The results in Figure 2.1 showed that the common colours were found in the samples at the studied areas are green, pink/red and blue colours. At Patong Beach, 33% of micro-plastics detected were green in color, followed by white/transparent (30%) and pink/red (23%). While in Tri Trang Beach, the results showed that 29% of the total representing the green micro-plastics, 23% representing white/ transparent microplastics and 22% of the total representing pink/red in colours of microplastics. At Kalim Beach, however, blue was predominant colours of microplastics (52%), followed by pink/red (18%) and green (17%).

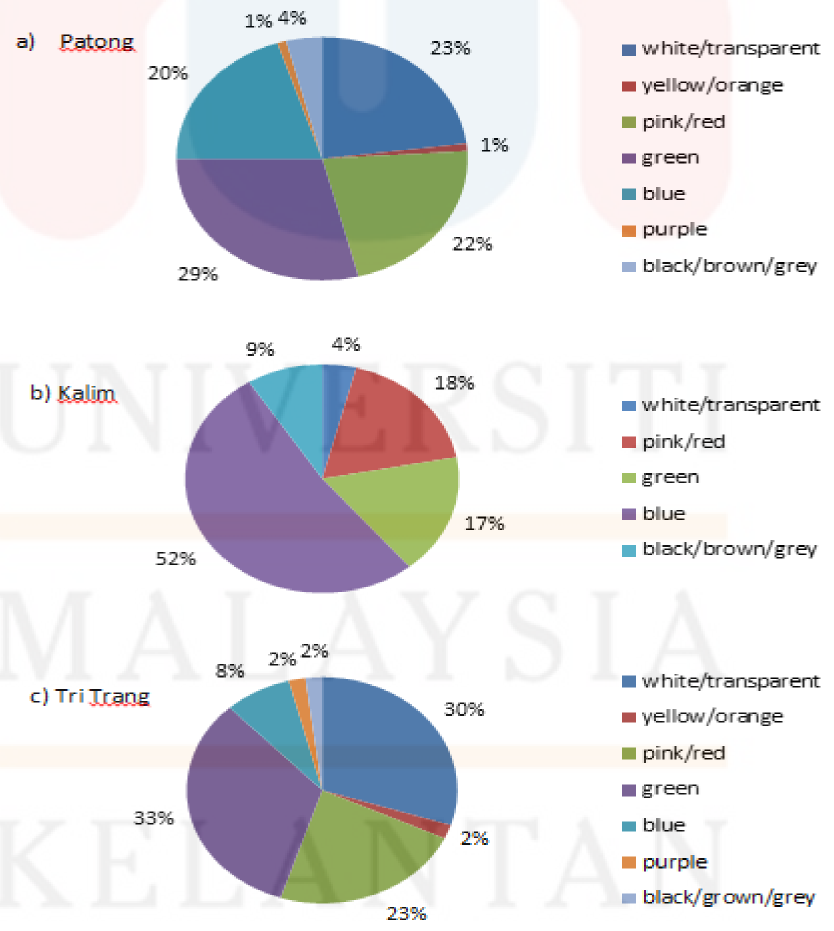


**Figure 2.1:** Colours of microplastics debris found on the beaches of a) Patong, b) Kalim, and c) Tri Trang Beach (Akkajit *et al.*, 2019)

This study found that higher levels of plastic debris at Patong Beach compare to the other beach is because of some factors such as heavy tourism pressure and recreational activities that held at the Patong Beach. The sampling site at Patong Beach was also near to the origins of plastic pollution, indicating the relationship between population density and microplastics debris accumulation. The majority of microplastics debris contained in the samples was made up of fiber, particularly in Kalim Beach, which is likely to have originated from ropes, lines of protection, personal care products and fishing materials. In Patong and Tri Trang Beach, green is the predominant colour of the micrplastics while in Kalim Beach, the predominant colour of microplastic debris is blue.

## 2.6 Effects of Microplastic to Environment

The degradation of plastics will create a mixture of parent materials, different sizes of fragmented particles and products from other non-polymer degradation. Based on other research, mostly biota get easy exposed to complex mixture of plastics and plastic-associated chemicals that change in time and space.

Based on the microplastic's specific characteristic, they are not just posed direct threat to organisms, but they also can pose indirect effects on organisms which this indirect effects defined as the microplastics act as the vector such as bacteria (bacteria threat) and chemical (chemical threat) that may affect the organisms (Van Cauwenberghe, Devriese, Galgani, Robbens, & Janssen, 2015).

The bacterial threat of marine litter and due to increasing of plastic debris can generate new surroundings or residence in the marine environment and the fact that they can be play as substrate and enhanced microbiological interactions (Van

Cauwenberghe *et al*., 2015). Microplastics can form biofilm due to its hydrophobic surface that can stimulate it rapidly due to 'great plate count anomaly' from conventional microbial identification methodologies and it inhibits the full of microbial film characterization (Staley, 1985).

For chemical threat of microplastic, it is complicated and it performance is at different levels. Plastic polymers are considered as biochemically inert as they have large size. However, in the matrix of the polymer, the plastic that contain the residual monomers vary from 4% to 0.0001% still can be found as the reaction of polymerization are barely complete (Arajo, Sayer, Giudici, & Poo, 2002). Some of the residual monomers are considered toxic as it can gives carcinogenic and mutagenic effects that lead to high risks towards environment when they leach out from the polymeric material. Lithner *et al*., (2011) has described that based on the ranking of monomer hazard, the effect can be estimated and listed families of PUR, PVC and styrene is the most hazardous of polymers.

Due to a lot of plastic additives during manufacturing of plastics also can increase the toxic effects of microplastics. For example, to acquire the specific features of the final polymer, the initiators, solvents and catalysts will be added and for agents of antimicrobial like plasticisers, triclosan, pigments, flame retardants (PBDEs) and fillers also will be used in the process plastic compounding. Due to low molecular weight of all these non-polymeric components, it has high potential to drift or diffuse from that plastic polymer.

Beside, chemical contaminants such as persistent organic pollutants (POPs) has similar behaviour which is migration behaviour that they will adsorbed on microplastics. POPs can sorb on or in the plastic matrix of microplastics from the environment such as seawater and sediment. These contaminants have great attraction on plastic matrix compare to surrounding seawater and lead to an accumulation onto the plastic particle. Hirai *et al*., (2011) stated that one million times higher of accumulation was found in some cases.

## 2.7 Effects of Microplastic to Organisms

The increasing of microplastics abundance in environment, leads the aquatic organisms to uptake the particles. The bioavailability of aquatic organisms can be affected by any circumstance such as charge, shape, size, density, colour, and plenty of plastic particles (Kach & Ward, 2008; Wright *et al*., 2013). The size and density of the particles is the key properties that mainly attribute the opportunity of the aquatic organisms to encounter the microplastics.

For example, the particles can be ingested for benthic suspension and deposit feeders is the particles that have higher density than seawater as the particles sink to the sea floor. Sediment-dwelling organisms is not exceptional in ingestion of microplastics even though the size fraction of microplastics is smaller than the grains sizes of sediments (Moore, 2008; Wright *et al*., 2013).

The potential of plastic particles to accumulate within the organisms at the time of ingestion is higher and resulting in injuries of the intestinal tract or might be translocation of microplastics to the other tissues or organs. As stated by Guidelines & Programme, (2007), Thain *et al*., (2008), Fleischer *et al*., (2010), sediment-dwelling organisms are species that used by worldwide as bio-indicators of ecosystem health due to their sensitivity indicator on many kinds of naturally and induced the disturbances by anthropogenic.

Recently studies there have been conducted on the ingestion of microplastics among estuarine fishes from Malaysia in Setiu, Terengganu, which is Lates calcarifer or commonly referred to as Asian sea bass, while in Malaysia, these fish can be found in large quantities in the estuary of Setiu, Wetlands, Terengganu with different habits of life (Ibrahim *et al.*, 2017).

The dominant shape and colour of microplastics and polymer composition has been identified through physical and chemical characterisations. Result has stated that the total number of microplastics was found is 4,498 with the size between 4.3 and 15.7 µm and an average length of 50.1 µm. Most of the microplastics found had threadlike shape with various colours (Ibrahim *et al.*, 2017).

It can be considered as long-term effects of human exposure towards microplastics due to the continuously exposure through several routes and the facts is there is no information of ingestion microplastics by humans (Rist *et al.*, 2018; Wright & Kelly, 2017). Higher potential in having immunotoxicity and trigger adverse effects when there is interaction between the microplastics and nanoplastic with the human's immune (Lusher, Hollman, & Mendoza-Hill, 2017); Wright & Kelly, 2017).

# CHAPTER 3

# MATERIAL AND METHOD

## 3.1 Chemicals and Instruments

The chemicals and instruments that have been used in this research had been listed in Table 3.1 and Table 3.2 respectively.

**Table 3.1:** List of Chemicals and Consumable

| List of Chemicals and Consumable | Brand |
|---|---|
| Whatman No. 4 Filter Paper | Smith |
| 30% Hydrogen Peroxide | Bendosen |
| Sodium Chloride (1.5 $gcm^{-3}$) | HMBG |
| Ferrous Sulphate Heptahydrate (278.02 g/mol) | SIGMA |
| Concentrated Sulphuric Acid | R & M |

**Table 3.2:** List of Instruments

| List of Instruments |
|---|
| Photographed Microscope |
| Fourier Transform Infrared (FTIR) Spectroscopy |

### 3.2 Sampling Sites

The sampling was performed in May and July 2019. Sri Tujuh Beach, Tumpat, Kelantan and Talo Kapo Beach, Pattani Bay, Thailand were selected to collect the sediment samples. By using the Global Positioning System (GPS), the location of the sampling points was determined. Four sampling points at Talo Kapo Beach, Pattani Bay and three sampling points at Sri Tujuh Beach, Tumpat were selected as sampling sites. Each of the sampling points was coordinated and illustrated as shown in Table 3.3 and Figure 3.1 and Figure 3.2.

**Table 3.3:** Information of each sampling points in this study

| Points | Place | Latitude | Longitude | Depth |
|---|---|---|---|---|
| S1 | Sri Tujuh Beach, Tumpat | 6°13’05.4” | 102°07’47.9” | 45cm |
| S2 | Sri Tujuh Beach, Tumpat | 6°13’00.4” | 102°08’02.4” | 40cm |
| S3 | Sri Tujuh Beach, Tumpat | 6°12’58.5” | 102°07’34.7” | 30cm |
| S4 | Talo Kapo Beach, Pattani Bay | 6°53’14.5” | 101°17’52.5” | 60cm |
| S5 | Talo Kapo Beach, Pattani Bay | 6°53’01.6” | 101°17’23.0” | 55cm |
| S6 | Talo Kapo Beach, Pattani Bay | 6°52’55.6” | 101°17’08.3” | 45cm |
| S7 | Talo Kapo Beach, Pattani Bay | 6°54’15.3” | 101°14’45.9” | 65cm |

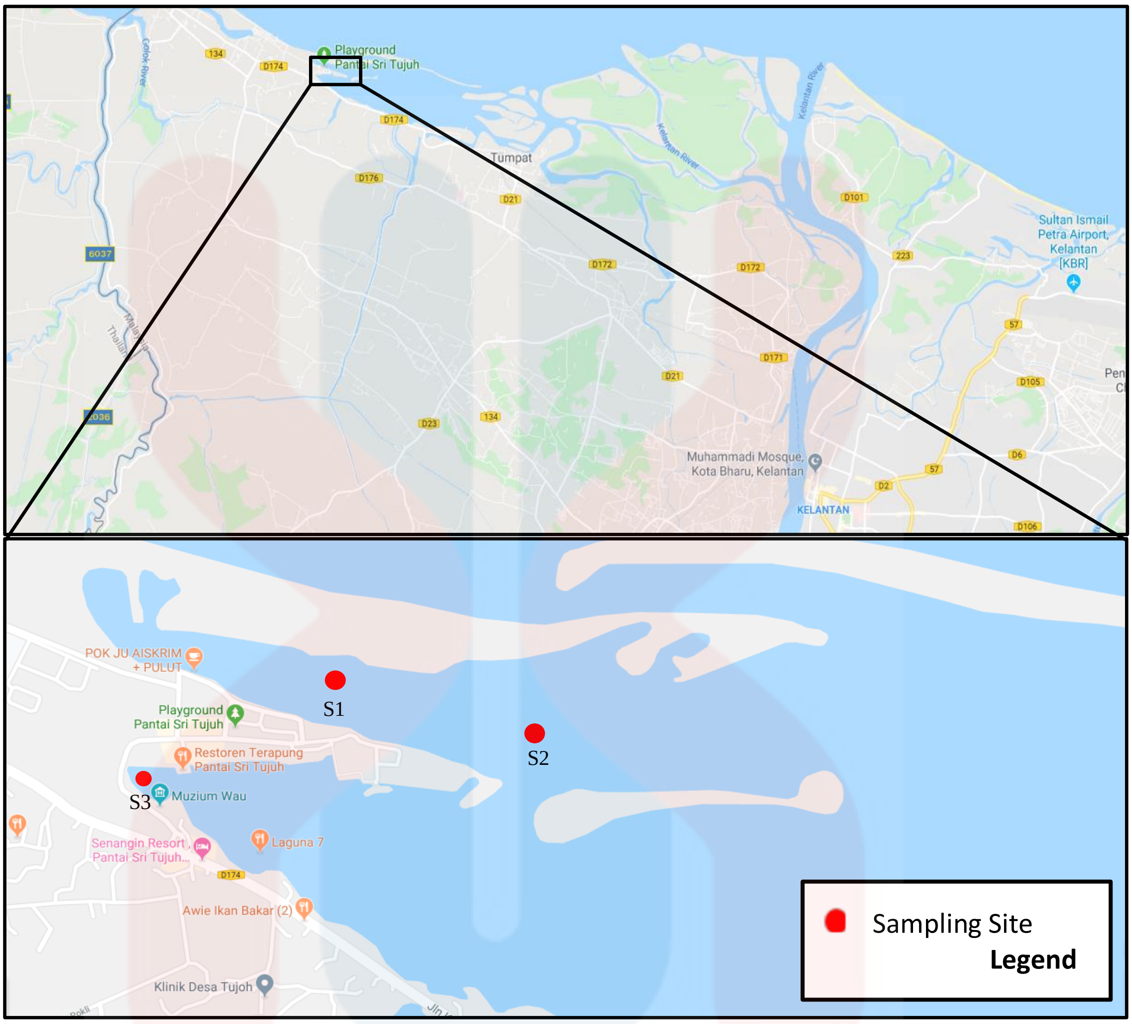


**Figure 3.1:** Three sampling points at Sri Tujuh Beach, Tumpat

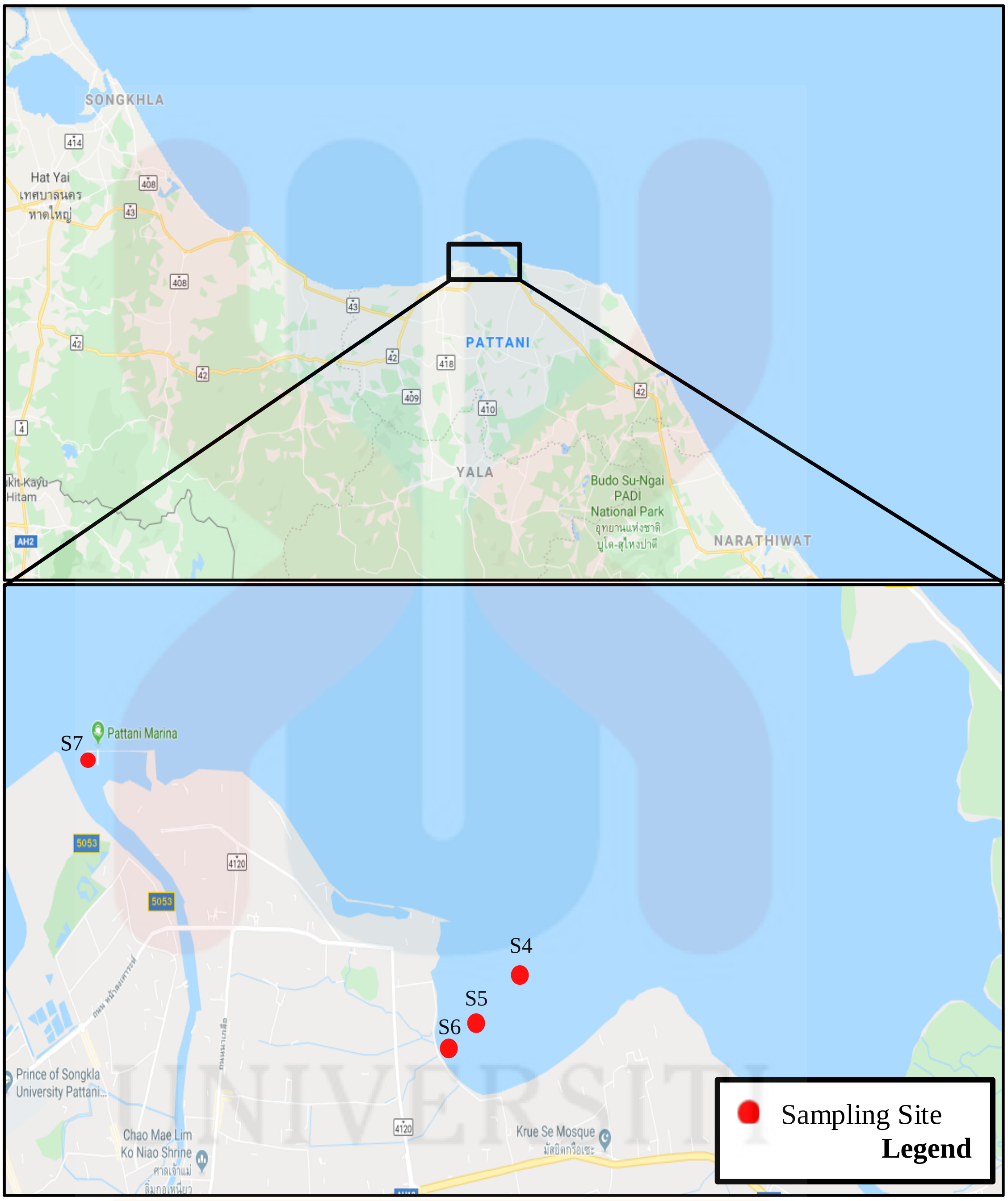


**Figure 3.2:** Four sampling points at Talo Kapo Beach, Pattani Bay

### 3.3 Sampling Procedures

A grab sampler (Ekman) was used to collect the sediment. The samples was stored in killing jar that was covered with aluminium foil to avoid airborne of microplastics contaminated (Masura, Baker, Foster, Arthur, & Herring, 2015). At each sampling interval, the Ekman grab sampler was cleaned carefully with deionized water to reduce cross-contamination. The sediment samples were kept in ice box during transportation and transferred to the laboratory to be kept in -2 ℃ freezer for further analysis.

### 3.4 Sample Preparation

The sample sediments were oven dried for one night or until completely dried at 60℃. Isolation process was performed in two replicates. About 20 g of dried sediment was weighed by using analytical balance and transferred into beaker (250 mL).

### 3.5 Wet Peroxide Oxidation (WPO) Process

About 40 mL of aqueous 0.05 M Fe (II) solution was added into the beaker contain 20 g of dried sediment and followed by 40 mL of 30% hydrogen peroxide ($H_2O_2$) and mixed it for 5 minutes at room temperature. A stir bar was added to the beaker and heated on a hotplate at 75℃ with watch glass covered on it. Remove the beaker from the hotplate as soon as gas bubbles were observed and placed it in the fume hood until the boiling subsides. About 20 mL of 30% ($H_2O_2$) was added if there is still visible of natural organic material. The purpose of this process is use to remove the organic materials in the sample to avoid the interference during observation (Masura *et al.*, 2015).

### 3.6 Density Separation Process

The abundance of microplastics in sediment can be determined by using density separation method where the sodium chloride (NaCl) (1.5 g $cm^{-3}$) was used to increase the solution density (Masura *et al.*, 2015). An amount of 6 g of NaCl was added into the solution and the mixture was stirred for 15 minutes on a hotplate. Then mixture was removed from hotplate and kept cover loosely for three days. After three days, the mixture was filtered by using Whatman no. 4 filter paper. The filter paper was dried in room temperature for further analysis.

### 3.7 Microscopy Exam

Filter paper contains microplastics were observed and photographed using a microscope (DS-Fi2) with 4x-10x magnification. With procedure described in the manual book, the observation of microplastics was carried out under microscope. The measurement was conducted by using with a resolution of 1280x960 pixels. Meanwhile, the particles that have an organic structure have been carefully classified and excluded from the study. Microplastic particles inspected were assessed on the basis of shape, color and size. The particle shape (fibre/line, fragment, film, foam, bead/pellet) category has been evaluated in accordance with the definition described in literature review.

### 3.8 FTIR Analysis

Samples were gently transferred to a sample carrier for FTIR analysis. Fourier transform infrared spectroscopy (FTIR) (Nicolet iS10 FTIR spectrometer) was used to identify the functional groups associated with polymer chemical properties. Microplastic particles were analysed using attenuated total reflection (ATR) in the mid-IR range of 4000 – 650 $cm^{-1}$ and 18 scans per analysis.

# CHAPTER 4

# RESULT AND DISCUSSION

## 4.1 Abundances of Microplastics

Based on this research, all the sediment samples from four sampling points at Talo Kapo Beach, Pattani Bay and three sampling points from Sri Tujuh Beach, Tumpat contains microplastics. In Sri Tujuh Beach, Tumpat, the abundance of microplastics was high in sampling point S1 and S3. Pollution level of sampling point S1 was slightly lower than sampling point S3. This result is understandable given that sampling point S3 is located downstream, which water flow to the sea from river. Compared with other sampling point, the amount of microplastics presents in the sediment of sampling point S2 is lower.

In Talo Kapo Beach, Pattani Bay, most of microplastics have been found in sampling point S7. Sampling point S7 is located at park and there is fishing activities among the local people. Compared to other three sampling points, these microplastics was common in the sampling point S7 due to high population and more visitors. The level of microplastics pollution is higher in some of the studies areas due to actively of human activity.

Comparison between Sri Tujuh Beach, Tumpat and Talo Kapo Beach, Pattani Bay, the abundance of microplastics in Sri Tujuh Beach, Tumpat is higher than Talo Kapo Beach, Pattani Bay which is 34 of microplastics particles were identified in Sri

Tujuh Beach, Tumpat while in Talo Kapo Beach, Pattani Bay, 18 particles of microplastics were detected. The difference between ranges of abundance is due to the location of the sampling points in Sri Tujuh Beach, Tumpat is located at beach that has been developed with resorts, restaurant, jetty and tourism attraction place compared to the sampling point at Talo Kapo Beach, Pattani Bay, average abundance is much lower.

These studies areas generally do not have the serious level of microplastics contamination compare to the previous case study which the average concentrations in Skudai and Tebrau River were 200 ± 80 and 680 ± 140 particles per kg however the abundance of microplastics in this studies areas is quite high than pristine areas. This shows that microplastic contamination in this studies area still needs to be concern.

## 4.2 Shape, Colour and Size of Microplastics

Results for the classification statistic of the microplastics are shown in Table 4.1, Table 4.2, Table 4.3 and Table 4.4. The microplastics that have been collected are classified in two ways: shape and colour. In this research, three types of microplastics were identified which are fiber, fragment and film by using photographed microscopy. The results of the photographed microscopy were shown in Figure 4.1. Fiber is the most common type of microplastics that were found at both studied areas, Sri Tujuh Beach, Tumpat and Talo Kapo Beach, Pattani Bay compare to the other types of microplastics.

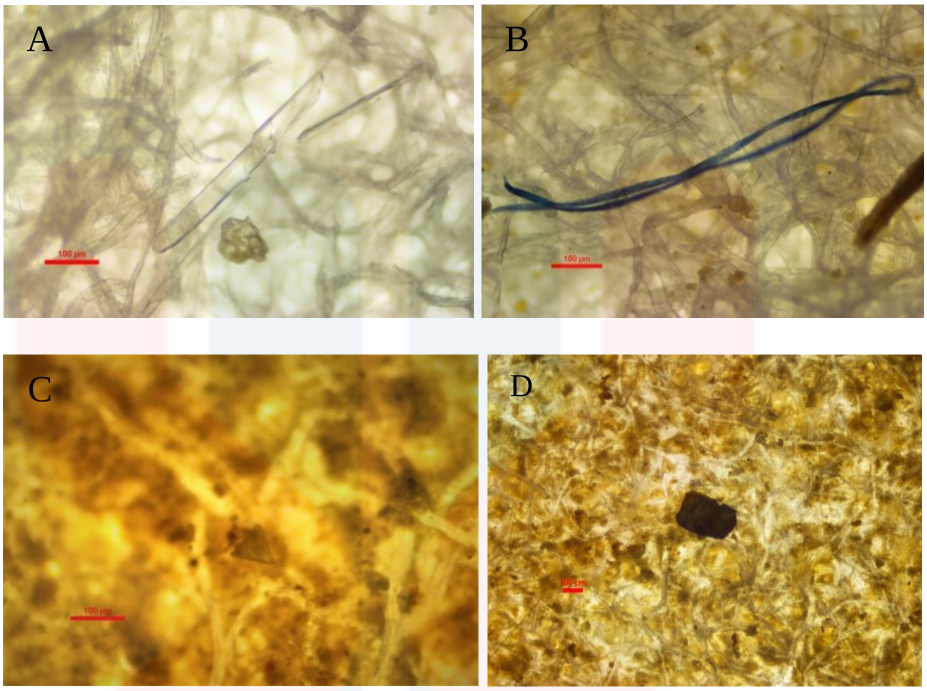

**Figure 4.1:** Different shape category of microplastic particles (A: fragment, B: fibre, C: film, D: fragment) found in Sri Tujuh Beach, Tumpat and Talo Kapo Beach, Pattani Bay.

Based on Table 4.1, it showed that fiber and fragment types of microplastics were found in the sediment samples of Sri Tujuh Beach, Tumpat. The amount of fiber found were higher than the other types of microplastics which is 65%. The abundance of the microplastics fiber and fragment are high in S3 compare to S1 and S2. Film was not detected in the sediment samples of Sri Tujuh Beach, Tumpat.

Result of Talo Kapo Beach, Pattani Bay was tabulated in the Table 4.2 and it showed that fragment, film and fiber were detected in the sediment samples. Film is the predominant types of microplastics in the sediment sample of Talo Kapo Beach which has 67% followed by fiber and fragment. From the Table 4.2, S7 has the most polluted by microplastics compare to the other sampling point in Talo Kapo Beach, Pattani Bay.

Based on the Table 4.1 and Table 4.2, it showed that the number of microplastics fibers in both studied areas is higher due to existing of the fishing activities. Refer to case study in the literature review stated that fiber is the most common found in the sample where the sources of this fiber is originated from ropes, lines of protection, personal care products and fishing materials.

**Table 4.1:** Types of microplastics found in Sediment at Sri Tujuh Beach, Tumpat, Kelantan

| Types | S1 | S2 | S3 | Total of Microplastics | Percentage (%) |
|---|---|---|---|---|---|
| Fragment | 4 | 1 | 7 | 12 | 35 |
| Film | 0 | 0 | 0 | 0 | 0 |
| Fiber | 6 | 3 | 13 | 22 | 65 |
| Total | 10 | 4 | 20 | 34 | 100 |

**Table 4.2:** Types of microplastics found in Sediment at Talo Kapo Beach, Pattani Bay, Thailand

| Types | S4 | S5 | S6 | S7 | Total of Microplastics | Percentage (%) |
|---|---|---|---|---|---|---|
| Fragment | 0 | 0 | 0 | 2 | 2 | 11 |
| Film | 1 | 3 | 2 | 6 | 12 | 67 |
| Fiber | 0 | 1 | 1 | 2 | 4 | 22 |
| Total | 1 | 4 | 3 | 10 | 18 | 100 |

There are four colours of microplastics that have been identified in the sediment samples. Blue was the most common colour that found in the sediment samples in both studied areas, then followed by transparent and red. The black colour of microplastics also been detected in the collected samples. The classification of microplastics colours were tabulated in Table 4.3 for Sri Tujuh Beach, Tumpat and Table 4.4 for Talo Kapo Beach, Pattani Bay. Based on Table 4.3, blue is the dominant colour that has been detected in the sediment samples of Sri Tujuh Beach, Tumpat followed by red, transparent and black. While in Table 4.4, transparent colour of microplastics is the most common found in the sediment samples of Talo

Kapo Beach, Pattani Bay. Red colour was not detected in the samples of Talo Kapo Beach.

**Table 4.3:** Colours of microplastics found in Sediment at Sri Tujuh Beach, Tumpat, Kelantan

| Colours | S1 | S2 | S3 | Total of Microplastics | Percentage (%) |
|---|---|---|---|---|---|
| Black | 1 | 0 | 1 | 2 | 6 |
| Blue | 8 | 3 | 12 | 23 | 67 |
| Red | 1 | 0 | 4 | 5 | 15 |
| Transparent | 0 | 1 | 3 | 4 | 12 |
| Total | 10 | 4 | 20 | 34 | 100 |

**Table 4.4:** Colours of microplastics found in Sediment at Talo Kapo Beach, Pattani Bay, Thailand

| Colours | S4 | S5 | S6 | S7 | Total of Microplastics | Percentage (%) |
|---|---|---|---|---|---|---|
| Black | 0 | 0 | 0 | 1 | 1 | 5 |
| Blue | 1 | 2 | 1 | 1 | 5 | 28 |
| Red | 0 | 0 | 0 | 0 | 0 | 0 |
| Transparent | 0 | 2 | 2 | 8 | 12 | 67 |
| Total | 1 | 4 | 3 | 10 | 18 | 100 |

The dominant size detected in both studied areas was 1000 to 5000 µm. Refer to case study in the literature review, microplastics size ranging from 100 to 5000 µm may lead to high chances of ingestion incidence by aquatic animals. All microplastics obtained are derived from the fragmented and weathered of larger plastic items where this type of plastic particles is usually categorised as secondary sources of microplastics. According to Eerkes-Medrano *et al*., (2015), secondary sources of microplastics are typically associated with high population density areas, of which based on the level of local human activities.

### 4.3 Composition of Microplastics

There were 52 totals of microplastic particles that have been collected in both studied areas. Not all the microplastics particle were performed under Fourier transform infrared spectroscopy (FTIR) due to limitation of time and costly in testing. Therefore, several microplastics have been chosen for identification in order to obtain a firm conclusion. These selected microplastics originated from all sampling points and were available in all shapes, sizes and colours. There were 27 totals of suspected microplastics that have been chosen for Fourier transform infrared spectroscopy (FTIR) analysis. The results of Fourier transform infrared spectroscopy (FTIR) are shown in Table 4.5. There are diverse types of microplastics polymers that have been identified, including Polyethylene (PE), Polyethylene Terephthalate (PETE or PET), High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), and Polyamide (PA).

**Table 4.5:** Polymer types for the result of the FTIR

| Types | Sri Tujuh Beach, Tumpat | Talo Kapo Beach Pattani Bay | Total of Microplastics | Percentage (%) |
|---|---|---|---|---|
| Polyethylene Terephthalate (PETE or PET) | 0 | 5 | 5 | 19 |
| High-Density Polyethylene (HDPE) | 0 | 3 | 3 | 11 |
| Low-Density Polyethylene (LDPE) | 4 | 2 | 6 | 22 |
| Polyethylene | 6 | 1 | 7 | 26 |
| Polyamide | 2 | 4 | 6 | 22 |
| Total | 13 | 14 | 27 | 100 |

Based on the Table 4.5, there were five totals of plastic types according to the composition of the microplastics that were found in sample. As the largest number of microplastic type found in this study, PE is the thermoplastic materials and an extremely large range of applications. PE is used in applications ranging for films, tubes, plastic parts, laminates, packaging and many more. PE is also one of the important raw material for fishing nets and sources of fiber. In Figure 4.2, the FT-IR spectrum showed the Polyethylene (PE) compositions that found in sediment sample of Sri Tujuh Beach. When compared to the spectra of sediment samples and library FTIR, the appearance and number of identifiable wavenumbers were nearly identical. Spectra of PE showed absorbance bands at the 2914 $cm^{-1}$, 2847 $cm^{-1}$, 1378 $cm^{-1}$ and 718 $cm^{-1}$ ($CH_2$ rock).

This findings reflect the living conditions and behavioural of the local people and foreigner who visit the Sri Tujuh Beach. The greater amount of the PE also may come from the rubbish that discarded by the people who visit the Sri Tujuh Beach for an activity purpose such as team building and picnic. Additionally, some villages are scattered along the Sri Tujuh Beach, which these villagers live by fishing activity. The blue and red colour of fibers that found in the sediment samples originated from fishing nets that used as fishing tools. Poor living habits and inadequate drainage systems have contributed to PE, PETE, and LDPE entering the ocean through the stream flow.

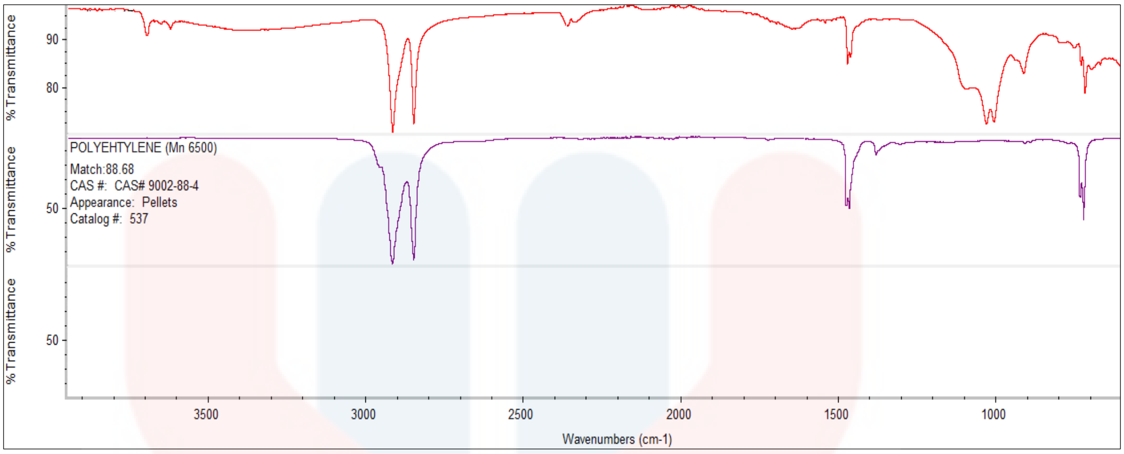


**Figure 4.2:** FT-IR spectrum showing the Polyethylene (PE) composition

Low Density Polyethylene (LDPE) is widely used to manufacture thin and flexible products such as plastic bags for dry-cleaning, newspapers, frozen foods, fresh produce and garbage products. The paper milk cartons coatings, plastics drink cups, shrink-wrap and stretch film also are made from LDPE. Additionally, manufacturers use LDPE to produce thin jar lids, squeezable bottles and certain toys. Based on this study, the restaurant located above the surface water may influence the greater amount of LDPE that found in the study area of Sri Tujuh Beach.

Figure 4.3 showed the spectrum of FT-IR of Low-Density Polyethylene (LDPE) composition that found in the sediment sample that collected from Sri Tujuh Beach. LDPE and HDPE share the same major structural unit, functional groups, chemical bonds which make difficult to differentiate both of this polymer. However, the different degree of branching results in small, but important differences, in the spectral region of 1400 $cm^{-1}$ to 1330 $cm^{-1}$ with LDPE having greater intensity at 1377 $cm^{-1}$ due to methyl bending deformation of the branched chain end. This LDPE has found more in Sri Tujuh Beach than in Talo Kapo Beach due to the development of both areas is different where Sri Tujuh Beach more onto recreational area but Talo Kapo Beach is an area of industrial.

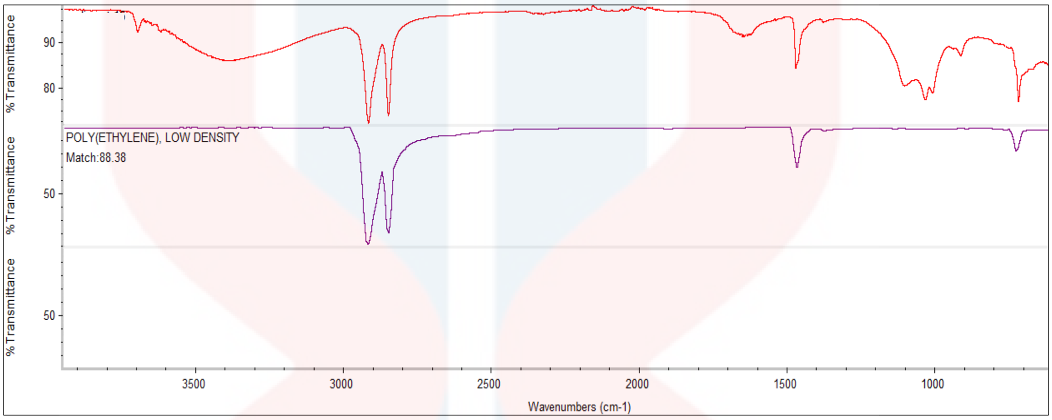


**Figure 4.3:** FT-IR spectrum showing the Low-Density Polyethylene (LDPE) composition

Polyethylene Terepthalate (PET) is spun into fibres for permanent-press fabrics, blow-molded into disposable beverage bottles, and extruded into photographic film and magnetic recording tape. PET is produced by ethylene glycol and terephthalic acid polymerization. PET is commonly used in water bottles, soft drink bottles, sports drink bottles and condiment bottles that are sold commercially. Although it is generally considered a "safe" plastic and does not contain BPA, for long time exposure to environment, it may cause the leach of chemical additives from the plastic particle which can affect the marine environment especially the aquatic life.

Figure 4.4 showed the FT-IR spectrum of Polyethylene Terephtalate (PETE or PET) composition that had been found in the sediment at sampling point S7, Talo Kapo Beach. Spectra of PETE/PET showed absorbance bands at the 1713 $cm^{-1}$ (C=O stretch), 1241 $cm^{-1}$, 1094 $cm^{-1}$ (C-O stretch) and 720 $cm^{-1}$ (aromatic CH). The sources of this PETE can be from the rubbish that has been discarded by the tourist who visited the Pattani Marina Park. The main activity in this area is fishing, and they are also one of the sources of PETE.

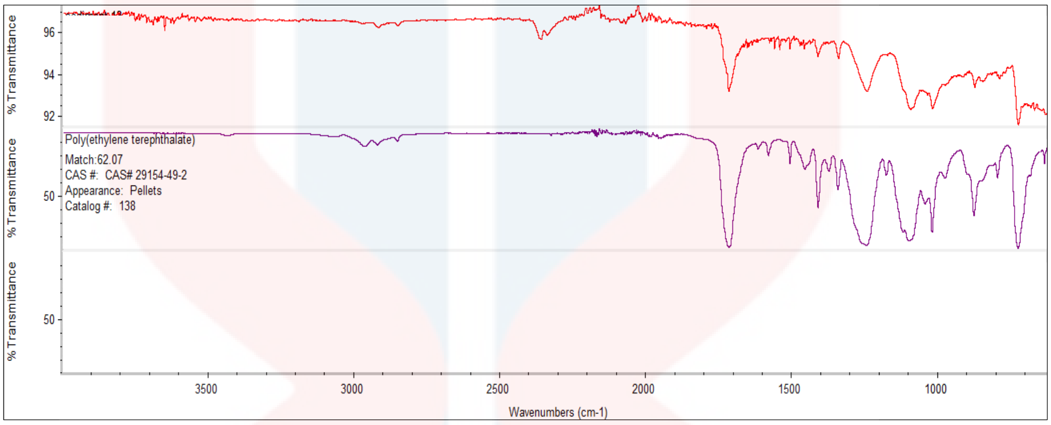


**Figure 4.4:** FT-IR spectrum showing the Polyethylene Terepthalate (PETE or PET) composition

Several microplastics were also identified as Polyamide (PA) and High-Density Polyethylene (HDPE). PA or commonly known as nylon is considered high-performance plastics and is widely used in automotive and transportation, consumer goods, electrical and electronic applications, among others. Aromatic polyamides (or aramids) are derived from terephthalic acid polycondensation with diamines. The properties of PA which are resistance to chemical, electrical and high temperature, made them used widely in automotive industry. The amount of PA present in Talo Kapo Beach is influence by the surrounding area where the sources of the PA may come from the effluent discharge from the industrial factory to the stream and end up flow to the ocean.

High-Density Polyethylene (HDPE) was only found in Talo Kapo Beach, Pattani Bay. More attention is needed even though there were only 11% of HDPE in samples have found. HDPE has been used widely in plastic packaging of food, laundry detergent, garbage bins and also cutting boards since its production in the

1930s. Due to its toughness and resistance to crack or corrode, makes it good packaging for detergents and household cleaners. It is also suitable for storage of perishable goods, such as milk, but not for long-term storage of food. HDPE is inexpensive to make and can be easily recycled. This HDPE is made of natural gas ethane and the molecules split apart when it is heated to 1500 degrees Fahrenheit. For a long time exposure of the HDPE to sunlight can make it harmful.

## 4.4 Comparison of Microplastics

Through this research, the comparison of microplastics presents in sediments at Kelantan and Pattani Bay based on types, colours and polymer origin have been shown in Table 4.6 and Table 4.7 respectively. Based on Table 4.6, all three types of miroplastics which is fiber, fragment and film has been detected at Pattani Bay while in Kelantan, only fiber and fragment were detected and it showed that all type of coloured microplastics (transparent, blue, black and red) were identified in Kelantan but in Pattani Bay samples, the red colour of microplastics were not found. The comparison of polymer origin of microplastics in sediment at Kelantan and Pattani Bay has been shown in Table 4.7 where the PETE or PET and HDPE were not found in sediment samples at Kelantan.

**Table 4.6:** Comparison of microplastics based on types and colours in sediment at Kelantan and Pattani Bay

| Location | Types | | | Colours | | | |
|---|---|---|---|---|---|---|---|
| | Fragment | Film | Fiber | Blue | Red | Black | Transparent |
| Sri Tujuh Beach, Tumpat Kelantan | √ | | √ | √ | √ | √ | √ |
| Talo Kapo Beach, Pattani Bay | √ | √ | √ | √ | | √ | √ |

**Table 4.7:** Comparison of microplastics based on polymer in sediment at Kelantan and Pattani Bay

| Location | Polymer | | | | |
|---|---|---|---|---|---|
| | PETE/PET | HDPE | LDPE | PE | PA |
| Sri Tujuh Beach, Tumpat, Kelantan | | | √ | √ | √ |
| Talo Kapo Beach, Pattani Bay | √ | √ | √ | √ | √ |

As an emerging pollutant, the research of microplastics still has many lacks especially in Malaysia and Thailand. Nevertheless, these studies often concentrate on abundance, distribution, morphological characteristics and composition, as the rates of microplastic contamination are determined solely by the quantity or weight of the particles collected. There are many plastic types and the environmental threats of different plastic forms differ significantly. The studies of chemical compositions and the ecological risks are needed in order to understanding more the effects of the occurrence microplastics in the marine environment.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

In this study, microplastics present in the sediment in Sri Tujuh Beach, Tumpat and Talo Kapo Beach, Pattani Bay has been reported. The abundance of microplastics in sediment is higher which is linked with the sources and distribution of the microplastics from both of the places. Fiber is the dominant types of microplastics that have been found in both studied areas and blue is the most common colour of microplastics that were detected in the sediment samples for both research areas. PE is the main polymers compositions found in the sediment that have been observed. Some types and composition of polymers may provide additional information regarding their origin. This polymer forms shows different environmental behaviours based on their distinct physicochemical characteristics and on the rate of weathering, additive chemicals and interactions in between chemicals and biota. Based on this study, the microplastics pollution still needs an attention even though the research areas do not have a major plastic pollution problem. This may cause more of aquatic life will be affected due to ingestion of the microplastics. The results have showed the value of the control of plastic products and the recycling program to avoid the increase of this risk in the aquatic environment.

## 5.2 Recommendation

Through the progress in conducting this research study, there are several limitations have been encountered and recommendations have been suggested in order to give benefits and convenience for others researchers to acknowledge and make an improvement.

The first limitation that has been discovered is the inaccurate or inappropriate chemicals used during the extraction analysis. Recovery rate and concentration of microplastics can be affected by extraction methods including the density separation process. Select the suitable chemicals such as Zinc Chloride which have high-density than Sodium Chloride is necessary where the density of the salt may influence the process of the density separation. When the density differences between solutions and the microplastic particles is only slightly different, the process separation can take longer time which the microplastics found floating after four days. In order to reduce the time taken, high density solution is more suitable to use during extraction method.

The second limitation that has occurred when conducting this study is the identification of polymer composition of mircoplastics by using FTIR spectroscopy. Due to the size of the microplastic is below than 5 mm, it is very difficult to identify the microplastics on the surface of the filter paper. Most of the microplastics that have found in this study cannot be identified their polymer composition by the FTIR spectroscopy. Therefore, the macroplastics that have been found in the same sediment sample must not be discarded in order to examine by the FTIR. It is possible that the present of the microplastics in the sediment is from the degradation of the macroplastics.

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