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Review on Microplastics Abundance in Malaysian Marine Environment

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***Abstract* – Microplastics in marine environment posed an alarming threat to aquatic lifeforms, and to human consumers. They are characterized according to their physical appearance (size, shape, colour) and its chemical composition through the types of polymers. However, the study on microplastics in Malaysian marine environment still limited due to few studies conducted. Hence, this study aims to visualize, assess and characterize the microplastics abundance in Malaysian marine environment. Ten years' duration of literature review (2010 until 2020) was used in this study. For water sample study, the highest microplastics abundance is from coastal area of Pulau Pinang and Langkawi meanwhile, in sediment sample study is from coastal zone at Straits of Johor. Tourisms and industrial are huge contributor on microplastics abundance in Malaysia. Fragment and fiber, dark colours (black, grey) and white showed the most dominant physical characterization of microplastics analyzed. The dominant polymer's composition is originated from the industry and consumer products.**

***Keywords:* - Microplastics, Marine Environment, Malaysia.**

I. INTRODUCTION

Plastics specifically microplastics (MPs) is one of today's major global issues in the marine environment and gives harmful effect to the environment, aquatic lifeforms, and human consumers. They are classified as either primary or secondary MPs. Primary MPs, such as microbeads and micro exfoliate with large size (1000 µm) and small size (< 400 µm) [1] are abrasive particles incorporated into personal care products. Secondary MPs are plastics with less than 5 mm [2] that are produced from plastic degradation due to sunlight exposure and weathering [3]. MPs characterization are divided into two characteristics: physical and chemical. Physical appearance includes size, shape and colour. The size of MPs is specifically less than 5 mm [2]. Shape of MPs are like fragments (including irregular shape and films), fibers (including microfibers and filaments), beads (including spherical microbeads and grains), pellets (including resin pellets and nurdles), and foams (including polystyrene) [4]. Meanwhile, colour characterization, are blue (including green), red (including pink), yellow (including orange), black (including grey), white and transparent [5].

Chemical composition is characterized by its type of plastic polymer utilized in the products [4]. Polypropylene (PP), polyethylene (PE), polystyrene (PS), polyethylene terephthalate (PET), polyvinyl chloride is used for packaging and container, polyamide (PA) and nylon for fisheries industry, while, rayon, polyacrylonitrile (acrylic) and polyester resin for textile applications [6].

MPs have over 80% annual input from land- based sources [7]. Mainly, MPs enter marine environment through surface runoff from land [8] which included domestic and storm water runoff, weathering of secondary MPs [9], coastal activities, tourisms and fishing activities [10]. While the locality of the MPs in marine environment depends on their density [11]. MPs with higher density are more abundance towards bottom area [4].

Less dense MPs suspends in the water column. However, the MPs in the water column can be accidentally ingested by marine organisms [10]. Presently, the study about MPs in marine environment become an interesting research area in Malaysia due to the limited study conducted [12], [13]. This review is aimed (1) to visualize and differentiate the MPs abundance study in Malaysian marine environment, (2) to review previous study of MPs abundance in water and sediment samples of marine environment, and (3) to characterized the MPs found in the Malaysian marine environment.

II. MPS IN MALAYSIAN MARINE ENVIRONMENT

Review on the recent occurrence of MPs in Malaysian marine environment was done from year 2010 to 2020. In total there are eight study found with four from MPs in water sample another four from sediment sample of marine environment (Table I) (Fig. I). The earlier study is dominated by sediment sample such as from [14] - [16]. This is due to easy method utilized to collect the samples. For instance, marine sediment was scooped using shovel

or stainless- steel scoop or gravity corer at different depth in selected area at mangrove and coastal area [14] - [16]. Water samples on the other hand needed boat to tow net such as manta net [17] and using the heavy steel sampler [18] to collect the water sample. Besides different finding between MPs in water and sediment sample was due to weathering, density presence of MPs at different layer (based on sampling and study area), and major activities occurred in the sampling area (Table I).

For water sample, the samples are mostly from coastal area except study by [18] at berth of Kuantan Port and mangrove area at Cherating [19] (Table I). Study from [17] recorded the highest MPs abundance due to higher population in Kedah, the state of Langkawi (2.19 million) and Pulau Pinang (1.78 million) by first quarter of 2020 [20]. According to the latest economic growth on 2017 recorded by [21] have Pahang (7.8%) as highest growth among study area followed by Kedah (6.2%), Terengganu (5.9%) and Pulau Pinang (5.3%). Both population and economic growth resulted in increasing of plastics and MPs discharge [22] (Table I). These activities contribute to MPs in water due to the runoff process (plastics from land discharge to drainage driven by wind then to river, estuary, coastal area then open sea), and weathering and degradation process due to sunlight exposure. The density of MPs at Kuala Nerus and Kuantan Port dominated by high density, $\geq$ 1.02 g cm^{-3}, made the MPs assemble more in seafloor level.

Meanwhile, for sediment sample (Table I), [14] focused on the MPs in different depth of sediment found that higher abundance at deeper depth due to eroding effect of environment, physical appearance of MPs (weight, density, and size) and further defragmentation allow the penetration of MPs in soil profile. In agreement to [16], higher abundance of MPs with ~400 pieces/kg was found at upper depth or topsoil, as the first layer that contact with most of debris at the terrestrial area also known as environmentally realistic [23].

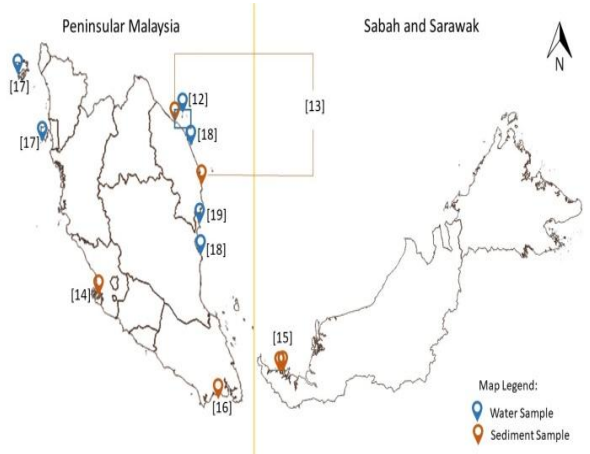

Fig.1. Geographical distribution of studies on MPs

Study from [15] focused on MPs at different strandline resulted higher MPs abundance at upper strandline. Same result presented by [13] which, high tide swash zone has higher MPs abundance (58%) compared to dune zone. This is because most of the debris are washed and sweep away to the uppermost strandline during the highest tide phenomenon the leaving them there as when tide recede [15], [13].

Table 1 Recent studies on MPs in Malaysian marine environment abundance for water and sediment samples of Malaysia's marine environment

Water Sample				
Place	MPs Abund-ance	Pre dominant MPs	Pollution Cause	Ref
Kuala Nerus	0.13-0.69 particles/ L	Density($\geq$1.02 gcm^{-3}:82.8-97.9%)Fragment (76.2%)Black (65.5%)Polyamide,polypropylene	Commer-cial fishing, tourisms	18
Kuantan Port	0.14-0.15 particles /L	Density($\geq$1.02 gcm^{3})Fragment(50.866.%) Grey(48.7%)Polyeser,polystyrne,polymide,polyvinyl chloride, polyethylene	Major multi-cargo port activities	
Lang-Kawi	15.67 particles/ L	Fragment (39%) White (50%)	Tourist spot	17
Pulau Pinang	35.67 particles/ L	Fragment (62%) White (52.34%0	Industrial complex	
Cheratin g Mang Rove	0.0051$\pm$ 0.0053particles/m^3	Fragment (67%) White (38%)	Fishing, tourisms activities	19
Pulau Karah, Pulau Bidong, PulauRedang,one site at upto 24m depth,Tok Jembal Lagoon	0.3-1.45 particles/ L	Fibers (>70%) Polyamide	Development, tourisms, fishing boating activities, coastal erosion	12
Sediment Sample				

Semen-ta Mang-rove, Kapar	N/A	Fragment(dominant at Some sub surface- and deeper depth)	Use of consumer plastic components (bottles,plates,toys and etc.) Boating,fishing,recreational activities	14
Santu-bong(STB)and Trom-bol (TRB)	N/A	at upper strandline . Polypropylene (28.0%, 31.0%: STB) Polyethylene (37.12%, 30.30%: TRB)	Household (items from broken kitchen, bathroom wares, toys, motor oil containers, derelict fishing gear and storage boxes) and heavy industrial .	15
Straits of Johor	~400 pieces/kg-dry sediment	Polypropylene (~200 pieces/kg)	Urban	16
South-ern:Pantai RantauAbang, Pantai Ma'Daerah.Northern:Pantai Penarik, Pantai Pengka-lan Atap.	Pantai Penarik (41.27% - highest) Northern > Southern	Fibers (96.18%) Black (35.68%) High tide swash zone is more contaminated (58%)	Household, sewage runoff (from washing machine), Fishing gear	13

1. Physical Characterization:
The identification technique on physical characterization is microscopy technique except for [16], that focused on analyzed the polymer type of MPs only.

1.1 Size of MPs: For water sample study, the plastics particles with size > 5 mm are discarded before future analysis [18], [12]. [17] and [19] has 1–3 mm and 0.5 – 1.0 mm (46%) as the highest abundance size class of MPs respectively. Meanwhile, for sediment sample study, two out of four studies are absence on the class size of MPs because, the study is focusing on MPs type (shape) [14] and type of polymer [16] crossing varying depth. Study from [15] has only one size class (1 - <5mm) for the sake of clarity. Study from [13] stated that within three size class, > 125 µm (55%) showed the highest abundance located at Pantai Penarik (northern beach).

1.2 Shape of MPs: Most of water sample study has fragment shape as the highest abundance MPs (50.8-76.2%: [18], 39- 62%: [17], 67%: [19]) which might have originated from hard- plastic items degradation of pollution cause's activities (Table I). However, for [12], their study has fiber (> 70%), utilized in textile as the highest abundance especially at near shore sampling area. Meanwhile, for sediment sample study, [14] has fragment as the most dominant shape attributed to utilized of bottles, plates, toys, etc. The compilation of MPs abundance at northern and southern beaches of Terengganu dominated by fibers (96.18%) [13]. The fibers might be originated from washing machine through the sewage runoff [13].

1.3 Colour of MPs: Various colour may give an idea on MPs origin [24]. [18] has black (65.5%) and grey (48.7%) as most frequent colour from Kuala Nerus and Kuantan Port respectively. Study from [19] has white as dominant colour (38%) same as both Langkawi and Pulau Pinang with 50% and 52.34% respectively [17]. Meanwhile, for the sediment sample, study from [13] has black (35.68%) as dominant composition. However, at Pantai Pengkalan Atap, white is the most dominant colour founded due to the usage of white polystyrene foam from fishing gear floats [13].

2. Chemical Characterization
The most common chemical identification technique used is FTIR spectroscopy. Some of the studies that have chemical identification technique as not applicable [17], [13] mentioned that this technique should be implemented in the future for a better result The polymers identified by [18] included polyethylene as widely utilized in fishing materials founded at fishery area. Meanwhile, study from [12] has polyamide as the most abundance polymer since all the water sample collected from different coastal area and nearer islands showed a similar peak for polyamide. Meanwhile, for sediment sample study, study from [15] resulted the polymers commonly found in industry and consumer products such as polypropylene and polyethylene. Meanwhile, study from [16] has polypropylene as the highest abundance with ~200 pieces/kg – dry sediment as contamination from urban area's activity at Johor straits.

III. CONCLUSION

MPs (< 5mm) abundance study in Malaysian marine environment is still limited among researchers. For water sample study, the highest MPs abundance is from coastal area of Pulau Pinang and Langkawi meanwhile, in sediment sample study is from coastal zone at Straits of Johor. The tourisms and industrial activities are high contributor on the MPs abundance in Malaysia. For water

sample, the most dominant physical appearance analyzed are fragment and fiber, dark colour (grey, black) and white, meanwhile for sediment sample are fragment and fiber, black and white. The dominant polymer's composition is originated from the industry and consumer products used in Malaysia.

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