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Microplastic Contamination in Marine Ecosystem of Peninsular Malaysia: A Review in Marine Water, Sediment, and Marine Fish

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ABSTRACT

This study discusses the numbers, types, shapes, and sizes of microplastics (MPs) in marine surface waters, sediments, and marine fish in Peninsular Malaysia. Research publications were gathered and organized utilizing Google Scholar, Science Direct, and Springer Link from 2015 to 2024. The review findings indicate a lack of evidence about microplastic contamination in Kelantan, Perlis, Johor, and Melaka, highlighting the necessity for more research in these regions. Moreover, research on microplastics in surface waters, sediments, and marine life, including fish, requires the standardization of methodologies and equipment. Currently, investigations on microplastics in fish flesh are still limited and require more studies concerning human health risk assessment. Ultimately, focused mitigation strategies and comprehensive research through the development of standardized equipment and methodologies are required to assess microplastic contamination in the marine environment to protect marine ecosystems and humans, particularly in Peninsular Malaysia.

Keywords: Marine microplastics, Peninsular malaysia, Surface water, Sediment, Marine fish.

INTRODUCTION

Microplastics (MPs) pollute oceans worldwide[1] and have been found on the sea floor, coastline, and surface water for decades, and their number has grown annually[2]. This fraction of surface water and beach sand litter consists of pellets and microscopic plastic fragments from larger plastic detritus[3]. MPs' contamination of aquatic ecosystems is a result of factors such as economic expansion, industrialization, urbanization, and inadequate waste management[4]. Primary MPs are released into the environment by the direct or indirect discharge of domestic and industrial waste, spills, and sewage[5]. Meanwhile, secondary MPs are formed by mechanical transformation and biological degradation of microorganisms, such as polyethylene (PE) and polystyrene (PS), by ultraviolet (UV) radiation, wave action, and wind abrasion[6,7].

Peninsular Malaysia is bordered by the Strait of Malacca to the west and the South China Sea to the east, both of which constitute the busiest maritime routes on a global scale[8]. With its large coastline and rich marine biodiversity, Peninsular Malaysia faces plastic pollution[9]. Moreover, fisheries, tourism, and local communities depend on coastal and marine habitats. Meanwhile, over 32 million Malaysians generate 38000 metric tonnes of rubbish daily, according to the Housing and Local Government Minister. This garbage is 24% recycled and 76% landfilled[10]. Furthermore, according to the United Nation Comtrade (UNC) data, [10]added that Malaysia imported 333.5 million kg of plastic garbage in 2019 without including illicit imports. During the breakdown, plastic trash can turn into tiny bits and may endanger wildlife and natural resources. Research indicates that marine organisms can consume MPs, leading to detrimental physical and chemical effects that affect the entire food chain, including that of humans[11,12].

The primary purpose of this review is to discuss MP contamination in the marine ecosystem of Peninsular Malaysia that focused to microplastic contamination on marine surface waters, sediments, and marine fish. To meet the purpose of this study, several approaches were defined: (1) to discuss MP contamination in marine surface waters, (2) to elaborate on MP pollution in the sediments of marine ecosystems, and (3) to investigate MP accumulation in marine fish around peninsular Malaysia.

MATERIALS AND METHODS

Qualitative research was performed in this review by employed the research articles from Google Scholar, Science Direct, and Springer link search engines to collect the data. All research articles in English version that related to MPs contamination in marine ecosystem around peninsular Malaysia including surface water, sediment and marine fish was gathered, examined, and filtered from papers published between 2015-2024, with the most recent search on May 10, 2024. The following keywords were used to find articles: microplastics (MPs), Malaysia, marine surface water, marine sediment, and marine fish. Data on the number, type, shape, and size of microplastics in the surface marine waters, sediments, and marine fish were collected from selected papers. All data collected will be displayed in the tabular form and will be discussed descriptively. Ultimately, it will be possible to identify research gaps that must be addressed in the future to protect the marine ecosystem and ensure the safety of the people of Peninsular Malaysia.

RESULTS AND DISCUSSION

Microplastics contamination in the marine waters of peninsular Malaysia

Microplastics pollution in the marine waters of Peninsular Malaysia was first documented in 2018 by Khalik[13], who conducted a study of MP contamination in Kuala Nerus, Terengganu. It has been detected throughout the West Coast of Kedah, Penang, Selangor, and Negeri Sembilan. Conversely, the MP pollution investigation was primarily focused on Terengganu and Pahang on the East Coast (Table 1). The eastern states of Kelantan, Terengganu and Pahang in Peninsular Malaysia produce 0.71 kg of solid waste/inhabitant/day[10,14,15]. Moreover, Fauziah *et al.,*[14] stated that the states of Johor and Melaka in the southern region produced 1.12 kg of solid waste per person each day. Meanwhile, there is limited evidence of the presence of MP pollution in the maritime seas of Kelantan, Perlis, Melaka and Johor, including both the West and East Coastlines.

Table 1: Microplastics contamination in the marine surface water of peninsular Malaysia

Location	Type	Marine water Shape	Size (µm)	MPs abundance (Particles/L)	Reference
Kuala Nerus, Terengganu	PA and PP	Fragment and filament	5000	0.13–0.69	13
Kuantan Port, Pahang	Polyester, PS, PA, PVC, and PE	Fragment, filament, and irregulars	5000	0.14–0.15	13
Terengganu Coastal waters	PA	Fibers	20–1680	3.3	16
Langkawi, Kedah	NA	Fragment, foam, film, and filament	1000–3000	15.67	17
Seberang Perai, Pulau Pinang	NA	Fragment, filament, foam,	1000–3000	35.67	17
Terengganu Estuary, Terengganu	PA, PE, and PP	Fiber, fragment, and pellet	>100	0.422	18
Klang River Estuary, Selangor	PA and PE	Fibers, fragment, and pellet	<300, 300–1000, >1000	0.5–4.5	19
Setiu Wetland, Terengganu	PP	Filament (fibres), Foam and Film	> 200	0.36	20
Port Dickson, Negeri Sembilan	Cellophane, Polyester and PE	Fiber, fragment, pellet, and bead	25–5000	2.1–6.80	21
Seberang Perai, Penang	10 types of polymers[a]	Foam, fragment, fibre, and film	<330	1407	22
Penaga, Penang	10 types of polymers[a]	Foam, fragment, fibre, and film	<330	358	22
Balik Pulau, Penang	10 types of polymers[a]	Foam, fragment, fibre, and film	<330	273	22
Kuala Muda, Penang	10 types of polymers[a]	Foam, fragment, fibre, and film	<330	201	22
Pulau Perhentian, Terengganu	6 types of polymers[b]	Fiber, fragment, and pellet	<500	588.33	23
Pulau Redang, Terengganu	6 types of polymers[b]	Fiber, fragment, and pellet	<500	314.67	23
Pulau Kapas, Terengganu	6 types of polymers[b]	Fiber, fragment, and pellet	<500	359.8	23
Pulau Tenggol, Terengganu	6 types of polymers[b]	Fiber, fragment, and pellet	<500	294.33	23

[a]Polyethylene (PE), Polystyrene (PS), Polyacetal, Polypropylene (PP), polybutadiene, polychloroprene, polyformaldehyde, polyvinyl chloride (PVC), polyamide-6, and polyethylene oxide (PEO)
[b]Polyethylene (PE), Polypropylene (PP), Polyvinyl methyl ether (PVME), Polyamide, Phenoxy-resins, and Polyurethane-acrylic

Microplastics abundance

Microplastics (MPs) in the sea waters around Peninsular Malaysia vary from 0.15 to 1407 particles per Liter, with Kuala Nerus in Terengganu exhibiting the lowest concentration of MPs. Meanwhile, the mangrove region surrounding Penang, especially Seberang Perai, shows the highest levels of microplastic contamination. Investigations in eastern coastal states revealed more minimal MP levels than in the western coastal, except for marine parks such as Perhentian and Kapas Islands. During the COVID-19 pandemic, the concentrations of MPs in marine park islands rose from 294.33 to 588.33 particles per Liter[23]. Moreover, Perhentian Island exhibited elevated microplastic concentrations due to its tourism sector and lack of sanitary landfills. Furthermore, Cai *et al.,*[24] added MPs are more prevalent in open water or non-point source locations than near pollution sources.

Seasonal fluctuations, such as the Southwest Monsoon (SWM) and Northeast Monsoon (NEM), profoundly influence MP levels in the waterways of Peninsular Malaysia. The SWM (late May to early October) brings drier and hotter weather to Malaysia with south-west winds from Indonesia. On the other hand, NEM produces excessive northeast Indochina rainfall from early November to late March. Intermonsoons (IM1 and IM2) have reduced wind speeds[25,20] stated that temporal trends affect MP movement more than geographical patterns, notably between monsoonal seasons for surface water. However, MP distribution in surface water and sediment varies greatly with sampling time, which can affect MP distribution in sediments.

Type of microplastic

Polymers (MPs) put forward a considerable issue throughout the West and East Coasts of Peninsular Malaysia, where their type, shape, size, and density are essential for assessing their sources and impacts on marine ecosystems. The most prevalent microplastics identified in Peninsular Malaysia include polyamide (PA), polypropylene (PP), polyethylene (PE), polystyrene (PS), polyethylene terephthalate (PET), polyester, rayon, and polyvinyl chloride (PVC).

PA dominated the coastal waters of Terengganu and is the predominant type identified in Port Klang, the second busiest cargo port in Southeast Asia. It is extensively utilized in the fishing, textile, and automobile industries[16,26,27]. Moreover, polyethylene, polypropylene, and polystyrene are also common in the marine waters of Peninsular Malaysia, encompassing the estuaries and coastal seas of Terengganu, Negeri Sembilan, Selangor, and Penang. These polymers have exceptional abrasion resistance and are frequently utilized in the production of fishing gear, food storage solutions, consumer products, disposable items, the textile sector, and cosmetic formulations[13,18,28–30].

Other common MPs in Peninsular Malaysia are polyester, cellophane, PVC, polyvinyl methyl ether (PVME), and several other polymers in small amounts. Polyester can be found at Kuantan Port in Pahang and Port Dickson in Negeri Sembilan, while cellophane contributes the highest proportion of MPs at Port Dickson, Negeri Sembilan. Moreover, PVC is present at Kuantan Port, Pahang, and specific sites in Penang but is either undetectable or infrequently detected at minimal concentrations. Furthermore, it has a higher density than water and is more likely to be found in sediment[31]. PVME, conversely, is hydrophilic and frequently combined with other polymers to formulate adhesives, coatings, finishes, and personal care products[23].

Shape of microplastic

Fibers, fragments, foam, film, and pellets are prevalent microplastics in the marine waters of Peninsular Malaysia (Fig. 1). Moreover, microplastic fibers are also commonly termed filaments, lines, or threadlike structures and consist of numerous polymers, including PA, PE, and PP. Throughout the COVID-19 pandemic, 99% of microplastics identified on Malaysian marine park islands were fibers, signifying a "plastic pandemic" as a significant contributor to microplastics in this region[23]. Furthermore, fragments are also present in the marine waters of Peninsular Malaysia, namely at ports such as Kuantan and Kuala Nerus, as well as in Langkawi and Pulau Pinang. Alomar *et al.,*[32] stated that substantial plastic litter, especially irregularly shaped fragments, markedly adds to microplastics in narrow intertidal and marine areas. In addition, fragments may be identified as originating from polyethylene and polypropylene components[13].

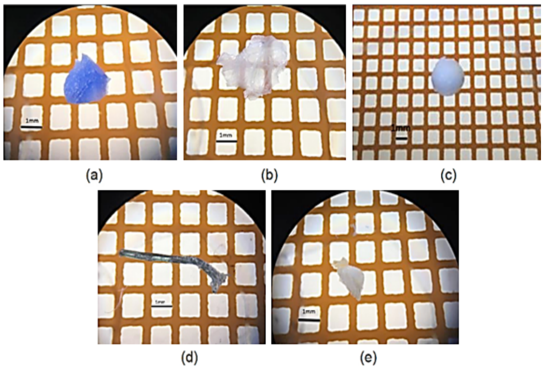

Fig. 1. Shape categories of microplastic a) Fragment; b) Film; c) Granule/Beads; d) Filament/Fibre and e) Foam[17]

Foams, films, pellets, and beads constitute microplastics present in the maritime waters of peninsular Malaysia. Foams in the coastal surface waters of the Penang area represent 43% of the total microplastics examined. It is predominantly produced by fishing operations utilizing PS boxes and buoys for catch storage[33]. Moreover, Film is present in the surface waters in Langkawi and Pulau Pinang, whereas pellets and microbeads are found in Port Dickson, Negeri Sembilan, and the Klang River estuary. In addition, these particles may originate from personal care and cosmetic products, which are in high demand among consumers. These particles are inadequately removed during wastewater treatment and are released into the aquatic ecosystem[34].

Size of microplastic

The size of microplastics can affect marine ecosystems, with smaller microplastics posing exacerbated risks to aquatic organisms. In the coastal waters of Terengganu, MPs vary from 20 to 1680 µm. Meanwhile, in Port Dickson, Negeri Sembilan, MPs range from 25 to 5000 µm in size, and at the ports of Kuala Nerus and Kuantan, MPs measure around 5000 µm in size. Therefore, as MPs become smaller, the likelihood of increased MPs in aquatic environments and the layer of particles at the bottom also increases[20].

Microplastic contamination in the sediment of marine ecosystems in peninsular Malaysia

MPs that enter the marine ecosystem are detected in surface waters, water columns, and sediments. Pollutants, such as MPs, are typically found in higher amounts in the sediment than in the surface and water columns. Moreover, most studies were conducted on the West Coast of Peninsular Malaysia rather than on the Eastern Shore. Furthermore, Fauziah *et al.,*[35] initiated the investigation of MP pollution in the sediment of marine ecosystems in Peninsular Malaysia, particularly in Port Dickson Negeri Sembilan, and Kuala Terengganu. The findings of the investigation of MPs in marine ecosystem sediments are presented in Table 2.

Microplastic abundance

The plastic pollution (MPs) in Peninsular Malaysia fluctuates based on the location and the measuring unit used (Table 2). Terengganu beaches have a greater accumulation of MPs, perhaps attributable to more vigorous waves and tides from the South China Sea coupled with a lack of regular cleaning 35. Moreover, Hamid *et al.,*[36] discovered in the Carey Island in Selangor has a greater abundance of MP because of its closeness to Port Klang and its heavily inhabited urban surroundings. Furthermore, the coastal regions of Penang exhibit differing levels of MP abundance, with Seberang Perai having the greatest concentration due to accelerated urbanization and industry[22]. In addition, the Kuala Gula mangrove region in Perak exhibits a comparatively low abundance of MP, varying from 25 to 130 particles per kilogram[37]. These results underscore the significance of adequate cleaning and management of MPs in Peninsular Malaysia.

Various studies exhibit discrepancies in the methodologies and units used for quantifying microplastics in marine ecosystem sediments. Moreover, prior studies applied various units, including particles per kilogram, particles per gram, items per square meter, and kilograms per cubic meter. Consequently, correctly comparing the extent of microplastic pollution between locations will be challenging.

Table 2: Microplastics contamination in the marine ecosystem sediments of peninsular Malaysia

Location	Type	Sediment Shape	Size (μm)	MPs abundance	Reference
Teluk Kemang Beach, Port Dickson, Negeri Sembilan	PS	Film, foam, fragment, and line	100-3000	230.67 items/m^2	35
Pasir Panjang Beach, Port Dickson, Negeri Sembilan	PS	Film, foam, and line	100-3000	211.33 items/m^2	35
Batu Burok Beach, Kuala terengganu, Terengganu	PS	Film, foam, fragment, line, and pellet	100-3000	780 items/m^2	35
Seberang Takir Beach, Kuala Terengganu, Terengganu	PS	Film, foam, fragment, line, and pellet	100-3000	878.67 items/m^2	35
Straits of Johor	PP, PS, and PE	NA	315-5000	300 p/kg	38
Carey Island, Selangor	NA	Line/fibre, Pellet, and Film	21-100	936-1,227 p/kg	36
Selat Pulau Tuba, Langkawi, Kedah	PP and PE	NA	500-1500	NA	39
Coastal area Kuala Perlis	NA	NA	<500	0.000096-0.000160 kg/m^3	40
Setiu Wetland, Terengganu	PP	Filament	>200	5.97 items/g	20
Seberang Perai, Penang (Coastal bottom)	10 types of polymers[a]	Fiber, fragment and foam	NA	350 p/kg	22
Penaga, Penang (Coastal bottom)	10 types of polymers[a]	Fiber, fragment and foam	NA	270 p/kg	22
Balik Pulau, Penang (Coastal bottom)	10 types of polymers[a]	Fiber, fragment and foam	NA	255 p/kg	22
Kuala Muda, Penang (Coastal bottom)	10 types of polymers[a]	Fiber, fragment and foam	NA	290 p/kg	22
Seberang Perai, Penang (Estuarine sediment)	10 types of polymers[a]	Fragment, Fiber and foam	NA	4000 p/kg	22
Penaga, Penang (Estuarine sediment)	10 types of polymers[a]	Fragment, Fiber and foam	NA	940 p/kg	22
Kuala Muda, Penang (Estuarine sediment)	10 types of polymers[a]	Fragment, Fiber and foam	NA	430 p/kg	22
Kuala gula mangrove area, Perak	Rayon, cotton, PET, and Azlon	Fiber and Fragment	<500 ->1000	25-130 items/kg	37

[a]Polyethylene (PE), Polystyrene (PS), Polyacetal, Polypropylene (PP), polybutadiene, polychloroprene, polyformaldehyde, polyvinyl chloride (PVC), polyamide-6, and polyethylene oxide (PEO)

Type of microplastics

The sediments of marine habitats in Peninsular Malaysia contain numerous varieties of MPs. Typically, they are composed of PP, PS, PE, rayon, cotton, polyethylene terephthalate (PET), and other polymers present in relatively small amounts. In the Straits of Johor, Malaysia, Matsuguma *et al.,*[38] found more MPs in the 2–4 cm layer dominated by PP and PS than in the sediment layer's 48–50 cm layer that dominated by PE. Moreover, Mohamed *et al.,* found that rayon was the most prevalent and plentiful type of microplastic found in the sediment. Furthermore, the occurrence of rayon, cotton, azlon, and PET may be linked to the discharge of municipal garbage, since these polymers are often used in the textile industry and are therefore discharged during the process of washing garments.

Shape of microplastic

Microplastics in sediment samples from Malaysia exhibit diverse shapes, indicative of their origins and the mechanisms of degradation in the environment. Most shapes in coastal waterways consist of fibers, fragments, films, and other forms. Fibers are commonly found in the coastal bottom sediment, derived from terrestrial sewage discharge and fishery activities. Plastic debris entangled in mangrove trees undergoes extended deterioration, resulting in increased fragmentation and accumulation in estuarine sediment[22]. Moreover, Line or fibre MPs are also higher found in Carey Island, Selangor, perhaps resulting from the degradation of synthetic fibre products[36]. In addition, the shape of microplastics in coastal sediments varies according to beach utilization, with recreational beaches exhibiting films, foam, and fragments, while fishing beaches present lines, foam, and films[35].

Size of microplastic

Microplastics identified in the sediment of marine ecosystem of Peninsular Malaysia exhibit many shapes, including fibers, fragments, films, foams, and pellets, with dimensions ranging from 21 to 5000 µm. Moreover, at certain Malaysian beaches, plastic waste varies from 100 to 3000 µm across all plastic categories, contingent upon beach activities[35]. Matsuguma *et al.,*[38] identified microplastics measuring between 315 and 5000 microns in the Straits of Johor. Meanwhile, Hamid *et al.,*[36] identified microplastic sizes in sediments of Pulau Carey, Selangor, ranging from 5 to 1000 microns, with the predominant size between 5 µm and 20 µm, constituting 52.89% to 57.12% of the total microplastics extracted from mangrove sediments. Additionally, as the size of microplastics diminishes, the likelihood of their prevalence in surface water and sediments increases.

Microplastic contamination on the marine fish in peninsular Malaysia

MPs in marine waters can be consumed by marine organisms such as fish. However, research on MP pollution in commercial marine fish in Peninsular Malaysia is still limited[16]. To date, at least five studies have examined MP pollution in marine fish, including commercial fish in Peninsular Malaysia (Table 3 and 4). Ibrahim began investigating MP pollution in marine fish in 2017, using wild and cage Lates calcarifer in the Setiu Wetlands of Terengganu. More than 30 species have been documented to be polluted by MPs, some of which have been discovered in the gastrointestinal tract (GIT) and gills. MPs detected in the gut and gills include PE, PA, PP, rayon, PET, acrylonitrile butadiene styrene (ABS), PS, and polyvinyl alcohol (PVA). MP shapes such as fibre (threadlike/filament), fragments, and films are widely observed in fish with sizes ranging from 4.3 to 5000 µm. Furthermore, the detected MPs abundance ranges from 0.39 to 1,125 particles per individual (Table 3).

Microplastic abundance

Research indicates that wild fish are more prone to acquiring microplastics than caged fish. Wild L. calcarifer exhibited markedly elevated microplastic concentrations in the gastrointestinal tract (GIT) compared to cage-cultured fish specimens 20. Wild fish in the South China Sea passage had a higher concentration of microplastics than those raised in cage culture. Moreover, various aquatic environments may exhibit elevated rates of trash ingestion among fish[41]. A study on 11 commercially harvested fish species in Malaysia identified 43 plastic polymers in the excised organs and gills, revealing notable differences across species[42]. The ingestion rates of African catfish and three-finger threadfin were 90% and 100%, respectively. Furthermore, marine organisms may ingest or confuse plastic for their food[43], and fish and bone byproducts are utilized to nourish farmed animals, potentially transmitting microplastics to humans[44]. In addition, the occurrence of MPs is not influenced by their size but rather by factors such as the diet of the organisms, their position in the ecosystem, and their selective feeding behavior[45]. Wieczorek *et al.,*[46] added that knowledge of MP contamination in marine organisms can indicate plastic pollution in their environment. Microplastic abundance in the marine fish of peninsular Malaysia can be seen in the Table 3.

Table 3: The sample used and abundance of microplastics in the marine fish of peninsular Malaysia

Location	Marine fish Sample	MPs abundance (pcs/ind)	Reference
Setiu Wetlands, Terengganu	Gastrointestinal tract	1,125	2
Fish Market, Seri Kembangan, Selangor	Excised organs and gills	0.39	42
Pantai Remis, Perak	Gastrointestinal tract and gills	9.88	45
Tanjung Penyabung, Mersing, Johor	Gastrointestinal tract and gills	5.17	45
Teluk Bahang and Penaga fish market, Penang	Guts	6.5	47
Sungai Besar, Kuala Selangor, Kuantan and Mukah	Gastrointestinal tract	2.44	48

Type of microplastic

Differences in the shape, type, and size of microplastics are likely indicative of variation sources and waste disposal method across various areas and sample sites. Ibrahim *et al.,*[2] discovered aquaculture uses synthetic materials for the cages, so GIT of the fish has higher PA levels because they are used as nets. Meanwhile, wild species have a higher PVA owing to their denser properties from broken fishing nets and gear. Moreover, the study conducted in Seri Kembangan, Selangor analyzed 11 species of commercial fish and showed that PE was the most commonly discovered plastic polymer, accounting for 88.4% of all samples. This was followed by PP at 9.3% and PET at 2.3%[42]. Furthermore, fish from fishing locations, markets, coast, and sea were most often discovered to contain PE and PP, which are the predominant plastic polymers. In addition, Lim *et al.,*[48] conducted a study in four states in Malaysia and found that the polymer type most often consumed by crescent perch was rayon, accounting for 83% of their ingestion. It is a partially synthetic cellulosic fibre that is extensively used in the production of garments, interior fabrics, and hygiene items[49].

Table 4: Location, Samples, type, shape and size of microplastic in the marine fish of peninsular Malaysia

Location	Sample	Marine fish Type	Shape	Size (µm)	Reference
Setiu Wetlands, Terengganu	Wild and cage Lates calcarifer	Polyamide (PA) and Polyvinyl Alcohol (PVA)	Threadlike, fragment, and Spherical	4.3-15.7	2
Fish market, Seri Kembangan, Selangor	11 species of fish[a]	PE, PP and PET	Fragment, film, and fibre	149-4000	42
Pantai Remis, Perak	7 species of fish[b]	PE, PP, ABS, PS and PET	Fiber, fragments, and filaments	50-5000	45
Tanjung Penyabung, Mersing, Johor	10 species of fish[c]	PE, PP, ABS, PS and PET	Fiber, fragments, and filament	50-5000	45
Teluk Bahang and Penaga fish market, Penang	4 species of fish[d]	NA	Fragment, fibers, pellet, and film	<5000	47
Sungai Besar, Kuala Selangor, Kuantan and Mukah	Terapon jarbua	Rayon, PET, and PE	Fibers, fragment, and film	30-3407	48

[a]*Megalaspis cordyla, Epinephelus coioides, Rastrelliger kanagurta, Euthynnus affinis, Thunnus tonggol, Eleutheronema tridactylum, Clarias gariepinus, Colossoma macropomum, Nemipterus bipunctatus, Ctenopharyngodon Idella* and *Selar boops*
[b]*Atule mate, Drepane punctata, Trachurus japonicus, Johnius borneensis, Panna microdon, Alectis indica* and *Megalaspis cordyla*
[c]*Chirocentrus dorab, Drepane longimana, Drepane punctata, Eubleekeria jonesi, Gazza minuta, Gerres erythrourus, Sardinella gibbose, Triacanthus nieuhofi, Tripodichthys blochii* and *Carangoides hedlandensis*

Shape of microplastic

Microplastics are classified based on shape, size, and colour to ascertain their origin and evaluate their impact[45]. The majority of MPs identified in the fish of Peninsular Malaysia are fibers and fragments (Fig. 2.). Fibers are found in the cage-cultured and wild Lates calcarifer from Setiu Island, with estimated percentages of 75% and

63.9%, respectively. Moreover, microplastics (MPs) are present in the gastrointestinal tract and gills of fish, with cage-cultured fish consuming a greater quantity of fibrous particles due to the degradation of aquaculture nets, while wild fish eat more compact fragments because these particles tend to settle and are accidentally consumed[2]. Furthermore, the primary source of marine microplastic fibers is sewage sludge or effluents from the fishing industry[50]. Commercially harvested fish from Pantai Remis, Perak, and Tanjung Penyabung, Johor, contain 80% fibre of all microplastics detected[45]. Fibers constitute 71% of the total microplastics in crescent perch across four study sites 48. Meanwhile, a study conducted on 11 commercial fish in the fish market of Seri Kembangan, Selangor, revealed that fragments were the most prevalent shape of MPs (67.45%), followed by fibres (16.3%) and films (16.3%)[42]. In addition, fragments are the primary shape of microplastics discovered in commercial marine fish from the seawater of Northwest Peninsular Malaysia, accounting for 49.5% of all microplastics[47].

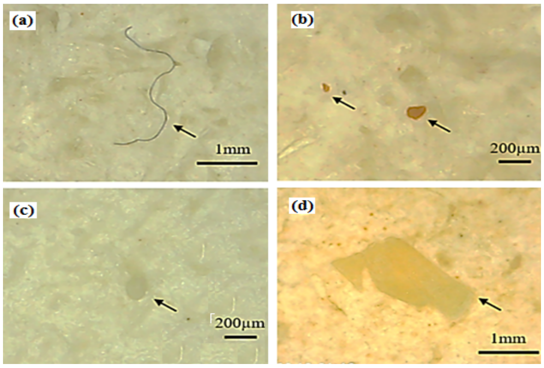

Fig. 2. Microplastic found in the guts of the fish. (a) Fibre; (b) Fragment; (c) Pellet/Beads and (d) Film[47]

Size of microplastic

The dimensions of microplastics found in the gastrointestinal tract (GIT) and gills of fish differ among species and research locations. Microplastics range in size from 4.3 to 5000 microns. The smallest size recorded in wild and farmed Lates calcarifer specimens from the Setiu wetlands in Terengganu ranged from 4.3 to 15.7 microns. Fish from several regions, including Pantai Remis Perak, Tanjung Penyabung Johor, and Teluk Bahang and Penaga Market Penang, possess microplastics with large sizes, ranging from 50 to 5000 microns. Moreover, the variations in microplastic buildup in fish among studies mostly result from differences in habitats, species, eating behaviours, and geographical locations[51]. Furthermore, although the mechanisms remain unclear, it may be inferred that the small size of particles enhances the accumulation of microplastics in fish.

Future research directions

Research data from sea surface waters, sediments, and marine fish in Peninsular Malaysia highlights several significant research gaps and domains for future investigation to thoroughly tackle the problem of microplastic contamination in marine ecosystems of Peninsular Malaysia. A significant gap is the insufficient comprehension of regional variations in microplastic contamination. The data collected offer insights into pollution levels in locations like Terengganu and Penang. However, variations in sampling methodologies and analytical techniques applied by researchers hinder direct comparisons across these areas. Future research must prioritize the establishment of standardized procedures for the measurement and characterization of microplastics to facilitate consistent global evaluations.

The research results indicated that several locations, including Kelantan, Perlis, Johor, and Melaka, possess insufficient information regarding microplastic pollution. Consequently, it is essential to perform further research on the concentration of MPs in these regions. Extending geographical coverage to underrepresented areas is crucial for comprehending the extent of microplastic contamination and its ecological and social consequences, particularly in peninsular Malaysia. It is highly recommended to consistently monitor changes to accurately evaluate the extent of microplastic pollution in the coastal waterways of Peninsular Malaysia.

The majority of studies in marine fish have focused on detecting microplastic contamination in the gastrointestinal system and gills of fish that are not consumed by humans. Nonetheless, information concerning microplastic contamination in the edible tissues (flesh/muscle) of commercial marine fish in peninsular Malaysia is limited. Meanwhile, MPs are present in the muscle of several commercial fish species, including bartail flathead, larger lizardfish, northern whiting, tongue sole, shrimp scad, orange-spotted grouper, and Pickhandle barracuda[52,53]. Moreover, research has identified microplastic fragments in the edible tissues of nine economically important pelagic fish species from Kerala, India, with an estimated prevalence of 0.07 particles/ind[51]. Therefore, investigating microplastic contamination in the edible tissues of commercially marine fish in Peninsular Malaysia is essential to ascertain the level of microplastic intake by people via food and requires comprehensive measures to mitigate its effects on marine ecosystems and human health.

These findings review also establish an essential basis for monitoring future alterations in the presence of MPs in marine ecosystems of peninsular Malaysia. Moreover, it is crucial to make firm commitments and exert diligent efforts to improve solid waste management practices by embracing the "reduce, reuse, recycle" (3Rs) strategy[35]. Furthermore, it is imperative to aid public awareness campaigns and coordinate efforts to clean up beaches to effectively reduce and prevent the pollution caused by plastic garbage.

CONCLUSION

Microplastic contamination (MP) in the coastal waterways of Peninsular Malaysia is pervasive, particularly in the states around the West Coast, which exhibit the highest concentrations of MPs. Microplastics predominantly comprise polyamide, polyethylene, polypropylene, and polystyrene fibers and fragments. Regional activities and seasonal monsoon patterns influence the dissemination of microplastics. Furthermore, investigations into microplastic contamination in fish meat need to be conducted to predict the amount of microplastics that may be consumed by humans. Finally, the impact of microplastic pollution on aquatic habitats and humans can be precisely quantified, requiring focused mitigation strategies and comprehensive research to properly understand its effects and devise appropriate solutions for the preservation of marine ecosystems and the evaluation of human health risks.

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Conflict of interest

The author declare that we have no conflict of interest.

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