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MICROPLASTIC POLLUTION IN MARINE WATERS: A MALAYSIAN PERSPECTIVE

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Abstract:

This article examines the literature study of the current situation of microplastic pollution in the marine ecosystems of Malaysia. The size, density, types of polymers, colour, and origins of microplastic in the ocean, coastal, and estuarine environments are all discussed in this article. ScienceDirect and Google Scholar search engines were used to collect, analyse, and sort the information. According to the literature search, the bulk of microplastics found in Malaysian ocean samples was between 100 and 5000 micrometres in size. The density of the microplastics discovered ranged from 0.88 g cm^3 to 1.01 g cm^3, which is lower than the density of seawater. In addition, the types of polymers were polypropylene, polyethylene, polyester, polystyrene, and polyamide. Red and transparent colour were two common colours found in the Malaysian ocean. The sources of microplastic such as industrial activities, anthropogenic activities, agricultural activities, and personal care products. Because microplastics can cause physical and chemical harm to marine species, pollute the natural environment, and negatively affect social and economic sectors, the critical information provided in this article may help government and non-government organizations develop strategic monitoring policies.

Keywords:

Colour, Malaysia, Marine, Microplastics, Size

Introduction

The marine ecosystem is the largest of the Earth's aquatic ecosystems, typified by salty seas. Good marine water is essential for marine life because it protects critical habitats (Kamaruddin et al., 2022a) and a diverse range of marine life, as well as aiding in the restoration of the ocean's production (Ahmed et al., 2022). The issue of marine pollution has started to become

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necessary due to increasing anthropogenic activities around the world (Kamaruddin et al., 2021a). Ocean acidification, the effects of climate change, and the impact of global warming on biodiversity and the natural environment are starting to become significant issues discussed by many politicians and people worldwide (Kamaruddin et al., 2022c). One marine pollutant that could harm us is plastics. Plastic has become an essential commodity on a global scale due to its extraordinary qualities and is found in all types of commercial items (van Bijsterveldt et al., 2021). Phelan et al., (2022) stated that oceans, wildlife, public health, and economic activities that rely on healthy marine ecosystems are all threatened by the presence of hundreds of millions of tonnes of plastic in the environment. Daoud et al., (2021) stated that plastics account for the most considerable percentage (24%) of total municipal solid trash in Malaysia, with a 2–3% annual rise due to population growth, changing consumer patterns, and the expansion of trade and industry in metropolitan areas. Plastic will gradually break down into vast microplastic fragments (Huang et al., 2020).

The problem of plastic pollution in Malaysia is serious (Daoud et al., 2021). An increase in plastic production will increase the number of microplastics in marine water (Liang et al., 2021). Several researchers have used the Geographical Information System (GIS) to map the distribution of microplastics in coastal waters (Kamaruddin et al.,2020). According to many studies, there is much research on microplastics, but this review will highlight the characteristics of microplastics that are widely found in Malaysia. Furthermore, microplastics in marine water can be increased due to a few human activities, and the sources of microplastic in the ocean, coastal, and marine water environment will be covered in this article. Besides, microplastics can cause physical and chemical harm to human and marine species when consumed. Microplastics also negatively affect water quality and Malaysia's economic sector.

Generally, the significance of this research is to review the current characterization of microplastics in the marine waters focusing on Malaysia. Microplastics can be classified based on their particle sizes, density, types of polymers, and colour of microplastics (Khalik et al., 2018). Thus, this also can help the researcher know more about microplastics' various characteristics. That has a few sources of microplastics. Furthermore, this research may aid in discovering specific elements from the sources that can lead to the existence of microplastics. Microplastics can pollute marine habitats, harm humans, and degrade water quality (Mehra, 2021). This research aims to figure out the economic impact of microplastics in Malaysia. Microplastics can harm human health, marine species, marine water, and the economy in numerous ways.

The primary purpose of this study is to discuss microplastics in marine ecosystem waters focusing on Malaysia. Several objectives are defined to meet the purpose of this study which were (1) to examine the characteristics of microplastics discovered in Malaysia’s marine ecosystem; (2) to investigate the origins of microplastics in Malaysia, and finally, (3) to investigate the socio-economic and environmental effects of microplastics in Malaysia.

Literature Review

The marine environment should be protected due to its importance for social-economic and living things to thrive (Kamaruddin et al., 2022b). water quality, for example, could affect delicate living things such as plankton that become food for many sea creatures (Kamaruddin et al., 2018). With the increasing climate change impact that may affect ocean acidification processes, other marine pollutants should also be acknowledged effectively (Kamaruddin et

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al., 2021b). Today, many scientists focus on microplastics as there is much evidence of their adverse effects on the environment and marine species. Microplastics are divided into two categories that are primary sources and secondary sources (Khalik et al., 2018). According to Mehra (2021), primary microplastics with a micrometre scale include microplastic fiber obtained from cosmetic goods (facial cleansers) with the word "microbeads". Secondary microplastics are introduced when bigger plastics break down due to weathering, such as exposure to wave action, wind abrasion, and UV radiation from sunlight (Di & Wang, 2018). Buwono et al., (2021), mentioned that microplastics have the potential to harm water quality, marine animals, and human health. Microplastic pollution in the marine environment significantly affects tourism earnings, marine life, and ecology (Othman & Ahmad Kamaruddin, 2016).

The physical properties of microplastics, such as particle sizes, density, polymer kinds, and colour, are used to classify them, according to a previous study (Khalik et al., 2018). Some sources lead to microplastics, such as industrial, anthropogenic, and agricultural activities (Phuong et al., 2022). According to Mehra (2021), personal care products such as toothpaste, facial scrubs, and soaps are essential to secondary microplastics. Microplastic pollution in aquatic habitats significantly affects commercial fisheries and aquaculture (Curren et al., 2020). Because water is so necessary to so many organisms, its quality is crucial. The better the water, the better the impact on humans (Buwono et al., 2021). Based on Ta & Babel, (2020) point out that microplastics can also have physical and toxicological impacts on humans when consumed. In addition, the industrial sector may suffer losses because of microplastics.

Methodology

The information was gathered, analysed, and sorted using the ScienceDirect and Google Scholar search engines. The data was collected, analysed, and sorted from publications published between 2016 and 2022. Three themes were identified, namely (1) characteristics of microplastics, (2) sources of microplastics, and (3) the impacts of microplastics.

Results and Discussion

Plastic marine pollution is still a growing environmental problem that impacts marine biota and ecosystems despite global acknowledgment of plastic as a persistent contaminant. The plastic output is increasing daily because of the growing worldwide population and the need for more plastic consumer items. Marine plastic waste negatively affects marine species and ecosystems, the tourism industry, fisheries, maritime equipment, and navigation safety due to its ubiquity and long-term presence in the environment (Karbalaei et al., 2019). Microplastics are incredibly minute bits of plastic garbage in the environment due to consumer product disposal and industrial waste degradation. Mehra (2021) mentioned that microplastics are divided into two categories: primary sources and secondary sources. Primary microplastics are small particles of plastic that have been created for a specific purpose. Secondary microplastics are introduced when bigger plastics break down due to weathering, such as exposure to wave action, wind abrasion, and UV radiation from sunlight (Mehra, 2021).

Characterization of Microplastics

Microplastics are found in all surface water in the marine ecosystems of Malaysia (Najihah, 2020). According to the literature search, a few characteristics of microplastics will be highlighted: particle size, density, types of polymers, colour, and sources of microplastics. Microplastics appear in a variety of sizes, although those smaller than 5000 micrometres in

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length are the most common (Wang et al., 2020). Table 1 depicts the particle sizes of microplastics discovered in a few Malaysian states.

Table 1: Particle Size of Microplastics Found in the Few States in Malaysia

State	Location	Sizes of Microplastics	Reference
Kuala Nerus and Kuantan Port	Surface water	5000 µm	Khalik et al., 2018
Klang River	Surface water	300 µm to 1850 µm	Zaki et al., 2021
Terengganu	Surface seawater	20 µm to 1680 µm	Amin et al., 2020
Setiu Wetlands	Surface water	900 µm to 4700 µm	Hamzah et al., 2021
Port Dickson and Lukut	Surface water coastal area	200 µm to 3000 µm	Zainuddin et al., 2022
Terengganu Estuary	Surface water	100 µm to 3617 µm	Daoud et al., 2021
Kuah, Langkawi	Surface water	1000 µm to 3000 µm	Najihah, 2020
Seberang Perai, Pulau Pinang	Surface water	1000 µm to 3000 µm	Najihah, 2020

Different areas have assorted sizes of microplastics according to various sources of microplastics. Microplastics' size range is crucial since it defines their potential impact on marine environment waters. According to Khalik et al., (2018), the particle size of microplastics discovered in Kuala Nerus and Kuantan port was 5000 µm in their research study. As shown in Table 1, most microplastics sampled in Kuah, Langkawi, and Seberang Perai, Pulau Pinang were in the 1000 µm to 5000 µm size range (Najihah, 2020). Microplastics ranging from 100 µm to 5000 µm pose a significant risk of ingestion by marine animals. Table 2 shows the density of microplastics found in a few Malaysian states.

Table 2: Density of Microplastics Found in the Few States in Malaysia.

State	Location	Density	Reference
Kuala Nerus and Kuantan port	Surface water samples	0.9 g cm $^{-3}$ 1.01 g cm^{-3}	Khalik et al., 2018
Klang River	Surface water	0.80 g cm $^{-3}$ to 1.75 g cm^{-3}	Zaki et al., 2021
Terengganu	Surface seawater	0.89 g cm^{-3} to 1.19 g cm^{-3}	Amin et al., 2020
Setiu Wetlands	Surface water	0.88 g cm^{-3} to 1.00 g cm^{-3}	Hamzah et al., 2021
Port Dickson and Lukut	Surface water coastal area	1.00 g cm^{-3}	Zainuddin et al., 2022
Terengganu estuary	Surface water	0.9 g cm^{-3} to 1.012 g cm^{-3}	Daoud et al., 2021
Kuah, Langkawi	Surface water	0.8812 g cm^{-3} to 0.9278 g cm^{-3}	Najihah, 2020

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Seberang Perai, Pulau Pinang	Surface water	1.0763 g cm^{-3}	Najihah, 2020

In **Table 2**, the density of microplastics found had a range of 0.88 g cm^{-3} to 1.01 g $cm^{-3,}$ which is less than the density of seawater, meaning they are generally considered floating. Plastics are made from several different polymers. According to Hamzah et al., (2021), the density of microplastics in their research region of Setiu Wetlands ranged from 0.88 g cm^{-3} to 1.00 g $cm^{-3.}$ The polymer kinds used to make plastic materials determine their properties and performance. Fourier transforms infrared (FTIR) spectroscopy is employed to determine the type of polymers in the composition of microplastics to identify the types of microplastics discovered in the samples. Table 3 depicts the type of polymer of microplastics found in a few Malaysian states.

Table 3: Type of Polymers of Microplastics Found in the Few States in Malaysia

State	Location	Types of polymers	Reference
Kuala Nerus and Kuantan Port	Surface water	Polyester, polystyrene, polyamide, polyvinyl chloride, and polyethylene	Khalik et al., 2018
Sungai Dungun, Terengganu	Surface water	Polyacrylonitrile, polypropylene, and polyamide	Yang Hwi et al., 2020
Klang River	Surface water	Polyester, polyethylene-propylene-diene (PE-PDM), and polyurethane	Zaki et al., 2021
Port Dickson	Surface water of a coastal area	Polyester, polyethylene, and polystyrene	Zainuddin et al., 2022)
Terengganu	Surface seawater	Polypropylene, polyester, polyethylene, polyamide, acrylic, and polyvinyl alcohol	Amin et al., 2020
Setiu Wetlands	Surface water	Polypropylene and polyamide	Hamzah et al., 2021
Port Dickson and Lukut	Surface water coastal area	Cellophane, polyester, and polyethylene	Zainuddin et al., 2022
Terengganu Estuary	Surface water	Polyamide, polyethylene, and polypropylene	Daoud et al., 2021

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Kuah, Langkawi	Surface water	Polyethylene, polyethylene terephthalate, polypropylene, and polystyrene	Najihah, 2020
Seberang Perai, Pulau Pinang	Surface water	Polypropylene, polyethylene, and polyamide	Najihah, 2020

Polypropylene, polyethylene, polyester, polystyrene, and polyamide are most widely found in microplastics. The presence of polypropylene microplastics in the area may be due to fishing activities (Bay et al., 2020). According to Yang Hwi et al., (2020) in **Table 3**, polypropylene is a common type of microplastic found in Sungai Dungun. Polypropylene is primarily used in the production of packaging materials and fishing equipment. Indeed, because fishing is the primary source of income in the Sungai Dungun, it is not surprising that propylene was discovered in the gathered water samples (Yang Hwi et al., 2020). Polyethylene and polystyrene are two typical forms of polymers found in tourist packaging and at fishermen's wharves, where plastic blocks and foam are regularly abandoned. Table 4 shows the colour of microplastics found in a few states in Malaysia.

Table 4: Colour of Microplastics Found in the Few States in Malaysia

State	Location	Colour	Reference
Kuala Nerus and Kuantan Port	Surface water	Black, blue, brown, grey, red, orange, yellow, and transparent	Khalik et al., 2018
Sungai Dungun, Terengganu	Surface water	Transparent, red, blue, black, green, purple, white, and brown	Yang Hwi et al., (2020)
Kelantan Bay	Surface water coastal	Transparent, red, and blue	Bay et al., (2020)
Klang River	Surface water	Black, red, transparent	Zaki et al., 2021
Terengganu	Surface seawater	Transparent, black, and grey	Amin et al., 2020
Setiu Wetlands	Surface water	Transparent, brown, red, blue, green, and black	Hamzah et al., 2021
Port Dickson and Lukut	Surface water coastal area	Transparent, black, and red	Zainuddin et al., 2022
Terengganu Estuary	Surface water	Transparent, black, red, and blue	Daoud et al., 2021
Kuah, Langkawi	Surface water	Red, transparent, black, blue, grey, yellow, and green	Najihah, 2020

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Seberang Perai, Pulau Pinang	Surface water	Red, transparent, black, blue, grey, yellow, purple, and green	Najihah, 2020

Based on Table 4, microplastics are divided into several colour categories based on their appearance, with transparent and red microplastics being the most common. Transparent microplastics are often employed in fishing equipment (Chen et al., 2021). Plastic bags, which people widely use in their everyday lives, could be a significant source of transparent particles. According to Daoud et al., (2021), microplastics can inherit their colours from their parent plastic items; however, owing to weathering, their colours may vary. Coloured microplastics are more likely than transparent microplastics to be eaten by marine animals, causing harm to their health. The impact of coloured microplastics on aquatic life deserves more attention in the future.

Sources of Microplastics

Environmental externalities, such as chemical or biological pollution, are frequently referred to as by-products of otherwise positive human activity (Ho & Goethals, 2021). Lin et al., (2021) mentioned that industrial, anthropogenic, agricultural, and personal care products are the sources that influence the existence of microplastics in the environment. Table 5 shows the sources that cause the microplastics.

Table 5: Sources of Microplastics

State	Location	Sources of Microplastics	Reference
Kuala Nerus and Kuantan Port	Surface water	Fishing activities, tourism, personal care products, and multi-cargo ports	Khalik et al., 2018
Klang river	Surface water	Fishing, commercial, and industrial activities.	Zaki et al., 2021
Terengganu	Surface seawater	Tourism, fishing activities, industrial activities, and recreational boating	Amin et al., 2020
Setiu Wetlands	Surface water	Aquaculture and fishing activities	Hamzah et al., 2021
Port Dickson and Lukut	Surface water coastal area	Fishing activities and tourism	Zainuddin et al., 2022
Terengganu Estuary	Surface water	Industrial activities, tourism, fishing activities, boat manufacturing, and recreation.	Daoud et al., 2021
Kuah, Langkawi	Surface water	Tourism activities	Najihah, 2020

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Seberang Perai, Pulau Pinang	Surface water	Industrial activities to produce electronics and personal care products.	Najihah, 2020

Wastewater from manufacturing or chemical processes in industries contributes to microplastics. Based on Table 5, industrial waste is one of the sources of microplastic in Malaysia, especially in Seberang Perai, Pulau Pinang (Najihah, 2020). Pulau Pinang is Malaysia's primary regional industrial complex for manufacturing electronics and other related products (Najihah, 2020). Next, anthropogenic activities contributing to microplastics are transportation, tourism, and recreational activities. Boats made from fiberglass harm our coastal marine life (Byrnes & Dunn, 2020). According to Zainuddin et al., (2022), microplastics from food packaging and bottles from tourism activities have impacted marine waters. Water is a critical input for agricultural production and plays a vital role in food security. According to Hamzah et al., (2021), agricultural activities, known for fishing and tourism in Port Dickson and Lukut are one of the sources of microplastics in those areas. Innumerable cosmetics and personal care items use plastic microbeads as ingredients research by Mehra (2021). They are both sorbents and exfoliators. According to Mehra (2021), personal care products are an essential contributor of secondary microplastics, for example, in toothpaste, facial scrubs, and soaps

Impacts of Microplastics

Microplastics can harm marine species, water quality, human health, and economic sectors. Khoironi et al., (2020) point out that living organisms, aquatic life, are harmed by microplastics because they can ingest, mistake them for food, and die as a result. Microplastic ingestion is a factor of endocrine disruption, mortality, delayed ovulation, hepatic stress in marine organisms, false satiation, pathological stress, and reproductive complications. In addition, microplastics in excessive quantities can impair water quality. The amount of oxygen microorganisms requires to break down the organic molecules in the water is reflected in the Biochemical Oxygen Demand (BOD) concentration. According to Buwono et al., (2021), a high BOD number indicates that microplastics have contaminated the ocean's water. Certain pollutants, chemicals, and microplastics will likely be found in oceans with high total solids and turbidity levels. The dispersion of microplastics is influenced by temperature, which influences the hydrodynamic mechanics of water and the mechanism of microplastic disintegration.

Ingestion of microplastics can harm human health, primarily when plastic is absorbed into the human body (Reza et al., 2021). Wright & Kelly (2017) mentioned that microplastics in the body could promote tissue inflammation, cellular proliferation, and necrosis, as well as weaken immune cells. Ingestible microplastic particles from toothpaste can be absorbed by the human gastrointestinal tract, according to Curren et al., (2020). Microplastics are a critical component that impacts human health and can cause death in chronic conditions (Suteja et al., 2021). As a result of a lack of infrastructure in many countries to prevent plastic pollution, 'plastic leakage' occurs into rivers and the sea. Economic losses include both lost income and consumer surplus, as opposed to economic consequences, which only include lost revenue. Microplastics could cause upsets in the industrial sector. In addition to the costs to marine life and our ecology, plastic pollution in the maritime environment influences lost tourism profits (Othman & Ahmad Kamaruddin, 2016). Plastic contamination in the ocean depreciates coastal properties and decreases the number of visitors and beachgoers. Consequently, strategic policies are

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required to safeguard the coastal and marine ecosystem (Kamaruddin et al., 2019). Government and non-government agencies may implement solutions for the conservation of marine life and environments following the Sustainable Development Goals of the United Nations.

Conclusion

Due to their unique properties, plastics have become a vital commodity on a global basis. Plastic pollution in Malaysia significantly impacts the oceans, human health, and economic activity that rely on healthy marine ecosystems. The presence of microplastics in water bodies is due to human activities. According to research, Malaysia's marine waters are in great danger of microplastic pollution. The current features of microplastics, causes of microplastic pollution, and societal and economic repercussions of microplastics in Malaysia are summarized in this paper.

Characteristics of the microplastics are categorized based on their physical parameters such as particle sizes, density, type of polymers, and colour of microplastics. Most microplastics have been found between 100 and 5000 micrometres in size. Microplastic size distribution patterns can be linked to microplastic sources. Next, the density of the microplastics discovered ranged from 0.88 g cm^{-3} to 1.01 g cm^{-3}, which is lower than the density of marine water. Polypropylene, polyethylene, polyester, polystyrene, and polyamide are usually polymers found in marine ecosystem water in Malaysia. Microplastics' transparent and red colour is the most seen in marine water in Malaysia.

The sources of microplastics include industrial, anthropogenic, agricultural, and personal care products. Wastewater from manufacturing or chemical processes in industries contributes to microplastics. Next, anthropogenic activities contributing to microplastics are transportation, tourism, and recreational activities. Microplastics have damaged marine waters from food packaging and bottles from tourism operations. Another probable source of microplastics in agricultural activities that employ chemical fertilizers, pesticides, and the breakdown of agricultural equipment. Personal care items, such as toothpaste, face scrubs, and soaps, are significant sources of secondary microplastics.

Microplastics can harm marine species, water quality, human health, and the economics of Malaysia. Microplastics harm marine species because they can ingest, be mistaken for food, and die. Then, microplastics harm water quality; when microplastics infiltrate ocean water, the BOD value rises dramatically. Ingestion of microplastics can negatively impact human health, primarily when plastic is absorbed into the human body. Microplastic pollution in the marine environment significantly affects tourism earnings, marine life, and our ecology.

Water is essential to our life in marine ecology. Many consumers can be harmed by microplastic, which can kill them. As a result, all groups must collaborate to solve the problem of microplastics, which is becoming more prevalent. To protect the beauty of Malaysia's marine water environment, strict microplastic monitoring policies must be implemented, and everyone must adhere to them.

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