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Microplastic Ingestion in Aquatic Animals in South East Asia

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ABSTRACT: The study aimed to review the ingestion of microplastics by aquatic animals in the South East Asia and the impacts of this ingestion on the environment, human health, and species health, as well as to explore technologies for remediation. Microplastic particles range in size from 1 to 5 microns and are the result of the breakdown of larger, original plastic particles. Microplastic was defined in 2011, but the majority of people did not view it as a serious pollutant or act accordingly. Microplastic is a serious pollutant that has prompted increased research and experimentation since 2005. Microplastics are so small that they can enter the tissues and organs of aquatic animals. Malaysia produces a quantity of plastic waste and receives plastic waste from other countries for disposal. The effects of microplastic on aquatic animals have been studied in relation to the ecosystem cycle and food chain. The presence of microplastic in aquatic animals has detrimental effects on the environment, human health, species health, and the ecosystem. Physical, chemical, and biological technologies are provided, as well as a combination of two technologies, for the remediation of microplastic, which aids in the removal of microplastic from the environment and the reduction of microplastic in aquatic animals. These technologies aim to reduce the concentration of microplastics in water bodies, preventing their ingestion by aquatic animals. However, their efficiency in tropical regions may vary, depending on the specific environmental conditions. It requires continued research, policy, and public awareness to mitigate the impacts of microplastics on the environment and human health. In addition, microplastics generate some challenges and opportunities for reducing microplastics' impact on humans and the environment in the future.

KEYWORDS: Microplastics; aquatic animals; remediation; ecosystem cycle

1. Introduction

The amount of plastic used and produced by humans is less than 367,000,000, and humans dispose of between 1% and 4% of plastic as waste to water resources. However, as the population grows each year, so does the production of plastic. Plastic is resistant to electricity, has a lower density than water, is a water-resistant material, is colorless or transparent, can be molded into a variety of shapes, and may or may not have an odor [1, 2]. Plastic is a toxic and poisonous substance that takes a long time to decompose, resulting in pollution or contamination of the environment, ecosystem, and living organisms on earth. The material of plastic production is polymeric, including polyvinyl chloride (PVC), polyethylene terephthalate (PET or PETE), the Higher or lower density of polyethylene (HDPE or LDPE), polystyrene (PS), polypropylene (PP), and other plastics listed in Table 1 [2, 3].

Table 1. Type of plastic available in the market.

Types of Plastic	Functions	Examples
Polyethylene Terephthalate (PET or PETE)	- Recyclable plastic, safe to store food and drink away from oxygen. - Low cost and transparent plastic product.	- Plastic cup can filled with any drinks except hot drinks. - Plastic container that can be put or store any food.
Polyethylene with higher density (HDPE)	- Plastic can store hazard materials and foods - The plastic is eco-friendly and safe to contact.	- Plastic water bottle and food storage container can be reused and recyclable. - Plastic toys which safe to human health. - Plastic combination on furniture and another hardware are chair, table, bad holder, wardrobe, water tank, bookshelves, and many more examples.
Polyethylene with low density (LDPE)	- Plastic more flexible than HDPE.	- Plastic that surround any kind of wire. - Plastic bag that can carried material. - Plastic bottle can be filled with drinks.
Polyvinyl Chloride (PVC)	- Plastic can be stand chemical and alkalies solution reaction. - Plastic can resist compaction. - It also a low cost plastic.	- Plastic pipe such as water pipe. - Any wire cover with plastic.
Polypropylene (PP)	- Plastic can stand heat or high temperature. - Plastic can be return original shape after band into another shape.	- Plastic furniture - Plastic surrounded any wire. - Plastic toys, plastic luggage and plastic outer surface of car parts.
Polystyrene (PS)	- Plastic that not toxicity and no smell.	- Vacuum plastic bag - Inner disc material and outer casing. - Outer surface of television, computer, projector and laptop. - It also as food packaging container.
Other (non above) E.g. fibre, nylon, polycarbonate and etc	- Some can be recycled but some cannot be recycled as PLE marked on the plastic product	- Plastic eyeglasses or spectacles. - Plastic food storage container. - Plastic baby bottles for the babies.

A large quantity of illegally discarded plastics has been discovered on the surface of the ocean near the coasts of numerous nations. By natural weather, plastic can be broken down, torn apart, or decomposed into microplastic. Microplastic consists of plastic particles with a size parameter of less than 5 mm to 1 um and can be found in the entire environment, within human organs, soil, water, within the organs of terrestrial species and organs of aquatic species, and in many other locations [4, 5]. In addition to toothpaste, dishwashing detergent, cosmetics, laundry detergent, and soup water, other products that were discharged as gray waste water into the water contain microplastic. It means released into a river, ocean, groundwater, or pond. Microplastic is a waste that is released or found in greater quantities in aquatic species, which can worsen the food chain and ecosystem. Similar to a magnetic source, microplastic bind or transport heavy metals pollutant, chemical solutions, dust, virus, and other types of pollutants to form or create new toxic and poisonous pollutants that were consumed by aquatic species or enter their bodies naturally. It kill or infect aquatic species, affecting the environment, ecosystem, and human and animal health [1, 6]. The disposal or discharge of microplastics that pollute or contaminate the water comes from both primary and secondary sources. Primary source refers to any plastic product or gray water discharged to the environment, such as water or land, from which microplastics run off into the water. Secondary source refers to untreated microplastic discharge from industries, factories, and laboratories [1, 7]. Microplastics are typically found in water, where they serve as junk food for aquatic organisms inhabiting the ocean, river, pond, or groundwater, as well as harm their inner and outer bodies.

2. Overview of Microplastics in Aquatic Animals

Scientists began to recognize microplastic as a serious pollutant affecting the environment, human health, and other forms of life, especially aquatic species, five years ago, but 2011 was the first year that microplastic was considered a pollutant. Humans are the primary source of plastic production and waste disposal, resulting in the degradation of plastic into microplastics by natural weather or the environment [8, 9]. The contamination or pollution of water sources caused by microplastics has an effect on aquatic species. The microplastic is discarded into the environment, where it is carried into the water by the weather and causes water pollution. The microplastics in the water may be ingested by aquatic organisms as food or drink, and may also enter their tissues or other organs, causing death or disease. As a result, aquatic species, especially endangered aquatic species, become extinct. Figure 1 illustrates microplastic pathway in environment.. The smaller aquatic organisms with microplastics in their organs serve as prey for the larger aquatic organisms. Jellyfishes, octopus, squids, salmon, mackerels, dory fishes, clamps, mussels, largehead hairtail fishes, zooplankton, and many other aquatic species are examples of edible aquatic species. Then, humans consume aquatic species contaminated with microplastics as food, affecting their health. The death or disease of aquatic species may cause environmental contamination [10-12]. Malaysia has the highest plastic waste disposal rate in the world, which refers to the plastic wastes discarded by Malaysia's population. Even so, plastic wastes from other nations have been shipped to Malaysia for treatment. Few river locations in Malaysia have been examined for microplastic contamination using a fourier transform infrared spectrometer (FTIR) and microscope [13, 14]. First, the microplastic contamination in Kuching, Sarawak, Malaysia was investigated. Kuching's Waterfront obtained microplastic contamination from the Kuap River, the Maong River, and the Sarawak River. Sarawak River was found to have the highest concentration of microplastics due to its proximity to Kuching, Sarawak's recreational park and commercial district, where the majority of microplastics were discarded by human activities. Humans typically use plastic to transport shop glossaries, clothing, and food in marine and terrestrial environments, and then discard the plastic everywhere, including marine and terrestrial environments. The industries illegally or inadvertently release microplastic during the manufacturing process, such as furniture production factories, packaging product industries, glove production industries, recycling product industries, plastic containers production industries, and other industries that may release microplastic to affect aquatic species [14]. During a flood, microplastics obtained on land may enter a river. Kuap River and Maong River contain the second- and third-highest levels of microplastic, respectively, due to the presence of only residential areas and human habitats. The majority of plastic wastes from residential or human living areas have been disposed of in the garbage or recycling bins, and then transported to an integrated waste management facility [15]. The gray water waste containing microplastics has been released directly into the river without treatment or filtration. The contamination of water by microplastics has affected aquatic species, human health, and the environment. Tebrau River and Skudai River are the two rivers located in Johor Bahru, west Malaysia, that contain the most contaminated water in west Malaysia. The percentage of microplastics found in the Tebrau and Skudai rivers of Johor Bahru, west Malaysia, was higher than that of other rivers, but lower than the percentage of microplastics found in the ocean as a whole. These two rivers have the highest abundance of microplastics in Malaysia due to the fact that Johor Bahru has the largest population in Malaysia, which means that there are more manufacturing industries, residential areas, commercial areas, and recreational areas, resulting in more microplastics being released and discharged into the water, which are then consumed by aquatic species [16].

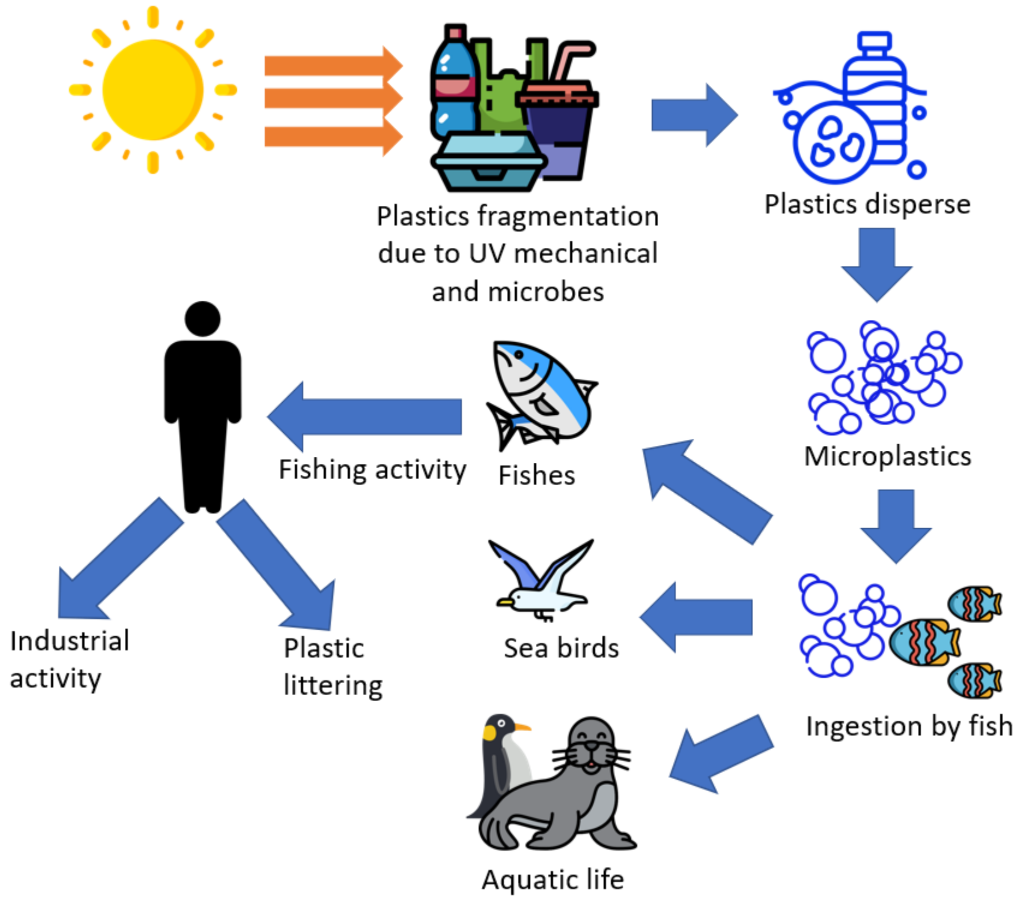

Figure 1. Microplastic pathway in environment [Icon from Flaticon Basic License CC3.0 (Creative Commons)].

3. Impacts Caused by the Microplastics in Aquatic Animals

Microplastics can produce harmful and poisonous substances that ruin the ecosystem's food chain. The presence of microplastics in aquatic species may contribute to the development of disease and an increase in the mortality rate of aquatic species. As the death rate of aquatic animals in marine life rises, the amount of protein, energy, and nutrients delivered by aquatic animals to human, animal, and plant species decreases, affecting the health of humans and other species. The majority of aquatic creatures were hunted for the economic development of a country, however the extinction of aquatic animals may have worsened the country's economy [17, 18]. Microplastics attract additional pollutants, including as heavy metals, dyes, chemical solutions, viruses, and dust, which have adverse effects on aquatic animals. The mixing of microplastics and another pollutant creates more hazardous pollutants, and microplastic pollutant in aquatic animals have a negative impact on human health, meaning it act as food for humans and spread or cause death, illness, and disease as indicated in Table 2. In addition, some farmers use the microplastics in aquatic species as natural fertilizer or the gray water containing microplastics from the drainage for their own plantation or small plantation, resulting in soil pollution and water pollution during runoff caused by rainy weather and irrigation on their own agricultural area, which affects the aquatic animals that have been living in the environment. The plantation was ruined due to contamination. In addition, the fruits or plants of agricultural areas may collect microplastics together with other contaminants and be consumed by humans in the future. The decomposition of microplastic in the bodies of aquatic organisms into the water created water pollution in rivers, ponds, the ocean, and groundwater. Humans drink water from rivers and groundwater contaminated with microplastics, with or without treatment that is detrimental to human health. The microplastics also have an effect on the habitats of aquatic species and plants in water, such as coral plants, which are the habitat of some aquatic species that were polluted by the toxicity of microplastics discharged or expelled from the decomposition of aquatic animal carcasses [19, 20]. As the ocean forests were lost owing to pollution and poisoning of water and soil, aquatic species became extinct. The forest's basic materials are destroyed owing to microplastic pollution or contamination in polluted water, and the country's economy declines as a result of microplastic pollution.

Table 2. Table of sickness, illness, and disease formed on species and human health.

Kinds of Sickness, illnesses and disease	**Condition**	**References**
Cancer	serious	[8, 12]
Food poison	moderate	[13, 17]
Virus	serious	[1, 6]
Lung tissue and cell destroyed	serious	[8, 12]
Immune system become weak	serious	[8, 12]
Death	serious	[8, 12]
Skin sensitivity	moderate	[8, 12]
Obesity	Serious	[4]
Oxidation strass	Serious	[4]
Deoxyribonucleic acid (DNA)	Serious	[4]

4. Technologies for Remediation

The contamination of aquatic animals with microplastics must be controlled or removed. There are three types of technologies to remove microplastic from the environment that help minimize microplastic in aquatic animals: physical technologies, chemical technologies, and biological technologies, as well as combinations of these technologies [21, 22]. Using green algae for adsorption is the primary physical method for microplastic removal. It indicates that the selected green algae can absorb microplastics from aquatic environments. Because the interior space size of green algae is less than the size of microplastics, microplastics only adsorb and adhere to the surface of green algae. P*seudokirchneriella Subcapitata*, Cladophora, and *Fucus vesiculosus* were able to absorb several types of microplastics [23]. The selected green algae must resist water or aquatic area contamination or pollution. It has the highest removal efficiency compared to other remediation methods. The absorption of microplastics by green algae depends on the surface charge of the algae, which has a positive charge that can attract microplastics with a negative charge. It indicates that microplastics with a positive charge were more attracted to or absorbed by the green algae surface area than microplastics with a negative charge [24]. After the green algae has absorbed the microplastic until the limited space of the green algae is completely filled, the green algae is collected or removed from the aquatic area and moved to the incineration industries, which means these green algae were burned or destroyed by using a fire incineration process. However, the green algae must be collected after adsorption, or toxicity be produced and released back into the water. Green algae with a wider inner space were able to absorb more microplastics than those with a smaller inner space. This adsorption technique is advantageous since it has a cheap operating cost and a high removal effectiveness rate for microplastic contaminants. It can also safeguard the ecosystem while eliminating microplastics, hence reducing their presence in aquatic animals [25]. The downsides of employing green algae for adsorption include that it takes longer to operate than other remediation technologies, and there are only a few species of green algae that can withstand contamination and pollution of water and conduct the adsorption process with high efficiency [26]. The second method of physical remediation is membrane technologies. There are a few membrane technologies to rseparate microplastic in water to prevent the increase of aquatic animals containing microplastic, such as membrane bioreactors, tertiary treatment technologies, and dynamic membrane filtration. However, there is a new membrane technology, reverse osmosis, which is more suitable for removing microplastic from drinking water [27]. The membrane technologies are a combination of technologies with chemical technologies known as the combination technology of membrane filtration and activated sludge with catalyst. They are also able to filter microplastic-contaminated water or water containing microplastics under high pressure. The membrane technology can filter an endless volume of water or water containing microplastic pollution. The components of the membrane technologies process include a pollutant detector to detect the pollutants that need to be detected, a filtration process to separate the pollutants from the water or contamination water, sedimentation to separate heavy particles such as soil, clay, rock, and sand, as well as the removal of air bubbles that are present within the water that needs to be filtered. Membrane materials for filtration must be resistant to contamination and not easily damaged [28]. The advantages of membrane technologies include a high microplastic removal rate efficiency, cost effectiveness, low maintenance costs for membrane-operated machines, an easy-to-learn membrane technology operation for engineers and technicians, and the absence of chemical reactions during filtration. The disadvantages of membrane technologies are that they require a great deal of energy to operate, the materials of the filtration membrane cannot be reused after each treatment, it takes longer to clean the dirt from the membrane, but the membrane must be discarded if the membrane filtration is contaminated or polluted, and different sizes of membranes produce different filtration results. It indicates that micro filtration membrane technologies only filter micro-sized pollutants, including microplastics, but nano-sized pollutants, such as nanoplastics, not be eliminated 27, 28].

In addition, two chemical technologies such as coagulation or flocculation, the sol-gel technique, and electrode-coagulation are employed in the remediation of miroplastics. The coagulation or flocculation process is the water added dose of concentration as iron or aluminium salt base, polyacrylamide or solution of FeCl.6H2O while mixing to generate coagulant particles, which indicates that microplastics and other pollutants combine together to form flocs [29, 30]. After coagulation or flocculation, the coagulant-water mixture was settled to create sedimentation. The influence of dosage and pH value on coagulation or flocculation was simple to have on removal rate. At the optimal pH, coagulants can be produced with a high removal rate. The advantages of coagulation or flocculation technology include its easy-to-learn operation steps, high cost-effectiveness, high removal rate, and absence of pollution after the coagulation or flocculation process; however, the separated floc continue to undergo additional treatment [31]. The downsides of coagulation or flocculation technologies include the use of chemical solutions as dose, the incompatibility of large microplastics with these technologies, and the high cost of chemical solutions. The subsequent chemical innovation is electrocoagulation. This technology utilized two electrodes without the addition of a chemical solution as the anode and cathode to operate coagulation with optimal pH value and sodium chloride concentration [29, 31]. The anion metal electrode is either iron (Fe) or aluminium (Al), whereas the cation electrode is hydroxide (OH^-). The selection of the anion metal electrode relies on the microplastic kinds. The advantages of this technology include a low price on cost effectiveness, a high efficiency on removal rate, an easy-to-learn operation method for engineers and technicians, and low energy consumption. The disadvantages of electrode-coagulation are the absence of chemical solutions as dosage for this technology, the need to replace the anion and cation of two electrodes when the charge of these two electrodes becomes neutral, and the large size of microplastics that can also be used for this technology [30]. Sol-gel coagulation technique is the newest and last chemical technology for the cleanup of microplastics. This indicates that sol-gel is a coagulant that utilizes silane or N-alkyl solution. This coagulant is more environmentally friendly than other coagulants since it does not discharge pollutants into the atmosphere. In coagulation, the contaminated water not form floc, but rather gel, which was then dried to produce additional particles. This innovative coagulant for coagulation technology is more environmentally friendly than conventional coagulants for coagulation, can coagulate microplastics of all sizes, is cost-effective, and produces no pollutant in the coagulation sludge. The disadvantages of this new coagulant are the high cost of the sol-gel solution and the absence of maintenance costs [29-31].

Biological degradation is the process used to remediate microplastics in water, which also assist diminish their presence in aquatic species. It refers to the eradication of microplastic using organisms and bacteria as their food source. There are a limited number of species and bacteria, including Bacillus cereus, Euphausiasuperba, Zalerion maritium, Souda consortium, and others [4]. The selected organism or bacteria must be suited to various areas of pollution and must be able to survive without the influence of microplastic. The advantages of biological degradation are that it is safe to develop in the environment, the selected organisms and bacteria can adapt to different types of water contamination, there is no cost effectiveness and cost for the technologies used, it is simple to spread to the environment while simultaneously removing microplastic, and transporting the selected organisms and bacteria to microplastic-contaminated aquatic areas is inexpensive. The disadvantages of biological degradation include that only a select few organisms and bacteria can be utilized, and the number of organisms and bacteria must be monitored or regulated during the degradation process. If no monitoring or control measures are employed, the number of organisms and bacteria increase and the reproduction process cannot be controlled [4, 32].

5. Challenges in Future and Prospect in Environment and Human

Microplastics are on the rise and continue to pollute or contaminate the environment and human health due to their association with aquatic species. Since 2011, microplastics have been studied as a pollutant, but 2015 has seen an increase in concern. The global community has devised a plan to remove and minimize microplastic from the environment, with the aim of achieving this objective by 2023. Due to a number of obstacles, this plan cannot be executed and microplastics cannot be simply eliminated. The main obstacle is that the majority of a country's economy depends on the sale of plastic products. Plastic is an essential material for the production of furniture, pipe for cables and sludge, packaging plastic bags, electricity machines, surface cars, PVC flooring materials, and food storage containers or cups [33]. In the future, aquatic and terrestrial creatures and plants go extinct owing to microplastic pollution in the ecosystem. For instance, the sea turtle is the most endangered aquatic mammal on the planet and is becoming extinct. Since microplastics impair their health and body mobility, such as the mortality of sea turtles due to disease growing in their organs, and also because their speed and movement is reduced, making them easy prey [17, 18] The Sustainable Development Goals 2023 cannot be attained due to microplastic pollution, which presents a second obstacle. No raw materials are protected from the environment, thus future generations cannot be sustained. The ultimate difficulty of the social environment in the future. It indicates that the majority of people do not wish to collaborate with government-set plans, laws, or regulations, and there are no government enforcement activities to minimize plastic consumption [14]. The microplastic contamination impact the environment and human health. When the death rate rises in the future as a result of diseased bodies and environmental degradation, the human lifespan decrease [33]. As a result, some prospects for reducing microplastic include the continuing development of recycling activities and the human obligation not to release plastic into the environment but to the garbage can. The government must enforce the law and regulations on the illegal disposal of plastic trash, and the punishment for violating the regulations is a fine. The government must also educate the public about the microplastic form of pollution and the solutions for reducing microplastic use. Before being used as food, aquatic and terrestrial species must be examined. Future sustainable development objectives can be attained if microplastic levels are decreased [34].

6. Conclusions

The south east asia regions of the world are known for their rich biodiversity, and it is no surprise that many aquatic animals are exposed to microplastics in various ways, such as through their food and environment. Studies have shown that microplastics are prevalent in tropical aquatic regions, with some areas having higher concentrations than others. Factors such as population density, industrial activities, and the amount of plastic waste generated contribute to the varying levels of microplastics found in these regions. Unfortunately, aquatic animals, including fish, crustaceans, and mollusks, are ingesting microplastics at alarming rates, posing serious threats to their health and the health of humans who consume them. The ingestion of microplastics by aquatic animals can lead to a variety of negative health effects. As such, the contamination of aquatic animals with microplastics must be controlled or removed. To minimize microplastics in aquatic animals, three types of technologies have been developed: physical technologies, chemical technologies, and biological technologies. A combination of these technologies is often used to effectively reduce microplastics in the environment. The global community has created a plan to remove and minimize microplastics from the environment by 2023, but executing this plan has proven difficult due to several obstacles. One major obstacle is that many countries' economies rely heavily on the sale of plastic products. Additionally, microplastic pollution presents a significant obstacle to achieving the Sustainable Development Goals 2023. Microplastic contamination has a significant impact on the environment and human health, and if the death rate continues to rise due to diseased bodies and environmental degradation, it will ultimately reduce human lifespan. To reduce microplastic pollution, it is essential that governments enforce laws and regulations on the disposal of plastic waste and educate the public on the dangers of microplastic contamination. By decreasing microplastic levels, future sustainable development objectives can be attained.

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Conflicts of Interest

The authors declare no conflict of interest.

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