The effects of microplastics in oceans and marine environment on public health – a mini-review

The effects of microplastics in oceans and marine environment on public health – a mini-review

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Abstract. Plastic's versatility is one reason why production or use has not decreased over the years. The production of plastic globally was 359 million metric tons as of 2018, and this number increased by 3.5% in 2019. Microplastics, which are tiny particles of various types and forms of plastic, can be found in cosmetics, fabrics, car parts, machinery, footwear,products packaging, polythene bags and so on. Over time, these particles, through the process of wear and tear of these various plastic products, indiscriminate disposal, runoffs, and erosion, find their way into water bodies from rivers and streams into larger water bodies like seas and oceans. These tiny non-biodegradable particles find their way into living organisms carrying along with them other harmful chemical contaminants. This study reviews the effects that microplastics found in marine environments have on public health in general. It covers the types and sources of microplastics and the various ways in which microplastics have affected human health and different aquatic species in the marine environment. The review showed all pointers of microplastics present in the environment to have negative impacts on the ecosystem. Certain research gaps are pointed out, like the integration of researchinto policies to help improve the environment and the standardization of dedicated procedures and methods of reporting microplastic pollution. Suggestions were made for possible solutions like the reduction of plastic use for product packaging, provision of biodegradable and eco-friendly materials as substitutes, and general public awareness on the harm of microplastic pollution in the immediate environement.

Keywords: Microplastics, Plastic, Contaminants, Pollutant, Marine Environment.

1. Introduction

Plastics, as useful to man as they are, have been created to the detriment of the health of all living organisms. From production processes to industrial, commercial, economic and domestic uses to being discarded properly or indiscriminately into almost all aspects of the environment, the effects of plastic have taken a toll on the public health of both man and other

living organisms. Although reuse and recycling have helped reduce the rate of plastic disposal, it still hasn't completely eradicated it. A continuous increase in world population has put the marine environment under constant pressure due to the continuous activities of man [1][2]. Continuous pollution of these marine bodies has now become a global problem that needs urgent solutions. The United Nations Environment Programme in 2018 approximated that about 50% of the world's coral reefs have been lost due to man's activities on land[3]. According to [4], it was estimated that the volume of plastic waste entering the ocean was about 12.7 million tons. Plastic, in all its various forms, is a non-biodegradable material. However, if it does degrade, it takes about hundreds, if not thousands of years, to do so. When this happens, it breaks down into what is known as microplastics.

Microplastics are not a particular kind of plastic. However, they are determined by size, any plastic particle about 5mm or less in length[5]. Approximately 80% of microplastics in the marine environment are from freshwater sources [6]. Microplastics have been found to enter the marine environment in many different ways, including sewage and wastewater effluent, riverine transport, through direct release in shipping processes and from ports and through atmospheric deposition [7][8]. Particles of Microplastics have been found in significantly large numbers in water bodies across India, Africa, Europe, North America and Asia [1]. Because of their small sizes (which is usually 5mm or less), different colours and shapes, they are often mistaken as food and ingested by aquatic animals and find their ways, through the food chain, into the digestive system of man[9]. These particles also can carry other chemical contaminants, which can be harmful and toxic to living organisms, including man[10].

2. Review of Literature

2.1 Types and Sources of Microplastics

Generally, microplastics can be classified based on their sources into primary and secondary microplastics.

1. **Primary Microplastics**: these are microplastics produced as micro-sized particles and are directly released into the environment. They can be found as microbeads in cosmetic products, household items and microfibers in clothing fabrics.
2. **Secondary Microplastics**: These microplastics are derived from the degradation/ breaking down of larger plastic products through processes like erosion, friction, and continuous movement of such products. Secondary microplastics are the most common form in the marine environment. Compared to primary microplastics, they are more diverse in colour, shape, size and composition.

2.2 Microplastics and the Environment

Scientists and researchers have been digging into the sources, movement, and effects of microplastics in recent years, with some coming up with possible solutions. Wang et al. [4]analyzed the effect of typhoons on the abundance of microplastics in seawater, sediments, and cultured oysters. The research stated that although microplastic pollution can be controlled by reducing the terrestrial input, severe weather conditions make it difficult. The Sanggou Bay was taken as a case study in this research within 8 days before and after two major typhoons to note the volume and type of microplastics being deposited in the water

body. It was noted that heavy metals and organic matter existed on the microplastics that were gotten from the oyster samples and that the typhoons changed the microplastics' colour distribution. This particular study suggested that weather conditions should be factored in when investigating microplastics in the marine environment.

Table 1: Increase in the production of plastic products in recent years [2]

Years	Amount of Plastic Production (Million Metric Tons)
2002	200
2008	245
2009	250
2010	270
2011	279
2012	288
2013	299
2014	311
2015	322
2016	335
2018	359
2019	372

A study carried out by [1] showed the transportation of microplastics through runoffs into marine bodies from the washing of synthetic fabrics to the disposal of laundry and domestic wastewater, degradation of plastic litters in the environment and ingestion, entanglement and suffocation of marine organisms. The study also discussed control measures to be taken to decrease microplastic pollution in the environment. Some of these measures are listed below:

1. Identifying the main source of microplastics.
2. Creating public awareness about microplastics through education.
3. Increasing reuse and recycling of plastic products and proper disposal of plastic wastes.
4. Understanding the behavioural mechanism between microplastics, marine organisms and the marine environment.
5. Exploiting the potentials of marine organisms (mostly those of marine origin) that can degrade microplastics.

Another recent study carried out byAlimba&Faggio[2] discussed the toxicology of organic compounds, metals, and pathogens absorbed by microplastics on marine organisms. Barboza et al. [11]analyzed the presence and effect of microplastics in samples of wild fish in the North-East Atlantic Ocean. It analyzed three different species of fish using 50 samples. Results showed that about 74 out of the 150 samples had microplastic contaminants in their gills, gastrointestinal tract and dorsal muscles. It also showed that contaminated fishes had higher lipid peroxidation levels in their brains, gills and dorsal muscle and increased brain acetylcholinesterase activity than fish samples without microplastic contamination. The study encourages more research to be carried out concerning microplastic effects on fishes that humans highly consume. Luo et al. [12] discussed the ageing process of microplastics in the

environment. The effects of enhanced ageing on the pyrolysis and characteristics of commercial pigmented microplastics were discussed and their interactions in simulated intestinal and gastric fluids of mammals. It was reported that the colours, shapes, surface area and carbonyl index of microplastics changes with time. Man's ingestion of contaminated aquatic animals was the first concern of microplastics related to humans [13]. Fish is widely eaten as a source of protein all over the world. Therefore, the need to analyze and protect the aquatic habitat is important to man's health. Li et al. [14]analyzed and discussed the distribution and ecological risks of microplastics in the mangroves of China stating that microplastics carry along with them metallic and non-metallic elements that are harmful to the ecosystem.

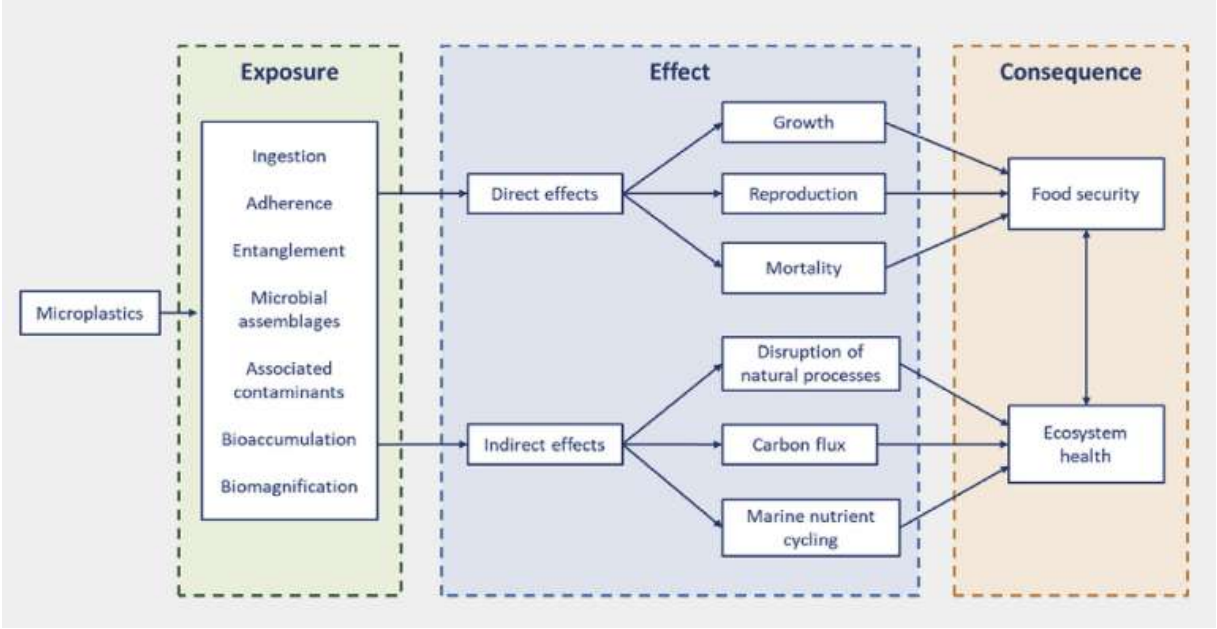

Figure 1:Movement of Microplastics in the Environment [8]

2.3 Effects of Microplastics Pollution in the Marine Environment

Measures are currently being taken by world organizations and the public health sector to see to the reduction and possible eradication of plastic debris and microplastics in the marine ecosystem. However, various research has highlighted the effects and damages caused by microplastics in the marine environment, some of which have been categorized and discussed.

i. **Presence of Bisphenol-A in the Livers of Wild Fishes**: Bisphenol-A is a colourless organic synthetic compound found in plastic water bottles, food containers, sports equipment and CDs or DVDs. Recent research conducted by Barboza et al. [5] analyzed the presence of bisphenol-A and some other related compounds in the muscles and livers of some samples of fish species from the North-East Atlantic Ocean. The connection between bisphenol and microplastic contamination levels in the fish samples and the risk of humans consuming these contaminated fishes was also evaluated. This research showed that the highest number of bisphenols were found in the liver and muscle with a maximum concentration of 302 and 272 nanogram/gram dry weight, respectively. It was

also discovered that fish samples contaminated with microplastics had ominously higher concentrations of bisphenols present in them than fish where no microplastics were found. The levels of bisphenols were connected with a higher intake of microplastics. The research suggested that continuous human consumption of these wild fishes might cause a buildup of microplastic contamination, which can eventually lead to health issues as time goes on.

ii. **Polystyrene Nanoparticles Present in Planktons**: A research was conducted by Bergami et al. [15]to identify the toxicity of Polystyrene nanoparticles in two planktonic species (the unicellular green microalga, Dunaliella Tertiolecta, as prey and the micro-crustacean brine shrimp Artemia Franciscana, as the predator). Polystyrene nanoparticles are tiny, lightweight particles of synthetic resins, which is a polymer of styrene. They are usually white and are used in the packaging process of fragile objects after manufacturing. In this particular research, growth inhibition tests were carried out for 72 hours and long-term toxicity tests for 14 days on both species to test for polystyrene nanoparticles while following standardized procedures. It was discovered that PS-COOH formed micro-scale aggregates and did not alter the microalgae's growth or brine shrimps. However, negatively charged nanoparticles were adsorbed on the microalgae and excreted in the brine shrimps. This shows that there is a possible trophic transfer from prey to predator. On the other end, PS-NH2 formed nano-scale aggregates and caused algal growth inhibition and eventual mortality of the brine shrimps at the end of 14 days. The results gotten from this research showed that continuous exposure to polystyrene particles will lead to the death of these marine organisms, and if measures are not taken to control the release of these particles into the marine ecosystem, some organisms stand a chance of going extinct with time.

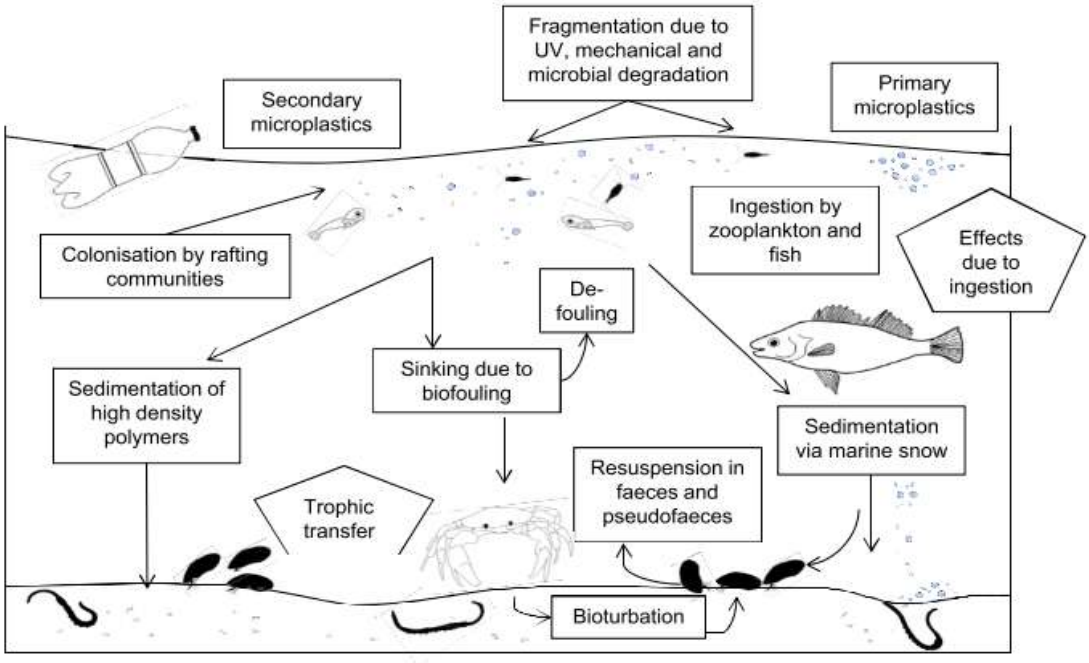

Figure 2:Biological Interactions between Microplastic particles and Marine Organisms [16]

iii. **Toxic Effect of Microplastics in Fish Larvae**: A very recent study was conducted to examine the behavioural and physiological effects caused by the consumption of environmental microplastics by fishes at different life stages [17]. Samples of microplastics were collected from beaches on three different islands located near the North and South gyres of the Pacific Ocean. The Japanese Medaka was used for this research, and larvae and juveniles were continuously fed for 30 days with three doses of microplastics equivalent to the concentration found in moderately and heavily contaminated ocean areas. This study showed that the ingestion of microplastics caused breaks in the fish DNA, alterations in their swimming behaviour, a decrease in the head to body ratio and eventually death of the sample fishes, especially larvae.

iv. **Tissue Damage and Reproductive Disruption in Marine Medaka**: Wang et al.[18] researched the adverse effects on the health of marine Medaka caused by exposure to and ingestion of polystyrene microplastic contaminants. The marine Medaka were exposed to concentrations of 10mm polystyrene microplastics for 60 days while being fed, and standardized procedures followed. This experiment showed an accumulation of microplastics in the gill, intestine, and liver of the fish samples, which caused oxidative stress and histological changes in them. It was also observed that the microplastics delayed gonad maturation and decreased the fertility of female fish. Parental exposure to microplastics also delayed the incubation time and decreased the offspring's body length, heart rate, and hatching rate.

3. Microplastics and Man’s Health

Exposure to microplastics may occur by inhalation, ingestion or continuous contact with the skin. Primary microplastics can get into man's body through cosmetics, clothes, foods, and even dust and over a long period, man’s health begins to deteriorate [19]. A person’s intake of microplastics based on food consumption is estimated to be about 39,000 to 52,000 particles per year [20]. Recent research was carried out on dairy products (specifical milk) to test for the presence of microplastics in branded milk products [21]. It was discovered that all 23 milk samples tested had a significant amount of microplastic particles of different colours with ranging sizes between 0.1 to 5mm. This shows that the rate of microplastic particles intake by man from food substances is significantly high, and measures need to be taken to reduce the release of these harmful particles. According to Xu et al. [22], it was discovered that microplastics are present in the drinking water distribution system in parts of mainland China. This contamination can be traced to ageing plastic pipes from the effect of Chlorine on them. A recent study shows the effects of ingested microplastics on the digestive system [10]. Although some of these particles can be excreted, not all leave the system, and constant exposure will, with time, lead to health issues. Some of the adverse effects of microplastics on the health of man are:

i. Disruption of the immune function.
ii. Neurotoxicity and neurodegenerative diseases.
iii. Energy disruption.
iv. Oxidative stress.
v. Cytotoxicity (the ability of certain chemicals or mediator cells to destroy living cells).
vi. Metabolism disruption.

vii. Skin cancer.
viii. Microplastics serves as a vector for chemicals and organisms.

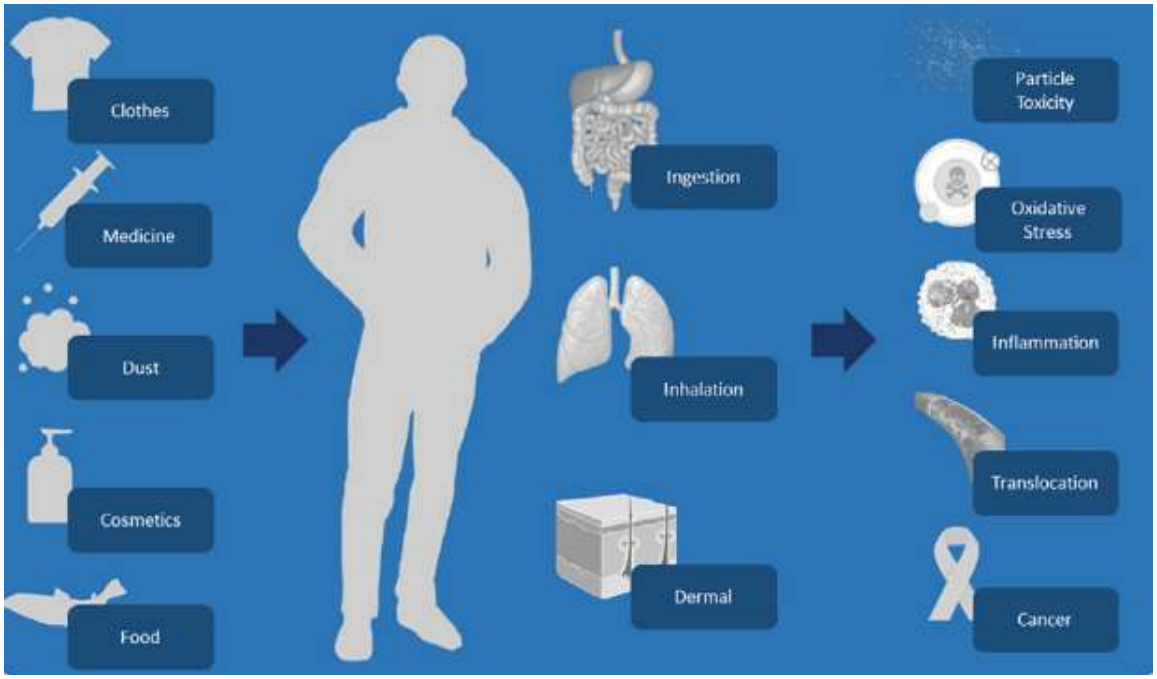

Figure 3: Health Effects of Microplastics on Humans [19]

4. Conclusion and Possible Solutions

All pointers of microplastics present in the environment show the negative impacts they have on the ecosystem. Specific measures have to be taken to first reduce then eradicate (if possible) the presence of microplastics in the environment. Ofcourse, the source must first be tackled; hence regulations should be in place for the production rate of plastics for product packaging. Other environmentally friendly and biodegradable materials should be substituted in place of plastic. It is also important that awareness be raised to the general public on the harms that plastic has caused and is currently causing in our immediate environment. Also, our water bodies need to be protected. From streams, lakes and rivers to oceans and seas, the water should be protected because only in doing so will contamination of aquatic organisms reduce. Awareness of plastic and microplastic pollution can be raised by integrating related topics into the school system, proper solid waste management, and organized environmental sensitization.

There is also a need to standardize methods applied in determining microplastic pollutants in various living organisms and a standardized method of reporting results for easy access and aid comparability of results. These processes are necessary to enable meaningful guidelines for monitoring plastic and microplastic contamination in the environment and improve the decision-making processes on all levels towards streamlined future efforts.Certain research gaps still need to be filled, like integratingresearch into policies to help improve the environment and standardization of dedicated procedures and methods of reporting microplastic pollution. Also, further methodologies used to visualize the heterogeneous

distribution of the different sizes, shapes and forms of microplastics found in the environment would be useful.In conclusion, replacing plastic with non-plastics and biodegradables, recycling already produced plastics, better solid waste management, and introducing policies that help.

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