EXTENDED ABSTRACT

A REVIEW ON INVESTIGATION OF MICROPLASTICS (MP) POLLUTION IN WATER & FUTURE PERSPECTIVES

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Abstract

The assessment & mitigation of microplastics (MPs) pollution in the aquatic environment is a major problem that the world is presently experiencing. This study comprehensively reviewed the existing literature to explore (a) the prevailing types, abundance, distribution & toxicity of MP in the aquatic environment, and (b) the MP investigation techniques. The key problem is the disparity of MP detection methodologies. Hence, conducting subsequent spectroscopic analysis to validate the identification results, for which Fourier Transform Infrared (FTIR) & Raman spectroscopies are the best-suited techniques is necessary. The joint use of spectroscopic techniques & extended equipment Focal Plane Array - FTIR and Thermo Extraction and Desorption coupled with Gas Chromatography-Mass Spectroscopy (FPA-FTIR & TED-GC-MS) able to enhance the identification. Future research should focus on establishing standardized methodologies for sampling & extracting MPs & developing highly efficient fully or semi-automated analytical techniques to facilitate rapid & accurate identification & quantification of MP.

Keywords: Aquatic environment, microplastics, detection, quantification, techniques.

1. Introduction

Recently, the production of plastic was boosted with all industrial sectors because plastics are flexible, cheap, corrosion-resistant, lightweight, and durable. Global plastic production was increased from 0.5 million tons per year in 1980 to 288 million tons in 2012 and it was 4% per year by 2016 (Cordova & Wahyudi, 2016). Annual plastic production in the year 2018 was 350 million tons and 10% of plastic waste reached into the ocean (Zhang et al., 2020). Particles less than 5mm in size were commonly referred to as MPs, and it produced by the breakdown of larger plastics (Van Cauwenberghe et al., 2013). There are five major categories used to identify MPs such as sources, types, shapes, erosion, and color (Hidalgo-Ruz et al., 2012). According to Veerasingam et al., (2016), all the 192 coastal countries release 275 million metric tons of plastic into the land and 4.8 to 12.7 million metric tons of plastic to the ocean in 2010. The chemical properties which are consisted of the MPs persist in the environment, are relatively stable and it has the lowest degradation process. Therefore, MPs act as a vector by absorbing pollutants and cause bioaccumulation (Amelia et al., 2021). Moreover, with the range of the sizes, MPs readily ingested by organisms such as mussels, oysters, whales and, shrimps (Auta et al., 2017) in the marine environment and tubifex worm in the freshwater environment

(Hurley et al., 2017). Consequently, this kind of ingested MPs causes to transfer of higher trophic levels via the food chain (Auta et al., 2017).

The first evidence of MP pollution in Sri Lanka was recorded in 2017 on beach sand from Negombo (Ranatunga et al., 2021). According to the MP pollution studies in Sri Lanka, the West Coast is more polluted than the East coast. Because of the highest abundance of MP in the Northwest region (0.85 particles/m^3). Further, Central East (0.27 particles/m^3) Sri Lanka is slightly more polluted than North East (18 particles/m^3) and South East (25 particles/m^3). However, MP abundance in Southern coastal region water was very lower than in other areas. In Sri Lanka average abundance of MP in coastal water is estimated as 0.31 particles/m^3 of surface water (Weerakoon et al., 2019). Therefore, the objective of this review is to provide better knowledge on the prevailing types, abundance, and distribution of MPs in marine environments. Additionally represent the investigation techniques of MPs.

2. The prevailing types, abundance, & toxicity of MP in the aquatic environment

Anthropogenic activities were the major cause of MP pollution in the aquatic environment. Tires, tiles, personal care products, textile industry, overseas harbors, tourism, fishing, plastic bottle, and many other industries release a significant amount of MP to the environment (Rezania et al., 2018). Prevailing types of MP can be varied according to their color, shape, and chemical constituents such as Polypropylene, polyvinylchloride, Polyethylene, polyethylene terephthalate (PP, PVC, PE, and PET) (Wang et al., 2020). According to (Rezania et al., 2018), MPs were categorized into two major types (Primary and secondary) considering their morphology. Consequently, primary MPs were originated as a result of the spillages during the production of plastic including, the cosmetic and cleaning product consists of polymer particles and textile, gel, and paints consisted of fibers. Secondary MPs were deriving through the breakdown of large particles into pieces under mechanical forces like biodegradation, thermal degradation, photolysis, and thermal oxidation (Rezania et al., 2018). Further, the MP pollution in aquatic environment is vary due to geography of the locations. Table 1 shows the differences in abundance of MPs in several locations in the world (Shahul et al., 2018).

Currently, MP has been distributed within the high populated areas and entered the marine environment, especially through terrestrial and land-based activities. Runoff, wastewater discharging systems, infiltration, river discharge, wind waves, and ocean currents were the major distribution methods of MPs in the aquatic environment (Du et al., 2021). Plastic composition and environmental conditions have been significantly affecting their distribution. According to the composition of MP, many studies were reported that PP, PE, PVC, PET, nylon are considered as most dominant forms of distribution in oceans, rivers, and estuaries (Ajith et al., 2020).

Moreover, the shape, size, density, and weight of the MP influenced dispersal thus, MPs which are consisted of higher densities than water tend to sink and accumulate in the sediment. MPs are classified into several shapes furthermore, the most abundant shapes are fibers (48.5%), fragments (31%), beads (6.5%), films (5.5), and foam (3.5%) in water and sediment (Mu et al., 2019).

Investigating the MPs toxicity has been widespread among the scientists as it's intended to adsorb waterborne organic pollutants, thereby prone to leaching plasticizer. Furthermore, MPs were contaminated with the persistent organic pollutant (POPs) and intend to release some toxins into the environment (Rodrigues et al., 2019). Overall, the major issue was the unavailability of technologically advanced techniques to evaluate the abundance, prevailing types, distribution, and toxicity of MPs (Auta et al., 2017).

3. The MP investigation techniques

MP investigation has been comprised of sample collection, separation, identification. MP sampling in the aquatic environment has been done in the water surface, water column, and sediment.

Table 1: Abundance and Distribution of MPs in aquatic environments

Materials and Tools used for Sampling MP	Abundance	Locations	References
Plankton net	$0.01E^6$–$6.8E^6$ items/km^2	Taihu Lake located in China	(Shahul et al. 2018)
Ekman bottom grab sampler	56 fragments per 400 g wet weight (or 0.45 fragments per g dry weight)	Near Petrie Island in the Ottawa River, Canada	(Vermaire, et al. 2017)
Trawl net (112 µm mesh)	0.55×10^5–342×10^5 particles km^{-2}	Xiangxi Bay of Three Gorges Reservoir, China	(Zhang, et al. 2017)
Steel sieve (50 µm mesh)	1660.0 ± 639.1–8925 ± 1591 particles m^{-3}	Urban lakes in Wuhan, China	(Wang et al. 2017)
Stainless steel scoop	66 particles 100 g^{-1}	River Thames tributaries, UK	(Horton, et al. 2017)
Plankton net (153 µm mesh)	51–27909 particles m^{-3}	Victoria Harbor, Hong Kong	(Tsang et al. 2017)

Most of the aquatic environmental sampling methods were used nets for surface samplings such as bongo/zooplankton nets and neuston nets (Hidalgo-Ruz et al., 2012). When considering the sediment sampling locations of the marine environment there were several types of samples for investigation deep-sea sand, beach sea sand, and mangrove mud, estuaries, harbors, (Zhang et al., 2019), and in the freshwater environment, samples have been collected from shoreline, river or riverbed. Further, density separation, filtration, digestion methods, visual sorting, and sieving (Hidalgo-Ruz et al., 2012) were the numerous methods used to separate MPs from water. Separation of seawater samples and organic materials were done using acid, oxidative, enzymatic, and alkaline digestion methods (Amelia et al., 2021). There were two instruments for separate larger sediment samples from plastics by Munich which is an effective method or MP sediment separator. As MP identification techniques FTIR, Infrared Spectrophotometer, and near-infrared spectrometer were the most common method (Hidalgo-Ruz et al., 2012). Using these methods Polypropylene (PP), Polyethylene (PE), and Polyester in polymers of MP have been identified. Moreover, Raman Spectroscopy is used to analyze the crystalline structure of the polymers (Rezania et al., 2018). MP pollution at the global level currently increasing at an alarming rate. Thereby it needs sustainable solutions to identify the MP releasing methods into the environment, collection, prevention and use sustainable material instead of plastic (Schmaltz et al., 2020). Satellite and model-based observations have been done to simulating the larger amount of MP discharging locations and observe the transportation of MP. Therefore, it has been enhanced the collection of MP from the point sources (Sherman & Van Sebille, 2016). Furthermore, enhancing biodegradable MP usage and production might be a significant solution for the MP pollution in the aquatic environment. In addition, several microbes *Staphylococcus sp., Pseudomonas sp., Bacillus sp., Aspergillus niger, Pseudomonas aeruginousa, Bacillus subtilis, Staphylococcus aureus, Streptococcus pyogenes, and Rhodococcus ruber* have been reported as plastic polymer degrading microorganisms (Auta et al., 2017).

4. Conclusion

Prevailing types of MPs, their abundance, distribution, and toxicity in the aquatic environments related studies have been conducted over the past decades but the studies related to investigating technologies were lack. This paper reviewed prevailing types, abundance, distribution, and toxicity of MP in the aquatic environment while emphasizing MPs investigating technologies. The majority of the previous studies have been focused on MP pollution in aquatic environments while others are focused on current research trends. Therefore, to mitigate the MPs pollution, there is a vital need for identifying the sources, transportation mechanism, and development of laboratory and field approaches to provide essential knowledge. Furthermore, there was a lack of evidence related to the biodegradation of MPs, especially polymer biodegradation. Hence, the biodegradability of MP in aquatic environment-related studies is intensified.

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