MICROPLASTIC POLLUTION IN FRESH WATER

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Abstract:

Water bodies are being slowly but inevitably suffocated by microplastics. Different routes, such as atmospheric deposition, runoff from contaminated soil, or municipal wastewater, allow microplastics to reach water bodies. The movement of plastic debris was significantly aided by storm-water runoff. Microplastics comprise fibres, shreds, particles, flakes, sheets, or foams and occur in a wide range of shapes, colours, and chemical compositions. Environmentalists, organisations, and governments are now aware of the contamination caused by microplastics in both the marine and terrestrial environments. The available literature on microplastic pollution in water systems was obtained for this review. It was noted that freshwater ecosystems and oceans might be comparable. The existence of microplastics as a stressor in freshwater habitats around the world, given that research on microplastics has just recently begun, our knowledge of their appearance, dispersion, and methods for reliable identification and quantification is still limited. Furthermore, it is unclear how microplastics could affect human health. Considering that extensively human populations rely on water supplies for food and drinking water, raising awareness in these areas is critical if we are to develop appropriate policies and management tools to address this emerging issue.

Keywords: *Water bodies, microplastics, storm-water runoff, plastic debris, human health*

1. Introduction:

Around the world, water pollution and its effects are gradually getting more complicated. Products made of plastic distinguish out for their outstanding characteristics, such as their light weight, robustness, and adaptability (Hammer et al., 2012, Ivleva et al., 2017). However, the ubiquity of plastic trash and its associated environmental consequences have caused significant concern. Microplastic pollution of marine structures, which has reached even the most isolated regions, is one of the biggest environmental issues facing the world today.

A preliminary investigation found that the distribution and interactions of microplastic in water bodies are equally important. The first significant amount of microplastics was documented in freshwater in 2004. One thing became quite evident as a result of that: plastic pollution doesn't quite disappear by itself. We are addressing a major, global environmental problem that includes microplastics in addition to "just" plastic.

Thompson et al. (2014) introduced the term "microplastics" (MP), who also brought attention to the growing issue of plastic pollution into the water. Since then, the researchers, decision-makers, and the public have all started to pay more attention to its existence in the environment. All terrestrial and freshwater systems in the atmosphere have been shown to contain microplastic particles (Wagner and Lambert, 2018). When larger plastic particles break down, tiny plastic pieces called microplastics are produced. Microplastic pollution endangers people's health and the environment. Microplastics, as the name suggests, are tiny pieces of plastic. Their diameter, which is smaller than the normal pearl used in jewellery, is specifically recognized as less than five millimetres (0.2 inches).

Primary and secondary microplastics are two basic types. The most common types of microplastics are those that have already been produced in a micro size, such as the microspheres (500 nm or smaller) used in a variety of cosmetic products, the mixtures used in sandblasting and shot blasting, and the microplastics used as a medicine accelerator and in 3D printing. Secondary microplastics are a by-product of the breakdown of larger plastic materials by mechanical or photo-oxidative means.

It is estimated that 1.5 million tonnes of primary microplastics are released into the environment annually. This occurs as a consequence of improper and unreliable sampling and analytical procedures. Finding solutions to prevent microplastics from entering the water supply is critical in this situation. Numerous methods, including engineering and biotechnology, have been used to remove microplastics from water systems.

However, removal techniques are still in their infancy, and many issues are yet unresolved. In order to provide a comprehensive assessment of the state of water bodies, this point of view gathers the developments in microplastics pollution analysis and prevention. This analysis identifies a number of research biases and knowledge gaps regarding water pollution and microplastics. Finally, a range of feasible remedies are proposed to overcome these knowledge gaps.

2. Definitions of Microplastics:

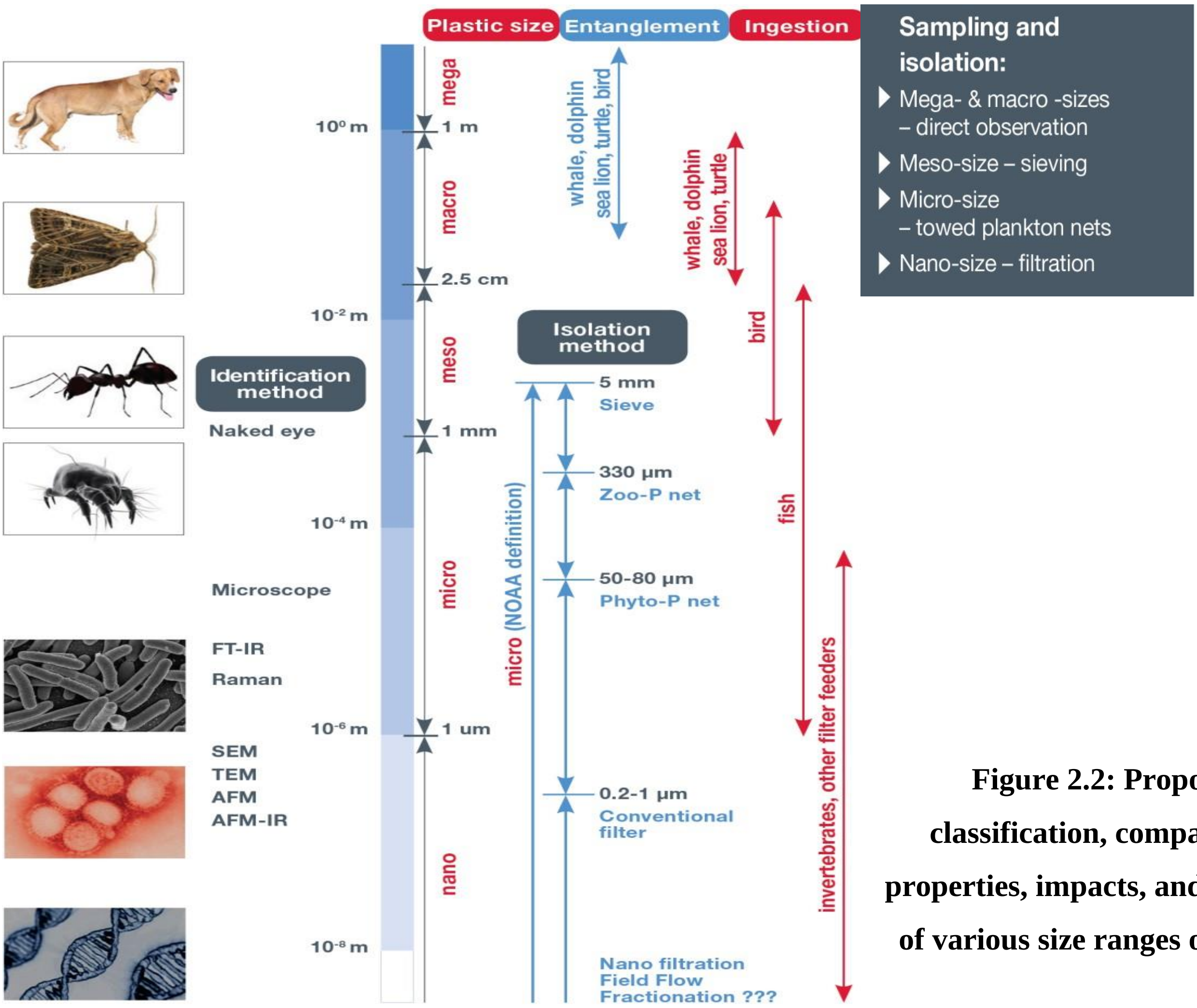
The definition of plastic refer to Synthetic (made from fossil fuels) and/or natural organic (derived from biomass) polymers that may be moulded into desired shapes and forms (Wagner & Lambert, 2018). Plastics are beneficial for a number of packaging needs because they preserve food and other products from causing hazards or being contaminated. Utilizing plastic pipe and storage containers can reduce the possibility of water pollution (Hahladakis et al., 2018).

Plastics are known to travel large distance in the oceans, therefore it may be expected that they are going to do so in freshwater systems (Desforges et al., 2014; Ryan, 2014; Barnes et al., 2009; Collignon et al., 2014). A typical environmental pollutant is plastic. Despite the fact that the problem of plastics in the marine environment has been identified for a long time (Ryan, 1987), preliminary acceptance was delayed. In a sense, plastic pollution has're-emerged' as a significant issue. Polypropylene, 21%, Polytethylene, 18%, Polyvynil Chloride, 17%, High-Density Polyethylene, 15%, Polystyrene, 8%, and Polyethylene Terephthalate, 7% are the most important pure polymer plastics in terms of demand worldwide (Hahladakis et al., 2018).

Table 2.1: Plastic additives (Lambert & Wagner, 2018; Hahladakis et al., 2018)

Additive	Function	Example
Accelerants	Speeds up curing of polymers	Ethylene thiourea
Antidegradents	Reduces the rate of degradation due to oxygen, heat, and light	N,N'-bis(1,4-Dimethylpentyl)-p-phenylenediamine
Antioxidants	Slow down the oxidation cycle during processing	2-2-Hydroxy-5-tert-octyphenyl benzotriazole
Antizonants	Slows degradation due to ozone	Nickel dibutyl dithiocarbamate
Biocides	Reduces biodegradation	Arsenicals, organotin, triclosan, Sn, Hg, Hg
Cross-linking additives	Links the polymer chains	2-Mercaptobenzothiazole
Flame retardants	Reduces flammability	Tetradecachloro-p-terphenyl
Inorganic fillers	Improves impact resistance	Mica and clays
Plasticisers	Making the material more pliable	Bis(2-Ethylhexyl) terephthalate
Photosensitizers	Absorbs radiation of a particular wavelength	Benzophenones
Surfactants	Modifies surface properties	Polysiloxanes
UV stabilizers	Protects plastic against UV or sunlight damage	2-(2-Hydroxy-5-methylphenyl) benzotriazole

The term "microplastics" was first used to describe particles up to 20 µm in size (Thompson et al., 2004). Practically, the majority of investigations identify the smallest size based on the size of the net or mesh sieve used for sampling (Blair et al., 2017). The field is still emerging, thus it may be necessary to acknowledge and/or assume some presumptions and knowledge gaps. Microplastics are a size group of plastic that lies between nanoplastics and microplastics in terms of size.



FT-IR Fourier-transform infra-red spectroscopy, Ramon Spectroscopy,
SEM scanning electron microscopy, TEM transmission electron microscopy,
AFM atomic force microscopy, AFM with IR

Figure 2.2: Proposed classification, comparisons, properties, impacts, and examples of various size ranges of plastics

(GESAMP 2015)

The size of manufactured Microbeads, which are tiny, typically ranges from 5µm to 1 mm (Hernandez et al., 2017). However little known about these tiny particles since they are challenging to detect and measure. The range was increased by Arthur et al. (2009) to include all particles less than 5 mm. However, there is currently a suggestion in recent literature to limit the maximum size of "microplastics" to 1 mm (1000 µm) (Van Cauwenberghe et al., 2015). The specific size criteria that make up microplastics are not well defined. Different parameters could be used to describe and characterise microplastics (Wagner et al., 2014). These comprise classification according to size, shape (such as fragment or fibre), and polymer composition, and source, location, application, and release patterns.

3. Factors affecting quantity of microplastics in the environment:

There is evidence that a number of factors influence the amount of microplastic found in freshwater ecosystems. The number of local residents, their proximity to urban areas, the amount of time people spend in the water, the size of the water body, how waste is handled, and the frequency of sewage overflows are among these factors in addition to physical ones (Moore et al., 2011; Eriksen et al., 2013; Zbyszewski and Corcoran, 2011;Free et al.,2014). The author suggested that the presence of microplastics in freshwater bodies and the players involved in their dispersion are caused by human use of certain items, such as microbeads in cosmetic and cleaning products, paired with wastewater treatment that can successfully absorb floating (Eriksen et al., 2013).

4. Factors involved in dispersal:

Although the distributions of microplastics in marine environments are still largely undefined, it is essential to take into account the external factors that affect the mobility of these materials when estimating their global distributions. Through quantitative and modelling approaches, the role of numerous physical elements that influence transport and dispersion at different spatial scales is highlighted. External elements that produce dispersion interact with the properties of the particles themselves (such as density, shape, and size) and other components of the environment (such as seawater density, sea bed topography, and pressure) (Ballent et al., 2012, 2013). Particle density frequently arises in marine studies as a factor influencing mobility and dispersal (Law et al., 2010; Moret-Ferguson et al., 2010; Ballent et al., 2012, 2013).

According to preliminary freshwater experiments, physical parameters that have been postulated for marine systems have an impact on the transport and dispersion of microplastics. According to studies of suspended sediments, additional physical factors that may influence particle mobility in freshwater include water depth, substrate type, flow velocity, bottom topography, and seasonal fluctuations in water flows (Simpson et al., 2005). Storms, floods, or manmade action (such a dam release) are a few examples of events that could have a temporal component. Tidal cycle is another (Moatar et al., 2006; Kessarkar et al., 2010). Travel distances can vary depending on physical forces and particle characteristics (density, size and charge).

5. Detecting and Monitoring Microplastics:

The ability to separate plastic fragments from other particles in a sample of water or sediment is such problem, and the other is being able to recover plastic fragments from the sample. The third difficulty is determining the sorts of plastics that are present and overcoming difficulties in identification brought on by procedures like the biofilms' process of discolouring microplastics.

In order to sample microplastics, various methods of collecting, identifying, and quantifying them are employed in marine research. (Hidalgo-Ruz et al., 2012). There are two types of sampling: bulk or volume-decreased sampling and selective sampling. Surface sediments have been sampled selectively, whereas sediment or water parcels have been sampled in bulk or through volume reduction techniques. After the sample has been collected, plastics are removed from it using density separation, filtering, sieving, and/or visual sorting. Morphological descriptions, sources, types, shapes, colours, chemical compositions, and phases of particle disintegration have all been used in the characterization of particles. Infrared spectroscopy has been the most reliable method of identification since it provides details on chemical composition. (Hidalgo-Ruz et al., 2012).

Table-5: Methods for Detecting Microplastics

Methods	Drawbacks
Visual inspection Including stereoscopy and manual microscopy	Can underestimate or over estimate the size of particles/plastics
Thermogravimetric Analysis	Complex method with labour – intensive cleaning and concentration processes. Costly and time consuming
FTIR (Fourier Transform Infrared) Spectroscopy	Can't analyse microplastics whose sizes are under 10 micrometer
Raman Spectroscopy	Takes a long time to get a descent signal to noise ratio because of weak Raman scattering
Atomic Force Spectroscopy	Slow scanning rate in order to get high-quality images

Light microscopy is an essential tool for locating microplastics, but it lacks the chemical information needed to identify the polymers in action. However, determining the impact and source of the detected microplastics depends on this identification. Because of this, experts in microplastics are increasingly adopting FT-IR imaging in combination with machine learning evaluation methods. As a result, complete particle characterisation is made possible, human error is eliminated, and precise, reproducible results are achieved.

6. Potential Impacts of Microplastic:

Even the effects of microplastics from freshwater or marine ecosystems on individuals are not fully understood by researchers. For instance, lack of information prevents literature reviews in the field of food safety from assessing the effects of microplastics presence (Hollman et al., 2013).

Investigating whether microplastics could have an effect on economies or human health, either directly or indirectly, is vital. The following topics could be the main focus of research in this area:

- Resources that are directly used by humans (such as drinking water, bathing water, or food resources);
- Logistics of water use; and
- Ecosystem services.

The following are examples of possible research methodologies:

- Presence of Microplastic
- Compounds from microplastics or chemicals they have absorbed and carried that are transferred to food.
- Economic factors, such as the degree of the expenditures connected with cleanup activities or if the presence of microplastic in aquaculture species could result in revenue losses.

7. Conclusions and Research Gaps:

Below are the findings discovered after a comprehensive literary and scientific review:

There are many problems that need to be tackled because the research on microplastics in freshwaters is still in its early stages and has only recently begun. More research is necessary 1) to develop the most effective technique for monitoring the presence of microplastics in water bodies; 2) to measure each factor influencing the presence, quantity, and dispersion of microplastics in the environment; 3) evaluate the efficacy of remediation solutions. 4) Understand the behaviour of degradation, including particle lifetimes and ultimate fate in freshwater.

Based on the available scientific evidence, the World Health Organization (WHO) determined that consuming water containing microplastics does not pose a threat to human health. According to the Plastic Health Coalition, there are too many knowledge gaps to assess the health impacts of microplastics. The data on human exposure currently available are incomplete and do not take into consideration the smallest and most hazardous plastic particles due to a lack of analytical methods. Furthermore, research on how microplastics affect humans is still in its infancy and has to be updated.

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