Toxicology: Open Access

Mini Review Open Access

Freshwater Ecosystems and Micro- (Nano) Plastics: Abundance, Toxicological Impact and Quantitative Methods

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Abstract

Under the influence of numerous environmental variables, plastics that enter the environment will linger, keep degrading, and break down into smaller particles. Due to their greater surface area to volume ratios, microplastics (MP) and nanoplastics (NP) are more likely to have a negative environmental impact and are also more likely to adsorb organic pollutants and pathogens from the media they come in contact with. On their traits, fragmentation, distribution, and effects on freshwater environments, nothing is known. Detailed sampling techniques and an automated, quick, inexpensive, and trustworthy analytical approach that is appropriate for routine examination must be developed in order to address these unanswered concerns about the dynamics of plastic particles and their consequences on the environment. The study describes the most recent developments in the investigation of potential freshwater biota's exposure to MP and NP toxicants, as well as the analytical techniques.

Keywords: Freshwater; Microplastics; Spectroscopic techniques; Thermo-Analytical Techniques; Nanoplastics

Introduction

The public and scientific community's attention has recently been focused on the aquatic contaminants caused by anthropogenic activities, particularly the contamination of freshwater and marine habitats with plastic trash. It was only a matter of time before synthetic polymers became a major ecological and environmental issue due to the high production of plastics, their physical-chemical characteristics, such as buoyancy and a very slow rate of (bio) degradation, as well as the ineffective and careless waste collection and recycling. As a result, the vast quantities of various plastic kinds dumped in landfills without any sort of recycling strategy are easily transportable as plastic debris in aquatic habitats, where they are broken down into smaller pieces by various degradation forces. However, the big pieces of plastic litter while it is simple to remove large pieces of plastic litter from the environment and send them for recycling; it is very hard to remove minute plastic particles (less than 5 mm) from the environment. Therefore, a more significant and pervasive ecological impact is anticipated for the small plastic particles (5 mm) [1].

The most popular plastics, which made up about 81% of the demand for plastic in Europe in 2016, are polystyrene (PS), poly (ethylene terephthalate) (PET), polyurethane (PUR), poly(vinyl chloride) PVC, polyethylene (PE), and polypropylene (PP). This is despite the fact that there are more than 30,000 different polymers registered for use in the European Union (Fig. 1). The polymeric materials were developed to meet the various demands of thousands of end products, including packaging materials (39.9%), building and construction (19.7%), automotive components (10%), electronic appliances (6.2%), household appliances and sporting goods (4.2%), and agricultural materials (3.3%). The remaining percentages included furniture components, medical supplies, and other items. The polymeric materials were developed to meet the various demands of thousands of end products, including packaging materials (39.9%), building and construction (19.7%), automotive components (10%), electronic appliances (6.2%), household appliances and sporting goods (4.2%), and agricultural materials (3.3%). The remaining percentages included furniture components, medical supplies, and other items [2, 3].

There are legitimate worries about the prevalence of micro (Nano) plastics in freshwater systems

The occurrence of MP in freshwater systems, including river beaches, surface waters, and sediments of rivers, lakes, and reservoirs around the world, has been documented by a number of studies. For the first time, Horton et al. described the existence of MP in a freshwater system in the UK that included both urban and rural areas. The majority of microplastics found in sediments were artificial fibres brought by sewage effluent and secondary MP that was locally produced (e.g., broken down from larger objects). Raman examination revealed that polypropylene, polyester, and polyarylsulfone were the most prevalent polymers.

Studies on rivers have revealed high MP flow and abundance in the Danube, Rhine, and Main Rivers as well as in the surface water of Greater Paris (Seine River) and both urban compartments and these rivers demonstrate rivers. Lechner et al. found that the Austrian Danube river contained about 937.6 8543.8 (2010) and 55.1 75.4 (2012) MP pieces 103 m3 utilising stationary driftnets and visual sorting. A sizable portion of the plastic waste was made up of industrial raw materials such pellets, flakes, and spherules. They calculated that the Danube would discharge 4.2 t of plastics per day into the Black Sea in the worst-case scenario. In a study of the German rivers Rhine and Main, it was discovered that the shore sediments included significant amounts of MP in various forms and polymer types. The MP was examined using IR spectroscopy, which revealed significant amounts of PE, PP, and PS. This study also showed that MP isolated from river shore sediments had a concentration, content, and size distribution that are mostly comparable to those found in sediments from marine settings. The

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closeness to industrial areas and sewage treatment plants, as well as the association between the MP concentration and population density, were not discovered. It is important to take into account how the channel current, channel shape, stagnant water zones, and flood occurrences may affect the buildup of microplastic. For the first time, Dris et al. documented the presence of MP, primarily fibres, in Greater Paris' total atmospheric fallout (29–280 items m2 day 1). Additionally, more fibres were discovered. Additionally, wastewater included 260–320 103 items m3 of fibres, whereas the treated effluent only contained 14–50 103 items m3 of MP. Additionally, a higher diversity of MP can be collected by combining several sample techniques, from minute fibres (plankton net, 80 m mesh) to pieces and beads (manta trawl) [4,5].

Through the ingestion of different species as well as the adsorption of organic pollutants including hydrophobic persistent organic pollutants (POPs) and infections from the surrounding medium, MP and NP may both have direct and indirect toxicological effects in the freshwater environment (Table 1). Additionally, monomers and additives from the polymer matrix may be released during the decomposition process and may harm organisms. The interrelationship between the stability of microplastics, exposure, and toxicological effects emphasises how complex this research area is. Prior to analysing more complex interactions, such as the interaction between MP and other pollutants, it is important to first examine the toxicological effects brought on by the individual particles (e.g. aromatic hydrocarbons, polybrominated diphenyl ethers and polychlorinated biphenyls) [6].

Freshwater organisms exposed to plastic particles, especially NP, may experience a number of negative consequences, such as early mortality, inflammatory reactions, stunted growth and development, decreased energy, decreased feeding activity, oxidative damage, immunity and neurotransmission dysfunction, and even abnormal behaviour. Additionally, the toxicological risk to a particular species depends on the duration of exposure, the concentration of the particles, their shape, chemical makeup, and size, with smaller particles having a stronger impact. The nanoparticles' small size makes it easier for them to get past biological barriers and build up in tissues and organs. For instance, zebrafish gills, liver, and gut can all accumulate 5 m PS, whereas fish gills and gut mostly accumulate 20 m PS. Additionally, it has been shown that exposure to PS NP caused.

Recent research has shown that, following a three-week exposure period, low density polyethylene (LDPE) plastic particles alone have no discernible impacts on zebrafish. In comparison to clams exposedto PE and PET, histological abnormalities were more prevalent in clams exposed to PVC and PS, according to a research by Rochman et al. Additionally, the effectiveness and performance of Pomatoschistus microps juveniles as predators were decreased in the presence of PE microspheres [7, 8].

The bulk of investigations using model organisms in lab settings included PE and PS micro- (nano) spheres that had been previously identified at high concentrations following brief exposure and were bought from various sources. It must be remembered that plastic particles often appear as pieces, fibres, foams, and films in freshwater environments and have unusual shapes. Therefore, compared to microbeads, plastic particles may have sharp edges, increasing the risk of physical harm to the skin, gills, and gastro-intestinal wall. Future research will likely uncover a wealth of material that will help us better grasp the possible negative impacts of MP and NP [9, 10].

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Potential conflicts of interest

No conflict or competing interests in the publication of this paper.

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