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On the Detection, Elimination, Toxicity Assessment, and Control Release of Microplastics in the Ecosystem

Rajia Sultan*

Department of Geography, Centre for Climate and Energy, Egypt

Abstract

Over the past few decades, the accumulation and fragmentation of plastics on Earth's surface has resulted in a number of long-term climate and health risks. plastic-based materials, particularly microplastics (MPs; They have received a lot of attention from scientists all over the world because of their bioaccumulation, non-biodegradability, and ecotoxicological effects on living things. This study explains how microplastics are produced, transported, and disposed of in the environment on the basis of their physicochemical properties and sources. Additionally, the study investigates the impact of COVID-19 on global plastic waste production. MPs can be quantified and identified using physical and chemical techniques like SEM-EDX, PLM, FTIR, Raman, TG-DSC, and GC-MS. This paper discusses both established and cutting-edge methods for removing microplastics from aquatic systems. The findings of this review help us better understand the studies on the toxicity of microplastics to humans, aquatic life, and soil ecosystems. Additionally, in order to lessen the risk posed by MP waste in the future, it is necessary to investigate the global efforts and measures taken to combat it.

Keywords: Microplastics; Environmental pollution; Covid-19; Detection techniques; Toxicity assessment

Introduction

Plastic, which permeates virtually every aspect of human existence worldwide, is heavily used in today's world. Due to their exceptional properties of durability, flexibility, lightness, and mechanical and thermal stability, organic polymers, also known as plastics, are utilized extensively in a wide range of industries, including the construction sector, the food and packaging sector, pharmaceuticals, and others. Despite the plastic industry's annual growth, the demand for plastic does not appear to have decreased. There will be approximately 33 billion tons of plastic produced by 2050. The environmental impact of plastic has been a major source of concern for government agencies, the scientific community, and the general public despite its long-term industrial benefits. The rapid production and distribution of extremely durable plastics has a significant impact on the ecology and the environment. By 2010, land-produced plastic waste had polluted the marine environment by four to twelve million metric tons, according to reports [**1**].

It has become increasingly evident over the past few decades that plastic waste pollutes the environment. Synthetic microplastics with a diameter of less than 5 millimeters are currently causing public concern, despite the fact that plastic debris can be as small as a microscopic particle and as long as several meters. The first time the term "microplastics" (MPs) was used, it was to talk about various common household plastics, how they were made, how they were used, and what might go wrong with them. For instance, polypropylene is a common household plastic that will naturally degrade in about 30 years and may have an unidentified adverse effect on the biosphere. In addition, organic contaminants such as polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), and polycyclic aromatic hydrocarbons (PAHs) are carried by these microplastics (MPs) in biomedical and cosmetic products. MP pollution is now a global issue because of the increasing impact that microplastics have on the environment [**2-5**].

Effects of COVID-19 on the environmental release of MPs

Throughout history, infectious diseases that have the potential to cause a pandemic have appeared and spread frequently. The Middle East respiratory syndrome coronavirus (MERS-CoV) and other pandemics and epidemics have already had an impact on humanity. Since December 2019, there has been a global pandemic of the novel coronavirus (SARS-CoV-2) that is believed to be the cause of COVID-19, a severe respiratory illness. In March 2020, the World Health Organization (WHO) declared COVID-19 to be a pandemic worldwide. Since then, efforts to stop its spread have been made. Biowaste and medical waste are abundant during the COVID-19 pandemic, indicating a sudden uptick in plastic pollution. This is because personal protective equipment (PPE), face masks, disposable utensils, food packaging plastics, and other items made of single-use plastic (SUP) are used a lot. Global demand for personal protective equipment significantly increased following the COVID-19 outbreak, with 65 and 129 billion pairs of gloves and masks consumed monthly, respectively. According to Benson and co., since the pandemic began, global plastic waste has increased by 1.6 million tonnes [**6**]. Approximately 3.4 billion disposable face shields and masks are discarded each day. In addition, According to a report, as of August 23, 2021, the amount of plastic waste that was produced by 193 nations during the pandemic reached over eight million tons and washed into the ocean in more than 25.000 tons worldwide. About 1.5% of the total amount of plastic that was dumped into the water comes from this. To confirm that face masks made of polypropylene (PP) release MPs into water, environmental waste processing, common sources, and the fate of MPs produced by COVID-19 are tested. To imitate the circular waves and motions of ocean water, they degraded three-layered surgical masks in water using a rotating blender. Under weathering conditions, the experiment demonstrated that a single mask can release a significant

***Corresponding author:** Rajia Sultan, Department of Geography, Centre for Climate and Energy, Egypt, E-mail: sultana@rajia.com

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amount of microplastics. The release of MPs from disposable masks, according to them, was also influenced by exposure time and shear intensity [**7**].

Identification of MPs and their detection

MPs with a wide range of characteristics are produced as a result of the worldwide excessive use of commodity plastics. It is necessary to identify and evaluate MPs in order to effectively eliminate them from aquatic systems. A wide range of physical and chemical methods are used to quantify MPs because a single identification method may miss some types. Physical detection is frequently used to quickly, cheaply, and easily identify MPs based on their size, color, and appearance [**8**]. Physical detection can be used to identify colored and larger MPs (>500 m), but smaller MPs cannot be effectively removed. As a result, chemical methods are used to determine the MPs' structure and composition. Examples include non-destructive techniques like SEM-EDX, PLM, FTIR, Raman spectroscopy, and GC-MS.

Morphological identification

Scanning electron microscopy (SEM) is frequently used to morphologically analyze MPs because it provides information about MPs' surface texture and deformities that help distinguish them from other wastewater materials. This is because SEM takes high-resolution pictures of the MP's surface. This method is frequently utilized in conjunction with the Energy Dispersive X-ray spectroscopy (EDX) method for the purpose of analyzing the MPs' components. Due to its high cost, low efficiency, and inability to detect colored MPs, SEM-EDX is not suitable for use in the detection of MPs. In order to improve SEM-EDX's capability of detecting MPs, fluorescent dyes such as Safranin T, Nile Red, and fluorescein isophosphate are frequently stained on MPs at high temperatures to reduce error probability [**9**].

With the help of PLM and other cutting-edge microscopy techniques, the type of MP can now be precisely identified. Using the polymer's anisotropic property, the PLM method involves passing unpolarized light through MP particles placed between cross-polarizers. The polarized light produced by the polarizers shows the crystallinity of MPs, making it simpler to identify the type of MP polymer. It is possible to use it with opaque and thick samples, but it is not a reliable method.

Chemical structure and composition identification

A variety of destructive and non-destructive methods are utilized to further improve MP identification and chemical composition determination. By irradiating the samples with infrared light and observing changes in the dipole moments of the sample's structural chemical bonds, FTIR can be used to identify IR-active MPs. The MPs' composition can be determined by comparing the sample spectrum to the reference spectrum. The use of FTIR for detecting larger particles is constrained by the sample's size, the difficulty of sample preparation, and the time and labor required. FTIR, on the other hand, is a good way to find agglomerates and smaller particles. Because it gives the MP particles a wider spectrum, the FPA-FTIR (Focal Plane Array-Fourier Transform Infrared spectroscopy) method is used to improve detection efficiency.

Chemical bonding

Alternatives to spectroscopic methods for identifying MP include destructive identification methods like TGA (Thermogravimetric Analysis), DSC (Differential Scanning Calorimetry), and GC-MS (Gas Chromatography-Mass Spectrometry). Based on their thermal stability and the glass transition temperature, which varies for each type of polymer, TGA and DSC are used to identify the polymers. To determine the MP type and its characteristics, the reference plots, as well as the TGA and DSC plots produced by the samples' thermal treatment, are compared. Another well-established and trustworthy method for identifying polymers in bulk mixture samples is GC-MS. High-temperature treatment of samples can significantly improve detection accuracy, and nanosized plastics can easily be used for this. The TD-GC-MS and pyro-GC-MS methods are used for this. Mass spectrometry analysis, gas chromatography separation, and high-temperature degradation of bulk samples are required[**10**]. These methods can produce qualitative and quantitative results with high precision and sensitivity. However, the thermal treatment conditions, sample preparation, and sample purity have a significant impact on the results' reproducibility. As a result, each of the various methods for quantifying MPs has drawbacks. As a result, MP particle detection and identification techniques still require improvement. Additional in-depth research is required to determine whether chemical methods can be used to detect MPs because the interaction and accumulation of MPs on other materials may have a significant impact on these methods' ability to detect MPs.

Techniques for separation and illumination: MPs are separated from contaminated water using these techniques, which make use of physical barriers like membranes and filter mechanisms. By allowing only liquids to pass through, these physical barriers separate microplastics from aqueous media. However, microplastics with higher viscosities in waste sludge are frequently not removed by these techniques. To separate micro- and nano-sized microplastics, which are only present in trace amounts, filtration methods also require a lot of manpower and water movement. Only the quantity of separated microplastics can be quantified using these methods; They provide no details about the microplastic pollutants' nature or structure. We will need to employ additional characterisation strategies in order to obtain complete information regarding the MP's structure and type.

Growth and surface adhesion methods: Surfactants, oxidants, coagulants, and disinfectants, as well as MPs, are captured and adhered to the surface of the additional materials. This makes it easier to remove the MPs by causing them to form aggregate-like macrostructures. Coagulation, flocculation and sedimentation (CFS), adsorption, and ion exchange are some of the methods used in this strategy. In contrast to filtration and segregation, these methods are effective, simple to manage, and they can even assist in the elimination of additional pollutants. They are still restricted to pilot-scale rather than large-scale operations due to a lack of information. However, because they lack sufficient surface area to either adhere to the surface of the added materials or form flocs, these methods are frequently time-consuming and ineffective for the uptake of smooth, small-sized microplastics. Deterioration methods include: The deterioration method is another way to separate microplastics. By converting MPs into simpler molecules like CO2, H2O, H2S, and methane through the action of external factors like heat, radiation, and microorganisms, this method alters the MPs' physiological structure. This group includes thermal, photocatalytic, and microbial degradation. One of the most effective strategies for combating MP waste is degradation, but the degradation mechanisms have not been thoroughly investigated. Increasing the breakdown capacities' efficiency can also shorten the degradation time. exposes the benefits and drawbacks of the aforementioned methods of removal.

Conclusion

Microplastic pollution may rise as a result of the anticipated rise in global plastic production and use in the coming years. In addition to their physicochemical properties—size, crystallinity, shape, density, and so on—microplastics are influenced by a wide variety of natural conditions, as this study demonstrates. in the formation, development, and transport of their bodies. To ensure that microplastics are effectively removed, it is necessary to quantify and identify them. However, there are some drawbacks to using visual analysis and spectroscopic methods together to locate microplastics in aquatic systems. Given the enormous amount of MP waste produced worldwide, better methods for MP detection and identification must be developed to reduce misidentification. Numerous treatment techniques have been developed to facilitate the quick and efficient removal of MP waste from wastewater. Combining traditional and cutting-edge techniques like CFS, membrane filtration, adsorption, and biological degradation can lead to removal efficiencies of up to 99 percent. Particle selectivity, membrane fouling, adsorption site blockage, and non-reusability are all issues with these treatment approaches. In addition, the effects of polymer size, shape, and type on removal efficacy are unknown. To improve these technologies' MP removal capabilities, additional research into these methods is required due to their limitations. The majority of studies have examined how toxic microplastics are in the marine environment, but they have not examined how they affect the soil biota or human health. Additionally, additional research is required to determine the in vivo effects of microplastics on human cells. At the international, national, and local levels, efforts are being made to combat MP waste accumulation because the accumulation of microplastic waste has reached epidemic proportions worldwide. Certain protocols and infrastructure have been enforced in order to cut down on the number of MPs that are produced in the future.

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