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Editorial

Plastic Pollution: Challenges and Innovative Solutions

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Plastic consumption is steadily increasing, resulting in a continuous release of microplastics into the environment. As size decreases, the number of particles grows. This is concerning due to a greater probability of smaller particles crossing biological barriers and causing adverse effects. Microplastics accumulate in the environment as a result of low degradation rates and irretrievability. Rising concentrations of microplastics will eventually exceed toxicity thresholds, if they have not already. Therefore, microplastics are presently a threat to environmental, animal, and human health.

Research and policies have primarily targeted the most common plastic applications, such as packaging, which accounts for approximately 40% of demand. However, microplastics can be released from any plastic item, and some sources may pose even greater risks. For instance, plastics used in agriculture are subjected to conditions that promote microplastic formation, which are often contaminated with plasticizers and pesticides [1]. These particles can alter soil conditions, affecting evaporation, nutrient cycling, microbial life, and ultimately crop yields and food security.

Another example is plastics used in glitter, which can be used in consumer products, cosmetics, and art. Glitter, sold as powder or a viscous liquid, is often made of hexagonal particles of synthetic polymers, such as polyamide or polyethylene terephthalate, coated with metals [2]. Thus, glitter directly contributes to environmental contamination with microplastics. Its associations with metals, like aluminum or titanium, may increase toxicity. Other less-visible plastic uses continue to contribute to microplastic release, warranting attention.

Disruptive events like pandemics, wars, and extreme weather can also increase microplastic release, as plastic consumption rises, waste management practices decline, and regulatory measures are often relaxed. In Taiwan, a temporary suspension on the ban of disposable tableware was allowed for up to 90 days during the COVID-19 pandemic, coinciding with changes in waste composition, particularly an increased chlorine content likely from kitchen waste, chlorine-based disinfectants, or polyvinyl chloride use [3]. Crises may also lead to the dissemination of plastic products. Disposable face masks, made of plastics, were used during the pandemic as a measure to reduce viral transmission. They were often released to the environment, contributing to plastic pollution. Moreover, disposable face masks were shown to fragment into small microplastics within 1–2 months of environmental exposure in hot climates [4].

The release of plastics and microplastics to the environment creates an international problem. Microplastics undergo global dispersion as a result of complex transport mechanisms dependent on environmental factors, leading to the exchange of particles between matrices and long-range transport that culminates in the contamination of remote regions [5]. While microplastics may cause adverse biological effects, association with other contaminants (e.g., Persistent Organic Pollutants) may increase their toxicity.

The Antarctic environment is an example of a remote location contaminated with microplastics [6]. In this case, microplastics are introduced to this pristine environment

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through ocean currents and atmospheric transport, in addition to local contamination. Research has primarily focused on areas near scientific facilities (e.g., the Antarctic Peninsula and Ross Sea), while more isolated regions remain underexplored. The persistence of plastics in Antarctica's cold climate raises important questions about their long-term degradation in extreme environments.

Microplastic contamination is a global issue that demands coordinated international action. There is an urgent need for an international agreement on plastics [7]. The prevailing focus on consumer accountability often overlooks other crucial stakeholders, such as governments and industries. Extended Producer Responsibility (EPR) is suggested as a strategy to hold industries accountable for their externalities, including waste and environmental impacts. Beyond just financing mitigation measures, the EPR model encourages sustainable design and production practices that help prevent impacts from the outset.

An example is the use of mulch films in agriculture, which help retain nutrients, conserve moisture, and suppress the growth of competing plant species [1]. Yet, these plastic films are difficult to recycle and can fragment into microplastics, potentially impacting soil quality over time. Alternatives include designing thicker films to reduce fragmentation and using biodegradable plastics [8]. While biodegradable plastics can break down in soil, they are most often composted. Anaerobic digestion is also suggested as a potential end-of-life option for these materials. Development of biodegradable plastics should target applications where biodegradability is beneficial, with continued testing under various environmental conditions beyond standard certification settings.

Common plastics are not easily degradable within short time frames. However, they still decompose slowly in the environment, even under challenging dark and aerobic conditions, releasing greenhouse gases [9]. Additives, like plasticizers and dyes, as well as smaller plastic particles, can contribute to a greater susceptibility of plastics to microbial degradation, potentially accelerating this process. This suggests that some plastics in the environment are already decomposing into simpler compounds (e.g., methane), though the degradation rate remains outpaced by the ongoing release of plastics.

Microplastics act as carbon sources that can exert selective pressure on organisms, potentially leading to metabolic changes or overexpression of certain pathways. Although microplastics have not been shown to alter the human gut microbiota, they may select for organisms carrying genes related to plastic degradation [10]. For instance, phenylacetaldehyde dehydrogenase encoded by the *feaB* gene, found in the human gut microbiota, may play a role in breaking down styrene. Identification of plastic-degrading genes could be a part of a biotechnological solution to deal with plastics. This discovery not only highlights a promising avenue for tackling plastic pollution but also underscores the importance of supporting exploratory science that could reveal unconventional solutions to this complex issue.

Conflicts of Interest: The author declares no conflicts of interest.

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