Plastic Degradation and its Effects

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Abstract

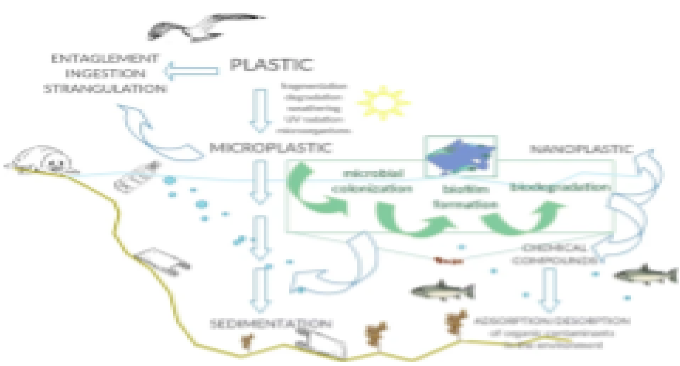
Plastic degradation, resulting in the formation of microplastics, poses significant environmental and health concerns. Microplastics, defined as plastic particles less than 5 millimeters in size, originate from both commercial products and the breakdown of larger plastics. These particles are pervasive in ecosystems globally, including air, water, and even within human bodies. The degradation process releases harmful toxins such as phthalates, leading to serious health issues and environmental contamination. Current solutions to mitigate plastic degradation include the use of biodegradable plastics, cyclones, electrostatic precipitators, recycling initiatives, plastic alternatives, waste management improvements, and microbial and enzymatic solutions. These methods aim to reduce the prevalence of microplastics and their detrimental effects. Biodegradable plastics, though helpful, require specific conditions to decompose effectively. Advanced technologies like cyclones and electrostatic precipitators separate microplastic particles from the air, while recycling and plastic alternatives reduce plastic waste. Improved waste management systems and biological solutions also play crucial roles in addressing plastic pollution. The document emphasizes the importance of these strategies in mitigating the impacts of plastic degradation on both the environment and public health.

What are microplastics?

Less than 5 millimeters in size, microplastics are tiny plastic particles that result from both commercial product development and the breakdown of larger plastics. They are synthetic solid materials with a high polymer content, insoluble in water, and not degradable. Due to these properties, microplastics have permeated diverse ecosystems, from oceans to remote polar regions, and even the human body. Microplastics can arise from many different sources such as clothing, vehicle tires, manufacturing, and plastic degradation.

Microplastics. (n.d.-b). National Geographic. https://education.nationalgeographic.org/resource/microplastics/

Microplastics are prevalent throughout the environment, from the air to even the water we drink from. A 2020 study in Environment International from a research team in London found 575-1008 microplastics per square meter of air in every air sample collected from the top of a 9-story building twice a week for a month. Even remote locations such as Greenland and Svalbard contained 1760 microplastics per liter of air. In a recent investigation conducted by OrbMedia, 159 water samples from 14 countries, including both tap water and bottled water, were examined. The study revealed that more than 80% of all samples contained minute plastic particles, averaging 4.34 particles per liter of water. Particularly noteworthy was the discovery that 94% of water samples from the United States contained microplastics, ranking it highest among the countries studied (IQAir).



Degradation of plastics and plastic-degrading bacteria in cold marine habitats. (n.d.). Springer Link. https://link.springer.com/article/10.1007/s00253-018-9195-y

The reason why plastic degradation is a major environmental and health concern is because of breaking down plastics into tiny particles that can release harmful toxins. One such toxin is phthalates (PAEs), which are commonly added to plastics to give them specific features like flexibility and durability. People primarily encounter PAEs through their food, and this exposure can lead to significant health issues, including endocrine disruption, metabolic disorders, and reproductive toxicity. As plastic degradation releases microplastics into the environment, this introduces a multitude of issues, including the contamination of aquatic ecosystems, soil degradation, and the release of harmful chemicals. The persistence of microplastics in the environment exacerbates pollution, harms wildlife, and affects ecosystems globally.

Existing Solutions

Cyclone

The contaminated air enters the cyclone separately through an inlet at the top, typically designed to be tangent to the cylindrical part of the cyclone, forcing the air to spiral inside, creating a vortex. The spinning motion generates centrifugal force, causing the heavier microplastic particles to be thrown outward towards the cyclone's walls. These particles lose energy through friction with the cyclone wall. Due to their greater inertia (heavier objects have a greater tendency to stay in motion/stay at rest unless a force causes their speed or direction to change) larger and heavier particles are pushed to the outside of the vortex and fall due to gravity into the storage area at the bottom of the cyclone. The clean air, now mostly free of heavier particles, moves towards the center of the vortex and exits the cyclone from the top through an outlet pipe. Because cyclones are not as effective with smaller, lighter particles, the cleaned air then moves into the electrostatic precipitator, a second separator.

Electrostatic Precipitator

The ESP is tasked with removing the smaller particles not separated earlier. This is especially important for microplastics, which can vary significantly in size, and smaller particles may escape the mechanical separation before entering the ESP. The contaminated gas is first passed through an area where it is subjected to a strong electrical field, generated by a discharge electrode that runs down the center of the duct. The microplastic particles passing by then become ionized. The charged particles then pass by collection plates which have an opposite/neutral charge to the particles. The charged microplastic particles are then attracted to the collection plates, being removed from the air stream. The collection plates are then cleaned either by rapping the plates mechanically or by using a reverse air flow, removing the microplastic particles and sending them into the storage area. The cleaned gas, now largely free of particulate matter, passes out of the ESP and can be released into the atmosphere or further processed if necessary.

Biodegradable Plastics

PLA (Polylactic Acid) and PHA (Polyhydroxyalkanoates) are two types of biodegradable plastics derived from renewable resources. PLA comes from corn starch or sugarcane and decomposes more easily than traditional plastics, while PHA is produced by microbial fermentation of sugars or lipids and is fully biodegradable in various environments. These can help mitigate the effects of plastic degradation by preventing microplastics from forming.

Recycling Initiatives

Recycling methods include mechanical recycling, which breaks down plastics into pellets for remodeling, and chemical recycling, which converts plastics into their chemical components for reuse. Additionally, plastic-to-fuel technologies convert waste plastic into usable fuels through processes like pyrolysis (decomposition through high temperatures).

Plastic Alternatives

Alternatives to traditional plastics include bioplastics made from natural materials like corn starch, cellulose, and algae. Promoting the use of reusable materials such as glass, metal, or paper also helps reduce reliance on single-use plastics.

Waste Management Improvements

Enhancing waste collection systems and upgrading sorting and processing facilities are crucial for better handling and recycling of plastic waste. These improvements increase efficiency and effectiveness in managing plastic materials.

Microbial and Enzymatic Solutions

Research into plastic-degrading bacteria and fungi aims to identify microorganisms that can break down plastics more effectively. Engineered enzymes are also being developed to specifically target and degrade plastic polymers, offering a biological approach to plastic degradation.

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