SETAC SCIENCE BRIEF

PLASTICS POLLUTION: A BREAKDOWN

Public awareness and concern over plastic waste in the environment is nothing new, but growing alarm has been fueled by distressing images of suffering wildlife, such as turtles and whales. Due to public concern over plastics, many jurisdictions have banned some products, such as bags, straws and single-use plastics, to reduce plastic pollution on land and in the waterway. Further, public alarm over microplastics has already resulted in the banning and phasing out of microbeads in cosmetics in many regions; however, microbeads are only a minor part of the problem. This issue is certainly troubling given our dependence on plastic items for everyday life.

The Big and Small of Plastic Pollution

To better understand issues related to plastic waste in the environment, we should first differentiate between several categories of plastic litter. Plastic particles are often categorized based on their size, shape and the type of material from which they are made. They are also categorized on their origin as primary or secondary microplastics based on whether the particles were originally manufactured to be that size (primary) or whether they have resulted from the breakdown of macroplastics (secondary).

Macroplastic products, whole or in fragments, are large items that can be seen by the naked eye and include plastic bags, bottles, cups, lids, straws, containers and fishing nets.

Microplastics refer to tiny plastic fragments less than around 5 millimeters in length. Microbeads and microfibers are included in this category:

- Microbeads are plastic "particles" intentionally manufactured for specific uses (for example for exfoliation in personal care products and abrasive properties in cleaners)
- Microfibers are small fibers that are shed from synthetic textiles such as those used for athletic clothing

Nanoplastics are extremely small microplastics. Scientists have not yet definitively defined what size particle is considered "nano" for plastic, but generally the term has been applied to any plastic smaller than 1 micron in size.

Tire-wear particles, which are tiny particles produced by friction of vehicle tires on roads, are sometimes confounded

with microplastics even though rubber is not classified as a plastic based on some definitions.

Plastic – It's Everywhere

Plastics have been found in virtually all environments – ranging from the arctic to deserts to household dust. Take for example an improperly discarded single-use plastic item such as a plastic bottle by the side of the road; they are everywhere. While microplastics are very small and not easily seen by the naked eye, researchers have also found them in many areas, including rivers, lakes, oceans, sea ice, snow, remote islands, sediments and soil, as well as in the gut contents of wildlife, including birds, mammals, reptiles, fish and shellfish.

Plastics are mainly introduced into the environment through ineffective waste management practices. The largest source of microplastics is from macroplastics that are broken up in the environment over time, so both issues are interconnected.

Plastics can be dispersed in the environment through atmospheric transport (wind) as well as through hydraulic systems (water flow). Plastics can be carried into streams, rivers, wetlands and oceans (aquatic ecosystems) by wind as well as flowing water such as rain, snow melt that makes its way to streams, or via municipal or industrial water discharges (sewer water). Plastic pollution on land is concentrated in landfills, urban spaces and some agricultural land that uses biosolids from municipal wastewater treatment plants.

Effects of Plastics in the Environment

Macroplastics have been shown to cause physical harm to wildlife. A lot of the harm stems from the physical effects of plastics when animals eat macroplastics, which then block their digestive systems. Macroplastics can also entangle wildlife and prevent them from moving, feeding or breeding. Macroplastics are a threat to marine ecosystems because oceans and seas are the final reservoir for flowing waters carrying plastic trash. While scientists have documented impacts on individual animals, the impact to populations and entire ecosystems is unclear.

As for microplastics, while there is little knowledge about their effects on human health, the current research shows that they may not pose a health risk to humans at current levels of exposure, but that far more research is needed before a full risk assessment is possible. Meanwhile, scientists are still learning about the effects of microplastics on the environment. They study common ways microplastics enter the environment, how long they take to breakdown, how and if potentially

Macroplastics have been shown to cause physical harm to wildlife. A dead Northern gannet trapped in plastic fishing net is shown washed ashore on Kijkduin Beach in The Hague, Netherlands.

hazardous chemicals in the environment could cling onto them and if this affects exposure of organisms to those chemicals, how they transfer from one organisms (prey) to another (predator), and what effects plastics have on organisms that eat them. They are also determining the levels of microplastics in waters, sediments, beaches and organisms in a wide range of marine, freshwater and terrestrial systems to characterize the current situation. Finally, researchers investigate these plastics in wastewaters and how well they are removed in wastewater treatment plants. As analytical methods improve and are harmonized, so too will the ability for scientists to identify different types of microplastics and quantify their levels.

Currently, the scientific literature on microplastics shows:

- Techniques for quantifying microplastic in the environment are in their infancy. We still do not know exactly how much and what type of microplastics are currently present in various environmental compartments, making it difficult to compare and interpret results.
- The levels of microplastics as currently found in the environment (determined by field studies) do not cause immediate or obvious harm to aquatic wildlife (such as fish and shellfish) based on our current knowledge, although some organisms are sensitive to very high concentration of microplastics, which may be found in certain environmental "hot spots" (e.g., near the effluent discharge of a manufacturing plant).
- Some potentially hazardous chemicals in the environment (e.g., pesticides) cling to microplastics; however, that does not increase the exposure of organisms to these chemicals.

Research needs to fill current knowledge gaps on microplastics are:

- Where do they come from? Scientists need to better understand the origin and sources of microplastics in the environment.
- How can we identify and measure them? Sampling and analytical methods for determining the type, shape, size and abundance of plastic particles need to be harmonized.
- Where do they go and where do they end up? Once plastics enter the environment, we need to determine their fate and how they are transported.
- What don't we know? There are a range of possible effects that different particle types with different compositions can have at environmentally relevant concentrations.
- How can we help prevent the problem? We need to determine the most cost-effective wastewaters treatment method.

The top research priority for plastics pollution is for all to work together to develop methods and policies to minimize plastic leakage to the environment throughout its whole life cycle – from production to eventual discard.

Final Word

Plastic has many useful properties and applications, so not surprisingly, it has become an integral part of our daily life. However, the downside of our excessive plastic use is becoming increasing clear, as plastic litter in all imaginable shapes and forms is found in every nook and cranny of our planet.

The top research priority for plastics pollution is for all to work together to develop methods and policies to minimize plastic leakage to the environment throughout its whole life cycle – from production to eventual discard.

Although the consequences of widespread plastic pollution to our environment are currently not fully understood and are therefore subject to intense research activities, it is obvious that plastic must be managed appropriately. This will require a concentrated effort from all aspects of society: consumers, regulators, educators, media, financers, researchers, developers and manufacturers.

Combating plastic pollution will be best achieved through a concerted and collaborative effort of all, including consumers, educators, scientists, journalists, policy makers and industry leaders.

To manage plastic, manufacturers and policy makers should manage both the generation and improper disposal of plastic. Where better alternatives to plastics or substances that go into plastics exist, they should be used. For irreplaceable plastics uses, we should work towards simultaneously keeping the value of plastics without allowing leakage into the natural environment consistent with a "circular economy" approach. Therefore, the best way forward is a combination of rethinking processes and products (alternative assessment) and redesigning products based on a circular economy.

Consumers can join the effort to manage plastic in the environment by refusing, reducing, reusing and recycling plastic, in that order, to prolong every item's life cycle as far as possible. A start would be a focus on limiting the use of single-use plastic products with a short lifetime, especially if alternatives are readily available.

Resources

Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP). 2015. Sources, fate and effects of microplastics in the marine environment: a global assessment. ISSN: 1020-4873.

European Food Safety Authority (EFSA). 2016. Presence of microplastics and nanoplastics in food, with particular focus on seafood. EFSA Journal.

European Commission. A European Strategy for Plastic in a Circular Economy.

Science Advice for Policy by European Academies. (SAPEA). 2019. A Scientific Perspective on Microplastics in Nature and Society.

Alliance to End Plastic Waste. The Issues. The Answers. The Latest.

United Nations Environnent Programme (UNEP). 2018. Single-Use Plastics: A Roadmap for Sustainability.

United Nations Environment Programme (UNEP). 2018. Mapping of Global Plastics Value Chain and Plastics Losses to the Environment: with a Particular Focus on Marine Environment.

World Environment Day. 2018. Beat Plastic Pollution Infographics.

Acknowledgments

SETAC is grateful for the efforts and technical contributions of everyone involved in the publication of this document: Thomas Backhaus, Susanne Brander, Allen Burton, John Davis, Amy Lusher, Sebastian Primpke, Violet Renick, Chelsea Rochman, Tamar Schlekat and Martin Wagner.

Copyright

When referring to this text, please use the following citation: [SETAC] Society of Environmental Toxicology and Chemistry. 2019. Science Brief: Plastics Pollution: A Breakdown. Pensacola (FL): SETAC. 4pp.