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Plastic – A Sign of Environmental Indifference?

The average consumer uses plastic packaging practically for just about everything: shopping, storing food, collecting waste. Very few people think about what happens to waste packaging and how it affects the environment.

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Plastics have not been part of our daily lives for very long. Their large-scale production only started around 70 years ago, which is a relatively short period in human history. Even so, they have become immensely popular and all-pervasive, as demonstrated by the widespread conviction that life without plastics is impossible. Plastics owe this exceptional success to their extraordinary properties: they are durable, resistant to external factors, relatively easy and inexpensive to produce, and lightweight, which also translates into low transportation costs. Plastics can be produced in various colors and enriched with many different additives that enhance their properties. Consequently, practically anything can be made using plastics!

It therefore comes as no surprise that the production of plastics grows every year: in the 1950s, the world produced around 0.5 million metric tons of plastic a year, compared with today's nearly 350 million tons. This means that mankind has produced a total of more than 8 billion tons of plastics over nearly 70 years. According to estimates, only a fraction of this volume (around 9%) has been recycled, a slightly larger share has been burned in special incineration plants, and the remaining nearly 80% has ended up in landfills. Plastics are extremely durable and take up to several hundred years to decompose, so we can say with all certainty that most of the plastics that have been produced since the 1950s are still around today – in some form or other!

Unfortunately, due to improper waste management or for an even more trivial reason, namely thoughtless littering, many plastics end up in the environment. We have all seen plastic bags, bottles, and cups littering not only city streets but also lakes and forests. What we are less familiar with is the sight of plastic garbage floating in the vast seas or sinking to the bottom of deep oceans. Unfortunately, it turns out that every year as much as 5% of the plastics

produced worldwide (around 15 million metric tons) ends up in the seas.

Degradation

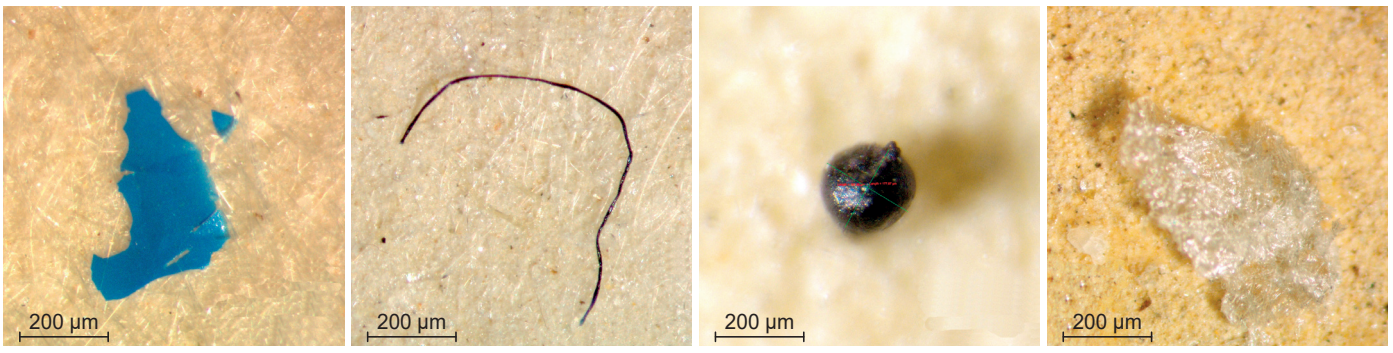
Plastics are extremely durable, but they do not last forever – they age over time, under the influence of various environmental factors, degrading into smaller and smaller pieces. But is this something we should be happy about? Should we be pleased when a plastic bag or a plastic bottle finally breaks down into smaller fragments? No, because these small pieces of plastic, invisible as they are to the naked eye, may together pose an even greater environmental danger than the plastic object that they originally comprised. Such tiny pieces are called microplastics, defined as plastic particles in the size range from 0.1 µm (0.0001 mm) to 5 mm (according to the EU and US criteria, but many other countries define microplastics as plastic fragments of up to 1 mm in size). The degradation of plastics is not, however, the only source of microplastics. Some microplastics are produced intentionally and added to such everyday products as cosmetics, cleaning products, and detergents, e.g. to improve their viscosity and abrasiveness or to add glossy shine. The microplastics present in wastewater are only partially filtered out in sewage treatment plants, so they leak into rivers, which transport them into the seas and oceans – the final destinations of all pollutants. Consequently, the waters of the Vistula River transport various colorful granules as well as plastic fragments and fibers of different shapes and sizes into the Baltic Sea.

> Around 5% of the plastics produced worldwide (15 million metric tons) ends up in the seas every year.

All plastic waste first floats in the sea water and then, over time, gradually sinks to the bottom. Such waste is often swallowed by animals, tempted by its unusual appearance, shape, or color. Large pieces can block the digestive tract of an animal and hinder or even block food intake, causing the animal to lose strength or ultimately even die. But this is not the only threat. Plastics made of synthetic or modified natural polymers are enriched with various chemical substances to improve their properties. Many such additives accumulate in the environment and in living organisms, in addition to being exceptionally persistent, which makes them some of the world's most dangerous chemicals. Moreover, the surface of plastics, especially microplastics, adsorbs various pollutants from the environment, especially persistent organic pollutants (POPs) and heavy metals, creating what is referred to as a sinister "cocktail" of pollutants. But this is still not the end of the list of dangers. The surface of microplastics gets colonized by numerous microorganisms, which create biofilms referred to as the "plastisphere." It turns out that such microorganisms may include many dangerous pathogens – their spread is facilitated by plastics, which transport them to faraway places. Unfortunately, the impact of microplastics on marine organisms remains very poorly studied, as are the processes that microplastics undergo in the environment. Consequently, it is hard to predict the long-term effects of their presence in the marine environment.

Abundance

Our institute is currently implementing a project aimed at performing a multilevel assessment of the occurrence of microplastics and associated pollutants in the Baltic Sea. As part of this project, we are gathering and analyzing information about the abundance of microplastics in the sea water and sediments and their impact on organisms. We have examined nearly 200 fish from the southern Baltic and found plastic waste in the digestive tracts of 9% of cod and 6% of herring. In most cases, these were small fragments of plastic (not exceeding 5 mm).



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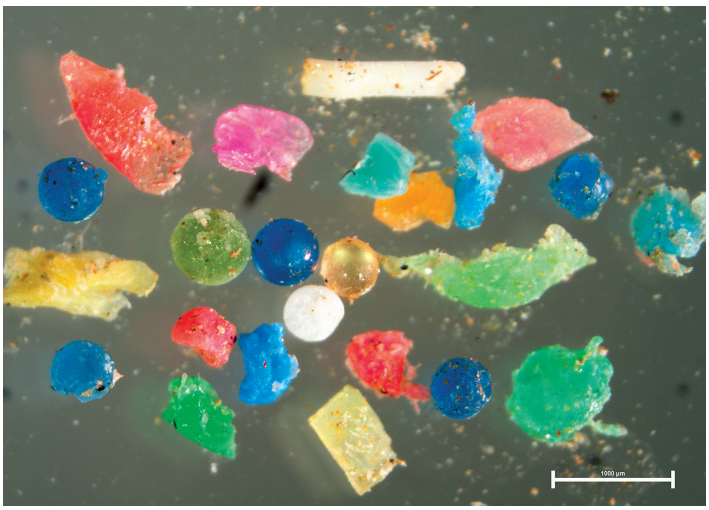
Examples of microplastics isolated from beach sand on the Polish coast (200 µm = 0.2 mm)



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Examples of microplastics isolated from water samples collected at the mouth of the Vistula River

In the digestive tracts of two fish, however, we have found surprisingly large pieces: a fragment of a plastic garbage bag and a fragment of a plastic bottle cap. Fish most probably swallow plastics directly or together with food. While small particles can be easily excreted without harming the animals, larger fragments can nevertheless block their digestive tracts, causing problems with food intake. The herring that had swallowed a large fragment of a plastic bag was characterized by the poorest physical condition as compared to other herrings. Simply put, it was emaciated, and the concentration of POPs and mercury in its muscle tissue were many times higher than in other fish. It is very likely that those pollutants were primarily linked to the plastic bag, and due to their chemical characteristics they moreover "eagerly" combined with the fat contained in the fish's muscle tissue. In other words, the plastic bag not only blocked the animal's digestive tract but most likely also leaked chemical pollutants into its tissues. Such effects are the most frequently mentioned examples of the negative impact of plastics on organisms.

We also carry out lab experiments in which marine organisms are exposed to specific concentrations of microplastics, varying in size and the type of polymers they are made of. Such experiments are conducted using juvenile fish and marine invertebrates (bivalves and polychaetes). Our observations indicate that the presence of plastic triggers a stress response in fish larvae, which is demonstrated by elevated levels of certain stress hormones, but the mechanism of this impact has yet to be elucidated. Moreover, we have observed that marine invertebrates burrow deeper into the seabed when there are microplastics present on its surface. Is this a means of "escape"? Very likely. Bivalves, which are filter feeders (i.e. they feed by filtering matter from water), also end up eating plastics suspended in water. Such plastics accumulate in their bodies and may lead to increased mortality among these animals.

Microplastics are currently regarded to be the most abundant type of solid-waste pollution on Earth. We encounter them on a daily basis. We can find them in the dust in our households, where they settle as a result of the slow aging and degradation of the plastics that are so abundant in our homes. Likewise, we cannot avoid them when spend our vacations at the seaside. All it takes is a walk on the beach. Tucked in among the sand grains are many fibers, granules, and multicolored fragments of plastic that we cannot see. These tiny particles result from the degradation of larger plastic objects, fragmented to smaller pieces under the influence of sunlight and the friction of waves and sand. These objects were carried to the beach by the sea currents, or were simply brought to the beach. But who brought them and left them there? Each of us should ask ourselves that question.

We find it hard to live our lives without plastics, but we can influence what we happens to them afterwards. Most importantly, we have choices to make. The most significant advantage of plastics, from the perspective of their applications, is their durability. It is therefore worth realizing that single-use plastics, or plastics used for one short moment, make little sense. If their producers do not know this or ignore this fact, maybe we as consumers could make them realize it, at least by refusing to buy or use single-use plastic products. ■

Further reading:

Bergmann M., Gutow L., Klages M., *Marine Anthropogenic Litter*, Springer 2015 (open-access book).

Ivar do Sul J.A., Costa M.F., The present and future of microplastic pollution in the marine environment, *Environmental Pollution* 2014, 185.

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