THE WORLD WITH AN ADMIXTURE OF MICROPLASTICS

Nowadays, plastic is the most popular synthetic product. Although this material's history is quite short – the first plastic was created in the mid-nineteenth century – its versatility has resulted in huge production around the world. The disposal of plastic waste cannot keep up with its milling, hence the growth of synthetic waste is constantly increasing. By means of their interventions, environmentalists hope to move the consciences of consumers who buy food in plastic packaging and are rather guided by convenience than care for the environment. How many of them actually know how dangerous the plastic that they purchase can be?

text: Katarzyna Stołpiec

Dr. Bożena Nowak
Prof. Agnieszka Babczyńska
Institute of Biology, Biotechnology and Environmental Protection
Faculty of Natural Sciences
University of Silesia
bozena.d.nowak@us.edu.pl
agnieszka.babczynska@us.edu.pl

Photo: Olena Sakhnenko (Ukrolenochka) – Freepik.com

British chemist and metallurgist Alexander Parkes worked on increasing the strength of metal alloys in the first half of the 19th century. By including phosphorus in their composition, he managed to achieve the expected result. At that time, rubber was also introduced to the processing industry. Contrary to what it might seem, this material has not been discovered recently, as it was already known to the pre-Columbian Maya and Aztec peoples (it was brought to Europe in the 15th century by Christopher Columbus). With the development of the processing industry in the 19th century, rubber began to increasingly attract attention. Parkes treated it chemically and hoped that it would be used to further his innovative metallurgical patents. In 1846, the inventor managed to mold it into a thin object – it was the first plastic to be discovered, a fact that made the year 1855 special. The real breakthrough, however, came 52 years later when Leo Baekeland developed Bakelite, the first mass-market plastic. From then on, many everyday products had the properties of plastics. Today, there are tiny admixtures of microplastic particles in almost everything.

Synthetic materials, commonly known as plastic(s), are considered to be one group of waste which, according to widely circulating information, decomposes for a thousand years. Although the topic of recycling, waste separation, and the decomposition time of plastics seems familiar, it has become surrounded by many myths and inaccuracies.

There are several groups of synthetic materials, ranging from those that are very well biodegradable to the hardest ones with a decomposition process of hundreds of years. Materials belonging to the latter group are the most problematic, since the question is how to degrade something that is practically not degradable?

"Several factors are responsible for the degradability of synthetic plastics," says Dr. Bożena Nowak of the Faculty of Natural Sciences at the University of Silesia. "The first of these are polymers, i.e. substances with a very high molecular weight resulting from repeating units called mers. Whether a plastic will decompose depends, among other factors, on the molecular weight of the polymer, the type of mers that make up the polymer, and the chemical bonds. The second most important factor responsible for the decomposition of plastic is the environment it will eventually reach. Seawater, into which a lot of synthetic waste flows, is often unable to completely decompose them. Hydrolysis, or decomposition involving water molecules available to the aquatic environment, photodegradation associated with the action of sunlight and oxygen when waste floats on the surface of water, or mechanical decomposition due to wave impact are mostly insufficient, especially at the low temperatures of these environments, which is why nowadays seas and oceans are such polluted water bodies."

The terrestrial environment is characterized by more favorable conditions. It has free access to oxygen necessary for decomposition, to water contained in the soil and atmospheric precipitation, and it is characterized by greater temperature variability. Moreover, it has a much greater variety of microorganisms, hence decomposition in the soil is much faster. By far the best environment for degradation is compost. In home compost, plastics should degrade by 90% up to a year, and in industrial compost this process should take no more than 6 months. In industrial compost, the factors supporting decomposition are the most favorable: water, oxygen and a variety of microorganisms, a temperature above 55 degrees Celsius in the initial phase, unattainable in other environments. Does this mean that we can degrade any material in industrial compost? Absolutely not. Only plastics bearing the symbol of a degradability certificate in a given environment can decompose in it. It should also be borne in mind that different requirements must be met by plastic that is susceptible to decomposition in either fresh water, salt water, soil, or compost.

The problem of waste in seas and oceans is very serious. The threat to fish and other organisms is sometimes fatal. According to the International Union for Conservation of Nature (IUCN), the most common sources of primary microplastic release into the oceans are synthetic textiles washed in washing machines, closely followed by microplastic rubbed off from tires while driving, and other dust and urban pollution. Secondary microplastic, in turn, is made from the breakdown of larger pieces of plastic into smaller ones. It accounts for 69%-81% of the microplastics floating in the seas and oceans. The polymer microparticles obtained in this manner range from 50 μm to 5 mm and become parts of sand in the seas and at coasts.

Assoc. Prof. Agnieszka Babczyńska from the Faculty of Natural Sciences at the University of Silesia, a specialist in the ecophysiology of animals in polluted environments, presents the dangers that can occur when fish ingest plastic particles or microparticles with their food.

"Plastic is not digested. Without bacterial symbionts to digest various molecules, including cellulose, organisms of vertebrates and invertebrates cannot digest it. However, even intestinal microorganisms can contribute to the degradation of plastic only to a very small extent. When this material passes through their digestive tract, it damages the active microcosms, either abrading them to a form resembling brushes or causing atrophy of digestive tract epithelium, or even its complete detachment. As a consequence, digestion and absorption are disturbed, and the bacterial flora is changed, making the animals malnourished, weaker, and unable to produce as many offspring as would be the case in healthy animals. Over the years, the population of species weakens and, consequently, disappears.

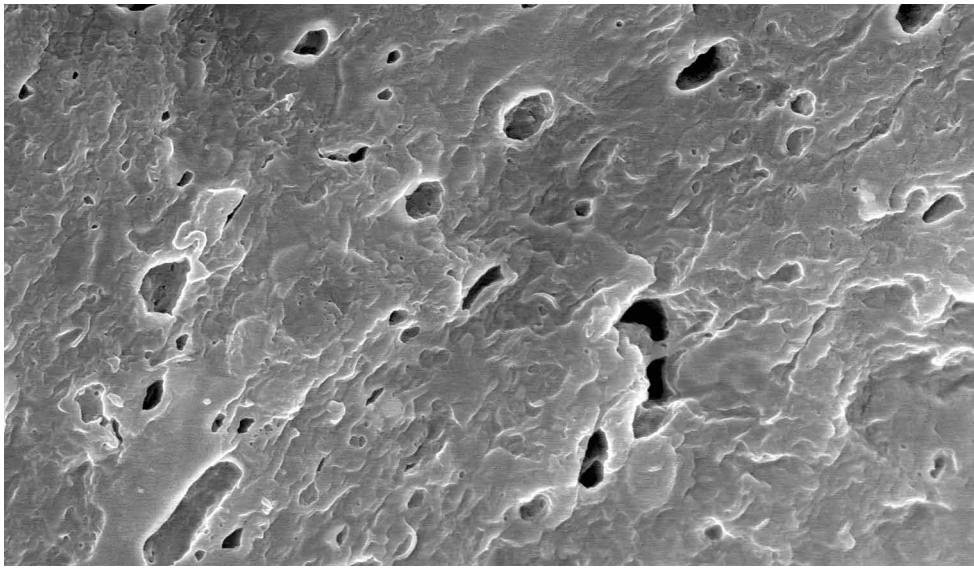
However, unfortunately this is not the end of all problems. Industrial microplastics used as ingredients to enhance elasticity or color contain plasticizers from which, upon decomposition, substances imitating female hormones (hormonomimetics) are released. By ingesting such substances with food, animals are exposed to compounds which, due to their properties, act mainly at the reproductive stage of an organism.

As a result, oocytes are undeveloped, spermatozoons are weaker, and the animals themselves exhibit abnormal behaviors due to the hormonal "treatment" they have received. Therefore, their organisms carry toxic chemical compounds and pathogens. Various fish and so-called seafood are caught in the sea and then served by restaurant owners as healthy and exquisite dishes, but along with their consumption in the human body, the level of harmful substances increases. After assimilation, they can lead to serious health complications, such as gastrointestinal lesions, liver problems, cancer, and endocrine disorders.

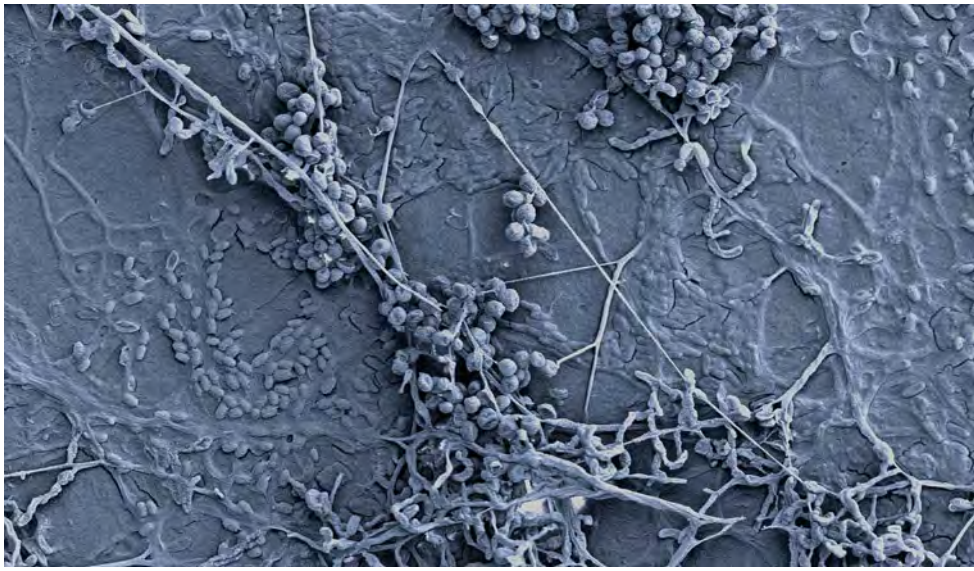
According to estimates, 2 to 5% of all plastic produced ends up in the seas. What can, therefore, be done to bring the ever-growing tide of accumulated plastic to a halt? Dr. Bożena Nowak states that the most effective way to get rid of excess used plastic is to recycle it immediately or limit its use.

"There is no other way to control the excessive build-up of synthetic waste," the researcher says. "There are many campaigns that mislead people instead of clearing the issue up. Plastics that have the same name are not identical. Producers often do not mark packagings or label them as biodegradable or eco-friendly without any proof, so that the average user is not able to independently determine whether a particular product of waste is subject to degradation or not."

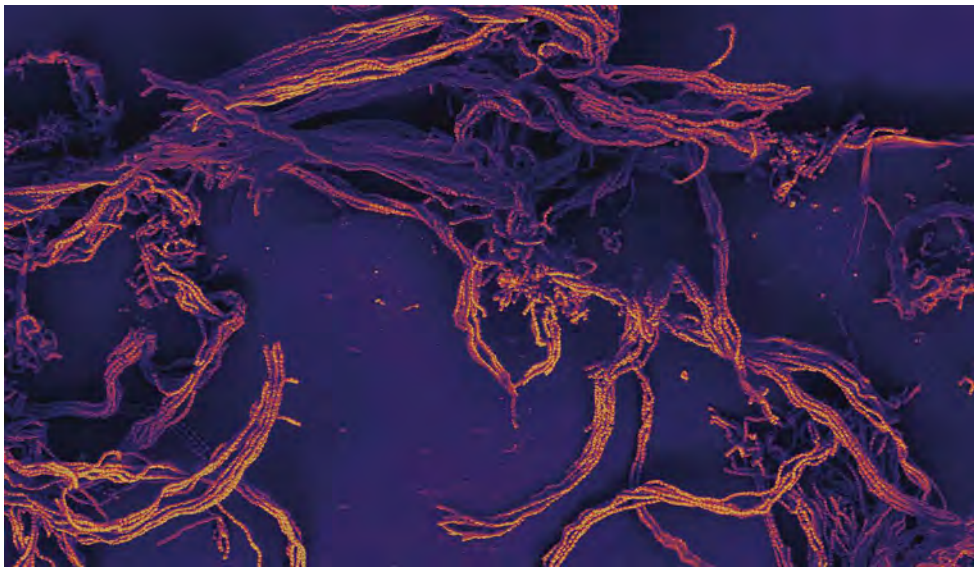
The dangers of uninformed synthetic waste management and widespread human ignorance do not merely threaten a narrow social group or animal species, but have become a real problem for everyone on our planet. Although nature tries to keep up with human progress, it is often unable to face all the difficulties on its own. It is therefore sensible to assume that humans are the protectors of the Earth, those responsible for the condition and situation of the surrounding world, and not merely a link in the evolutionary sequence with no obligation of responsibility.



Biodegradation of plastic surface (polyethylene film) by filamentous fungus *Absidia corymbifera*, magnification 10000× / Photo: Jagna Karcz



Biodegradation of plastic surface (polyethylene film) by microorganisms (bacteria, fungi, filamentous fungi), magnification 2000× / Photo and coloring: Jagna Karcz



Biodegradation of plastic surface (polyethylene film) by filamentous fungus *Aspergillus niger*, magnification 250× / Photo: Jagna Karcz, coloring: Bartosz Baran