Combining different organisms to convert non-recyclable plastic waste

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Short of cutting down on the amount of plastics used in food packaging and the agricultural cycle, researchers are looking into a more natural solution – one that involves creepy crawlies like earthworms. Credit: Bernhard Richter, Shutterstock

What to do with the non-biodegradable plastics used in food packaging and agriculture? Researchers are turning their attention to microorganisms, enzymes, earthworms and insects to break down plastics.

Plastics are everywhere, and farms are no exception. Plastic sheets are spread on the ground as a form of mulch to suppress weeds. Plastic is also used to cover greenhouses and plastic packaging helps protect and transport fresh produce.

But there's a downside. While most plastic waste from agricultural applications and packaging can be collected separately, it can't be easily recycled using today's standard procedures. That's because it's a mixture of plastics with different compositions or mixed with other materials such as food leftovers that are difficult to extract.

Plastics are a big pain to recycle, and waste either ends up in landfills or is burned. This is why reducing the plastic footprint of food packaging and agriculture is high on the environmental agenda.

Short of cutting down on the amount of plastics used in food packaging and the agricultural cycle, researchers are looking into a more natural solution—one that involves creepy crawlies and microscopic bacteria.

"The secret lies in the combination of different organisms—insects, earthworms and microbes—to convert non-recyclable plastic waste streams into bioproducts, or to remove them from the soil or compost," said María José López, microbiology professor at the University of Almería, Spain, and RECOVER project coordinator.

Prof. López and the RECOVER team are investigating the use of these tiny creatures to not only degrade conventional food packaging, and plastic and agriplastic waste streams, but also produce bioplastics and biofertilisers for industries. Their goal is to convert plastic made from fossil fuels into biodegradable equivalents in a single step.

Stopping pollution at its source

The team also wants to design innovative enzymes that will break down plastics. "These enzymes will reinforce the capabilities of living organisms to deal with a material that is difficult to convert or remove through biological means," said Prof. López.

These new methods to combine organisms will be used to remove or convert non-recyclable plastics in composting reactors that extract plastic directly from compost and insect breeding boxes. As it could happen in the same facility, this method saves having to transport large amounts of contaminated materials to a dedicated facility.

This twin approach of removing directly from the soil and compost and converting conventional plastics into biodegradable ones could also provide a long-term solution for removing non-biodegradable plastics and microplastics (plastic under 5 millimeters long) from the environment.

By-products from these processes will form the basis for producing bioplastics, including food packaging and agricultural materials. Chitin, which will be extracted from insects, is a chemical currently used for bioplastics production and many other products. RECOVER is going to utilize chitin to produce coatings for food, biodegradable food packaging and improved plastic films that are used to cover the soil. This will further contribute to the removal of plastics from the environment by replacing conventional non-recyclable plastics that would normally be discarded or incinerated with more eco-friendly alternatives.

This research could also influence urban waste management and agriculture. For example, investing in bio-recycling plants has the potential to create new side revenues for farmers. All this will one day contribute to Europe's transition towards a circular economy, a system where waste is minimized and the products of today are also the raw materials of tomorrow.

Uniting against the plastics pollution challenge

Prof. López is keen to take the research to the next level. In addition to developing new techniques for recovering non-recyclable plastic, his team joined forces in 2020 with projects BIZENTE and ENZYCLE to tackle the entire range of non-recyclable plastics.

BIZENTE is looking into solutions for the disposal of thermoset composite plastics—polymers combined with reinforcing fibers such as glass and carbon. Valued for their strength and lightness, these materials are a staple of many industries and frequently found in aircraft, cars, electronic appliances and other everyday items.

"However, they still have many technical limitations because they are complex and generate plastic waste," explained Berta Gonzalvo Bas, research director at the Aitiip Technology Centre in Spain who coordinates BIZENTE. "Most thermoset composite waste, from production to end-of-life, is not properly recycled. It is either incinerated or diverted to landfills."

BIZENTE is exploring other approaches to modifying enzymes. The enzymes, plastics and degradation conditions are different from RECOVER. The researchers are developing specialized enzymes to degrade plastics found in thermoset composites. This should significantly reduce the amount of non-recyclable plastics and prevent pollution by keeping plastics out of landfills and incinerators. The result of this process will be the recovery of materials that can be put back into the manufacturing industry. Fibers, monomers and by-products will be obtained from the degradation. They will be repurposed as feedstock for industrial purposes in sectors such as waste, aviation, construction and railway.

The technology being developed also aims to be future-proof. "It can be adapted to other different thermoset materials, which makes it very versatile. In the end, BIZENTE is kind of mimicking nature in a faster and more controlled procedure," stated Gonzalvo. The results are already promising for composites containing epoxy, polyester and vinyl ester resins.

ENZYCLE, meanwhile, is focused on the environmental challenge presented by non-recycled, fossil-based packaging. "We intend to go one step further to overcome the technical limitations for the recycling of trays made of polyethylene terephthalate (PET) and clamshells—plastic containers commonly used in food packaging applications—multilayer trays composed of PET and polyolefins, and microplastics," said project coordinator Dr. Licinio Díaz-Expósito, head of the Industrial and Environmental Biotechnology Unit at the Packaging, Transport & Logistics Research Center in Spain. PET, commonly known as polyester, is the most recycled plastic in the world.

Dr. Diaz-Expósito and the project team are developing microorganisms and highly specialized enzymes to break down these plastics into valuable compounds such as polyols and PET that can be put back into European industry. There is also a focus on water treatment since significant amounts of microplastics end up in water and wastewater. According to Dr. Diaz-Expósito, developing enzymes specifically tailored to break down these plastics, ideally in a low-energy, more cost-effective environment, provides a competitive advantage.

Working toward an interconnected, fossil-free future

The momentum created by the three initiatives is generating new ideas, innovative technologies and groundbreaking solutions for a broad range of industries. These include food packaging, agriculture, waste management, biotechnology, aeronautics, construction and green energy. The novel solutions will join the dots between a variety of industries, combining biotechnology with sectors such as waste treatment, agriculture, waste management and manufacturing, moving them away from dependence on fossil fuels.

Innovation is now critical to propel Europe and the entire world forward to meet ambitious energy and emissions targets to mitigate and adapt to the effects of climate change and the crisis in the natural world.

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