Plastic-Eating Bacteria Found in Urban Waterways

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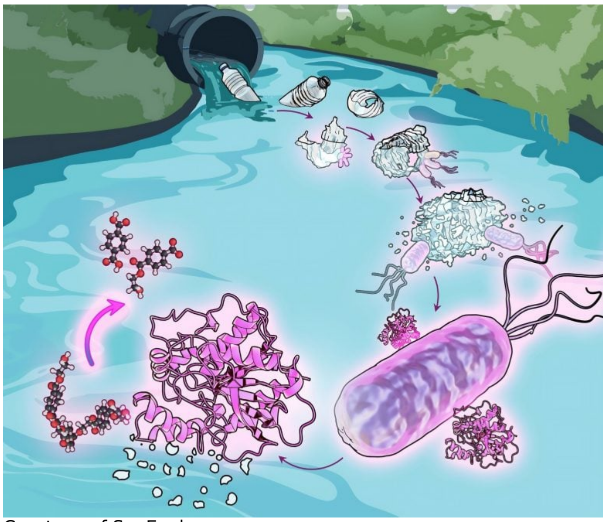

Courtesy of SynEvol
Credit: Aristilde/Northwestern University

Researchers have long noted that Comamonadacae, a widespread family of environmental bacteria, grows on plastics scattered throughout metropolitan rivers and wastewater systems. However, the specific function of these Comamonas bacteria remains unknown.

Northwestern University researchers have identified how cells of the Comamonas bacterium break down plastic for sustenance. First, they chew the plastic into tiny fragments known as nanoplastics. Then they secrete a specific enzyme that degrades the plastic even further. Finally, the researchers discovered that the bacteria feed on a ring of carbon atoms found in the plastic.

The discovery offers up new avenues for developing bacteria-based engineering solutions to help clean up hard-to-remove plastic debris that pollutes drinking water and destroys wildlife.

"We have systematically shown, for the first time, that a wastewater bacterium can take a starting plastic material, deteriorate it, fragment it, break it down, and use it as a source of carbon," said Northwestern's Ludmilla Aristilde, who led the research. "It's incredible that this bacterium can complete the full process, and we discovered a critical enzyme responsible for breaking down the plastic materials. This might be enhanced and used to help eliminate plastics in the environment."

Aristilde is an associate professor of environmental engineering at Northwestern's McCormick School of Engineering. She is also a member of the Center for Synthetic Biology, the International Institute of Nanotechnology, and the Paula M. Trienens Institute for Sustainability and Energy. Rebecca Wilkes, a former Ph.D. student in Aristilde's lab, and Nanqing Zhou, a current postdoctoral associate in Aristilde's lab, serve as co-first authors on the paper. Several former graduate and undergraduate researchers from the Aristilde Lab also contributed to the project.

The new work expands on prior research by Aristilde's team, which uncovered the processes that allow Comamonas testosteri to digest simple carbons derived from degraded plants and plastics. In the present study, Aristilde and her colleagues returned to C. testosteroni, which grows on polyethylene terephthalate (PET), a form of plastic often used in food packaging and beverage bottles. PET contributes significantly to plastic pollution since it is difficult to degrade.

"It's important to note that PET plastics represent 12% of total global plastics usage," Aristilde told the crowd. "And it accounts for up to 50% of microplastics in wastewaters."

Aristilde and her team employed a variety of theoretical and experimental approaches to learn more about how C. testosteroni interacts with and feeds on plastic. First, they isolated a bacterium from wastewater and cultivated it on PET films and pellets. Then they employed sophisticated microscopy to see how the surface of the plastic altered over time. They next studied the water surrounding the bacteria, looking for signs of plastic broken down into tiny nano-sized particles. Finally, the researchers examined the bacteria to identify the instruments they utilized to assist destroy the PET.

"In the presence of the bacterium, the microplastics were broken down into tiny nanoparticles of plastics," according to Aristilde. "We discovered that the wastewater bacterium had the natural ability to degrade plastic all the way down to monomers, which are microscopic building pieces that combine to form polymers. These tiny units provide a viable source of carbon for bacterial development."

After confirming that C. testosteroni can break down polymers, Aristilde wanted to know how. Her team used omics tools to detect all enzymes inside the cell and uncovered one specific enzyme that the bacterium expressed when exposed to PET plastic. To further investigate the role of this enzyme, Aristilde requested researchers at Oak Ridge National Laboratory in Tennessee to create bacterial cells that lack the ability to express the enzyme. Surprisingly, without the enzyme, the bacteria's capacity to breakdown plastic was lost or greatly reduced.

Aristilde notes that while this discovery may have applications in environmental remediation, it can also provide new insight into the evolution of plastics in wastewater.

Aristilde stated, "Wastewater is a huge reservoir of microplastics and nanoplastics." The majority of people believe that nanoplastics are what enter wastewater treatment facilities. However, our research demonstrates that microbial activity during wastewater treatment can result in the formation of nanoplastics. As our society attempts to comprehend the behavior of plastics along their trip from wastewater to receiving rivers and lakes, that is something we need to be aware of.