Video shows how swarms of miniature robots simultaneously clean up microplastics and microbes

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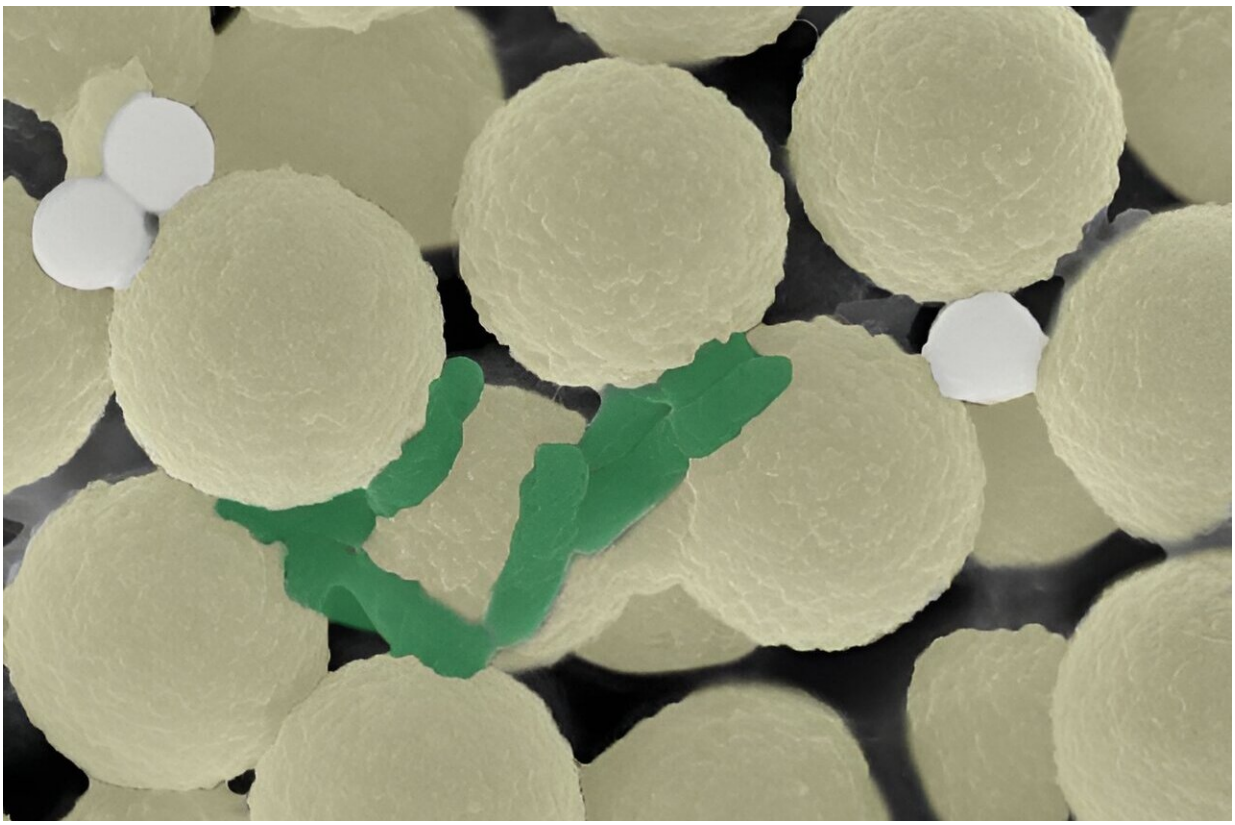


To clean water, researchers have designed swarms of tiny, spherical robots (light yellow) that collect bacteria (green) and small pieces of plastic (gray). Credit: Adapted from ACS Nano 2024, DOI: 10.1021/acsnano.4c02115

When old food packaging, discarded children's toys and other mismanaged plastic waste break down into microplastics, they become even harder to clean up from oceans and waterways. These tiny bits of plastic also attract bacteria, including those that cause disease.

In a study appearing in *ACS Nano*, researchers describe swarms of microscale robots (microrobots) that captured bits of plastic and bacteria from water. Afterward, the bots were decontaminated and reused.

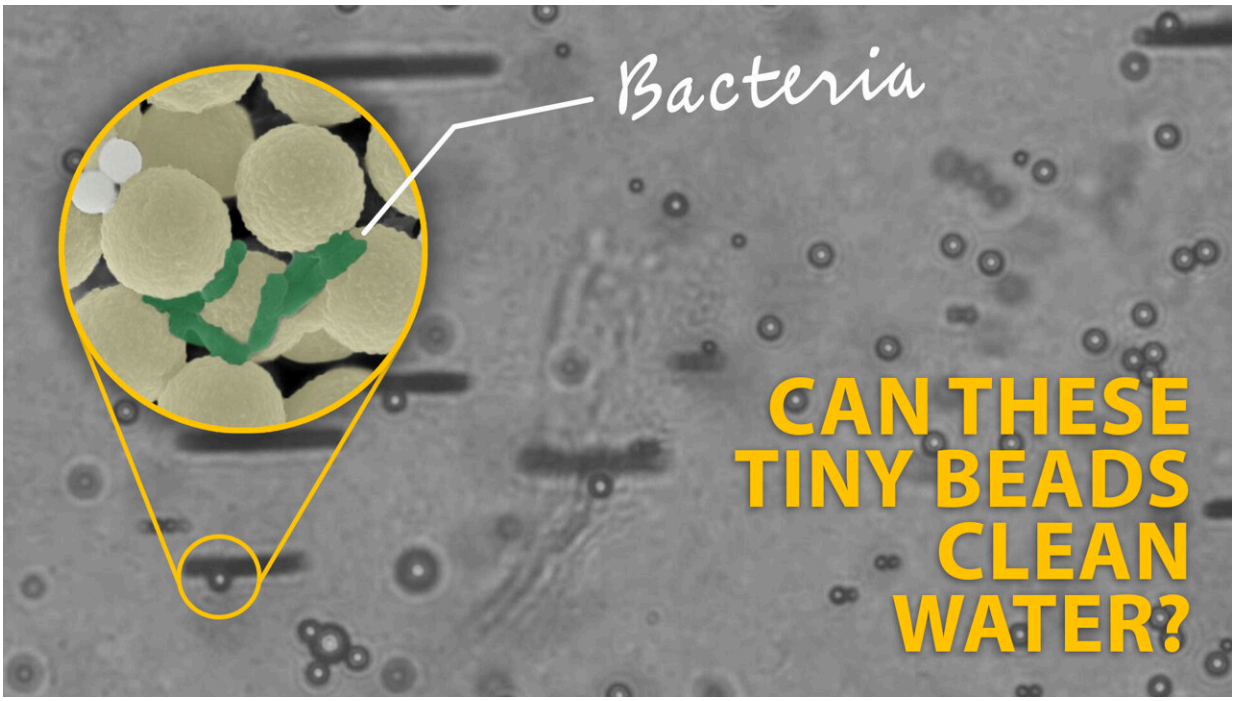
The size of microplastics, which measure 5 millimeters or less, adds another dimension to the plastic pollution problem because animals can eat them, potentially being harmed or passing the particles into the food chain that ends with humans. So far, the health effects for people are not fully understood. However, microplastics themselves aren't the only concern. These pieces attract bacteria, including pathogens, which can also be ingested.

To remove microbes and plastic from water simultaneously, researcher Martin Pumera and colleagues turned to microscale robotic systems, composed of many small components that work collaboratively, mimicking natural swarms, like schools of fish.

To construct the bots, the team linked strands of a positively charged polymer to magnetic microparticles, which only move when exposed to a magnetic field. The polymer strands, which radiate from the surface of the beads, attract both plastics and microbes.

The finished products—the individual robots—measured 2.8 micrometers in diameter. When exposed to a rotating magnetic field, the robots swarmed together. By adjusting the number of robots that self-organized into flat clusters, the researchers found that they could alter the swarm's movement and speed.

In lab experiments, the team replicated microplastics and bacteria in the environment by adding fluorescent polystyrene beads (1 micrometer-wide) and actively swimming Pseudomonas aeruginosa bacteria, which can cause pneumonia and other infections, to a water tank. Next, the researchers added microrobots to the tank and exposed them to a rotating magnetic field for 30 minutes, switching it on and off every 10 seconds. A robot concentration of 7.5 milligrams per milliliter, the densest of four concentrations tested, captured approximately 80% of the bacteria.



To clean water, researchers have designed swarms of tiny, spherical robots that collect bacteria and small pieces of plastic. Credit: American Chemical Society

Meanwhile, at this same concentration, the number of free plastic beads also gradually dropped, as they were drawn to the microrobots.

Afterward, the researchers collected the robots with a permanent magnet and used ultrasound to detach the bacteria clinging to them. They then exposed the removed microbes to ultraviolet radiation, completing the disinfection. When reused, the decontaminated robots still picked up plastic and microbes, albeit smaller amounts of both.

This microrobotic system provides a promising approach for ridding water of plastic and bacteria, the researchers note.

More information: Magnetic Microrobot Swarms with Polymeric Hands Catching Bacteria and Microplastics in Water, *ACS Nano* (2024). DOI: 10.1021/acsnano.4c02115

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