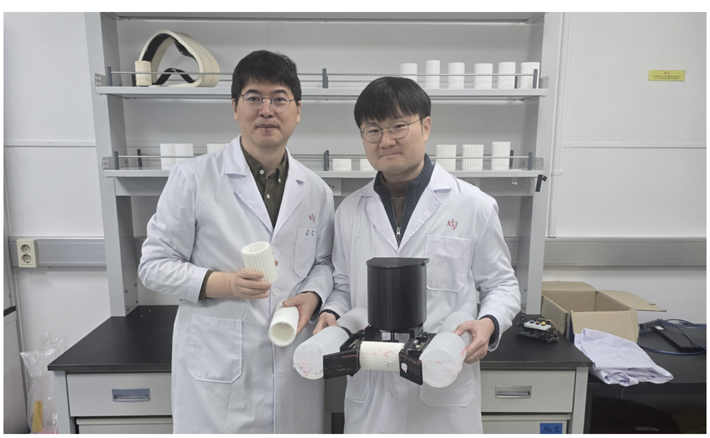
Robotic Vacuum Cleaner for Microplastics

Seong Jim Kim and Myoung-Woon Moon of the Korea Institute of Science and Technology have developed a device that can "vacuum" up tiny pieces of plastic floating on the surface of a body of water.

By **Katherine Wright**

There is a buzz around microplastics, and it's not a good one. These tiny pieces of plastic, which range in size from 1 µm to 5 mm, are polluting waterways in ever-increasing concentrations. Their size means that microplastic particles can easily be chomped by fish, mollusks, and birds, allowing them to enter the food chain and end up on a dinner plate. Scientists have shown that, if consumed in sufficient quantities, microplastic particles can clog a fish's digestive system, which ultimately leads to a deterioration of the fish's gastrointestinal tract and the fish's death.

Microplastic particles have also been detected in bottled drinking water and in reservoirs and lakes, and while some methods exist for removing these particles before they reach the consumer, Seong Jim Kim and Myoung-Woon Moon of the Korea Institute of Science and Technology say that more and better methods are needed. To that end, the duo, along with others, has developed a new technology for "vacuuming" up microplastic particles floating on the surface of a body of water [**1**]. The technology has already been deployed at a reservoir in South Korea. *Physics Magazine* caught up with Kim and Moon to find out exactly how their new technology works.



Credit: S. J. Kim and M.-W. Moon/KIST

All interviews are edited for brevity and clarity.

How are microplastic particles currently removed from water supplies?

Moon: Most technologies for removing microplastic particles use filters, which are designed to let water through while halting the flow of particles above a certain size. These filters, however, are prone to clogging as the halted particles pile up. We wanted to develop a technology that avoids filters and so gets around this issue.

How does your microplastic vacuum cleaner work?

Moon: Our device consists of a rotating drum with a set of angled teeth—a ratchet. These teeth are shaped so that the microplastic particles are attracted to them by fluid forces. The ratchet then scoops the particles out of the water and deposits them into a dustbin attached to the back of the device. It uses both capillarity and the Cheerios effect—a fluid mechanics phenomenon whereby two objects floating on a liquid surface can attract or repel one another.

Can you elaborate on how the device uses these two effects?

Kim: The ratchet is made of a hydrophilic material, meaning it

A foam ball being skimmed from a water surface.
Credit: S. J. Kim and M.-W. Moon/KIST

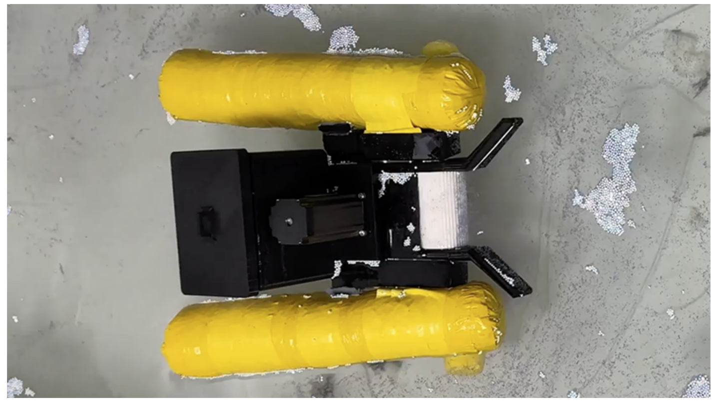
attracts water. At the tip of the tooth nearest the water surface, the water forms a concave meniscus. A concave meniscus also forms around most microplastic particles. When the device gets close enough to the particle, the two concave menisci start to attract each other, drawing the particle closer. Once it is close enough, capillary forces then adhere the particle to the ratchet through a liquid bridge known as a capillary bridge.

Your current devices are relatively small. How much plastic can they remove?

Moon: That's a tricky question to answer. Our devices move around the surface of a body of water, continuously skimming the surface. How much they can remove depends on the density of the microplastic particles and how fast the device moves. When the density of the particles is low, the cleaning rate might be small, but the device is still cleaning the water. The process is akin to how robot vacuum cleaners work—they aren't necessarily the fastest way to clean a house, but set them going and they can completely clean a designated area.

Could these microplastic vacuum cleaners help in removing plastic from the ocean?

Kim: Probably not. Capillarity and the Cheerios effect are relatively small in magnitude. If there is some flow in the water, that will compete with the attractive forces pulling the particle toward the ratchet. In the ocean, those flows can be high in magnitude, and so the performance of our devices would be reduced.



A prototype device skimming foam balls.
Credit: S. J. Kim and M.-W. Moon/KIST

How close are your devices to being deployed?

Moon: They are already being used by the South Korean government to clean water trapped by a dam. That water needs to be cleaned up every day as new microplastic particles enter the reservoir. Our device can do that—it can just keep going and going.

Katherine Wright is the Deputy Editor of ***Physics Magazine***.

REFERENCES

1. S. Cho *et al.*, "Capillary skimming of floating microplastics via a water-bridged ratchet," **Adv. Sci. (2024).**