Microplastics have moved into virtually every crevice on Earth

By Laura Parker, *National Geographic*, Aug. 7, 2020
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The Maldives archipelago in the Indian Ocean includes 1,192 islands. In 1992, the government added one more—an artificial construct that serves as a landfill, where 500 tons of trash are dumped every day.

Two truisms of island-living everywhere are especially true in the Maldives: Most consumer goods must be shipped in, and most waste is produced by tourists. In the Maldives, a developing nation that lacks much local manufacturing, a single tourist produces almost twice as much trash per day as a resident of the capital city of Malé, and five times as much as residents of the other 200 populated islands, according to government statistics. Consequently, the tiny island nation was ranked last year as the world's fourth largest producer per capita of mismanaged waste.

Now marine scientists at Flinders University, near Adelaide, Australia, have added another, predictable statistic to the Maldives' trash horror story: The island chain, renowned for its rich marine biodiversity, is also home to the world's highest levels of microplastics on its beaches and in the waters near shore.

Across 22 sites on Naifaru, the most populous island, the Flinders team counted high concentrations of microplastics in beach sand and shallow coral reef waters. Aside from the sheer volume, the team made an even more discouraging discovery. Most of the particles were the same size as prey consumed by various marine life on the reef.

That was not good news for a tropical marine ecosystem that supports more than 1,100 species of fish and 929 other species, ranging from amphipods to whales, as well as 170 species of sea birds. Of 71 trigger fish collected by the researchers, all had plastic in their bellies, on average eight fibers per fish.

"The size of the microplastics is extremely important because they get into the smallest fish and invertebrates, which are then consumed by larger fish," says

Flinders conservation biologist Karen Burke Da Silva, the senior author of the study.

The findings in the Maldives, published August 2 in the journal *Science of the Total Environment*, are part of an impressive body of scientific literature published so far this year that adds new understanding of this plastic scourge—and that may aid efforts to combat it. (Read more: We depend on plastic. Now we're drowning in it.)

The microplastic cycle

"In order to understand how to mitigate plastic pollution, we have to know the flux," says Chelsea Rochman, a marine ecologist at the University of Toronto. "It's one thing to know it's there, and now we need to know the rate at which it gets to places. To hot spots, and what happens to it as it moves through ecosystems."

While most of the early research focused on the larger plastics found on beaches and floating on the surface, less visible and more pervasive plastic bits have spread into virtually every crevice on Earth, from the deepest sea trenches to the highest alpine mountains. Some microplastics are so tiny they are part of the dust that blows around the planet, high in the atmosphere.

In recent years, scientists have tracked microplastics to thousands of locations. The new research marks a shift toward figuring out what Rochman calls the "microplastic cycle"—how microplastics travel, where they accumulate, and how they are transformed en route.

The term microplastics refers to plastic particles that measure less than five millimeters. There are two basic kinds.

Primary microplastics, such as microbeads used in personal care products or the pellets used in plastics manufacturing, are intentionally manufactured small. Secondary microplastics are the consequence of one of plastic's most valued assets: its durability. They begin as discarded products that are broken down in the oceans by sunlight and wave action. Over time, the fragments become smaller and smaller. They will presumably survive for centuries.

A sample collected off Hawaii contains plastic particles.
PHOTOGRAPH BY DAVID LIITTSCHWAGER, NAT GEO IMAGE COLLECTION

Scientists are still sorting out the central question underlying the research: What harm does ingesting microplastics cause to human health? Microplastics have been detected in drinking water, salt, and other food. So far, no harm has been demonstrated. But for fish and other marine and freshwater wildlife, studies find that microplastics disrupt reproductive systems, stunt growth, diminish appetite, cause tissue inflammation and liver damage, and alter feeding behavior.

Ocean numbers get bigger

In 2015, the yearly flow of plastic waste into the oceans from the world's coastal regions was estimated to average 8.8 million tons. Last month, in a new report by the Pew Charitable Trusts and Systemiq, a London-based environmental think tank, scientists concluded that about 11 percent of that flow into the seas—about 1.4 million tons—includes four prime sources of microplastics: tires, production pellets, textiles, and microbeads.

If the "tap" into the oceans were turned off tomorrow, microplastics would continue to accumulate for generations from trash already in the sea. That continual fragmentation makes it hard to calculate how many microplastics are floating in the ocean today. Most counts estimate what's on the surface. Counts modeled in 2014 put the figure between 5.25 and 50 trillion pieces. New research this year found those estimates to be far too low.

A team from the Plymouth Marine Laboratory, the University of Exeter, and King's College in the U.K. and the Rozalia Project in Vermont, which supplied the boat, sampled coastal waters on both sides of the Atlantic. The researchers used smaller-mesh nets to collect [RK7] smaller nanoplastics and fibers that resemble prey that earlier counts had missed. Their estimate, published in *Environmental Pollution*, puts the global microplastic total at between 12.5 and 125 trillion particles—at least twice as high as the earlier figure.

"We've been vastly underestimating how many microplastics are out there using traditional sampling methods," says Matthew Cole, a Plymouth marine ecologist and co-author of the study. "With small enough nets, it is possible to reveal this hidden, otherwise invisible map within the oceans. And this is just the surface. What sinks to the bottom is not included in these global calculations."

Scientists have long recognized the global seafloor as a major sink for microplastics. But little was known about their concentration and distribution there. A team from Germany, France, and the U.K. has now discovered that powerful bottom currents play a crucial role in concentrating microplastics in specific hot spots—seafloor versions of the floating "garbage patches" that collect inside ocean-current gyres at the surface.

Scouring the Mediterranean seafloor west of Italy, the team found accumulations of microplastics in higher amounts than have ever been recorded, even in deep sea trenches. A single square meter (10.8 square feet) held a thin layer of up to 1.9 million microplastics.

Distressingly, these hotspots are also key habitats for sponges, cold corals, and ascidians or "sea squirts," which are especially vulnerable to microplastics because they are filter-feeders.

The land isn't spared

Researchers also are hunting down microplastics in fresh water and soil, all the while charting potential entry points into the food web.

At 15 river sites in South Wales, scientists combing through the droppings and regurgitations of white-throated dippers discovered that the birds, which feed on freshwater invertebrates that ingest plastics, were eating about 200 pieces of plastic a day—creating opportunity, the scientists concluded, for plastic to move up the food web. Their findings were published in the journal *Global Change Biology*.

Scientists at the Chinese Academy of Agricultural Sciences found that the farming practice of plastic mulching could pose a long-term threat to crop yields. The technique involves spreading plastic sheets over fields to conserve moisture, control weeds, and boost soil temperatures, which in turn can increase crop yields on average between 25 and 42 percent. The practice is widely used on small farms in China, which make up about 13 percent of China's total cropland. Its use is increasing in China and around the world as drought worsens in semi-arid and arid regions.

The most commonly used plastic sheets are easily torn and break down over time. In research published in *Global Change Biology*, the team concluded that the

practice could be safe if the sheets are collected after harvest. But 66 percent of the Chinese farmers surveyed told the scientists they don't do that. The researchers estimate that more than half a million tons of plastic have accumulated in Chinese soils.

Plastic fragments alter the structure and chemistry of the soil; additives, such as phthalates, have been linked to soil contamination. Crops grown in soil containing plastic debris have lower yield, height, and root weight. The study found that plastic pollution has already decreased cotton yields in China.

In the air, everywhere

Research on how microplastics get around the world used to focus on the oceans. The movement of global dust had been studied for decades, Rochman says, but scientists only recently discovered that dust carries "substantial amounts of microplastics."

Janice Brahney, a scientist at Utah State University, stumbled onto plastics while she was studying how winds spread nutrients like nitrogen and phosphorus across the western U.S. "I study dust and how it transports nutrients to remote ecosystems," she says.

But as she examined samples collected from 11 national parks and wilderness areas under the microscope, she was shocked to find tiny plastic fibers.

"At first, I thought I had contaminated my sample," Brahney says. "Then I realized we should not have been surprised."

She concluded that more than 1,000 tons of microplastics a year drift down on the wilderness areas and national parks of the American West. Her analysis, published in the journal *Science,* found that microplastics traveled at different levels through the atmosphere. Larger particles are deposited in wet weather and most likely come from nearby. Tiny, lightweight fibers travel long, cross-continental distances, becoming part of the global movement of dust, before settling to the ground, usually in dry weather.

"Plastic is falling out of the sky into everything," Brahney says. "What should be imprinted on the broader public view is although we're only noticing this problem now, it is not a new problem. It's going to get worse before it gets better.

There’s so much that we don’t know, it’s really difficult to fully comprehend the implications of plastics that are absolutely everywhere.”