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How Do We Clean Up All That Ocean Plastic?

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Abstract

There are currently 75 to 199 million tons of plastic polluting our oceans, according to the World Economic Forum. This is a result of humans recycling only nine percent of plastic waste and dumping 10 million tons of it into the seas each year. If we continue on this path, the annual flow of plastic into the ocean could triple by 2040 as plastic production continues to increase. Marine plastic pollution may be costing the world economy trillions of dollars every year because it affects fisheries, coastlines, tourism, marine life, and the food we eat. Some ocean plastic ends up in one of five major gyres, systems of ocean currents that corral marine garbage into their vortexes.

Keywords*: Clean up, Ocean, Plastic, Pollution*

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Background to the Study

The Great Pacific Garbage Patch, the largest gyre, located between Hawaii and California, covers 1.6 million square kilometers, an area twice as big as Texas. It's estimated that it contains 1.8 trillion pieces of plastic, weighing almost 90,000 tons. While there are many identifiable floating items in the gyre macroplastics such as cigarette butts, plastic bags, food containers, laundry baskets, plastic bottles, medical waste, fishing gear, and more most of the plastic is the size of pepper flakes or smaller, broken down by the sun and waves over the years. Despite the fact that the majority of large plastic pieces are spread out across the vastness of the oceans and the rest may be too small to collect, there are a number of organizations attempting to clean up the oceans.

Collecting Plastic from the Oceans

The most high-profile effort to clean up ocean plastic is being conducted by Ocean Cleanup, a Dutch nonprofit whose goal is to get rid of 90 percent of floating plastic pollution in the ocean. Its first collection system proved ineffective when plastic garbage was able to escape its barriers and a part broke off due to the winds and waves. Its more successful current iteration has removed 220,000 pounds of plastic from the Great Pacific Garbage Patch.

Ocean Cleanup's system consists of a large floating net-like barrier three meters deep that forms a large U shape which is slowly towed by two ships. The natural flow caused by the movement directs plastic to the central retention zone. Once a week, the two vessels come together to close the barriers, pick up the retention zone, and empty the plastic out onto one of their decks. There it's separated into different recycling streams, packaged, and sent to recycling facilities onshore. The organization's System 03 is in the works; it's three times bigger and will reduce the cost per kilogram of plastic collected.

While Ocean Cleanup has received a lot of attention for its efforts, some marine biologists believe its methods could actually do more harm than good. They point to the fossil fuel-powered ships towing the barriers that emit 660 tons of carbon dioxide per month of cleanup. Ocean Cleanup says it offsets its emissions and that it is experimenting with biofuels. Several ocean plastic experts are also worried that Ocean Cleanup's system will harm marine life and could kill creatures even if they are returned to the ocean. Ocean Cleanup counters that fish can escape its system. In addition, there are breathing ports for mammals, birds, or turtles that get caught in the retention zone, underwater cameras to ensure that marine life doesn't get entangled, and a remote-controlled trigger release which opens one end of the retention zone if a creature is trapped. Protected species observers are always onboard to monitor and document all animals.

Another concern is that Ocean Cleanup's system could harm a little understood ecosystem called neuston, comprising insects, worms, snails, nudibranchs, crabs, sea anemones and more that float on the ocean surface much like the plastic before scientists have even had sufficient time to study it. Other critics say that Ocean Cleanup's technique cannot get rid of the microplastics, and some believe lower tech strategies like beach cleanups are more effective because they prevent plastics from reaching the ocean in the first place.

Plastic on the Beaches

While much of the plastic floating around in the gyres has been found to be decades old, it turns out that more of the recently produced plastic stays near shorelines. One study found that, for the first five years after entering the ocean from land, 77 percent of plastic remained on beaches or floated in coastal waters. According to Utrecht University oceanographer Erik van Sebille, most plastic in the ocean remains within 100 miles of the shore between the coastline and ocean, washing back and forth and scraping on the sand, a process that eventually breaks it down into microplastics. This means that beach cleanups may be one of the most effective ways of dealing with ocean plastics and microplastics. A number of organizations regularly arrange beach cleanups for volunteers: The Ocean Conservancy, Surfrider Foundation, American Littoral Society, and Ocean Blue Project, to name a few.

Cleaning up Rivers

Most plastic enters the ocean from rivers. Scientists have found that 1,000 rivers around the world are responsible for 80 percent of the plastic in rivers that ends up in the ocean. Ocean Cleanup also has river cleanup technology called Interceptors, solar-powered catamaran-like vessels that are put into the mouth of polluted rivers. As the water flows, trash is guided by a barrier onto the Interceptor's conveyor belt which dumps it into a shuttle; the shuttle carries the trash to dumpsters on a barge that are brought to the riverside and emptied. The trash is sent to a waste management facility. So far, eight Interceptors have removed over 2.2 million pounds of trash from rivers in Indonesia, Malaysia, Vietnam, Dominican Republic, and Jamaica.

In Baltimore Harbor, Mr. Trash Wheel catches plastic pollution from a local river. Its containment booms direct trash flowing down the river into its mouth where a rake lifts it onto a conveyor belt. The trash is dropped into a dumpster on a separate barge at the top of the belt, and eventually incinerated for electricity. A giant water wheel powers the rake and conveyor belt, but if the current isn't strong enough, solar power is used to pump water onto the wheel to keep it going. Four trash wheels currently working in Baltimore have picked up 2,000 tons of trash including 1.5 million plastic bottles, 1.4 million foam containers, and 12.6 million cigarette butts. Trash wheels are being planned for Texas, California, and Panama. AlphaMERS, an Indian company, makes stainless steel mesh fences that block river trash. They are strong enough to withstand fast currents that might overwhelm barriers. The angle of the barriers directs trash towards the shore where it is collected. Thirty-four fences are currently installed in eight Indian cities. This year, a Dutch startup installed its first Bubble Barrier in an Amsterdam canal. A perforated tube placed diagonally at the bottom of a river pumps out air, generating a bubble curtain. The pump is powered by renewable energy if possible. When the river current meets the bubble barrier, plastic waste is pushed to the side and into a catchment system. The technology enables ships and migrating fish to easily pass through the bubbles. A Bubble Barrier in Katwijk, Netherlands prevents plastics from reaching the North Sea, and others are being planned for Portugal and Southeast Asia.

Where is the Rest of the Ocean Plastic?

Van Sebille's research estimated that there are 276,000 tons of small floating plastic on the surface of the ocean. But scientists believe that between 5.3 to 14 million tons of plastic entered the oceans in 2010 alone. If what is found floating on the ocean surface represents only one percent of the plastic that ends up in the ocean each year, where is the rest of it?

Microplastics

Scientists think that the ocean contains 24.4 trillion pieces of microplastics, fragments of plastic less than five millimeters in length, or about the size of a sesame seed weighing between 82,000 and 578,000 tons. There is likely more. Most microplastics come from synthetic clothing, personal care products, tires, city dust, and from the breakdown of plastic debris. Current technology is not able to filter them out at sewage treatment plants, so most of it washes out to sea and ends up in the ocean or in the sediment. A sediment sample taken off the coast of Santa Barbara, CA showed the contents of the sediment from 1870 to 2009. In the layers representing 1945 to 2009, researchers found plastic fibers one millimeter or smaller in size. As the years went on, the amount doubled every 15 years, an increase that reflects the actual rate of global plastic production. Australian researchers analyzing ocean sediments estimated that almost 15.5 million tons of microplastics now exist on the ocean floor.

Marine animals eat microplastics, which means they also ingest the toxic chemicals that were added to make the original plastic product flexible, colorful, waterproof, or flame resistant. Microplastics can also absorb other toxic chemicals and carry harmful bacteria. They have been shown to harm marine life by disrupting reproductive systems, stunting growth, and causing tissue inflammation and liver damage. Because microplastics have been found in all marine life even in the guts of tiny crustaceans in the ocean's deepest trenches, they are part of the food chain and are also consumed by humans. Microplastics have already been found in human blood, feces, and in the placentas of unborn babies, but so far there have been no large definitive studies on how microplastics harm human health.

Beizhan Yan is a Lamont Associate Research Professor at Columbia Climate School's Lamont-Doherty Earth Observatory, where he specializes in plastic pollution. He is collaborating with researchers from the Columbia Chemistry Department and the Mailman School of Public Health to examine the presence of microplastics and nanoplastics (tiny pieces less than one micron in size) in humans - what exposure levels people have, how the plastic particles get into the blood, whether microplastics are transported to the organs, and whether they are able to cause adverse health effects. Yan is also working with Riverkeeper, Philip Orton from Stevens Institute of Technology, and his colleague Joaquim Goes at Lamont to study the sources and environmental fate of microplastics in NYC waterways. Cleaning up microplastics while also protecting ecosystems will not be easy. Yan said, "Those tiny microplastics coexist with many other minerals and fine particles, like silt, clay, plant debris, and black carbon—all sorts of other particles, whether natural or anthropogenic. They have a similar size and density, so it's difficult to efficiently separate microplastics from other particles. In terms of concentration or mass, the microplastics are probably less than 0.1 percent of the total mass of these particles." He believes that in the future, researchers may develop technology to separate the elements out efficiently, but today it does not exist. There are, however, ongoing efforts to deal with microplastics. NASA's Cyclone Global Navigation Satellite System can help track microplastics as they move by analyzing where the ocean surface is smoother and thus likely to have more microplastics. This enables organizations attempting to clean up microplastics to identify the areas of greatest density.

Numerous experiments are being conducted to capture microplastics. Wasser 3.0, a German company, uses a special non-toxic compound which, when circulated in a vortex, pulls microplastics into popcorn-like clumps that can then be collected. The technique could be used in sewage treatment plants or industrial processes. It is already being used in a paper processing plant and a wastewater treatment plant in Landau-Mörlheim where it has removed 600 pounds of microplastics. Some scientists discovered enzymes that can break down polyester. Researchers from Hong Kong Polytechnic University devised a sticky biofilm from a bacterium that can incorporate microplastics. At the University of Adelaide, scientists created spring-shaped carbon nanotube magnets that grab microplastics and break them down into harmless water-soluble pieces. And a chemistry student in the Netherlands invented a device where microplastics attach themselves to a magnetic liquid; the contents can then be removed with a magnet, leaving only water behind. Yan contends that the most cost-effective way to deal with plastic pollution, however, is to control its sources. For example, sewage is one of the primary sources of microplastics, though microplastics originate from the products people use. Studies show that most of the microplastics in sewage effluent are microfibers that come from laundry—washing machines and driers. Yan's study of New York City waters found that more than 90 percent of the microplastics greater than 0.2 millimeters were microfibers shed from clothing, transported by the wastewater of washing machines. With more and more people dressing in clothes made from synthetics that shed microfibers, it's unlikely that the fashion business will stop using these materials, so microfibers must somehow be prevented from getting into the sewage system to begin with. Yan and researchers from SUNY Stony Brook and North Carolina State University are proposing a study to NOAA to develop advanced filtration techniques that can capture microplastics and fibers from the laundry and repurpose them into new fibers for use in the fashion industry.

Plastic on the Seafloor

In addition to the microplastics accumulating in sediments, larger plastic also sinks to the seafloor. One study found that 50 percent of the plastic in landfills is denser than seawater, which means these objects may sink on their own. The other 50 percent can be colonized by barnacles and other organisms over time, making them heavier than seawater, so eventually they sink as well. An image that has become iconic is that of the plastic bag found in the Mariana Trench, the deepest point in the ocean, 36,000 feet below sea level in the Pacific Ocean. Other single-use plastics have also been found on the ocean floor and while there have been a few limited estimates of how much plastic resides in certain areas, there is no data for most areas of the overall seafloor.

Fig. 1: Plastic bag on the seafloor. Photo: NOAA

According to Yan, the two fundamental questions about plastics on the ocean floor are: where are the macroplastics, and are they causing trouble? “The scientific community can use models to figure out where most of these plastics are, because we don't know right now,” he said. But cleaning up the plastics on the ocean floor is challenging because they settle so deep, and a cleanup would be very costly. Another concern is that plastics on the ocean bottom become part of the ecosystem. “Some of the animals use the plastics and live with them,” Yan said. “How do you do a cleanup without interfering with the ecosystems of those animals?” Yan believes that scientists may eventually develop an underwater drone that can identify macroplastics and gather them from the ocean bottom. However, this would be expensive because of the need to lower the drones, pick up the macroplastics and bring them to shore, and possibly the need for trained pilots to operate the drones.

Conclusion

While cleanup technologies have a role to play in cleaning up ocean plastic, no single solution can effectively reduce ocean plastic. What is required is fundamental and systemic change that includes the banning of single-use plastics in favor of products designed to be recycled or repaired, and more recycling infrastructure. *Breaking the Plastic Wave,* a Pew Report, identified the measures which, if implemented, could cut annual dumping of plastic into the ocean by 80 percent in 20 years. These include reducing plastic consumption, substituting plastic with compostable materials, designing products and packaging with recycling in mind, increasing recycling, proper disposal of plastics that can't be recycled, and reducing the export of waste.

Reference

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