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NCEAS Researcher Shows Microplastic Transfers Chemicals, Impacting Health

With global production of plastic exceeding 280 metric tons every year, a fair amount of the stuff is bound to make its way to the natural environment. However, until now researchers haven't known whether ingested plastic transfers chemical additives or pollutants to wildlife. A new study conducted by UC Santa Barbara's National Center for Ecological Analysis and Synthesis (NCEAS) shows that toxic concentrations of pollutants and additives enter the tissue of animals that have eaten microplastic. The findings are published today in Current Biology.

Lead author Mark Anthony Browne, a postdoctoral fellow at NCEAS, had two objectives when the study commenced: to look at whether chemicals from microplastic move into the tissues of organisms; and to determine any impacts on the health and the functions that sustain biodiversity. Microplastics are micrometer-size pieces that have eroded from larger plastic fragments, from fibers from washing clothing or from granules of plastic added to cleaning products. Microplastics are then consumed by a variety of animals, beginning with the bottom of the food chain. These tiny bits of plastic act like magnets, attracting pollutants out of the environment to attach to the plastic.

"The work is important because current policy in the United States and abroad considers microplastic as non-hazardous," Browne said. "Yet our work shows that large accumulations of microplastic have the potential to impact the structure and functioning of marine ecosystems.”

Browne ran laboratory experiments with colleagues in the United Kingdom in which they exposed lugworms (Arenicola marina) to sand with 5 percent microplastic (polyvinylchloride) that also contained common chemical pollutants (nonylphenol, phenanthrene) and additives (triclosan, PBDE-47). Results showed that pollutants and additives from ingested microplastic were present in the worms’ tissues at concentrations that compromise key functions that normally sustain health and biodiversity.

“In our study, additives, such as triclosan (an antimicrobial), that are incorporated into plastics during manufacture caused mortality and diminished the ability of the lugworms to engineer sediments,” Browne said. “Pollutants on microplastics also increased the vulnerability of lugworms to pathogens while the plastic itself caused oxidative stress.”

As test subjects, lugworms were not chosen at random. They are found in the United States and Europe, where they comprise up to 32 percent of the mass of organisms living on some shores, and are consumed by birds and fish and used as bait by fishermen. When the worms feed, they strip the sediment of silt and organic matter, giving rise to a unique and diverse number of species. Consequently, governments use this species to test the safety of chemicals that are discharged in marine habitats.

“They also suffer from mass mortalities during the summer,” Browne said of the worms. “In the areas where a lot of the mortalities occurred, there has been extensive urban development so some mass mortalities could be potentially tied to plastic. On a hot summer’s day when the tide is out, these organisms cook slightly because their hydrogen peroxide levels increase. And we found that the plastic itself reduces the capacity of antioxidants to mop up the hydrogen peroxide.”

Although sand transferred larger concentrations of pollutants — up to 250 percent — into the worm’s tissues, pollutants and additives from microplastic accumulated in the gut at concentrations between 326 percent and 3,770 percent greater than those in experimental sediments.

The pollutant nonylphenol from microplastic or sand suppressed immune function by more than 60 percent. Triclosan from microplastic diminished the ability of worms to engineer sediments and caused mortality, each by more than 55 percent. Triclosan, an antibacterial additive, has been found in animal studies to alter hormone regulation. Microplastic also increased the worms' susceptibility to oxidative stress by more than 30 percent.

These chemicals are known as priority pollutants, chemicals that governments around the world have agreed are the most persistently bioaccumulative and toxic. Previous work conducted by Browne and his colleagues showed that about 78 percent of the chemicals recognized by the U.S. Environmental Protection Agency are associated with microplastic pollution.

"We've known for a long time now that these types of chemicals transfer into humans from packaged goods," Browne said. "But for more than 40 years the bit that the scientists and policymakers didn't have was whether or not these particles of plastic can actually transfer chemicals into wildlife and damage the health of the organism and its ability to sustain biodiversity. That's what we really nailed with the study."

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