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Science for Environment Policy

Nanoplastics damage marine creatures' natural defences, increasing lethal effects of POPs

Nano-sized particles of plastic can be more damaging to marine species than larger sized microplastics, a new study shows. Lab tests revealed that nanoplastics can damage cell membranes in tiny marine creatures called rotifers (Rotifera), disrupting their natural defences against toxicants. The researchers found that rotifers that had been exposed to nanoparticles of polystyrene were significantly more susceptible to the lethal effects of persistent organic pollutants (POPs).

Plastic pollution in our seas is a cause for concern. Most of this concern is focused on microplastics — particles of plastic smaller than five millimetres (mm) in diameter — which can be ingested by marine creatures. The smaller the particle, the greater its potential toxicity to these creatures. Nanoparticles, those smaller than 100 nanometres (0.0001 mm), are therefore of particular concern.

This study explored the effects of nano-sized microplastics on the planktonic species rotifer *Brachionus koreanus*. Rotifers play an important role in marine ecosystems; they ingest floating particles such as algae, thus transferring energy from the bottom of the food chain to species higher up. As filter feeders, they are also at increased risk of ingesting microplastics.

In particular, the researchers investigated the effects of nanoparticles of polystyrene on the rotifers' 'multixenobiotic resistance': the ability of aquatic organisms to defend themselves against toxins. This presumably evolved as a means of defending organisms against natural toxins, but also happens to provide some protection against environmental pollutants such as POPs.

In lab tests, the researchers exposed *B. koreanus* to three different sizes of polystyrene microparticle — 50 nm — i.e. a nanoparticle, 500 nm, and 6000 nm — over a 24-hour period, at a concentration of 10 micrograms per litre (µg/L) of water. They also observed the effects of the POP, 2,2',4,4'-tetrabromodiphenyl ether (BDE-47) and of another chemical, triclosan, on rotifers that had been exposed to the nanoparticles, compared with those that had not been exposed to any microplastics.

All particle sizes were ingested by the rotifers; the larger two sizes were seen only in the digestive system and were easily excreted when the rotifers were transferred to clean seawater following the 24 hours of exposure. The nanoparticles, on the other hand, had spread into surrounding organs, indicating that they had permeated membranes. They were not as easily expelled after the experiment ended, which also suggests that they are more likely to accumulate within the rotifers. Around half of the nanoparticles remained in the rotifers after sitting in the clean seawater for 24 hours, compared with around 10-15% for the larger particles.

Moreover, rotifers which had been exposed to nanoparticles were less likely to survive exposure to the POPs. Based on the results, the researchers calculated that the average lethal concentration of BDE-47 for non-nanoparticle-exposed rotifers is 205.03 µg/L, but just 146.01 µg/L for those which had been exposed to the nanoparticles. For triclosan, the average lethal concentrations were 307.42 µg/L and 179.19 µg/L for non-exposed and exposed rotifers, respectively.

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Molecular analyses revealed that the nanoparticles inhibited the activities of two key proteins involved in multixenobiotic resistance. The inhibitory effects were stronger than for the two larger particles. Cell membrane damage caused by nanoparticles may be to blame, as that is where these proteins are found.

The effects of the nanoparticles on the rotifers generally increased with concentration, in terms of oxidative stress (which affects the body's biological balance) and damage to lipid cell membranes. These effects increased with concentrations tested, rising between 0.1 µg/L to 10 µg/L, and then dropped off at the highest concentration tested, 20 µg/L.

Complex cocktails of pollutants are present in the environment; some of these, including POPs, attach to and interact with microplastics. While other studies have shown that microplastics enhance POPs' toxic effects on marine organisms, including zooplankton, this is the first to offer a molecular explanation.