Science for Environment Policy

Transformed nanoparticles in effluent can affect aquatic organisms

Silver nanoparticles present in the effluent from waste-water treatment plants could have toxic effects on aquatic organisms, new research suggests. The lab-based study tested the effects of nanoparticle-containing effluent on several crustacean and algae species. The researchers observed that epibenthic crustaceans (those living in or on sediments at the bottom of water bodies) were the most sensitive; notably, a 20–45% higher death rate was observed compared with those exposed to nanoparticle-free effluent.

This raises concerns for aquatic wildlife, as research has shown that these nanoparticles can have toxic effects. However, most previous studies have explored nanoparticles’ effects at concentrations that are higher than those expected to be found in the environment. This study instead investigated their effects at concentrations considered to be more environmentally relevant. Importantly, the particles in this study had also been altered or ‘transformed’ by the waste-water treatment processes; evidence shows that transformed nanoparticles can have effects different from those of pristine nanoparticles.

Silver and titanium dioxide nanoparticles are being increasingly used in various consumer products, from toothpaste and sunscreen to textiles and food packaging, and are, therefore, also finding their way into waste water. They are removed efficiently by waste-water treatment plants; removal rates of 95–99% are reported in previous research cited by this study1. However, the design and efficiency of the plant2 affects the rate of removal, and silver and titanium dioxide nanoparticles have been detected in waste-water effluent.

The researchers applied the resulting effluent, containing transformed nanoparticles, to four different organisms: two marine species, Skeletonema pseudocostatum and Tisbe battagliai (an alga and a crustacean), and two freshwater species, Raphidocelis subcapitata and Daphnia magna (also an alga and a crustacean). This acknowledged the fact that effluent is released into both freshwater and marine environments in many countries. In addition, the effects on cultured gill cells from rainbow trout were studied.

Post-treatment, the effluent contained silver nanoparticles at concentrations of 0.1–0.22 µg/L and titanium aggregates (present in the fraction above 0.7 micrometres in size) at 0.9–24.2 µg/L, varying irregularly over the five weeks. The silver nanoparticles were associated with sulphur, copper and zinc.

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The effluent had various effects. Notably, death rates of the marine crustacean *T. battagliai* were 20–45% higher than for those exposed to nanoparticle-free effluent. No effects on mortality were observed for the freshwater crustacean *D. magna*. The effluent also inhibited growth of the marine alga *S. pseudocostatum* by 20–40%, but increased growth in the freshwater alga *R. subcapitata* by 40%. This growth may be explained by increased cell aggregation, a defence mechanism which reduces the amount of exposed surface to foreign substances. Increased oxidative stress levels were observed in the cultured gill cells, resulting in increased permeability of the layer of cultured cells.

The researchers conclude that nanoparticle effects vary by species. Those that live or feed on or near the seafloor, like *T. battagliai*, may be most at risk because they come into more direct contact with nanoparticles that settle on the floor after attaching to suspended solids. Over 80% of the silver and titanium in the effluent was associated with suspended solids.

The study, therefore, also raises concerns regarding land-based species, which may be exposed to nanoparticles in sewage sludge when it is used as ‘biosolids’ to improve agricultural soil quality. This study also highlights the need for further investigation into the potential hazards of transformed nanomaterials at realistic concentrations in more relevant exposure scenarios and complex matrices.