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Even low concentrations of silver can foil wastewater treatment

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Research at Oregon State University has shed new light how an increasingly common consumer product component—silver nanoparticles—can potentially interfere with the treatment of wastewater.

The findings suggest conventional toxicity testing methods for silver concentrations at treatment plants may produce results that yield a false sense of security.

The research is important because if silver, which has broad-spectrum antibacterial properties, thwarts the work of the plants' beneficial bacteria, then too many nutrients end up in waterways.

That in turn can lead to eutrophication: An overabundance of nutrients in a body of water that results in an explosion of vegetation, such as an algae bloom, and a squeezing out of animal life due to a lack of oxygen.

"Silver nanoparticles are being incorporated into a range of products including wound dressings, clothing, water filters, toothpaste and even children's toys," said corresponding author Tyler Radniecki, an environmental engineering assistant professor at OSU. "The nanoparticles can end up in wastewater streams through washing or just regular use of the product."

The work by Radniecki and collaborators in the College of Engineering looked at silver nanoparticles, the ionic silver they release and an ammonia-oxidizing bacterium, *Nitrosomonas europaea*.

Ammonia-oxidizing bacteria, or AOB, are crucial because they convert ammonia to nitrite to begin the process of getting one of those nutrients, nitrogen, out of the wastewater. The study looked at both free-floating, or planktonic, *N. europaea* and also the biofilms they create.

The OSU research confirmed earlier observations that biofilms are better able than planktonic bacteria to ward off silver's effects.

"Biofilms showed higher resistance for multiple factors," Radniecki said. "One was simply more mass of cells, and the top layer of cells acted like a sacrificial shield that allowed the bacteria below not to be inhibited. Slow growth rates were also a protection from silver toxicity because the enzymes that silver prevents from turning over aren't turning over as frequently."

More importantly, the work unveiled a new wrinkle: That the inhibition of AOB's ammonia-conversion ability is more a function of silver exposure time than the level of silver concentration.

"Most of the studies investigating the inhibition of wastewater biofilms by nanoparticles have been conducted in short-term exposure scenarios, less than 12 hours," Radniecki said. "Also, they've used an equal amount of time for hydraulic residence and sludge retention."

The problem with that, he explains, is that in a treatment plant that uses biofilms, the sludge retention time—the time the bacteria are in the plant—will be much greater than the hydraulic residence time, i.e. the time the wastewater is in the plant.

"That allows, over time, for the accumulation and concentration of metal contaminants, including ionic silver and silver nanoparticles," said Radniecki, whose worked involved exposure times of 48 hours. "The immobilized biofilm cells are exposed to a much greater volume of water and mass of contaminants than the planktonic cell systems. What that means is, the results of short-term exposure studies may fail to incorporate the expected accumulation of silver within the biofilm; wastewater plant monitors might be underestimating the potential toxicity of long-term, low-concentration exposure situations."

More information: L.K. Barker et al, Effects of short and long-term exposure of silver nanoparticles and silver ions to Nitrosomonas

europaea biofilms and planktonic cells, *Chemosphere* (2018). DOI: 10.1016/j.chemosphere.2018.05.017

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