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Effects of silver nanoparticles on nitrification and associated nitrous oxide production in aquatic environments

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Silver nanoparticles (AgNPs) are the most common materials in nanotechnology-based consumer products. Due to wide application of AgNPs, their potential environmental impact is a current and highly topical focus of concern. Nitrification is one of the most susceptible processes to AgNPs in the nitrogen cycle, but effects of AgNPs on nitrification in aquatic environments are not well understood. Here, we report the AgNP impacts on nitrification and associated nitrous oxide (N2O) production in estuarine sediments. AgNPs inhibited nitrification rates, which decreased exponentially with increasing AgNP concentrations. The response of nitrifier N2O production to AgNPs exhibited low-dose (<534, 1476, 2473 μg L-1 for 10, 30, and 100 nm AgNPs, respectively) stimulation and high-dose inhibition (hormesis effect). Compared with control, N2O production could be enhanced by >100% at low doses. This result was confirmed by metatranscriptome studies showing upregulation of nitric oxide reductase (norQ) gene expression in the low-dose treatment. Isotopomer analysis revealed that hydroxylamine oxidation was the main N2O production pathway, and its contribution to N2O emission was enhanced when exposed to low-dose AgNPs. This study highlights molecular underpinnings of AgNP effects on nitrification activity and demonstrates that the release of AgNPs into the environment should be controlled because they interfere with nitrifying communities and stimulate N2O emission.