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Fate of engineered silver nanoparticles in primary treatment plants: A preliminary study at laboratory scale

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Engineered silver nanoparticles (Ag-NPs) are used widely as antimicrobial agents in consumer products including clothes, toothpastes, shampoos and detergents. Several studies have shown that the majority of Ag-NPs and ionic Ag in these products are released into domestic wastewater, ending up in wastewater treatment plants (WWTPs). In conventional municipal WWTPs, Ag-NPs are removed efficiently (about 90%) and/or reduced and accumulated in activated sludge or biosolids in reducing conditions as Ag_2S. However, there is limited information about the fate and transformation of Ag-NPs in domestic WWTPs such as septic tanks or small-scale packaged treatment plants. These systems are commonly used in regions with significant share of dispersed settlements and serve a total of 23% of households in the European Economic Area (EEA).

Studying the fate of Ag-NPs in septic tanks is critical for their potential release into water bodies. Moreover, if Ag-NPs are preferentially sequestered into the sludge phase, disposal of the latter to landfill and/or its use as a fertilizer can act as a source of Ag-NPs through leaching and surface runoff under oxidising conditions. The objective of this study is to assess the fate of Ag-NPs under different septic tank operational conditions in batch reactors and then to establish the potential release of Ag-NPs from the sludge to soil and groundwater. The size distribution of silver nanoparticles was measured by inductively coupled plasma mass spectrometry (ICP-MS) operated in a single particle mode and an initial visual characterization was completed using a transmission electron microscope (TEM).

Preliminary results for wastewater and sludge sampled from septic tanks located in County Limerick (SW Ireland) indicate that Ag is predominantly associated with the particulate fraction. Total Ag concentration in the sludge varied between 0.17 and 0.85 mg/kg, with a Ag concentration $\sim$4 times higher in the second chamber of a two-chamber septic tank compared with the first. The measured Ag concentrations are in the lower part of the range of variation reported in previous studies for WWTPs (0.22 – 856 mg/kg). If all of the Ag measured in the sludge is present as nanosilver particles with an average diameter of 100 nm, approximately $8*10^{12}$nanoparticles of Ag are present per kg of sludge. The characterization of these nanoparticles is in progress, as well as spiking experiments using citrate coated Ag-NPs of different diameters to better understand the fate and the interaction of nanosilver in septic tanks and in the wider environment.