Fertilization using sewage sludge: Impact of sulfate amount in sewage on bioavailability of Ag-NM

MARCO KRAAS[1,2], KARSTEN SCHLICH[2], KONSTANTIN TERYTZE[1], KERSTIN HUND-RINKE[2]

[1] Freie Universität Berlin, Department of Earth Sciences, Malteserstr. 74-100,12249 Berlin

[2] Fraunhofer Institute for Molecular Biology and Applied Ecology, Auf dem Aberg 1, 57392 Schmallenberg, marco.kraas@ime.fraunhofer.de

Silver nanomaterials (Ag-NMs) are used in many cosmetics and textiles because of their antimicrobial properties. Several studies have shown that silver is released from textiles during washing and reach wastewater treatment plants (WWTPs), where significant amounts adsorb to sewage sludge (Kaegi et al. 2013; Schlich 2013). As sewage sludge is used as fertilizer in agriculture, adsorbed NMs enter the soil resulting in a negative impact on soil microorganisms (Schlich 2013).

The aim of our study was to investigate the influence of sulfidation on the bioavailability of Ag-NMs as one of the observed transformation processes occurring in WWTPs. Ag_2S is less toxic than Ag^+. Therefore, a comprehensive risk assessment regarding the pathway "effluent – WWTP – soil" requires information on the effect of sulfate in wastewater on the bioavailability of Ag-NMs.

We conducted two batch experiments with Ag-NMs and different sulfate concentrations simulating processes occurring in wastewater treatment plants. Before mixing the biosolids into soil the sewage was conditioned using two different methods. The soil sludge samples were incubated for up to 140 days and the impact of the Ag-NMs on the nitrification process was determined at regular intervals.

Sewage sludge (0.8% dry matter) was amended with four sulfate concentrations (100, 200, 500 mg S/L) and one ecotoxic concentration of Ag-NMs (5.4 mg/g dm sludge resulting in 9 mg/kg dry soil). Additionally, four negative control treatments containing sewage sludge and the various sulfate concentrations were performed. After a contact period of 18 h under constant aeration and stirring the samples were divided in two halves. One half was directly dewatered and mixed into soil in accordance to the German sewage sludge ordinance. The other half was digested anaerobically for 35 days before application to soil. After 30, 60, 90 and 140 days of incubation we determined the following parameters in samples of the soil-biosolid-mixture:

- Microbial transformation of ammonium to nitrite (first step of nitrification) according to DIN ISO 15685
- The acid volatile sulfide (AVS) content after digestion
- Presence and diversity of sulfate reducing bacteria by DGGE (Denaturing Gradient Gel Electrophoresis).

Biosolids with adsorbed Ag-NMs directly applied to soil (1st pre-treatment) significantly inhibited the ammonium oxidation activity compared to the controls. Inhibition increased from about 20% on day 30 to nearly 100% on day 140 without any difference between the different sulfate concentrations. The results of the control treatments showed that the tested sulfate concentrations had no negative impact on the nitrifiers. Comparable results were obtained for digested sewage sludge (2nd pre-treatment) with an inhibition increasing from almost 60% on day 30 to nearly complete inhibition on day 140. The determination of AVS and DGGE samples is still ongoing.
Inhibition of ammonia oxidizing bacteria by Ag-NMs occurring in the digested and non-digested sulfate treatments indicate that long-term effects of Ag-NMs on the soil microflora in wastewater treatment plants cannot be excluded even if sulfidation processes during wastewater treatment are considered.