

Nanoparticles in Sewage Sludge: Natural, Incidental or Engineered?

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Distinguishing between engineered (ENP), incidental (INP) and natural nanoparticles (NNP) in complex media is challenging due the possible similarity between all particle types and the overwhelming number concentrations of NNP. Mass flow analyses revealed that a substantial fraction of ENPs is released to the sewer system. Thus, wastewater (and sewage sludge) seem to be the prime targets to detect ENPs.

Gold (Au) usually occurs only at low concentration in wastewater and Au-NP may preferentially be assigned to engineered sources. We, therefore, collected samples from the influent of a wastewater treatment plant showing elevated Au concentrations (2.5 ppm in the digested sludge) for more detailed analyses.

Wastewater samples were diluted (1:10 - 1:1000) in dispersion agent (0.2% FL70) and sonicated for 1 minute using a vial tweeter. Diluted samples were either investigated using single particle inductively coupled plasma mass spectrometry (sp-ICP-MS) to determine the size and the number concentration of Au-NP and transmission electron microscopy (TEM) to characterize their morphology.

Sp-ICP-MS measurements revealed Au-NP with an average diameter of ~ 20 nm and concentrations of ~ $3 \cdot 10^7$ particles / mL in the wastewater samples. After filtering the samples using 10 kDa filters, number counts of Au-NP reached values close to background measurements, confirming that Au indeed was present as nanoscale particles. TEM analyses of selected samples confirmed the presence of individual Au particles in the nanoscale range consistent with the results obtained from sp-ICP-MS measurements. Furthermore, TEM analyses revealed complex shapes of the Au-NP, which is in stark contrast to the almost perfectly spherical particles usually observed for engineered Au-NP. We therefore assign these Au-NP to anthropogenic sources, but classify them as INP rather than as ENP.

This study demonstrates the challenges of an unambiguous identification of ENP in complex matrices and questions the usefulness and the feasibility of specific emission guidelines for ENP in a regulatory context.