Introduction

Recent mass flow models suggest that the majority of engineered nanoparticles (ENP) are collected in managed waste streams and either eliminated during waste treatment processes (namely wastewater treatment and waste incineration), recycled or transferred to landfills, either directly or after passing through waste treatment and waste incineration), recycled or transferred to landfills, either directly or after passing through managed waste facilities (Keller et al., 2013; Sun et al., 2014). The largest share of waste originates from the construction industry and is classified as inert construction waste in Switzerland and the leachate from these landfills can be directly discharged into surface waters.

Experimental setup

The settings of several landfills (age, type of waste) were evaluated and leachate samples were collected from selected landfills (Figure 1) under dry weather conditions. Bulk parameters, including temperature, oxygen content, redox potential, and electrical conductivity were measured in the field. Furthermore, total suspended solids (TSS), total and dissolved organic carbon (TOC/DOC), and the concentrations of selected elements were determined in the lab. Elemental concentrations were determined by inductively-coupled plasma optical emission spectroscopy (ICP-OES) measurements. Particles smaller than a few microns were investigated using scanning electron microscopy (SEM) under low vacuum conditions. The morphometric parameters and the elemental composition of all individual particles were determined using an automated particle analysis system.

Computer controlled SEM (CC-SEM)

To screen the samples for the presence of TiO2 particles, we conducted an automated particle analysis using an scanning electron microscope (NanoSEM230, FEI, USA). In total, 2707 particles were detected and the particle size distribution an exponential increase of the particle number with decreasing diameter (Figure 4A), typically observed for particles in surface waters (Gregory, 2005). Energy dispersive X-ray analysis of the individual particles reveal that 48 particles contained substantial amounts of Ti (Figure 4B) and particles containing more than 20 wt% of Ti were defined as pure TiO2 particles. The histogram of these 48 TiO2 particles again shown an exponential increase with decreasing particle diameter (Figure 4C). The results from the microscopy analysis suggested that about 1 – 2 % of the detected particles were TiO2 particles. A closer inspection of the automatically detected TiO2 particles (Figure 5) revealed that these particles show rather spherical morphologies and consisted of aggregates of several smaller particles (Figure 6A, B). Such characteristic particle morphologies have been described from façade runoff (Kaegi et al., 2008) and represent white pigments which are essential components in paints.

Conclusions and outlook

The first results from this study clearly indicate that colloidal particles (and possibly also ENP) are present in the leachates of landfills. Thus, contrary to the general assumption that landfills represent ultimate sinks for ENP, landfills may serve as continuous sources for ENP, which, depending on the type of landfill, will be directly discharged into the surface waters.

References


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