INVESTIGATIONS ON RELEASE OF NANOPARTICLES FROM WASTE AND SEWAGE SLUDGE INCINERATION RESIDUES DURING DEPOSITION AND AGRICULTURAL USE – COMPARISON OF PILOT SCALE SIMULATION AND LABORATORY TESTS

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Introduction

- Engineered nanomaterials (ENMs) used in products (e.g. textiles or paints) enter the waste (water) stream and thus waste incineration and waste water treatment plants.
- Residues from waste and sewage sludge incineration are either deposited in landfills or used in agriculture as fertilizer, where they possibly can be released to the environment [1].
- The aim of this project was to whether the possible release from both scenarios can be assessed by lab-scale column elution experiments.
- Comparison of the column experiments with pilot scale simulation reactors (Landfill simulation of ENP-amended incineration bottom ash and simulation of agricultural use of ashes from ENM-amended sewage sludge after application to soil).

Conclusions

- Release of TiO_2-ENMs can be simulated using lab-scale column elution experiments according to DIN 19528.
- The reactors offer a realistic simulation of real scenarios and confirm results of column experiments.
- Spiking amount unrealistically high for improvement of detection limits, therefore no direct conclusions for real life scenarios possible.
- Additional studies with different ENMs and more soil types are needed to support the results, evaluate reproducibility and derive recommendations for regulatory action.

Experimental Setup

Municipal solid waste incineration ash

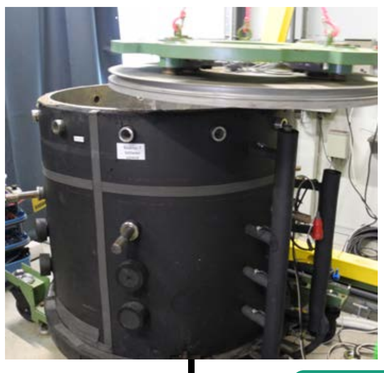
Column elution experiments

Pilot scale simulation reactors (1.5m³)

Sewage sludge + soil

(i) Landfill simulation

- Watering (every 14 days, 36 L synthetic rainwater)
- Temperature control 20°C (determined in depth of 20, 30, 40 cm)
- Pressure 15 t/m²



ICP-QQQ-MS (© Fraunhofer IME)

Leachates

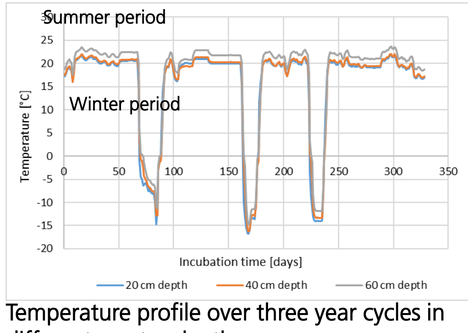
Nanoparticle analysis | Chemical analysis | Total analysis

spICP-QQQ-MS

ICP-OES/-MS

(ii) Simulation agricultural use

- 3-year time-lapsed seasonal cycles (repeated freezing / thawing)
- Summer period watering (50 L synthetic rainwater)
- Temperature control (20, 30, 40 cm depth)



Temperature profile over three year cycles in different reactor depth.

Results

- Domestic waste landfill simulation → no significant release of TiO_2 ENMs was observed compared to the reference simulation (Fig.1).
- Same results for lab-scale elution experiments.

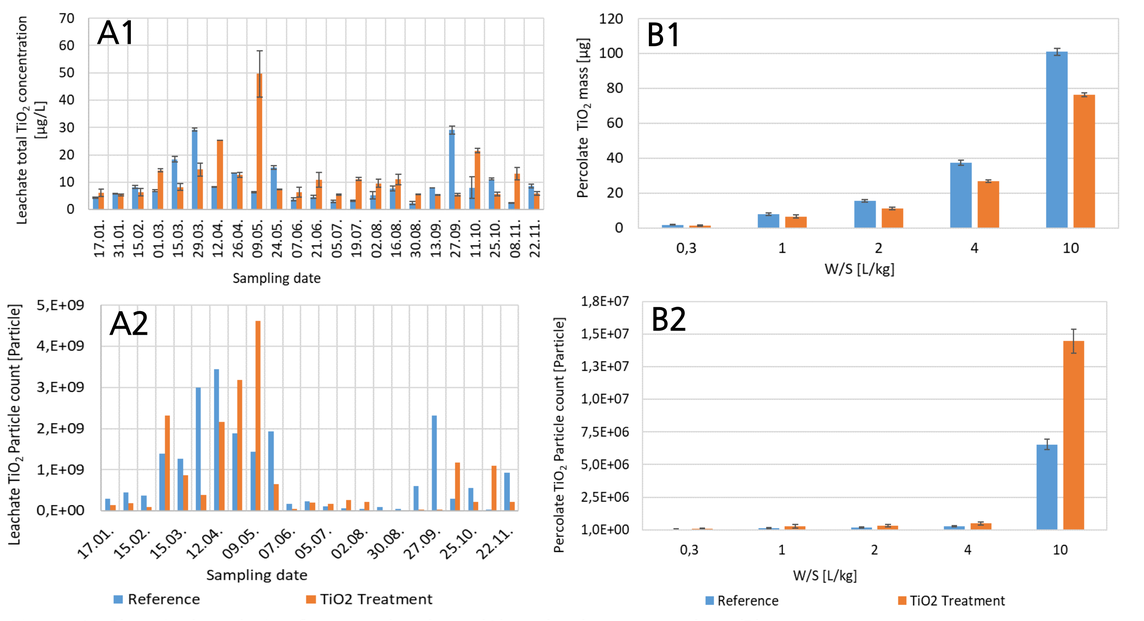


Figure 1: Chemical analysis of reactor leachate (A) and column percolate (B); (1) total TiO_2 concentration (ICP-OES/-MS), (2) particle count (spICP-QQQ-MS).

- Agricultural use simulation with spiked sewage sludge ashes → release of nanoparticles in comparison to the control simulation (Fig. 2).
- Same results for lab-scale elution experiments.

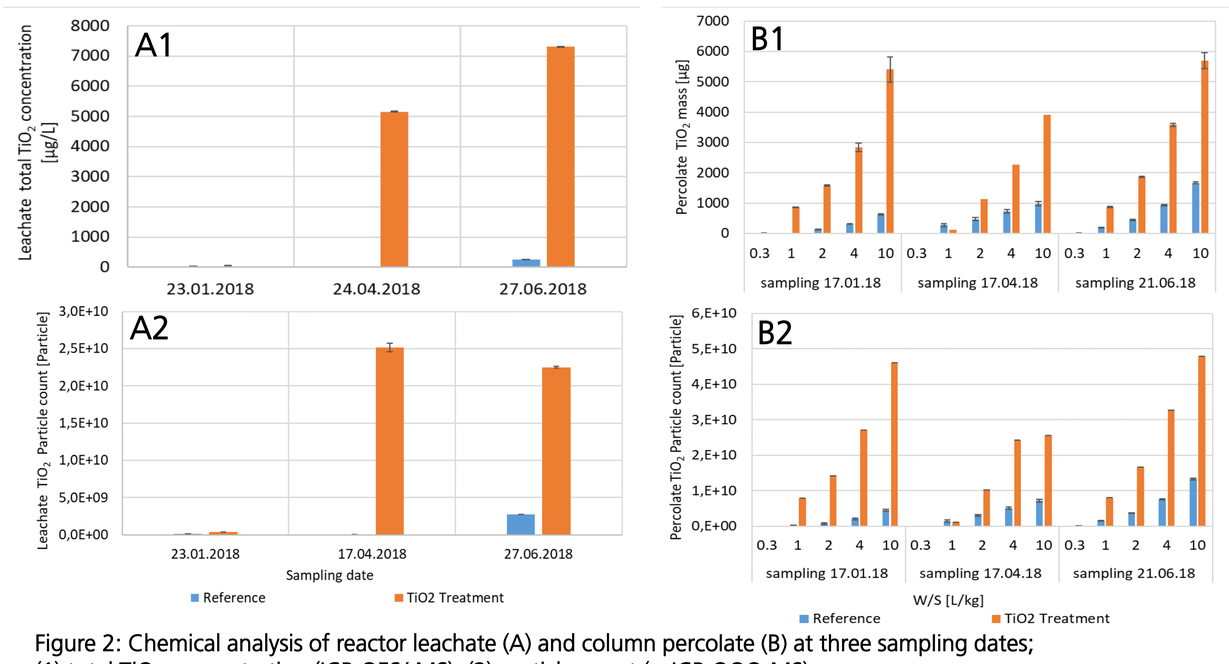


Figure 2: Chemical analysis of reactor leachate (A) and column percolate (B) at three sampling dates; (1) total TiO_2 concentration (ICP-OES/-MS), (2) particle count (spICP-QQQ-MS).

References: [1] Walser, T. et al, Nature Nanotechnology, 2012, 7, 520-524

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Session: The environment as a reactor determining fate and toxicity of nanomaterials (P)
Poster, Exhibition hall, ID WE087
Wednesday May 29th, 2019, 8:30 AM

Investigations on release of nanomaterials from waste and sewage sludge incineration residues during deposition and agricultural use-comparison of pilot scale simulation and laboratory tests.

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Engineered nanoparticles (ENPs) are used in consumer products such as textiles or paints. Thus, it can be expected that a considerable fraction will enter the waste stream, which means in most cases incineration and deposition of the incineration slag in landfills. Most of the sewage sludge in Germany is also incinerated, but the incineration ashes are frequently used in agriculture as fertilizer. Investigations with CeO_2-ENPs by Walser et al [1] showed, that nanoparticles are possibly not permanently bound to incineration residues and may become released. The aim of the present project was therefore to investigate the possible release of TiO_2-ENPs in two different scenarios: (i) pilot scale landfill simulation of ENP amended domestic waste after incineration and (ii) simulation of agricultural use of ashes from ENP-amended sewage sludge after application to soil. For landfill simulation a special reactor was used which allows to set up conditions present in a real landfill. For agricultural use, the same system was used but for time lapsed seasonal simulation by repeated freezing / thawing of the material. Both simulations had a scale of about 1.5 m3 and were periodically applied with artificial rain in order to obtain leachates. The leachates were analysed for total titanium-concentration (ICP-OES after digestion) and for the particle concentrations and size distributions by means of single particle ICP-MS (spICP-MS). For both scenarios, reference simulations without spiking of TiO_2-nanoparticles were run simultaneously. For the domestic waste landfill simulation, no significant release of titaniumcontaining nanoparticles was observed compared to the reference simulation, indicating that the added nanomaterials are strongly bound to the incineration slag. In contrast, in the simulation of agricultural use of sewage sludge ashes the observed release of nanoparticles in comparison to the control simulation was significant and even higher than could be expected from the amount of TiO_2 spiked. The results from the simulation experiments could be reproduced with the same materials in standard laboratory soil elution experiments according to DIN 19528.

[1] Walser, T. et al, Nature Nanotechnology, 2012, 7, 520-524