The nanofraction of fly ashes in Swiss waste incineration plants (WIP) and the respective modelled contributions of engineered nanomaterials (ENM)

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In the past, waste incineration processes had been identified as an important source of ultrafine air pollutants, implying necessary treatment systems for exhaust air. Today, these systems are able to remove around 99.99% of all ultrafine particles as measured in the Swiss waste incineration plants (Burtscher et al. 2002). However, studies investigating the size distribution of fly ash from waste incineration plants so far focused on micro-sized particles only (Cobo et al. 2009).

This study aims at identifying the nano sized fraction (by particle weight and number), and characterize physical and chemical properties of fly ash from waste, wood and sludge incineration in Switzerland. Samples from five different waste incineration plants were pre-fractionated, aerosolized and then analysed with a scanning mobility particle sizer (SMPS) and aerodynamic particle sizer (APS) for the accurate size determination. First results show that a large number fraction of all particles are smaller than 2 µm - while this fraction accounts for only a small part of the total weight.

Additionally, we assess the contribution of ENM to the nanoparticulate fraction of the generated ash. In general, little is known about the behaviour of ENM at the interface from the technosphere to the ecosphere. Previous modelling of ENM flows to the environment revealed that significant amounts enter the waste stream and therefore waste incineration plants and landfills. In order to model the flows of ENM during waste incineration and landfilling by including a more detailed description of the different processes and considering ENM-specific transformation reactions, a novel model was generated (Mueller et al. 2013). It allows a quantitative prediction of expected ENM flows to waste incineration processes. Four substances were modelled: nano-TiO_2, nano-ZnO, nano-Ag and carbon nanotube (CNT). These ENM are representative for commonly used materials and products, illustrating a variety of ENM with different behaviours. The modelling was performed for Switzerland where almost 100% of the municipal waste and sewage sludge are burned. The mass-based modelling showed that the major ENM flows go from the waste incineration plant to the landfill as bottom ash. All other flows within the system boundary (e.g. with the fly ash) were predicted to be about one magnitude smaller than the bottom ash flow. Example for one of the substances modelled (TiO_2) is shown in Figure 1.

Comparing these numbers to the total amount of fly ash produced in Switzerland, ENM amount to only a small fraction of the nano-sized fly ash even in the unlikely case that all ENM survive the incineration process unchanged. It is thus highlighted that the majority of the nanoparticles in fly ash is combustion generated. The results of the modelling show that waste incineration can have a strong influence on some ENM but that still the majority of the ENM-mass is expected to end up in landfills.

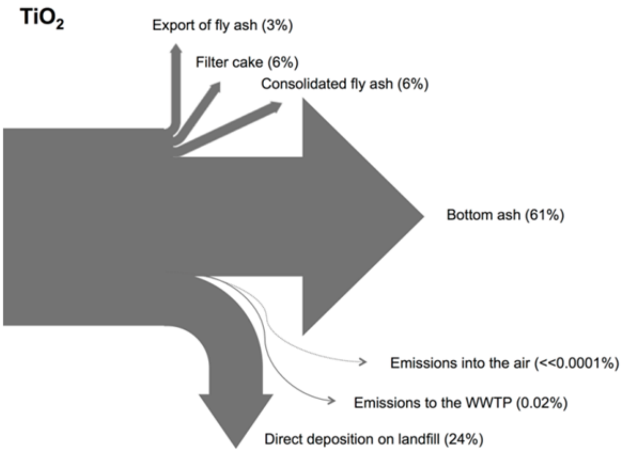

Figure 1: Waste disposal as input-output system for the ENM (TiO_2). Flows are shown in % of the total flow that enters the landfill (WWTP-waste water treatment plant).

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Burtscher, H.; Zürcher, M.; Kasper, A.; Brunner, M. (2002) *Proc. Int. ETH Conf. on Nanoparticle Measurement, Mayer, A., Ed. BUWAL*, **52**.

Cobo, M.; Gálvez, A.; Conesa, J. A.; Montes de Correa, C. (2009) *Journal of Hazardous Materials*, **168**, 1223–1232.

Mueller, N. C.; Buha, J.; Wang, J.; Ulrich, A.; Nowack, B. (2013) *Environmental Science: Processes & Impacts*, **15**, 251-259.