Detection of engineered cerium oxide nanoparticles in soils

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The detection of engineered CeO_2-nanoparticles (NPs) in water, soils and sediments is very challenging due to the low concentrations of emitted CeO_2-NP and the comparatively high background of Ce-containing minerals of similar size range. We here present different analytical methods, based on colloid extraction followed by Field-Flow Fractionation (FFF) and single particle SP-ICP-MS analysis, for identification and quantification of engineered CeO_2-NPs. Ce is evenly distributed over the size range of natural colloids. We found the 2:1 ratio of Ce:La to be present also in the colloidal size range. This elemental ratio can be utilised to distinguish natural Ce-NPs (ratio:2) from engineered (ratio 500 – 5000). SP-ICPMS offers the inspection of individual NPs for their Ce content. As long as Ce is not highly concentrated in particles < 1 μm the SP-ICPMS pulse signals remain below the detection limit. In contrast, engineered CeO_2-NPs > 30 nm appear as a spike and can be used to determine the concentration as well as the size of the CeO_2-NPs. Our hypothesis was tested on CeO_2-NP-spiked natural colloid suspensions as well as colloidal extracts of a natural soil spiked with CeO_2-NPs. With our current single-isotope method in sp-ICP-MS we are able to detect the addition of 5% Ce-NPs compared to the background concentration in all types of samples. Multiple isotope techniques extend our method by enabling the use of elemental ratios on single particle level and improving the detection limits considerably.