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DISTRIBUTION OF INORGANIC NANOPARTICLES IN A NORWEGIAN FJORD

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The marine environment is the principal sink for natural, incidental and engineered nanoparticles (NPs). Due to the analytical challenges of detecting and quantifying nanoparticles in seawater, the data on distributions of NPs the marine environment is limited to qualitative studies or by ensemble measurements subject to various analytical artifacts. Single particle inductively coupled plasma mass spectrometry (SP-ICP-MS) is a technique allowing precise determination of individual inorganic NPs at concentrations in the nanograms per liter range, yet thus far only few studies have been done on select elements in surface sea water. Here, a multi-element screening method using SP-ICP-MS was developed and applied using a trace element sampling procedure using acidification and a neutral sampling protocol developed for NP specific purposes. Employing this method, a first survey of the horizontal and vertical distributions of inorganic nanoparticles and trace elements was performed in a pristine Norwegian fjord prospect for submarine tailings deposition. Statistical control of false positive detections while minimizing the size detection limit was ensured using a novel raw signal processing. To confirm the results of the single particle measurements, and for qualitative information regarding particle morphology and composition, scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) was used. Following SP-ICP-MS screening for particles of 16 elements, particulate Al, Fe, Mn, Pb, Si and Ti were found and determined to number concentrations in the range 4×10^6 to 10^8 particles per liter. A strong depth dependence was observed for both trace elements and particles, concentrations increasing with depth. The particulate fraction was for all elements found to compromise only a few mass percent of the total metals, at concentrations mostly in the hundreds of ng/L range versus μg/L for total metals. The sampling protocol was found to have a strong influence on the particles consisting of Fe, Mn, Pb and Ti, whereas no significant influence was found for Si and Al containing particles. Our results provide a baseline for the fjord and new data on environmental levels of both total metals and metal containing nanoparticles including the vertical and horizontal distribution of natural nanoparticles.