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Metals in aerosolizable and water-extractable ultrafine road dust particles

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Transition metals in inhaled particles are believed to play a central role in the development of respiratory diseases by inducing cellular oxidative stress. Exposure to airborne ultrafine particles (UFP; < 0.1 µm) is of particular concern due to their ability to reach the alveoli and be translocated into the blood stream. Data on elemental composition of UFP remain limited due to challenges in collecting enough material for chemical analysis. This study characterized UFP-bound metal(loids) in road dust samples using two different approaches: (i) resuspension / size-fractionation and (ii) water extraction / single-particle ICP-MS (sp-ICP-MS).

In approach I, triplicate road dust samples were resuspended using a fluidized bed aerosol generator connected to a cascade impactor for separation of particles into size fractions ranging from 0.01 to 10 µm. The dust-loaded filters were acid digested (HNO_3/HF) and elemental concentrations were measured using ICP-MS or ICP-OES. The most abundant elements in UFP were Si, Fe, Al, and Mg (> 1 wt.%); these elements are related to the dust matrix. Among the contaminants often associated with vehicular emissions, Zn, Ti, Ba and Cr were moderately abundant (500 to 1000 mg kg^{-1}), while Ce, V, Sb, Co, La and Cd were in concentrations ≤ 100 mg kg^{-1}. However, some metal(loid)s (Cu, Sn, Pb, Ni, Bi and As) could not be quantified due to the potential cross-contamination by bronze beads during resuspension. Therefore, approach II relies on a water extraction to extract readily mobilizable UFP. The elemental composition, number, concentration, and size distribution of nanoparticles in the water extracts were determined using sp-ICP-MS. The occurrence of Cu-, Pb-, Ni- and As-containing nanoparticles was confirmed in these water extracts. The highest number concentrations were measured for Cu and Zn, followed by V, Cr, and Ba. In line with results from approach I, higher numbers of nanoparticles were measured in water extracts from the local road compared to the arterial road dust.

Our results provide evidence that potentially toxic metal(loid)s (Cd, Cr, Co, Ni, Pb, As, Sb) co-occur in UFP from resuspended road dust, which has important implications for human health risk assessments of non-exhaust emissions.