Tracing Sources of Atmospheric Particulate Matter in the Rust Belt: A Combined Os and Pb Isotope Approach

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Steel manufacturing and associated industries such as coke production release metal-rich airborne contaminants that may be linked to a range of potential health risks including pulmonary, cardiovascular, and central nervous system diseases, among other adverse effects. Steel manufacturing-related industrial activities can have local and regional impacts, and can adversely affect nearby residential areas. Methods to monitor the level and geographic distribution of metal-rich airborne particulate matter (PM) are important for risk assessment, but equally important for mitigation, when required, is source attribution.

In this study, we have employed biomonitoring to assess the distribution and levels of heavy metals in atmospheric particulate matter in the vicinity of a steel manufacturing plant in the rust belt of the US mid-west, using lichen and tree bark as passive collectors of particulate matter over the decadal scale. Our results show that concentrations of many heavy metals in the lichen samples are above background levels, with enrichments that vary from minor to moderate (Fe, Co, Mo, V and Pb) or moderate to severe (Cr, Mn, Ni and Zn). Concentrations of these elements are generally highest in lichen sampled in close proximity to the steel-production facility, and decrease progressively with distance. Imaging and chemical analysis of total suspended particulate matter (TSP) from the vicinity of steel plant by scanning electron microscopy (SEM) and X-ray spectrometry (EDS) have revealed an abundance of Fe- and Mn-rich particles, suggesting that these elevated metal abundances likely relate to atmospheric PM from steel production.

In order to better constrain the relative contributions to the atmospheric PM metal load from the steel industry and associated activities (e.g. coke production), as well as other potential pollution sources (e.g. traffic) in this urban-industrial study area, we have employed a combined Pb and Os isotopic study of lichen and tree bark. The Pb isotope data clearly identify natural background and anthropogenic components in the atmospheric PM, including industrial and traffic related emissions. Preliminary Os isotope data further indicate contributions from both steel and coal. Together, these data suggest that the atmospheric PM is derived predominantly from a mixture of steel, coal and traffic-related emissions, with a contribution from natural background dust.