

Identification of atmospheric dust sources around a smelting site within the Congolese Copperbelt

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Mining activities are expected to increase in the DR Congo due to the growing demand for cobalt and copper, that are strategic metals for the energy transition (Crundwell et al., 2020). However, previous toxicological studies conducted in the Congolese Copperbelt have shown high health impacts associated with mining activities (Cheyns et al., 2014). The aim of our study is to identify the possible sources of atmospheric dust collected around a smelter in the Congolese Copperbelt and their respective chemical tracers using a Principal Component Analysis (PCA) model.

The smelter produces white alloy (Co-Cu) rich in cobalt and zinc oxide powder (ZnO) by carbothermic reduction from an old slag heap (Co-Cu-Zn-(Ge)) using a pyrometallurgical process at 1450 °C. Aerosols were collected from July 2022 to August 2022 using a Dekati 3-stage cascade impactor operating at a flow rate of 30 L min⁻¹ for 2–5-hour sampling periods and separated aerosols into 4 size fractions : >10 µm, 2.5-10 µm, 1-2.5 µm and <1 µm. Eleven sampling points with three replicates each, both inside and outside the smelting site, were selected based on prevailing winds and potential sources of dust emissions. 27 elements were analyzed using Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) and ICP-Mass Spectrometry (ICP-MS), of which 17 robust elements were selected in order to produce a robust PCA output.

The gravimetric results showed that the fine fraction (< 2.5 µm) was the most abundant (134-457 µg m⁻³) at each sampling point. Metal(loid)s related to the slag composition and industrial process were predominant. Lead (1-55 µg m⁻³) and Zn (14-152 µg m⁻³) were found in the 1-2.5 µm range, while germanium (0.01-0.35 µg m⁻³) was found primarily in the <1 µm range (Fig. 1).

Five source factors (F1-F5) were resolved by PCA and explained 79% and 89% of the total data variance for the fine (<2.5 µm) and coarse fractions (>2.5 µm), respectively. The factors for PM_{2.5} were physically interpreted to contribute to the particulate pollution around the smelter site as follows: F1 (31%): As, Cd, Co, Cu and U, stack gas and smoke; F2 (22%): Co, Ge and Mo, emitted during metal granulation in the alloying (Co-Cu) circuit; F3 (12%): Ca, Fe, Mn, Ti et Al, emitted during granulation of unenriched slag and raw materials ; F4

(7%): Cr and Ni, likely fine particles from chrome furnace refractories and wear of mechanical parts; F5 (7%): Pb and Zn, fugitive dust from zinc oxide powder circuit. PCA factors for the coarse fraction showed that 39% (As, Cd, Co, Cu and U) and 20% (Al, Ba and Ti) of the variance was due to dust resuspension from polluted soils and crustal sources, respectively.

The identification of PM emission sources indicates that atmospheric dust is mainly generated both inside and outside the smelting sites by dust resuspension from contaminated soils due to unpaved roads. Further research may focus on identifying transport pathways of metals and metalloids from the atmosphere to soils.

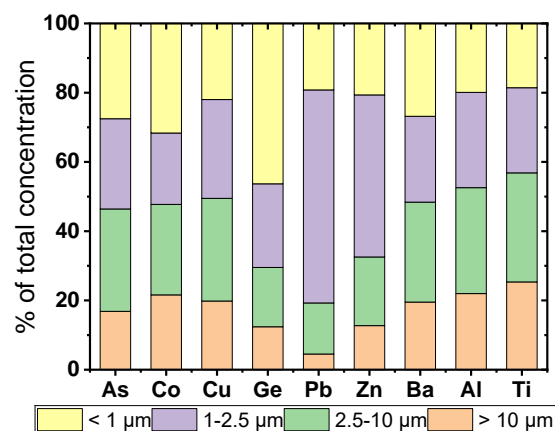


Figure 1 Percentage of total concentration according to the size distribution within the smelting site

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