

Bioextraction, isotope composition, and water leaching of Cu and Zn from a burnt coal waste pile: the Novátor mine, Czech Republic

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Mining in the coal mine Novátor near the town of Trutnov (Czech Republic) was terminated in 1969, and its coal waste pile was largely burnt. The Cu- and Zn-rich pile during the subsequent nearly fifty years was spontaneously revegetated. Copper and Zinc were extracted by the birches. The contents of Zn and Cu in the sap of the birches growing on the pile are higher (Zn = 10.2 to 22.9 mg.l⁻¹, Cu = 0.4 to 0.74 mg.l⁻¹) compared to the sap of birch trees growing outside of the pile (Zn = 2.1 to 2.6 mg.l⁻¹, Cu = 0.31 to 0.41 mg.l⁻¹), and correlate with the contents of these metals in the leaves. The birch sap and leaves are depleted of heavy isotope ($\delta^{65}\text{Cu} = -1.04$ to -1.4‰ and -1.57 to -2.59‰ , respectively) in comparison with isotopic composition of copper in the pile substrate ($\delta^{65}\text{Cu} = -0.22$ to $+1.49\text{‰}$ and -1.57 to -2.59‰ , respectively). This shows the isotope fractionation of copper in birches roots. The isotopic composition of Zn in the pile substrate in contrast to Cu is very variable ($\delta^{66}\text{Zn} = -0.13$ to $+1.43\text{‰}$), which is reflected in a wide range of isotopic composition of Zn in the sap and in the leaves ($\delta^{66}\text{Zn} = -0.41$ to $+1.0\text{‰}$ and -0.21 to $+0.51\text{‰}$ respectively). To assess the “labile” (extractable) concentrations of Cu and Zn in the humus layer and in the burnt substrate, Cu and Zn were extracted using a solution of diethylenetriaminepentaacetic acid (DTPA). While the amount of extractable Cu and Zn in the pile substrate was very small (about 0.1% of the total amount of both metals), the amount of extractable Cu and Zn in the humus reached up to 2.1 and 3.6%, respectively. This suggests that the source of the high Zn content (233 to 468 $\mu\text{g.l}^{-1}$) and Cu (31 to 45 $\mu\text{g.l}^{-1}$) in waters flowing out of the pile is in its surface layer which is rich in humus. Concentrations of both metals in water with increasing distance from the pile rapidly decrease due to the sorption of Zn and Cu onto organic matter and on Fe- and Mn-precipitates.

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