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Solubility of Cu, Zn, Pb and As in variously treated historical mining soils under waterlogged conditions

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The Sudetes, a mountain range in the south-western Poland, and the Sudeten Foreland have a complex geological structure, with numerous metamorphic zones that host a great number of genetically and geochemically diverse ore deposits. Various metals and metalloids were the targets of exploration and mining for centuries. Ore mining and processing produced large amounts of wastes but the majority of historical mine waste dumps were left non-reclaimed. In this study, we examined a release of Cu, Zn, Pb and As into pore water from four soils collected in the areas of historical mining. The soils were treated with FeOx-rich wastes, beech forest litter or diluted mineral acid and kept in waterlogged conditions in a 140-day incubation experiment. The concentrations of Cu, Zn, Pb and As in soils were in the ranges: 261–918 mg Cu kg^{-1}, 130–2456 mg Zn kg^{-1}, 87.8–57330 mg Pb kg^{-1} and 69.2-44518 mg As kg^{-1}. Soil pore water was collected 5 times with MacroRhizon suction samplers, and Cu, Zn, Pb and As concentrations in water were measured using ICP-MS (8800 QQQ, Agilent Technologies). The study confirmed high concentrations of Pb in pore water, that in three out of four soils exceeded 10 $\mu g \cdot L^{-1}$ set as a threshold for satisfying quality underground water. The permissible limit was exceeded by 20 to even 12 000 times. The maximum concentrations of Pb in pore water were measured in soils treated with acid where they reached 122 mg $Pb \cdot L^{-1}$ at pH<3.0. At the same time, the concentrations of As was exceeded even 10 000 times. The waterlogging considerably reduced final Cu, Zn and Pb concentrations in pore water, irrespectively of the kind of pretreatment, but triggered the release of As from soil solid phase. These results showed, that unexpected changes in environment can cause a significant release of potentially toxic elements to groundwater. Therefore, the applicability of any treatments designed for remediation of soils affected by mining activity should be thoroughly examined in relation to the properties of those particular soils and the behavior of various hazardous elements.