Environmental drivers for arsenic solubilization from floodplain soils

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Mining activities have contaminated many riverine floodplains with arsenic (As). When floodplain soils become anoxic under water-saturated conditions microbially-driven reductive processes can release As from the solid to the dissolved phase. Numerous influential factors, such as the availability of substrates for microbial metabolism, the type of Fe minerals, and temperature, were recognized in the last decades. But the interplay between soil properties, of which many natively (co)vary in a floodplain, and the influence of environmental factors (e.g., temperature) remain poorly understood. In this study, we conducted anoxic microcosm experiments at three different temperatures (10, 17.5, and 25 °C). We used 65 representative soils from the mining-impacted Ogosta River floodplain in Bulgaria, covering soil pH values of 5.4–7.6, organic C contents of 93–744 mM kg^{-1}, and As, Fe, and Mn levels of 0.2–221, 502-2629, and 18-518 mM kg^{-1}, respectively. To investigate mechanisms of As solubilization and its quantitative variability, we followed the As and Fe redox dynamics in the solid and the dissolved phase and monitored a range of solution parameters including pH, Eh, dissolved organic C, and dissolved Mn. We related soil characteristics to dissolve As observed after 20 days of incubation to identify key soil properties for As solubilization. Our results show that high solubilization occurred via reductive dissolution of As-bearing Fe oxyhydroxides. The availability of nutrients, most likely organic C as the source of energy for microorganisms, was found to limit the process. Following the vertical nutrient gradient common in vegetated soil, we observed several hundred µM dissolved As after 1-2 weeks incubation of some topsoils (0–20 cm), while for subsoils (20–40 cm) with comparable total As levels only minor solubilization was observed. While high Mn contents were evidenced to inhibit As solubilization, the opposite applied for higher temperature. Q_{10} temperature coefficients for As solubilization were 2.3–6.1, similar to other soil fluxes involving microbial respiration. Environmental impacts of our findings will be discussed.