Effects of compost on Fe minerals and As mobility of legacy tailings during redox oscillation

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Legacy sulfide mine tailings piled on Earth's surface generate significant environmental concern due to high concentrations of toxic elements and acid drainage during oxidative weathering, which may disperse contaminants and threaten environmental and community safety. The US EPA Superfund site at Iron King Mine and Humboldt Smelter in Arizona was one of these legacy tailing piles, which was characterized by high Fe (> 9%) and S (*ca.* 5%), high concentrations of As, Zn and Pb (> 2000 mg kg^{-1}), low pH (*ca.* 2.5) and low C and N. Compost amended phytostablization was carried to reduce the wind blown dispersion of toxic elements. The compost amendments added nutrients and provided a pH buffer against increased acidity, and also introduced microbes and a labile carbon source, which could increase reductive dissolution of Fe (hydr)oxides and release As during rainy season or irigation event. However, as redox conditions in periodically flooded settings fluctuate, these redox oscillation change the stability of Fe minerals, and subsequently change mobility of As, generally coupled with Fe minerals. This study aimed to investigate the effects of compost on Fe minerals and As mobility during redox oscillation in controlled static redox reactors.

Compared to the control group, compost amendment significantly increased Fe reduction (*ca.* 5% of total Fe) in anoxic conditions, which was coupled with As release. Reduced Fe was then re-oxidized in oxic conditions, which immobilized As. Aqueous pH decreased by 2 units, SO_4^{2-} doubled, due to oxidation of pyrite, demonstrated by the XRD results. Selective extraction procedures from redox reactors showed that Fe and As fractionation changed slightly. The crystallinity of Fe minerals decreased after 7 cycles of redox oscillations, and extracted As decreased, indicated decreased As mobility. In conclusion, compost amended mine tailings accelerated pyrite oxidation, decreased pH, increased Fe reductive dissolution and released As in anoxic condition.