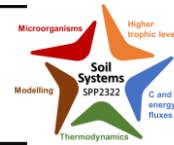

Soil Systems Ecology

Organic Matter, Energetics & Turnover



International Conference
9th – 11th September 2024
Humboldt-Universität zu Berlin

Effect of organic matter on the bioenergetic landscape of phytostabilized mine tailings

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Total mining waste in Europe amounts to 6Gt, most of which contains iron (Fe), sulfur (S), and other toxic pollutants including metalloids and metals such as lead (Pb), arsenic (As), and zinc (Zn). To reduce pollutant fluxes from mine tailings, phytostabilization based on growing metal-tolerant plants is a common practice, notably to reduce erosive fluxes. Usually, organic amendments are also added in the mine tailing to promote plant growth. This practice as well as root growth impacts the biogeochemical properties of the tailings. They are suspected to drastically modify the microbially-mediated redox reactions controlling metal fluxes but this impact still remains unclear. Combining mesocosm and microcosm experiments with a geochemical model based on simulations of microbially-mediated redox reactions thermodynamically constraints, our study evaluates the impact of assisted phytostabilization on the bioenergetic landscape of mine tailings. In mesocosm (i.e. an instrumented metric column containing homogenized mine tailings), the 6-month pre-amendment period showed a decrease of NO_3^- concentrations followed by an increase of Fe(II) and As concentrations. Simulations suggest that Fe(II) concentrations, pH values, and redox potentials are controlled by Fe(II) reductive reactions, promoting the dissolution of hematite. NO_3^- and As(V) reduction reactions also occur. The presence of heterotrophic anaerobic bacteria suggests that traces of organic matter in the mine tailings (i.e. roots and barks) are sufficient to act as an electron donor in order to induce the aforementioned redox reactions. Results provided by microcosm-scale experiments (mine tailings batch experiments where increasing concentrations of sodium acetate are used) confirm this hypothesis. A decrease in redox potential and acetate concentration was indeed measured after 27 days of experiments. Our results highlight the key role of organic carbon (either naturally occurring or added as an amendment) as an electron donor regulating the bioenergetics landscape. A Comprehensive study of the bioenergetics landscape seems a suitable framework to improve the management of phytostabilization practices by assessing the interplay between organic carbon and the Fe, S, and As redox couples.