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Role of organic matter on the bioenergetic landscape of mine tailings

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Europe hosts more than 6 Gt of mining waste, most of which containing iron (Fe), sulfur (S), and toxic pollutants including arsenic (As) or metals. Assisted phystostabilization prevents contaminants transfer by erosion. However, the organic matter brought by amendments represents an additional source of electrons, which modifies the nature and the magnitude of the microbially-mediated redox reaction shaping the energetic landscape, hence on As and metal mobility. To assess the response of microbial activities to change in energy availability and its effects on As mobility, long-term (3 months) batch experiments were conducted under anaerobic conditions, involving fine tailings from an old tin mine (water-rock ratio of 10). Different energy conditions were fixed by adding acetate to reach initial concentrations of 0, 1.19 ,12.0, 24.2 µM. Water was sampled weekly for assessing the main physical and chemical properties. Microbial functional diversity (most probable number) and more refine monitoring of porewater chemistry were done every month. A thermodynamic geochemical model, using WORM portal with its database (modified), was used to interpret the experimental results. During the first month, NO_3^- concentrations decreased and FeII concentrations increased, as a consequence of the reductive dissolution of iron hydroxide catalyzed by a FeIII-reducing microbial community. The increase of pH from 6.5 to 7.3 results in the desorption of AsV from the iron hydroxides and an increase of AsV concentrations from 0.23 to 5.63 µM after 3 months. In parallel, the concentration of AsIII increases, consistent with the presence of AsV-reducing microorganisms. Yet, considering either the measured Eh or the calculated $Eh_{FeIII/FeII}$ at equilibrium with ferrihydrite, the AsV reduction is not energetically favorable. Bioenergetic calculation highlights the role of natural organic matter as an electron donor in the AsV reduction. Moreover, electron balance calculation indicates that the number of electrons provided by the oxidation of acetate was not enough to fuel all the reduction reactions observed, suggesting that the traces of natural organic matter initially present in the tailing (bark, dead roots, TOC<0.02wt.%) have been used by microorganisms. Bio-molecular analyses are currently performed to determine the microbial functional diversity and further constrain the bioenergetic calculations.