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Exploitation of microbial Fe and As oxidation for semi-passive treatment of high-As Acid Mine Drainage (AMD) in a field-pilot

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The weathering of sulphide minerals promoted by mining activities can lead to the formation of arsenic rich Acid Mine Drainage (AMD). This extreme pollution of water resource is a threat to human and environmental health. Natural attenuation of As has been evidenced in AMD. This process is driven by native microorganisms and results in the immobilization of As with/onto ferric(hydroxy)sulfates. Exploitation of this biogeochemical process could enable the development of a sustainable strategy to treat As-rich AMD.

In this study we evaluated the performances of semi-passive units exploiting biological Fe and As oxidation for the bioremediation of AMD ([As(III)]= 42-102 mg.L-1; [Fe(II)]= 430-1000 mg.L-1; pH=3.1-5.1) from the ancient Carnoulès mine, France. The water geochemistry and the bacterial communities of this As-rich AMD have been characterized in the framework of the regional Pollumine Observatory (OSU OREME, University of Montpellier) and project COMPAs (ADEME). Two treatment units of 1 m3 each were installed in-situ and monitored for one year (2019-2020). The design of the units optimized oxygen supply and bacterial colonization which were the main limiting factors of natural attenuation identified in previous studies. Inlet and outlet waters and bioprecipitates were periodically sampled for chemical and microbial characterization.

Under steady-state conditions, the system oxidized 92 ± 6% Fe and removed 30 to 60% of Fe and 50 to 80% of As, showing improved performances compared to previous field studies. The system showed good and stable performances towards seasonal changes of AMD physico-chemistry. The precipitates contained jarosite and accumulated up to 90 g/Kg of As mainly under arsenate form (60-90%), which is the most stable As species.The microbial oxidation rates were globally estimated. Although not fully at thermodynamic equilibrium, dissolved Fe(III) concentration in the treated water seemed to be controlled by the solubility of jarosite or poorly-crystalized schwertmannite depending on the pH and As(V) concentration by amorphous ferric arsenate. Additional steps are considered to further drop the As and Fe content in the treated water.

Work under the challenging conditions of the Carnoulès As-rich AMD provides fundamental and technical advances to define extrapolation rules applicable to different sites.