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Long-term evaluation of an organic-carbon permeable reactive barrier remediating mine impacted groundwater and the potential of emulsified vegetable oil to increase treatment performance

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Contamination of water resources by acid mine drainage and metal contaminants from the oxidation of mine wastes that are improperly managed is a global environmental concern. An established economical passive method for managing the transport of oxidation products in groundwater is the installation of an organic matter permeable reactive barrier (PRB) to promote sulfate reducing bacteria (SRB) growth and dissimilatory sulfate reduction (DSR) in situ. A detailed biogeochemical evaluation was conducting on a PRB remediating AMD from an abandoned Ni-Cu mine after 26 years of treatment, providing the first long-term evaluation of this technology. Pore-water concentrations of Ni decrease from concentrations up to 255 µg L^{-1} (97 µg L^{-1} mean) to < 25 µg L^{-1} while Fe decreases by 402 mg L^{-1} (77% of mean influent) through the PRB. Pore-water SO_4 decreases by 1243 mg L^{-1} (70% of mean influent) coinciding with an increase in pore-water SO_4 ^{34}S suggesting DSR is actively occurring. There are distinctly different populations of putative SRB present within the sampled PRB material compared to the surrounding aquifer material. Low abundances of S and Fe oxidizing prokaryotes were detected which may contribute to re-mobilization of Fe and S or formation of Fe (oxy)hydroxide phases. A preponderance of S immobilized within the PRB is in the form of acid volatile sulfur with mineralogical investigations identifying FeS phases often replacing organic carbon in plant cellular material and framboidal pyrite. These results demonstrate that the PRB is still operating as designed with complex organic carbon compounds supporting a diverse microbial community that sustain rates of DSR to effectively precipitate Fe sulfides, reduce the acid potential of groundwater and immobilize contaminants. Column experiments were designed to evaluate the incorporation of emulsified vegetable oil (EVO) into solid-phase organic carbon through soaking and injection to promote and sustain treatment performance. Column effluent results demonstrate EVO soak columns were capable of high levels of Fe removal for the duration of observation (315 days). Moreover, an EVO injection was able to re-establish treatment after removal rates declined, providing a viable alternative to PRB replacement to maintain effective treatment system performance and extend PRB lifespan.