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Bioremediation of Mercury Contamination in Kazakhstan: A Multifaceted Approach

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Mercury poses an ecological and human health risk due to its volatility, solubility and mobility in the environment, where it often forms organo-metallic compounds (e.g. monomethyl mercury, a potent neurotoxin). The former operation of the Khimprom Plant in northern Kazakhstan resulted in the release of 970 tonnes of elemental mercury into the surrounding soil and a further 50 tonnes into wastewater, creating a plume more than two kilometres in length that is one of the largest mercury spills in the world; an ideal location for the development and transfer of new remediation technologies. Site sampling in September 2007 indicated that groundwater mercury levels in the plant vicinity are as high as 154 .g/L, a substantial increase from background concentrations; approximately 0.171 .g/L.

A promising avenue for mercury remediation involves the combination of unique sorbent materials with the mercury fixation capacity of sulfate-reducing bacteria (SRBs) in order to enhance the natural transformation and immobilization processes taking place in the environment. Current laboratory studies are focused on: establishing the sorption potential of mercury by nanoparticles of zero-valent iron (nZVI) and charcoal compounds; examining the contribution of soil constituents and SRBs to the fixation process; and exploring the potential of combining SRBs and sorbent materials to capture and stabilize mercury within the environment.

The three types of nanoparticles tested (nZVI, annealed nZVI, and nZVI containing 20% nickel) all sorbed approximately 1045 mg Hg2+/g nZVI, when utilized in a 1:1 ratio in both MilliQ water and in a SRB medium, each spiked to contain 100 mg/L Hg2+. Equilibium sorption was reached within an 8-hour period. The nZVI was also tested in combination with the sulfate-reducing genera Desulfovibrio to explore the potential toxicity of the nanoparticles to SRBs, the subsequent impact on bacterial growth rates and also the bioavailability of mercury bound to nZVI when exposed to SRBs. Initial results show that nZVI does not significantly retard bacterial growth at concentrations of up to 1g/L. Also, following the initial removal of Hg2+ ions from solution by nZVI, there was no indication of a subsequent increase in Hg2+ concentration in solution as a result of bacterial growth and metabolism. The Hg2+ sorption capacities of charcoal compounds and the growth of Desulfovibrio in the presence of varying charcoal and Hg2+ concentrations continues to be investigated.

A bi-lateral approach that utilizes such sorbent materials as an innovative support matrix for sulfate-reducing bacteria would enhance the overall potential for mercury immobilization and could ultimately be incorporated into a long-term site solution.