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Novel anaerobic bioremediation strategies for organic and metal contaminants

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Abstract

Bioremediation is becoming a widely accepted solution for cleaning up contaminated sediment, water, and soil. The associated microbial, chemical, and geologic principles are still in their relative infancy compared to other common remediation strategies. The list of contaminants that are susceptible to biotransformation has grown to encompass metals as well as organic compounds. The goal of this research was to develop anaerobic bioremediation strategies for two compounds—the fuel oxygenate methyl tert-butyl ether (MTBE) and the heavy metal uranium. ^ The potential for anaerobic degradation of MTBE as well as its metabolite tert-butyl alcohol (TBA) was tested in aquifer and freshwater aquatic sediment. Aquifer sediment amended with Fe (III) oxide plus the electron shuttling compound humic acid degraded 50 mg/l MTBE to levels below detection. The humic acid analog anthraquinone-2,6-disulfonate (AQDS) also stimulated MTBE degradation. Aquifer sediment without Fe (III) plus the electron shuttle did not degrade MTBE. Freshwater aquatic sediment converted uniformly labeled [^{14}C]-MTBE to $^{14}CO_2$ and over time. Adding Fe (III) and electron shuttling compounds did not significantly increase the rate and extent of MTBE mineralization. TBA was also rapidly degraded in the aquatic sediment in the absence of any amendments. Both $^{14}CO_2$ and $^{14}CH_4$ were produced when sediments were incubated with uniformly labeled [^{14}C]-TBA. ^ Microbial U(VI) reduction was stimulated in uranium-contaminated aquifer sediment upon the addition of acetate. U(VI) reduction was concurrent with Fe (III) reduction and preceded sulfate reduction. In sediments that also contained nitrate, nitrate first had to be completely reduced prior to the onset of U(VI) reduction. U(VI) reduction was solely a biological process; abiotic interaction with Fe (II), sulfide, or electron shuttles did not affect U(VI) in solution. ^ Nitrate added to sediment that contained microbially reduced U(VI) re-oxidized U(IV) to U(VI) and Fe (II) to Fe (III). Over 80% of the initial reduced U(IV) was recovered as U(VI). Pure culture studies with *Geobacter metallireducens* confirmed that the most likely mechanism was biological oxidation of Fe (II) to Fe (III) with abiotic U(IV) oxidation via Fe (III) produced. ^ Finally, two novel Fe (III)-reducing bacterial species were isolated from these sediments—*Desulfitobacterium metallireducens* and *Geoferax ferrireducens*. ^

Subject Area

Microbiology|Environmental science|Environmental engineering

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