Influence of Activated Carbon on Microbial Transformation of Chlorinated Solvents and Explosives

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Background/Objectives. The objective of this research was to quantify the impact of activated carbon on secondary biodegradation of two contaminants: chlorinated solvents (TCE) and explosives (RDX). Activated carbon is a reactive sorbent used to control contaminant transport in groundwater, both in situ and ex situ. In addition to sorption, activated carbon is electrochemically active and microorganisms can transfer electrons via granular or powdered activated carbon to sorbed contaminants, which may include nitramines, nitroaromatics, or chlorinated aliphatic compounds. We have been investigating activated carbon as a reactive amendment in remediation applications, and results demonstrate that it can greatly accelerate biotransformation (in the case of explosives), or it can limit biodegradation (in the case of chlorinated solvents). In addition, an unintended reaction of in situ activated carbon is rapid and extreme methanogenesis, via intraspecies electron transfer.

Approach/Activities. Data will be presented from two different studies. The first is an ex situ RDX biological granular activated carbon (Bio-GAC) reactor. RDX was transformed via formaldehyde to mineralization products after sorption to GAC. While electron shuttling molecules increased the rate of reaction, the cells only systems rapidly transformed sorbed RDX via activated carbon electron transfer. No residual RDX was quantified on the GAC, indicating that this strategy can be used to regenerate activated carbon for continuous groundwater treatment, without GAC disposal.

Results/Lessons Learned. Trichloroethylene (TCE) biodegradation was limited in the presence of activated carbon. TCE sorbed rapidly, but the daughter products were not identified, suggesting that sorbed TCE was less microbially available. TCE was completely reduced to ethene (1:1 stoichiometry) in any system in which activated carbon was absent, irrespective of the electron donor used (lactate, acetate, or EVO). All data suggest that activated carbon has a deleterious impact on chlorinated solvent biodegradation. RDX biodegradation, conversely, was greatly accelerated by activated carbon. This was due to a combination of direct electron transfer through the activated carbon (since it is electrochemically active), and reduction by secondary minerals on sorbed RDX. All data indicate that activated carbon is more appropriate for specific contaminants, and the nitrated compounds may be the most reasonable for treatment.

Methane concentrations were extreme, and some PAC/GAC amended systems generated 20 times the methane of relative control incubations. This was due to direct interspecies electron transfer (DIET). This unintended consequence of activated carbon may make this strategy dangerous for any sites in proximity to underground structures.