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NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION RESEARCH

Natural Anaerobic Biodegradation of Biofuels

Introduction to the Problem

There were 7,364 new releases of motor fuel from underground storage tanks in 2008 (data reported to EPA Office of Underground Storage Tanks). Many of these releases contained biofuels. The release of biofuels can impact ground water quality. In particular, biofuels in petroleum gasoline may increase the length of the benzene plume in ground water. To evaluate the risk provided by biofuels, EPA and the state agencies that implement the underground storage tank program described in the Resource Conservation and Recovery Act need information on the rate and extent of natural biodegradation of biofuels in aquifer sediment.

Background

In the Energy Policy Act of 2005, Congress directed EPA to design a program that requires the blending of renewable fuels into our nation's motor-vehicle fuel supply. This program is called the Renewable Fuel Standard. Under the Energy Independence and Security Act of 2007, EPA is responsible for revising and implementing regulations to ensure that gasoline sold in the United States contains a minimum volume of renewable fuel. The Renewable Fuel Standard program will increase the volume of renewable fuel that must be blended into gasoline from 9 billion gallons in 2008 to 36 billion gallons by 2022.

Objectives

This project will develop information on the rate and extent of biodegradation of biofuels in aquifer sediment under the two most common biogeochemical environments: sulfate-reducing conditions and methanogenic conditions. The project will also determine the effect of the presence and biodegradation of the biofuels on the anaerobic biodegradation of benzene, toluene, ethylbenzene, and the xylenes (benzene, toluene, ethylbenzene, and xylenes; also called the BTEX compounds) in ground water.

Approach

Microcosms were be constructed with sediment from a site with an historical spill of a variety of petroleum fuels and a site with a recent spill of biodiesel made from soybean oil. The site of petroleum fuel spills is currently sulfate-reducing, iron-reducing, and methanogenic.

Microcosms were spiked with BTEX compounds alone, or with BTEX compounds and the common biofuels ethanol or biodiesel, or with the proposed biofuels n-propanol, iso-propanol, n-butanol, and 2,5-dimethylfuran. Some of the microcosms were amended with 1,300 milligrams per liter (mg/L) of sulfate to stimulate sulfate-reducing conditions; others were not amended with sulfate to stimulate methanogenic conditions. The microcosms will be incubated for two years and sampled periodically for remaining concentrations of the biofuels; the BTEX compounds; and the production of methane, volatile fatty acids, and dissolved organic carbon in ground water.

Accomplishments to Date (August 2009)

The microcosms study was initiated in October 2008. Low concentrations (100 to 200 mg/L) of all the biofuels, except biodiesel and 2,5-dimethylfuran, were degraded to their detection limit (greater than 99 percent removal) within four months. In the absence of a sulfate amendment, degradation was accompanied with near stoichiometric production of methane. The concentrations of methane greatly exceeded the solubility of methane in water. The biodiesel produced as much methane as the alcohols. In the presence of the sulfate amendment, large amounts of

methane were still produced from the degradation of ethanol and biodiesel. The amendment of sulfate stopped the production of methane from the other biofuels.

Near-Future Tasks

The sediment in the microcosms has been respiked with higher concentrations (near 2,000 mg/L) of the biofuels. These concentrations are near the concentrations that would be expected in ground water in equilibrium with 10 percent of the biofuel in petroleum gasoline.

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