gPRO® Technology

gPRO® Applications

Contaminant	Gas Delivered	Electron Donor	Carbon Source	Process
Hydrocarbons	O_2	Contaminant	Contaminant	Aerobic Degradation
Hydrocarbons	O_2+ Alkane	Alkane + Contaminant	Alkane + Contaminant	Aerobic Degradation
MTBE	O_2	Contaminant	Contaminant	Aerobic Degradation
MTBE	O_2 + Alkane	Alkane + Contaminant	Alkane + Contaminant	Aerobic Cometabolism
CAH	H_2	H_2	In-Situ Organics	Anaerobic Degradation
CAH	H_2	H_2 + Organic Electron Donor	Added Organic	Anaerobic Degradation
CAH	Alkane	Alkane	Alkane	Anaerobic Degradation
CAH	O_2 + Alkane	Alkane	Alkane	Aerobic Cometabolism
CAH	O_2	Alkane	In-Situ Organics (natural methane)	Aerobic Cometabolism
CAH (Vinyl Chloride)	O_2	Contaminant	Contaminant	Aerobic Degradation
CAH (Vinyl Chloride)	O_2 + Ethene (Co-Substrate)	Ethene + Contaminant	Ethene + Contaminant	Aerobic Degradation
Ammonia	O_2	Ammonia	In-Situ Organics or CO_2	Nitrification (Aerobic)
Nitrate	H_2 +/- CO_2	H_2	In-Situ Organics or CO_2	Denitrification (Anaerobic)
Perchlorate	H_2 +/- CO_2	H_2 Organic or CO2	In-Situ or Added Organic or CO2	Dissimilatory Reduction (Anaerobic)
1-4, Dioxane	O_2 + Propane	Propane	In-Situ or Added Organics	Aerobic Cometabolism

Methods for Petroleum Releases

Direct aerobic treatment of petroleum hydrocarbons and MTBE only requires the addition of oxygen and sufficient mineral nutrients. In cases were released petroleum hydrocarbon products have undergone significant weathering, more bioavailable constituent compounds may be depleted in groundwater but more recalcitrant petroleum hydrocarbons remain. The delivery of a dilute mixture of non-flammable alkane gas with nitrogen as a co-substrate along with delivery of oxygen may stimulate an increased biomass resulting in faster removal of recalcitrant compounds. A similar approach has also been developed for the addition of alkane gas for stimulation of cometabolic degradation of MTBE. In the case of cometabolic treatment, the alkane gas serves as a growth substrate and energy source for microorganisms while the contaminant MTBE is fortuitously degraded by the enzymes produced in this process.

Methods for Chlorinated Aliphatic Hydrocarbons

Both anaerobic and aerobic biostimulation methods can be used to degrade chlorinated solvents dissolved in groundwater. Certain highly oxidized CAH compounds such as tetrachloroethylene (PCE) must be biologically treated under anaerobic conditions, while lower CAHs such as trichloroethylene (TCE), dichloroethylene (DCE) and vinyl chloride (VC) can be more efficiently treated with aerobic systems. PCE contaminated groundwater can be effectively remediated with a two-stage sequential bioremediation approach that combines reductive dechlorination and aerobic cometabolic and direct oxidation. In the first step, PCE is degraded to TCE and possibly lower CAHs in an anaerobic process stimulated by delivery of hydrogen through the gPRO gas infusion system. If additional treatment is needed, in the second step, gPRO is used to deliver oxygen and propane as required to effect aerobic cometabolic treatment of the daughter products of reductive dechlorination. If only vinyl chloride remains, oxygen can be used to stimulated direct aerobic degradation. If concentrations of vinyl chloride are too low to stimulate adequate biomass production, ethene can be added as a co-substrate.

Methods for Ammonia and Nitrate Treatment

A two step sequential aerobic – anaerobic process can be used for in situ treatment of ammonia in groundwater. In the first step the nitrification process converts ammonia to nitrate, followed by denitrification, the conversion of nitrate to nitrogen gas. gPRO units placed in treatment wells are used to deliver oxygen to stimulate conversion of ammonia to nitrate under aerobic conditions in the first step. To switch to anaerobic conditions, hydrogen is delivered through gPRO units. In the anaerobic environment, denitrifying bacteria are able to use NO_2 and NO_3 instead of O_2 as their terminal electron acceptor. In the presence of an electron donor such as hydrogen, the net effect is conversion of nitrate to inert nitrogen gas.

Methods for Emerging Contaminants

The need for in situ biological treatment methods for emerging contaminants has led to the ongoing development of gPRO methods for perchlorate and 1,4-dioxane. The gPRO (Per)Chlorate System developed by inVentures Technologies is designed to biodegrade perchlorate and chlorate by stimulating autotrophic bacteria by delivering hydrogen and, where necessary, carbon dioxide in groundwater treatment zones.

Several authors have reported aerobic cometabolic 1, 4-dioxane degradation where propane was the primary growth substrate. The gPRO system can be used to deliver these substrates. This application shows promise for a compound that is otherwise very difficult to treat.