

How Can We Overcome Limitations of Bioremediation?

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The widespread contamination of drinking water sources with chlorinated organic compounds (COCs) has led to a concerted effort to find efficient and cost effective treatment methods for these compounds. Chlorinated organic compounds such as tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethylene (*cis*-DCE) are primarily used as industrial solvents. These chemicals are prevalent and persistent groundwater contaminants, which are all known or suspected human carcinogens, mutagens or toxins. The most cost effective method used to treat contamination by COCs involves bioremediation. However, degradation using biological methods often takes longer than other processes, such as chemical reduction, and may produce toxic by-products resulting in incomplete biodegradation.

PCE must be degraded to nonchlorinated, environmentally harmless products. Environmental accumulation of *cis*-DCE and vinyl chloride (VC) is undesirable, because *cis*-DCE is a suspected carcinogen and VC is toxic. Although, *Dehalococcoides* sp. 195 and *Propionibacterium* sp. HK-1 have been known microorganisms capable of dechlorinating PCE to ethane [1], most anaerobic bacteria dechlorinate PCE to principally *cis*-DCE. On the other hand, aerobic degradation of *cis*-DCE by *Rhodococcus rhodochrous* and *Nitrosomonas europaea* has been reported. Thus, *cis*-DCE accumulation in the anaerobic system can be eliminated by further degradation using such aerobic bacteria. The combination of aerobic and anaerobic treatment will be a key answer to overcome limitations of bioremediation.

Another dechlorination approach that has recently garnered substantial interest is the use of zero-valent metals, and iron, in particular, has been successful in the dechlorination of COCs. Iron is relatively inexpensive, but it is still a precious resource in the steel industry. Thus, a recycled material, slag, waste blast furnace slag has been used as a substitute for zero-valent iron for the treatment of COCs. Although slag is, in fact, classified as a waste material, it has been reused for various purposes for a long time. Thus, combination of biological and chemical methods can be a major technology to overcome limitations of bioremediation.

Bioremediation is limited to environments where dissolved contaminants are available to microbes. Rapid removal of a non-aqueous phase liquid (NAPL) source is not realistic by any known bioremediation technology; source reduction and source control

are more realistic goals. In this case, some products (oxygenation system, emulsified vegetable oil as electron and nutrients sources, and insoluble solid buffer as a keeping pH buffer) must be helpful for *in situ* bioremediation.

Arsenic (a combination of arsenate and arsenite) is toxic to bacteria, as well as to most other forms of life. Arsenic has been identified as a major risk for human health. Under oxidizing conditions in the surface soil, the predominant form of arsenic is As(V). Bacterial reduction of arsenic in surface soil from As(V) to As(III) can cause the transfer of arsenic from the solid to the liquid phase because As(III) is much less strongly adsorbed to soil than As(V). Once the As(III) is present in the liquid phase, it can easily be removed from the liquid phase through precipitation or complexation with sulfide or sulfide-containing materials or adsorption to Fe(II)-based solids. Recently, *Citrobacter* sp. NC-1, which was isolated from arsenic contaminated soil [2]. The reducing activity of strain NC-1 is comparable or superior to that of previously reported arsenate-reducing bacteria, and occurred even at an extremely high concentration of arsenate (~60 mM). In addition, a two-step process with the mixed culture of two lactic acid bacteria (*L. bulgaricus* and *S. thermophilus*) has been suggested for effective extraction of heavy metals from chromium copper arsenate (CCA) treated wood [3]. However, at low temperature those strains do not work at all. This problem is not only related to bio-extracting of heavy metal but also all biodegradation process. To resolve this problem /or enhance the activity of microbes at low temperature our research group has been studying “genetic modification technology” and “anti-freeze proteins”.

References

1. Chang YC, Ikeutsu K, Toyama T, Choi D, Kikuchi S (2011) Isolation and characterization of tetrachloroethylene and *cis*-1,2-dichloroethylene-dechlorinating propionibacteria. J Ind Microbiol Biotechnol 38: 1667-1677.
2. Chang YC, Nawata A, Jung K, Kikuchi S (2012) Isolation and characterization of an arsenate-reducing bacterium and its application for arsenic extraction from contaminated soil. J Ind Microbiol Biotechnol 39: 37-44.
3. Chang YC, Choi D, Kikuchi S (2012) Enhanced extraction of heavy metals in the two-step process with the mixed culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Bioresour Technol 103: 477-480.

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