# Enhanced In Situ Bioremediation in Source Zones

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## Resumo

A biorremediação in situ (ISB) pode ser uma abordagem de baixo custo para acelerar cronogramas de remediação em locais impactados com densidade de líquidos não fase aquosa (DNAPLs), tais como tricloroetileno (TCE) e tetracloroeteno (PCE). Para alcançar altas taxas de dissolução biologicamente avançada, doador de elétrons tem de ser entregue, bem como sustentado em uma concentração eficaz na DNAPL: interface de água para o crescimento do consumo e por dechlorinating biomassa. Doadores de elétrons, tais como óleos vegetais de lactato e emulsionados (EVO) são consumidos à medida que migram em direção às zonas de origem por não dechlorinating biomassa. Aplicações típicas de doadores de elétrons têm apenas 1-10% de eficiência. Assim, aplicações típicas foram responsáveis pela perda de equivalentes redutores com a adição de vezes 09:55 a quantidade de doadores de elétrons necessária como um fator de segurança. Adição de altas concentrações de doador de elétrons podem superar estas limitações, permitindo maior concentração de doador de elétrons para atingir a DNAPL: interface de água, porém, este por sua vez, aumentam o custo de aplicação de forma significativa. Melhorar a doadores de elétrons pode ser uma forma de reduzir custos para as zonas de origem. A apresentação irá apresentar um resumo de uma demonstração realizados para verificar o que a biorremediação pode ser usado para tratar uma área de origem PCE DNAPL e um doador de elétrons novos que estão sendo investigadas para melhorar a prestação dos doadores para as áreas de origem.

## Abstract

In situ bioremediation (ISB) can be a low-cost approach for accelerating remediation timelines at sites impacted with dense non-aqueous phase liquids (DNAPLs) such as trichloroethene (TCE) and tetrachloroethene (PCE). To achieve high rates of biologically-enhanced dissolution, electron donor needs to be delivered, as well as sustained at an effective concentration at the DNAPL:water interface for the growth of and consumption by dechlorinating biomass. Electron donors such as lactate and emulsified vegetable oils (EVO) are consumed as they migrate towards source zones by non-dechlorinating



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biomass. Typical electron donor applications have only 1 to 10% efficiency. Hence, typical applications have accounted for the loss of reducing equivalents with the addition of a five to ten times the amount of electron donor required as a safety factor. Adding high concentrations of electron donor may overcome these limitations by allowing higher concentrations of electron donor to reach the DNAPL:water interface; however, this will in turn increase the application cost significantly. Improving electron donors may be a way to reduce costs for source zones. The presentation will present a summary of a demonstration completed to verify that bioremediation could be used to treat a PCE DNAPL source area and a new electron donor being investigated to improve donor delivery to source areas.

**Key Words:** Bioremediation, Electron Donor, Bioaugmentation

## 1 – INTRODUCTION

Achieving high dechlorination rates near the DNAPL:water interface determines the effectiveness of enhanced in situ bioremediation (EISB) to treat DNAPLs. It has been demonstrated in previous studies that many chloroethene-dechlorinating microbial species can tolerate high VOC concentrations [1] and the location of the dechlorinating biomass relative to the DNAPL:water interface is controlled by (1) toxicity effects of high chlorinated compound concentrations, and (2) the concentration profiles of both the electron donor and the dissolved phase VOCs coming from the DNAPL. When the electron donor and the dechlorinating microorganisms are near the DNAPL:water interface, high rates of biologically enhanced DNAPL dissolution can result.

## 2 - BIOAUGMENTATION TO TREAT PCE DNAPL

From 2002 to 2005 a field demonstration was conducted to evaluate the performance of bioaugmentation at field scale to enhance rates of biodegradation at the DNAPL:water interface thereby increasing the concentration gradient driving DNAPL dissolution [2]. This demonstration used PCE as the primary DNAPL to determine if bioaugmentation can stimulate complete dechlorination to non-toxic end products, as well as increasing the mass flux from a source zone when biological dehalorespiration activity is enhanced through nutrient addition and or bioaugmentation. Figure 1 below shows the results from this demonstration.

This successful demonstration proved that biological systems can be applied and enhanced dissolution of a PCE DNAPL. This demonstration helped develop an interpretation methodology for efforts that biologically enhance or contain the mass flux from DNAPL source zones. The demonstration also provided an estimation of the enhancement in the mass flux and the corresponding decrease in treatment time that ultimately justifies the selection of this technology as a source remediation alternative.

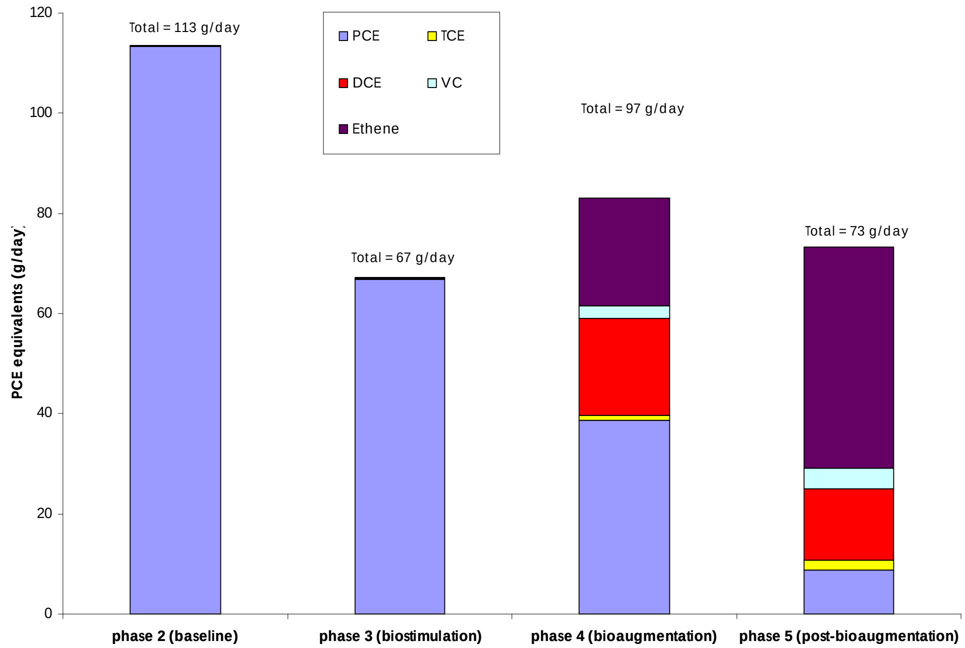


Figure 1: Mass Discharge by Phase Calculated from Data Collected during Major Sampling Events for DNAPL Source Study

## 3 - PARTITIONING ELECTRON DONORS

The concentration profile of the electron donor is controlled by the rate at which it is consumed by microbes relative to its transport rate by diffusion and advection processes. This results in the electron donor concentration being higher in the bulk water phase, and lower near the DNAPL:water interface.  In contrast, the concentrations of dissolved phase chlorinated VOCs will be higher near the DNAPL and decrease away from the DNAPL:water interface. Biomass that forms too far away from the DNAPL:water interface will significantly lower dissolved VOC concentrations near the interface where diffusion forces dominate mass transfer of the VOC from the DNAPL into solution.

Partitioning electron donors (PEDs) are electron donors that partition directly into a target DNAPL.  PEDs are water soluble, hence they are easily transported to the DNAPL source zone. This property aids in their mixing throughout the source zone and maximizes contact with the DNAPL. PEDs partition strongly into DNAPL from which they are subsequently released.  Laboratory work completed by Capiro et al (2011) support the hypothesis that a field injection should provide a long term electron donor supply. An field injection using a PED is planned for 2011 at Launch Complex 34 at NASA Kennedy Space Center in a TCE source area. The purpose of the study was to confirm that partitioning occurred and that dechlorination of the TCE increased.

## 4 – CONCLUSIONS

Bioremediation can be used to treat source zones of chlorinated ethenes. Care needs to be taken to not over apply donor and not deliver donor to the source zone. Electron donors can be amended to target intervals in a wide array of techniques but unless the VOC, electron donor and correct microbial populations are present complete dechlorination may not be achieved. Partitioning electron donors (PEDs) are electron donors that partition directly into a target DNAPL. PEDs are water soluble, hence they are easily transported to the DNAPL source zone and can serve as long term electron donors.

## 5 – REFERENCES


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