Ten years of experience with the new TCE-concept for Bioaugmentation in Full-scale Applications

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Begin 2000 a completely new concept for bioaugmentation, the addition of specific microorganisms to the soil matrix and groundwater, was developed, the TCE-concept. This technology has been fine-tuned over the last 10 years and has proven to be a very strong and robust technology for remediation of chlorinated ethylenes contaminated sites. Nowadays it has been implemented on more than 15 sites, both in the Netherlands and Denmark, with very good results, showing that in situ bioremediations can be fast, cheap and also sustainable.

For bioremediation projects at sites contaminated with chlorinated ethenes, inoculation of soil is not necessary if the soil already contains the essential dechlorinating organisms. However, mainly sandy soils or till soil that are not strongly reduced seem to lack the bacteria for a quick and effective bioremediation. In these cases bioaugmentation can be a good solution.
In 1999, Bioclear started the first full scale bioaugmentation project at a tetrachloroethylene (PCE) contaminated site in Hoogeveen, the Netherlands. Using Dutch fundings for research on in situ bioremediation, a new concept for bioaugmentation was developed, called the Totaal Concept Evenblij (TCE concept). In this concept, an anaerobic bioreactor containing biomass (among others *Dehalococcoides ethenogenes*) that is capable of dechlorinating PCE into ethylene is used to inoculate the soil. PCE contaminated groundwater is used as feed for this reactor system and effluent of the system is infiltrated for inoculation.

At this first Hoogeveen site the source and plume area consist of approximately 300,000 m^3 groundwater contaminated with PCE up to 50,000 ug/l. The contamination is present down to 50 metres below ground level. By injection of microorganisms in situ bioremediation could take place and remediation of the total plume area took only 12 months. All chlorinated ethylenes were degraded to ethylene, whereas concentrations of all chlorinated ethenes were and stayed less than 2 µg/l. Monitoring in 2003 and 2005 indicated that the soil still contains the capacity to degrade the contamination leaching from the source zone (underneath buildings) and no rebound has taken place.

Based upon the very quick remediation with the first system and the huge amount of biomass coming from the system, a small scale mobile bioreactor of 8 m^3 was designed and built. This system is nowadays used for the inoculation at other contaminated sites. At the Almelo site an airsparging system, unsuccessful during 2 years, was replaced by this anaerobic bioaugmentation system with the mobile bioreactor. PCE concentrations of 15,000 µg/l and the subsequent chlorinated intermediates in an area of 15,000 m^3 (depth 10 metres) were degraded to less than 1 µg/l, with ethylene and ethane being the only detectable end products. This process took only 14 months to complete, from installation of wells to site closure. Remediations with this system are also carried out at sites in The Hague, Zeist-Driebergen, Twello (the Netherlands) and Copenhagen (Denmark).

In this presentation we would like to show the background of the concept and results gained from the various projects, also showing its limitations, as – just like any other technique – there is a certain range of use for this concept. Recently a sustainability check has been carried out comparing this technology with other more traditional techniques like excavation and pump-and-treat, showing biological remediation to be the most sustainable one.