




# BEAT

## Bioreactor Enhanced Augmentation Technology

Another category of soil remediation covers sites that have been contaminated by the use of solvents, especially VOC's - volatile chlorinated hydrocarbons such as Per and Tri. These contaminants can be removed by enhanced natural attenuation using the so-called BEAT® concept. Artificially cultivated bacteria (Dehalococcoides, DHC) with the required carbon source and nutrients are introduced into the soil in order to stimulate anaerobic degradation. The process can be controlled by constantly monitoring the influent, infiltrate and bioreactor streams for pH, oxygen and ORP. The strength of this concept lies in its relatively short active degradation phase with complete degradation of the chlorinated hydrocarbons to harmless end products.

The general remedial approach involves extraction, amendment and re-circulation of groundwater in the targeted aquifer zone. About 10 % of the extracted groundwater is passed through the bioreactor, while the other part is bypassed. After filtration, both feeds

### Why NTP?

- ✓ In house soil experts and chemical oxidation specialists.
- ✓ Strategic alliances with experts and third parties.
- ✓ Self designed soil remediation concepts (chemical, biological).
- ✓ Own laboratory.
- ✓ Partner of choice for many private and public clients.

BEAT® concept





are mixed and infiltrated through injection screens or wells located up gradient of the treated zone. This anaerobic bioremediation approach can be applied in urbanized areas with limited site access to prevent site disruption and reduce impacts to the environment. This semi-passive method can expedite the time of remediation, compared to passive approaches. Over the last several years, NTP has optimized the use of the bioreactor system in bio-remediation projects, including the development of an automated application of the carbon source. The fully automated remotely controlled bioreactor system provides to our clients an enhanced anaerobic bioremediation method that is safe and dependable.

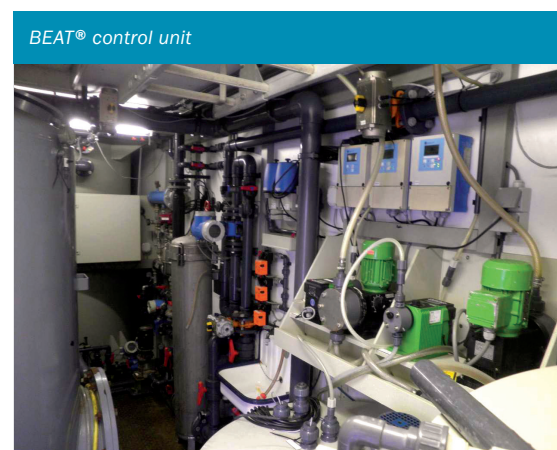
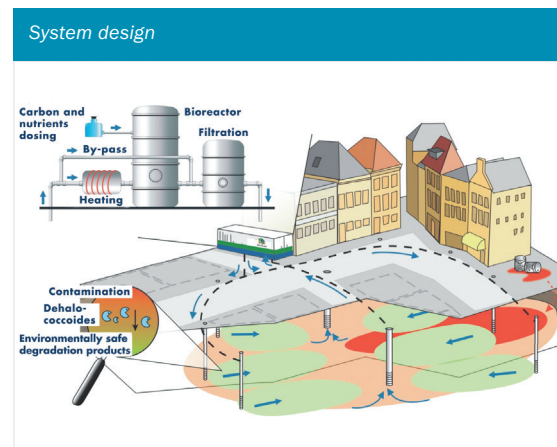
## Specifications

The system consists of a control unit, a bioreactor and a filtration and charging system. Once the DHC inoculum is added to the bioreactor, their growth is enhanced by feeding the system, until a cell count of  $10^5$  cells/ml is achieved. Bioreactor operating conditions include ORP levels of less than -300 mV, while oxygen levels are diminished to zero at a temperature of about 20 °C. The bioreactor operates at an extraction/infiltration flow rate of about 10 m<sup>3</sup>/hr. Depending on the size of a pore volume for the targeted zone, the system may be able to treat a site within a period of several months. Based on previous experiences, amendment of one pore volume of the targeted aquifer zone is sufficient for complete VOC treatment at most sites.

## Process and performance monitoring

Monitoring our process and performance is crucial to the success of the enhanced bioremediation projects. Therefore, defined parameters such as oxygen concentration, pH, water temperature (°C) and oxidation-reduction potential (ORP) are monitored continuously. When the parameters exceed threshold levels, the bioreactor is automatically switched off. Monitoring wells in the field are used to assess the efficacy of enhanced bioremediation. The design and operation of this in-situ system of extraction and infiltration can be adjusted depending on the volumes of groundwater to be treated, site specific circumstances and remedial targets to be met.

Over years several chemical laundry stores situated in the city of The Hague caused contaminated sites with chlorinated solvents in the shallow and deeper groundwater. Soil properties, in the area of The Hague, are characterized by sediments of medium fine sand and heterogeneous intermediate layers of clay and/or peat. Groundwater contamination plumes had spread underneath private properties and forms a threat for the deeper aquifers and the abstraction of drinking water. Recently NTP has successfully treated many of these groundwater contaminations by enhanced anaerobic bioremediation. VOC's at initial ground-water concentrations above 10 ppm's were successfully decreased to below detection levels and have shown to be stable over time.



*BEAT®: A remediation technology developed by Bioclear and NTP. For more than 10 years Bioclear and NTP are collaborating in various remediation projects using the BEAT® concept for successful bioremediation of chlorinated solvents. As the inventor and developer of the BEAT® concept back in 1998, Bioclear offers a huge experience in the technical and (micro) biological aspects of the system. As a contractor NTP has build up an extensive field experience in using the BEAT® system.*

*Bioclears "software" - (bio)technological expertise - and NTPs "hardware" - the bioreactor and its steering - provides a strong, complementary collaboration, combining the best of both worlds. A collaboration that also can be implemented in other arrangements, with other foreign contractors and consultants. Our aim: work together and deliver a sustainable solution to environmental problems!*

NTP B.V.

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