

## **ConSoil 2003**

Poster Session C: Remediation Technologies and Concepts

# FIRST REMEDIATION PILOT OF BTEX AND TPH USING ISOC™ IN BELGIUM

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### **Abstract**

A feasibility study has been performed in Belgium on the effect of using supersaturated oxygen diffusion with *iSOC™* (In situ Submerged Oxygen Curtain) for the groundwater remediation of a site contaminated with BTEX and TPH.

Based on it being a nearly passive, low maintenance, and low cost oxygenation alternative, Esher BVBA and Bioclear BV selected *iSOC™*, a unique groundwater gas infusion device to infuse super-saturated dissolved oxygen into existing wells. The *iSOC™* should be able to enhance the biodegradation of the hydrocarbon related compounds. Positive results will determine the full scale use of *iSOC™* on the site.

The experimental results after a three months pilot remediation show an increase in oxygen concentration in the groundwater, thereby creating aerobic conditions for the biodegradation of BTEX and TPH contaminations.

### **Introduction**

A conventional in situ remediation was attempted at a typical mineral oil and BTEX contamination at a gasoline station. Even after years of application it led to unsatisfactory results against high cost. The unsuccessful approach involved pump-and-treat methods, where dissolved phase gasoline contaminated groundwater was treated with an air stripper and compost biofilter. These methods usually involve many years of on-site remediation and monitoring. This excessive remediation period not only proves to be extremely expensive (through the tailing and rebound effect), but also extends risk exposure for the neighbours (noise and BTEX vapours through groundwater cleaning).



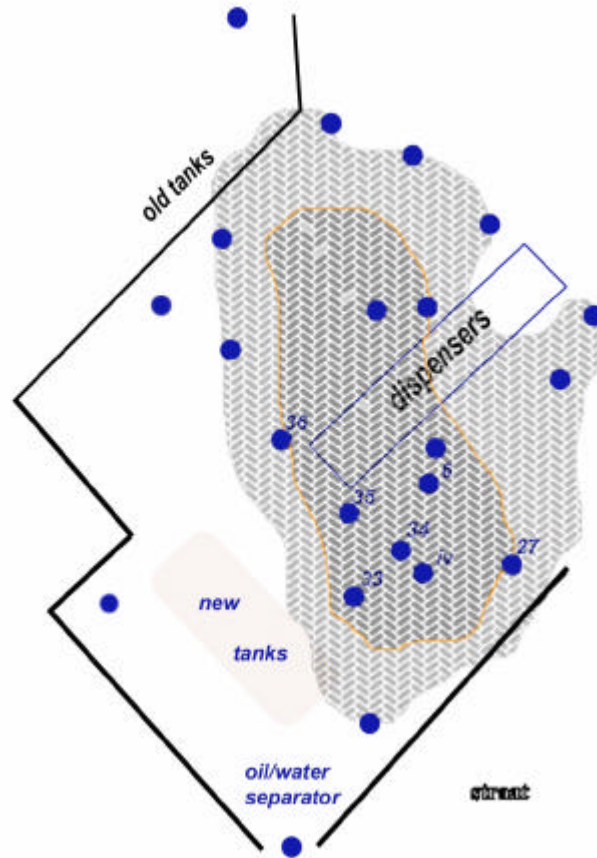
In response to the owner's request for a less cumbersome remediation project, and in an attempt to reduce the cost and time for remediation of the dissolved phase, Esher BVBA and Bioclear BV initiated an innovative pilot study to enhance natural biodegradation of hydrocarbons in the groundwater.

## The site

At the small scale local gasoline service station, located in the village of Kessel, Belgium, contamination from the underground storage tanks was identified in 1996, see the adjacent site layout sketch, and the remediation via traditional pump-and-treat was ongoing since that time. The approach did not result in significant reduction of dissolved hydrocarbon concentrations, which was mainly due to the low permeability soil conditions in the area,

The geohydrological conditions of the site are such that groundwater flow is extremely low and in varying directions.

Investigations performed subsequently to assess the potential for biodegradation, revealed that nutrients were sufficiently available in the subsoil, while there was a general oxygen deficiency.

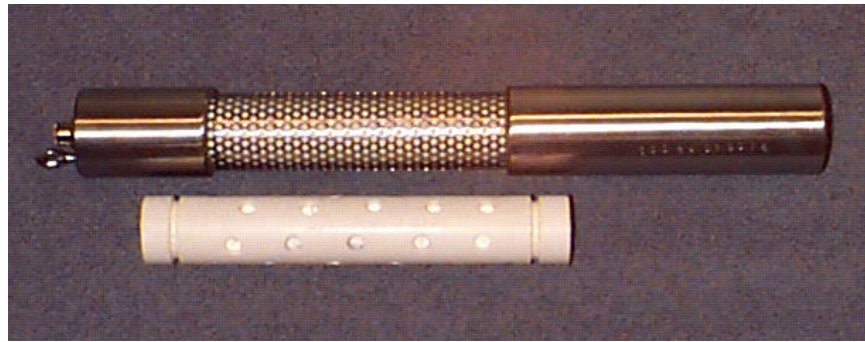


## The iSOC™ method

Due to the unsatisfactory performance of pump-and-treat, and the measured biodegradation capacity, an alternative remediation technology was identified and applied on a pilot scale during 2002. The selected alternative was *iSOC™* (In situ Submerged Oxygen Curtain). Choice for this method was based on various considerations, being:

- *iSOC™* was considered a possible cost efficient method for extensive treatment of the relatively low hydrocarbon rest concentrations
- *iSOC™* can be applied in existing groundwater extraction wells, and thus requires limited installation cost;
- *iSOC™* does not rely on power supply, nor does it produce a waste stream, and therefore the operational cost are low as well;
- *iSOC™* can be configured as using very little above ground space, important in densely occupied areas;

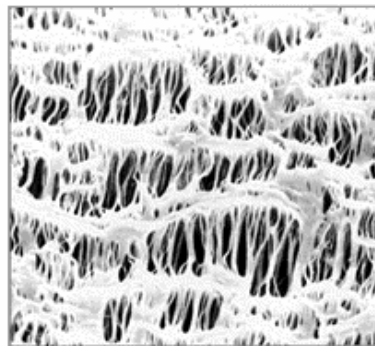
Over the last years the use of oxygen as in situ remediation technique for carbohydrate contaminations has greatly increased. Methods that are applied on a wide scale include air sparging and soil vapour extraction. The methods are efficient,



relatively cheap and there is no need for large installations. For low concentration or dispersed hydrocarbon plumes however, these techniques may become less cost effective, due to the cost involved with stripping effects, purification of off gases and energy supply.



Cross Section 200  $\mu\text{m}$



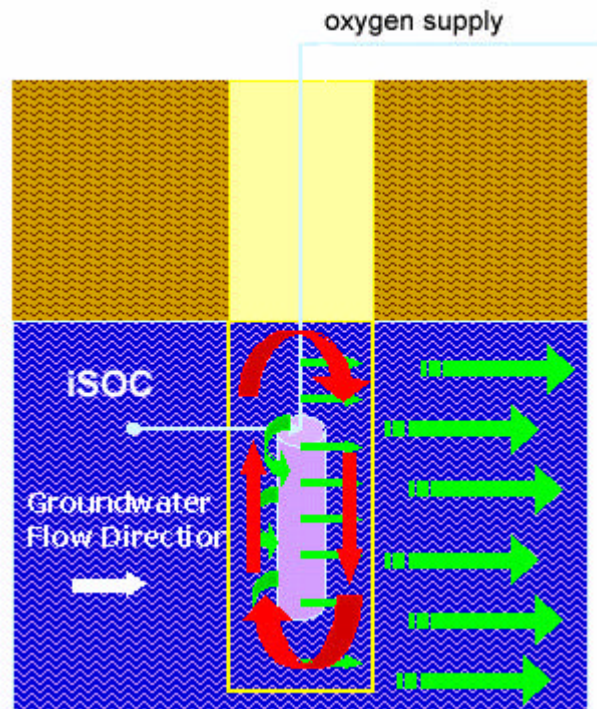
Inner Surface 1  $\mu\text{m}$

*iSOC<sup>TM</sup>* ("in situ Submerged Oxygen Curtain") was considered to be a cost effective alternative for the Kessel site. It is a small cylinder that is placed in the monitoring well and it dissolves oxygen using *Gas Infusion*. With gas infusion, oxygen is dissolved in groundwater via micropores, and thus without or with very little, bubble formation. The concentration of dissolved oxygen (DO) becomes ultrahigh and is fully

available for hydrocarbon biodegradation.

An *iSOC<sup>TM</sup>*, applied in a monitoring well with its filter section in the contaminated zone, will supersaturate the well with low decay DO, typically to concentrations of 40-200 ppm, dependent on depth. Due to natural convection, the DO will fill the whole well, which will then function as the oxygen source over its entire filtered section. Oxygen then floods into the surrounding groundwater through diffusion and groundwater flow.

An *iSOC<sup>TM</sup>* system is installed in a few hours, and is easily moved during a remediation to optimize its performance. There are no power requirements, pumps, off gases or hazardous byproducts, which makes the system easy to apply and low in maintenance cost. Generally, limited permits are required.



## The pilot remediation

The pilot remediation was performed by installation of one *iSOC*<sup>TM</sup> unit in an existing extraction well from the previous pump and treat installation (well IV in the site layout sketch), and monitoring the development of relevant parameters in other monitoring wells, at various distances ranging from 0,5 meter to 2,7 meter. In the site layout sketch, the wells used for monitoring of the pilot are the numbered ones.

The construction of Well IV was reshaped for a special purpose. The top one meter of the well was widened to allow for extra subground space, in which a 10 liter oxygen cilinder plus flow control unit could be placed. In this manner, the *iSOC* remediation system was fully contained within the extraction well, with no above ground facilities such as flow lines or oxygen containers necessary.

## Results

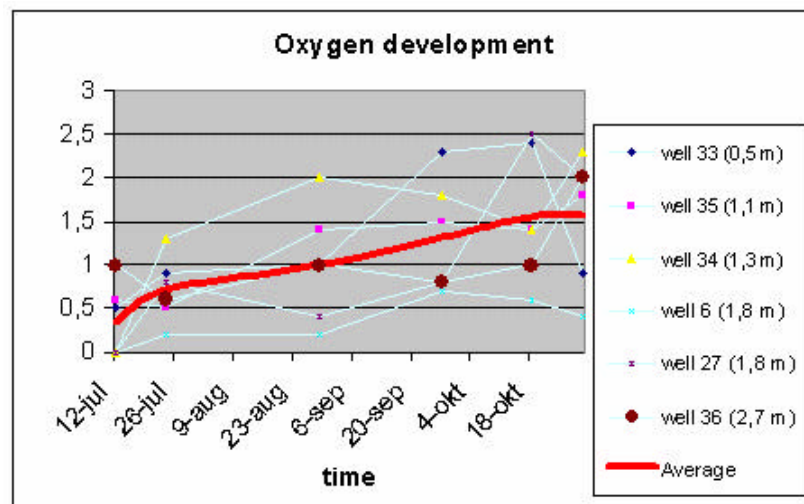
A variety of different parameters can be measured in an effort to monitor the performance of an *iSOC*<sup>TM</sup> – or more in general a bio – remediation. Important parameters and their pros and contras include:

- The biomass itself: the bacteria count will show increase as function of increasing bioactivity in the soil/groundwater system; generally an increase is found when higher hydrocarbon concentrations are concerned than those found at plume contaminations.
- The constituents and their related parameter that are formed by the bacterial metabolism: Main parameter is the total inorganic carbon concentration, or carbon dioxide. As with the previous parameter, higher hydrocarbon concentrations are generally needed to measure significant changes.
- The constituents that are to be consumed in the metabolism process: these are the hydrocarbon contaminant concentrations, as well as the oxygen and nutrient concentrations in the system;

In this pilot project, the parameters that were measured to monitor the system's performance, included the consumption parameters hydrocarbons and oxygen.

**Oxygen** was measured for two reasons, being (1) whether *iSOC*<sup>TM</sup> would succeed in its gas-infusion task, and (2) whether oxygen would remain available in sufficient concentration to create and sustain aerobic conditions within the influence zone of the *iSOC*<sup>TM</sup>.

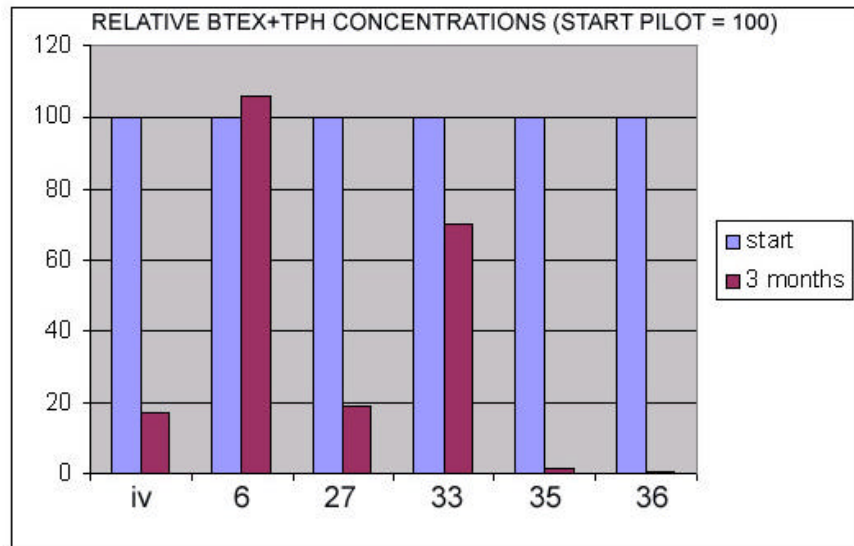
The concentration in the *iSOC*<sup>TM</sup> well itself – positioned only two meters below groundwater table - was raised to well over 40 ppm, which is in line with theory.



The Graph indicates the DO development in the monitoring wells, positioned at various distances from the *iSOC*<sup>TM</sup> well. The oxygen concentration raised from average 0,5 to 1,5 ppm, which is sufficient for sustaining aerobic conditions throughout the monitored zone with radius of 2,7 meters.

When looking at individual wells, more can be learned of the effectiveness of oxygen infusion. Well 36, at the greatest measured distance, shows significant oxygen increase 3 months after start of pilot, indicating the time required for oxygen to travel 3 meters. Well 6, where high BTEX concentration is present, shows oxygen increase, however far less than average. The rate of biodegradation of these high concentrations could be increased by installation of an *iSOC* in the source.

**Hydrocarbons** were measured for one undisputable objective, i.e. to monitor the actual remediation. The Graph shows\* that *iSOC*<sup>TM</sup> has a twofold effect: Well 6 shows a slight increase in BTEX+TPH concentrations, while the other five wells (iv, 27, 33, 35, 36) show a decrease. These two tendencies are explained as follows:



- Most wells are situated in the contaminant plume with BTEX concentrations ranging from 100 – 1000 ppb, without contaminant source available for new hydrocarbons supply. As a result, hydrocarbons are quickly consumed.
- Well 6 has relatively high concentrations of dissolved hydrocarbons (30,000 ppb in well 6), which could be linked to free phase hydrocarbons still available in the soil matrix. Due to the high concentrations, the effect of any biodegradation taking place, can not be distinguished nor interpreted within the short pilot period of three months.

\* the values represented in the graph are a summation of observed concentrations of Total Petroleum Hydrocarbons + benzene, toluene, ethylbenzene and xylenes. Where concentrations were below detection limits, these were assumed to be zero. TPH concentrations were not included in the values for wells 33, 35 and 36, since these analyses were not performed.

## Conclusion

The pilot remediation revealed that, where other methods for in situ remediation reach their performance limit, the application of *iSOC*<sup>TM</sup> can successfully be used for the extensive treatment of low BTEX and TPH restconcentrations.

This study shows the effectiveness of *iSOC* in creating aerobic conditions in groundwater. The diffusion of oxygen into the subsoil was shown to successfully reach a radius of 2,7 meters (the maximum monitored distance) in low permeable soils. The spreading would further increase if groundwater flow would be present in the subsoil.

The usefulness of *iSOC*<sup>TM</sup> as plume remediation tool, is certainly made credible by the pilot results.

The usefulness of *iSOC*<sup>TM</sup> for free phase remediation could not be established during the short period of the pilot.