IN SITU BIORESTORATION OF A SUBSOIL, CONTAMINATED WITH GASOLINE

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SUMMARY
Column studies have been performed with the objective to study the technical and financial feasibility of in situ biorestitution of contaminated soil.

In the soil columns the gasoline was removed by two processes: leaching and (bio)degradation. By leaching predominantly the aromatic compounds were removed and especially in the first few weeks.

Considerable (bio)degradation and thus cleaning of the soil, besides leaching, was observed only in the cases of hydrogen peroxide used as additional oxygen source, recirculation of the effluent and a combination of these two. Both aromatic and especially aliphatic compounds were biodegraded.

It is concluded that a combination of hydrogen peroxide and recirculation will offer good prospective for clean-up of the soil, even reaching concentrations below the Dutch A-reference value.

The design of the actual clean-up has been made based on the hydrology and the results of the column research.

The costs seem to be lower than for the conventional techniques.

Therefore it is concluded that in situ biological treatment offers a good alternative as a soil clean-up method, with advantages with respect to excavation with subsequent treatment.

1 INTRODUCTION
Many methods have been and are developed for the remediation of soil contaminated sites. Generally, the soil is excavated and treated one way or another or stored temporarily waiting for a suitable treatment technique. The ground water contamination, which in most cases is also present has to be remediated separately. An important part of the costs of soil clean-up is involved with excavation of the contaminated soil. These costs could be reduced considerably by an in situ treatment of the location. Because a lot of organic compounds are in principle biodegradable, the choice for biological remediation techniques was obvious. In situ biological treatment has a number of advantages:

- soil and ground water are cleaned-up at the same time;
- no costs for excavation and transport of the soil;
- remediation under buildings is possible;
- in principle contaminations at higher depth may be treated;
- the soil ecosystem is not destroyed and can restore itself more easily;
- in case of complete degradation safe endproducts are produced.

In the framework of the Research Program on Biological Soil Clean-up Techniques the Ministry of Housing, Physical Planning and the Environment has assigned a research project to RIVM in co-operation with the Division Technology for Society of TNO.

The aim of the research project is to study the feasibility of biological in situ treatment, including aspects of costs and time.
The project consists of three stages:
1. A literature study and the selection of an experimental site;
2. Laboratory research, research in undisturbed soil columns and detailed [geohydrological and chemical] investigation of the site;
3. Design and execution of the clean-up.

The results of the literature study (1,2), the laboratory research (3,4) and the site investigation (5) have been reported. In this paper the results of the column study will be discussed, as well as the design of the clean-up.

The conclusions of the laboratory research which were important for the column research are:
- the biodegradation is increased in case of water saturated conditions and neutral pH;
- addition of nitrogen and phosphorus is necessary, but is not related to the theoretical ratio based on growth;
- hydrogen peroxide, which decomposes into water and oxygen in the soil, might offer a suitable oxygen source. Nitrate was unsuitable and sometimes gave decreased degradation rates;
- the rate of biodegradation was limited probably by the rate at which the hydrocarbons came available.

Moreover, it appeared that the highest increase in rate was caused by an addition of actively oil degrading microbes. But, because in this soil the transport of microbes is very limited, this was not seen as a practical solution.

To increase the rate of availability it was tried to use detergents. But in column experiments this only gave negative effects, by plugging of the columns.

2 DESCRIPTION OF THE SITE

A gasoline polluted site has been chosen as the test site because a large number of sites in the Netherlands are contaminated with gasoline or oil products and because oil components are in principle biodegradable and may affect the groundwater quality as a consequence of leaching.

The selected site is a petrol-station located at Asten, in the province of Noord-Brabant. The subsoil has been contaminated with 30,000 l of gasoline from a leaking tank. In observation wells installed free product has been measured upto 150 cm thickness. As control measures immediately wells have been installed for pumping off of the free product. About 20,000 l of free product has been recovered by pumping off. As result of this pumping-off the ground water level decreased from 2.5 to 3.5 meter below surface level. This process has caused a severe contamination of this layer from 2.5 to 3.5 m.

Sampling at the site has provided information about the distribution of the remaining contamination. The horizontal distribution of the contamination is given by the dotted line in figure 1. The contaminated area is about 25 x 25 m². In depth the soil is contaminated from about 2 to 4.5 meter below surface level. About 1500 m³ of soil is contaminated with a measured maximum gasoline concentration of 12,000 mg.kg⁻¹ (table 1). The groundwater is contaminated upto 10 meters below surface with volatile aromatics (table 2). From a comparison of