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## SCREENING OF THE FEASIBILITY OF BIOLOGICAL (IN-SITU) SOIL DECONTAMINATION

In the last few years the importance of biotechnological means for soil decontamination has increased considerably. An important reason was the favourable cost/performance ratio and the possibilities to carry out the decontamination in-situ (without excavation) or on-site (after excavation). When using in-situ techniques buildings and infrastructure can be left intact and the regular use of the location is hardly hindered. On the other hand the remediation itself may take several years and it is, therefore important to be able to estimate the duration of the remediation and the level of decontamination, which may be reached as accurate as possible. For that reason laboratory tests are carried out to show:

- the presence of the micro flora necessary for an undisturbed degradation process;
- the need to supply extra nutrients and the expected quantities thereof;
- the conditions favourable for growth of micro-organisms;
- and not in the least the level of decontamination that is feasible.

During the performance of an in-situ remediation it may also still be necessary to carry out tests to demonstrate the activity of the micro-organisms present.

The methodology of the tests depends on the nature of the contaminants and whether the tests are to be run under aerobic or anaerobic conditions. Mineral oil, PAH's (poly aromatic hydrocarbons), solvents, etc. are degradable under aerobic conditions. Many chlorinated compounds, however, such as tetrachloro-ethylene, hexachlorobenzene and some PCB's can only be degraded under anaerobic conditions.

The tests under *aerobic* conditions are based on the measurement of the respiration of the micro-organisms when degrading the contaminants, either as carbon dioxide production or oxygen uptake.

The rate of the degradation is studied with the soil as such since mass transfer processes will then equal the conditions in practice as much as possible and results can be translated to the real world. When the level of decontamination is to be determined the soil is tested as a slurry to maximise the bioavailability of the contaminants and to shorten the test duration.

In the tests under *anaerobic* conditions the disappearance of the parent compound and the appearance of degradation products are determined with the aid of chemical analyses.

The tests described below are supported with chemical analysis were indicated.

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## REVIEW OF THE TESTS

### **Test 1:     *Checking the course of a biotechnological remediation***

This test is carried out with samples from a soil that is in the process of being decontaminated biologically. It aims at checking the activity of the micro flora with respect to the degradation of the contamination. The test duration of two weeks is sufficient to distinguish between the increased degradation following the disturbance of the soil by sampling and the level of degradation that is representative for the situation in the field.

The test is based on measuring the carbon dioxide production resulting from biodegradation. Further analyses are not carried out.

For performing this tests about 1kg of soil from the location is required.

Costs of the test are € 1017,-

### **Test 2:     *Determining feasibility biotechnological remediation***

For determining the feasibility of bioremediation of contaminated soil it is very sensible to perform some tests with regard to rate and level of achievable biodegradation in advance. The following questions need to be answered:

- are the required micro organisms present;
- which will be the need for addition of extra nutrients for an undisturbed bioremediation process;
- to what extent it is possible to stimulate the biological process?

The nutrient requirements will be compared with the phosphate fixation capacity of the soil. Based on the experience of BioSoil R&D BV with this type of tests the expected remediation period and level of decontamination to be obtained will be indicated.

The rate of the bioremediation is derived from the tests with the soil as such in which the carbon dioxide production is used as an overall parameter. For determining the expected level of remediation the soil is tested in suspension to maximize mass transfer rates. In that case the oxygen uptake is used as the test criterion.

For both test conditions the levels of contamination at the start and the finish of the test period are determined and compared with the results from the respiration measurements. To gain a better view of the possible problems and limitations for the performance of bioremediation the soil will also be analysed on certain parameters such as pH, organic matter and iron. When the course of the respiration measurements show a clear fall of remediation rate, the level of contamination at that point may also be analysed in order to determine at what level the biological availability becomes determinative for the degradation rate.

To carry out this feasibility test about 4 kg of soil is needed (small bucket). The soil must originate from the contaminated area, which will be decontaminated biologically. In case of large differences between certain soil parameters such as pH and/or organic matter, it is better to perform two separate tests. The level of contaminants at the beginning of the feasibility test requires a minimal level of 1000 mg/kg.dm (aromatics minimal 100 mg/kg.dm)

Costs of this test are € 4033,-

This price is determined for a contamination with mineral oil and aromatics only. You can contact BioSoil R&D BV when other contaminants are present, from which also the feasibility of a biotechnological remediation needs to be tested. In a consult with BioSoil R&D BV a proper definition can be made of the activities which are needed to be carried out and what to determine the costs of the study.

**Test 3: Biodegradability under anaerobic conditions**

The degradation process of chlorinated hydrocarbons such as tetrachloro-ethene (PCE) and trichloro-ethene (TCE) is an anaerobic one. This process can be imitated at laboratory scale. Soil and (ground)water are transferred to flasks under complete anaerobic conditions (N<sub>2</sub>/CO<sub>2</sub> atmosphere). An electron-donor and the test compound are added and the flasks are closed. Appropriate blank experiments are carried out as well. The flasks are incubated tightly closed. The progress of the degradation is followed by sub-sampling and chemical analysis after 3, 7, 14, 28 and 56 days.

The procedure depends on the nature and the behaviour of the contaminant and will be adapted accordingly. In principle the following conditions will be tested:

- Blanc
- + electron donor
- + test compound
- + electron donor and test compound

**REMARK:**

In this test the BioSoil standard electron donor is used. Other electron donors can be tested after consultation with BioSoil R&D BV.

The degradation process is dependent on several circumstances. To have a better insight in the possible problems/limitations for this process, the following measurements/analysis need to be performed:

**Table 1: required measurements and analysis for an anaerobic degradation test at BioSoil R&D BV\***

Field**	Laboratory	
Groundwater	Soil	Groundwater
pH	Organic matter	Nitrate
DO <sub>2</sub>	Nitrate	Sulphate
Oxidation Reduction Potential (ORP)	pH	Iron II
Conductivity		Iron total
		DOC

\* : to determine on soil and groundwater which is used with the test.

\*\* : by principal

For performing this test about 4 kg of soil and about 10 litre of groundwater is needed. Both the soil and the groundwater must stay anaerobic during sampling and shipment to BioSoil R&D BV. In case there are any questions about how to take the samples, BioSoil R&D BV can be contacted and instructions (Standard Operation Procedure) can be supplied.

The costs of this test amount to € 8040,-.

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The costs are based on performing a test with soil and groundwater contaminated with PCE or TCE. In case of other or a combination of contaminants, BioSoil R&D BV may be contacted for defining the activities which are needed to be carried out and which costs will be involved.

In the table at the end of this document an overview is given which activities are carried out per test and which costs (ex. VAT) for performing these tests are involved. When more than one test may be carried out in parallel on different samples at the same time and when the results can be presented in one report a discount can be offered.

Costs for analyses on mineral oil and aromatics are included in those of the tests for aerobic biodegradation and in the anaerobic tests the costs for the analysis of the volatile chlorinated hydrocarbons are included. When additional or specific analyses are required a separate offer will be made.

BioSoil R&D BV is pleased to help in the selection of the test most suited to the problem to be solved. If required a research protocol can be drafted for tests or studies on a specific subject.

Besides the test indicated above BioSoil R&D BV can carry out field and pilot tests for in-situ remediation at a scale of a few hundred square meters and at every required depth. The special character of that type of work requires a proper definition of the activities to be carried out and a specific costing of these activities.

Further information can be obtained from:

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**Table 2: review of activities and costs per test**

Review of activities and costs (excl. VAT) per test			
Activity	TEST		
	1	2	3
CO <sub>2</sub> -production	+		
Slurry: O <sub>2</sub> of anaerobic		+	+
Nutrients		+/-	+/-
Test period in weeks (excl. Reportage)	2	10 <sup>a</sup>	8 <sup>a</sup>
Sampling	By principal (otherwise after consultation)		
Field measurements		Principal (otherwise after consultation)	
ANALYSIS			
Contaminant	None	Start Intermediate Final	Intermediate Final
Organic matter		+	+
Nitrate		+	+
Phosphate		+	
Phosphate fixation		+	
Iron total		+	
Iron II			+
Sulphate			+
DOC			+
Costs (€) <sup>b</sup>	€ 1017,-	€ 4033,-	€ 8040,-

a The test is prolonged when insufficient biodegradation was obtained within the indicated test period.

b Costs based on sampling days and analyses as indicated. In case of less work or extras the price can be changed after consultations between sponsor and BioSoil R&D BV

**SCREENING OF THE FEASIBILITY OF BIOLOGICAL SOIL REMEDIATION**

**Project data**

Project name	
Project number	
Principal	
Contact	

*The above-mentioned principal commissions BioSoil R&D B.V. to perform the following tests:*

Initials	Test	Definition
	<b>1</b>	Checking the course of a biotechnological remediation
	<b>2</b>	Determining feasibility biotechnological remediation
	<b>3</b>	Biodegradability under anaerobic conditions
	<b>4</b>	Other research by BioSoil R&D BV according to separate offer with number: .....

**Report deadline** (cross out what doesn't apply)

Standard	<b>URGENT</b> , at the latest - -
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**Sample data**

Sample date	
Date of arrival of sample	
Sample labelling	
Type of contaminants	
Concentration of contaminants	

**Objectives of the tests / Remarks**

Name : .....	Signature:
Company : .....	
Date : .....	.....