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Bioscreens – the soil is the bioreactor

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background
In city areas it may be difficult or even impossible to reach the exact locations of soil contamination by the presence of buildings and infra structure. When there is a serious risk of transport in groundwater of the contaminants leading to the spreading of the contamination, containment is required. Various techniques may be applied in that case such as:

- impermeable walls with groundwater extraction;
- hydraulic containment by large scale groundwater extraction;
- reactive barriers;
- bioscreens.

Impermeable walls like those with sheet piles are very expensive and may have to cross infra structural works like roads and pipes and cables, which adds up to the costs. Groundwater extraction has to be applied also to obtain a slightly lower groundwater level within the contained area. The water has to be purified before discharge. When *hydraulic containment* is applied even larger quantities of groundwater have to be extracted and treated, which will lead to large treatment installations, which have to be maintained for long periods of time.

Reactive barriers are constructed in such a manner that all groundwater passes through an in site cell, in which the contaminants may react and decontaminations takes place. In practice this will require a funnel like underground structure and a gate in which the reactive barrier itself is placed. In particular the construction of the funnel has the same disadvantages as containment with impermeable walls.

In those cases where the contaminants are biodegradable either under aerobic or anaerobic conditions a *bioscreen* may be installed that is constructed in such a manner that a stretch of soil, as well as possible perpendicular to the direction of groundwater flow, is turned into a bioreactor. Any contamination entering that soil compartment is biodegraded, because the conditions that are created in the bioscreen are such that the contaminants are the limiting factor for growth of the degrading micro-organisms.
The bugs so to say are sitting and waiting for the contamination to arrive because they are starving in plenty of all other prerequisites.

the screen

The bioscreen consists of a row of extraction/injection wells, from which groundwater is extracted an reinfiltrated after being amended with nutrients, which are necessary for growth of micro-organisms (picture to the right). When aerobic conditions are required oxygenation is applied (e.g. air sparging). In build areas the screen follows the infra structure as well as feasible (figure page 1).

The lay out of the screen is designed to assure full coverage of the contaminated cross section of the groundwater flow. When the depth of the aquifer is relatively large or when it is geologically layered the wells are grouped in horizontal layers to prevent preferential path ways and consequently the creation of windows in the screen through which contaminated groundwater may escape.

The depth of the screen along the flow path of the groundwater depends on the biodegradation rates of the contaminants and the groundwater flow rate. Since the bio-availability of the contaminants is high (they are in solution) biodegradation is rapid. An average residence time of a few days in the activated zone is normally sufficient for full degradation. So, a few meters behind the screen is all that is required for decontamination of the groundwater.

The wells and when applicable the sparging points are connected to manifolds in a central unit (photograph below). When a screen is long, it may be divided over more units.

required activities

For performing a bioscreen operation the extracted groundwater is amended with nutrients and reinfiltrated. The dosage is linked to the level of contamination of the groundwater entering the screen. That dosage is determined in laboratory experiments or on the basis of BioSoil R&D's experience. Under anaerobic conditions for the dehalogenation of chlorinated hydrocarbons an electron donor is dosed, which apart from an organic fraction also contains the necessary inorganic nutrients. When aerobic degradation is required as is the case with aromatic compounds like benzene, toluene, etc. or polynuclear aromatics like naphthalene air sparging is applied as well or an oxygen carrier such as hydrogenperoxide is used. The level of oxygenation is also linked to the level of the contamination

The wells are maintained for optimal extraction and infiltration and the functioning of the bioscreen is monitored in wells, which are not part of the screen and placed up- and downstream from the screen at a distance of about 10 m or more.

experience

Anaerobic screens have been operated since the year 2000 in Wageningen in the Netherlands and for two years now in Germany. Pilots are performed in Belgium, Wales and Finland. Aerobic screen like structures have been operated in a number of cases, with contaminations with hydrocarbons such as diesel fuels and petrol. A pilot is carried out to control a contamination with creosote (polynuclear aromatics) in Finland

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