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Applicability of different remediation technologies for sustainable development of several contaminated sites. Activity carried out during the training course in Ambiente S.p.A., ENI group

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Abstract

The main aim of typical soil and/or groundwater remediation project is to determine the extent of their contamination. It is often accomplished by site characterization and remedial investigation (RI).
Site characterization determines the conditions on and beneath a site that are pertinent to hazardous waste management. When site remediation is deemed necessary, remediation investigation will be employed. Remediation investigation activities consist of site characterization and additional data collection. The additional data are necessary for control of plume migration and selection of remedial alternatives.
Subsurface contamination from spill and leaky underground storage tanks (UST) creates environmental problems which usually require corrective actions. The contaminants may be present in one or a combination of following locations and phases:

- Vadose zone: vapors in the void; free product in the void; dissolved in the soil moisture; adsorbed onto the soil matrix; floating on top of the capillary fringe (NAPLs);
- Groundwater: dissolved in the groundwater; adsorbed onto the aquifer material; sitting on top of the bedrock (DNAPLs).

Various aspects of contaminant partitioning and the resulting fate and transport were discussed in this work. It is important to understand the behavior of contaminants in the subsurface environment to design properly and implement successfully a remediation system.
The contaminants present in subsurface environment should be understood (from chemistry point of view) as perturbation of partitioning of the contaminants to the most favorable compartment and/or phase. However, the efforts to perturb the system may have non equilibrium limitations. These non equilibrium limitations have a significant impact on the tailing effect of contaminant concentration levels at various remediation sites. This tailing effect has been observed even at site where a significant amount of money and time have been spent implementing the most state-of - the- art remediation technologies.
The reason for the tailing effect of contaminant concentration levels can be summarized as:

- Nonhomogeneous advective flow;
- film limitation;
- sorption effect;
- transport effect;
- intraparticle diffusion;
- micropore diffusion;
- macropore diffusion.

Common remediation investigation activities include:

- removal of contamination source(s) such as leaky USTs
- installation of soil borings
- installation of groundwater monitoring wells;
- soil sample collection and analysis;
- groundwater sample collection and analysis;
- aquifer testing.

Due to these activities the following data are collected:

- Types of contaminants present in soil and groundwater;
- Concentrations of contaminants in the collected samples;
- Vertical and area extents of contaminant plumes in soil and groundwater;
- Vertical and area extents of free-floating product or the DNAPLs;
- Soil characteristics including the type of soil, density, moisture content, etc.
- Groundwater elevation;
- Drawdown data collected from aquifer tests.

An engineering remediation practice has to learn the nuances of investigative techniques, data collection, and on the basis of these investigations should choose the remediation technology. The remediation technologies can be divided into:
- In situ remediation (such as bioremediation, biosparging, bioventing, phytoremediation, reactive walls, reactive zones, enchanted reductive dechlorination, etc.);
- Ex situ remediation (such as Soil washing, Stabilization and solidification (which can be in situ), etc)

In this work the particular aspects of remediation technology are described, such as biosparging, soil washing, pump and treat, and in situ enhanced reductive dechlorination, and the applicability of these technologies on contaminated sites. The literature researches and full - scale studies have shown that the selection of a remediation technology is a delicate step, which requires a deep comprehension of both available technologies and site characteristics. So, it's very important (after evaluating remediation alternatives) to choose one of the approaches to provide pilot test verification, before full- scale application. Sometimes the chosen technology cannot be appropriate; but the data received can be useful selecting another remediation method.

1. *__Biosparging Pilot Test__*

The site selected for the test was a closed industrial facility that had handled petroleum products. Based on the data from previous investigations, the groundwater beneath the site contained petroleum hydrocarbons, that derive from an accidental contamination, such as breach of one tank in the reserve area.
The activity in the contaminated site was done respecting following steps:
- Realization of air sparging points and monitoring wells;
- System checking;
- Air sparging tests using four different flow ranges;
- Permeability verification in unsaturated zone via Soil Vapor Extraction test

Taking into account the observed low soil permeability and the presence in groundwater hangingwall confines, that caused problems for contaminant stripping and removing, thoughout the pilot test, the application of Air Sparging and SVE tends to be very difficult. The presence of LNAPL observed in some piezometers, is an obstacle to the applicability of this method.

As an alternative remediation method the installation of a drain trench contextually with the realization of a bioventing system was chosen. This solution was selected because while performing the test it was possible to observe a high microbial activity.

2. *Soil Washing*

The site is an ex-deposit area of petroleum products and metaxil. During the period 1999 - 2000, several site investigations were conducted to determine the nature and extent of contamination, and to identify appropriate remedial techniques. The site characterization work identified major contaminants in the form of petroleum hydrocarbons C < 12 and C > 12, with relative concentration 3500 mg/kg and 12.000 mg/kg respectively and BTEX (with maximum concentration about 900 mg/kg of xylene). The soil contamination begins on the depth about 2,0 meters and reaches to 3,5 meters from g.l.

A detailed review of the site characterization data suggested that the granular nature of the natural soil and made ground and contaminant concentrations were likely amenable to treatment by soil washing.

The soil washing technology is capable of treating a wide range of soil types (made ground to natural sands) contaminated with petroleum hydrocarbons and VOCs. This project will show that one of the main factors governing the economic viability of soil washing is the amount and moisture content of the contaminated fines fraction and the associated disposal cost. In the extreme it is possible that a landfill operator would refuse to take such fines on the grounds of geotechnical properties alone (or at least charge a premium to take them).The new method to treat the fines would either render them suitable for re-use on the site or more acceptable to the landfill operator and therefore would significantly improve the economic viability of soil washing.

3. *P&T and in situ enhanced reductive dechlorination*

The contaminated site is an industrial facility where petroleum products were handled.

During the feasibility studies of one industrial site the petroleum hydrocarbon contamination of soil and tetracholoroethene impacts in groundwater were observed.

Remedial alternatives were evaluated for the site, and the approaches recommended are as follows:
- dilling up high contaminated soil and disposal;
- Pump and Treat Technology for groundwater remediation, and
- In situ enhanced reductive dechlorination.

On the site a Pump and Treat system constituted by a hydraulic barrier of ten wells for groundwater pumping is operating. The dimensioning of the hydraulic barrier has been carried out on the basis of the data gathered during the field test, and the data supplied by the Client, the calculation executed with traditional methods and the simulations carried out with computer models.
The existing system encountered several difficulties. During the execution of a flow test a low productivity was observed, that was caused by sediments which blocked the draining system.
It was decided to rebuild the hydraulic barrier with addition of a new well, which would be used to perform the pilot test.
The existing hydraulic barrier is transporting the wastewater in the canalization. In the future it will not be possible anymore.
Furthermore a collector will be realized in order to collect wastewater and send it to the treatment system. The collector was designed in order to maximize the existing pipe network reusing. In particular, some wells will unload in the North pipe network, already present on the site. The same situation - well will unload in the South pipe network. The collector will unite wastewater from these two pipe networks and other wells, and unload them to a treatment system, with previous passing through an automatic sampling system.
An innovative remedial solution will be used to create temporary anaerobic conditions and provide the necessary substrate and nutrients to enhance reductive dechlorination of PCE in the source area. A series of injections using a mixture of sodium lactate, yeast extract, and sodium sulfate will be performed over a one-year period. The pump and treat remediation technology is effective for LNAPL, and not applicable for DNAPL. During the enhanced reductive dechlorination an increasing of NAPL (such as TCE, DCE,VC) concentration, and decreasing or complete decline in DNAPL (PCE) will be expected. This process will support groundwater remediation.