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INTEGRATED FIELD ASSESSMENT OF CONTAMINANT FATE AND TRANSPORT IN THE UNSATURATED AND SATURATED ZONE

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The identification of contaminant sources, attenuation and their transport in the unsaturated and saturated zone in the vicinity of contaminated brownfields is important to control and manage groundwater quality of aquifer systems.

Such characterization is challenging due to multiple contaminant sources, the heterogeneity of geochemical processes in the medium and the spatial and temporal variability of soil and aquifer properties.

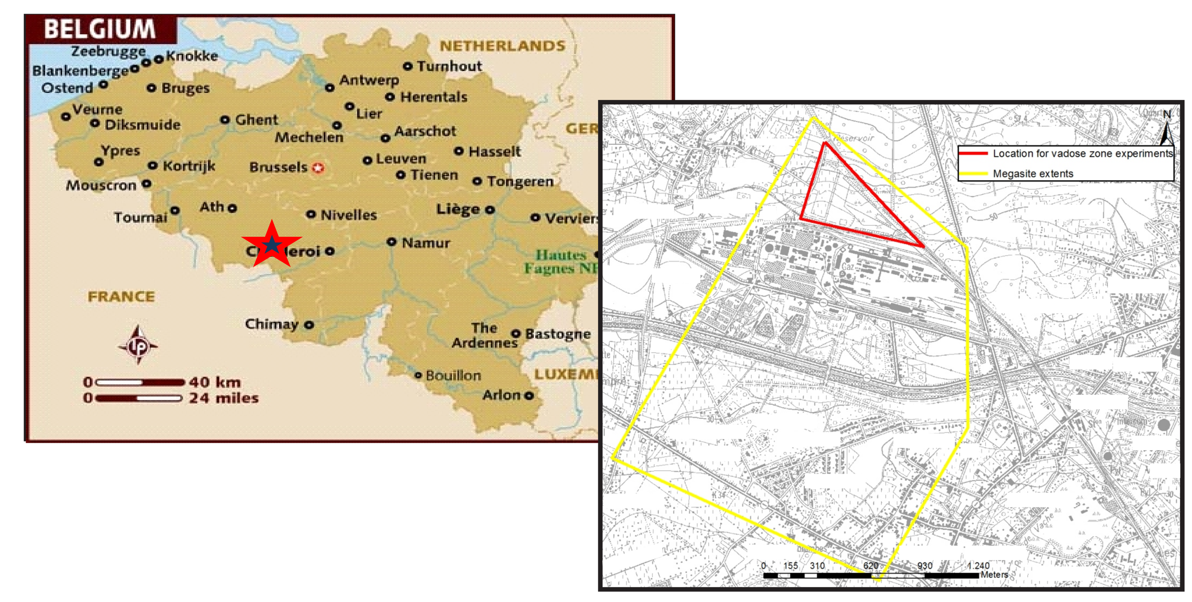
In order to overcome such difficulties in soil and groundwater pollutant characterization, unsaturated and saturated field experiments have been setup at an industrial site in Belgium. The objective is to develop a methodology that is capable to quantify contaminant fluxes, identify their sources and pathways and understand the various reactive processes in soil and groundwater.

For unsaturated zone studies, the proposed methodology is the combination of a Vadose Monitoring System with surface and cross-borehole geophysics. Such techniques aim to provide a conceptual model of solute distribution and transport in the subsoil.

For saturated zone studies, the approach consist in the chemical and isotopic analysis of the various contaminants present on site. The expected outcome of such data interpretation and modelling is the characterization of geochemical processes and contaminant sources at a megasite scale.

The study site

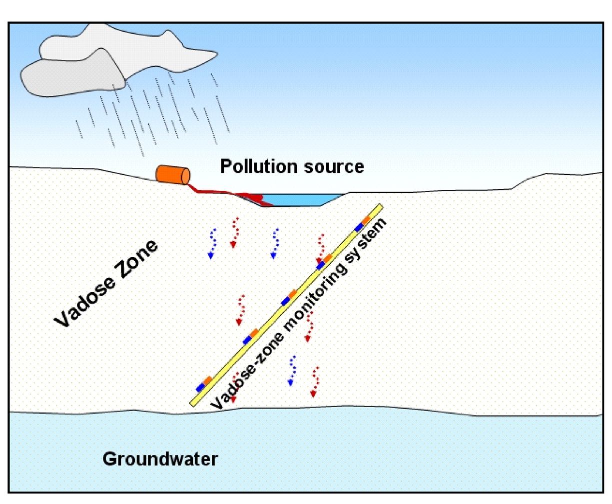
The field site is an industrial complex in which different activities have taken place throughout the years. Such activities comprise among others coke production and dye manufacturing. Some of these factories are still active.



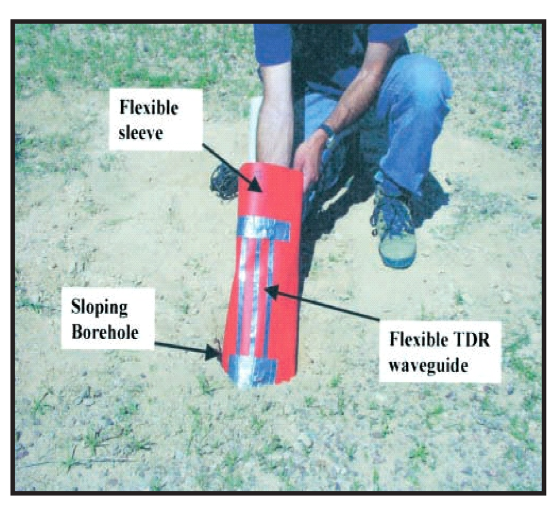
The legacy of such activities is soil and groundwater contamination in:

-Inorganic compounds (sulfate, nitrate, nitrite, ammonium)
-Cyanide -Heavy metals
-BTEX -PAH

Methodology for the unsaturated zone



(a)



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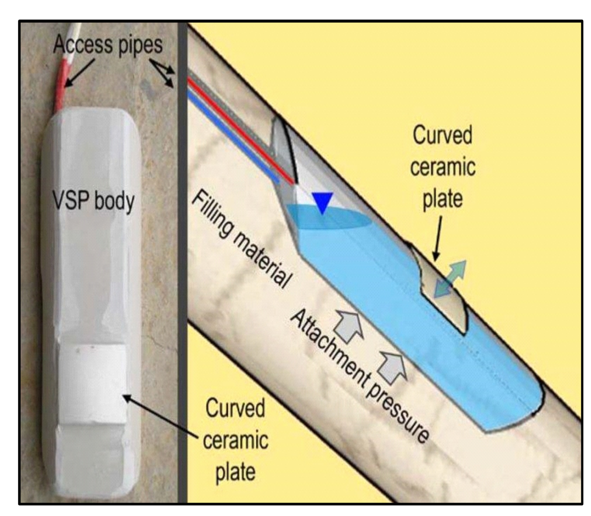

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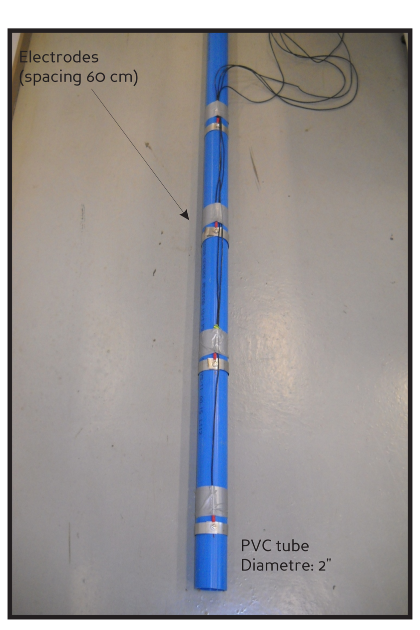

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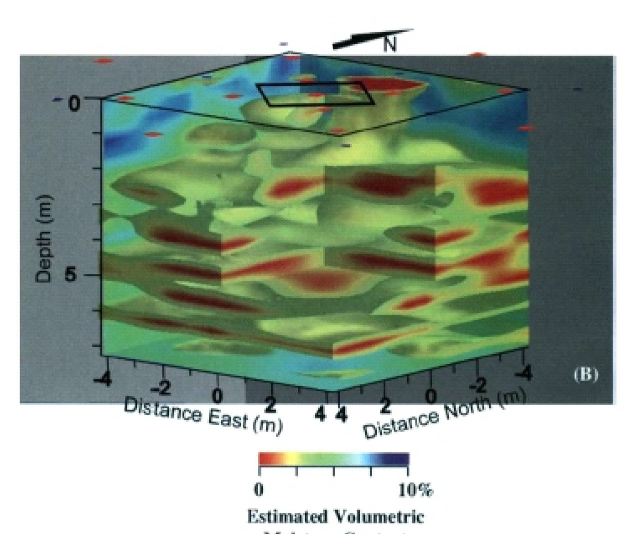


(f)

STEP 1: INSTALLATION OF THE VADOSE MONITORING SYSTEM

(a) A flexible sleeve is installed in an slanted borehole with the aim of capturing a tracer infiltrated throughout undisturbed material above the borehole. The flexible sleeve has two types of monitoring units installed within its entire length:

(b) Flexible Time Domain Reflectometry probes (FTDR), which contain stainless steel waveguides installed in the outer wall of the flexible sleeve to measure vadose zone pore water

(c) Vadose Sampling Ports (VSP), containing a ceramic plate and a sampling cell that capture vadose pore zone water. This type of monitoring unit is installed in the inner wall of the flexible sleeve

STEP 2: GEOPHYSICAL MEASUREMENTS OF THE WETTING FRONT VIA CROSS-HOLE GEOPHYSICS

(d) Four boreholes containing 24 stainless steel electrodes spaced 0.60m are installed for cross-hole ERT measurements that will capture the transport throught the vadose zone of the applied tracers at the land surface

STEP 3: COMBINATION OF CROSS-BOREHOLE AND SURFACE GEOPHYSICS TO DEVELOP A 3D MODEL OF SOLUTE TRANSPORT IN THE VADOSE ZONE

(e,f) A grid of 8x8 electrodes with spacing of 3m together with two lines of 32 electrodes will be combined with cross-borehole geophysics for obtaining 3D images of the distribution and transport of the tracer in the vadose zone.

STEP 4: DEVELOPMENT OF A QUANTITATIVE MODEL OF SOLUTE DISTRIBUTION AND TRANSPORT IN THE VADOSE ZONE OF THE STUDY SITE

The model is expected to combine time-lapse images of tracer distribution and transport in the vadose zone with quantitative measurements of tracer flux and mixing with the water table.

Methodology for the chemical and isotopic survey

STEP 1: SELECTION OF SAMPLING SITES ON THE REGIONAL SCALE

Selection of sampling wells based on most recent contaminant data and ideal locations for sampling (figure 1).

STEP 2: SOIL AND GROUNDWATER SAMPLING FOR CHEMICAL AND ISOTOPIC ANALYES

Collection of samples for sulfate isotopic analysis to determine contaminant sources and pathways and identify various reactive processes (figure 2).

Collection of samples for cyanide isotopic analysis and cyanide speciation for identification of cyanide sources and investigate possible relations between the specific cyanide species and cyanide isotopic fractionation processes (figure 3).

Collection of samples of BTEX and its products for isotopic analyses to identify evidence of the occurrence of natural attenuation.

STEP 3: DATA INTERPRETATION AND MODELLING

Characterization of geochemical processes, contaminant sources and interpretation of regional scale isotopic patterns.

Calculation of contaminant dispersion and identification of plumes extents using numerical groundwater flow and transport models developed for the regional scale.

STEP 4: DEVELOPMENT OF A METHODOLOGY FOR MEGASITE ASSESSMENT

Establishment of methodologies for identifying sources and relevant transformation and natural attenuation processes for a complex release of contaminants at a megasite scale that will lead to improved contaminant site assessment.

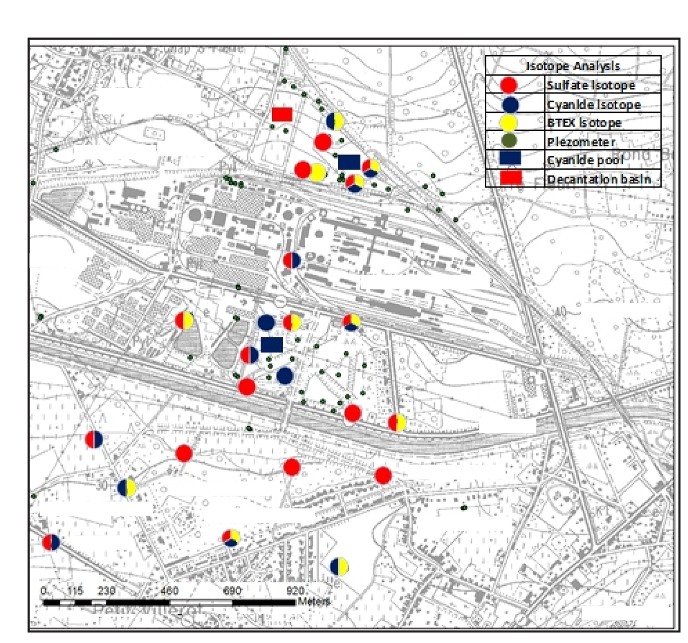


Fig. 1

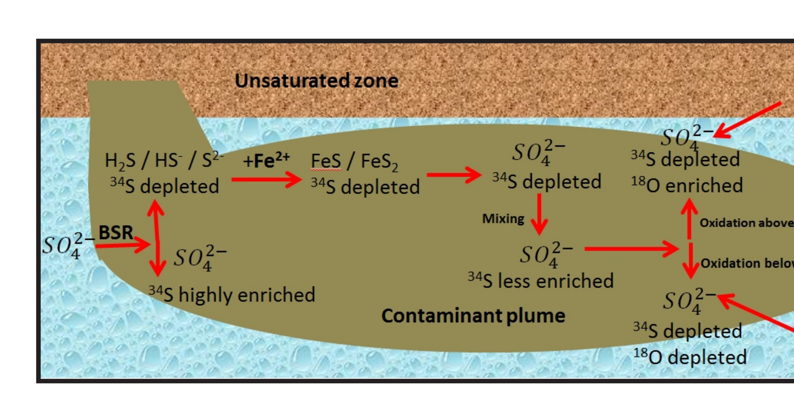
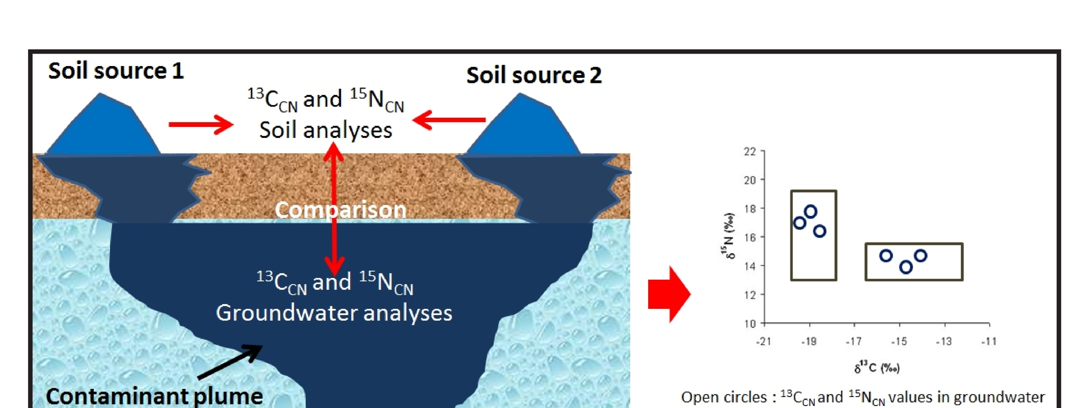


Fig. 2

Fig. 3



Perspectives

The combination of the Vadose Monitoring System and geophysical techniques aim to develop a conceptual model that better characterizes the transport of pollutants in the vadose zone of industrial sites. The objective is to use such methodology as an approach to improve risk assessment and remediation measures for the vadose zone.

The combined hydrochemical-multiple isotope survey of the megasite will provide a more clear and global view of the problem as well as the possible identification of contaminant sources and pathways and the identification of various reactive processes, in soils and groundwater.

References

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