Treatment MEthodology and MOnitoring for sequenced Reallocation of severely polluted Industrial Sites (MEMORIS) :

A combination of innovative technologies

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Project founded by The Walloon Region – Greenwin (Belgium)

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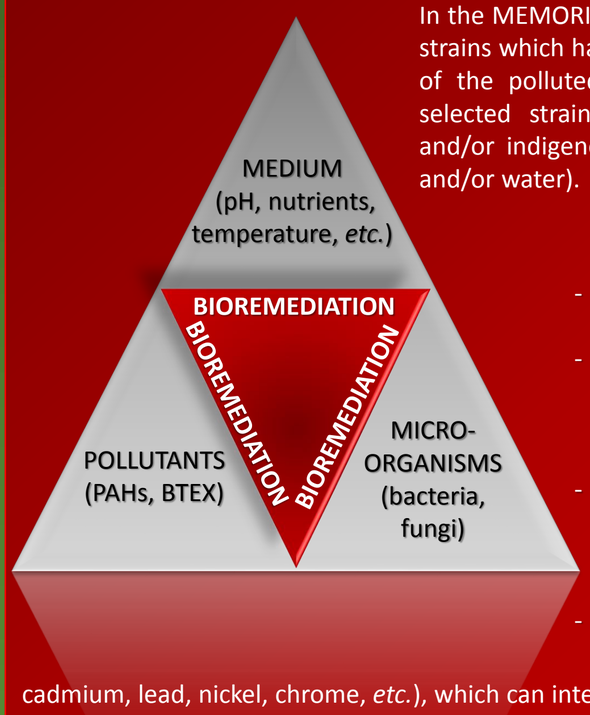
Introduction

The economic redeployment of the Walloon Region requires the reallocation of many fallow land requiring substantial rehabilitation work. Indeed, sites from old steel industry are the subject of mixed pollution and generally occupy very large surfaces. Therefore, the excavation, transport and storage of contaminated materials become financially and ethically not feasible also involving risks for the health of the residents.

The MEMORIS process combines 4 techniques in a unique way and provides innovative and effective solutions for sanitation and *in situ* monitoring. The remediation - monitoring coupling will constitute a new approach for the management and sequential re - use of highly polluted sites according to toxicological risks.

In situ Sanitation

Bioremediation is the use of living organisms such as bacteria, fungi and algae to decontaminate polluted soil and/or water. Some species are known to be efficient for the biodegradation of polycyclic aromatic compounds (PAHs), among them bacterial strains *Pseudomonas sp.*, *Rodococcus sp.*, *Mycobacterium sp.* and white rot fungi *Phanerochaete chrysosporium* or *Pleurotus ostreatus* are commonly found in litterature as degrading strains [1,2].

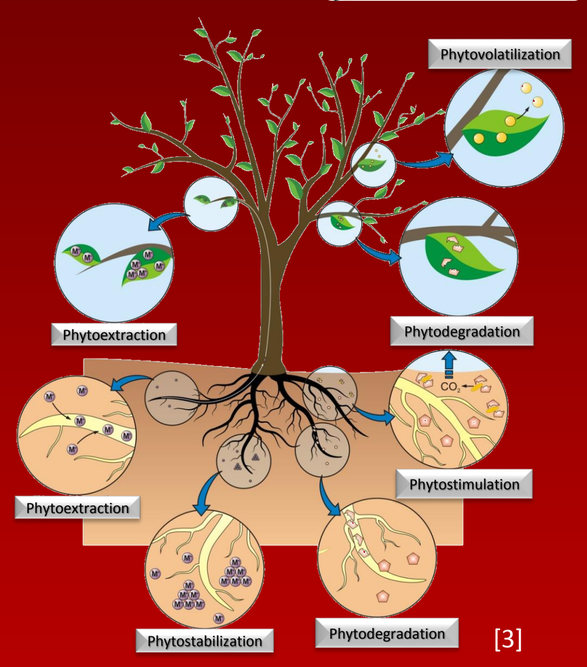


In the MEMORIS project a consortium of bacterial and/or fungal strains which have the ability to degrade PAHs and BTEX content of the polluted soil at a large scale will be proposed. The selected strains will be either commercial selected strains and/or indigenous strains isolated from the polluted site (soil and/or water).

Several parameters will be studied:

- **Bioavailability of pollutants** (use of surfactants such as Tween or cyclodextrins)
- **Enzymatic system** (increasing production or activity of enzymes involved in the pollutant degradation *i.e.* lignin peroxidase, manganese peroxidase and laccase)
- **Influence of soil temp**erature (soil will be heated using heating pipes or hot water circulation) on micro-organism growth, pollutant bioavailability and bioremediation
- **Influence of other pollutants** present in the polluted soil, especially heavy metals (zinc, cadmium, lead, nickel, chrome, *etc.*), which can interfere with thebioremediation process (inhibition of enzymatic system, inhibition of micro-organisms growth)
- **Identification of bioremediation products** (are the obtained compounds safer than original PAHs/BTEX or are they worse?)

Phytoremediation developed under the MEMORIS project aims to (i) degrade organic compounds and (ii) stabilize and extract metal contaminants. To do this, tests will be developed in bins or containers with soil sampled on the site. Each bin will be vegetated with woody species (e.g. willow, poplar or birch) and / or herbaceous (e.g. alfalfa, miscanthus). The effectiveness of technique on soil decontamination and biomass production will be assessed at different time steps (seasonal).

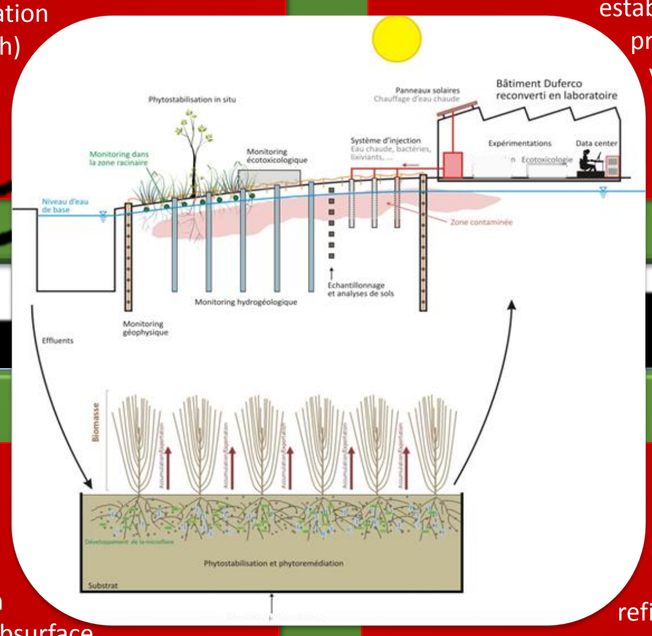


[3]

Subsequently, phytoremediation technique will be applied to a green unit set up on the MEMORIS site. The substrate of this unit will be composed of a leachate / sand mixture and will be inoculated by a consortium of microorganisms.

Phytostabilization as well as **phytoextraction** will be assessed by monitoring the contents of mobile metals in the substrate and the metal contents present in the biomass produced (stem and leaf). The micro-organisms will allow the biodegradation of organic compounds in support of **phyto / rhizo-degradation** by plants.

In areas with moderate surface pollution of the experimental site, an *in situ* plantation will be established. The choice of plants will be defined on the basis of the preliminary results obtained by the experimentation in bins (plants survival, vegetation cover, mobile fraction in metals in the soil, metal contents in the leachates and metal concentrations in the biomass).



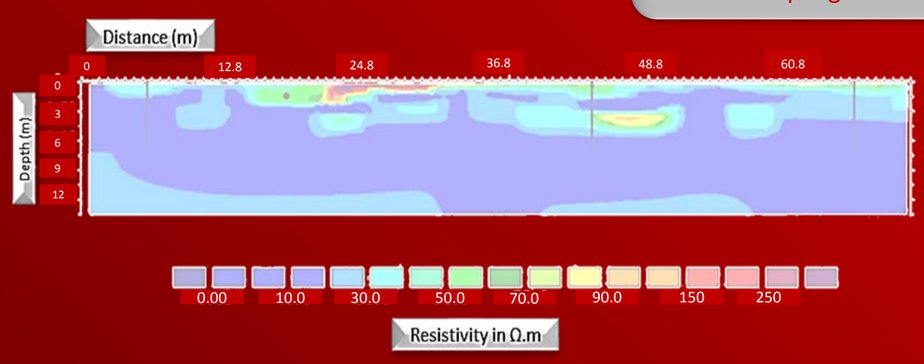
Electric geophysical methods are sensitive to changes in the electrical properties of soils and groundwater that are affected by the presence of contaminants.

The objective is to develop geophysical techniques, for imaging the evolution of the contaminant plume under stimulated biodegradation as well as the subsurface temperature, continuously in space and time. The biodegradation of pollutants is stimulated by the injection of nutrients, and by the increase of the subsurface temperature with external intakes of heat.

This part of the research project covers several aspects:

(1) Design and implementation in the field of the monitoring system using hydrogeophysical techniques;
(2) Acquisition, processing and interpretation of the measured data;
(3) Field sampling to calibrate and validate the methods;
(4) Numerical modeling of flow and heat transfers.

This follow-up allow to extend, at low cost, interpretations derived from chemical analyzes on water and soil sampling



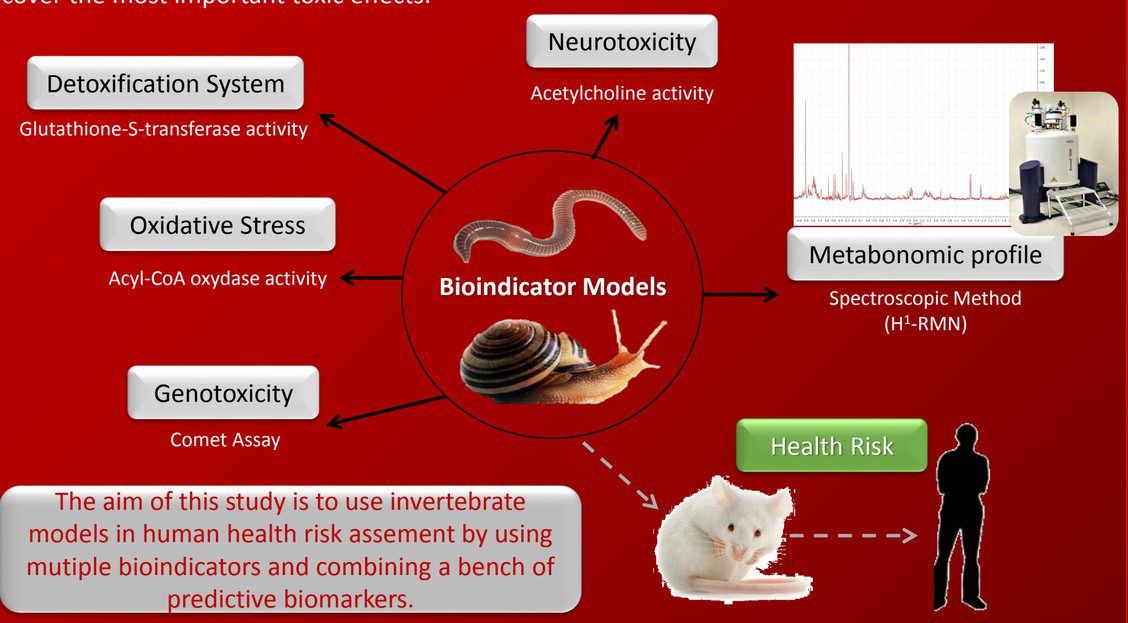
"Electrical resisitivity section showing variations in the subsurface electrical resistivities along a profile. This section results from the inversion of electrical resistivities carried out with electrodes spreaded". [6]

Laboratory studies on mammals are being increasingly the subject of new legislations, it becomes important to implement alternative solutions that respond to the law of the 3Rs (Reduce, Replace, Refine) [4].

Omics approaches allow to reduce the number of organisms as well as a refinement of experiments by using non-invasive methods.

However, mammals species remain largely exploited in biomedical research and in toxicology studies in particular. Invertebrate animal models which are already used in the environmental risk assessment [5] could be transposed from ecotoxicology to the evaluation of health risks. Indeed, many similarities exist between the detoxification systems and the involved pathways.

The study is based on predictive biomarkers allowing to integrate different absorption pathways as well as being a global reflect of exposition. The use of mutiple bio-indicators allows to follow the evolution of the effects across seasons and the combination of several biomarkers assures us to cover the most important toxic effects.



The aim of this study is to use invertebrate models in human health risk assement by using mutiple bioindicators and combining a bench of predictive biomarkers.

Monitoring

[1] Haritash A.K., Kaushik C.P., Journal of Hazardous Materials 169 (2009) 1-15, [2] Gan S., Lau E.V., Ng H.K., Journal of Hazardous Materials 172 (2009) 523-549, [3] Favas P. J. C. et al., 2014. Phytoremediation of Soils Contaminated with Metals and Metalloids at Mining Areas: Potential of Native Flora, [4] Riley et al., *Rapid, responsive, relevant (R3) research : a call for a rapid learning health research enterprise*. Clinical and Translational Medicine. 2013; [5] Cortet et al., The use of invertebrate soil fauna in monitoring pollutant effects. Eur. J. Soil Biol. 35, 115-134. 1999. [6] Etienne A. 2014. Amélioration du suivi de la contamination des sols et des eaux souterraines dans le cadre de la gestion des risques environnementaux. Thèse de doctorat en sciences de l'ingénieur. UMONS.