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

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Introduction

20th century was the golden age of steel industry in Wallonia, Belgium, especially in the provinces of Hainaut (cities of Charleroi or La Louvière), Walloon Brabant (Tubize) and Liège. The consequence of this past is nowadays the presence of **multiple wastelands severely polluted by mainly PAHs (Polycyclic Aromatic Hydrocarbons), BTEX (Benzene, Toluene, Ethylbenzene, Xylene) and heavy metals**.

The reallocation of those sites for new activities is a major challenge and requires preliminary soil remediation to obtain pollution levels below legislation limits. The traditional technique used for soil remediation in Wallonia includes the excavation of contaminated soils, transport and treatment *ex situ* in specialised centres. However, this procedure is very expensive, may present health risks for local population and leads to negative carbon footprint. Consequently, ***in situ* decontamination methods** must be considered.

In this context, the **MEMORIS project (Treatment MEthodology and MOnitoring for sequenced Reallocation of severely polluted Industrial Sites)** was born.

The main goal of this project funded by the Walloon Region (Greenwin, Belgium), in collaboration with Duferco Wallonie and Siterem, is the **combination of treatment and monitoring methods allowing sequential reuse of a severely polluted industrial site in order to decrease the financial impact of sanitation costs**.

For this purpose, different techniques will be used in combination, namely, **bioremediation** (degradation of PAHs and BTEX), **phytoremediation** (phytostabilization of heavy metals), **thermal treatment of the soil** (stimulation of the microbial activity), **monitoring** (pollution evolution in continuous and during long periods) and **health risk assessment** (application of bio-indicators (invertebrates) and transposition of ecotoxicological tests to assess the impact of pollution on human health).

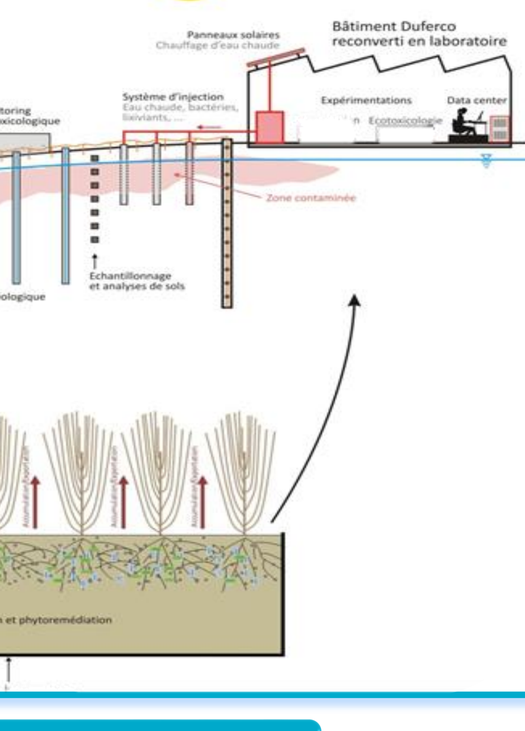
Bioremediation

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.*, *Rhodococcus 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 with 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 **temperature** (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 the bioremediation 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?)



Analytical Methods

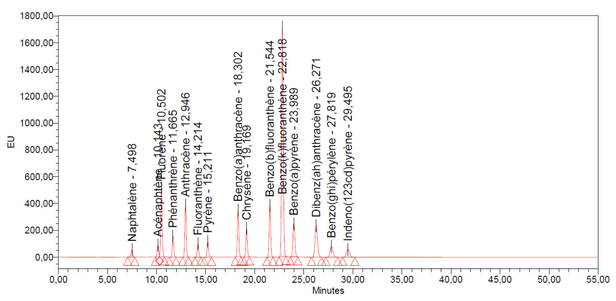
The first PAHs-bioremediation experiments at lab-scale will be processed in liquid medium. The final mixture of the bioreactor will contain microorganisms, pollutants, metabolites, cell fragments, salts, proteins, *etc.* that should be removed (SPE purification) before PAHs quantification.

The quantification is done by chromatographic method (HPLC-PDA-FLD) after SPE purification

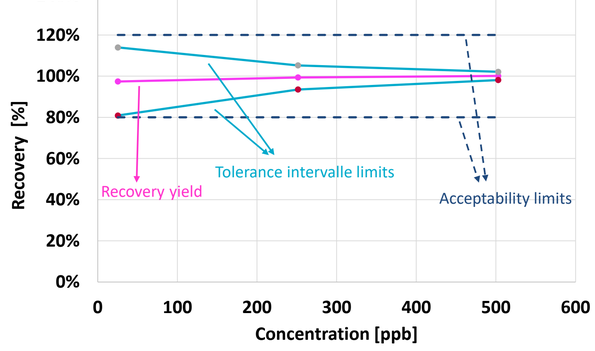
The chromatographic system consists in: Waters Alliance 2695, PDA Waters 996 detector and Waters 2475 fluoresence detector with Empower 2.0 software.

The column used is Agilent Zorbax Eclipse PAH (4.6 x 250 mm, 5 µm) with guard column Agilent Zorbax Eclipse PAH (4.6 x 12.5 mm, 5 µm). Temperatures of column and samples are respectively 25°C and 5°C.

The column is eluted by a mixture ACN/water in gradient mode at a flow rate of 1.5 mL.min^{-1}



Chromatogram (FLD – mixture of 15 PAH)



PAH	Coefficients of variation, CV						Limit of detection	Limit of quantification
	10 ppb	25 ppb	50 ppb	100 ppb	250 ppb	500 ppb	[ppb]	[ppb]
Naphtalene	27.19%	2.35%	0.55%	0.39%	1.95%	0.78%	4.87	16.22
Acenaphtene	4.25%	2.48%	0.77%	0.36%	1.38%	0.64%	5.18	17.28
Fluorene	3.58%	1.59%	0.26%	0.15%	0.32%	0.47%	4.63	15.45
Phenanthrene	9.47%	2.16%	0.41%	0.25%	1.98%	0.78%	4.72	15.73
Anthracene	4.25%	0.90%	0.73%	0.18%	0.32%	0.50%	5.06	16.86
Fluoranthene	4.91%	1.25%	0.23%	0.13%	0.78%	0.66%	5.39	17.96
Pyrene	14.88%	3.21%	0.96%	0.47%	4.98%	1.42%	5.13	17.09
Benzo(a)anthracene	7.73%	1.71%	0.47%	0.29%	2.38%	0.91%	4.52	15.07
Chrysene	11.38%	2.09%	1.42%	0.35%	3.01%	0.99%	4.47	14.91
Benzo(b)fluoranthene	6.07%	1.05%	0.31%	0.22%	1.44%	0.68%	4.94	16.47
Benzo(k)fluoranthene	9.87%	0.78%	0.27%	0.15%	0.87%	0.54%	4.99	16.63
Benzo(a)pyrene	5.23%	1.34%	2.20%	0.74%	3.71%	0.86%	5.92	19.73
Dibenz(ah)anthracene	6.26%	1.53%	0.55%	0.28%	2.56%	0.83%	4.29	14.30
Benzo(ghi)perylene	8.09%	1.30%	0.20%	0.12%	4.90%	1.19%	5.62	18.73
Indeno(123cd)pyrene	16.52%	1.33%	0.13%	0.29%	0.96%	0.52%	2.75	9.17

Memoris future pilot

References

[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

Aknowledgement

The MEMORIS project has been funded by the Région Wallonne, Belgium (Greenwin program).