The PHYTENER project: Development of phytostabilisation combined with energy crop production on agricultural soils highly contaminated by metals

POURRUT Bertrand and the Phytener consortium

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Regional context

- Metaleurop Nord, one of the biggest lead smelter in Europe, was in activity from 1894 to 2003

- Nyrstar, a zinc smelter in activity since 1869, is located approximately 3 km from Metaleurop smelter

- Around 120 km² are affected by the dust fallouts coming from two smelters and are mainly contaminated with Cd, Pb and Zn

- 55 000 inhabitants are living in these contaminated area

- Cd and Pb concentrations in several food productions exceed the threshold limits for human and animal consumption (Douay *et al*. 2008)

- The contaminated area is too large to be remediated in an economically relevant way by the currently applied remediation techniques

Fig 1: Metaleurop smelter before its closedown in 2003

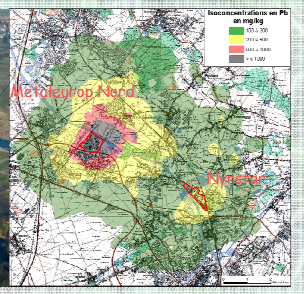


Fig 2: Lead iso-concentration curves in agricultural topsoils

Consequences:

- Human risks associated with food crop consumption (Pruvot *et al*., 2006)

- Human risks associated with contaminated dust ingestion (Mazzuca *et al*., 2006)

- Food chain contamination risks (Bidar *et al*., 2007)

- Environmental risks (Fritsch *et al*., 2010)

➔ **Sustainable management of these highly polluted soils is crucial**

The PHYTENER project

- The **PHYTENER project** is a multi-disciplinary consortium of 9 research teams, coordinated by the "Sols et Environnement" research team (LGCgE, Groupe ISA).

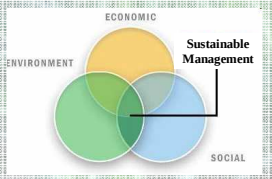
- It aims at studying **phytostabilisation in combination with energy crop production**. Two energy crops were selected: wood (Lopareva *et al*., 2011) and *Miscanthus x giganteus*.

- As feasibility of the long term strategy of phytostabilisation has to be tested against the current remediation techniques, the project focuses on three research axis:

A) Study of the impacts of these crops on the soils and the environment
- evolution of soil physico-chemical parameters and metal behavior
- metal accumulation in crops
- environmental impact : effects on biodiversity, ecotoxicology
- landscape impact

B) Social study
- farmers and neighborhood population perception
- landscape management
- land reorganization in the agricultural farms

C) Economic study
- crop yields
- yield of the experimental multi-fuel boiler
- economic evaluation of the use of these phytoremediation techniques



Experimental site set-up

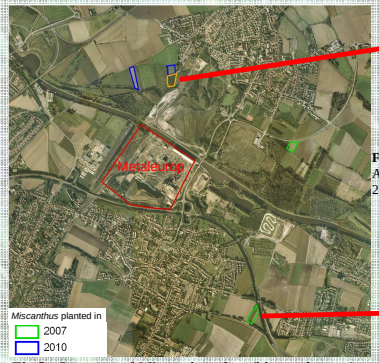


Fig 3: Location of *Miscanthus* plots (blue and green) and wood crop plot (orange)

Fig 4: Set-up of the "wood crop" site planted with a tree mix
A: fly ash amendment (2000); B: tree plantation (2001); C: site in 2007; D: scheme of the experimental site (Lopareva *et al*., 2011)

Fig 5: Set-up of one of the *Miscanthus* plots.
A and B: *Miscanthus* plantation (2009); C: site in spring 2010; D: harvesting in early 2011

Miscanthus x giganteus

- 3 approximately-1 ha experimental sites were set up in 2007 on former agricultural fields contaminated with different levels of metals

- A new experimental site (approximately 1 ha) was set up in 2010 on a former agricultural site, 700 m north and downwind of the former smelter. It was divided in 72 sub-plots (5x10 m):

Fig 6: Scheme of the randomized sub-plots of the *Miscanthus* experimental site

- 3 different cultivars of *Miscanthus* (called B, A and I respectively green, pink and white)

- half of sub-pots were mycorhized (M)

- two densities of plantation: 15 000 plants/ha or 20 000/ha (hatched sub-plots)

- half of sub-plots will be fertilized in 2013 (F)

Several parameters will be evaluated on this plot:

- *Miscanthus* growth (survival rate, stem height, number of stems,…) and yield

- *Miscanthus* mycorhyzation

- *Miscanthus* health: stress biomarkers (oxidative stress, genotoxicity), photosynthesis efficiency, water statue, mineral nutrition…

First results

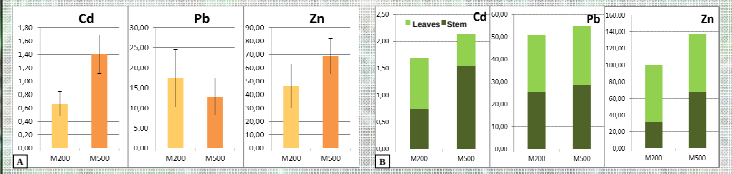


Fig 7: Metal accumulation (mg.kg^{-1} DW) in above ground parts (A) or leaves and stems (B) of *Miscanthus* plants grown on two different soils: M200 (around 200 mg Pb.kg^{-1} DW soil) and M500 (around 500 mg Pb.kg^{-1} DW soil)

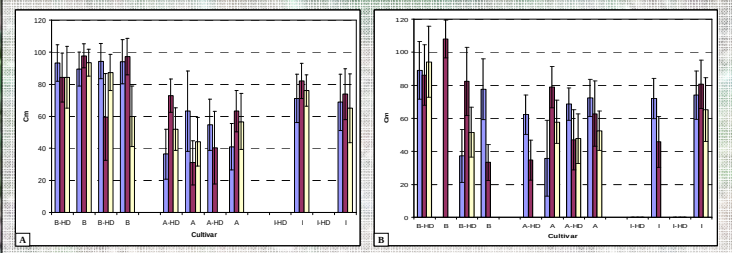


Fig 8: *Miscanthus* growth measured in Autumn 2010 depending on cultivar (B, A and I), density (HD: high density) and mycorhization (Fig 8A: unmycorhyzed; Fig 8B: mycorhyzed)

References

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