PHYTOCHEM: DEVELOPING ECO-INNOVATIVE CHEMICAL PROCESSES TO VALORISE PHYTOREMEDIATION-BORNE BIOMASSES

Michel Chalot[a], M Assad[b], N Brosse[b], V Bert[c], L Ciadamidaro[a], A Durand[a], G Clave[d], G Gorazureta[d], C Grison[d], L Marchand[e], M Mench[e], C Moyen[a], N Oustrière[e], J Parelle[a], P Reynaud[f], F Tatin Froux[a]

[a] **Université de Bourgogne Franche-Comté, Laboratoire Chrono-Environnement, Montbéliard, France**
[b] **Université de Lorraine, LERMAB, Vandoeuvre-Les Nancy, France**
[c] **INERIS, Clean and Sustainable Technologies and Processes Unit, DRC/RISK, Parc Technologique Alata, Verneuil en Halatte, France**
[d] **CNRS – Université de Montpellier, ChimEco Laboratory, Cap Delta, Grabels, France**
[e] **INRA-Université de Bordeaux, UMR 1202 BIOGECO, Pessac cedex, France;**
[f] **Groupe Pépinières Daniel SOUPE, Les Lazares, Châtillon sur Chalaronne, France;**
michel.chalot@univ-fcomte.fr

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Introduction

Industrial and urban activities impact our environment, especially in terms of soil pollution. During the last two decades, gentle soil remediation techniques have emerged using various plant species and the combination of microbial biotechnologies. Several phytotechnologies can be applied to produce useable biomass, alleviate pollutant linkages and restore services of polluted soils: (1) phytostabilisation, which uses perennials able to sorb and immobilize trace elements (TE) in excess in the root zone, avoiding their transfer toward groundwater and aerial parts while preventing their bioaccumulation in the food chain as well as dispersion by natural agents (2) phytoextraction, based on root-to-shoot transfer and storage of TE in harvestable plant parts. The PHYTOCHEM project aims at promoting chemically-based valorisation processes of the plant biomasses collected from polluted sites managed by eco-innovative phytotechnologies.

Methods

Implementing new field trials and plant monitoring

Two TE-contaminated sites (site 1 : Leforest, North of France, an agricultural soil contaminated by Cd, Pb and Zn from a Zn/Pb smelter; and site 2 : Thann, North-East of France, tailings pond from a TiO_2 extractive industry, with high Fe- and Mn-enriched gypsum red) were selected for planting large panels of woody species, *i.e.* 16 species at site 1 and 18 species at site 2. Leaf and twig samples of all plant species were collected in october 2015 after two growing seasons and analysed for their ionome (*i.e.* TE and major macronutrients), following a protocol described by (Migeon et al 2009), using ICP-AES (Inductively Coupled Plasma-Atomic Emission Spectroscopy).

Valorizing plant biomasses through sustainable chemically-based processes

In one option, the harvested biomass was treated through a prehydrolysis step to convert the phytoremediation-borne phytomass into valuable starting materials for biorefineries and the production of biofuel and biomaterials. In another option, the phytomass of metal-accumulator plant species was used for ecocatalysis.

Results

As a first step towards the development of chemically-based valorisation processes of plant biomasses collected from polluted sites, we have successfully implemented 16 and 18 woody species at two phytomanagement sites in 2014 (Figure 1). Based on ICP-AES analysis, TE concentrations in aboveground tissues highly varied, illustrating the metal tolerance processes developed by plants, either by exclusion or accumulation. We further applied chemical processes to contaminated biomasses. For instance, optimization of an organosolv pre-treatment allowed for removing ca. 50% of Fe and Mn from contaminated biomasses, while **Ecocatalysis was also successfully applied to i.e. Zn hyperaccumulating species (*Arabidopsis halleri* L.) through innovative domino reactions.**

Figure 1. Photograph of the experimental site 2 (October 2015) showing the successful implementation of woody crops (left) and details of a *Salix* species (right)

Conclusion

Chemical valorization processes based on ecocatalysis concept were successfully applied to phytoremediation-borne biomasses. The PHYTOCHEM project will lead to the marketing of a truly eco-innovating production chain that could meet the needs of an emerging, high-prospect market within the bio-economy.

References

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