

PHD PROPOSAL FOR THE DOCTORAL SCHOOL « Ecologie, Géosciences, Agronomie, ALimentation »

GENERAL INFORMATION

Thesis title: Synergistic improvement of soil decontamination: combination of nanoparticles with phytoremediation
Acronym: SYNAPHYTO
Disciplinary field 1: Ecology Disciplinary field 2: Geosciences
Three keywords: phyto-extraction, pollutants, nanotechnology
Research unit : UMR 6553 ECOBIO
Name of the thesis director HDR (Habilitation thesis to supervise research) required: CABELLO HURTADO, Francisco Email address of the thesis director: francisco.cabello-hurtado@univ-rennes1.fr Name of the thesis co-director (if applicable): HDR (Habilitation thesis to supervise research) required: PÉDROT, Mathieu Email address of the thesis co-director (if applicable): mathieu.pedrot@univ-rennes1.fr
Thesis grant (funding origin and amount): Contrat Ordinaire UR1 (UR1 Ordinary Contract)
Contact(s) (mailing address and E-mail): Francisco CABELLO HURTADO Université Rennes 1, Campus Beaulieu, UMR ECOBIO , BAT 14A, Avenue Général Leclerc, 35042 Rennes francisco.cabello@univ-rennes1.fr
Recruitment process: Recruitment process depends on thesis funding. To select the corresponding recruitment process, please visit the EGAAL website here . This information is needed for proposal publication. <input checked="" type="checkbox"/> Doctoral school contest <input type="checkbox"/> Interview <input type="checkbox"/> Other (indicate) :

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SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

Socio-economic and scientific context: (10 lines)

Water, soil and air pollution have dramatically increased with industrial development, it is estimated that there are several million of potentially polluted sites in Europe and hundreds of thousands in France. Indeed, the development of urban, industrial and agricultural activities in recent decades has led to many pollution problems, notably in Trace Elements (TE) and organic pollutants and is thus one of the major problems of our time since they pose significant risks for human, animal and plant health. Conventional remediation methods are extremely costly and often harmful to soils. In facing this environmental challenge, it was considered important to develop a low-cost, environmentally-friendly technology that uses plants for soil remediation by phytoextraction. On the other hand, these methods are slow and several years are needed to clean up pollution. It is therefore appropriate to increase the phytoavailability of these elements by promoting their transfer from the solid phase of the soil to plant tissues.

Assumptions and questions (8 lines)

The stimulation of phytoextraction by the use of adjuvants impacting the dynamics of contaminants and/or plant development is an alternative explored in the host laboratory. In this context, inorganic colloid-based adjuvants (AdjuvOx) have been shown to be high potential candidates, which may increase the amount of pollutants available to the plant. In addition, this interaction can be beneficial for plants, as AdjuvOx has shown an ability to stimulate plant growth. In particular, AdjuvOx is extremely reactive to the 'organic matter' compartment of soils and TE, improving agronomic potential. The ambition of this project is to prove *in situ* the stimulative potential of AdjuvOx on phytoextraction, in order to propose it as a means of natural, ecological and low-cost rehabilitation.

The main steps of the thesis and scientific procedure (10-12 lines)

The project targets are a) to determine the behaviour of AdjuvOx in soil and the changes induced on the physico-chemical properties of the soil and on the elemental composition of the soil solution, (b) study the impact of these changes on the mobility of pollutants in soils and (c) analyze soil/plant transfer and cover behaviour. The main steps of the thesis will be to:

- (i) Establish a protocol to compare several different situations at the plant diversity level. The experiments will cover soils with varying degrees and nature of pollution belonging to former industrial sites and urban lands,
- (ii) Establish a system to facilitate the availability of pollutants to plants,
- (iii) Establish and characterize a soil modifying system to stimulate plant action and protect plants,
- (iv) Work systemically on this environment by observing earthworm populations, plants and insects.

Methodological and technical approaches considered (4-6 lines)

A qualitative (DLS, Imaging) and quantitative characterization of the composition of soil leachate (ICP-MS, TOC, Fluo 3D) will be performed. Soil/plant transfer and translocation of EMTs to different parts of the plant will be determined from elementary geochemical analyses (ICP-MS after chemical digestion) and magnetic susceptibility measurements. The precise location of the ETM in the various plant organs can be determined by imaging (MEB-EDS, HR-MET, NanoSIMS).

Scientific and technical skills required by the candidate

Plant biology and biochemistry, soil bio-geochemistry, analytical chemistry, data analysis and processing, ability to interact with multidisciplinary scientists

THESIS SUPERVISION¹

Unit name: ECOBIO (UMR 6553 UR1-CNRS)	Team name: EcoStress-EcoTox
Unit director name: Joan VAN BAAREN	Team director name: David RENAULT
Mailing address of the unit director: joan.van-baaren@univ-rennes1.fr	Mailing address of the team director: david.renault@univ-rennes1.fr
<p>Thesis director</p> <p>Surname, first name: CABELLO HURTADO, Francisco</p> <p>Position: Maître de Conférences HC</p> <p>Obtained date of the HDR (Habilitation thesis to supervise research): 26th of January 2012</p> <p>Employer: Université de Rennes 1</p> <p>Doctoral school affiliation: EGAAL</p> <p>Rate of thesis supervision in the present project (%): 50</p> <p>Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 50</p> <p>Number of current thesis supervisions/co-supervisions: 1</p>	
<p>Thesis co-director</p> <p>Surname, first name: PÉDROT, Mathieu</p> <p>Position: Maître de Conférences</p> <p>Obtained date of the HDR (Habilitation thesis to supervise research): 21st of September 2018</p> <p>Employer: Université de Rennes 1</p> <p>Doctoral school affiliation: EGAAL</p> <p>Rate of thesis supervision in the present project (%): 50</p> <p>Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 100</p> <p>Number of current thesis supervisions/co-supervisions: 2</p>	
<p>Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years)</p> <p><i>Please provide the following information for <u>each</u> PhD students supervised</i></p> <p>Surname, first name: KELLER, Jean</p> <p>Date of PhD beginning and PhD defence: 01/10/2014 - 07/12/2017</p>	

¹ In EGAAL Doctoral School, if only one scientist in thesis supervision = 100% of supervision rate; if 2 people involved in thesis supervision = from 50% to 70% of supervision rate for the director; if 3 people involved in thesis supervision = 40% / 30% / 30% of supervision rate distribution among supervisors.

Thesis supervision: Director: F. Cabello Hurtado; Co-supervisor: A. Aïnouche

Professional status and location: Researcher. Symbiose mycorhizienne et Signalisation cellulaire (University Paul Sabatier-Toulouse III, UMR 5546 - LRSV)

Contract profile (post-doc, fixed-term, permanent): Post-doc

List of publications from the thesis work:

Cabello-Hurtado F., Keller J., Ley J., Sanchez-Lucas R., Jorrín-Novo J.V., Aïnouche A. (2016) Proteomics for exploiting diversity of lupin seed storage proteins and their use as nutraceuticals for health and welfare. *Journal of Proteomics* 143 : 57–68 ; **Keller J., Rousseau-Gueutin M., Martin G. E., Morice J., Boute J., Coissac E., Ourari M., Aïnouche M., Salmon A., Cabello-Hurtado F., Aïnouche A. (2017)** The evolutionary fate of the chloroplast and nuclear *rps16* genes as revealed through the sequencing and comparative analyses of four novel legume chloroplast genomes from *Lupinus*. *DNA Research* 24(4) : 343-358 ; **Keller J., Imperial J., Ruiz-Argüeso T., Privet K., Lima O., Michon-Coudouel S., Biget M., Salmon A., Aïnouche A., Cabello-Hurtado F. (2018)** RNA sequencing and analysis of three *Lupinus* nodulomes provide new insights into specific host-symbiont relationships with compatible and incompatible *Bradyrhizobium* strains. *Plant Science* 266 : 102-116 ; **Keller J., Delcros P., Libourel C., Cabello-Hurtado F., Aïnouche A. (2020)** DELLA family duplication events lead to different selective constraints in angiosperms. *Genetica*, 148 : 243-251.

Surname, first name: DEMANGEAT, Edwige

Date of PhD beginning and PhD defence: 01/10/2015 - 10/12/2018

Thesis supervision: Director: F. Cabello Hurtado, Aline Dia, Mathieu Pédrot

Professional status and location: Researcher. Equipe du Pr Ilya Gelfand, Ben Gurion University of the Negev, Israel

Contract profile (post-doc, fixed-term, permanent): Post-doc

List of publications from the thesis work:

Demangeat E., Pédrot M., Dia A., Bouhnik-le-Coz M., Grasset F., Hanna K., Mahamadou K., Cabello-Hurtado F. (2018) Colloidal and chemical stability of iron oxides nanoparticles in aqueous solutions: the interplay of structural, chemical and environmental drivers. *Environmental Science: Nano* 5 : 992-1001 ; **Demangeat E., Pédrot M., Dia A., Bouhnik-Le-Coz M., Davranche M., Cabello-Hurtado F. (2020)** Surface modifications at the oxide/water interface: implications for Cu binding, solution chemistry and chemical stability of iron oxide nanoparticles. *Environmental Pollution*, 257 : 113626 ; **Demangeat E., Pédrot M., Dia A., Bouhnik-Le-Coz M., Roperch P., Compaoré G., Cabello-Hurtado F. (2021)** Investigating the remediation potential of iron oxide nanoparticles in Cu-polluted soil-plant systems: coupled geochemical, geophysical and biological approaches. *Nanoscale Advances*. doi: 10.1039/D0NA00825G.

Five main recent publications of the supervisors on thesis subject:

Cabello-Hurtado F., Lozano-Baena M.D., Neaime C., Burel A., Jeanne S., Pellen-Mussi P., Cordier S., Grasset F. (2016) Studies on **plant cell toxicity** of luminescent silica **nanoparticles** (Cs₂[Mo₆Br₁₄]@SiO₂) and its constitutive components. *Journal of Nanoparticle Research* 18 : 69.

Guénet H., Davranche M., Vantelon D., Gigault J., Prevost S., Tache O., Jaksch O., **Pédrot M.**, Dorcet V., Boutier A. and Jestin J. (2017) Characterization of **iron-organic matter nano-aggregate** networks through a combination of SAXS/SANS and XAS analyses: impact on As binding. *Environmental Science: Nano*, 4: 938-954.

Pellen-Mussi P., Tricot-Doleux S., Neaime C., Nerambourg N., **Cabello-Hurtado F.**, Cordier S., Grasset F., Jeanne S. (2018) Evaluation of functional SiO₂ **nanoparticles toxicity** by a 3D culture model. *Journal of Nanoscience and Nanotechnology*, 18(5): 3148-3157.

Demangeat E., **Pédrot M.**, Dia A., Bouhnik-Le-Coz M., Grasset F., Hanna K., Mahamadou K., **Cabello-Hurtado F.** (2018) Colloidal and chemical stability of **iron oxides nanoparticles** in aqueous solutions: the interplay of structural, chemical and environmental drivers. *Environmental Science: Nano*, 5: 992-1001.

Al-Sid-Cheikh, M., **Pédrot, M.**, Dia, A., Davranche, M., Jeanneau, L., Petitjean, P., Bouhnik-le-Coz, M., Cormier, M.-A., Grasset, F. (2019) Trace element and organic matter mobility impacted by Fe₃O₄-nanoparticle surface coating within wetland soil. *Environmental Science: Nano*, 6, 3049-3059.

Demangeat E., **Pédrot M.**, Dia A., Bouhnik-Le-Coz M., Davranche M, **Cabello-Hurtado F.** (2020) Surface modifications at the oxide/water interface: implications for Cu binding, solution chemistry and chemical stability of iron oxide nanoparticles. *Environmental Pollution*, 257 : 113626.

Demangeat E., **Pédrot M.**, Dia A., Bouhnik-Le-Coz M., Roperch P., Compaoré G., **Cabello-Hurtado F.** (2021) Investigating the remediation potential of iron oxide nanoparticles in Cu-polluted soil-plant systems: coupled geochemical, geophysical and biological approaches. *Nanoscale Advances*. doi: 10.1039/D0NA00825G.

THESIS FUNDING

Origin(s) of the thesis funding: Contrat Ordinaire UR1 (UR1 Ordinary Contract)

Gross monthly salary: 1 769 euros

Thesis funding state : Non acquired

Funding beginning date/Funding ending date: 01-10-2021 / 3 years

Date: 15 march 2021

Name, signature of unit director: Joan Van Baaren



Joan VAN BAAREN
Directrice de l'UMR Ecobio

Name, signature of team director: David Renault



Name, signature of thesis project director: Francisco Cabello Hurtado

