LE STUDIUM RESEARCH FELLOWSHIP

– PIVOTS PROGRAMME – ARD 2020

(Open to international experienced researchers)

Research Project: Development of numerical models for the characterization and treatment of vadose zone contaminated by light non-aqueous phase liquids

Research Field: Flow and transport in porous media

CONTEXT

The Région Centre-Val de Loire Ambition for Research and Development 2020 (ARD 2020) PIVOTS (Environmental Technology Innovation, Development and Optimisation Platforms project) Programme is supported by LE STUDIUM Loire Valley Institute for Advanced Studies for the attraction and recruitment of international experienced researchers.

The PIVOTS Programme is a coordinated set of seven experimental and analytical platforms focused on environmental quality monitoring and sustainable management of natural resources (soil, subsurface, surface water, groundwater, sediment and air) within a context of global change.

Innovation in the area of the environment, ecotechnology, and ecoservices is a major challenge for sustainable development in today's societies. Innovations may arise from an integrated approach based research involving academic and industrial experts together at all stages of the value chain, from fundamental research to validation of products and services. The goal of the PIVOTS Programme is to accomplish this integration and to promote the emergence of an economic stream in the area of environmental metrology, remediation processes and associated services.

The successful candidate will be invited for a one-year fellowship to work on the PRIME Platforms for the Remediation and Innovation for Environmental Metrology and will benefit from the dynamic scientific environment of the region Centre-Val de Loire (France). As a LE STUDIUM Loire Valley Institute for Advanced Studies Research Fellow, s/he will be part of an outward looking and stimulating pluri-disciplinary scientific and international community.

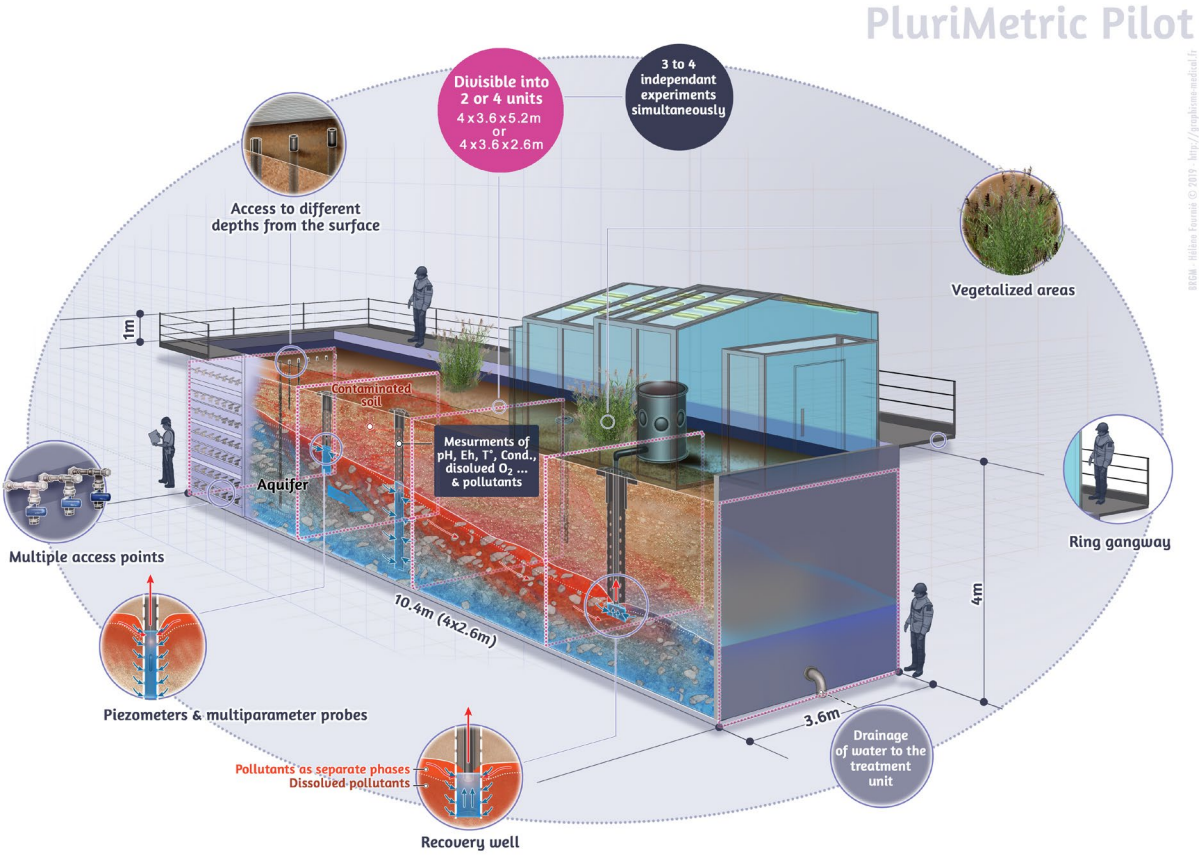
SCIENTIFIC RESEARCH CONTEXT

Sustainable and effective remediation of contaminants from subsurface is one of the biggest challenges in current environmental issues. This requires the use of innovative and effective treatment techniques to remediate polluted sites and to limit the risk of spreading the contaminations to groundwater. A research team at BRGM (see references below) is working to study the fate and transport of organic pollutants for remediation perspective using a multiscale approach. One of the main current research projects of the team is to study new techniques for the characterization and treatment of vadose zone contaminated by light non-aqueous phase liquids (LNAPLs).

LNAPLs are among the persistent sources of pollution that often comes from accidental oil spills (gasoline, diesel, engine oil, etc.). Under the action of capillary forces, part of the LNAPL remains trapped during its

downward migration. LNAPLs typically comprise a complex mixture of predominantly hydrocarbon organic chemicals. Their subsurface transport is complex, being a multi-phase (LNAPL-water-air) flow problem, but is often characterized by an accumulation of buoyant hydrophobic LNAPL in the vicinity of the water table interface that has potential to migrate laterally or redistribute vertically due to water table fluctuations.

Water table fluctuations, geological heterogeneity and complex LNAPL distributions makes them difficult to remove using standard methods. Foam injection presents an innovative and alternative of great industrial interest for the in-situ remediation of contaminated aquifer. The few tests carried out show a significant increase of the treatment efficiency compared to the conventional technique in the saturated zone. Foam for dense non-aqueous phase liquids mobilization use the low surface tension of surfactant solution and the foam high viscosity to desorb and push oil or pollutant to a recovery well. However, its application in vadose zone for LNAPL treatment is questionable. Experimental studies are under consideration in order to assess the efficiency of foam for LNAPL treatment in the vadose zone as well as in the capillary fringe using a multiscale approach (column, 2D small tank and especially the BRGM PluriMetric Pilot, see Fig. below). The modeling of the LNAPL flow is based on the characteristic curves of the three-phase flow which makes it possible to relate the capillary pressures and the saturations in water, in NAPL and in the air. The equations that govern these phenomena (*i.e.* the generalized Darcy equations) can be combined in a fractional flow formulation, *i.e.* in terms of global pressure and two saturations. However, this simplified model cannot capture the capillary behavior of a three-phase water-NAPL-air system in porous media, in particular, when the NAPL saturation is low. The overall pressure-saturation formulation has been shown to be most effective from a numerical point of view. The objective of the work to be conducted through the fellowship is to develop a numerical model that appropriately integrates the imbibition and drainage behavior of LNAPLs, taking into account the complex behavior of the foam flow in porous media particularly, non-Newtonian and compressibility effects.



Multi-metric pilot (MMP). © BRGM

References

Colombano, S., Davarzani, H., van Hullebusch, E., Huguenot, D., Guyonnet, D., Deparis, J. and Ignatiadis, I.: 2020, Thermal and chemical enhanced recovery of heavy chlorinated organic compounds in saturated porous media: 1D cell drainage-imbibition experiments, *Science of The Total Environment* 706, 135758.

Davarzani, H., Smits, K., Tolene, R. M. and Illangasekare, T.: 2014, Study of the effect of wind speed on evaporation from soil through integrated modeling of the atmospheric boundary layer and shallow subsurface, *Water Resources Research* 50(1), 661–680.

Iravani, M. A., Deparis, J., Davarzani, H., Colombano, S., Guérin, R. and Maineult, A.: 2020, The influence of temperature on the dielectric permittivity and complex electrical resistivity of porous media saturated with DNAPLs: A laboratory study, *Journal of Applied Geophysics* 172, 103921.

Maire, J., Davarzani, H., Colombano, S. and Fatin-Rouge, N.: 2019, Targeted delivery of hydrogen for the bioremediation of aquifers contaminated by dissolved chlorinated compounds, *Environmental Pollution* 249, 443 – 452.

Maire, J., Joubert, A., Kaifas, D., Invernizzi, T., Marduel, J., Colombano, S., Cazaux, D., Marion, C., Klein, P.-Y., Dumestre, A. and Fatin-Rouge, N.: 2018, Assessment of flushing methods for the removal of heavy chlorinated compounds DNAPL in an alluvial aquifer, *Science of The Total Environment* 612, 1149 – 1158.

MISSION OF THE RESEARCH SCIENTIST

The successful candidate will have the following missions:

- to strengthen the theoretical and modeling knowledge of the research team
- to develop the numerical models to study the foam flow in porous media at laboratory scale
- to use the simulation outcomes to help design and validate new experimental setup and protocol for the projects.
- to use the PRIME platform as a frame to validate the developed model against the experimental results
- to carry out internationally outstanding research for the above-mentioned project
- to disseminate this research through articles in journals of international standing, monographs and other appropriate forms of dissemination, including national and international conference presentations
- to support, comply with, and fully contribute to research plans and policies of the project team

ESSENTIAL SKILLS AND EXPERIENCE

- Senior researcher profile with:
    - record of publications in international peer-reviewed journals and significant international networks;
    - ability to mobilize the literature and to build testable hypotheses;
    - research experience in the field of study, able to innovate and interact with diverse stakeholders including industry;
- Experience in modeling flow and transport in porous media, NAPL fate and transport, complex fluid flow in porous media;
- Experience in pore and Darcy scale numerical simulation including multiphase flow;
- Ability to initiate new projects in the field of soil remediation;
- Strong organizational and time management skills - able to prioritize work, manage time effectively and deliver results on time;
- Excellent written and verbal communication skills, including the ability to make clear and concise presentations and prepare compelling grant proposals.
- Proven ability to control the whole research chain from the definition of the problem to the communication of results, both for academic, industrial R & D and non-academic audiences;

- Experience and motivation for team work and ability to establish fruitful scientific exchanges with researchers and actors of different technical and scientific cultures;

CONDITIONS OF ELIGIBILITY

The fellowship is intended to attract an experienced international researcher in possession of a doctoral degree and a minimum of five years of full-time research experience, preferably ten.

- Applicant researchers must be national or long-term resident of a country other than France, i.e. having spent a period of full-time research activity of at least 5 consecutive years in a country other than France.
- Applicant researchers must also comply with the following mobility rule: not having resided or carried out their main activity (work, etc.) in France for more than 12 months in the 3 years immediately prior to the deadline of application.

CONDITIONS OF EMPLOYMENT

The position is based in Orleans, France and offers 12 months of residency (two periods of 6-month residency can be considered).

The successful candidate will be welcomed into the PIVOTS team network and LE STUDIUM faculty of international research fellows working in the region Centre-Val de Loire. Researchers will be provided with the necessary means of work (laboratory facilities, office, telephone, internet, access to databases, computer tools, etc ...).
The scientific working languages are French and English.
Entitlements detailed in the French labour contract of employment include:

- a personal salary.
- rental costs of a fully furnished apartment for the candidate and her/his family. Utilities (water, heating, electricity, tax) have to be paid by the fellow.
- Affiliation to the French social security protection scheme and a contribution to a private medical protection scheme for all health costs complementing the French basic social security coverage.
- Working hours, vacation and travelling expenses are bound by the same regulation as those effective for the personnel of the hosting laboratory.
- Logistics and administrative assistance by a member of LE STUDIUM operational team before and during the fellowship (housing, bank, insurance, schooling…).

CONDITIONS OF APPLICATION

Online application via LE STUDIUM platform: **Apply section**
The deadline for application is **30 April, 2020.** Applications will be reviewed as they come in.
The position is expected to be filled no later than September 2020.
The application shall consist of three elements:

- A completed online LE STUDIUM application form with personal information and details of track records;
- A curriculum vitae of maximum two pages including information not in the online application;
- A motivation letter.

Upload documents as pdf files.