LE STUDIUM RESEARCH FELLOWSHIP

– PIVOTS PROGRAMME – ARD 2020

(Open to international experienced researchers)

Research Project: Development of numerical models for the characterization of natural hydro-systems, and treatment of vadose and capillary zones contaminated by light non-aqueous phase liquid

Research Field: Flow and transport in porous media

CONTEXT

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

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 eco-services 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 the 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 and O-ZNS (https://plateformes-pivots.eu/?lang=en) Platforms for the Vadose Zone fluid flows and 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

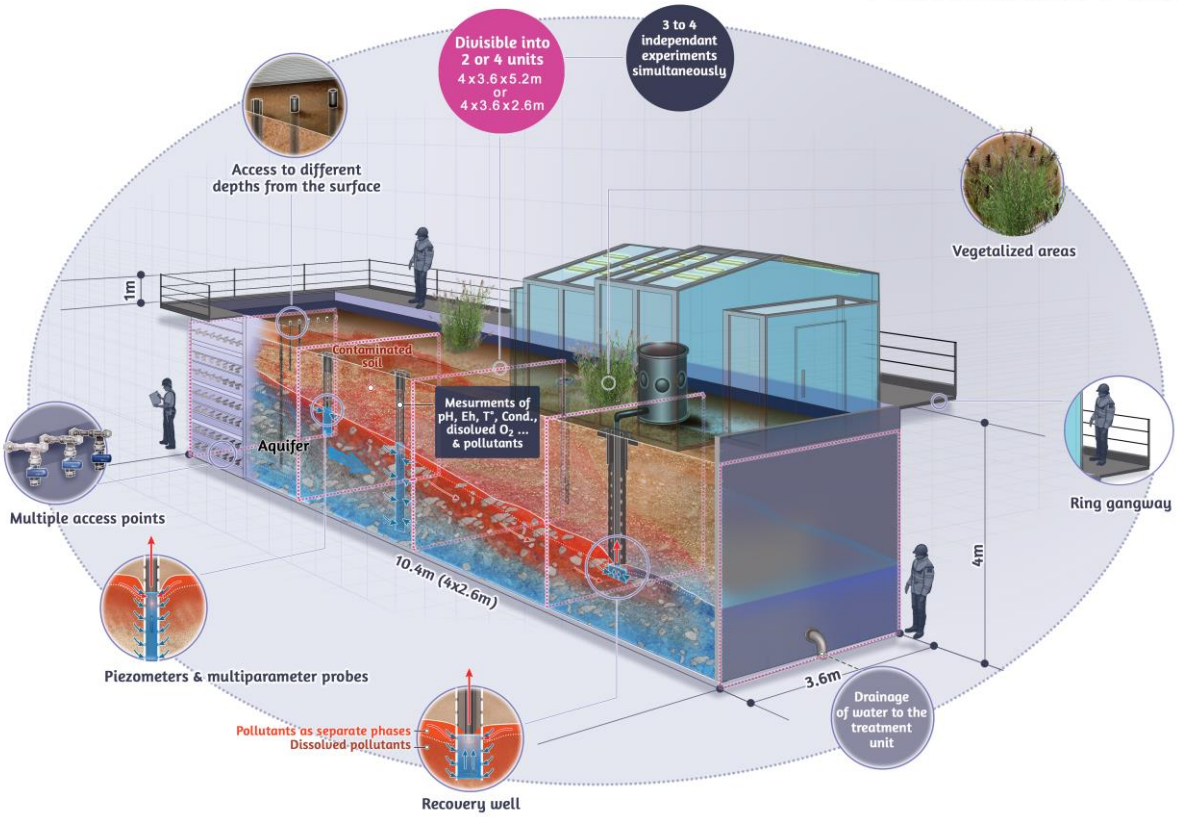
Sustainable and effective remediation of contaminants from the subsurface is one of the biggest challenges in current environmental issues. This requires the use of innovative and effective treatment techniques to remediate polluted sites and to limit the risk of spreading the contaminations to groundwater. A research team at BRGM (the French Geological Survey) and ISTO (Earth Science Institute of Orléans) is working to study the fate and transport of organic pollutants for remediation perspective using natural observatories and multiscale pilots approach (see references below). One of the main

current research projects of the teams is to study natural flows on the unsaturated zone and 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.

The vadose zone (VZ) is known to play a major role within the critical zone as a controlling agent in the transmission of recharging water as well as contaminants from the land surface to groundwater. A quantitative study of the hydraulic properties of the VZ materials and the water flow in the VZ represents a first step towards analyzing and capturing heterogeneous vadose zone characteristics and environmental pollution problems. For this purpose, O-ZNS observatory provides an instrumented experimental site located in the heart of the Beauce region and a specialized laboratory situated at the ISTO. By combining characterization in the laboratory (tri-axial system, pressure-plate apparatus, elution experiments in undisturbed columns, micro-tomography, etc.), in situ measurements in the vadose, O-ZNS platform will allow a precise determination of the hydraulic properties of the VZ materials and monitoring of the water flow in the VZ at various temporal and spatial scales. However, major issues and challenges remain concerning the further conceptualization of vadose zone complexities, incorporation into, and parameterization of models.

In addition, water table fluctuations, geological heterogeneity, and complex LNAPL distributions make them difficult to remove using standard methods. Foam injection presents an innovative and alternative of great industrial interest for the in-situ remediation of the contaminated aquifer. The few tests carried out show a significant increase in 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 the vadose zone for LNAPL treatment is questionable. Experimental studies are under consideration 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 was 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 (i) the heterogeneous vadose zone architecture, (ii) the multi-scale aspects (iii) the imbibition and drainage behavior of LNAPLs in a three-phase system; (iv) (v)the complex behavior of the foam flow in porous media particularly, non-Newtonian and compressibility effects. The developed model will be then validated against the experimental and observatory data of the PRIME and O-ZNS platforms.



Multi-metric pilot (MMP) © BRGM

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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 multiphase flows (air-water, air-water-LNAPL) in porous media at laboratory and observatory scales
- to use the simulation outcomes to help design and validate new experimental setup and protocol for the projects and identify missing measurements
- to use the PRIME and O-ZNS platforms as a frame to conceptualize and validate the developed model against the experimental and observatory 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 PRIME and O-ZNS teams.

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 and multi-disciplinary teams and stakeholders including industry;
- Experience in modeling flow and multiphase 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 and water resource protection;
- 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 teamwork and the 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 **16th June, 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.