Université de technologie de Compiègne – Thesis proposal

Part 1: Scientific sheet	
Thesis proposal title	Pili implication from pathogenic bacteria into groundwater contamination
PhD grant	PhD Grants from the China Scholarship Council: Co-operation Program with the UTs and INSAs (France), Program 2023
Research laboratory	Laboratory: EA 4297 Transformations Intégrées de la Matière Renouvelable (TIMR) Website: https://www.utc.fr/timr/ UMR 8576 CNRS, Unité de glycobiologie structurale et fonctionnelle (UGSF)
Thesis supervisor(s)	Edvina LAMY, Ass. Prof. Yannick ROSSEZ, CNRS Ass. Prof.
Scientific domain(s)	Science and technology Earth science, Environnement and Biology.
Research work	Microorganisms such as bacteria, coming from human or animal wastes may travel through soil to groundwater from a contamination source, and when these microorganisms are present in drinking water or fresh produces, they can result in serious health hazards (Bai *et al*., 2022). Thus, a better understanding of the transport and adhesion of bacteria in soil is necessary to elaborate future strategies to protect the surface and groundwater supplies and soil from microbiological contamination. Bai *et al*. (2021, 2017, 2016) performed bacteria transport and deposition experiments at laboratory column scale to investigate the simultaneous influence of both soil physical and cell properties on the mechanisms governing transport and deposition processes. Motile and non-motile bacteria were used for this work. They found that preferential transport reduced non-motile bacteria retention in the porous medium, by reducing the contact between bacteria and retention sites. But this trend was not confirmed for the motile bacteria (*E. coli*). For this reason and due to recent studies on flagellar implication on bacterial adhesion (Rossez *et al*., 2015, Cazzola *et al*., 2020 and Horstmann *et al*., 2020), flagellar properties and motility are currently investigated at UTC and university of Lille laboratories by using different mutants. The understanding of the mechanisms governing water flow and transport of pathogenic/indicator microorganisms from the soil and the vadose zone to groundwater will be investigated during this research work. *Salmonella enterica* serovar Typhimurium: this Enterobacteriaceae is found in all warm-blooded animals and in the environment. When ingested in food, *Salmonella* can invade the small and large intestine and are responsible of gastroenteritis (diarrhea, abdominal cramps, and fever) to enteric fevers (including typhoid fever). To survive in the environment, bacteria need to adhere first to the surfaces via dedicated appendages like pili or flagella. Recently, the type IV pili has been highlighted to play a crucial role for bacterial survival and spreading in water (Aguilo-Ferretjans *et al*., 2021). So far nothing is known about the role of this appendage for *Salmonella* spreading in the environment and their role into groundwater contamination. For this purpose, lab scale infiltration/percolation experiments at Darcy scale will be performed in soil with distinct pore size distribution in order to investigate and quantify contaminant and microorganisms transport process under various hydrodynamic (saturated and unsaturated) and hydraulic (various flow rates) flow conditions. To provide a better understanding of the mechanisms involved on microorganisms transport and deposition, numerical simulations with HYDRUS code will be performed to characterize water flow (tracer tests) and to estimate microorganisms transport and deposition

	parameters. The latter will be explored to identify microorganisms flow patterns and physicochemical, physical and biological mechanisms involved in microorganism's deposition. The information obtained from laboratory experiments and numerical modelling will be improved by theoretical calculation of different interactions between microorganisms and soil at air/water/solid interfaces. Interactions such as hydrophobic, steric, capillary and hydrodynamic forces involved in microorganisms deposition will be considered to describe microorganisms-interface interactions in order to identify their relative impact on microorganisms transport deposition.
Key words	bacterial transport, porous media, metabolomics, adhesins, adhesion, contamination.
Requirements	- Background and strong interest in one of the research fields: soil science, microbiology, chemical or biochemical engineering. - Good written and oral communication skills in English would be desirable. - Strong motivation for experimental work is required.
Starting time	October 2023
Location	Université de technologie de Compiègne – TIMR, Compiègne, France and université de Lille – UGSF.
References	1. Bai H., Chen J., Yang B., Hu Y., Liu W., Lamy E. (2022). Biocolloid transport and deposition in porous media: A review. Korean Journal of Chemical Engineering 39 (1), 38 – 57. 2. Bai H., Lamy E. (2021). Bacteria transport and deposition in an unsaturated aggregated porous medium with dual porosity, Environmental Science and Pollution Research 28, pages 18963–18976. 3. Bai H., Cochet N., Pauss A., Lamy E. (2017). DLVO, hydrophobic, capillary and hydrodynamic forces acting on bacteria at solid-air-water interfaces: their relative impact on bacteria deposition mechanisms in unsaturated porous media. Colloids and Surfaces B: Biointerfaces 150, 41-49. 4. Bai H., Cochet N., Pauss A., Lamy E. (2016). Bacteria cell properties and grain size impact on bacteria transport and deposition in porous media. Colloids and Surfaces B: Biointerfaces 139, 148-145. 5. Rossez, Y., Wolfson, E. B., Holmes, A., Gally, D. L. and Holden, N. J. (2015). Bacterial Flagella: Twist and Stick, or Dodge across the Kingdoms. *PLoS Pathogens*, 11. 6. Cazzola, H., Lemaire, L., Acket, S., Prost, E., Duma, L., Erhardt, M., Čechová, P., Trouillas, P., Mohareb, F., Rossi, C. and Rossez, Y. (2020). The impact of plasma membrane lipid composition on flagellum-mediated adhesion of enterohemorrhagic Escherichia coli. *MSphere*, *5*(5), pp.e00702-20. 7. Horstmann, J., Lunelli, M., Cazzola, H., Heidemann, J., Kühne, C., Steffen, P., Szefs, S., Rossi, C., Lokareddy, R., Wang, Lemaire, L.,…Rossez, Y., Kolbe, M. and Erhardt, M. (2020). Methylation of Salmonella Typhimurium flagella promotes bacterial adhesion and host cell invasion. *Nature Communications*, *11*(1). 8. Pinto, D., Santos, M. A., & Chambel, L. (2015). Thirty years of viable but nonculturable state research: unsolved molecular mechanisms. *Critical reviews in microbiology*, *41*(1), 61-76. 9. Aguilo-Ferretjans, M.D.M., Bosch, R., Puxty, R.J., Latva, M., Zadjelovic, V., Chhun, A., Sousoni, D., Polin, M., Scanlan, D.J. and Christie-Oleza, J.A. (2021). Pili allow dominant marine cyanobacteria to avoid sinking and evade predation. *Nature communications*, *12*(1), pp.1-10.

Part 2: Job description	
Duration	42 months
Research laboratory	TIMR (EA 4297) Laboratory: Chemical engineering, green chemistry and environmental engineering. Particularly, the fields of expertise related to this project are: - Hydrodynamics and mass transfer in porous media. - Transport and adhesion of bacteria in subsurface soil. - Remediation of contaminated soils. UGSF (UMR 8576): Glycobiology and bacterial adhesion.
Material resources	All of the tools and equipment needed for this PhD are available in the TIMR and the UGSF Laboratories: - Analytical platforms (Mass spectrometry, MNR...) - Documentary portals - Class 2 laboratory for microbial pathogens - Shared office with other PhD students including PC.
Human resources	TIMR laboratory is composed of 51 permanent staff members (41 academic staff and 10 technical and administrative staff), ≈42 PhD students and postdocs. UGSF laboratory is composed of 100 permanent staff members (60 academic staff from university, 20 CNRS researchers and 20 technical and administrative staff) 50 PhD students and postdocs.
International collaborations	- Dr. Bai - Ass. Prof. Henan University of Technology, School of Chemistry, Chemical and Environmental Engineering, Zhengzhou, China. - Prof. Erhardt - Humboldt-Universität zu Berlin, Germany.
Contact	Please contact: • Edvina LAMY, Ass. Prof. +33 (0)3 44 23 79 33, edvina.lamy@utc.fr • Yannick ROSSEZ, CNRS Ass. Prof. yannick.rossez@univ-lille.fr Sorbonne Université, UTC Centre de Recherches de Royallieu, TIMR 60203 Compiègne cedex, France

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