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A comprehensive study of bacterial cells reactive transport in porous media and some applications in civil and environmental engineering.

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It is now well known that we live in a microorganism's world. Indeed, microorganisms are everywhere on earth including in unsuspected places such as the troposphere, deep frozen lakes, deep aquifers, pristine media or highly aggressive environments with extreme pH, temperatures, toxic elements concentrations... This means that they are capable of moving or being mobilised through almost all environments, and colonizing all ecosystems including the human body through symbiosis or close associations. Their ubiquity, due universal occurence and ever increasing field application by humans and animals (field application of manure and sewage sludge, intensive farming, bioremediation,...), combined with their almost infinite metabolic potential make bacteria powerful allies in numerous human applications such as water and soil treatment, civil engineering, environmental restoration, pollutant degradation, etc. However, many applications remain limited or impossible due to our lack of understanding of the fine mechanisms by which bacteria are transported in the environment, particularly in porous media. Industrial processes based on injecting selected bacteria into soils or sediments are emerging in the context of in situ bio-reinforcement, metal bio-leaching, bio-augmentation, etc. It is therefore crucial to improve our understanding of the transport and retention of bacteria in porous media in order to predict and control their diffusion in the environment. In this context, we studied and modeled the factors controlling the mobility of several bacterial species of specific interest (Agrobacterium tumefaciens, Escherichia coli, Cupriavidus metallidurans CH34, Pseudomonas putida and Sporosarcina pasteurii) in porous media using a column approach. Various physical and chemical factors influencing the transport of the five bacterial species were studied in water saturated columns. The experimental and modelling results showed that these factors have a variable effect on the mobility of these model bacteria (bacterial species, cell concentration, ionic strength, solution composition...), while others have much smaller effects (cell size, pH, water flow rate, etc.). On the basis of these results, we have been able to effectively use bacterial cells injection in porous media in several types of application. For instance, we were able to bioreinforce different porous materials from river dykes in order to strengthen dykes and industrial soil environments. We were also able to apply the technology of selected bacteria injection to mobilize metals of interest from several types of materials such as polluted soils, mine tailings and waste from Electrical and Electronic Equipments (WEEE). This was done with a view to valorisation through the development of nature based solutions that can be transposed to various conditions, contexts and scales.

Keywords:
Bacterial cells, reactive transfer, porous media, columns, breakthrough curves, solution geochemistry, water flow, pH, transport modeling

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References

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