Modelling subsurface transport of antibiotic resistant bacteria in the context of wastewater reuse

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Reuse of treated wastewater (TWW) for irrigation, and aquifer recharge is an approach to overcome increasing water scarcity in many regions of the world. However, TWW reuse can be associated with a risk of spreading contaminants such as antibiotics- that are present in the treatment plant's effluent. The focus of this study; is to understand the transport of sub-inhibitory concentrations of antibiotics, antibiotic resistant bacteria and antibiotic resistance genes, in the subsurface. A process-based modelling approach is used to simulate the most important processes affecting bacterial abundances and antibiotic concentrations during soil passage.

The reactive transport model can be broadly divided to include hydrodynamic (transport) and chemical/biological (reactive) processes that are possibly active when bacteria and antibiotics move through the subsurface. The model is implemented in R/Fortran using the 'rodeo' package [1]. The governing 1-dimensional partial differential equations (PDE) are solved by the Method-of-Lines approach.

The model is non-dimensionalized, to achieve, a moderate reduction in the number of parameters. Information on the parameter values is obtained by fitting the model to data acquired in soil column experiments making use of FME [2].

Knowledge of the parameters and the dimensionless numbers give insights into the relative importance of the process in the model. Based on this information the model is further simplified to include only the important (rate limiting) processes that occur during bacterial and antibiotic transport in the subsurface.

Further scope of the project is aimed at conducting parameter estimation studies and sensitivity analysis to develop models that can simulate bacterial transport in the subsurface at larger scales. This will enable quantitative and qualitative risk assessment in the context of TWW reuse.

References:

[1] Kneis. D, Petzoldt. T, Berendonk. T. (2017). An R-package to boost fitness and life expectancy of environmental models. Environmental Modelling & Software, 96, 123-127. https://doi.org/10.1016/j.envsoft.2017.06.036.

[2] Soetaert, K., & Petzoldt, T. (2010). Inverse Modelling, Sensitivity and Monte Carlo Analysis in R Using Package FME. Journal of Statistical Software, 33(3), 1 – 28. http://dx.doi.org/10.18637/jss.v033.i03.

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