

Modelling the transport of antibiotic resistant bacteria in the subsurface

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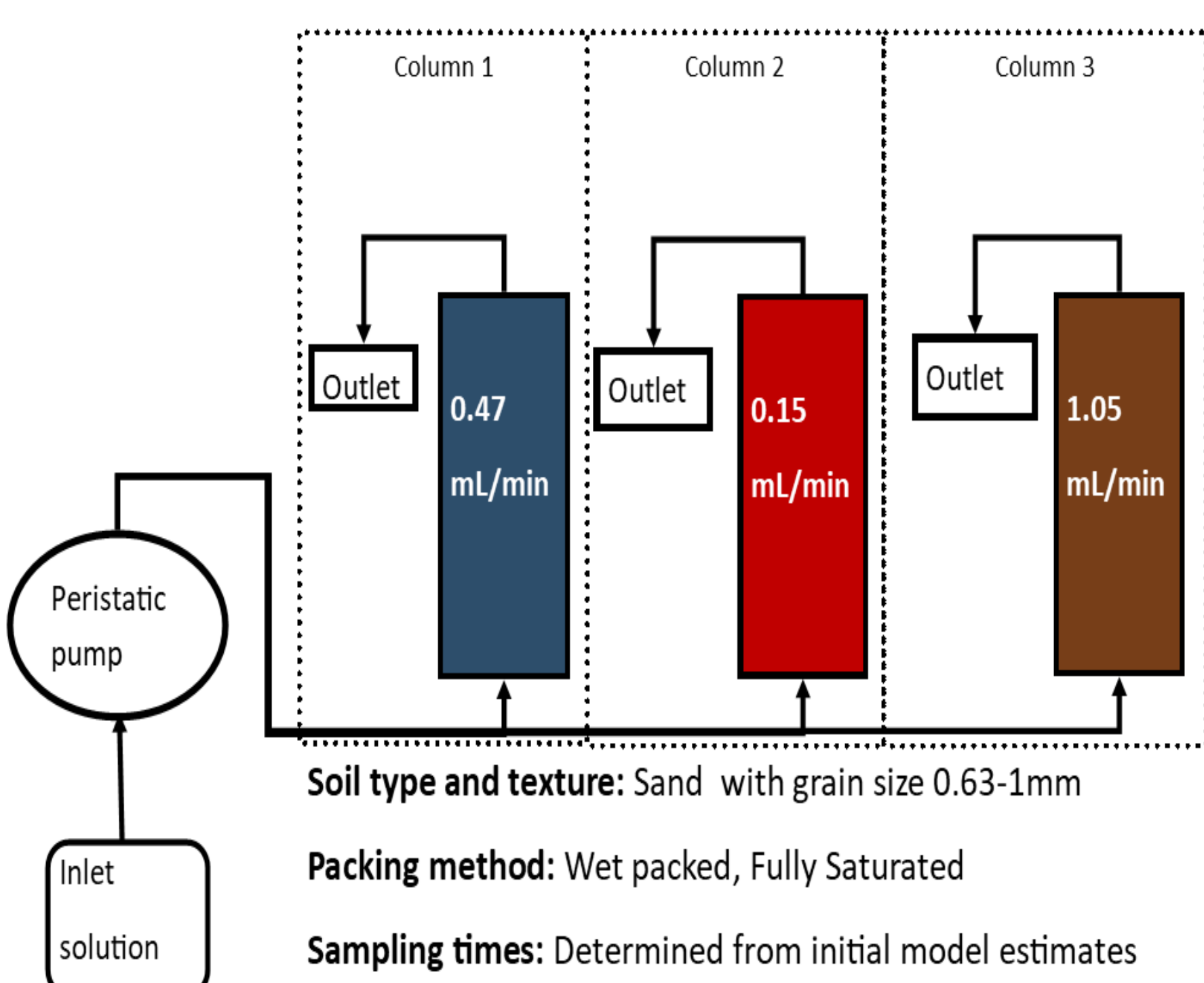
Background

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 an underlying risk of spreading contaminants like antibiotics, antibiotic resistant bacteria and antibiotic resistance genes, that are not readily removed by waste water treatment plants.

Objective

The objective of this study is to identify, and simulate the fundamental processes governing transport and proliferation of antibiotic resistant bacteria in the subsurface.

Experimental Setup



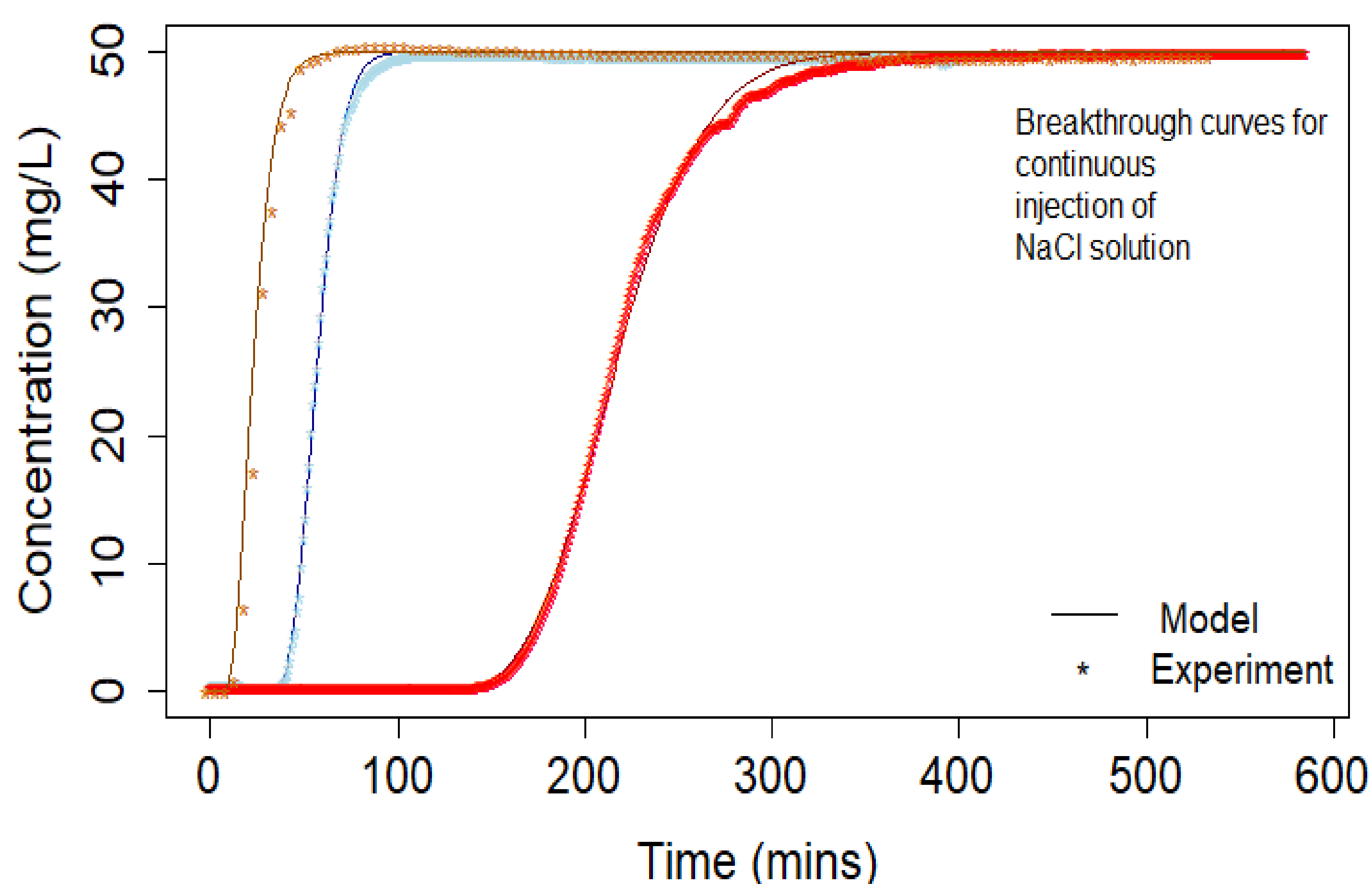
Model Equations

Variable	Accumulation	Advection	Dispersion	Growth	Respiration	Attachment	Detachment
Water-phase bacteria	$\frac{dC}{dt}$	$-V_{lin} * \frac{dC}{dx}$	$D * \frac{d^2C}{dx^2}$	$\mu_g * \frac{S}{K_g + S} * C$	$-\mu_r * \frac{C_{O_2}}{K_r + C_{O_2}} * C$	$-K_a * C$	$K_d * C * \frac{\rho}{\theta}$
Substrate	$\frac{dS}{dt}$	$-V_{lin} * \frac{dS}{dx}$	$D * \frac{d^2S}{dx^2}$	$-\frac{\mu_g}{Y_g} * \frac{S}{K_g + S} * C$ $-\frac{\mu_r}{Y_r} * \frac{S}{K_r + S} * C^*$			
Dissolved Oxygen	$\frac{dC_{O_2}}{dt}$	$-V_{lin} * \frac{dC_{O_2}}{dx}$	$D * \frac{d^2C_{O_2}}{dx^2}$		$\frac{\mu_r}{Y_r} * \frac{C_{O_2}}{K_r + C_{O_2}} * C$ $-\frac{\mu_r}{Y_r} * \frac{C_{O_2}}{K_r + C_{O_2}} * C^*$		
Soil-phase bacteria	$\frac{dC^*}{dt}$			$\mu_g^* * \frac{S}{K_g^* + S} * C^*$	$-\mu_r^* * \frac{C_{O_2}}{K_r^* + C_{O_2}} * C^*$	$K_a * C * \frac{\theta}{\rho}$	$-K_d * C^*$

Parameter list

V_{lin}	Linear/Pore velocity	ρ	Bulk density
D $= (d * V_{lin})$	Dispersion co-efficient (dispersion*linear velocity)	θ	Porosity
μ_g, μ_r	Growth and respiration rates in water phase	μ_g^*, μ_r^*	Growth and respiration rates in sand phase
K_g, K_r	Half-life for growth and respiration in water phase	K_g^*, K_r^*	Half-life for growth and respiration in sand phase
Y_g, Y_r	Yield factor for growth and respiration in water phase	Y_g^*, Y_r^*	Yield factor for growth and respiration in sand phase
K_a	Attachment rate	K_d	Detachment rate

Fitting of Hydrodynamic parameters



	1	2	3
θ	0.257	0.298	0.240
d (cm)	0.230	0.191	1.137
V_{darcy} (cm/min)	0.066	0.020	0.149
flowrate (mL/min)	0.47	0.15	1.05

Software used for modelling

The processes that are intended to be modelled are shown in the matrix on the right. The model is set up in the R software, using the "rodeo" [1] and "FME" [2] package, respectively. Furthermore, initial estimates for porosity and dispersivity are obtained from the equations by Käb [3].

Conclusions and Outlook

The model and experiments have been set up to the objectives of the study. The columns have been fully saturated and tracer experiments were used to determine the porosity and the dispersivity. Further experiments will be conducted to fit the model parameters involved in the equations for growth, respiration, attachment and detachment. This will enable understanding the importance of the processes for the proliferation of bacteria in soil.

References

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[3] Käss, W. (2004). Geohydrologische Markierungstechnik. Gebrüder Borntraeger. Berlin, Stuttgart, 2. Auflage. pp. 557



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