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Effects of Soil Heterogeneity and Transient Flow on Multicomponent Biodegradation

Wednesday, 2 June 2021 10:30 (15 minutes)

Aerobic biodegradation is an important mechanism of organic contaminant removal from soils. We simulate nonlinear multicomponent biodegradation and transport of contaminants in spatially autocorrelated heterogeneous unsaturated soils under transient infiltration conditions. These processes introduce spatio-temporally complex behaviour that affect contaminant travel times, the extent of reactant mixing, solute and biomass distributions in the soil, and thus also biodegradation and leaching outcomes. In heterogeneous soils, significant changes in infiltration rate may induce switching of preferential flow zones, as discussed by Roth (1995). Such interactions between the modelled complex processes also determine the extent of biodegradation. Behaviour is found that essentially differ from simplified models with monocomponent biodegradation, homogeneous soils, or steady flow. Under mixing-limited conditions, soil heterogeneity is likely to significantly increase biodegradation. Heterogeneity is less impactful under rate-limited conditions, and is neither more likely to increase or decrease biodegradation. Multicomponent biodegradation is more likely mixing-limited when infiltration rates are small, contaminant concentrations are high, and electron acceptors are abundant. Transient flow has little effect on rate-limited scenarios, but significantly decreases biodegradation in some mixing-limited scenarios. This decrease is more likely in homogeneous than in heterogeneous soils. Under transient flow, preferential flow zone switching reduces the spatiotemporal heterogeneity of biomass and contaminant concentrations, and contaminant plumes have a smaller upstream tail because there are less stagnant flow zones for contaminants to be trapped in. For the same reasons, transient flow also reduces outcome variability across heterogeneous realizations with identical macroscopic properties. Altogether, the results suggest that flow rate variability tends to suppress the effects of soil heterogeneity, while soil heterogeneity decreases the influence of flow rate variability. Furthermore, the influence of additional model complexity on outcomes is larger for mixing-limited than rate-limited biodegradation. Numerical models of multicomponent biodegradation may be simplified accordingly, allowing the computational burden of simulations to be reduced when necessary.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

Roth, K. (1995). Steady State Flow in an Unsaturated, Two-Dimensional, Macroscopically Homogeneous, Miller-Similar Medium. Water Resources Research, 31(9), 2127-2140.

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