Contribution ID: **417** Type: **Oral Presentation**

Dynamics of contaminant flow through porous media containing biochar adsorbers

Monday, 13 May 2024 17:45 (15 minutes)

Biochar is used as an additive in green roof soil substrates to aid in the regulation of fertilizer storage and dispersal, preventing unwanted runoff of the chemicals. The evolution of contaminant transport and adsorption by biochar added to a packed bed is analyzed using experiments and simulations. Experiment 1 is used to determine the equilibrium capacity and adsorption rate of two types of biochar when immersed in a methylene blue solution. Experiment 2 determines the breakthrough curves of a packed bed of glass beads with randomly interspersed biochar as a methylene blue solution is circulated. Simulations are run using the properties extracted from experiment 1 and the results are compared with experiment 2. An analytical model is proposed and utilized to mimic the behavior of biochar reaching equilibrium, unable to remove additional solute. Monodisperse beds are superior in the removal of solute but removal efficiency is heavily related to the surface area of the reactive particles and the rate at which they become unable to remove additional solute. The cases using the analytical model display a tight distribution of particle surface concentration at times after the solution front passing, indicating full immersion in the solution and therefore maximum removal efficiency. In comparison, the cases with constant reactivity display a much wider distribution of surface concentrations, indicating uneven exposure. The polydisperse beds create more channeling effects which reduce reactive particle efficiency and lead to higher breakthrough concentration profiles. Comparison between experiments and simulations show good agreement with breakthrough curves.

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Session Classification: MS08

Track Classification: (MS08) Mixing, dispersion and reaction processes across scales in heterogeneous and fractured media