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Three-Dimensional Numerical Simulations of Variably Saturated Flow Through Woodchips

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The leachate generated from open stockpiles of recycled woodchip materials has been linked to several cases of aquatic impairment. To better understand the environmental impact of these recycling practices, flow models can be used to simulate the movement of water within stockpiles as well as predict subsequent leachate quantities/pollutant loadings. The objective of this work was to optimize a three-dimensional numerical model that could simulate transient water movement through actual woodchip stockpiles in an effort to forecast leachate generation. Leachate measurements from an experimental stockpile (32 m^3) with known geometry, and consisting of woodchips with a mean diameter of approximately 2.5 mm, were continuously collected over a period of six months using a one-liter tipping bucket flow gauge. The commercially available HYDRUS-3D modeling software was used in conjunction with the Bayesian MCMC package $DREAM_{zs}$ to optimize the hydraulic parameters of a single porosity (SPM-based on an S-shape representation of the water retention function) and dual porosity (DPM-sum of two SPM functions) model that best simulated leachate data. Since the computational demand of optimizing a three-dimensional numerical model with an MCMC scheme is relatively large, an estimability analysis was used to decrease the number of parameters to three and four for the SPM and DPM, respectively. In addition, posterior distributions derived from one-dimensional (1D) column experiments were used to develop informed prior distributions, thereby constraining the proposal space of each hydraulic parameter within a reasonable range of values. In both the SPM and DPM, the parameters defining the shape of the water retention and water content at saturation were ranked the most estimable, while saturated hydraulic conductivity was consistently ranked one of the least. In comparison to using those hydraulic parameters obtained from 1D column experiments, preliminary modeling results highlight a significant reduction in model uncertainty/bias. Nash-Sutcliffe efficiency values as high as 0.86 were also observed in preliminary runs. The final optimized model can be used to retrofit passive treatment infrastructure, analyze stockpiles' internal moisture content distribution and better understand the effect pile geometry has on leachate generation.