Mathematics Colloquium

Modelling Preferential Finger Flow Through Porous Media using Preisach Hysteresis

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Abstract

An in-depth understanding of preferential finger flow through the vadose zone is critical to widen our knowledge on the processes of infiltration, runoff, erosion, plant growth, and contaminant transport. The paths formed during this fingered flow can be "remembered" by the soil matrix during future infiltration, even after periods of desaturation. It has been shown many times that the traditional porous media equation, Richards' equation, is incapable of capturing this phenomenon. However, recent studies demonstrate the process can be described by coupling a non-equilibrium, relaxation version of Richards' equation with hysteresis (applied to the pressure–saturation relationship). For this talk, we present numerical algorithms for solving both the one- and two-dimensional modified Richards' equation in both 1D and 2D. Furthermore, we advance upon previous work in the field by using a novel class of Preisach hysteresis for the modelling of preferential finger flow, where the strength of hysteresis present in the soil matrix may be adjusted by simply varying a single parameter. By evaluating the effectiveness of our solution algorithm with previously published research, the findings of this work suggests that the Preisach Wedge model, coupled with an alternate dimensional operator splitting method, is indeed a promising mechanism for the modelling of preferential finger flow in porous media.

About the speaker: Warren Roche is a Frost Postdoctoral Research Fellow at Cal Poly in the Mathematics Department, and is originally from Waterford, Ireland. He earned his BSc in Mathematics from Trinity College Dublin in 2012. He attended University College Dublin to earn a MSc in Mathematical Science in 2016. In 2022, Warren earned his doctorate in Mathematics from the South East Technological University in Waterford, Ireland - where he was a PhD Scholar - under the guidance of Dr. Denis Flynn and Dr. Kieran Murphy. Warren's doctoral work explored differential equations and modelling preferential finger flow through a porous media using hysteresis operators and operator splitting techniques. In July 2022, Warren was presented with the Howard Medal at University of Cambridge for his work on the importance of effect sizes for clinical trial experiments. Currently, Warren's research is in mathematical biology, where he explores the use of agent-based modelling as a tool to develop a deeper understanding of how electrical activity propagates through cardiac tissue.