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Further Analysis of the Flow through Porous Bodies with Application to Stormwater Management

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In the work of Lundström et al [1], a new concept of stormwater storage in sponge-like porous bodies (SPBs) is suggested: down-flow and up-flow SPB storage. The analytical and numerical results of the analysis based on the first principles argue that the studied up-flow model can capture and control the stormwater runoff for various conditions of Swedish design rainfalls. In the present research study additional work on the existing model is carried out.

The model presented [1] consists of a solid cylinder (radius δ) surrounded by an inner and outer porous annulus (radii a and b respectively, where b>a). The inner and outer porous media is made of thin vertical cylindrical fiber rods with dimensions Ri,Ro « a, b, δ, where Ri and Ro represent their respective radii. For such a model of the water uptake, the governing equation is the Darcy Law, and the flow is mainly driven by the capillary action ($\Delta p \propto 1/R$). Further advances of the model are presented in this research including the diffusion of water into the dry soil, for which the diffuse-front modeling, as done by Zarandi and Pillai [2] (Richard's equation), is applied. The corresponding set of equations for the motion of liquid fronts for each of the channels with the corresponding boundary conditions are given and the pressure quantities are averaged over the cross-section. Numerical integration is carried out in MATLAB. The diffuse-front model is resolved with COMSOL Software using Porous Media Flow Module. The numerical simulation results will be validated against the experimental measurements planned on a physical up-flow model in the laboratory setting. Similarly, to the work of Lundström et al [1], the model storage inflow rates and volume absorption will be plotted against time and compared to the Swedish design rainfall data.

References:
[1] Lundström, T. Staffan, et al. "Dynamic distributed storage of stormwater in sponge-like porous bodies: Modelling water uptake." Water 12.8 (2020): 2080.
[2] Zarandi, Amin, and Krishna M. Pillai. "Application of Sharp-and Diffuse-Front Models for Predicting Mass Gain and Saturation in Fibrous Wicks." (2018).

Participation

In-Person

References

[1] - Lundström, T. Staffan, et al. "Dynamic distributed storage of stormwater in sponge-like porous bodies: Modelling water uptake." Water 12.8 (2020): 2080.

[2] - Zarandi, Amin, and Krishna M. Pillai. "Application of Sharp-and Diffuse-Front Models for Predicting Mass Gain and Saturation in Fibrous Wicks." (2018).

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