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Dissipation of boundary-induced flow disturbances in cylindrical soil columns

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Laboratory soil column experiments, often involving steady flow, have a long and enduring history in hydrology and soil science. Typically, analyses of laboratory column data assume that the flow is both steady and uniform within the soil column. However, the establishment of uniform, steady flow requires careful construction of the experimental apparatus. Recently, Bromly et al. (2007, Eur J Soil Sci 5, 293-301) carried out a meta-analysis of 216 solute transport experiments, considering reported dispersivities and their relation to flow velocity, clay and silt content, bulk density, and column diameter and length. They found dispersivity increased with column diameter. Consistent with this finding is the hypothesis that, in experiments, larger column diameters lead to increased disturbance in the flow. This hypothesis was investigated by solving the flow equation in cylindrical coordinates, and examining the dissipation length scale associated with both smooth and abrupt disturbances at the column entrance and/or exit planes. For a homogeneous soil, the analysis reveals the remarkably simple result that, independent of the disturbance itself, the dissipation length of the relative disturbance magnitude equals the column radius, i.e., the disturbances die out at a longitudinal distance from the boundary of one column radius. This result provides the basis for designing baffle zones in soil column experiments.