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An annulus-and-core device to simultaneously measure longitudinal and transverse dispersivities

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This paper presents a novel laboratory device designed to simultaneously estimate longitudinal and transverse dispersivities. The experimental device is an annulus-and-core device: it is based on a classical cylindrical column system, of which the inlet and the outlet reservoirs are divided into three independent concentric zones. Non-uniform tracer injections can be performed by feeding solutions at different concentration to different inlet annular zones. Information on the radial distribution of concentration is available through mean effluent concentration measurements in each outlet annular zone. In this study, we only investigated continuous tracer injections through the central inlet zone under uniform flow conditions. An analytical solution to a similar problem was available in the literature, and was adapted to compute effluent concentrations. A general methodology is suggested to obtain transport parameters from breakthrough curve analysis. Effective porosity and longitudinal dispersivity are obtained by analyzing the full surface-averaged breakthrough curve using classical one-dimensional tools. Since annular zones have the same cross-sectional surface area, this average curve is simply computed by summing the three breakthrough curves measured in the annular outlet zones. Transverse dispersivity is determined by comparing steady-state concentration levels measured in different outlet annular zones. Preliminary experiments were performed on a glass bead porous medium, on a gravelly sand and on a natural medium sand. Transverse dispersivities were found to be higher than values previously reported in the literature, probably as a result of plume meandering, which cannot be detected nor corrected when using annulus-and-core devices.