ELIMINATION OF BOUNDARY-FLOW ERRORS IN LABORATORY HYDRAULIC CONDUCTIVITY MEASUREMENTS¹

Laboratory hydraulic conductivity measurements on fragmented soils are frequently used as a guide to predict soil behavior under various management regimes (4). Although laboratory measurements may be quite different from those obtained in the field, they are useful for studying the effect of the composition of the applied water on hydraulic conductivity. Reeve and Tamaddoni (3), while studying the rate of flow of salt solutions through a high-sodium montmorillonitic soil, obtained unrealistically high apparent hydraulic conductivity values with high-salt waters following equilibration with low-salt waters. The high values have been found to result from boundary flow (leakage at the soil-permeameter wall interface) as a consequence of contraction of the entire soil mass upon passage of the high-salt solution through the previously swollen soil. This note describes a modified permeameter which allows simultaneous evaluation and elimination of such errors. It also presents data on the magnitude of the errors for two widely different soils.

The permeameter (Fig. 1) is constructed from acrylic resin tubing (Plexiglas or its equivalent). It consists of two chambers, made from 2½-inch o.d. tubing, and designated in Fig. 1 as chambers A and B. Chamber A is further divided into two concentric regions of nearly equal area by cementing a 1-cm. length of 1½-inch o.d. tubing (C) to the bottom of the chamber. The inner region is drained by a 10-cm. length of½-inch o.d. tubing (E), while the outer or boundary region is drained into chamber B by three equally spaced 5/16-inch holes (D). The effluent is drained from chamber B through a removable length of glass tubing, which is fitted through a latex gasket into a ½-inch diameter outlet port (F). Fitted sections of 20-mesh copper screen are placed at the bottom of chamber A and covered to a depth of 0.3 cm. with fiberglass matting. Sufficient soil is placed into the permeameter to give a 3-cm. depth of compacted material. Upon application of the solution, the sample is covered with another layer of fiberglass matting to prevent disturbance of the sample. While the boundary region is drained into chamber B, the effluent from tube E is collected to measure the actual hydraulic conductivity of the soil sample above the inner region of chamber A. Effluent from port F is either discarded or collected to measure the apparent hydraulic conductivity through the outer region of chamber A, where boundary flow is appreciable.

Two different soils were employed to demonstrate the differences between the actual hydraulic conductivity and the apparent hydraulic conductivity for a given sample. The sample of Pachappa fine sandy loam, a highly saline, highly sodic soil from near Hemet, California, has a large proportion of montmorillonite minerals in its clay fraction (1). The sample of Waukena clay loam, a moderately saline, nonsodic soil from Riverside, California, contains predominantly micaceous minerals in its clay fraction (2). The Waukena sample has a moderately high hydraulic conductivity to high-salt waters, but is essentially impermeable to the passage of low-salt waters. The Pachappa sample maintains a high hydraulic conductivity upon the passage of low-salt, low-sodium waters, but exhibits marked hydraulic conductivity decreases when equilibrated with high-salt, high-sodium waters.

Triplicate 75-g. samples of < 1 mm. soil were packed into the permeameters, covered with a 500-g. fiberglass matting, and compacted by dropping 200 times through a 2.5 cm. (2). After air was displaced from the permeameters, they were immediately wetted with a mixed solution of NaCl and CaCl₂, having a total concentration of approximately 1,000 ppm. of NaCl and 250 ppm. of CaCl₂. The solution also contained 15 ppm. of HgCl₂ to inhibit biological activity. A controlled hydraulic gradient was applied and the effluent from tube E is collected to measure the hydraulic conductivity of the soil sample above the inner region of chamber A. Effluent from port F is either discarded or collected to measure the apparent hydraulic conductivity through the outer region of chamber A.

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