Where does the fluid go?

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Combined mechanisms of transport have important applications -- transport of nutrients across cell membranes in plants and animals, the aeration of agricultural soils, performance of chemical reactors, the design of membranes for desalting brackish water, and the design of clay membranes for retaining dangerous chemicals. Because mass transport of fluid constituents has important roles in biology, physics, and chemistry, one would assume that such transport would be well understood by the scientific community. However, transport of fluid constituents continues to be a source of confusion, particularly regarding models for combining transport by molecular diffusion and advection.

In a recent article in *Vadose Zone Journal*, A.T. Corey, W.D. Kemper (both of Colorado State Univ., Fort Collins), and J.H. Dane (Auburn Univ., Auburn, AL) show that the developers of popular models of diffusion have made invalid assumptions. Currently popular models define diffusion of a particular constituent as a flux relative to mass average flux so that diffusive flux of all constituents in a fluid mixture must sum to zero, and self-diffusion of a single-specie fluid cannot exist, contradicting experimental evidence previously reported in the literature.

Research conducted and referenced by the authors shows that these assumptions and their models do not provide a satisfactory description of the flux taking place in media with small pores. The authors provide an improved analysis, based on the principle that driving forces (for both advection and diffusion) are each equal in magnitude (and opposite in direction) to the associated rate of change of momentum. Mass average flux resulting from combined advection and diffusion is shown to be evaluated as the vector sum of advective and diffusive fluxes, rather than diffusive flux being evaluated as a flux relative to a mass average flux. This procedure is necessary because "mean flux" cannot be determined independent of an evaluation of diffusive flux.

Corey et al. describe two experiments with transport of gas constituents through porous media (providing data consistent with their revised model) that contradict widely accepted models. One of the experiments presents previously published data and the other describes new data obtained by the authors. Three additional experiments are presented (one representing new data) showing that self-diffusion of pure liquid water occurs in response to a temperature gradient, contradicting theory that diffusion of a single-specie fluid cannot occur, and showing that the sum of diffusion fluxes do not sum to zero in the general case. The measured diffusion of water was proportional to the gradient of the vapor pressure, which is a well-documented measure of the kinetic energy of water.

More information: View the abstract at vzj.scijournals.org/cgi/content/full/9/1/85 .

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