3.3.6 Air–Water Interfacial Area

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3.3.6.1 Introduction

In unsaturated soils, the air–water interface plays an important role in mediating many environmental processes. Some examples of the retention and transport processes that are mediated by the air–water interface include water evaporation in soils; vaporization of volatile organic chemicals (VOCs); sorption and transport of organic contaminants, colloidal particles, and microbial pathogens during water movement; and exchange of constituents between soil–gas and aqueous phases. Therefore, it is essential to measure and predict the total amount and spatial distribution of the interface present between immiscible fluids in porous media. The accumulation of chemicals or pathogens at the air–water interfaces is also studied in the fields of atmospheric (e.g., Valsaraj et al., 1993; Goss, 1994) and marine sciences (e.g., Mitchell et al., 1996).

Calculating the air–water interfacial areas as a function of water saturation presents considerable challenges even for very simple media, such as uniformly packed spherical particles with a known geometry (Rose, 1958; Gvirtzman & Roberts, 1991). Several complex models have been developed to calculate the interfacial areas between immiscible fluids in porous media. Most of these models depend on the pressure–saturation relationship (water retention curve), which is analyzed using either thermodynamic principles or physical models simplified to fit the measured pressure–saturation relationship (Leverett, 1941; Skopp, 1985; Miller et al., 1990; Cary, 1994; Reeves & Celia, 1996; Bradford & Leij, 1997).

Experimental methods for measuring fluid–fluid interfacial areas in porous media began to appear in the mid 1990s. Karkare and Fort (1996) introduced a method that included the use of surfactant-containing aqueous solutions premixed with soil to measure the air–water interfacial areas as a function of water saturation. Saripalli et al. (1997, 1998) and Kim et al. (1997, 1999a) developed a miscible displacement method using anionic surfactants as the interfacial tracers. A static equilibration method, also using an anionic surfactant as the interfacial tracer, is available as well (Scheffer et al., 2000a). Gaseous interfacial tracer methods were