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Discussions

Interactive comment on "A new technique using the aero-infiltrometer to characterise the natural soils based on the measurements of infiltration rate and soil moisture content" *by* M. A. Fulazzaky et al.

Anonymous Referee #1

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General Comments:

The paper describes a new device which the authors called an aero-infiltrometer. The aero-infiltrometer consists of a pressurized air-filled tube that can be discharged into the soil. The rate of pressure drop is measured by use of a manometer. The authors also performed double-ring infiltration tests 1 m from the site of the aero-infiltrometer tests, and developed a power function based on the observations to relate air and water infiltration rates. The authors' primary claim is that whereas water infiltration tests can

be expensive, time-consuming, and/or difficult to perform in remote parts of the world, the aero-infiltrometer is portable, inexpensive and easy to use. This claim may be technically correct, but the physics of air and water infiltration are different enough that the theory presented in the paper is suspect at best. In their assumption #3 (page 2521 line 26) the authors state: "air movement is analogous to water movement into the ground". This is generally not true for multiple reasons: 1) the mean free path of travel of gas molecules can approach the size of pores ([Selker et al., 1999], p. 69-70), which means that the effective air permeability can be pressure dependent [Wu and Pruess, 1998]; 2) water, unlike air, is subject to surface tension (capillary) forces; 3) the differences in density and viscosity between water and air are such that under normal circumstances water will readily displace air whereas air cannot displace water; and 4) permeability of water and air have opposite dependences on water content (water permeability increases at higher water contents; air permeability decreases as the water content increases).

Point 1 means that the time-dependent decrease in air infiltration rate (Figure 3) is likely caused in part by the decrease in air pressure within the aero-infiltrometer chamber. It should be noted that the double ring water infiltration test also has a decreasing supply pressure, but judging by the data in Figure 3 the decrease in water elevation within the double ring instrument was minor relative to the decrease in air pressure in the aero-infiltrometer.

Points 2-4 mean that the relationship between air and water infiltration rate observed at a given initial soil water content would likely not hold at a different initial water content.

In total, three soils were tested, which is an insufficient number to prove the claimed relationship between air and water infiltration. The number of tested soils seemed particularly limited given that the fitting parameters used in the power function varied by multiple orders of magnitudes between soils, and all three curves had different shapes from the others. For these reasons, this paper requires substantial revision in order to be considered for publication.

I suggest that the authors rewrite their paper to focus on the applicability of this instrument as a method to determine the air permeability of soils. Soil air permeability in itself is an important parameter to quantify for a number of reasons – please refer to a recent review paper by Kuang et al. [2013] for more discussion of the approaches and utility of air permeability measurements. This would allow the authors to discuss the extensive literature which has examined the relationship between air and water permeability (i.e. [Klinkenberg, 1941; Kirkham, 1946; Tanikawa and Shimamoto, 2006]). The authors do cite two papers related to air permeability – DiGiulio (1992) and Suthersan (1999) – but unfortunately neither paper was listed in the references. In such a revised paper, the authors could include a section on the empirical relationships they observed between double ring infiltration tests and aero-infiltration rates, so long as the correct caveats were included. However, as currently presented in this paper, the physical linkage between those two processes is far too tenuous to serve as the main result.

Specific comments:

It is unclear how soil type helps identify the number of capillaries of a soil (p. 2516, l. 26), unless you are referring to some type of pedotransfer function. This sentence does not make sense as written.

As the only support to the claim that the pressure drop in their aero-infiltrometer can be used to infer water content, the authors cite three of their own presentations (p. 2518, l. 25).

It seems disingenuous to claim that equations developed to analyze air diffusion are insufficiently reliable (p. 2522, l. 4-8), when the method proposed in this paper does nothing to avoid or improve on the noted deficiencies of the other models. The section of P. 2522, l. 15-20 belongs in the introduction and could likely be removed altogether.

Equation (4) does not make sense. Infiltration tests measure the equivalent depth of water which enters the soil during a time period; the resultant depth of wetting of the soil will depend on the initial water content (available porosity). Without knowing the

initial soil water content, it is impossible to know 1 cm of infiltrated water reached a depth of 5 cm or 15 cm (for example). In essence this leaves two unknowns with only one equation. If you knew the total depth of the soil column and the time at which the column completely saturates you could estimate both unknowns, but that does not appear to be what is argued here. Since steady-state infiltration conditions can be observed in a long unsaturated column, it is unclear how the authors are determining the cumulative water depth after achieving saturation.

The authors claim that since both P and f (air pressure and water infiltration rate) decrease with time, they are physically related. However, as discussed above air flow is dependent on air pressure, so as the tank becomes depressurized the air flow rate will naturally decrease.

References:

Kirkham, D. (1946), Field method for determination of air permeability of soil in its undisturbed state, paper presented at Soil Sci. Soc. Am. Proc.

Klinkenberg, L. (1941), The permeability of porous media to liquids and gases, Drilling and production practice.

Kuang, X., J. J. Jiao, and H. Li (2013), Review on airflow in unsaturated zones induced by natural forcings, Water Resour. Res., 49(10), 6137-6165.

Selker, J. S., C. K. Keller, and J. T. McCord (1999), Vadose zone processes, 339 p. pp., Lewis Publishers, Boca Raton, Fla.

Tanikawa, W., and T. Shimamoto (2006), Klinkenberg effect for gas permeability and its comparison to water permeability for porous sedimentary rocks, Hydrology & Earth System Sciences Discussions, 3(4).

Wu, Y.-S., and K. Pruess (1998), Gas flow in porous media with Klinkenberg effects, Transport in Porous Media, 32(1), 117-137.

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