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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.

M. A. Fulazzaky et al.

fulazzaky@gmail.com

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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 Received and published: 11 March 2014 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). * To have a rational argument, the sentence of "air movement is analogous to water movement into the ground" was changed to "laminar air flow is analogous to laminar water flow from the surface to subsurface land". (see page 5 lines 201-202 in Marked Manuscript)

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. * Evidence (Figure 3) shows that the decrease in water elevation observed from the double ring instrument was minor relative to the decrease in air pressure drop

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observed from the aero-infiltrometer due to the behaviours of air diffusion and water infiltration into the ground are different from each other; however, this study presented empirical evidence that a plot (Figure 4) of infiltration rate versus air pressure dropping rate gives a very good correlation to model testing data hence the use of the empirical equation can be used as the method of rationality.

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. * The relationship between the air pressure dropping rate and the water infiltration rate can be traced evidently even though the experimental tests were observed at different initial soil moisture content; however, the initial water content of a soil can be described by the change in value of the parameters in equation, as shown in Table 4.

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. * We believe, due to experimental tests, that this study does have enough information, and therefore more accurate the text can be improved as follows: "Despite many experimental tests have been performed for the soils in different locations to validate data and experimental procedure, the data collected from three natural soil sites around the Universiti Tun Hussein Onn Malaysia campus and supporting by the data of laboratory tests for the artificial sandy clay (50% sand; 50% clay) were used to describe the below ground and surface processes that involve the dynamics of air and water movement from the land surface to subsurface." (see page 6 lines 233-238 in Marked Manuscript)

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

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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. * We believe that this study has sufficiently focused on the applicability of aero-infiltrometer to determine the air permeability of soils even though both the measurements of water infiltration and soil moisture were also presented due to the empirical evidence is required for a hypothesis to gain acceptance in the scientific community. The citations of DiGiulio (1992) and Suthersan (1999) have been listed in the references (thank for your kind advice) (see list of the references). The empirical relationships of linking the pressure dropping rate against either the infiltration rate or soil moisture content have been considered as a means for characterising the natural soils.

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. * The sentence of “Soil type helps identify size and number of capillaries through which water and air penetrate a vadose zone.” was deleted from the text.

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). * The sentence has been improved with more literature citations by the following statement: “Under steady state and laminar flow conditions, the permeability of soil to air is approximately a linear function of the reciprocal pressure; aero-infiltrometer as a new hydrological device based on the measurement of the changes in air pressure drop (Lp) over time would be useful to determine f due to air flow induced by f and then can be extended to determine θ due to air flow also induced by water table fluctuations (Klinkenberg, 1941; Kirkham, 1947; Fulazzaky et al., 2008; 2009a, b; Kuang et al., 2013)." (see page 3 lines 97-103 in Marked Manuscript)

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. * The sentence of "The equations to analyse air diffusion into the ground and underground flows have been proposed by Petersen et al. (1994), Bartelt-Hunt and Smith (2002), Althaus et al. (2009) and Aharmouch and Amaziane (2012). Still the application of these equations for natural soils that have heterogeneous structures and erratic particle-size is insufficiently reliable." was deleted from the text * The sentence of "State of soil can be described considering five soil-forming factors, i.e., parent material, topography, climate, biological activity, and time, which can determine soil drainage characteristics. More than 3,000 specially named the soil types were recorded (Wanielista, 1990). Simplified approaches to determine f of a soil including the empirical models proposed by Kostiakov (1932) and Horton (1939) use t for the variable." has been inserted into Introduction. (see page 3 lines 114-119 in Marked Manuscript)

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 sentence has been improved with considering the initial soil moisture content by the following statement: "Theoretically, the value of θ can range from 0% when a soil is completely dry or certain initial-θ depending on shallow water table fluctuations to 100% when a soil is fully saturated (van Genuchten, 1980; Dingman, 2002; Lawrence and Hornberger, 2007)." (see page 8 lines 331-333 in Marked Manuscript)

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. * The sentence has been improved to include the reason of why the correlation of the variations of P and f can be established, as the following statement: "In this study, the empirical equations are able to be formulated considering the most fundamental aspects that both the variations of P and f have the decreasing trends pursuant to the test time (t) because the physical and chemical properties of the soil control the movement of fluids by hindering the flow of either air or water from the surface to subsurface land until it reaches at a constant rate." (see page 5 lines 213-218 in Marked Manuscript)

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C771/2014/hessd-11-C771-2014-supplement.zip

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 2515, 2014.