

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.

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Received and published: 22 April 2014

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 #3 Received and published: 14 April 2014

The manuscript is a resubmission of a former one, published on HESSD

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201310:12717-12751, that I commented as Anonymous Referee on 5 December 2013. In that occasion, I highlighted several limitations of the manuscript including vagueness of the underlying theory, limited number of field tests, lack of statistical support for the results. Most (if not all) of those weak points were not addressed by the Authors' reply (posted on 13 December 2013) and, unfortunately, the resubmitted version has not been substantially improved. As matter of fact, the present version is (practically) identical to the previous one. Therefore, I don't repeat in detail the criticisms that I raised to the previous version of the manuscript but I try to summarize why, in my opinion, its publication is not recommended.

Apart from being unnecessary long and wandering, the manuscript basically tries to prove that the pressure drop rate, P , measured by the aero-infiltrometer can be used to estimate the water infiltration rate, f , and the soil moisture content, θ , at a given site. At this aim, two empirical relationships are presented that were calibrated using infiltration rates collected by the classical double-ring infiltrometer.

The relationship between f and P (eq. 3) is potentially sound but its parameters were calibrated with only three field tests and no independent validation is performed. As I stated in my former review, parameters of the suggested relationship are prone to the influence of several factors (soil heterogeneities, spatial variability, initial conditions etc.) that are not specifically assessed by this study. Even if limited to the three considered soils, a much greater number of field tests should have been conducted to assess statistically the reliability of the proposed parameters, i.e., the reliability of the proposed technique. Considering that a site specific calibration is necessary in any case, I think that this analysis is critically important to decide whether or not the technique is suitable as a surrogate of more tedious and time-consuming infiltration experiments.

The relationship between θ and P (eq. 5) is even more questionable given that it lacks of theoretical support. As matter of fact, the soil water content is estimated by a relationship (eq. 4) that supposes a proportionality to cumulative infiltration. However, it should be considered that, during the infiltration process, the soil water content un-

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der the double ring infiltrometer is rapidly changing both in time and space. The soil saturated bulb underneath the infiltrometer ring extends and the wetting front deepens and enlarges. Therefore, the attempt to estimate $\bar{\theta}$ from the cumulative water infiltration is misleading, at least because the measurement volume is not defined. I also note that the Authors endure in confusing volumetric water content (that is the volume of water per unit volume of bulk soil) with degree of saturation (that is the percentage of soil porosity occupied by water). Probably, a detailed monitoring of soil moisture conducted during the water displacement by air from the aero-infiltrometer could be suggested to usefully investigate, at least empirically, the relationship between the two variables.

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

Response to the comments from Anonymous Referee #3

Even if the Authors' reply (posted on 13 December 2013) regarding the highlighted several limitations of the manuscript (posted by Anonymous Referee on 5 December 2013) was not statistically significant, we believe that with a convincing response, the resubmitted version of the manuscript has been substantially improved to consider all the comments from three Anonymous Referees.

(1) To having more experimental supports on the data validation and experimental procedure, the text in manuscript has been improved as follows: "Despite many experimental tests have been performed for the soils in different locations to validate data and experimental procedure (Lai and Ibrahim, 2006; Jalali and Ibrahim, 2007; Lau and Fulazzaky, 2010; Mustapha and Fulazzaky, 2011), 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. Temporal variability in site conditions of the natural soils does not consist of a simple observation in com-

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paring flow behaviours of the fluids with each other." (see page 5 lines 219-227 in Marked Manuscript after Referees 1,2,3) The following literatures have been inserted into the list of references: Lai, T.H., and Ibrahim, I.: Soil infiltration rate measurement using air flow into the porous media, Technical Paper of Project Report, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, Malaysia, 2006. Jalali, H., and Ibrahim, I.: Calibration of aero-infiltrometer for air diffusion into the ground and soil moisture content. Technical Paper of Project Report, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, Malaysia, 2007. Lau, S.S., and Fulazzaky, M.A.: Comparison of aero-infiltrometer to double ring infiltrometer in measuring the infiltration rate and soil moisture. Technical Paper of Project Report, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, Malaysia, 2010. Mustapha, N., and Fulazzaky, M.A.: Measurement of infiltration rate using Aero-infiltrometer with variable initial soil moisture content. Technical Paper of Project Report, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, Malaysia, 2011.

(2) To avoid of confusing volumetric water content, the text in manuscript has been improved as follows: "Spaces in soil that are not occupied by solids are known as the soil pores; the total volume of pores is the soil porosity, which consists of the part of the soil volume occupied by air and water (Rahardjo et al., 2004; Chinevu et al., 2013). If the vadose zone envelops soil, the water contained therein is termed soil moisture. Since θ is defined as quantity of the water contained in the soil porosity, the portion of the soil volume occupied by water is measured by θ . This property is used to a wide range in scientific and technical areas and is expressed as ratio of the water volume contained in the soil porosity, comparing the total volume of pores. Theoretically, the value of θ can range from 0% when soil porosity is completely dry, or certain initial- θ depending on shallow water table fluctuations, to 100% when soil porosity is fully saturated (van Genuchten, 1980; Dingman, 2002; Lawrence and Hornberger, 2007). (see pages 7-8 lines 315-325 in Marked Manuscript after Referees 1,2,3)

The following literatures have been inserted into the list of references: Rahardjo,

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H., Aung, K. K., Leong, E. C., and Rezaur, R. B.: Characteristics of residual soils in Singapore as formed by weathering, *Eng. Geol.*, 73, 157–169, doi:10.1016/j.enggeo.2004.01.002, 2004. Chinevu, C. N., Unanaonwi, O. E., and Amonum, J. I.: Physical and chemical characteristics of forest soil in southern Guinea savanna of Nigeria. *Agric. Forest. Fisher.*, 2, 229-234. doi: 10.11648/j.aff.20130206.15, 2013.

(3) To having more theoretical supports on the relationship between $\bar{\alpha}_s$ and P (Eq. 5), the text in manuscript has been improved as follows: “It seems that Eq. (4) remains workable due the decrease in water level as shown in Table 1 is equal to zero when the degree of saturation has reached at 100% (Gruescu et al., 2007). Once the soil porosity becomes saturated, the diffusion of air into the ground is markedly hampered (Papachristodoulou et al., 2007). The rate of air diffusion into the ground depends on capillarity and therefore soil texture, depth to water table, and θ ; however, air diffusion occurs most rapidly with increasing depth to the water table to a critical depth below which groundwater is not involved in the diffusion process (Kyrke-Smith et al., 2014). With a critical depth of the water table, the process of air diffusion into the ground is effectively controlled by θ (Ma et al., 2013). The pressure gradient force is a force that tries to equalise pressure differences. This is the force that causes high pressure in air tank of the aero-infiltrometer to push air toward low pressure in the soil. Since the movement of air is faster than the movement of water, it follows that air temperature changes more quickly than water temperature. Thus, air that flows from the aero-infiltrometer into the soil to move faster than water infiltrates from the double-ring infiltrometer into the ground. The relationship between P and θ could be a subject of this study since the measurements of L_p and L_w were performed independently at the soils with similar characteristics. Having a serial Cum. L_p and Cum. L_w dataset is able using Eq. (1) to calculate P and using Eq. (4) to calculate θ_{exp} . Accordingly, Figure 6 shows the resulting plots P versus θ_{exp} and gives the following equation that:” (see page 8 lines 334-352 in Marked Manuscript after Referees 1,2,3)

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The following literatures have been inserted into the list of references: Gruescu, C., Giraud, A., Homand, F., Kondo, D., and Do, D. P.: Effective thermal conductivity of partially saturated porous rocks. *Int. J. Solids Struct.*, 44, 811-833, doi: 10.1016/j.jjsolstr.2006.05.023, 2007. Papachristodoulou, C., Ioannides, K., and Spathis, S.: The effect of moisture content on radon diffusion through soil: assessment in laboratory and field experiments, *Health Phys.*, 92, 257-264, doi:10.1097/01.HP.0000248147.46038.bc, 2007.

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/11/C1041/2014/hessd-11-C1041-2014-supplement.zip>

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

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