

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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Response to Referee #3 Comments

In spite of many questions have been addressed by Referee #3 to criticise this manuscript, we would like to rebut all the questions to make our messages clearer for readers.

- The introduction is lacking in focus and depth of the methods being used in the study.

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Because the aero-infiltrometer is a new method to be used for determining the infiltration rate and soil moisture content, the introduction must be focused on the reasons of why this method is reliable to be used as a new approach for hydrological data collection (P. 12719, L. 1 to P. 12720, L. 5)

- The units should be put into SI Even if the unit of pressure in psi is not expressed as SI unit, it is still relevant to be maintained the unit of air pressure dropping rate in psi h⁻¹ (if possible) due to the real measurements of air pressure drop by the aero-infiltrometer were carried out in psi.

- The choice of the symbol Lp for pressure drop is curious, since L is generally associated with length terms The symbol Lp using for measuring air pressure drop is still relevant to have a similar symbol matching the measurement of decreasing water level (Lw) associated with length of water level drops.

- The authors claim that the nozzle of their aero-infiltrometer is analogous to the inner ring of a double ring infiltrometer (DRI), which does not hold up to reason. The purpose of the inner ring of a DRI is for creating 1-d flow conditions, which is clearly not the case with the aero-infiltrometer. In our opinion, the inner wall of air injection nozzle to diffuse air from the surface to subsurface land has a similar functioning like the inner tube functioning of a double-ring infiltrometer when water infiltrates. Both have a function for controlling the movement of fluid through the soils. (this highlighted sentence can be inserted to ... when water infiltrates. Both have a function for controlling the movement of fluid through the soils and (2) the aims of ...) (P. 12721, L. 16).

- There is no discussion of the DRI setup and how the tests were performed. In developing the empirical models must be accounted the trends of air diffusion and water infiltration from surface to subsurface land, which depend on texture and structure of the soil. As a consequence, the discussion related to the double ring infiltrometer setting up is not urgently considerable to provide into the text, due to the main focus of the study is to promote a new device named as aero-infiltrometer.

C6719

- There is no discussion of DRI theory, nor mention of the many solutions which have been developed over the past 80+ years to interpret infiltration results. In our opinion, the discussion of DRI theory would be outside of this study.
- The authors base their infiltration analysis on Horton's equation, which specifies that rainfall intensity is greater than infiltration rate. The coarse soils used in the study, with infiltration rates greater than 2 cm-hr⁻¹, would seem to invalidate this requirement. Even if the infiltration rate for site-1 ranged from 4.1 to 80.6 cm h⁻¹ for gravel coarse sand, we have proven that the use of data of infiltration rate for such natural soil was still valid to have a reasonable model and looks like Horton's equation.
- The authors should realize that the infiltration rates observed in their DRI depend on the upper boundary conditions imposed in the test. The observed infiltration rate will vary as a function of head. The study performed to assess the reliability of using the aero-infiltrometer as a new method to be useful for hydrological data collection. The discussion on the observations using a double-ring infiltrometer were not provided more detail and thus only used as the supporting data for the validation of a new method proposed based on the use of air as dynamic vector.
- The authors claim that air pressure drop will depend on capillary forces, which does not make sense. Instead, the authors should realize that one key difference between air and water infiltration is that water is pulled by capillary forces (as wetting front potential), whereas air is not. This distinction may make it difficult to develop a fundamental relationship between the two (though permeability can be measured using both water and air). Even though the theoretical explanation is quite difficult to differentiate the behavioural soils between air diffusion and water infiltration into the ground, 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 time (t).
- The authors acknowledge that soil has high variability, yet assume that air and water

C6720

infiltration tests performed 1 meter apart reflect identical soil conditions. The main consideration of this study is that the measurement should be sufficiently reliable and is necessary to be avoided from any risks of such soil deformation which may lead to inaccurate data. Therefore, at each location, the measurement of decreasing water level (L_w) using the double-ring infiltrometer was carried out at the same soil type near the measurement of air pressure drop (L_p) using the aero-infiltrometer with a distance of about one meter, which can represent identical soil conditions, and the data obtained from these measurements should be independent of each other.

- Equation (4) would only work if the infiltration front stopped advancing. Also, the authors seem to be describing degree of saturation (S), which scales from 0 to 100%, rather than water content. The use of Eq. (4) is still workable due the decreasing of water level as shown in Table 1 is equal to zero when degree of saturation has reached at 100%. The degree of saturation commonly termed as soil moisture content such as in this study can theoretically range from 0 to 100%.

- The three curves relating Pressure drop to infiltration rate (Figure 4) have very different shapes. Even though it is possible to describe them all with a power function, there does not appear to be a true predictive relationship between the two parameters. The different shapes of figure could be related to texture and structure of the soil to characterise the movement of fluid (air or water) into the ground. The most appropriate approach to be used for formulating the empirical equations is the power function due the power regression analysis has a good correlation for all the experiments (R² > 0.907, see Table 2).

- Since the results presented in Figure 4 do not suggest a predictive (fundamental) relationship between infiltration rate and air pressure drop, infiltration tests would need to be performed at every site anyway, which would seemingly defeat the purpose of using the aero-infiltrometer. The predictive relations between infiltration rate and air pressure dropping rate for each power curve are presented in Table 3 with its correlation coefficient. The use of aero-infiltrometer can be used also to characterise types of

C6721

the natural soil, and thus the measurements of infiltration rate and soil moisture content can be performed anywhere since the natural soil type has a similar character.

- The authors state that it is cumbersome and inconvenient to use single or double ring infiltration rings, yet the proposed method relies on an instrument with a valve, an air pump, a pressure gauge and nozzles. It seems that the ring infiltrometer are relatively simple and easy to use, and have the benefit of actually measuring the parameter of interest. The goal of this study was not conducted for extending the measurement capability of a ring infiltrometer; therefore, the use of a ring infiltrometer associated with a typical instrument does not have an interest in this research study.

In spite of the deficiencies stated above, I do not wish to discourage the authors, as their instrument is a good idea and has potential to help us better understand the vadose zone. I encourage the authors to continue to develop this instrument and its applications. Thank you for the comments. We believe that the application of aero-infiltrometer will be practically feasible due to the encouragement of researchers to continue to develop future research opportunities on basic knowledge of air diffusion into the ground.

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/10/C6718/2013/hessd-10-C6718-2013-supplement.pdf>

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 12717, 2013.