EGU General Assembly 2021

HS 1.1.5: Experimental hydrology and hydraulics in Geosciences
DOI- 10.5194/egusphere-egu21-7099

A Comparative assessment of estimated soil hydraulic conductivity from rainfall simulator and infiltrometer using laboratory repacked soil samples

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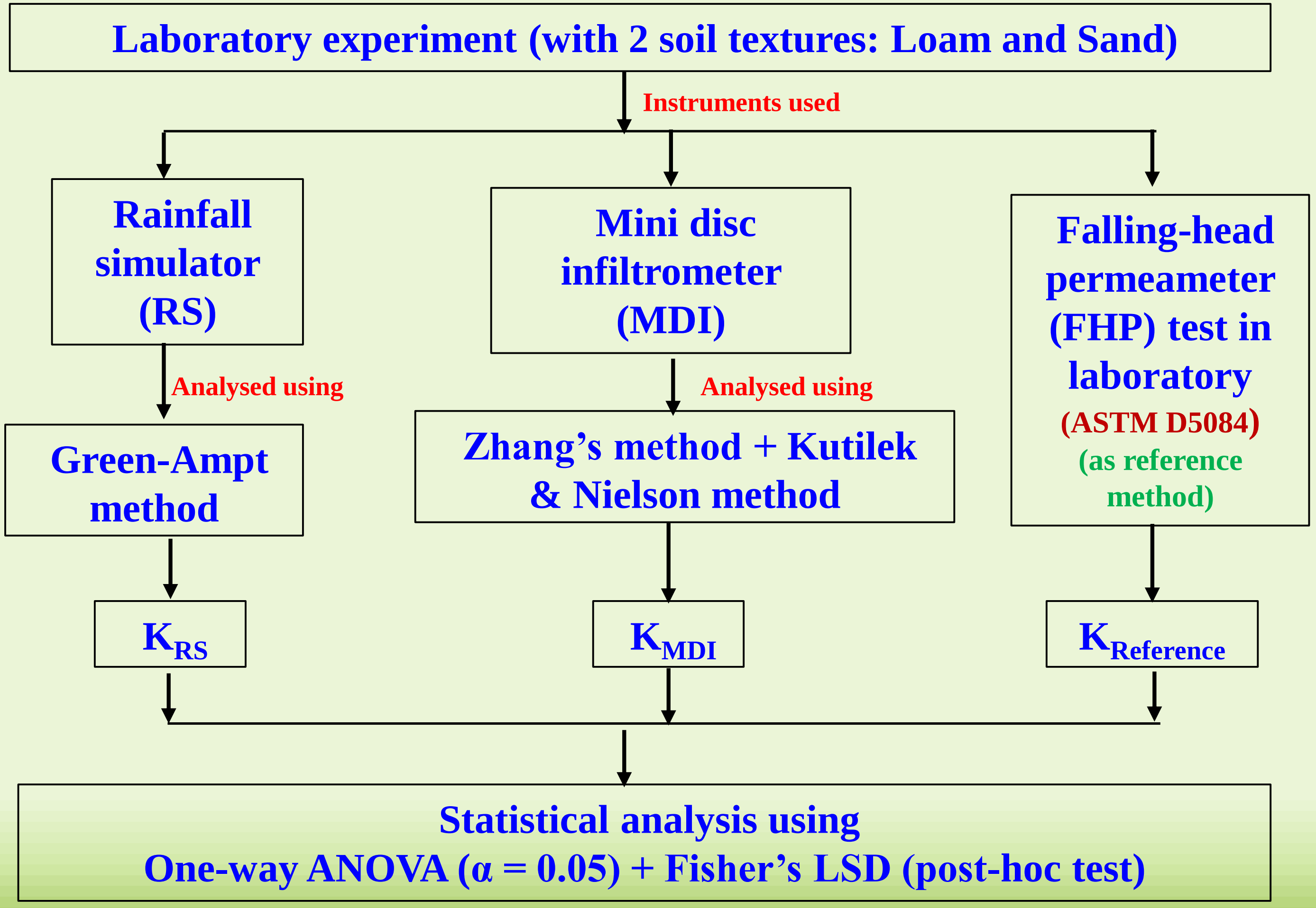
MOTIVATION

- **Soil hydraulic conductivity (K) - an essential parameter affecting water entry and flow inside soil.**
- **Several instruments (such as infiltrometers, and simulators) are in practice for evaluating this parameter, both in field, and laboratory.**
- **Simulator and infiltrometers work on different principles, use different methodologies**
- **Both devices offer inherent pros and cons.**
- **A comparative assessment would benefit the users to chose the device comprehensively and avoid inaccurate predictions.**

OBJECTIVE

- **Evaluating the K estimates from a rainfall simulator and disc infiltrometer using controlled laboratory studies.**

METHODOLOGY



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METHODOLOGY

INSTRUMENTS SPECIFICATION

Rainfall simulator (RS)

- **Rectangular c/s with length = 200cm, width = 91 cm and height = 25 cm (Norwood instrument Ltd., Great Britain)**
- **Infiltration experiments conducted by supplying artificial rainfall (of constant intensity).**
- **Experiment duration < 1 hour**
- **Two repetitions for each soil (Total 4 experiments).**

Mini disc infiltrometer (MDI)

- **Circular c/s with diameter = 4.5cm, cylindrical tube of total height = 32.7 cm (METER Group, USA)**
- **Infiltration experiments conducted after setting minimal suction =0.5 cm**
- **Experiment duration = 1 hour**
- **Four repetitions for each soil (Total 8 experiments).**

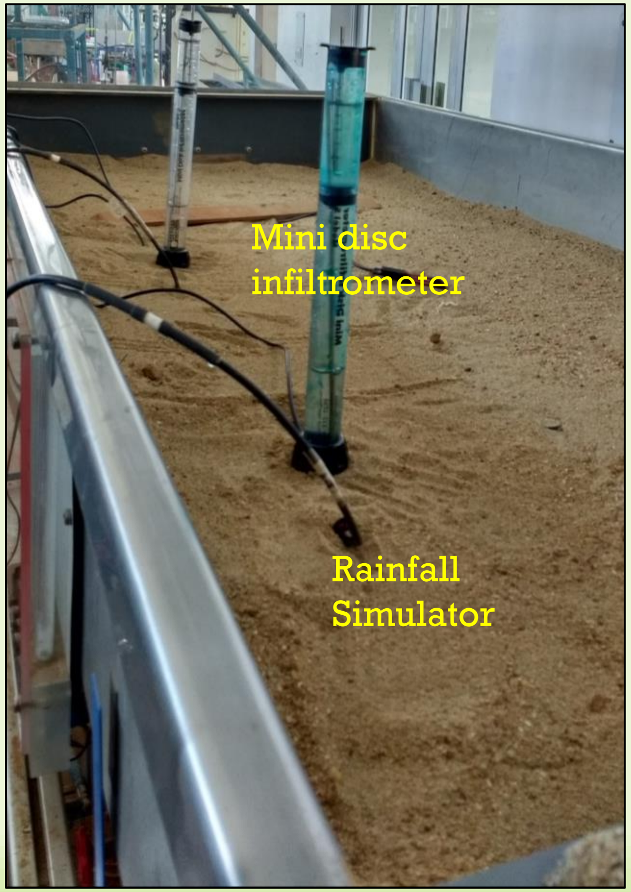

Fig: MDI placed on RS filled with sandy soil

	RS	MDI
Geometry	Rectangular	Circular
Size	Larger	Smaller
Sampled volume	Large	Small
Used for	Catchment scale analysis	Point measurements due to small size (requires large number of repetitions for catchment scale analysis)
Transport and installation	Relatively difficult	Easy
Water requirement	More	Less
Skilled worker requirement	Yes, in some cases	No, easy to operate
supply pressure head	Positive (ponding)	Negative
Flow dimension	1 D	3 D

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METHODOLOGY

METHODS OF K_S ANALYSIS

Green-Ampt method (1911)

$$K_s = \frac{1}{t}\left\{ I(t) - \psi\Delta\theta \ln\left[1 + \frac{I(t)}{\psi\Delta\theta}\right]\right\}$$

- *Ks* – saturated soil hydraulic conductivity,
- *I*(t) - cumulative infiltration, (calculated using measured runoff)
- ψ - wetting front soil suction,
- Δθ - moisture deficit (difference between porosity, and initial moisture content)

Zhang's (1997) and Kutilek and Nielson Method (1994)

$$I = C_1\sqrt{t} + C_2 t \approx C_1\sqrt{t} + mK_s t$$

$$K_s = \frac{C_2}{m}$$

- C_1 and C_2 are parameters related to soil sorptivity and hydraulic conductivity respectively
- C_1 and C_2 are obtained by fitting I vs $\sqrt{t}$ to the above two-term infiltration equation where C_2 is the slope.
- *m* is a constant (= 0.667 in general, Kutilek and Nielson, 1994)

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RESULTS

	Estimated Mean Ks (m/s)	
	Loam	**Sand**
RS	9.6E-07	1.8E-05
MDI	4.9E-05	5.2E-04
FHP	5.8E-07	2.4E-05

ANOVA and Post-hoc test result		
	Loam	Sand
RS vs FHP	NS	NS
MDI vs FHP	NS	NS
RS vs MDI	Sig	Sig

- ✓ Estimated Mean K_s were not equivalent for RS and MDI.
- ✓ MDI measurements were one to two orders higher than RS for both textures.
- ✓ RS was closer to the reference FHP measurements (1.65 for loam and 0.76 times for sand).
- ✓ Statistical difference between mean Ks of RS and FHP were Not significant (NS).
- ✓ Similarly, MDI and FHP mean Ks were also statistically Not significant.
- ✓ However, RS and MDI mean Ks difference were significant (Sig).

DISCUSSION

- RS estimates were closer to the reference FHP unlike MDI

  - as in RS, the flow is within the soil mass from one point to another similar to that of FHP.

  - while in MDI, the K_s calculated is based on water entry at the soil surface and not within the soil mass

- Overestimated predictions from MDI could be due to interplay of several factors

  - 3-dimensional flow path characteristics in MDI

  - Slow saturation in its case due to its smaller outlet area consequently maintaining longer dry soil condition, and thus, higher Ks

  -Failure of assumptions involved in its mathematical evaluation formulation in relation to validity of infiltration data

  - use of a constant value for *m* in the calculation may have added some amount of error

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CONCLUSION

- **The accuracy of K_s estimates from rainfall simulator and Mini disc infiltrometer was checked by comparing with reference falling-head permeameter tests.**
- **Simulator gives more accurate K_s predictions than the MDI due to its working philosophy similar to that of permeameter. However, its bulky size and cumbersome installation procedure make it one of the less convenient devices to use.**
- **MDI, although offers several advantages over RS, nonetheless, has predicted less accurate K_s estimates than RS in this study.**
- **The overestimation by 1- 2 orders of magnitude by MDI could be due to interplay of several factors, such as the difference in flow dimensionality, failure of assumptions of mathematical model used, and prevalent longer dry conditions in soil etc.**
- **However, the reasons for discrepancy in observed K_s for MDI is not clear from this study, and requires further evaluation for robust conclusion.**

FUTURE SCOPE

- **Further studies including more number of textures is needed for the two devices.**
- **Considering potential advantages of MDI over RS, a scale factor establishing relation between the two devices would benefit the user community.**

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