Determination of the infiltration rate of soils using a concentric ring infiltrometer

Diogenes Antille, Ben Macdonald, Mike Webb

CSIRO

Water infiltration – Some useful definitions

- For efficient water management (rainfall and irrigation) and prevention of deep losses of applied nutrients it is necessary to know the rate at which water moves into and through the soil.

- ***Infiltration*** is the process of water entry into the soil. After water enters the soil, it moves within the soil by a process known as ***percolation***.

- The rate at which the water infiltrates into the soil is the ***infiltration rate***, which has the dimensions volume per unit of time per unit of area (this reduces to depth per unit of time).

- Infiltration rate should not be confused with ***hydraulic conductivity*** (the ratio soil-water flow rate or flux to the hydraulic gradient.

- **Major factors influencing the rate of infiltration are:**
  - Physical characteristics of the soil, particularly surface layers (e.g., compaction, cracks, biopores)
  - Surface cover (e.g., crop residue, vegetation)
  - Soil water content.

Theory

- Concentric rings (Fig. 1) are forced into the soil to a depth of 30-50 mm and water added.
- The water in the outside ring acts as a buffer to minimize any lateral movement from the inner ring.
- It is assumed that all the water in the inner ring moves vertically downwards and the rate of inflow through the area of the central ring is measured.
- When the intake rate becomes constant, this is known as the infiltration rate.

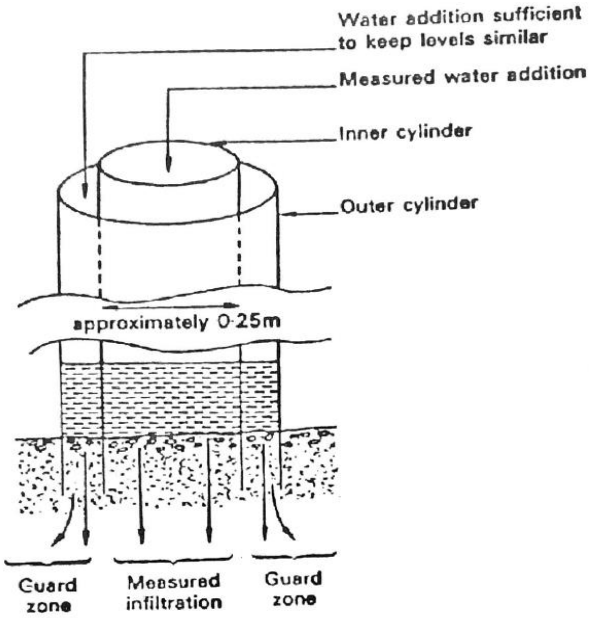

Diagram of concentric ring infiltrometer

Apparatus

- Two concentric ring infiltrometers (see approximate dimensions shown in the diagram)
- Ruler and paper clip to secure ruler against inner cylinder (see the photo below)
- Containers for water storage to recharge cylinders
- Stopwatch to record time
- A notebook to record depth of water and time.

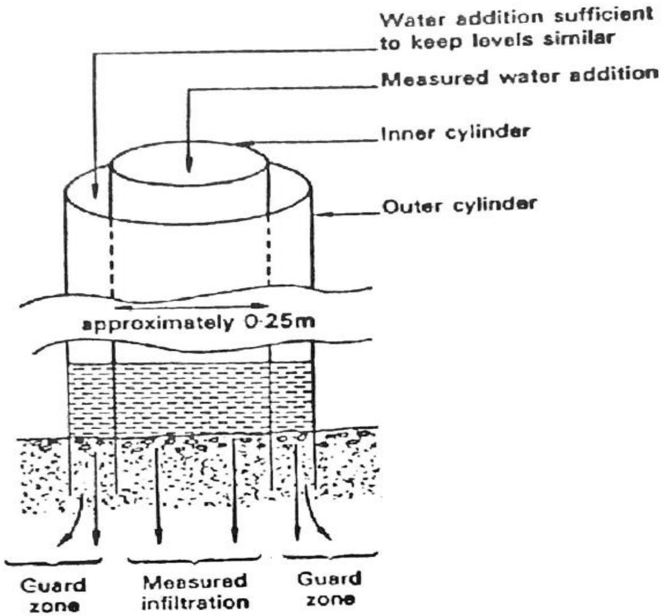

Diagram of concentric ring infiltrometer

Method

1. Drive the rings into the soil to a depth of about 50 mm, taking care to keep the rings vertical and minimize any disturbance of the soil within the rings,
2. Tap soil into the space between the soil and the rings; if this space is greater than 3 mm, the ring should be re-set,
3. Add a measured quantity of water into the central ring to give a head of about 75 mm above the soil surface. Add water to the outer ring to give exactly the same head,
4. To avoid undue disturbance to the soil surface, it may be necessary to pour the water onto a board instead of directly on the soil. Note the time at the start of the experiment,
5. Add further measured quantities of water to the central ring at convenient time intervals to keep a fairly constant head, noting the time at each addition. Try to maintain the head in the outer ring similar to that in the inner ring.
6. The quantity of water added at each interval represents the intake over that particular time interval,
7. Continue the experiment until the intake rate becomes constant.
8. Carry out at least two experiments at the same time (must be replicated).

Worked example

The following data were obtained from a concentric ring infiltrometer. The cross-sectional area of the inner ring was 500 cm^2.

Time (min)	Cumulative infiltration (cm^3)
0	0
2	270
4	450
6	620
8	770
10	900
20	1420
40	2410

Worked example

First, we can re-tabulate the data and derive various other columns of data:

Time (min)	Time (h)	F (cm^3)	F (mm)	I ($mm\ h^{-1}$)	Average time (h)
0	0.000	0	0.0		
2	0.033	270	5.4	162.0	0.017
4	0.067	450	9.0	108.0	0.050
6	0.100	620	12.4	102.0	0.083
8	0.133	770	15.4	90.0	0.117
10	0.167	900	18.0	78.0	0.150
20	0.333	1420	28.4	62.4	0.250
40	0.667	2410	48.2	59.4	0.500

(See next slides)

Worked example

- The cumulative infiltration, F, is obtained by dividing the cumulative infiltration in cm3 by the cross-sectional area (in our example, 500 cm2) and by multiplying by 10 to convert cm to mm.

- The infiltration rate, I, is calculated from the depth of infiltration (mm) divided by the elapsed time over each time increment, e.g., for the period from 10 to 20 mins gives:

$$I = \frac{(28.4\,mm\ - 18.0\,mm)}{(0.333\,h\ - 0.167\,h)} = 62.4\,mm\,h^{-1}$$

- The infiltration rates correspond to the mid-points of the time periods to which they refer, e.g., the rate between 10 and 20 mins is plotted at 15 mins or 0.25 hours.

Useful bibliographic sources

- Huffman, R. L. *et al*. (2011). *Soil and water conservation engineering* (6th Edition). ASABE Publication No.: 801M0411. ISBN: 1-892769-79-4.
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THANK YOU

Dr Diogenes Antille
Senior Research Scientist (Soil Physics)
E: Dio.Antille@csiro.au
T: +61 (02) 6218 3835

Dr Ben Macdonald
Group Leader (Soil Process and Function)
E: Ben.Macdonald@csiro.au
T: +61 (02) 6246 5947

Dr Mike Webb
Team Leader (Northern Cropping)
E: Michael.Webb@csiro.au
T: +61 (07) 4753 8562

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