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# Experimental evidences on the scaling behavior of a sandy porous media

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## Abstract

Various authors treated the scaling of the hydrodispersive parameters in porous media. Nevertheless several studies and reports finding in literature on this matter, specifically on the dispersivity increases with scale of measurement, are based on a statistical or experimental approach.

Following this last approach, we analysed the scale behaviour of a sandy porous media.

For this aim we carried out several tracer tests on three cylindrical samples of the considered sandy soil, with three different lengths respectively equal to 0.15 m, 0.30 m and 0.60 m.

For all tests the utilized tracer was NaCl, that was let in at first in short times and after with continuity, repeating the tests. For each of test the breakthrough curve was obtained and successively the longitudinal dispersivity ($\alpha_L$) and the coefficient of longitudinal dispersion ($D_L$) were calculated. These values, considering also the lengths of the samples, allowed to verify the scaling behaviour of the examined sandy porous media.

## 1. Introduction

The scale effect of the hydrodispersive parameters was verified from several authors (1984; Wheatcraft & Tylor, 1988; Neuman, 1990; Clauser, 1992; Schulze-Makuch, 2005).

Effectively these studies show for the hydrodispersive parameters a scaling behaviour. Specifically an increment of the dispersivity ($\alpha_L$) with scale and of the dispersion coefficient ($D_L$) with the velocity.

The aim of the present work is to investigate in laboratory on the scaling effect by several tracer tests on three cilyndrical samples of a sandy soil showing different length, using as tracer NaCl and letting in it at first in short times, using five different effective flow velocities. Successively the same experiments, to the same conditions, were repeated letting in the tracer with continuity.

## 2. Measurements and methods

The modality of the mass transport are strongly related to the type of the in let of the tracer in the soil. The Fig. 1a) and b) show the scheme of propagation of the tracer (contaminant) in the porous media for inlet in short time and continuous.

For inlet in short time, considering the case of monodimensional flow, the transport equation is:

$$C(x,t)=\frac{M/\omega}{\sqrt{4\pi Dt}}\cdot e^{-\frac{(x-ut)^2}{4Dt}} \qquad (1)$$

where $M$ is the tracer mass for unit of section [M], $x$ the distance between inlet and drawing points [L], $t$ the time [T], $u$ the effective velocity [$LT^{-1}$], D the coefficient of dispersion [$L^2T$], $\omega$ the kinematics porosity [0], $C$ the concentration at $x$ distance and $t$ time [$ML^{-3}$] and $C_{max}$ the maximum value of concentration [$ML^{-3}$].

Analogously for the continuos inlet the transport equation is:

$$C(x,t)=\frac{C_0 u}{2\sqrt{\pi D}}\int_0^t\frac{1}{\sqrt{\tau}}\cdot e^{\left[-\frac{(x-u\tau)^2}{4D\tau}\right]}d\tau \qquad (2)$$

where the symbols are the same of above (Bear J., 1979).

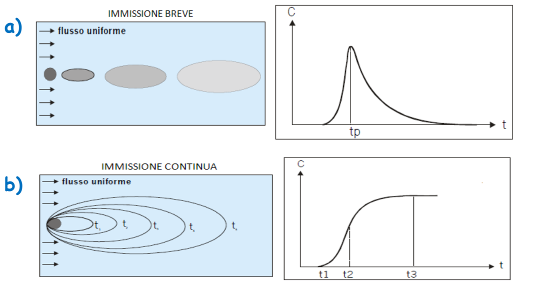


Fig. 1: Conceptual model of mass propagation for a) in short time and b) continuous inlet.

## 3. Experimental laboratory measurements

The granulometric analysis gave the results shown in Fig. 2:

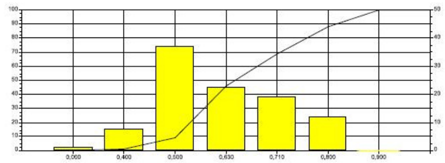

Fig. 2: Sieve analysis of soil used for the tracer tests.

The total porosity was measured, resulting equal to 42%.

The three examined cylindrical samples show a diameter of 6.35 cm and a length respectively equal to 15, 30, e 60 cm. Each test was carried out for five different effective velocities. Moreover for each sample the hydraulic conductivity ($k$) was measured by flow cells used as permeameters, obtaining the following values: 0.000286, 0.000982 e 0.000767 m/s.

The experimental apparatus is shown in Fig. 3.

Fig. 3: Experimental apparatus of laboratory.

A solution of 50 ml of distilled water with a concentration of NaCl equal to 5 g/l was utilized for each test. In Fig. 4 the breakthrough curves for all tests with inlet in short time are shown.

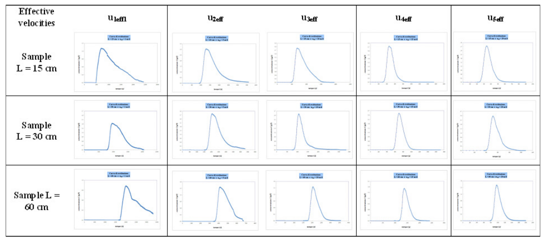


Fig. 4: Breakthrough curves for inlet in short time.

Analogously in Fig. 5 the breakthrough curves for all tests with continuous inlet are shown.

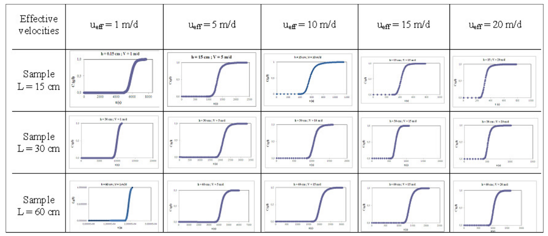


Fig. 5: Breakthrough curves for continuous inlet.

## 4. Results

For each test the $\alpha_L$ and $D_L$ values was determined. The mean values of $\alpha_L$ relative to all the test carried out with the same effective velocity were determined and these were related with the considered measurement scales. The results are shown in Fig. 6. Analogously in Fig. 7 the trends of $D_L$ with the velocity are shown.

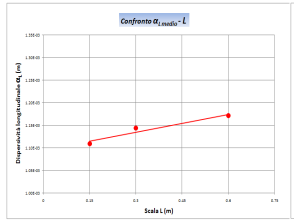

Fig. 6: Trend of $\alpha_L$ vs scale (inlet in short time).

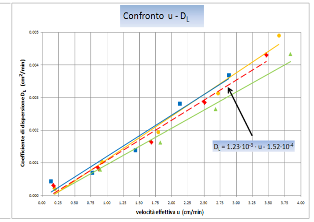


Fig. 7: Trend of $D_L$ vs velocity (inlet in short time).

For the tests carried out in continuous inlet the results, relatively to $\alpha_L$ and $D_L$, are reasumed respectively in Fig. 8 and Fig. 9.

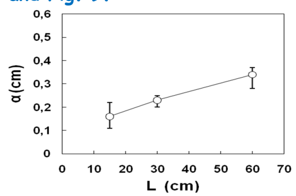


Fig. 8: Trend of $\alpha_L$ vs scale (continuous inlet).

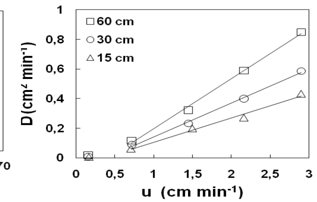


Fig. 9: Trend of $D_L$ vs velocity (continuous inlet).

## 5. Conclusions

The experimental results, obtained by the tracer tests in sandy soil with inlet both in short time and continuous, confirmed the scale behaviour of dispersivity and coefficient of dispersion.

## 6. References

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