The WormEx I Experiment: Effects of biopores and earthworm holes on soil hydraulic conductivity, sorptivity and macroscopic capillary length

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The WormEx I Experiment was launched on 9 March 2016 to investigate the effects of biopores and earthworms holes on soil-water constitutive laws. Particularly, changes in the soil hydraulic conductivity, in the soil sorptivity and in the macroscopic capillary length were evaluated in different soil conditions, by means of infiltrometric tests performed in a shallow anthropogenic soil of the Central Italian Alps (Cividate Camuno, Italy). About 50 field infiltration tests were performed by means of a tension infiltrometer (TI) and by means of a small single ring infiltrometer, in view of applying the simplified BEST method (Beerkan Estimation of Soil Transfer parameters).

The worms presence was accounted for by counting worms' castings in 1 m$^2$ experimental plots, and it was considered a proxy of the biogenic activity. Various meteorological conditions and various conditions of the presence of worms' castings were sampled during a period of three years. Obtained results highlight how soil hydrological properties change depending on the biopores presence.

As a result, the hydraulic conductivity greatly increased in presence of soil biopores, both in ponding and in near-saturation conditions. Conductivity at saturation increased on average by 45% (TI method), between great and small presence of earthworms' holes. Considering soil conditions that stimulate the biological activity (e.g. the previous days precipitation and the great water content at the beginning of the infiltration tests), the conductivity at saturation increased more, i.e. by 85% (TI) and by 105% (BEST) on average. The increase is even more relevant passing from adverse conditions (low castings number and small initial soil-water content) to optimal conditions (high castings number and great initial soil-water content). In these cases average increments are more than 200% (TI).

Also the hydraulic conductivity of the nearly saturated soil, with pressure potential ranging between -5 cm and 0 cm, meaningfully increased in case of biopores presence. The greatest (relative) increase of the soil hydraulic conductivity was observed in most of the cases at a pressure potential of -2 cm.
Sorptivity meaningfully increased from low to high wormholes number (45% at saturation) and from optimal to adverse conditions (114% at saturation). As for the hydraulic conductivity, this increase was even greater nearby ponding conditions. Field-tests results changed greatly depending on time and space: great standard deviations were observed for both hydraulic conductivity and sorptivity at all the values of pressure potential.

The macroscopic capillary length $\lambda_c$, which provides concise information about the soil attitude to diffusion, determined by numerically evaluating the subtended area to the experimental hydraulic-conductivity curve, also evidenced the presence of earthworms' burrows, ranging from 16.9 mm to 11.6 mm in optimal and adverse conditions respectively.