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Preferential flow dynamics in agricultural soils in Navarre (Spain): an experimental approach to gain insight into water connectivity

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To address studies on soil erosion and water quality it is essential to understand and quantify water movements through the soil. The estimation of this movement is usually based on soil texture and structure since it is assumed that the water moves across soil matrix. However, soils prone to the formation of cracks or macropores could trigger rapid flow paths, capable of drastically changing the movement of the water and, therefore, its connectivity across the soil. This would have important consequences both for runoff –and thus for erosion– and for groundwater quality. Local preliminary studies have shown that in many agrarian soils in Navarre (Spain), infiltration rate was mainly determined by this type of preferential flow. On the other hand, the formation of these cracks basically responded to expansion/contraction processes of clays due to changes in soil moisture content caused by rainfall.
The aim of this work was to quantify in agricultural soil the presence of cracks/macropores responsible for preferential flow and their temporal variation compared to different soil moisture contents.
The work was carried out in experimental plots (150 m2) of the UPNA with different type of conventional tillage: (i) mouldboard plough: (ii) chisel and (iii) mouldboard+Molon rake. Each plot was divided into two halves or subplots. On half was submitted to the action of 4 simulated rainfall (5 days passing between each event); whereas in the other half, no rain was applied. Six subplots were thus defined.
After each of the 4 rainfall, and once the 5 days had passed, the following experiments were conducted in each of the 6 subplots. In microplots (0.5 m2) a colourant (aqueous solution of bromide) was applied (Lu and Wu, 2003). To be specific, 8 mm of this solution was applied as intense rain with a sprinkler, but avoiding any waterlogging. Then, vertical cuts of 50-60 cm were made where the cracks/macropores were evidenced by the colourant. Photographs of the profiles were obtained. From these, binary images were obtained: soil matrix vs macropores/cracks. Statistical analysis was performed to characterize the macropore/crack distribution pattern.
First results indicated clear differences between the different tillage in the crack/macropores distribution. For example, in treatments in which the mouldboard plough was used, (i and iii), a greater presence of macropores was observed in the upper 20 cm. However, with the treatment with chisel (ii), macropores were evident in the whole soil profile; this was due to the chisel making cracks in the plow sole thus promoting water flow. Also, this pattern was affected by rainfall (and therefore in soil moisture) but information is still scarce for any greater precisions.
The extrapolation of these results would serve, for instance to (i) gain a better understanding of water movement and its connectivity in the soil and, thus, of the hydrological behaviour of typical agrarian catchments in Navarre; (ii) to improve the performance of hydrological models for land management, and (iii) optimize irrigation design and soil management practices.
Reference
Lu, J., Wu, L. 2003. Visualizing bromide and iodide water tracer in soil profiles by spray methods. Journal of Environmental Quality 32(1): 363-367