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Macroporosity and saturated hydraulic conductivity of a silty clay soil as affected by different applied pressure, moisture content and land use.

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Soil compaction due to the ever-growing size and power of machinery is unanimously considered one of the main causes of decreasing soil productivity and, generally, of environmental degradation.

In fact, stress application causes strong modifications to soil structure, reducing soil porosity and impairing soil hydraulic properties.

The aim of this study is to characterize soil porosity following different stress application and to establish possible correlation with hydraulic conductivity in order to set up a correct physically based formulation of soil hydraulic functions. This is an indispensable basis to improve models of soil water retention and movement.

Uni-axial compaction tests were carried out on air-dried and sieved (2 mm) samples of a silty clayey Vertic Haploxerept from central Italy (Vicarello di Volterra, Pisa) under arable (AR) and natural vegetation (NV). Soil samples were moistened and equilibrated at 3 different water contents: field capacity (-33 kPa), 110% and 90% (w/w) of plastic limit (FC, 1.1PL and 0.9PL, respectively). Four different pressures (50, 100, 200 and 400 kPa) were then applied by a hydraulic press. Saturated hydraulic conductivity measurements were performed by falling-head method on the soil samples previously compacted at different moisture content. The same samples were used to obtain soil thin sections on which total macroporosity ($>50\mu$m) and pore shape and size distribution of the surface soil layer (0-1 cm) were measured by image analysis.

Results confirm the well-known role of soil moisture in reducing internal friction, therefore making the soil more compactible. With increasing soil moisture content

even low applied pressures (50 and 100 kPa) caused a clear porosity decrease, so inducing an evident reduction of hydraulic conductivity.

When higher pressures were applied (200 and 400 kPa), both AR and NV soils showed total macroporosity values lower than 10%, the threshold for defining a soil as compacted (dense) according to the micromorphometric method, with the exception of soils at 0.9PL water content under the 200 kPa applied pressure. These critical conditions are confirmed by corresponding hydraulic conductivity data that always came out very low. On the whole, different land use showed a higher capacity of NV soil to counteract the negative effect of mechanical load on water conductivity, even if significance levels were not reached.

Furthermore, significant correlations were detected between log-transformed hydraulic conductivity data and both total and elongated porosity.

Further research is needed to verify whether the observed results will be confirmed for other soils prone to compaction; moreover, it is important to prove the effect of pore orientation on water transmission.

Key words: Soil compaction; Soil macroporosity; Saturated hydraulic conductivity; Soil thin sections, Image analysis; Plastic limit; Land use.