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Soil architecture relationships with dynamic soil physical processes: a conceptual study using natural, artificial, and 3D-printed soil cores

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Pore system architecture is a key feature for understanding physical, biological and chemical processes in soils. Development of visualisation technics, especially x-ray CT, during recent years has been useful in describing the complex relationships between soil architecture and soil functions. We believe that combining visualization with physical models is a step further towards a better understanding of these relationships. We conducted a concept study using natural, artificial and 3D-printed soil cores. Eight natural soil cores (100 cm3) were sampled in a cultivated stagnic Luvisol at two depths (topsoil and subsoil), representing contrasting soil pore systems. Cylinders (100 cm3) were produced from plastic or from autoclaved aerated concrete. Holes of diameters 1.5 and 3 mm were drilled in the cylinder direction for the plastic cylinder and for one of the AAC cylinders. All natural and artificial cores were scanned in a micro x-ray CT scanner at a resolution of 35 μm. The reconstructed image of each soil core was printed with 3D multijet printing technology at a resolution of 29 μm. In some reconstructed digital volumes of the natural soil cores, pores of different sizes (equivalent diameter of 35, 70, 100, and 200 μm) were removed before additional 3D printing. Effective air-filled porosity, Darcian air permeability, and oxygen diffusion were measured on all natural, artificial and printed cores. The comparison of the natural and the artificial cores emphasized the difference in pore architecture between topsoil (sponge like) and subsoil (dominated by large vertical macropores). This study showed the high potential of using printed soil cores for understanding soil pore functions. The results confirm the suitability of the Ball model partitioning the pore system into arterial, marginal and remote pores to describe effects of soil structure on gas transport.