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Application of X-ray computed tomography for the visualisation of the soil microstructure and soil organic matter

S. Sleutel (1), V. Cnudde (2), B. Masschaele (3), J. Vlassenbroek (3), M. Dierick (3), L. Van Hoorebeke (3), P. Jacobs (2) & S. De Neve (1)

(1) Dept. of Soil Management and Sol Care, Ghent University, Belgium, (2) Department of Geology and Soil Science, Ghent University, Belgium, (3) Department of Subatomic and Radiation Physics, Ghent University, Belgium (steven.sleutel@UGent.be / Fax: +32 9 264 6055)

Advances in non-destructive techniques such as X-ray computed tomography (X-ray CT) scanning combined with spatial analysis, open up the opportunity to directly quantify the internal architecture of soil, and crucially in three dimensions. We explored the potential of different state-of-the-art X-ray CT set-ups (Centre for X-ray tomography - Ghent University) for the discrimination of soil mineral matter, soil organic matter (OM) and the pore phase. The acquired radiographs were converted into 2D reconstructed cross-sections by the in-house developed software package Octopus (Dierick et al., 2004). 3D analysis of the reconstructed images was conducted with the μCTanalySIS software package (Cnudde et al., 2004). Different X-ray sources, detectors and filtering methods were investigated. Use of a low energy detector as well as a Cu-filter decreased the potential for phase segmentation in X-ray CT images of an artificial sand-OM mixture. A mid-range X-ray detector showed to hold more potential. Results obtained for an artificial sand-OM sample showed that attenuation coefficient (AC) grey-value histogram-based single threshold was unsuitable for automated phase segmentation. A full 3D dual thresholding approach (performed with the recently developed Morpho+ software (Vlassenbroeck et al., 2006)) enabled a better separation of the different phases.

Secondly, the minimal measurable pore size class in a clay loam soil aggregate was compared using micro-focus and nano-focus X-ray CT. The resolution of the scanned

images is depending on the spot size of the X-ray source, the resolution of the detector and the used magnification. Reliable discrimination of pore and solid phases was expected to be limited by the X-ray tube's focal spot size to 2.5 μm, in contrast to the here attained voxel size of 0.84 μm at nano-focus CT. Although this study was limited in its extent, indications were found that more porosity is visible at higher resolutions and that large connected pore spaces may be observed on such a fine resolution. Further fundamental research into AC grey-value automated segmentation of OM from the mineral and pore phases, and into the truly achievable minimal pore size class using artificial calibration samples is necessary.

References:

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