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New approach to measure soil particulate organic matter in intact samples using X-ray computed micro-tomography

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Particulate soil organic matter (POM) is biologically and chemically active fraction of soil organic matter. It is a source of many agricultural and ecological benefits, among which are POM's contribution to C sequestration. Most of conventional research methods for studying organic matter dynamics involve measurements conducted on pre-processed i.e., ground and sieved soil samples. Unfortunately, grinding and sieving completely destroys soil structure, the component crucial for soil functioning and C protection. Importance of a better understanding of the role of soil structure and of the physical protection that it provides to soil C cannot be overstated; and analysis of quantities, characteristics, and decomposition rates of POM in soil samples with intact structure is among the key elements of gaining such understanding. However, a marked difficulty hindering the progress in such analyses is a lack of tools for identification and quantitative analysis of POM in intact soil samples. Recent advancement in applications of X-ray computed micro-tomography (μ-CT) to soil science has given an opportunity to conduct such analyses. The objective of the current study is to develop a procedure for identification and quantitative characterization of POM within intact soil samples using X-ray μ-CT images and to test performance of the proposed procedure on a set of multiple intact soil macro-aggregates. We used 16 4-6 mm soil aggregates collected at 0-15 cm depth from a Typic Hapludalf soil at multiple field sites with diverse agricultural management history. The aggregates have been scanned at SIMBIOS Centre, Dundee, Scotland at 10 micron resolution. POM was determined from the aggregate images using the developed procedure. The procedure was based on combining image pre-processing steps with discriminant analysis classification. The first component of the procedure consisted of image pre-processing steps based on the range of gray values (GV) along with shape and size of POM pieces. That was followed by discriminant analysis conducted using statistical and geostatistical characteristics of POM pieces. POM identified in the intact individual soil aggregates using the proposed procedure was in good agreement with POM measured in the studied aggregates using conventional lab method (R^2=0.75). Of particular importance for accurate identification of POM in the images was the information on spatial characteristics of POM's GVs. Since this is the first attempt of POM determination, future work will be needed to explore how the proposed procedure performs under a variety of potentially influential factors, such as POM's origin and decomposition stage, X-ray scanning settings, image filtering and segmentation methods.