Soil matrix characteristics within macro-aggregates determined from µCT images

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Introduction

Computed microtomography allows for the study of soil aggregates at a scale of a few microns. Computed microtomography produces gray scale 3D images. The gray scale values (GVs) of these images roughly correlate to atomic number or density: mineral material have lighter (higher) values while pores/organic matter having darker (lower) values. Little work has been done looking at patterns within the soil matrix (mineral portion) as most work focuses on pore structure and roots.

The goal of this research is to examine how gray scale values can indicate dissolved organic matter (DOM) distribution near soil aggregate pores from different management practices.

Methods

- Aggregates were scanned at 13 µm resolution at Advanced Photon Source, Argonne National Lab, Argonne, IL.
- In order to avoid edge effects, the outside ~1 mm of the aggregates were eroded using the erode tool in ImageJ and the remainder used for analysis.
- Pores within aggregates were identified using indicator kriging in 3DMA.
- Three layers at 13-78 µm, 78-143 µm and 143-205 µm distances from pores were obtained. The GVs and variance from these layers were analyzed for treatment differences using ANOVA statistics in SAS.
- Gray scale values (GVs) were normalized to account for any between image differences by using the following equation:

$$(\text{average } GV_{section} - \text{average } GV_{total\ sample})/(\text{average } GV_{total\ sample})$$

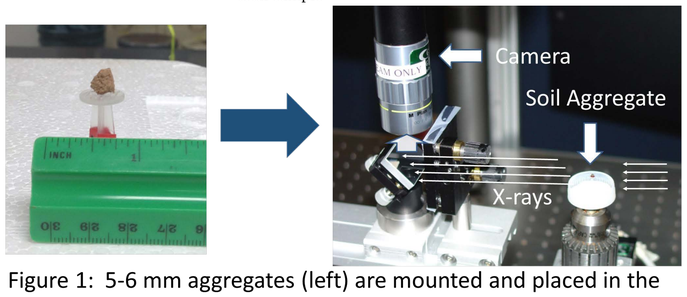


Figure 1: 5-6 mm aggregates (left) are mounted and placed in the x-ray beam. Non-absorbed x-rays are converted to visible light and captured with a camera.

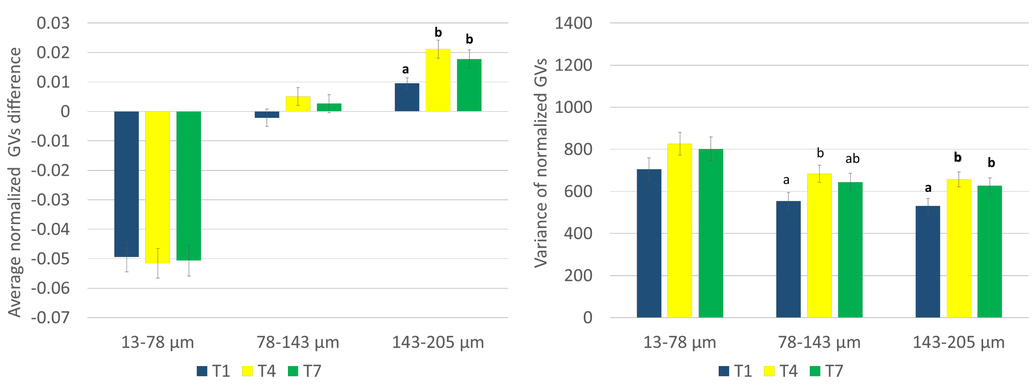


Figure 2: Comparison of the averages and variance of GVs at each layer for the three treatments. Different letters indicate significant differences at α=0.05 (bold) and α=0.1.

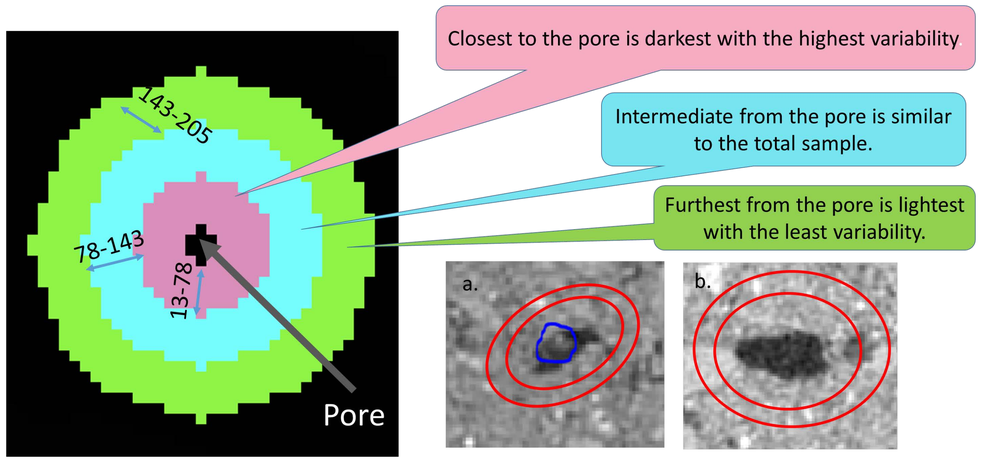


Figure 3: Schematic of a pore with the layers taken for analysis.

Figure 4: Pictures of a. root pore and b. non-root pore. The blue circle indicates the root within the pore. The red outlines are the 143-205 µm layer.

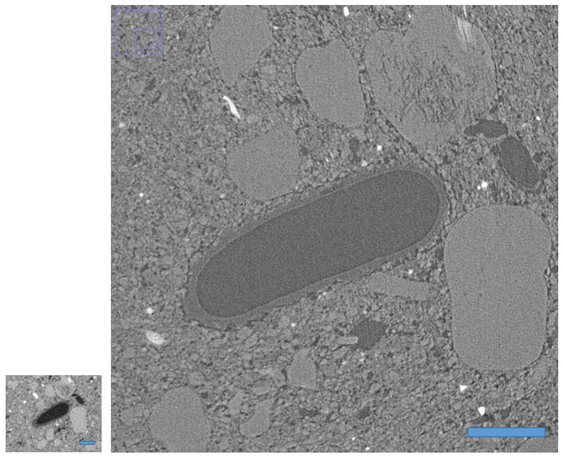


Figure 5: Size difference between 13 µm and 2 µm scanning size. The blue bar is ~200 µm. The smaller scan size allowed for the viewing of micro-porosity, which was the same for all treatments at all distances, indicating that gray scale differences are most likely from DOM.

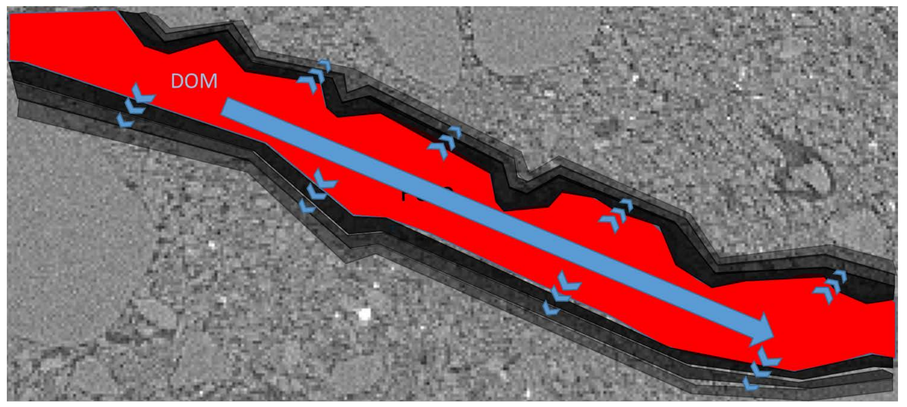
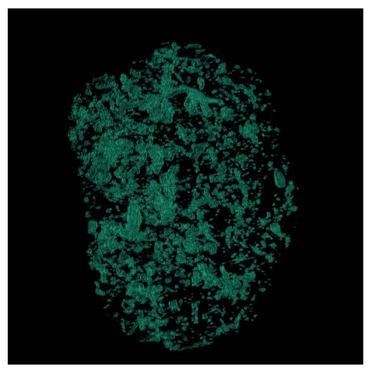
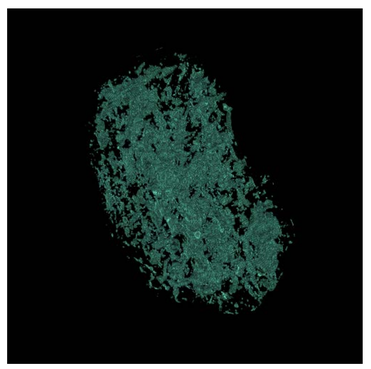


Figure 6: Illustration of believed DOM diffusion into the soil matrix from pores within soil aggregates.





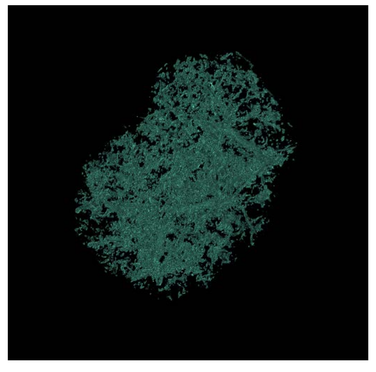


Figure 7: 3D image of surface area of pores within a typical soil aggregates from three different treatments. Top left is conventional management. Top right is biologically based. Bottom left is primary succession. Note the increased surface area in biologically based and primary succession as compared to conventional management.

Conclusions

- For all managements, there is no difference near pore surfaces.
- Biologically based and primary succession lighten faster than conventional management.
- This lightening does not seem to be an effect of micro-porosity as micro-porosity is the same in all managements. DOM seems a likely reason for the differences.
- The differences in DOM distribution may be due to the increased pore surface area present in biologically based and primary succession as compared to conventional management.
  - More surface area equates to more places directly adjacent to pores that DOM may get bound and therefore, not diffuse further into the soil matrix.
- Current experiments are testing this hypothesis.

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