Organic Matter Characteristics of Soil Aggregate Fractions under Different Ecosystems

Yili Meng[1], Jim J. Wang[1], Shuai Liu[1], Zhuo Wei[1], Zhou Tian[1] and Michael A Blazier[2]

(1)School of Plant, Environmental and Soil Sciences, Louisiana State University, Baton Rouge, LA, (2)LSU Agricultural Center - Hill Farm Research Station, Homer, LA

Introduction

The interaction between organic matter with mineral constituents plays an important role in soil organic carbon (SOC) stability. Ecosystem difference imposed by different land use likely influence this interaction. Past research has shown that field management practice especially in crop lands tends to change the distribution of soil aggregate fractions, which, in turn, influence the stability of SOC. However, there has been very limited study to systematically evaluate land use change effects on the nature of soil organic matter (SOM) associated with different sized aggregates. In this study, the effect of land use change from an originally pasture land to newly established four agroforestry systems on SOC characteristics of different aggregate fractions were investigated.

Objective

The aim of this study is to characterize soil organic matter in different sizes of soil aggregates from four agroforestry systems using FTIR.

Methods and Material

Study Site and soil aggregate fractionation

The agroforestry experiment site is located in the southeast U.S., at Archibald, LA. The site was in pasture for 5 years before a portion of the field was changed to agriculture row crop land (currently in crop-rotation of sorghum and soybean), switchgrass and cottonwood in 2009 and maintained. Surface soil samples (0-15cm) were collected from the original pasture and the newly established agroforestry systems in 2013. The collected field-moist soil samples were wet-sieved to fractionate into aggregates into three size fractions: macroaggregates (>250µm), microaggregates (53-250µm), and silt+clay fraction (<53µm). Among the three aggregates, the macroaggregates had C content 13.7g C/kg soil in average, which is higher than microaggregates with 13.2 C/kg soil in average, and silt-clay fraction 9.7 g C/kg soil in average. There is no significant difference of soil C and N among different ecosystems. Soil total N generally followed the same trend as soil C, with an average C/N ratio of 7.9.

Soil organic matter extraction and characterization

Soil organic matter was extracted from each aggregate fraction and purified following the procedure outlined by the International Humic Substances Society (Dodla et al., 2012). Briefly, soil aggregate samples were first treated with 1M HCl to remove carbonates, Fe and Mn oxides, and hydroxides. Then the soil was neutralized and extracted using 0.1 M NaOH under N_2 atmosphere. The aqueous SOM solution was acidified and precipitated by adding HCl, and the supernatant discarded. The SOM precipitate was re-dissolved by adding of 0.1 M KOH under N_2 atmosphere, followed by acidification to precipitation, and then treated with 0.1 M HCl/0.3 M HF solution to decrease the ash. Finally the obtained SOM samples were dialyzed (exclusion size: 6,000 D) and freeze-dried. The characterization of the respective SOM from each aggregate fraction was performed using Attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR).

Results

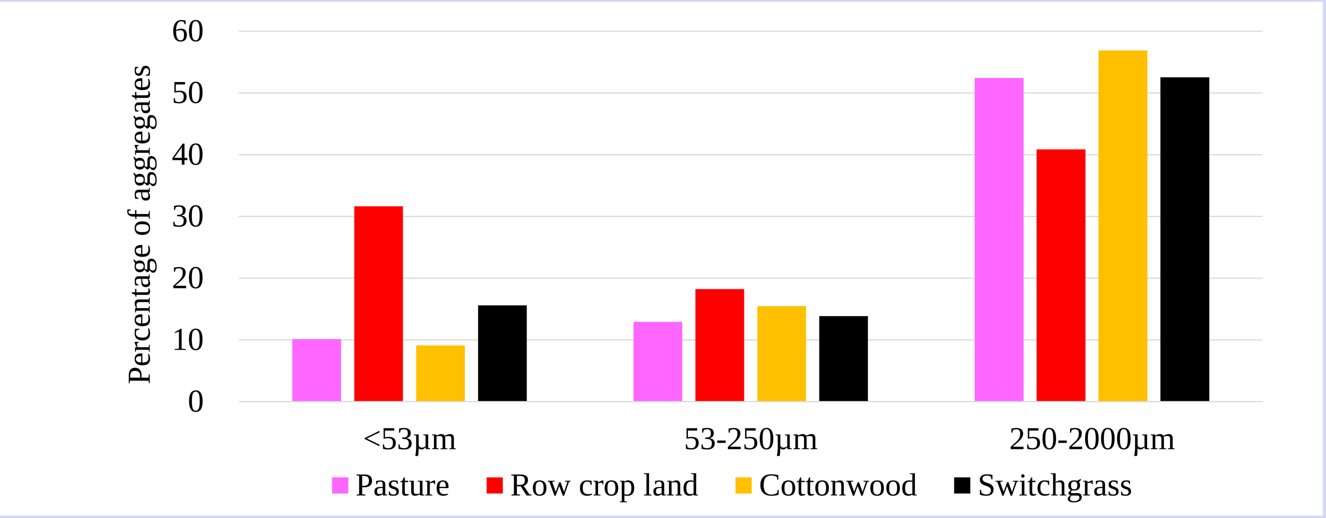

Figure 1. Relative distribution of <53µm, 53-250µm, and 250-2000µm aggregates fin different ecosystems.

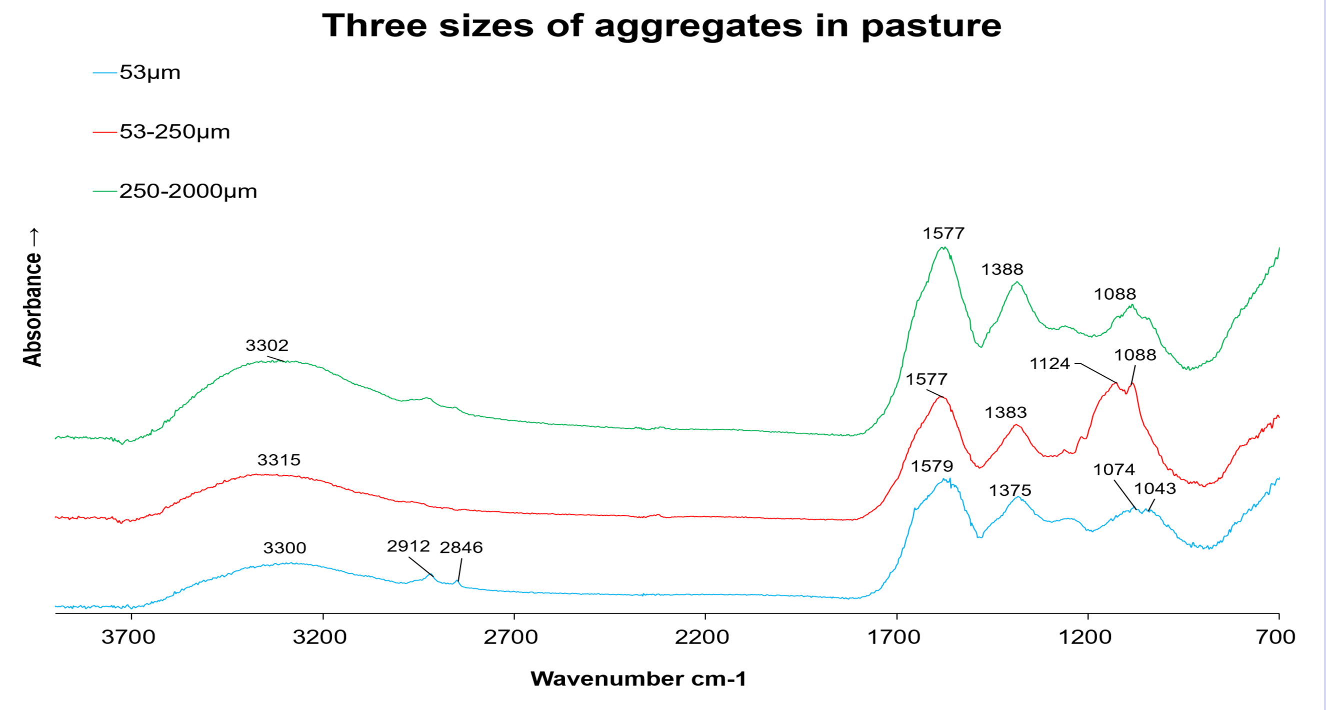

Figure 2. ATR-FTIR spectra of SOM from three aggregate fractions (<53µm, 53-250µm, and 250-2000µm) of pasture land.

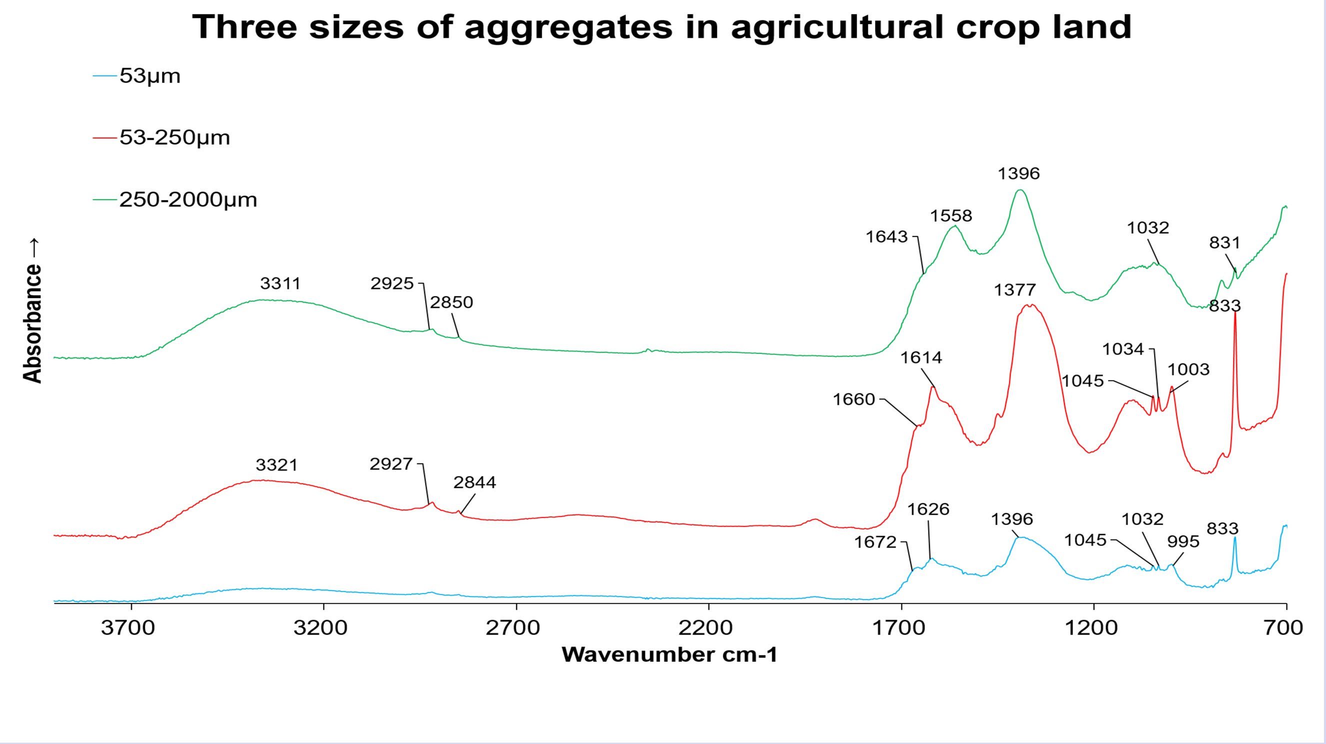

Figure 3. ATR-FTIR spectra of SOM from three aggregate fractions (<53µm, 53-250µm, and 250-2000µm) of agricultural row crop land.

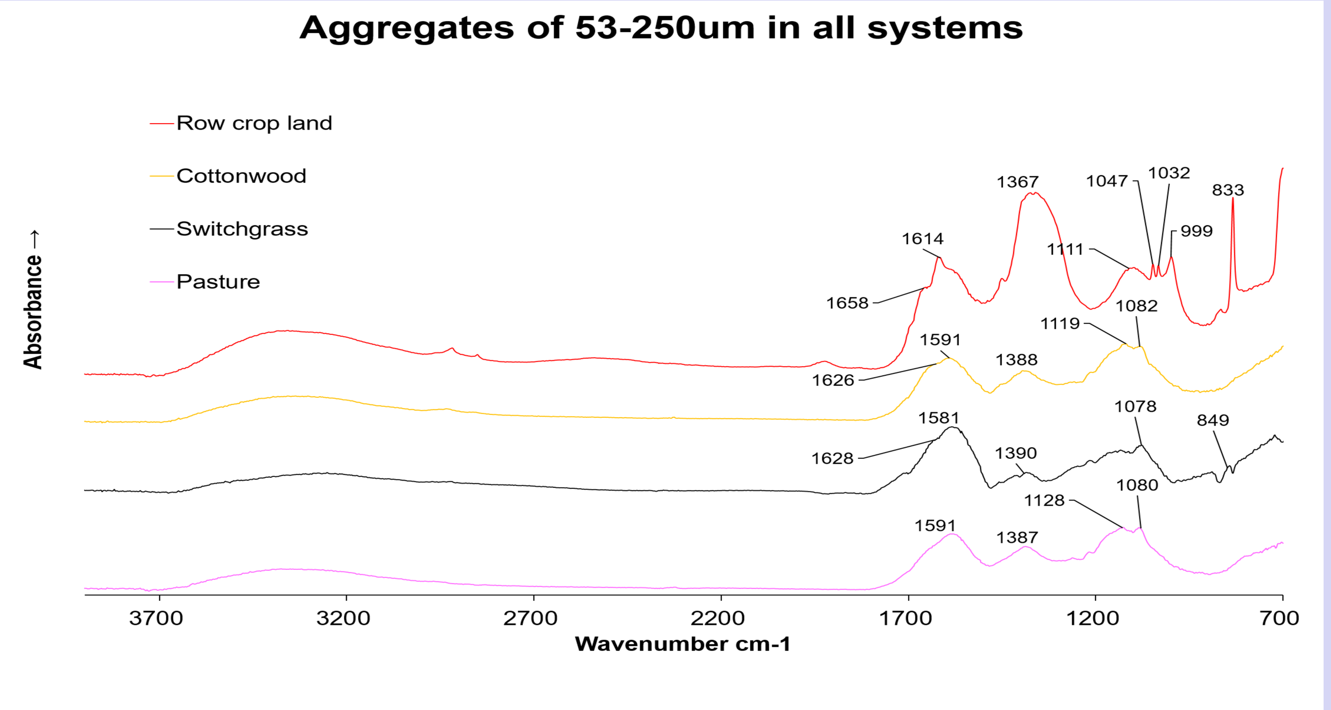

Figure 4. ATR-FTIR spectra of 53-250µm aggregate fraction SOM obtained from pasture, agricultural row crop land, cottonwood, and switchgrass.

Table 1. FTIR absorbance bands and their assignments

Wavenumbers (cm^{-1})	Assignment
3288-3324	O-H stretching of cellulose, H-bonded hydroxyl
2910-2930	Asymmetric aliphatic C-H stretching of CH2 and CH3
2844	Symmetric aliphatic C-H stretching of CH2 and CH3
1628-1670	C=O stretching of carboxyl, ketone, aldehyde
1560-1620	Aromatic C=C stretch
1367-1400	O-H bending of phenols or alcohols; COO- stretching
1130-995	C-O stretching of cellulose and hemicellulose; aromatic ethers(lignin)
830-850	Aromatic C-H out-of-plane deformation

Conclusions

Soils from all four ecosystems were dominated by aggregate fractions of 250-2000µm (40%-50%), followed by 53-250µm (12%-20%), and <53µm (9%-30%). Land use changed from pasture to row crop land significantly increased the fraction of <53µm and 53-250µm aggregates, but decreased 250-2000µm aggregates. Whereas, the change to cottonwood increased 53-250µm and 250-2000µm aggregates, but had no effect on <53µm aggregates. Land use changed to switchgrass increased <53µm aggregates but had little effect on the percentages of 53-250µm and 250-2000µm aggregates.

FTIR spectra showed generally similar patterns for different size aggregates within a specific ecosystem (Fig. 2, Fig. 3), which suggests an inherently preferential accumulation of similar nature of SOM in aggregates of soils under the specific ecosystem of a particular land use.

Pasture generally exhibited greater aromatic moieties in all three aggregate fractions as evident by greater aromatic C=C stretching band intensity at 1577 cm^{-1} although it also had dominant polysaccharides as seen by higher intensity of C-O stretching of cellulose and hemicellulose at 1043-1124 cm^{-1} in its microaggregate fraction (53-250 µm) than the other two fractions (Fig. 2).

The land use change from the original pasture to agricultural row crop land changed SOM characteristics dominated by phenolic functional groups (at 1367-1390cm^{-1}) in all three aggregate fractions, suggesting the greater percentage of the reactive C in the soil (Fig. 4).

Land use change to switchgrass and cottonwood from the pasture did not result in any significant change in SOM characteristics after four years as evident in the FTIR spectra of the microaggregates fractions among different ecosystems (Fig. 4).

Reference

Dodla, S. K., J. J. Wang, and R. L. Cook. 2012. Molecular composition of humic acids from coastal wetland soils along a salinity gGradient. Soil Sci. Soc. Am. J. 76:1592-1605. doi:10.2136/sssaj2011.0346