Investigating the Stability of Carbon in Soils to Observe the Effect of No Tillage Over a Period of Twenty Years

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INTRODUCTION

SOIL COMPOSITION

- Soil is unconsolidated rock.
- It's composed of about 45% mineral matter, 5% organic matter, 10-40% water, 10-40% air.
- As primary particles aggregate, they form secondary particles.

CARBON SEQUESTERING

- Carbon sequestration is the process of moving and storing carbon dioxide from the atmosphere into soil.
- Plants take carbon dioxide out of the air, and turn it into carbon fuel.
- Microorganisms in the soil turn this carbon into glomalin, storing the carbon in the soil.

CURRENT AGRICULTURAL PRACTICES

- Tillage had been shown to decrease soil function.
- In the 1990s, Alberta started to recommend Conservation Cropping which does not use tillage.
- We have access to 25 years of archived soil collected from 1997 to 2020 from agricultural benchmark sites across the province.
- The archived data can be used to determine if no till agriculture has an effect on C storage and stability.

METHOD - OXIDATION

OBJECTIVE

- Oxidation is the process of removing organic matter by mixing the soil with a sodium hypochlorite adjusted to pH 8.5 with hydrochloric acid.
- It is a variation on the traditional alkaline extraction technique, where a solution with pH 13 is used to ionize functional groups that contain oxygen, which dissolves many of the organic compounds in soil organic matter.

PROCESS

- 2g of ground samples are weighed into Falcon tubes
- 30mL of sodium hypochlorite solution with pH lowered to 8.5 using hydrochloric acid (Figure 1) are dispensed into each tube.
- The samples are shaken for 18 hours, and then placed in the centrifuge (Figure 2) for 30 minutes to settle the solid soil fragments. The supernatant is drained and the process is repeated three times for each set of soil samples.
- Ultra-pure water is used to wash the soil after the oxidations. There are five rounds of washing.
- Samples are dried in a forced-air oven at 55°C for 48h and stored.

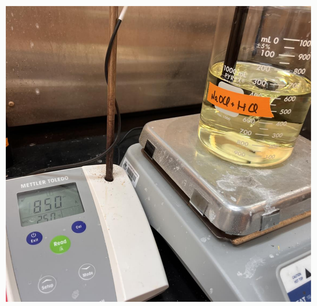

Figure 1: A solution of sodium hypochlorite (NaOCl) is mixed with hydrochloric acid using a magnetic stirring apparatus to lower the pH to 8.5. A pH probe (black rod) is placed into the solution to measure the pH precisely.

Figure 2: The centrifuge is used to separate the components of the Falcon tube. It spins at 3500 rpm for 30 minutes.

METHOD - FRACTIONATION

OBJECTIVE

- Fractionation is the process of splitting the soil into parts based on particle size.
- The largest particle size is called *particulate organic matter* (POM), and is between 0.53mm and 2mm.
- *Aggregated mineral-associated organic matter* (A-MAOM) and *non-aggregated mineral-associated organic matter* (NA-MAOM) is everything smaller than 0.53mm.

PROCESS

- 4g of soil is put in a sieve and into the wet sieving apparatus (Figure 3, 4).
- Ultra-pure water is sprayed and then the sieves are lowered into tins with ultra-pure water to avoid breaking aggregates.
- The sieves are loaded into tins with the dispersing agent (sodium hydroxide or sodium hexametaphosphate) and ultra-pure water is strongly dispensed out, breaking down the aggregates and causing A-MAOM to be filtrated out.
- The remaining soil in the sieves is back-washed with ultra-pure water; this is the POM.
- Samples are dried in a forced-air oven at 55°C for 48 hours and then stored.

Figure 3: The wet sieving apparatus is used for most of the fractionation process. The black cylinders are the sieves which have a filter-like mesh on the bottom.

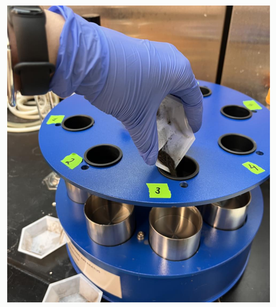

Figure 4: Soil samples are being poured into the sieves. As the samples are poured, some of the smallest particles (NA-MAOM), go through the sieve. The water tin is there to catch all the material. After the soil is poured, water is sprayed into the sieve to break down larger aggregates.

RESULTS

DRIFT SPECTROSCOPY

- Diffuse reflectance infrared Fourier transform (DRIFT) is a method of analysis that involves exposing samples to infrared radiation, and measuring how much light is absorbed.
- Different chemical bonds have different energies, and these particular energies will absorb different frequencies and amounts of the radiation.
- This data is used to analyze what chemical bonds are within a sample, thus being used to analyze what chemicals are within a sample.

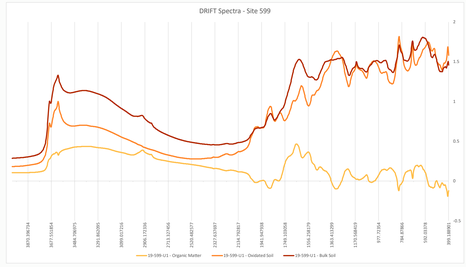

Figure 5: DRIFT spectra for the site 599, in upper slope position, depth 1 (15-30cm) (19-599-U1) – organic matter, oxidated soil, and bulk soil spectra

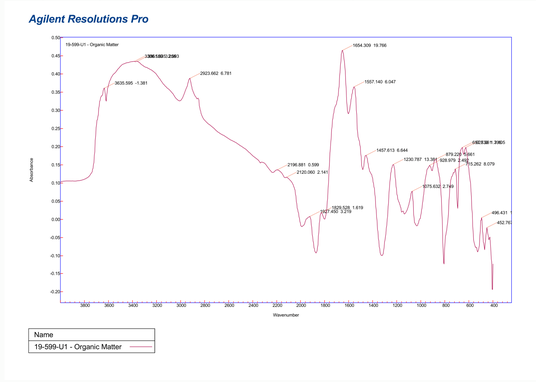

Figure 6: DRIFT spectra for the site 599, in upper slope position, depth 1 (0-15cm) (19-599-U1) – organic matter spectra; peak values calculated

INTERPRETATION

- The peaks on the graph tell us about the presence or absence of specific bonds and functional groups within the soil.
- For example, Figure 6 depicts a small peak at around wavenumber 2197, which is the absorption band for C≡C. The largest peak at around 1654 depicts the presence of a carbonyl bond (C=O) within an amide group (functional group containing NH_2).

CONCLUSION

FINAL RESULTS AND MEANINGS

- The soil samples were processed and examined for their chemical stability through DRIFT spectroscopy.
- If the spectra demonstrates an increase in the stability of carbon in soil (stability of carbon functional groups demonstrated by spectra bands), the absence of tilling has a positive effect on the stability of carbon in soils.
- If spectra demonstrates no change or decrease in the stability of carbon in soil, the absence of tilling has no effect or negative effect on the stability of carbon in soils, respectively.
- Further research must be performed to achieve a more conclusive dataset and result.

APPLICATION

- According to the proposed hypothesis regarding modern agricultural practices, the avoidance of tilling may result in a minimized disturbance of microorganism ecosystems within soil, allowing for greater rate of carbon sequestration.
- As rate of carbon sequestration increases, there can be a minimization in the concentration of carbon dioxide in the atmosphere.
- This can minimize climate change and global warming.
- Overall, more research must be conducted.

ACKNOWLEDGEMENTS

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