Soil and Sediment Analysis for Agricultural and Arctic Landscapes

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INTRODUCTION

Soil plays in integral role in our terrestrial ecosystems. It is the membrane between the atmosphere and the biosphere. Soils provide a medium for vegetation, a filtration system for water, and contain the essential minerals and nutrients plants require (ref). Soil is composed of living (biotic) and non-living (abiotic) material. Soil development is a dynamic and ongoing process that depends on local climate, parent material, topography, vegetation, and time. The size of the inorganic mineral particles within a soil is referred to as grain size. Soil grain size is classified as Clay if the particle diameter is <0.002 mm, as silt if it is between 0.002 mm and 0.06 mm, or as sand if it is between 0.06 mm and 2 mm (Figure). The texture of a soil, or the distribution of particle grain size, can be a determining factor on how the soil drains or retains water, and its ability to retain nutrients, and its susceptibility to erosion, all of which can be direct factors in the development of natural vegetation or crop suitability.

To classify a particular soils texture the proportions of particle size (% Sand, % Silt, % Clay) of a given sample is required. The use of a standard method is essential in order to compare data obtained at different locations (ref). A well-developed method for determining the quantitative proportions of particle size is the hydrometer method. Additionally, local soil conditions, or infrastructure (Roads) can have a direct impact on the water quality, specifically the turbidity of local water. The quantitative measure of sediment with water is known as Total Suspended Sediment, and can be related to other water quality measures such as conductivity. Total suspended solids is determined by filtering a known volume of water and measuring the mass of the suspended material that is captured on a fine filter.

Soil Texture and Grain Size Analysis Projects

Agricultural Soils and Nutrient Modeling

The texture analysis undertaking in this project is helping to support the creation of a model for phosphorus in soils. Phosphorus is an essential element for plant growth, and crop productivity needs phosphorus. Phosphorous also fuels the growth of nuisance and harmful algae in freshwater ecosystems. Farmers historically applied phosphorus in excess of crop needs, and so there has been a buildup of phosphorus in agricultural soils. The extent of phosphorus buildup, and the precise locations within an agricultural watershed, is not known. Researchers in Dr. Wellens lab are working to develop models to predict the levels of phosphorus in soils across Ontario. An important co-variate in the model is that of soil texture. Processing the known locations of soil samples for soil texture provides calibration and validation data for the model development.

Arctic Soils and Sediment Connection to Water Quality

In most Nunavut communities, there exists an immense lack of detailed data on the connection between terrestrial ecosystems, hydrological behaviour, water quality and climate change, limiting our ability to predict future trends in fresh water systems and to determine the risks to people and the environment. Soil texture is a co-variate in the distribution, composition, and biogeochemical out-

METHODS

Hydrometer Method

Soil was collected from several watersheds by Dr. C. Wellen's team. Each soil sample was oven/air dried to remove excess moisture. Using a mortar and pistil samples were ground to break down large clumps. The samples were then passed through a 2mm soil sieve to remove larger stones. 100g were subset from the sample for processing of soil phosphorous levels to be completed at a separate laboratory. 40 g subsampled for texture analysis. 200ml of deionized (DI) water was added to the texture analysis subsample and blended for five minutes with a mechanical mixer. The sample were the taken from the mixer and poured into a 1000ml graduated cylinder. The cylinder was topped up with more DI water for a total volume of 1000ml. The hydrometer method is based on stokes law that describes the resisting force on a particle moving through a viscous fluid and the maximum velocity it obtains. Essentially the larger particles will settle out of suspension over time, reducing the density of the solution. A hydrometer, (ASTM 152H) g/L, is used to measure the change of particle concentration in a suspension with time of settling. Clay (<2 µm) and silt (2 to 50 µm) fractions are determined from the sedimentation curve or a simplified calculation (Gee and Bauder, 1979). Using the hydrometer, the solution density is measured at set time intervals to determine the soil particle settling curve.

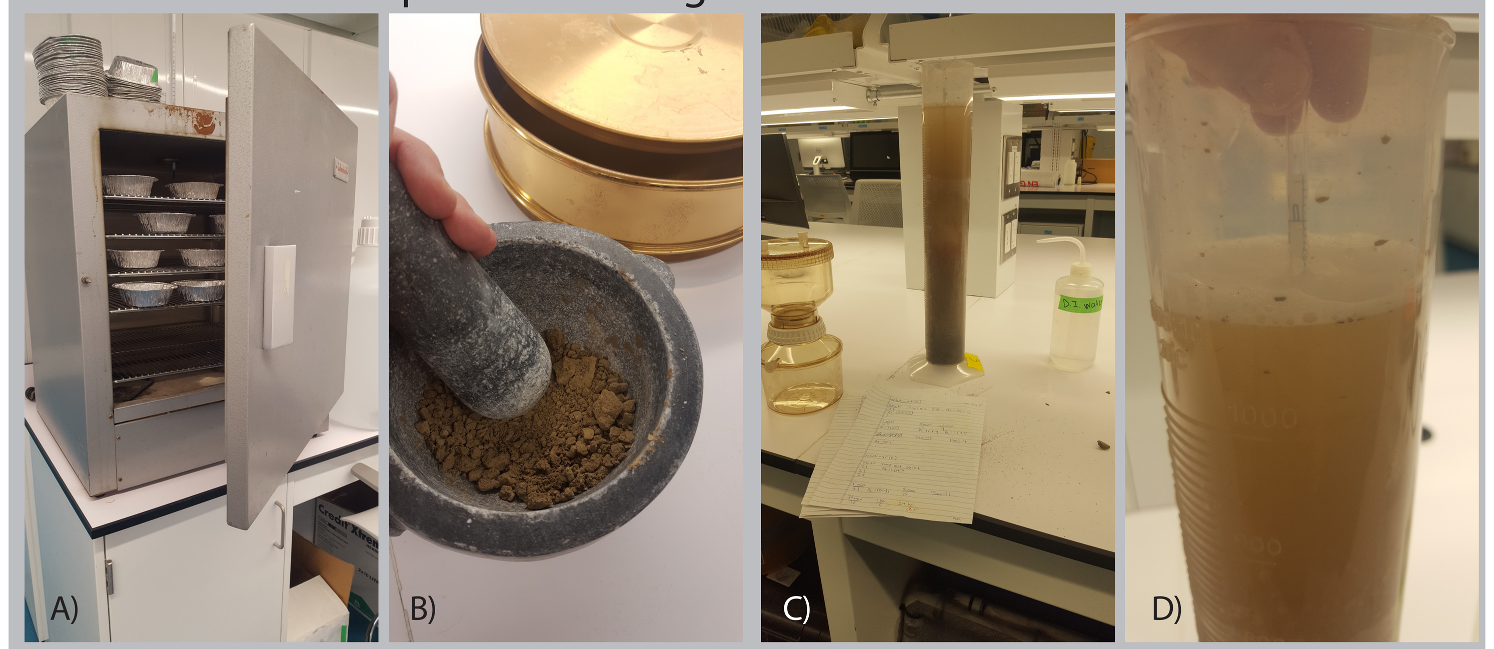

Figure 1
Hydrometer Texture Analysis Procedures. A) Oven Drying Soil Samples, B) Grinding Soil, C) Sediment in Suspension, D) Measuring Solution Density

Total Susspended Solids (TSS)

Total suspended solids (TSS) is the dry-weight of suspended particles, that are not dissolved, in a sample of water that can be trapped by a filter that is analyzed using a filtration apparatus. Samples for TSS were determined by filtering the sample through a 0.45 µm filter and subtracting the filter weights before and after filtering. Detection limits for TSS was 0.1 mgL-1

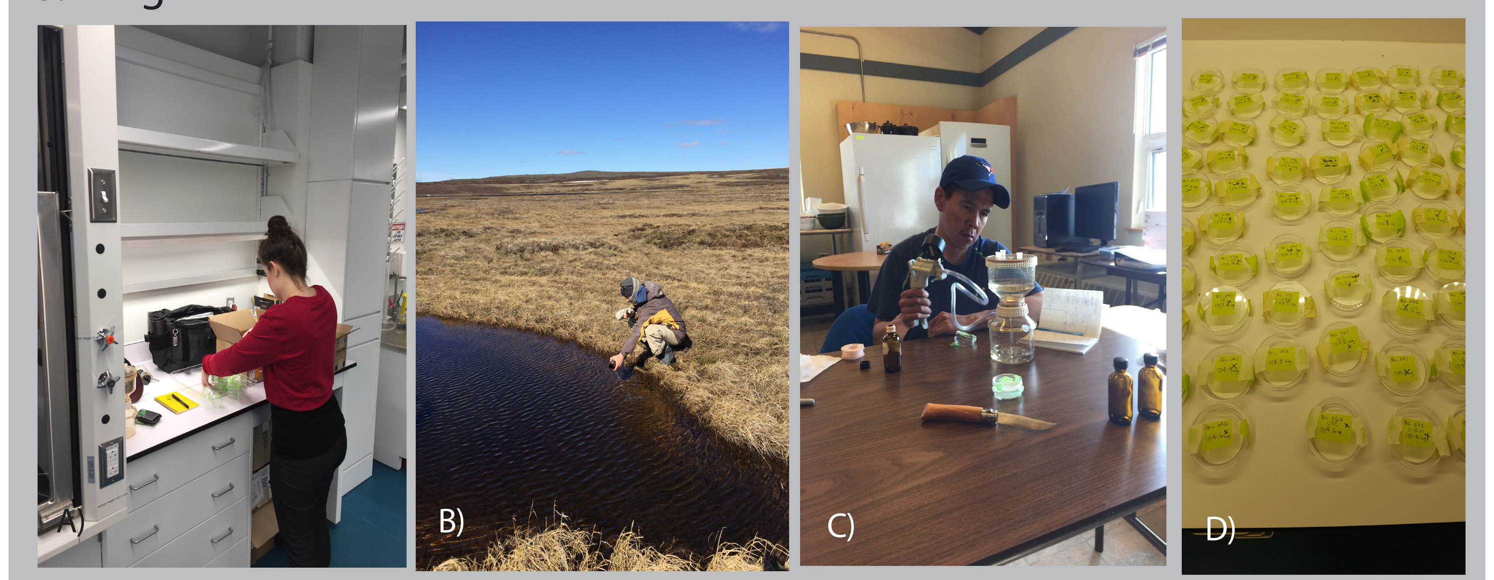

Figure 2
Total Suspended Sediment Analysis Procedures. A) Preparing Pre-Weighed Filters, B) Collection Water Samples, C) Filtering Water Samples, D) Preparing Sediment Filters For Final Weighing

RESULTS

Table 1 Hydrometer Texture Analysis Data Table with Time Interval, Density, and Control Values

HMP Con.:	0.05	g/ml		Procedure
Soil Name ==>		User Pedon ID ==>		
User Site ID==>	UW2	Sample Number =>	1	
Elapsed Time (min)	Time	Hydrometer Reading R	Temp °C	Blank Reading
0	10:28:00 AM			
0.5	10:28:30 AM	27.2	21.3	1
1	10:29:00 AM	21	21.2	1
5	10:33:00 AM	14	21.2	1
10	10:38:00 AM	10.5	21.1	0.5
30	10:58:00 AM	7	20.9	0.5
60	11:28:00 AM	6	20.8	0.5
90	11:58:00 AM	5	20.8	0.25
120	12:28:00 PM	5	20.8	0.25
120	12:28:00 PM	5	20.8	0.25
1440	10:28:00 AM	3	21	0.25

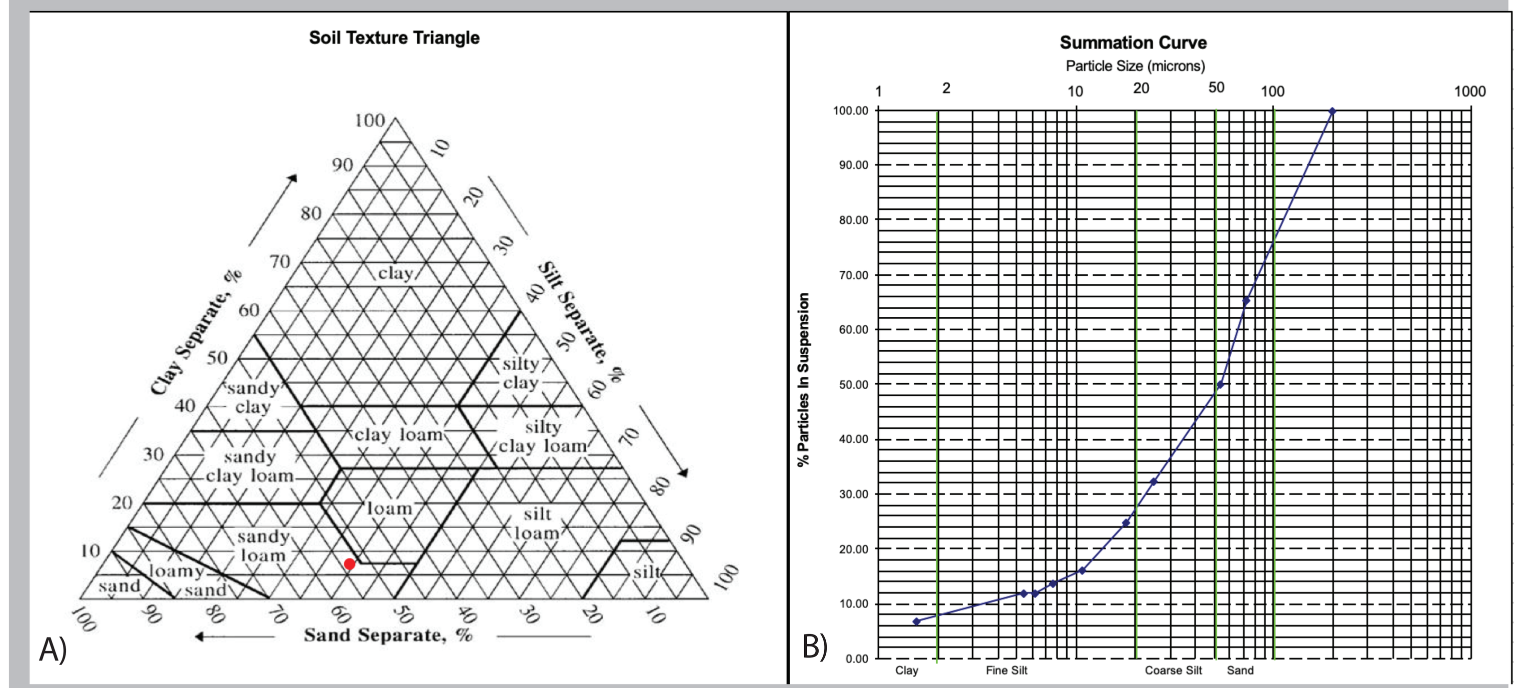

Figure 3
A) Soil Pyramid Combining Soil Texture Components To Identify Soil Type
B) Soil Sediment Curve Illustrating The Settling Rate Of the Suspended Soil Sample

DISCUSSION

Agricultural Soils and Nutrient Modeling

With the processing of over 196 agricultural soil samples from across two watersheds there is now sufficient co-variate data to being the model calibration and validation. Moving forward, historical soil phosphorus data from 1975 has also been compiled to allow for change modeling. This information is important to help inform watershed models of phosphorus non-point source loading. This work is ensuring that the models are predicting the right phosphorus source areas to prescribe the right types of intervention to reduce phosphorus loadings to local streams and lakes.

Arctic Soils and Sediment Connection to Water Quality

This analysis is still ongoing. The TSS samples have recently been dried and weighed to examine sediment loadings within two watershed near the community of Baker Lake. Additionally, landscape soil samples were collected from various vegetation types within these watershed. These soils samples will be processed for soil texture and sub-sampled for nutrient analysis.

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