ESCI 221 Soils and Sustainable Agriculture

Measuring Cation Exchange Capacity

Choose 2 different soils to analyze

Extract soil cations (Part I)

Weigh 2g soil to nearest 0.01 g

Place in a 50ml centrifuge tube

Add 40ml 1M NH4Cl

Shake for 10 minutes

Filter through #1 Whatman filter paper in glass funnel into 300 ml Erlenmeyer flask

Rinse filter with three 10ml aliquots of NH4Cl

use 70ml NH4Cl in all between shaking and rinsing

Pour filtrate into graduated cylinder and add deionized water to 100ml

Place in labeled polyethylene bottle

The filtrate (filtrate #1) contains the cations that were attached to exchange sites in the soil in its natural state.

Saturate with Ca2+ cations

Rinse soil off filter paper into a beaker using deionized H2O

Disperse with ultrasound for a few seconds

Vacuum filter the sample (0.45um pore size)

stop the vacuum before the soil is sucked completely dry

Add 50ml 0.1M CaCl2 in 2 or 3 increments

Vacuum filter the sample

Stop the vacuum before the soil is sucked completely dry

Rinse filter vessel with 50ml of CaCl2 and re-filter

use 100ml CaCl2 in all between filtering and rinsing

Rinse the filter with a couple hundred ml of deionized water

The soil sample is now saturated with Ca2+ cations. Discard the filtrate.

Remove Ca2+ cations

Scrape soil off filter and place in a 50ml centrifuge tube

Add 45 ml NH4Cl

Shake 10 minutes

Filter with any 0.4 or 0.2um filter apparatus

Pour filtrate into graduated cylinder and add deionized water to 100ml

Place in labeled polyethylene bottle

The filtrate (filtrate #2) contains the Ca2+ cations that were attached to exchange sites in the Ca-saturated soil. These samples will be analyzed by IC (ion chromatography) and ICPAES (inductively coupled plasma argon emission spectroscopy).

Calculations (Part II)

To convert ICP analyses to CEC values (in cmolc/kg):

*NB*: (M) = cation of interest

If there are two analytical lines, use the average of their values

1. ICP (mg/L) \* 0.100L (volume of solvent) = mg of (M) extracted

2. mg of (M)/weight of soil sample (g) = mg of (M)/g soil

3. mg(M)/g soil \* 1g/1000mg \* 1/MW (M) (mol/g) = moles of (M)/g soil

The summation of these values for all exchangeable cations gives CEC in terms of the number of individual atoms, and is used for determining the percentage of each cation, and the base cation saturation.

4. moles of (M)/g soil \* moles of charge/mole of (M) = equivalents/g soil

5. equivalents/g soil \* 1000g/kg = equivalents/kg

6. equivalents/kg \* 100 centimole charge (cmolc)/equivalent = cmolc/kg

The summation of these values gives CEC in terms of the total charge.

Amazingly enough, because of the way units cancel, the whole calculation can be boiled down to

[ICP(ppm) \* 5]/[MW/charge (M)] = CECc (cmolc/kg) for a 100ml extract.

Mole Weight (MW) of cations:

Na = 23

Mg = 24

Al = 27

K = 39

Ca = 40

Mn = 55

Fe = 56

Charges on cations

Na+

Mg2+

Al3+

K+

Ca2+

Mn2+

Fe2+

Note:

CECe = total cations in natural state (in cmolc/100g soil) (filtrate #1)

Filtrate #2 gives total potential CEC, a measure of the charges available

Base cation saturation = [(Ca + Mg + Na + K)/CEC] \* 100

*NB*: Ca and Mg are mole percentages (from step 3)

Test these questions:

Is there a correlation between [Al3+] and pH?

Between CEC and %OM (by LOI)?

Between CEC and % clay?

Based on the OM and clay fraction analyses, estimate the CEC using table 8.3 in the textbook. Assume that the clay fraction has equal parts vermiculite and fine-grained micas, and that the OM fraction includes all organic colloids.

Write up (Part III)

Standard scientific format

Discuss results and answer questions

Extra credit: how do ICP results for Ca and Mg compare with IC results?

Due 11/11/11