Proper Data Evaluation for Highly Organic Soils

Anthony Neumann, Darlene Lintott

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Overview

- Organic Soils Abundance and Characteristics
- Comparison to Mineral Soils
- Review of Test Methods
  - Metals, Organics, Salinity
- Factors affecting Results
  - Moisture, Organic Content, Dry Bulk Density, Water Holding Capacity, Organic Transformations
- Conclusions

Organic Soils

- Wetlands compose 20% of Alberta's Surface Area
  - Anaerobic activities cause the incomplete breakdown of plant material resulting in soils with high organic matter content and very little mineral content.
    - 90% of these wetlands are peatlands
  - 1.7 million hectares of wetlands in Saskatchewan
  - 5.3 million hectares of wetlands in BC

Source: Hatfield Consultants 2008

Characteristics of Organic Soils

- Water Retention is high
  - High Moisture Content at most times of the year.
- High Organic Matter, Low Mineral Content
  - Partially decayed and fully decayed plant material
- Very low Bulk Density
  - Lots of air/water pockets, large pore spaces
- High Capacity to Absorb Water
- Biologically Diverse and Active Ecosystem

Source: www.envirologic.ie

- These characteristics make the behavior of contaminants in organic soils very different from mineral soils.

Comparison to Mineral Soils

Physical and Aggregate Property	Organic Soil	Mineral Soil
Organic Matter Content	25%+	<10%
Moisture Content	50-95%+	20-50%
Dry Bulk Density	<0.2 kg/L	>1.5 kg/L
Water Holding Capacity	100%-1000%+	25-75%
Particle Size	>>2mm	<2mm
pH	<5	5-7.5
Biological diversity	High	Lower

Test Methods to be Discussed

- Hydrocarbons – BTEX, F1, F2-F4, PAHs
  - **Organic Solvent** Extraction, analyzed **as received** and corrected to dry weight basis.
- Metals and Mercury
  - **Dried and ground** sample, acid extraction, reported on dry weight basis.

Source: watercanada.net/2014

Test Methods to be Discussed

- Soil Salinity - Soluble Ions, pH and Electrical Conductivity, Boron
  - **Dried and ground**, **water extraction**, reported on dry weight basis
  - Saturated Paste Extraction, not a fixed extraction.
    - Field Capacity ~1/2 X Saturation percentage
    - Wilting Point ~1/4 X Saturation percentage

Saturated Paste Extract.

So – How will Moisture affect my results?

- **High Moisture Content**
  - Affects all tests that require samples to be analyzed “as received” but reported on a dry weight basis.
    - BTEX, F1, F2-F4, PAHs
  - Drying the sample would result in losses of analyte or potential transformation of analyte.

Source: www.agr.gc.ca

So – How will Moisture affect my results?

- **High Moisture Content**
  - How does Moisture content affect my results?
  - The moisture takes away from the initial mass of the sample.
  - **DW =(Wet weight mass x (1-Moisture))**

    Example:
    - Tier 1 Benzene = 0.046 mg/kg (FS)
    - Tier 1 Toluene = 0.12 mg/kg (CS)
    - Wet weight result of 0.005 mg/kg for benzene, 0.02 toluene

DW result=(Wet weight result / (1-Moisture))

Moisture Content	Benzene	Toluene
	Dry weight	Dry Weight
10%	0.0056	0.022
25%	0.0067	0.027
50%	0.01	0.040
80%	0.025	0.10
90%	0.05	0.20
95%	0.1	0.40
98%	0.25	1.00

So – How will Moisture affect my results?

- **High Moisture Content**
  - What can I do to minimize it?
  - In the lab, we can try to use a larger sample size.
    - Limitation is the absorption of the solvent.
  - In the field, consider the possibility of separating the sample into a water phase and solid phase.

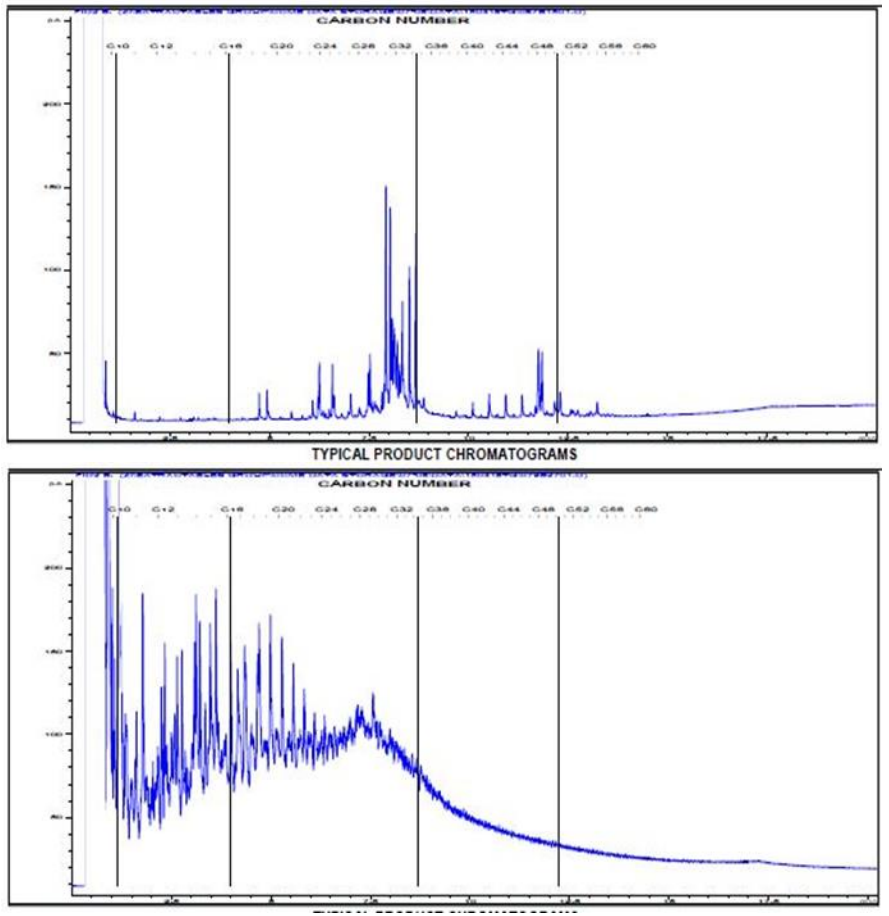
So – How will High Organic Content affect my results?

- **High Organic Matter Content**
  - Hydrocarbons –
    - Both mineral hydrocarbons and the organic matter are potentially extractable by solvents so now we need to differentiate biogenic from petrogenic.
  - Pertains mostly to F2-F4 since biogenic material will be in this range.
  - Can possibly be interferences with other hydrocarbons, like PAHs, but generally not a significant problem.
  - Silica gel can remove biogenic but can be overwhelmed

Source: www.popularmechanics.com

So – How will High Organic Content affect my results?

- **High Organic Matter Content**
  - How do we differentiate the two types of hydrocarbons?
  - Always request a chromatogram and become familiar with biogenic patterns.
    - Chromatogram interpretation but can be difficult to quantify.
  - Try to take a background sample that is similar in composition.
  - What about multiple Silica gel extractions?



TYPICAL PRODUCT CHROMATOGRAMS

So – How will Bulk Density affect my results?

- Dry Bulk Density
  - Affects all results.
  - Alberta Tier 1 guidelines are based on mineral soils and on a weight basis.
  - This weight basis assumes a typical volume occupied by the soil.
  - Eg. Mineral soil of 1.5kg/L. The same mass of peat with a DBD of 0.1kg/L would occupy 15 L!

	Soil Density (kg/L)	Volume Occupied by 1kg (L)
Mineral	**2**	**0.5**
Mineral	**1.5**	**0.7**
Organic	**0.5**	**2.0**
Organic	**0.1**	**10.0**

So – How will Bulk Density affect my results?

- Dry Bulk Density
  - Eg. Arsenic present in both a mineral soil and organic soil at 20 mg/kg.
  - Convert to a volume basis to see the concentration in the same volume of soil
  - Example calculation in mineral soil:
    - 20mg/kg X 2 kg/L = 40 mg/L

	Soil Dry Bulk Density (kg/L)	Final Concentration in the Soil (mg/L of soil)
Mineral	**2**	**40**
Mineral	**1.5**	**30**
Organic	**0.5**	**10**
Organic	**0.1**	**2.0**

So – What Can I Do About it?

- Dry Bulk Density
- **Solution:**
  - For organic soils, it is a good idea to request the bulk density to help with the interpretation of the data.
    - It is a good indicator of organic matter content, potential environmental effects.
  - When taking samples in the field for Bulk Density, it is best to take a defined volume in the field, record it on the information sheet and have the lab complete the bulk density.
  - This sample should only be analyzed for bulk density with a separate bag and jars for other tests.

So – How will Water Holding Capacity affect my results?

- **Water Holding Capacity**
  - Different from moisture
  - Affects any test that is a water based extraction
  - Organic soils can hold 1000%+ of their weight in water (10X their mass).
  - Therefore, will affect analytes with fixed water extractions – nutrients, hexavalent chromium, phenol.
    - Lab needs to know maximum extraction ratios in order to meet guidelines. Example - Hexavalent chromium (0.4 mg/kg).

So – How will Water Holding Capacity affect my results?

- **Water Holding Capacity**
  - For salinity testing, results are reported on a weight basis but a conversion factor, called the saturation percentage (SP), is needed to complete this calculation.
  - Calculation:

    (mg/L from extract) X (SP/100) = mg/kg of soil
  - When SP>100%, the soluble ions appear higher when converted to mg/kg.
  - ***Solution*** – compare results on a mg/L basis, not mg/kg.

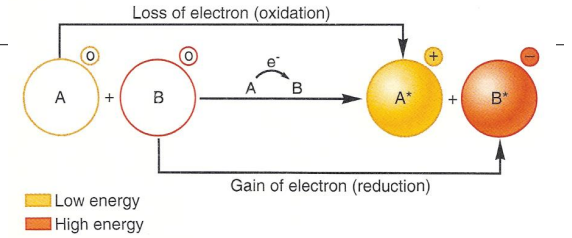
An Example of Water Holding Capacity Effects

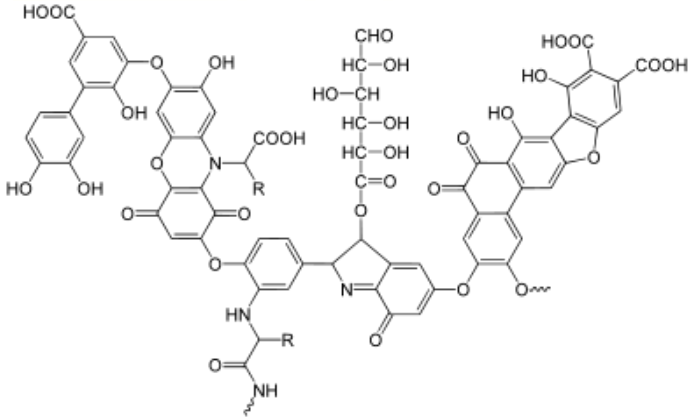
EC	SAR	Sodium (Na)	Sodium (Na)	Calcium (Ca)	Calcium (Ca)	Chloride (Cl)	Chloride (Cl)	S.P.
dS/m at 25 C		mg/kg	mg/L	mg/kg	mg/L	mg/kg	mg/L	%
2.55	0.2	16	24	478	705	28	42	**68**
1.37	0.3	36	20	483	270	237	133	179
0.19	0.7	181	14	256	19.6	409	31	**1310**
0.42	0.6	154	18	510	60.5	198	24	843

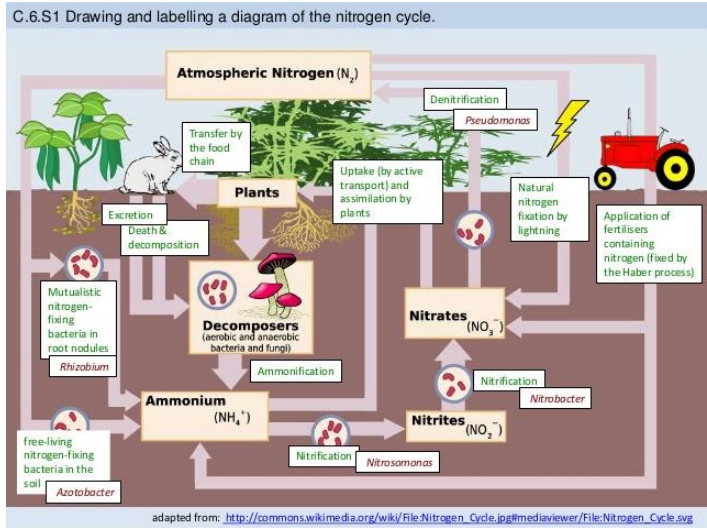
mg/L = concentration of analyte in the extract.
Convert to weight basis by multiplying by the SP
Mineral soil example: 42 mg/L X (68/100) = 28 mg/kg
Organic Soil example: 31 mg/L X (1310/100) = 409 mg/kg

So – How will Chemical Transformations affect my results?

- Abiotic and Biotic Transformation
  - Wetlands are extremely active systems with chemical and biological reactions constantly happening.
  - Both aerobic and anaerobic bacterial consortiums consisting of SRB, methanogens, IRB, aerobic, diazotrophs, methanotrophs.
  - Can incorporate or sediment metals into the matrix, making them unavailable.
  - Can incorporate hydrocarbons, PAHs into the matrix.
  - Can also create hydrocarbons and release these into the water
    - Biogenic toluene







Conclusions – what should I consider when looking at my results?

– **Hydrocarbons:**

- Get a chromatogram
- Take a control sample if possible
- If only toluene present in BTEX, consider possibility of biogenic origin
- Since high moisture content can affect results significantly, consider separating the phases.

– **Salinity:**

- Moisture does not affect results, but water holding capacity does.
- If saturation percentage is high (above ~150%), you likely have an organic soil and get results reported in mg/L for comparison.

- **Metals:**
  - Samples already run on a dry weight basis so neither moisture or water holding capacity will affect the results.
  - Bulk density is an important consideration in toxicity
  - Biological transformation can also affect bioavailability

Thanks for your time.

Questions?

So – How will these factors affect my results?

- High Organic Matter Content
  - – Particle Size –
    - Used to determine the potential rate of flow of a contaminant through the soil.
    - For a mineral soil - sand, silt and clay dictate the hydraulic conductivity.
    - Organic soils – water flow rates will be dependent on average pore size of the fibers.
    - for hydrometer, it behaves like a sand.
    - For a sieve test, it behaves potentially like a fine soil

Organic Soils

- Functions of Wetlands:
  - Flood mitigation
    - Serve as a sink for absorbing larger precipitation events.
    - Regulates the waterflow in watersheds – absorbs the water and then slowly releases into surface water, groundwater and atmosphere.
  - Filtration
    - Slows the flow of water through the system to allow for suspended sediments to settle.
    - Absorbs some organic sediments.
  - Erosion Control
  - Nutrient cycling, availability and export.

Source: Wetlandspolicy.ca

Conclusions – what should I consider when looking at my results?

	Organic Matter	Moisture	Bulk Density	Water Holding Capacity	Biological transformation
Hydrocarbons	√	√	√		√
PAHs		√	√		?
Particle Size	√				
Salinity			√	√	
Metals			√		√