Is There a Relationship Between Soil Composition and Water Hardness?

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Introduction

- Urban wetlands provide positive impacts on surrounding areas including runoff management, storm protection, maintenance of water quality and supply, and promotion of biodiversity by supporting a variety of plant, animal, and invertebrate species (1).
- Soil near wetlands plays a crucial role in the filtration of rain and groundwater (2).

Figure 1: The three components of soil texture in order from least fine to most fine: sand, silt, and clay. Photo Credit: http://www.online-sciences.com

- Clay has the finest soil texture, silt has a medium soil texture, and sand has the highest soil texture. Because clay particles have the smallest size, they comprise a larger surface area for a given mass. This additional surface area gives clay a higher ability to retain nutrients and water (3).

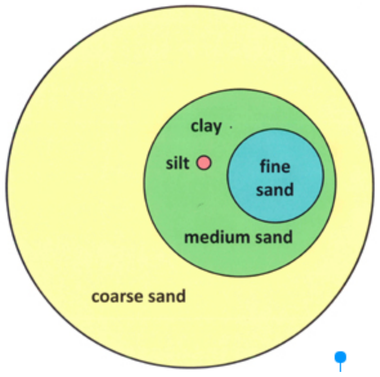

Figure 2: Shows the relative sizes of the particles found in each component of soil. Photo Credit: http://www.ext.colostate.edu

- Soil compaction, the act of applying pressure to soil, helps determine its filtration ability. A soil's moisture content is the water that is held between soil particles. Soil moisture is a strong indicator of the amount of precipitation that runs off into nearby wetlands (4).

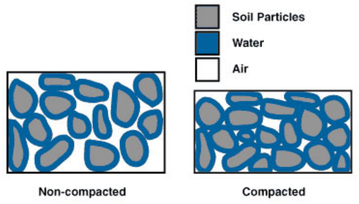

Figure 3: Shows the difference between compacted and non-compacted soil. Photo Credit: http://www.online-sciences.com

Image 1: Shows soil cores with defined layers of soil composition.
Photo Credit: http://buzzardsbay.org

- Water hardness is defined as the amount of calcium and magnesium dissolved in water. The harder the water the more calcium and magnesium ions (5).
- Literature indicates that the salinity of a water sample is correlated with the hardness of the water sample; higher salinity leads to increased hardness (6). Additionally soil with very sandy textures is less able to absorb and filter heavy metals compared to soil with less sand and more clay (7).
- Therefore our team investigated whether soil texture also influences the ability of calcium and magnesium to be absorbed by different textures and compositions of soil and not end up in nearby wetland water.

Hypotheses

- Water near soil with a higher percentage of clay will have lower water hardness.
- Water near more compact soil will have lower hardness.
- Water near soil with a high percentage of moisture will have lower amounts of hardness.
- Water bodies with higher amounts of salinity will have higher amounts of hardness.

Methods

Image 2: Collecting soil cores.

Texture: To visualize soil texture, soil cores were taken at each site and placed into settling jars. After being thoroughly combined with water and soap, jars settled for at least 24 hours. After settling the depth of the clay, silt, and sand layers in the sample were recorded.
Hardness: To determine total and calcium hardness, the LaMotte Total Calcium & Magnesium, DRT Test was used. Multiple samples were analyzed for each site. Sites with a salinity greater than zero were diluted as per manufacturer instructions.
Compaction: Pressure was applied to a handful of soil. Compaction was visually assessed on a scale of one to four with one being least and four being the most compact.
Moisture: One hundred grams of soil was weighed and placed in a heating oven at seventy degrees celsius for twenty four hours. The sample was then weighed again, and the percentage of moisture was determined by the difference in weight.
Salinity: Salinity was measured with either a hydrometer or refractometer.

Results

	Total Hardness (ppm $CaCO_3$)	Calcium Hardness (ppm)	Magnesium Hardness (ppm)	Salinity (ppt)	Compaction	Percentage Moisture
The Rambles	53	22.5	30.5	0	2	38.00
Meadow Lake	980	284	695	6.33	3.5	20.18
Willow Lake	864	194	516	2.28	3.75	42.78
Spuyten Duyvil Creek	2425	484	1942	7.98	2	16.00

Table 1: Abiotic Soil and Water Values.

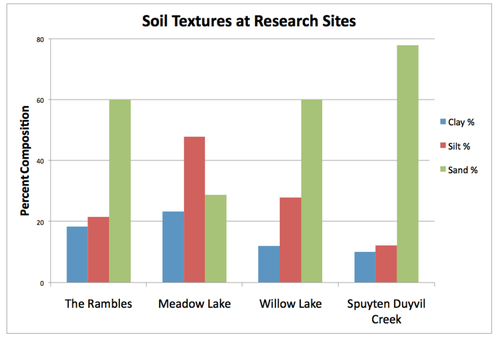

Figure 4: Soil Textures at research sites

Images 3 and 4: The photo on the left shows equipment used to determine hardness. The photo on the right shows equipment used to create soil cores and shows finished soil texture jars.

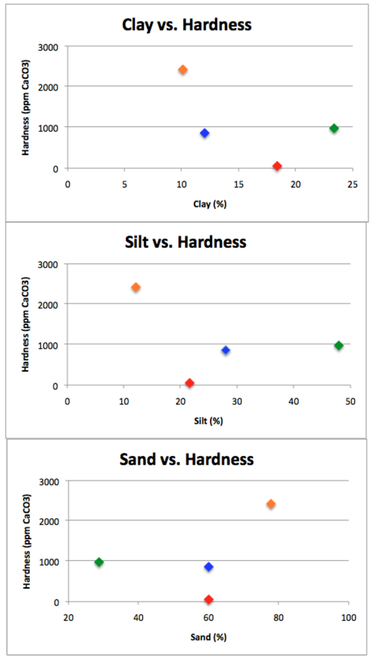

Figure 5: Shows the relationship between total hardness and the percentage of sand, silt, and clay found. The figure indicates a decreased amount of hardness when a lower percentage of silt and clay are present and an increased amount when there is an higher percentage of sand.

Site Key
The Rambles
Meadow Lake
Willow Lake
Spuyten Duyvil Creek

Independent Teen Studies

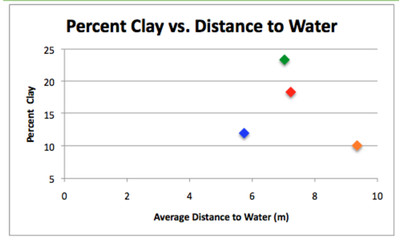

Figure 5: Shows distance of soil from water to the percent clay found. This figure shows a general trend toward less clay found in soil closer to the water.

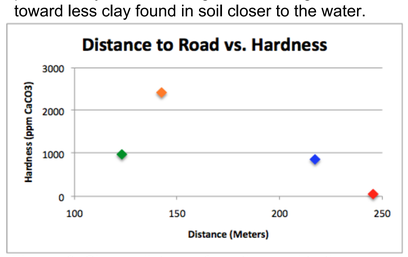

Figure 6: Shows distance from the road to the percent hardness found. The figure shows a trend towards more hardness found closer to the road.

Question Does the distance of a soil sample from a body of water affect its texture?
Hypothesis If the soil sample is closer to the water, then more clay will be found.
Methods Two coordinates, one at the water and the other at a soil sample site away from the water, were identified using Google Maps. The distance was measured by subtracting the GPS coordinates.
Results The closer the soil was to the water, the less clay was observed.
Discussion This could be 1) due to erosion OR 2) because the soil composition at most of the sites has been manipulated.

Question Will water be harder if it is closer to the road?
Hypothesis When the water source is closer to a road there will be a higher amount of hardness found in the water sample.
Methods Followed the same procedure as above but measured the distance from the road in place of water distance.
Results The data suggests that water further from the road has less hardness.
Discussion Cars in the surrounding area produce more chemicals and pollutants which can increase the hardness in the water.

Discussion and Conclusion

- Our results support the hypothesis that there would be lower hardness in water found around wetlands with higher levels of clay. This is most likely because clay contains the ability to filter pollutants found in nearby bodies of water due to high surface area. Clay granules attract positively charged particles, such as calcium and magnesium.
- Our results did not conclusively support our hypothesis that water near soil with higher levels of compaction would have lower hardness. There is a trend indicating that there is in fact less hardness at sites with more compact soil. However, The Rambles also had a low level of compaction despite its very low hardness. The water at this site had zero salinity which likely accounts for its very low hardness.
- As hypothesized, the site with the highest salinity, Spuyten Duyvil Creek, had by far the highest hardness and The Rambles, which had no salinity, had by far the smallest hardness. This can be explained by the fact that magnesium and calcium comprise hardness, but are also components of salts.
- Our results support our hypothesis that soil with more moisture will be found near water with lower hardness levels. This may be due to the fact that when water and ions are not absorbed by soil they run off in to water bodies nearby.
- Our results may have been affected by the various weather conditions that took place during the time we collected data. There may have been higher levels of moisture and soil compaction due to rainfall prior to some collections. Runoff from additional rainfall could have cause pollutants and ions to be washed into our sites.
- Our experiment was limited by the fact that only four wetland areas were tested and each was only tested on one day. Additional testing days and sites would help us find more definitive trends.
- Additional experiments could include measuring heavy metal in addition to hardness and determining the effect hardness has on macroinvertebrates and other wetland organisms.

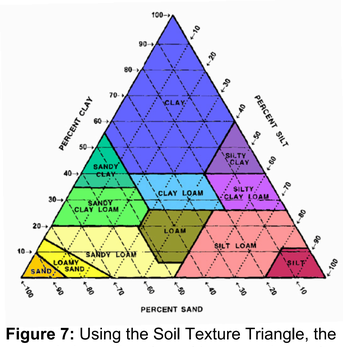

Figure 7: Using the Soil Texture Triangle, the percent clay, silt and sand in a sample can be used to determine the soil composition. The majority of our sites had soil that is considered sandy loam. Photo Credit: www.ext.colostate.edu/mg/gardennotes/214

References

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