Variation of Magnetic Susceptibility in Tacoma, WA Urban Garden Soils

Timothy Wahlstrom, Peter Selkin
Science and Mathematics Division, University of Washington - Tacoma

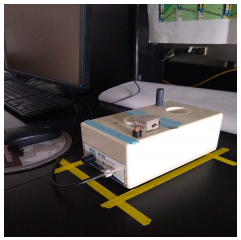
INTRODUCTION

- The magnetic makeup of our soils is important in monitoring changes in soil chemistry and allows us to make accurate predictions on the health of our soils - which subsequently affects the biodiversity and abundance of life around us.
- Frequency-dependent magnetic susceptibility (χ_m) is a measurement sensitive to the composition, grain size and shape of iron-bearing minerals.
- This study examined frequency-dependent magnetic susceptibility of soil samples from two urban gardens in Tacoma, WA to determine the relationship between iron oxide mineral content and soil health.

Above: Aerial drone image of the UW-T Giving Garden sample site. Photo courtesy of Courtney Kneer and David Schoenfield.

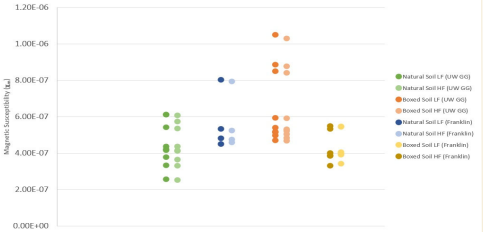
METHODS

- Sample sites included Franklin Park Garden and the UW-T Giving Gardens, where 18 samples (9 natural soil + 9 boxed soil) were taken from each garden – totaling 36.
- Post collection samples were heated in an oven to reduce inorganic material and to be dried for analysis.
- Dried soil samples were then weighed, cubed, and sealed for analysis for use of the MS2B dual frequency sensor. The MS2B recorded data, including mass susceptibility and volume susceptibility.
- The MS2B dual-frequency sensor uses both a low frequency (470Hz) and a high frequency (4700Hz) magnetic field to calculate magnetic susceptibility of the samples.
- We used mass-normalized susceptibility, meaning the calculation involves taking the volume susceptibility number and dividing it by the density of the sample. This gives us the units (m3/kg) which allows for clearer analysis.



Top: Soil corer and sharpie during soil extraction. Left: MS2B dual frequency sensor. Right: Cube samples ready for analysis

RESULTS



Above: Frequency dependent (high frequency/low frequency) magnetic susceptibility chart illustrates clear distinction between natural soils and boxed soils. Higher overall susceptibility was discovered with boxed soil when averaged against natural soil at UW Giving Gardens. Inversely, natural soil had higher magnetic susceptibility at Franklin Park Garden.

UW Giving Garden – Natural soil HF (χmAVG) =	4.36E-07
UW Giving Garden – Natural soil LF (χmAVG) =	4.46E-07
UW Giving Garden – Boxed soil HF (χmAVG) =	6.50E-07
UW Giving Garden – Boxed soil LF (χmAVG) =	6.58E-07
T-test (UW Giving Garden NS vs BS) =	0.01945045433 (Distinction)
Franklin Park – Natural soil HF (χmAVG) =	5.63E-07
Franklin Park – Natural soil LF (χmAVG) =	5.67E-07
Franklin Park – Boxed soil HF (χmAVG) =	4.31E-07
Franklin Park – Boxed soil LF (χmAVG) =	4.39E-07
T-test (Franklin Park NS vs BS) =	0.213025477 (No distinction)

Above: Frequency dependent magnetic susceptibility averages gives us clues to the effects compost can have on the magnetic particulates in soils.

DISCUSSION

- Magnetic susceptibilities of all soils sampled in this study were in the range expected for soils containing magnetite produced during soil formation (e.g. Geiss et al., 2008).
- Magnetic susceptibility differences between natural soils and boxed soils were inverse of each other at each site. These differences could have been attributed to several factors including: material sources, water content, microbial activity, and contaminants.
- UW Giving Garden showed distinction in magnetic susceptibility between natural soils and amended soils. Amended soils showed higher susceptibility on average, potentially due to the added particulate matter of compost and was on par with what was expected.
- Franklin Park magnetic susceptibility did not show distinctive differences between natural soil and boxed soil.
- Franklin Park does not have traditional raised beds, but mixture of in-ground gardening/compost which could attribute to the inverse magnetic susceptibility measurements found opposite of UW Giving Garden.
- Additionally, the number of data points used at Franklin Park limits the ability to really distinguish between natural/amended soils.
- Lastly, there is a small frequency dependence in the compost-added Giving Garden samples and in the Franklin samples. This is consistent with the presence of very fine-grained magnetite (Worm 1998).

FUTURE WORK

Sample size matters. 9 samples per site is not enough to distinguish between magnetic properties of untreated soils and amended soils.

Further analysis, such as magnetic separates via magnets, inductively coupled plasma mass spectrometry (ICP-MS), or particle analysis using scanning electron microscopy (SEM), can be useful methods for more specific identification of which factors had the greatest impact in determining magnetic susceptibility differences.

REFERENCES

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Worm H. 1998. On the superparamagnetic—stable single domain transition for magnetite, and frequency dependence of susceptibility, Geophysical Journal International, Volume 133, Issue 1, April 1998, Pages 201–206, https://doi.org/10.1046/j.1365-246X.1998.1331468.x

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