The Relationships Between Climate Variability and Soil Element Concentrations Across Climate Regions in the United States

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Introduction

Understanding the relationship between climate variability and element concentrations in soil is important as we continue to learn about how climate impacts Earth's ecosystems. Soil is important for agriculture, ground water protection, flood prevention, and is an essential part of Earth's ecosystems (Woodruff et al., 2015). Changes in climate variability, as a result of climate change, can have major impacts on soil element concentrations, as many elements found in soils are sensitive to changes in climate (Duran et al., 2017). Studies have found that increases in temperature or precipitation can cause variances in soil element concentrations (Nottingham, 2020) (Landré et al., 2020). The goal of this research project is to identify how precipitation and temperature impact Al, Ca, Fe, K, and Total C concentrations in soil in four different U.S. climate regions (West, Southeast, Northern Rockies/ Plains, and Northeast).

Research question: How do temperature and precipitation impact element concentrations in soil horizon A in different climate regions across the United States?
Hypothesis: Results will show significant correlations between element concentrations and climate (precipitation and temperature).

Methods

All 20 sample sites are from the USGS Report 2014-1082 (Map.1). The sample sites for this project were randomly selected in four climate regions from the 4,857 sample sites analyzed in the USGS study.

Soil Data

- Soil element concentrations were taken from a USGS mineralogical and geochemical study
- Soil samples taken from soil horizon A and were then analyzed using x-ray diffraction

Climate Data

- All climate data is from the U.S. Climate Data website
- Temperature data for each soil sample is the average annual temperature recorded at each sample site
- Precipitation data of each soil sample is the average annual precipitation recorded at each sample site

Statistical tests

- All correlation tests were completed using R Studio data analysis software (Table 1 and Table 2)

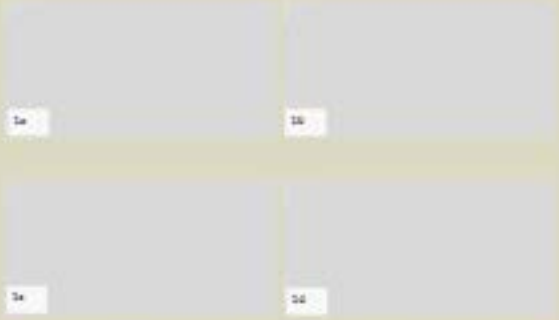
Results

Annual Precipitation		
	p-value	r
Al	0.008-03	-0.88
Ca	8.82E-03	-0.79
Fe	0.00871	-0.72
K	7.22E-03	-0.88
Total C	1.08E-02	0.76

Table 1. Correlation test results for average annual precipitation and each element concentration.

Average Temperature		
	p-value	r
Al	0.3268	-0.38
Ca	0.8872	0.03
Fe	0.1137	-0.47
K	0.2082	-0.37
Total C	0.0357	-0.58

Table 2. Correlation test results for average annual temperature and each element concentration.



Figures 1a – 1b. Element concentrations compared to average total annual precipitation from the location of each sample site in four different climate regions.

- Statistical analyses show there is a significant relationship between all element concentrations and precipitation
- High annual precipitation in the Southeast has resulted in extensive leaching
- When comparing climate variability to participation, there is a noticeable trend by climate region (Figures 1a -1d)

Map 1. Location of the 20 sample sites used for soil data . Location of each site is marked by a cyan marker.

Discussion

While results from the statistical analyses show that there is a significant relationship between all element concentrations and precipitation (Table 1), the only element to have a significant relationship with temperature is Total Carbon (Table 2). This supports the findings from similar studies that also found significant relationships between element concentrations and precipitation, where as precipitation increased, element concentrations decreased (Landré et al., 2020).

Understanding the relationship between precipitation and element concentrations is extremely important for agriculture. Farmers in climate regions with highly leached soils have to compensate with fertilizers and supplements in order to sustain crop growth/success. Potassium in particular is essential for plant growth, so farmers in areas where K leaching occurs must supply additional potassium to their soil for their crops. High annual precipitation also leaches Al from the soil, carrying it into groundwater and surface water which can be harmful to other plants and animals.

The results of this project are important because they show how changes in climate can impact soil element concentrations, which can negatively affect agriculture.

References

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