Small Scale Weather and Climate Change Study in Columbus, Indiana

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ABSTRACT

The effects of severe weather such as extreme rainfall and temperature on soil health have not yet been adequately studied in order to predict and manage their effects. This study involved observing the effects of varying amounts of precipitation, sunlight, and temperature on grassy soil located in the recently built Student Experiment & Research Enclosure (SERE). Specifically, we tested soil nitrate concentrations in varying conditions.

Nitrates' purpose in soil is to "serve as a source of nitrogen for the nutrition and growth of plants and soil microorganisms" ("Soil Quality Indicator"). Therefore, testing the concentration of nitrate in soil is important in indicating its health. The results allow a greater understanding of how the effects of human-induced climate change may affect Indiana's forest ecosystems and agriculture.

Our study found that soil with decreased precipitation contains the most nitrate, soil with increased warmth contains an intermediate amount, and soil with increased precipitation contains the least, compared to an unaltered area. These findings show that soil nitrate is strongly influenced by precipitation and temperature. Too much nitrate in soil caused by increased warmth and decreased precipitation and too little nitrate in soil caused by decreased precipitation will have detrimental consequences for both ecosystems and humans ("Soil Quality Indicator").

Introduction

Climate change is a proven phenomenon that is occurring, but the effects are not certain (Hannah, 2010). This is true especially for soil, which is a complex, natural body, comprised of minerals, organic matter, liquid, and gases that serve as a medium for the growth of land plants ("What is soil?"). Climate change not only means warming temperatures and drought, but it also includes increased precipitation, more severe weather, and cooler temperatures in some places. Through altering the soil, climate change will affect Indiana's forest ecosystems and agriculture (Widhalm, 2018). Conducting studies about the effects of climate change on soil allows us to better predict and manage their effects.

Too much and too little nitrate in soil have both been associated with negative consequences in research studies. Excess nitrate in soil caused by decreased precipitation and increased warmth has been shown to initially positively effect plant and crop growth, but over time, nitrate accumulates in the edible parts of leafy vegetables. Consuming these crops can harm human health. Excess nitrate in soil can also be easily transported by runoff and other surface and subsurface flows to contaminate rivers, lakes, and ground water (Ward). Increased precipitation will lead to anaerobic, water-logged soil, causing nitrification (the conversion of nitrogen to compounds such as nitrous oxide, a greenhouse gas). Increased precipitation will also dilute nitrate in soils and result in less nitrate for plants. This will lead to less healthy forests and crops. Nitrogen in the form of fertilizers might have to be added back to crops; fertilizers are detrimental to wildlife and human health.

Materials & Methods

The apparatus shown in Figure 1 was used to increase the amount of precipitation in one area. Another patch contained a passive warming device (shown in Figure 2) made of a tomato cage with durable plastic sheeting wrapped around it to intensify sunlight and block wind convection in order to raise the temperature. A different patch, shown in Figure 3, had durable plastic sheeting draped over it to block most precipitation but not sunlight. These patches were compared to an unaltered patch. Samples were taken from the top eight centimeter of soil containing the microorganisms and roots that utilize nitrate with a soil sampler (shown in Figure 3). To decrease soil microbial activity after collection, 200 grams of each sample were placed in cloth bags that facilitate drying and minimize changes in nitrate concentrations. Drying of the sample was done over a four hour period in an oven in IUPUC's chemistry lab at 60°C. The soil was then crushed with a mortar and pestle to ensure homogeneity. To extract nitrate from the dried and mixed samples, the procedure stated in Chapter 15: Soils: Method C: Nutrient Capture By Soils of Kingsolver, 2006 was used. Here, a solution of potassium nitrate was allowed to drip over 50 grams of sample, eluting about 100 mL of liquid (shown in Figure 4). The solutions were then used in a nitrate testing kit to deduce the amount of nitrate in each sample.

Figure 1.
Shown is the apparatus used to increase the amount of precipitation in one area.

Figure 3.
Shown is the tool used for soil sampling.

Figure 2.
The passive warming device is shown at the bottom of the picture. Shown at the top is the plastic sheeting draped over an area to decrease precipitation.

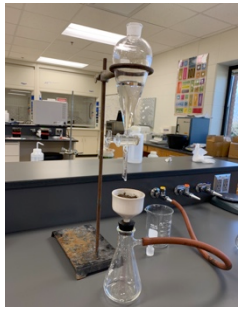

Figure 4.
The apparatus used to extract nitrate from the soil samples is shown.

Results

Decreased precipitation area: 4875 mg/L nitrate
Increased warmth area: 3000 mg/L nitrate
Unaltered area: 2000 mg/L nitrate
Increased precipitation area: 1250 mg/L nitrate

Conclusions

Our data are consistent with the idea that too much or too little nitrate in soil will be adverse for Indiana's forest ecosystems, agriculture crops, and human life.

Future directions

- This procedure can be repeated annually or biennially to gain a greater understanding of how the effects of climate change on soils will affect ecosystems long-term.
- Areas of research for students utilizing the SERE can include vegetation and water studies.
- The soil sampler is a multipurpose tool that can be used to collect both terrestrial soil and marine sediment samples for research.
- The nitrate-nitrite testing kit can be used by chemistry students to test the concentration of nitrates and nitrites of many solutions.

Acknowledgments

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