The Effects of the Accumulation of Heavy Metals in Soil on the Growth of Vegetation in the Long Island Solar Farm

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Abstract

The construction of the Long Island Solar Farm (LISF) at Brookhaven National Laboratory is a step towards our nation's goal of a renewable energy future. The LISF will be built on what is currently two hundred acres comprised of a variety of habitat types. Before clear cutting these habitats, it is necessary to do an assessment of the vegetation, soil, and wildlife to gain baseline data to discover effects of acid rain in a more concentrated area under the solar panels. In relation to soil, the aim of this project was to explore the connection between soil composition and the vegetation growing within the LISF. Specifically, the study focused on the effect of heavy metals, such as aluminum, calcium, magnesium, and mercury, on vegetation growth. In order to find metals present in soil, samples were taken in each habitat location within the solar field perimeters. Each location had two samples at depths of 0-6 inches and 10-16 inches. Using an auger and following a composite sampling procedure, soil was extracted at each depth. A total of ten locations and six control locations were visited and the soil samples were sent to TestAmerica labs to be analyzed for TAL metals, pH, and mercury. In addition, the vegetation in the overstory and the understory were observed and recorded to analyze later in the study. After discovering the concentration of metals in each soil sample, it was evident that aluminum, calcium, and magnesium impact vegetation growth. A common cause of accumulation of metals and increased acidity in soil is acid rain. For example, each sample showed high concentrations of aluminum, which is normal for Pine Barrens soil. However, too much soluble aluminum, caused by increased acidity in soil, damages plant roots. Due to the porous, sandy Pine Barrens soil, metals and nutrients leach down even faster and prevent plants from taking in other important nutrients, like calcium and magnesium. It is evident that metals effect soil composition, but future research will indicate what amounts are the most harmful to vegetation and organisms in the micro-habitats under the solar panels.

Introduction

The baseline soil data collected in this study will help researchers further understand the effects of acid rain in soil. The solar panels will act as a pathway for water to flow down into the soil. The area directly below the bottom end of the solar panel is the drip line and will be the most concentrated area of moisture. It will be useful to study the drip line area and analyze the potential increase in concentration of heavy metals and type of vegetation able to grow in the micro-habitat. The unique acidic, sandy characteristics of Pine Barrens soil and the role that soil plays in plant growth, makes this chosen site extremely beneficial to research.

Methods and Materials

Soil Samples were collected using a composite sampling method. An auger was used to dig down to the desired depths of 0-6 inches and 10-16 inches. First the top soil layer was measured to determine depth of the organic and leaf layer. These layers act as a buffer to acid rain.

According to the composite sampling procedure , a few samples were taken for each location and each depth. The three small samples from each depth were mixed in separate bags. Only 125mL of mixed soil from each depth were needed to be sent out for analysis at TestAmerica Lab. The samples were analyzed for TAL metals, pH, and mercury concentration.

A total of 16 locations were visited in order to include all habitats in the southern property of Brookhaven National Laboratory. Each location point was recorded using a global positioning system (GPS) unit. Ten locations were "samples" and were chosen by their habitat type within the 200 acres of land to be used for the solar farm. A variety of habitat types were selected, including pine forest, oak-pine mix, and maple-scarlet oak. Six "control" locations were also chosen outside of the 200 acre perimeters. Each point can be seen on Figure 1. Understory and overstory were observed to analyze with the metal analysis later in the study.

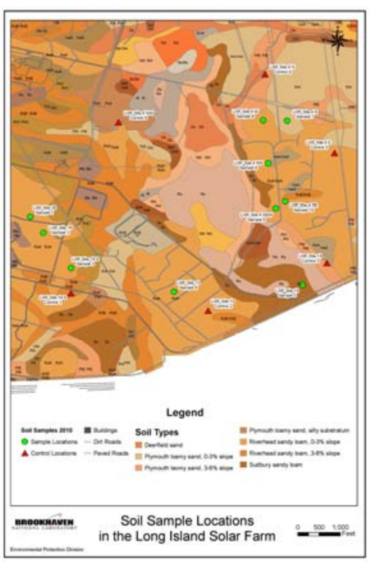

Figure 1: Soil samples and soil series types in study area

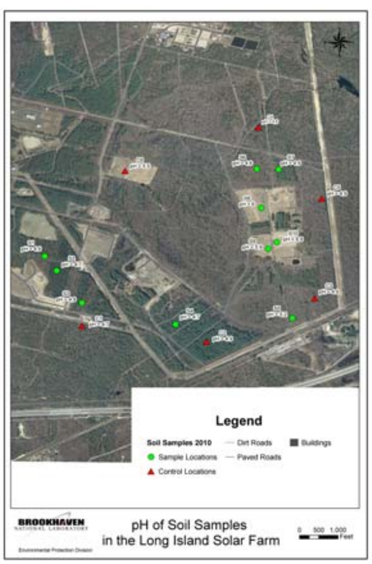

Figure 2: pH of soil samples and controls in study area

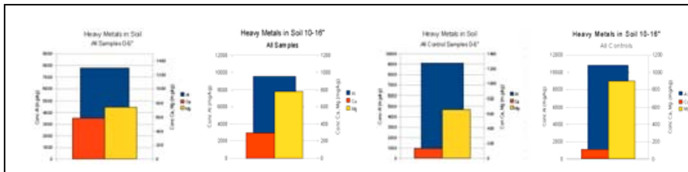

Figure 3: Concentration of Al, Ca, Mg in Soil Samples and Controls

Results

The TAL metals analysis results gave a wide scope of the concentration of heavy metals in the soil sample locations. The main metals I focused on were aluminum, calcium, magnesium, and mercury. It was predicted that trends would show correlation between magnesium, calcium, and aluminum. Aluminum characteristically increases with depth and calcium and magnesium decrease. In each location, except in the Biofields, these trends were true. The Bio fields showed opposite results due to nutrient treatment of the soil in the past.

The concentrations found for each metal were at normal levels. According to the Suffolk Country soil standards, a normal level for aluminum is 33,000mg/kg (see Table 1). Any concentration above that level is considered hazardous and must be cleaned up.

In addition, the samples and controls were tested for pH. Each location, except for the Biofields, had a pH between 4.5-5.5 (See Figure 2). The Biofields soil had pHs between 6.0-6.8 due to treatment in the past. The vegetation also varied with relation to pH. There was a higher pH where grass was growing, whereas there was a lower pH where pines and oaks were growing.

Furthermore, the soil characteristics matched the typical soil found in the Pine Barrens. The soil series found were Riverhead sandy loam (RdA, RdB), Sudbury (Su), Plymouth (PlA, PlB, PsA), and Deerfield (De). The majority of soil was of the Riverhead sandy loam series (See Figure 1). The soil texture for each sample was porous sand with fine grains and few coarse grains.

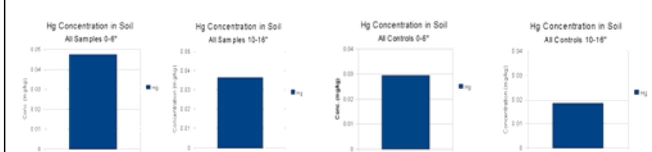

Figure 4: Concentration of Mercury in Soil Samples and Controls

Heavy Metal	Concentration before Cleanup (mg/kg)
Aluminum (Al)	33000
Calcium (Ca)	130-35,000
Magnesium (Mg)	100-5000
Mercury (Hg)	0.001-0.20
Iron (Fe)	2000-550,000

Table 1: Concentrations of heavy metals in Soil before clean up , Eastern USA Background

Discussion

After discovering the concentration of metals in each soil sample, it was evident that aluminum, calcium, and magnesium impact vegetation growth. Soil with high levels of aluminum does not provide the best growing environment for plants. Vegetation needs calcium and magnesium to grow, as well as potassium, nitrogen, and phosphorous. The levels of calcium and magnesium in this study were normal. This supported the idea that the soil in the Pine Barrens is not completely barren and can support life.

However, the accumulation of acid rain changes metal concentrations and directly effects vegetation growth. For example, each sample showed high concentrations of aluminum, which is normal for Pine Barrens soil. However, too much soluble aluminum, caused by increased acidity in soil, damages plant roots. The acidity from acid rain changes some harmful metals, like aluminum, from an insoluble state to a soluble state. As a result, soluble metals leach down into the soil and damage root structure.

Due to the porous, sandy Pine Barrens soil, metals and nutrients leach down even faster and prevent them from taking in other important nutrients, like calcium and magnesium. It is evident that metals effect soil composition, but future research will indicate what amounts are the most harmful to vegetation and organisms in the micro-habitats under the solar panels.

Also, the Biofields showed varied results due to treatment of the soil. The fields were used for growing crops and were fertilized and limed every third year up until about 2007. Liming soil lowers the acidity and increases the concentrations of calcium and magnesium.

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