

Application of Near-Edge X-Ray Absorption Fine Structure Spectroscopy to Detect Nitrogen in Solar Farm Soils in Long Island, New York

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Abstract

Nitrogen (N), in humic substances, serves as a major N reservoir in soil; what role nitrogen plays in supplying the soil as a nutrient to the environment, how and at what rate the humic nitrogen is mineralized, and what role it plays in biogeochemical cycles, is poorly understood. However, due to the vast amount of N stored in the humic/organic portion of soils it is critical to better understand the chemical speciation and transformation pathways of nitrogen. The potential ecological and economic impact lies in the fact that N is one of the three major plant nutrients; an understanding of the nitrogen cycle will help us to better understand the environment in which we live and will help us develop more ecologically friendly ways to deliver N nutrients to crops.

The primary source of nitrogen in the humic substances is decomposition of organic matter broken down by microbes and fungi, ultimately resulting in changes to the chemical form of N present in soil. This project is designed to establish baseline scientific information on soil N before construction of a solar farm on Long Island Pine Barren (LIPB). The specific objectives of this study are: a) to identify N from the humus layer of the A-horizon, and b) to identify the chemical changes that N undergoes in the soil. We used Near-Edge X-Ray Absorption Fine Structure (NEXAFS), a synchrotron based spectroscopy of specific elements, to obtain electronic and structural information on nitrogen speciation. The total amount of N in the soil samples was quantified by comparing the spectra to a known standard of boron nitride. Our results indicate an average of 0.35 percent N content in soil samples taken from various sites representative of different Pine Barrens sub-environments, with a range varying from ~0.1 to 1 percent. The initial hypothesis was that the chemical speciation of N in soils would vary among different sample sites, due to the fact that vegetation and habitat type varied significantly. However, it was observed that N speciation was nearly identical in all samples for each sub-environment type

Introduction/Background

- Nitrogen is one of the essential plant nutrients
- Nitrogen incorporated into geomacromolecules in the soil account for over 90% of the total N in soils[3]
- In living plant matter, the majority form of N is in proteins[3].
- The changes in N that occur upon decomposition of plant and animal matter are poorly understood
- N K-edge NEXAFS holds promise to help identify the N species in soils

Experimental Sites

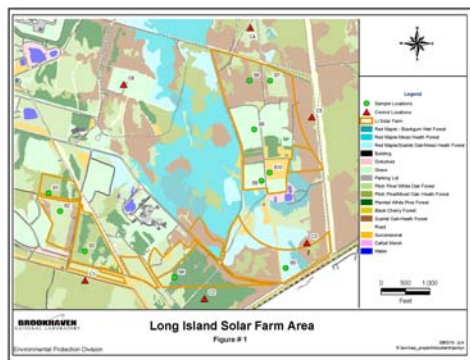


Fig. 1 Shows the sampling location, Long Island Pine Barren and Solar Farm areas

References

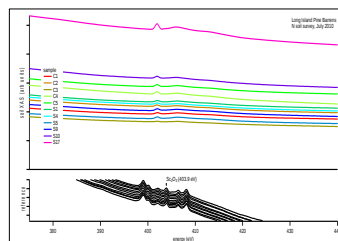
1. Catroux, G. & Schnitzer, M. (1987). Soil Sci. Soc. Am. J. 51, 1200-1207.
2. Vairavamurthy, A. & Wang, S. (2002) Environ.Sci.Technol. 36, 3050-3056.
3. Nouri, J. et al (2009) Environ Earth Sci. 59, 315-323.

Materials and Methods

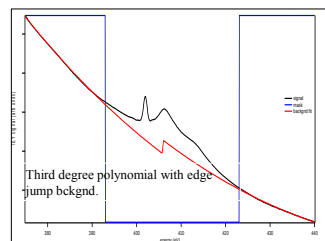
- Near-Edge X-Ray Absorption Fine Structure (NEXAFS) spectroscopy, a synchrotron based elemental specific spectroscopy, was used to obtain information on the N concentration and speciation
- Soil samples were collected from a depth ranging from 3 to 6 inches below the humus layer of the A-Horizon, and then pressed on conductive carbon tape and then loaded onto a sample paddle for measurement
- Spectra were measured in total electron yield (TEY); The spectra were fit using Gaussian peak shapes to calculate the area and height of the spectral features

Results and Discussion

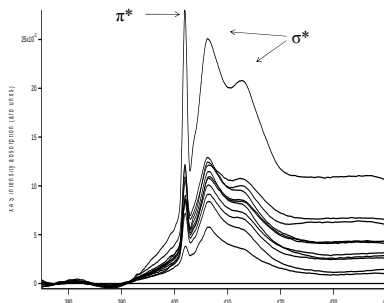
N soft x-ray spectra:



Data analysis: background subtraction

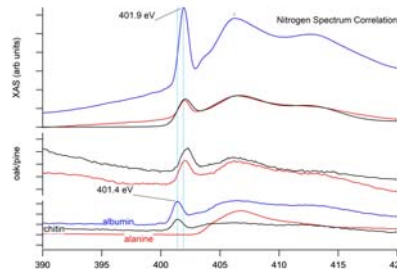


Raw total electron yield N spectra of all the samples taken from the sampling site. Note the similar low concentrations of N at various locations



- The spectra represents a collection of all samples, confirming the similarity in each sample site.
- π^* transitions represents the excitation of an electron from the N 1s core level to a π^* antibonding orbital. This feature is most useful in identifying N species
- σ^* features occur for all N species, making them less useful for chemical identification

N Chemical Speciation:



- Albumin and chitin represents an amide functional group (protein) with energy values of ~401.4 eV
- Alanine represents a saturated amine functional group with only σ^* features
- The soil N species is clearly altered from amide N, but is very similar to the N found in the leaf litter, indicating N transformation

Conclusions

- Contrary to initial hypothesis, N soil speciation was very similar at all sites, regardless of differences in vegetation
- N found in both the leaf litter layer and the top section of the A-horizon was identical
- The N was not in protein form (amide N)
- Since the majority of the N in the live plant source material is in the protein form, our results show that an initial, rapid change in the chemical form of N occurs in the top leaf litter layer. The changes are similar at all sites regardless of the vegetation type. Any subsequent changes to the chemical form of the N occur on a much slower time scale
- Additional research is needed to gain further insight into the chemical transformation of the N

Acknowledgements

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