PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Carbon Sequestration

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ASSESSING FOSSIL AND RECENT CARBON POOLS IN RECLAIMED MINED SOILS

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Background

There is ample indication that reclaimed mine lands have great capacity to be used to sequester carbon dioxide (CO_2) generated by coal-fired utility and industrial power plants. This carbon could offset CO_2 emissions associated with extraction and burning of coal and provide public utilities and other industries with carbon credits. However, the present estimates of carbon pools in reclaimed mined lands are uncertain. This uncertainty is linked primarily to failure to account for carbon (C) associated with coal particles and, given the variability of soil properties at reclaimed land sites, the lack of standardized sampling protocols in assessing carbon pools.

Organic carbon present in mined lands is a mixture of carbon from coal particles (old carbon) and carbon resulting from decomposition of plant residues (recent carbon). In these soils, carbon sequestration essentially refers to the increase in the new carbon pool. However, because of their high carbon content, coal particles represent a large carbon background against which detection of small increases in recent carbon are difficult to determine. This analytical challenge must be resolved in order to generate credible information on carbon sequestration rates in reclaimed mined lands.

Description

In nature, carbon occurs as stable isotopes carbon-12 (12C) and carbon-13 (13C) (1.12 percent of atmospheric CO_2) and as the radioisotope carbon-14 (14C), which has a half-life of 5,730 years. Given that coal was deposited several hundred million years ago, coal shows no radiocarbon activity. Thus, 14C activity recorded in soil samples from reclaimed mined lands can be attributed to new carbon. Although this approach has been successfully used in assessing the contribution of lignite to carbon pools in reclaimed lands, its high cost precludes widespread adoption of this technique. In this study, carbon that is the result of the decomposition of plant

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residues (e.g., corn) is determined by a chemo-thermal procedure, making it possible to partition the total carbon pool in reclaimed soils into coal carbon and recent carbon. This chemo-thermal procedure assumes that coal carbon is less reactive than recent carbon. Therefore, a series of chemical and thermal treatments will be applied to selectively remove the new carbon from the sample so that the refractory coal carbon left behind can be quantified.

This project includes mining sites, reclaimed cropland with a recent corn crop, and reclaimed grassland at various locations across a 300-400 km transect spanning the Northern Appalachian coal basin in Ohio, West Virginia, and Pennsylvania. Topography and grid-based soil sampling is being conducted at selected reclaimed grassland sites and, through assessment of the spatial patterns of carbon distribution, a sampling design is being proposed to better estimate carbon in reclaimed mined lands. Radiocarbon activity will only be used to validate the proposed chemo-thermal and 13C -based procedures. The 13C approach exploits differences in 13C composition between coal and new carbon.

Primary Project Goal

The primary goal of this project is to develop and test several analytical procedures that can reliably determine the amount of coal-derived C in reclaimed mined lands.

Objectives

The objectives of this project are to:

- Develop and test a 13C-based procedure to determine the fraction of coal carbon present in reclaimed soils.
- Evaluate a chemo-thermal procedure, based on the lower reactivity of coal carbon compared to recent carbon, to partition organic carbon in reclaimed soils into coal-derived and newly deposited carbon fractions.
- Establish an optimum sampling protocol (intervals and number of sampling points) to produce an accurate assessment of carbon sequestration in reclaimed mined lands.

Benefits

One option for sequestering CO_2 is increasing the amount of carbon stored in reclaimed mined lands. However, the granting of credit for such sequestration hinges on the availability of replicable analytical techniques and methods to determine and verify the increased (recent) carbon content of the soil. A major problem, however, is the presence of coal carbon, which greatly increases the difficulty of accurately determining recent carbon. By addressing this problem, this project will make a significant contribution toward determining the viability and potential of carbon sequestration in reclaimed mined land to reduce greenhouse gas emissions in the United States.

FIGURES 1 & 2
Coal mined lands in southeastern Ohio

PERFORMANCE PERIOD

09/01/2004 to 09/30/2008

COST

Total Project Value
$551,719

DOE/Non-DOE Share
$425,532/$126,187

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Accomplishments

- Two chemical methods were modified and tested for selective removal of recent carbon in mine soils:
  - Sodium hydroxide (NaOH) extraction
  - Acidified chromium potassium oxide ($K_2Cr_2O_7$) oxidation
- Soil coal mixture analysis indicated that both methods were effective in removing recent carbon with little effect on coal carbon.
- An Evaluation determined that top soils appear to be losing density over time; this is attributed to the increasing concentrations of nitrogen (N) and carbon, whereas deeper soils are increasing in density with their N and C contents remaining relatively constant.
- Tests determined that the recent carbon concentrations vary by the type of agriculture occurring on the reclaimed mine lands, with forest areas having low concentrations and grazing areas having high concentrations of recent carbon.