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A Comparative Analysis of Flue Gas Desulfurization Byproducts to Limestone in an Increase in the Soil pH

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ABSTRACT

Coal power plants need to find a cost effective and efficient way to rid themselves of flue gas desulfurization byproducts (FGD). In 1996 there was approximately 4 million tons taken to landfills in a single state alone. With the cost of dumping this byproduct ranging from ten to thirty dollars a ton, it is imperative to discover a more economical and environmentally friendly way for these byproducts to be disposed. This study was to find out whether flue gas desulfurization byproducts could raise the soil pH and whether it is an economical and practical way to raise the pH of the soil. This was done by comparing the flue gas desulfurization byproducts to limestone as agents for increasing the soil pH. This study was significant because with the increasing cost of dumping this byproduct into landfills and the wasted landfill space that occurs, it is important to find an alternative use for this byproduct. Flue gas desulfurization byproduct was added to farmland to see how it compared to limestone in raising the pH of the soil. The FGD byproduct was found to be moderately effective. The single rate application (136 kg/116 m^2) of FGD increased the pH from 4.40 to 4.92, while triple the rate (408 kg/116 m^2) of FGD increased the pH from 4.80 to 5.43. The limestone (136 kg/116 m^2) increased the pH from 5.1 to 6.68. The target increase for the limestone treated soil was 6.5.

INTRODUCTION

Flue gas desulfurization byproduct (FGD) comes from the scrubbers on coal plants. These scrubbers are used to capture fly ash and sulfur dioxide. Several scrubbers are used to control SO_2, but wet scrubbers are the most widely used FGD technology for SO_2 control. Calcium-, sodium-, and ammonium-based absorbents are used in a slurry mixture and are injected into a special tank to react with the SO_2 in the flue gas. Most of the scrubbers use limestone to absorb the SO_2 because it is very effective and very cheap. The overall chemical reaction that occurs with the limestone can be expressed by $SO_2 + CaCO_3 = CaSO_3 + CO_2$. Air in the flue gas can cause some oxidation and the ending product is a wet mixture of calcium sulfate and calcium sulfite. This comes out in the form of sludge (IEA Coal Research).

FGD byproducts are filling up landfills and there is a need to identify ways to use these residues (Raley). One possible use of FGD byproducts is to raise the pH of the soil. Low pH in the soil is detrimental to many crop plants because of the aluminum, causing aluminum toxicity that is released when the soil becomes too acidic (Miller). Currently limestone or a liquid lime is used to raise the pH of the soil. This has been done for years, but now it may be possible for the use of a different product to raise the pH of the soil.

Using flue gas desulfurization byproducts would not only benefit the soil's pH, but it would also have environmental benefits.

Power plant scrubbers that help to clean the air make flue gas desulfurization byproducts. These large scrubbers can produce 22 tons of byproducts per hour. This results in 4 million tons a year in one state alone (Raley). By decreasing the amount of byproducts distributed to the landfills, it will prevent them from filling up prematurely and decrease the land required to build more landfills to support the exorbitant amounts of waste produced. FGD byproducts are high in calcium because the scrubbers use lime or limestone in the cleaning process so they have the potential to raise the soil's pH (Raley).

The purpose of this study was to find out if FGD byproducts could be used as a comparable agent to limestone to raise the pH of the soil.

MATERIALS AND METHODS

A site was chosen that had a low pH in order to obtain the greatest potential for change. This was on a section of silt loam land six miles southeast of McPherson, Kansas. The study began with the separation of the land into three plots of 7.6 by 15.2 meters. Each plot was tested for pH at four separate locations, approximately 3 meters from each corner at a 45-degree angle. These four selected locations were the sites at which all the samples were taken throughout the experiment. The pH of the plots was 5.1, 4.4 and, 4.8 from west to east. These initial tests were done to determine the location of the FGD byproduct and where limestone was to be placed. The FGD byproduct came from the Lawrence Coal Power Plant in Lawrence Kansas. The FGD byproduct was then added to the east plot because of its lower pH at a rate of 136 kg (5.2 tons per acre). The FGD byproduct was also added to the center plot, which had the second lowest pH at a rate triple that of the first plot at 408 kg (10.5 tons per acre). The third plot had the limestone added to it at a rate of 136 kg (5.2 tons per acre). All the plots were disked to a depth of three inches to help incorporate the products into the soil. Each plot had two passes made across them with the disk at 90-degree angles to each other. Each plot was then tested every three weeks beginning May 16, 1998.

A total of 16 samples of soil were taken in each plot from May 16,1998 through January 23, 1999. Each sample was bagged, air dried and stored until the end of the sample period when they were all tested for soil pH. The pH was determined by adding five grams of soil to five milliliters of distilled water and mixing together. The samples were allowed to stand for 15-20 minutes and a Corning pH-30 Sensor (Check-Mite) was used to take the pH readings. Each sample was tested twice and the average of the two recorded.

A soil temperature logger by Spectrum Technologies, Incorporated was used to monitor soil temperature. It was placed 3 inches below the surface of the soil in the center plot. It was set to a take temperature reading every hour. The purpose of recording soil temperatures was to find out whether temperature variance had any relationship to the rate at which pH increased in the soil.

RESULTS

In the first plot (136 kg. rate of FGD byproduct) there was an increase in the soil pH level from the original 4.40 pH on May 16, 1998 to a pH of 4.92 on January 23, 1999. The average rate of increase per three week period was 0.04 pH units. The actual rate of change per three week period is shown in Figure 1.

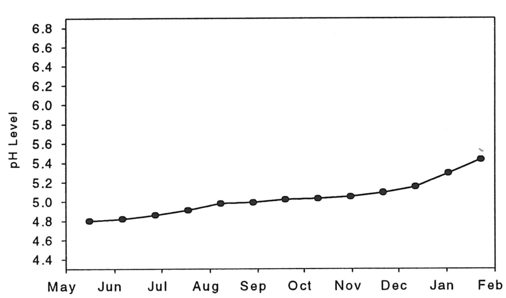

Figure 1. pH change of FGD byproduct (136 kg) from May 16, 1998 through January 23,1999.

In the second plot (408 kg. rate of FGD byproduct) there was an increase in the soil pH level from the original 4.80 pH on May 16, 1998 to a pH of 5.43 on January 23, 1999. The average rate of increase per three week period was 0.0485 pH units. The actual rate of change per three week period is shown in Figure 2.

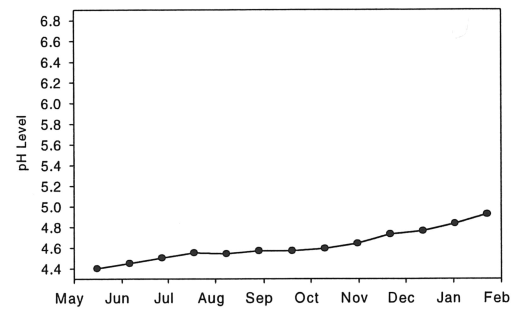

Figure 2. pH change of FGD byproduct (408 kg) from May 16, 1998 through January 23,1999.

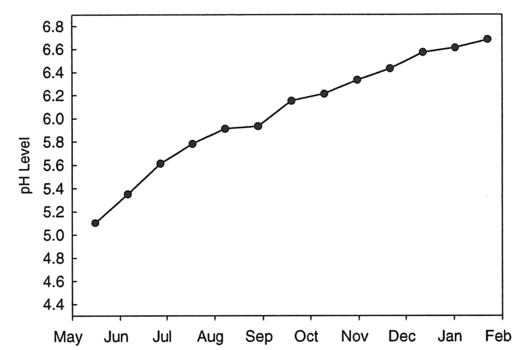

Figure 3. pH change of limestone (136 kg) from May 16, 1998 through January 23,1999.

Within the third plot (136 kg. rate of limestone) there was an increase in the soils pH level from the original 5.1 pH on May 16, 1998 to a pH of 6.68 on January 23, 1999. The average rate of increase per three week period was 0.1215 pH units. The actual rate of change per three week period is shown in Figure 3.

A graph of the average daily temperatures for the period of May 28, 1998 to October 13, 1998 is shown in Figure 4.

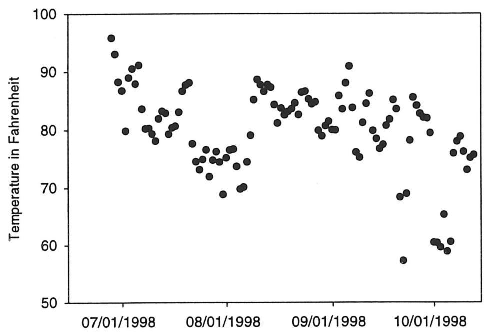

Figure 4. Average daily temperature in Fahrenheit from May 18,1998 to October 13,1998.

DISCUSSION

The flue gas desulfurization byproduct didn't do as well as had been expected. With the single rate of application there was only a .52 pH increase as compared to the limestone which had a 1.58 pH increase. With double the application rate of FGD byproduct there was a .63 pH increase in the soil. There was the expectation that the double rate would have increased much more. The lack of pH increase in the FGD byproduct could be attributed to a very low level of limestone in the byproduct.

The temperature readings that were taken had several areas of data that were missing. This occurred during several days at the beginning and several weeks at the end of the study. This was due to problems in the launching of the temperature data logger and to animals digging it up and chewing through the wires.

From the data that was collected there was no significant correlation between the pH increase rate and the temperature. All data was collected when the temperature was warm and if data could have been collected throughout the winter there may have been some correlation between the two. If this experiment were to be done again it would be beneficial to have a full year time period to view the correlation between the soils pH change and the temperature of the soil.

While FGD byproduct did not prove to raise the pH as much as limestone it did have a positive effect. The FGD byproduct was increasing more rapidly at the conclusion of the study so it is unknown how much the byproduct would still increase. With coal plants needing a place to dump this byproduct it may be economical for it to be used on land close to the coal plants. The environment would also benefit because large areas of land would not be taken from production to be used in disposal of FGD byproduct. With no harmful observations observed to the soil or the plants growing on the plots FGD byproduct may have it's place, under the right conditions, to be used in raising the pH of the soil.

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