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OCDO MONTHLY PROJECT STATUS REPORT

LAND APPLICATION USES OF DRY FGD BY-PRODUCTS

OCDO GRANT AGREEMENT NO. CDO/D-89-35

STATUS REPORT NUMBER 30

REPORTING PERIOD - JULY 1993

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Land Application Uses of Dry FGD By-Products
Monthly Report
July, 1993
Warren A. Dick and Joel H. Beeghly

1.0 OSU Land Application Project

1.1 Project Organization & Plans

A final draft budget revision for Phase 2 was given to OCDO for review. Because of the 7 month extension of Phase 2 to June 30 there is a projected shortfall of \$27,575 out of a budget of \$1,737,075 (or 1.6%). This shortfall will grow slightly as the books for Phase 2 are closed out. About half will be made up from unspent Phase 1 money and the balance reduced from the Phase 3 budget. The revisions to the Statement of Work for Phase 2 and 3 were worked out but not completed pending discussion of Phase 3 site plans with Holmes Limestone in early August. Jackie Bird has expressed deep concern that the Statement of Work is out of date particularly because of the new direction given to the research team to build a stabilized base for the cattle feedlot project out of the fixated Conesville wet FGD scrubber solids. The change inground water studies from an active mine site to an abandoned mine site must also be made. In doing field research on neutralizing and stabilization of acidic coal refuse from their Strasburg wash plant, Holmes Limestone is interested very much in cooperating with us without requiring indemnification from Ohio State University, Dravo Lime, other sponsors, and the FGD ash source or generator. Holmes is also interested in applications for road base stabilization in their Stone Creek plant where coal is received from the mines, crushed, screened and shipped out (no washing). More discussion on plans for Holmes Limestone and the EORDC cattle feedlot demonstration sites is below.

2.0 Technical Progress and Presentations

- 2.1 A presentation on ash by-products from the Tidd PFBC project that was given orally by J. H. Beeghly at a DOE-METC conference in late June was written for the conference proceedings. A copy is enclosed. W. A. Dick and J. Harness assisted in editing this report.
- 2.2 Spreadability in a commercial size drop spreader and spinner spreader was demonstrated in a field of alfalfa using Ohio Edison - B&W SNRB ash at the Wooster OARDC. A report will be written. A video and photos were taken.
- 2.3 Three papers were submitted about FGD research and land application to the International Land Reclamation and Mine Drainage Conference by Dravo Lime (J. H. Beeghly and J. College), W. A. Dick of Ohio State, and U.S. Dept. of Agriculture to be held in Pittsburgh, PA, April, 1994.

- 2.4 Bob Carter of Dravo Lime Co., has greatly assisted the future capability to deliver dry FGD ash from the OSU spray dryer unit. He coordinated a plan with Bulk Transit and Jon Harris of McCracken Power Station on how to load bulk pneumatic tankers by installing a special fitting in the silo. The truck cannot get under the silo due to height restriction but now it can connect a flexible hose to the silo from the outside. The OSU spray dryer is scheduled to operate in late fall or early winter after a long outage.
- 2.5 Both OSU Civil Engineering and Dravo Lime Co. have continued to produce interesting strength data on fixated wet FGD sludge showing notable strength gains over 200% from 28 to 85 days curing. Testing has included Mitchell, Zimmer, and Conesville plus trying Dravo's Maysville lime kiln dust (LKD) as an amendment in lieu of extra pulverized quicklime (CaO).

3.0 Field Demonstration Site

3.1 OSU Bull Test Station - Stabilized Base

The construction of the cattle feed lot stabilized base was completed at the OSU Bull and Ram Test Station EORDC using a blend of bed ash and conditioned cyclone ash. A total of 37 loads were used represented by four products forms: 1) dry cyclone ash as a soil cement to stabilize sub-soil, 2) conditioned cyclone ash at OMC for stabilized base delivered directly "fresh" from the silo conditioner, 3) dry bed ash to put a non-skid wearing surface on the final grade, and 4) a blend of bed ash and conditioned cyclone ash containing a minimum amount of water and loaded out from the stockpile made at the landfill. Bob Petigene, the ash handling contractor at Tidd and Cardinal AEP plants was a great help in doing the blending of bed and cyclone ash and loading out this last phase in a short amount of time. Steve Tutokey of Dravo Lime performed standard Proctor test on samples of the new blend. At 9 days curing, a strength of 700 psi was found and at 28 days was 990 psi. Bill Wolfe cored the base immediately after compaction with a rented vibratory roller to obtain test cylinders. The men at the Bull Station worked very hard and need to be commented for the job done. This research will attract much attention. This project is indebted to AEP who paid the freight and Bob McConnell and Jack Cline of Ohio State University, Dept. of Animal Science.

3.2 Abandoned Mine Site

The Fleming AML bids for reclamation as per the OSU Research design were submitted by contractors. The revised sludge management plan was revised by OSU Agronomy and N-Viro and re-submitted to Ohio EPA, who now must issue a public notice of the project plan and schedule a public hearing on the plan. ODNR Division of Reclamation plans to proceed with bid acceptance followed by site preparation while the Ohio EPA studies the plan acceptance and goes through public review. We have been told to expect public resistance at the hearing. Studies investigating the impact of FGD on groundwater quality will occur at the abandoned mine land site. With the soil, plant, surface water quality data, and the area to be treated makes this a much more comprehensive study then could have occurred at an active mine site.

3.3 Coal Refuse Stabilization

Holmes Limestone Company has suggested two ways they can use dry FGD by-product in a beneficial manner at their coal mine business. They are 1) stabilized base course material in the coal load out yard and screening plant and 2) stabilization and neutralization of acidic coal refuse from the wash plant. OSU will finalize a statement of work and budget to conduct this Phase 3 research.

4.0 Contract Problems

See 1.0

5.0 Project Work Schedule

- 5.1 Refine work plans for use of FGD by-product at the Holmes Limestone active mine site.
- 5.2 Complete revision of Phase 2 and Phase 3 workplans.
- 5.3 Continue efforts to gain Ohio EPA approved for work plan at the Fleming AML site.
- 5.4 Complete rainulator studies on the agronomic plots.
- 5.5 Both W. A. Dick and L. Forster are to make presentations at the 1993 EPRI/EPA SO₂ Control Symposium, Boston, Mass.
- 5.6 Finalize mix design and make plans for shipping about 900 tons Conesville FGD by-product to OSU Bull Test Station to construct stabilized base. Also, make plans to ship extra pulverized lime and lime kiln dust for use as strength accelerators. The willingness for AEP to help ship the Conesville material is needed.

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OCDO MONTHLY PROJECT STATUS REPORT
LAND APPLICATION USES OF DRY FGD BY-PRODUCTS
OCDO GRANT AGREEMENT NO. CDO/D-89-35

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REPORTING PERIOD - AUGUST 1993

Joel H. Beeghly (412) 777-0711
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OCDO Report
August, 1993
Warren A. Dick and Joel H. Beeghly

1.0 Land Application Project

1.1 Project Funding & Organization

- 1.1.1 The revised statement of work was submitted to OCDO along with the final Phase 2 budget and proposed Phase 3 budget. Phase 2 ended June 30 with the exception of writing the Final report. Despite a 7 month extension, Phase 2 was completed only about 1% over the budget.
- 1.1.2 The budget process for Phase 3 with the DOE-METC was also reviewed with DOE-METC for the period July, 1994, to July, 1995.
- 1.1.3 Ruth Smith is the new contracts representative from OSURF replacing Gun Seren. Gun was very helpful to the project in revising budgets and projecting expenses.
- 1.1.4 Meetings were held with USGS to discuss their Phase 3 budget. The USGS was asked to do the acid base accounting on the R&F overburden core logs.

1.2 Reports and Technical Papers

- 1.2.1 OCDO and other sponsors have expressed satisfaction and praise to OSU in the quality of the Phase 1 report. Additional copies are being made. Work on the Phase 2 report has begun.
- 1.2.2 Warren Dick and John Raush made presentations at the EPRI-EPA-DOE SO₂ Control Symposium. Warren spoke of the Phase 1 characterization and Phase 2 greenhouse work. John spoke on the economics of land application versus landfilling.
- 1.2.3 A report on the environmental impact (i.e. leachate) of the LIMB stockpile was finished and put in the process for external review before submittal to Ohio EPA.

1.3 Field Test Projects

1.3.1 Fleming AML

Plans for the Ohio EPA public hearing on September 22 and a preliminary meeting with local politicians were made for the Fleming AML site. The contractor was chosen by the Division of Reclamation and earth work and site contouring has begun.

OSU has completed negotiations with Ohio EPA on the site plan. A fact sheet was written and is attached. A fugitive dust permit will be required. We have to get General Motors to "release" 200 ton of FBC ash (for the watersheds receiving no N-Viro Soil).

1.3.2 Holmes Limestone Coal Screening Plant

Two 5,000 sq. ft. test areas are being planned using General Motors FBC conditioned ash for base stabilization at the Holmes Limestone Co. coal load out yard. One test will add the ash to the "coarse" size coal refuse removed in the coal wash plant. An effort is being made to get GM to pay for the backhaul freight at \$16/T. They will still gain a savings over the landfill tipping fee.

1.3.3 Wet FGD Stabilized Base Material at OSU Bull Test Center

Plans were presented to AEP Ash Management Department to produce and donate approximately 1400 ton of fixated Conesville FGD solids to the OSU Bull Test Center in Southeastern Ohio. They agreed to cooperate and also deliver the material with a prescribed level of solids. Extra fly ash and lime will be added to enhance strength. At least three mix designs will be evaluated. After our initial curing period extra lime using lime fines (1/4 inch x 0) or lime kiln dust from Maysville will be mixed at the feed lot in separate plots using a rotatiller in lieu of a pug mill. Unconfined compressive strengths of about 300 psi are sought.

J. Bird of OCDO considers this test top priority because of the interest by the Ohio Department of Development.

S. Tutokey of Dravo Lime performed proctor tests using lime kiln test which was suggested by AEP due its success in the tests in Columbus at the I-670 soil stabilization test site. At 28 days an unconfined compressive strength of 280 psi was attained.

1.3.4 ODOT Rt. 83 Highway Reconstruction

Bill Wolfe has instituted, in cooperation with Ohio Dept. of Transportation (ODOT), plans to use Tidd PFBC material to repair an earth slide that has damaged approximately 1000 ft of Rt. 83 south of Cumberland, Ohio. The FGD by-product will be used as fill to replace the soil. As much as 14,000 cu. yds may be required this fall.

2.0 Contract Problems

None (This is a 1st!)

August 1993

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3.0 Projected Work Schedule

- 3.1 Complete plans for Ohio EPA compliance. Construct plots at the Fleming Site-to be treated next spring. Get clearance from GM for FBC ash alone treatment plot.
- 3.2 Continue formulating plans for work at Holmes Limestone Site. Submit a proposal to GM to release FBC ash for Holmes coal load out yard stabilized base.
- 3.3 Present paper at the Pittsburgh Coal Conference.
- 3.4 Complete harvest and enter data obtained during first year of studies at the agronomic plots.
- 3.5 Complete plans for use of FGD Tidd by-products for O.D.O.T. soil for stabilization and embankment.
- 3.6 Construct OSU feedlot with Conesville stabilized wet FGD by-product.

OARDC

Ohio Agricultural Research
and Development Center

Department of Agronomy
1680 Madison Avenue
Wooster, OH 44691-4096
Phone 216-263-3878
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Fact Sheet: AML Reclamation

Project Title: *Land Application Uses for Dry FGD By-Products*

Subproject Title: *Use of FGD By-Product Materials as an Amendment for Reclamation of the Fleming AML Site*

What is the Project Objective?

To demonstrate beneficial high-volume uses of clean coal technology by-products that are created when high sulfur coal is burned and the exhaust (flue) gases scrubbed. The abbreviation, FGD, which is short for **Flue Gas Desulfurization**, is often used to refer to these by-products. In the broadest sense, this project was created to encourage the use of Ohio coal. The people in Ohio who mine coal and whose livelihood depends on the use of Ohio coal are the ultimate beneficiaries of the results of this project.

Where will this Project be Conducted?

The actively eroding and very acidic Fleming AML site located in Franklin Township, Tuscarawas County (west of Dover, OH). This 40 acre site was mined and abandoned several decades prior to the Surface Mining and Reclamation Act of 1977.

What is the Composition of the FGD By-Products?

Ohio State University has analyzed more than 50 FGD by-product samples. They are made up of fly ash, limestone, and gypsum. Limestone and gypsum are commonly used to improve conditions for crop growth in acid agricultural soils.

Will Other Materials Also be Used for Reclamation?

Both topsoil and topsoil substitutes will also be used. Based on past research activities, a topsoil substitute composed of a mixture of limestone and organic matter provides the best reclamation results. Therefore we have proposed using a mixture of FGD by-product and sewage sludge. All materials will have been approved by Ohio EPA and the Ohio Department of Natural Resources prior to their use in the reclamation project. A management plan will also have been approved prior to application of any reclamation materials.

Where are the Reclamation Materials Coming From?

The FGD by-product and sewage sludge are from sources in Ohio.

What Will be the Rates Applied?

Approximately eight inches of topsoil will be applied to 26 acres of the Fleming site. Seven acres will receive a FGD/sewage sludge mixture applied at rates specified by Ohio Department of Natural Resources in accordance with Ohio EPA guidelines. An additional seven acres will be treated with topsoil, FGD, or FGD/sewage sludge mixture. Tests by the Ohio State University Soil Testing Laboratory indicate that approximately 40 tons/acre of limestone will be required. An additional 10 tons/acre will be added to the surface eight inches of the regraded spoil. FGD by-product with an equal amount of neutralizing power will require a total of 125 tons/acre be applied. The FGD/sewage sludge mixture will be applied at a rate of 250 tons/acre because the FGD comprises only 50% of this mixture. This high rate of the FGD/sewage sludge mixture will be applied to only four acres as part of an Ohio State University research study.

Who Will be Responsible for this Project?

The reclamation of the Fleming AML site will be conducted in accordance with established procedures of the Ohio Department of Natural Resources. The plans for reclamation using the FGD/sewage sludge mixture are based upon two years of laboratory and greenhouse studies conducted at The Ohio State University.

Will There be Follow-up Monitoring of the Project?

Over \$1 million will be spent to monitor soil, plant, surface and groundwater quality at the site after reclamation has been completed. All measurements will be made under the supervision of personnel at The Ohio State University and the U.S. Geological Survey.

What are the Expected Benefits?

The most immediate benefit will be the restoration of a site that is causing environmental problems due to acid mine drainage and transport of toxic sediments to adjacent sites. Also, information gained from this demonstration project will provide long-term answers as to any potential benefits of using clean coal technology (FGD) by-products for reclamation of acidic materials.

If I Want More Information, Who Should I Call?

For more information about the reclamation project at the Fleming AML site, call Warren Dick, Department of Agronomy, at 216-163-3877 or write to Warren Dick at Department of Agronomy, The Ohio State University, 1680 Madison Avenue, Wooster, OH 44691

Ohio State University has faculty and staff located at Columbus, Wooster and 13 outlying research locations. Support is provided by an appropriation from the Ohio Legislature, by federal funding, and by grants, gifts and contracts.

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OCDO MONTHLY PROJECT STATUS REPORT
LAND APPLICATION USES OF DRY FGD BY-PRODUCTS
OCDO GRANT AGREEMENT NO. CDO/D-89-35

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REPORTING PERIOD - SEPTEMBER 1993

Joel H. Beeghly (412) 777-0711
Warren A. Dick (216) 263-3877

OCDO MONTHLY REPORT
September, 1993

1.0 Land Application Project Results

1.1 Project Organization & Funding

- 1.1.1 The final "official" revision of the Phase 2 Statement of work and budget was submitted to OCDO after Dravo Lime approving same from OSU's submittal. Also, a more detailed Phase 3 Statement of Work and budget was submitted to OCDO for the first time. Largely due to the reduced USGS scope of work at the mine sites, the Phase 2 expenses will not significantly be more than the former budget in spite of 7 extra months work. A recap is attached.
- 1.1.2 A meeting was held with DOE-METC to discuss Phase 3 budget and their support. DOE will allocate funds for the fiscal year beginning October 1, 1994.

1.2 Reports, Meetings, Conferences

- 1.2.1 A workshop on the meaning and implications of the expansive mineral, ettringite, sponsored by DOE-METC and hosted by University of Kentucky was attended. Sam Traina, Randy Fowler, and Jerry Bigham of OSU Agronomy attended and gave a report. Bill Wolfe of OSU Civil Engineering also gave a report. Joel Beeghly attended. All FGD by-products will generate ettringite but only some have shown swelling.
- 1.2.2 The Pittsburgh Coal Conference was attended by J. Beeghly and Rick Stehouwer who gave an oral presentation on some of the greenhouse results. A copy is enclosed of the published paper.
- 1.2.3 Two reports were submitted by OSU Agronomy for review before external release. First, the report on LIMB pile environmental impact was likewise released by Ohio Edison, B&W, and Central Fuel Co. Second, a report on the SNRB ash spreadability field tests was reviewed and sent to Babcock & Wilcox.
- 1.2.4 General Motors CFBC, Pontiac, MI

A meeting was held with Great Lakes N-Viro and General Motors, Pontiac, MI. Acting upon our lead, N-Viro has been using GM's CFBC ash to make their N-Viro Soil which will be used at the Fleming AML site. In addition, we were meeting to set up delivery of CFBC ash alone for 2 of the 6 experimental watersheds. This quantity of 250 ton would have to be conditioned with water due to dust control requirements whereas N-Viro only gets dry silo material. GM was reluctant to release this 250 ton without first receiving approval of our Ohio EPA permit. GM reported they are using the FBC ash for stabilization of hazardous waste at one of their plants.

We also discussed our interest in developing a field demonstration based on backhauling conditioned ash to the coal mine to construct a stabilized base in their (Holmes Limestone Stone Creek Yard) coal load out yard. Another application would be to mix dry or slightly moistened ash to coarse coal refuse to make stabilized base or fill material. The acid producing substances in the coal refuse would also be neutralized. Holmes Limestone suggested this experiment be delayed until next spring to avoid adverse fall weather and mud. Plans for treating fine coal refuse sludge have not progressed.

1.2.5 DOE-METC Meeting on Marketing Barriers.

Warren Dick attended the workshop on "Barriers to Increased Utilization of Coal Combustion/Desulfurization By-Products by Government and Commercial Sectors" sponsored by the Department of Energy's Morgantown Energy Technology Center on September 27 and 28. One result of this meeting is that the final report will now include a greater emphasize on land application uses of ashes and FGD by-products. The report of barriers is being prepared by the Energy & Environmental Research Center, Grand Forks, North Dakota.

1.3 Phase 3 Field Demonstration Projects

1.3.1 Fleming AML

A public hearing was held by Ohio EPA September 22 to allow public comment on our proposal to study FGD use for AML reclamation with and without sewage sludge. Previously, a meeting on September 14 was arranged by Jackie Bird in the Statehouse with State Representative, Greg DiDinato, Ohio DNR, Ohio EPA, Senator Burch's aid, and our group to discuss the issues. One key suggestion by Representative Greg DiDinato was to form a citizens advisory committee to oversee the Fleming Project. Prior to the September 22 hearing, many contacts were made to mount support for our project because many negative comments were expected. In fact, the Mayor of Dover, a local public health official, township trustees, and others spoke against it because of fear of endangering their ground water supply. The Ohio EPA conducted the hearing and had 3 of the 6 panel members there to comment and answer questions. Other members were Professor W. Dick of OSU, Mark Smith of the Ohio DNR AML Program, and Ralph Haefner of the USGS. We expect that Ohio EPA will still approve the project and will now require a fugitive dust permit. Contractors of AML jobs have not herebefore been required this regulation. We expect the Club 3000 group to intimidate the landowner and the contractor.

J. Bird does not want the Project to get involved in any litigation or political crossfire. Ohio EPA should make a decision of their recommendation by November. Information is attached supplied by Great Lakes N-Viro that discusses their product and its role at the AML site along with other information. A newspaper clipping is also attached describing the public hearing.

1.3.2 Stabilized Wet FGD Base Course Installed

In a second OSU feedlot stabilized base experiment, (the first was using Tidd PFBC) fixated wet FGD scrubber by-product from Conesville AEP Plant was used where large round (1000 lb.) hay large round (1000 lb.) hay bales are stored and eaten over the winter by brood cows. Fixated calcium sulfite/sulfate vacuum filter cake was mixed with fly ash 1.5:1.0 and pulverized quicklime (Maysville lime fines) in three mix designs. The amount of pulverized quicklime and timing of application was varied. The percent solids of the resultant mixes were specified to be a minimum of 60%. The mixes were spread and compacted in two-6 inch lifts. The strength objective is to attain 500 psi in 60 days.

About 1,500 tons was trucked by AEP to the OSU Research facility. Two truckloads of lime fines were provided and delivered by Dravo Lime Co. For the most part all of the material got placed and compacted in an efficient manner. We were not able to test the use of lime kiln dust from Maysville. The feedlots are to be cored after periods of curing and tested for strength, permeability, and density. One lot using Conesville FGD is 216 x 72 ft. Another is 150 x 100 ft.

Bill Wolfe and Jack Cline worked on the mix designs. Jack Cline and Bob McConnell of OSU Animal Science are owed a huge amount of gratitude for getting the test pads constructed in an efficient and safe manner. AEP Conesville personnel were likewise very cooperative and supportive. Steve Tutokey of Dravo Lime was of great assistance in constructing these test pads.

The three mixes were:

#1 - About 42% solids filter cake got mixed with fly ash at a weight ratio of 1.5:1:0 fly ash: cake (dry weight). Five per cent lime fines was added at the feedlot via rotatiller in each 6" lift and compacted with a large drum roller. The normal addition of lime @ 1.5 - 1.7% lime at Conesville was done. Thus, this Conesville mix is their normal mix assuming they have adequate amount of fly ash available and the filter cake solids is near 40%. This mix material must cure about 4 days but not much more before being shipped.

#2 - About 37% solids filter cake got mixed with fly ash at a weight ratio of 1.5:1.0 and 5% pulverized lime at Conesville. At the OSU feedlot, it was put down with 5% more lime fines mixed in.

#3 - Same as #2 but no lime was added at the feedlot.

1.3.3 ODOT Projects - Embankment and Soil Stabilization

Bill Wolfe reports plans are set to use TIDD PFBC material on two different Ohio Department of Transportation (ODOT) projects. Ohio EPA and AEP are both cooperating.

1.3.4 Agronomic Liming Plots

Corn and alfalfa harvests have been completed for 1993. Approximately 500 water sample, collected as part of a rainulator study to evaluate surface water runoff quality from FGD treated soils, were combined according to hydrograph information and have been prepared for quality analyses.

2.0 Contract Problems - See 1.3.1

3.0 Projected Work Schedule

- 3.1 Contact Ohio EPA about fugative dust permit for Fleming Site.
- 3.2 Schedule Steering Committee meeting in November.
- 3.3 Assist ODOT in use of TIDD by-product.
- 3.4 Joel H. Beeghly is to present paper at Coal Market Strategies Conference, St. Louis, Mo.
- 3.5 Warren A. Dick will assist in formation of local citizens advisory committee to oversee Fleming AML project.
- 3.6 Begin Phase 2 Final Report writing.

DRY FGD BY-PRODUCTS AS AMENDMENTS FOR ACID MINE SPOIL

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ABSTRACT

Reclamation of mine-sites with acid overburden requires the use of alkaline amendments and represents a potential high-volume use of alkaline dry flue gas desulfurization (FGD) by-products. In a greenhouse study, 25-cm columns of acid mine spoil were amended with two FGD by-products; lime injection multistage burners (LIMB) fly ash or pressurized fluidized bed (PFBC) fly ash at rates of 0, 4, 8, 16, and 32% by weight (0, 40, 80, 160, and 320 tons/acre). Amended spoil was covered with 20 cm of acid topsoil amended with the corresponding FGD by-product to pH 7. Column leachate pH increased with FGD amendment rate while leachate Fe, Mn, and Zn decreased. Leachate Ca, S, and Mg decreased with LIMB amendment rate and increased with PFBC amendment. Leachate concentrations of regulated metals were decreased or unaffected by FGD amendment except for Se which was increased by PFBC. Spoil pH was increased up to 8.9 by PFBC, and up to 9.2 by LIMB amendment. Spoil pH also increased with depth with FGD amendments of 16 and 32%. Yield of fescue was increased by FGD amendment of 4 to 8%. Plant tissue content of most elements was unaffected by FGD amendment rate, and no toxicity symptoms were observed. Plant Ca and Mg were increased by LIMB and PFBC respectively, while plant S, Mn and Sr were decreased. Plant Ca and B was increased by LIMB, and plant Mg and S by PFBC amendment. These results indicate dry FGD by-products are effective in ameliorating acid spoils and have a low potential for creating adverse environmental impacts.

INTRODUCTION

Dry FGD by-products are a mixture of conventional coal combustion ash (either bed or fly ash), the SO_2 reaction product (primarily anhydrite, CaSO_4), and unspent sorbent (generally lime, limestone, or dolomite). Due to the unspent sorbent, dry FGD by-products have a significant neutralization potential (1,2). These FGD by-products may also be high in soluble salts and contain some trace elements of environmental concern (2). Development of uses for these by-products which are demonstrated to be environmentally benign or even beneficial would significantly reduce the costs of SO_2 emission control by eliminating the expense of landfilling these materials.

One potential high-volume use for dry FGD by-products is in reclamation of surface coal mines with acid spoil materials. Such areas are frequently strongly acidic and drainage water can cause severe off-site environmental damage due to its acidity and high salt content (3).

One objective in surface mine reclamation is to prevent the occurrence of acid mine drainage. This is done by neutralizing spoil acidity and limiting further oxidation of iron disulfides by revegetating and stabilizing the area. This greenhouse study was conducted to investigate the effects of dry FGD by-products on spoil acidity and plant growth, and possible environmental impacts, particularly with respect to the solubility and mobility of salts and potentially toxic trace elements.

MATERIALS AND METHODS

Spoil and topsoil were collected from an active surface coal mine located in east-central Ohio and dry FGD by-products were collected from two different scrubber process: lime injection multistage burner (LIMB), and pressurized fluidized bed combustion (PFBC) (Table 1). Spoil (6.2 kg) was mixed with FGD by-products at rates of 0, 4, 8, 16, and 32% by weight and placed in 60 cm PVC columns (15 cm diameter). Topsoil (5.4 kg) was mixed with LIMB (0.4%) and PFBC (0.8%) to bring its pH to 7, and placed in the PVC columns above spoil treated with the same FGD by-product. A complete factorial experimental design was used with all treatments replicated 4 times and arranged in randomized complete blocks.

After filling the columns, sufficient deionized water was added to each column to produce between 150 and 200 ml of leachate. Columns were then planted with 30 seeds of Kentucky 31 tall fescue (*Festuca arundinacea* Schreb.). After a 3-mo growth period fescue was harvested once each month for a total of six harvests. Plant tissue was dried, weighed, and analyzed for N and for the elements listed below for leachate analysis. Columns were leached following the sixth harvest, but between these leachings the columns were watered only to replace evapotranspiration losses. Following the final leachate collection, columns were sampled at various depth intervals for pH determination, and selected samples were analyzed for crystalline mineral phases by X-ray diffraction. Leachates were analyzed for pH, electrical conductivity, for As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Se, Si, and Zn by inductively coupled plasma emission spectrometry (ICP), and for Cl^- , SO_3^{2-} , and SO_4^{2-} by ion chromatography (IC).

RESULTS AND DISCUSSION

Both FGD by-products were effective in raising spoil pH (Fig. 1). Because of its lime and portlandite content the LIMB by-product raised the pH of the first leachates to 12, but by the second leaching pH had decreased to below 10. The PFBC by-product, in which alkalinity is due primarily to Ca and Mg carbonates with some periclase, initially raised pH to 9.5 at the highest amendment rate. At application rates of 4% these FGD by-products, with neutralization potentials of about 60% CaCO_3 equivalency, increased spoil pH to around 7 and sustained this pH throughout this 8-mo experiment. It should be noted, however, that dry FGD by-products vary considerably in their total neutralization potential (2). Therefore the amount of material needed to neutralize acidity in the treated spoil is expected to vary from one type of FGD by-product to another. Application of alkaline materials in excess of that needed to neutralize acidity in the treated zone may be desirable if downward leaching will increase the pH and base status of spoil below the treated zone.

Conditions of high pH, high levels of soluble Ca and SO_4^{2-} , and adequate moisture promoted the formation of cementitious secondary minerals. Extensive ettringite ($(\text{Ca}_3\text{Al}_2(\text{SO}_4)_3(\text{OH})_{12}\cdot 26\text{H}_2\text{O})$) formation occurred throughout the spoil amended with 16 and 32% LIMB. Ettringite is highly expansive and cementitious and thus severely restricted both water movement and root extension below the depth at which it occurred. With PFBC amendment cementing occurred only at the 32% rate due to the hydration of anhydrite to form gypsum. This very different behavior of the two FGD by-products with respect to secondary mineral formation is due to the differing mineralogies and solubilities of their constituent components.

The first leachates, collected from previously air-dry spoil materials, were not representative of equilibrium conditions in the spoil+amendment mixes. This discussion, therefore, will focus on the final leachates which, because they were collected after 8 months of reaction and equilibration, provide a much better indication of equilibrium soil solution chemistry.

Leachate soluble salt concentrations (as determined by EC) were decreased by LIMB and increased by PFBC amendment up to 16% (Table 2). Similar patterns were seen in amendment effects on concentrations of Ca, Mg, and S, the major elements in the leachates. In all leachates, greater than 90% of the total S was in the form of SO_4^{2-} . Concentrations of Ca and S in LIMB amended spoil appeared to be controlled by the solubility of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) where ettringite did not form. Because ettringite is much less soluble than gypsum, Ca and S concentrations decreased in leachates where ettringite was present even though the total amount of Ca and S in the columns increased. The increase in S at 32% LIMB was accompanied by an increase in K and Na. With PFBC amendment, leachate Ca appeared to be controlled by the solubility of gypsum, while Mg and S were likely controlled by the solubility of epsomite ($\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$). Leachate S and Mg went to much higher levels with PFBC amendment than leachate S and Ca with LIMB amendment because epsomite is approximately 300 times more soluble than gypsum. The decrease in EC, S, and Mg at 32% PFBC was apparently the result of gypsum cementing. Thus the presence of Mg in the PFBC by-product gives it a greater potential for excessive salt loading than the LIMB by-product.

Leachate concentrations of Al, Fe, Mn, and Zn, which are often toxic in acid conditions, decreased with FGD amendment (Table 2). This was expected since the solubility of each of these elements is greatest under acid conditions and decreases rapidly with increasing pH (4). Table 2 gives leachate concentrations of elements which are of environmental concern and have been regulated with respect to land application of sewage sludge. Not listed are Hg and Pb. Mercury was below detection limit ($<0.04 \text{ mg kg}^{-1}$) in all of the column leachates and was also not detected ($<0.0002 \text{ mg kg}^{-1}$) in Toxicity Characteristic Leaching Procedure (5) extracts of LIMB or PFBC by-product. Lead was detected at a level of 0.12 mg kg^{-1} in leachates from unamended spoil. In all other leachates, Pb was below detection limit (0.04 mg kg^{-1}). Leachate Cd, Cu, and Ni decreased with increasing FGD amendment (Table 2). These results are consistent with most studies of trace metal behavior in soils which have found that trace metal solubility and mobility decreases as pH increases above the acid range (6, 7). Thus with respect to these metals there appears to be little potential for environmental contamination as a result of using FGD by-products as spoil amendments.

With respect to some oxyanions of concern, As remained below 0.05 mg kg^{-1} and was not affected by FGD amendment (data not shown), B increased with LIMB amendment, and Se increased with PFBC amendment (Table 2). While B can be phytotoxic, the most phytotoxic B species are relatively water soluble (7) and in actual mine reclamation, leaching due to natural precipitation may rapidly move soluble B below the root zone, thereby decreasing the potential for B phytotoxicity.

With PFBC amendment Se concentrations increased at all amendment rates except 32% where concentrations decreased. Because total Se in the PFBC by-product was less than the LIMB by-product (Table 1), it would appear that Se was mobilized from the spoil. If the Se in the spoils was present in part as adsorbed SeO_4^{2-} or SeO_3^{2-} , these species could have been mobilized by exchange with SO_4^{2-} . Due to their weak acid character, SeO_4^{2-} and SeO_3^{2-} should be held more strongly by soils than SO_4^{2-} (4), thus high SO_4^{2-} concentrations would be necessary to exchange with SeO_4^{2-} and SeO_3^{2-} . The decrease in Se with 32% PFBC, where there was also a sharp decrease in SO_4^{2-} , is consistent with such a mechanism.

Fescue growth was increased by FGD amendment of 4 to 8%, and decreased at higher rates, although good growth was achieved at all amendment rates (Fig. 2). It should be emphasized that the 20 cm of topsoil in all columns was amended with LIMB or PFBC to achieve a pH of

7. Therefore the underlying spoil with much higher FGD amendments had little effect on plant growth in these experiments. Root growth into the spoil was prevented by LIMB amendments of 16 and 32% and PFBC amendment of 32%. This could have been caused by a number of factors including cementing, high pH, and high soluble salts. Fescue tissue composition was relatively unaffected by the FGD amendments and no symptoms of phytotoxicity were observed. LIMB amendment decreased tissue S, Mn, and Zn, and increased tissue Ca and B. PFBC amendment decreased tissue Mn and increased tissue Mg.

CONCLUSIONS

Both dry FGD by-products were effective in neutralizing spoil acidity and decreasing the solubility of elements which are often phytotoxic under acid conditions. At amendment rates of 16% or less, leachate concentrations of elements of environmental and regulatory concern remained very low. Exceptions included Se mobilization with PFBC and increased B with LIMB. Dry FGD application is likely to be limited by high salt concentrations with Mg-containing by-products such as the PFBC material, and by excessively high pH and ettringite formation with CaO- and $\text{Ca}(\text{OH})_2$ -containing by-products such as the LIMB material. If amendment rates are held at levels below those which would cause these effects, there appears to be little potential for adverse effects on water, soil, or plant tissue quality.

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Table 1. Characterization of LIMB, PFBC, and spoil.

Parameter	LIMB	PFBC	Spoil
Particle size (%)			
Sand (0.05-2mm)	0	25.5	14.4
Silt (2-50µm)	90	74.1	54.9
Clay (<2µm)	10	0.4	30.7
Mineralogy (%)			
Anhydrite (CaSO ₄)	25	22	
Calcite (CaCO ₃)	15	11	(Shale fragments,
Dolomite (CaMg(CO ₃) ₂)	—	23	kaolinite
Lime (CaO)	21	—	and illite
Portlandite (Ca(OH) ₂)	5	—	clays)
Periclase (MgO)	—	13	
Fly ash	30	32	
CaCO ₃ equiv. (%)	59.4	60.3	0
pH (1:1, water)	12.5	10.5	5.8
Elemental Analysis			
Ca (%)	35.96	17.53	<0.01
Mg (%)	0.60	10.64	0.18
S (%)	5.77	5.21	1.06
Al (%)	3.52	3.93	9.2
Si (%)	6.58	7.24	23.5
Fe (%)	5.56	5.17	1.3
Na (%)	0.33	1.03	—
P (%)	0.02	0.02	0.04
K (%)	0.91	0.50	2.3
Ba (%)	0.03	0.02	0.04
As (mg kg ⁻¹)	55.1	1.9	13.7
B (mg kg ⁻¹)	233.1	171.2	—
Cd (mg kg ⁻¹)	1.0	1.9	0.8
Cr (mg kg ⁻¹)	28.0	36.9	79.8
Cu (mg kg ⁻¹)	21.0	52.5	79.0
Pb (mg kg ⁻¹)	16.0	16.0	30.5
Mo (mg kg ⁻¹)	5.9	6.6	<0.9
Ni (mg kg ⁻¹)	31.1	52.1	65.1
Se (mg kg ⁻¹)	8.1	5.6	4.3
Zn (mg kg ⁻¹)	86.0	74.0	<0.3

Fig. 1. First and second leachate pH, and spoil pH at two column depths, of spoil columns amended with LIMB (O) and PFBC(●) by-products.

Fig. 2. Fescue yield from the sixth harvest of topsoil spoil columns amended with LIMB (O) and PFBC(●) by-products.

Table 2. Chemistry of leachates from columns of active mine topsoil and spoil amended with FGD by-products.

Amendment Rate	EC [†]	Ca	Mg	S	Al	Fe	Mn	B	Cr	Cu	Mo	Ni	Se	Zn
weight %	dS m ⁻¹	mg kg ⁻¹												
LIMB amended topsoil and spoil														
0	9.56	404.5	1180	2985	2.57	1.37	114.9	1.40	0.021	0.04	<0.018	2.45	0.94	2.67
4	6.29	647.3	7.00	1318	<0.05	<0.01	0.100	1.34	0.018	0.04	0.583	<0.01	1.17	0.02
8	5.91	225.4	3.09	719	0.58	<0.01	0.029	0.55	0.036	0.06	1.499	0.01	0.65	<0.01
16	5.92	2.37	2.59	335	5.87	<0.01	0.012	4.16	0.021	0.03	0.879	<0.01	<0.27	0.02
32	15.92	2.93	2.64	2027	1.04	0.02	0.002	2.67	0.008	0.23	0.964	0.03	0.55	0.01
Untreated Spoil vs spoil+LIMB [‡]	ns ^{††}	***	***	**	ns	***	***	ns	ns	ns	***	***	ns	***
Spoil+LIMB: linear [§]	***	***	*	ns	***	***	*	**	ns	***	ns	ns	ns	ns
Spoil+LIMB: quadratic [§]	***	***	***	***	***	***	***	**	ns	***	ns	**	**	*
PFBC amended topsoil and spoil														
0	10.58	418.7	1220	3260	0.03	0.06	135.1	1.53	0.020	0.02	<0.018	1.77	1.33	1.33
4	20.19	437.9	4738	7546	<0.05	<0.01	1.923	1.00	0.024	0.01	0.090	0.02	2.17	0.04
8	24.68	442.6	6288	9530	<0.05	<0.01	0.296	0.91	0.034	0.01	0.202	0.01	3.03	0.03
16	29.53	447.5	7632	11260	<0.05	<0.01	0.118	0.79	0.036	<0.01	0.343	<0.01	2.83	<0.01
32	8.82	441.6	40	2059	<0.05	<0.01	0.025	1.35	0.009	<0.01	0.252	<0.01	0.55	0.01
Untreated spoil vs spoil+PFBC [‡]	***	ns	***	***	ns	ns	***	ns	ns	ns	ns	***	**	*
Spoil+PFBC: linear [§]	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	*	*	*	ns
Spoil+PFBC: quadratic [§]	***	**	***	***	ns	ns	***	ns	***	**	**	***	***	**
LIMB vs PFBC [‡]	***	***	***	***	***	ns	ns	***	ns	***	***	ns	***	ns

[†] Electrical conductivity

[†] Electrical conductivity[‡] Single degree of freedom contrasts[§] Linear regression of the response variable against FGD rate.[¶] Quadratic regression of the response variable against FGD rate and FGD rate squared.^{††} ***, **, *, and ns indicate significance at the 0.99, 0.95, 0.9 levels, and non-significance respectively.

TABLE 1

Land Applications Uses of Dry FGD By-Products

OSU ONLY	Sept., 1990 Original Budget and Subsequent Revisions			
	Original Budget <u>Sept.'90</u>	Revised Budget <u>June,1991</u>	Revised Budget <u>March,1992</u>	Revised Budget <u>Sept.,1993</u>
PHASE 1	\$586,160	\$712,521	\$701,849	\$701,849
PHASE 2	\$1,905,398	\$1,730,832	\$1,737,075	\$1,739,480
PHASE 3	\$1,677,641	\$1,725,844	\$1,730,274	\$1,727,870
TOTAL	\$4,169,199	\$4,169,199	\$4,169,199	\$4,169,199

Mud-slinging order of the night at sludge meeting

GARIN LAUTENSCHLEGER

...for a proposed mine reclama-
...near Winfield hasn't even been
...yet, but area officials and resi-
...dents plenty of their own mud at
...planners Wednesday night.
...from a public hearing

about the state proposal to reclaim 10
acres of the former Blue Creek Coal
mine off Tuscarawas County Rd. 80 in
Franklin Township questioned every-
thing from the amounts of certain
materials being used to the role of one of
the project's planners as a consultant for
the company providing sludge material.
Officials from the Ohio Department of

Natural Resources and Ohio Environ-
mental Protection Agency told the
crowd of about 100 in Tuscarawas Coun-
ty of Kent State University at New
Philadelphia that they never would have
proceeded with the plan if they did not
consider it safe to the environment and
human health under state and federal
regulations.

But at least two area officials said
those regulations may not be enough to
guarantee the safety of the large water
supply running below the area.
Dover Mayor Rick Homrighausen and
Earl Paulus, chief environmentalist for
the county health department, said they
have many concerns about the proposal.
Homrighausen, who told the state offi-

cials that Dover City Council passed a
resolution opposing sludge application
at the site, said his main concern is the
apparent close proximity of the site to
the aquifer feeding Dover's water sup-
ply.
"I can assure you that the city of
Dover is not going to get this stuff for free," he said.

*Don - New Philadelphia
7/23/93*

Meeting

From A-1

Dover will do everything within
its means to protect its source of
drinking water," Homrighausen
said. "This is not merely a 'not in
my backyard' argument, but one
of common sense."

Paulus said his study of the
area revealed 50 to 60 private
water supplies located within a
mile of the area to be reclaimed.

"The research and work in this
(study of reclamation materials
and sites) needs to be done,"
Paulus said, "but we also feel
that we need to have it done in
an area where the public health
is not threatened. There are too
many unknown factors in this
area for a project of this type."

Steve Wermuth, county health
commissioner, and Franklin
Township Trustee Max Bonifant
said they have received many
questions from area residents
about the project, but have had
minimal or no contact with state
officials about it. Wermuth said a
copy of the application has never
been sent to the health depart-
ment.

According to the \$380,000 plan
developed by Ohio State Univer-
sity and ODNR officials, sewer
sludge from Toledo - the solid
material removed during treat-
ment of municipal wastewater -
would be applied on two one-
acre plots as part of a study of
materials used to reclaim mine
sites. An eight-acre plot using a
commercially produced sludge
material also is part of the plan.

Other materials to be tested at
the site are lime and flue gas desul-
furization byproduct, the waste
product of coal burned by utili-
ties. Application would not begin
before the spring of 1994, said
Mark Smith, an ODNR environ-
mental specialist.

OEPA officials said testing at
sludge application sites in Ohio
during the past 10 years has re-
vealed no major problems posed
to the environment and health of
surrounding residents. The Blue
Creek Coal mine site, which has
showed erosion rates much
greater than normal for several
years, would not exceed current
rates on all identified harmful

substances.

However, several area officials
and residents said that debate
continues among experts about
the existence of safe levels for
substances such as lead and diox-
ins.

"We're here to make sure the
current regulations are being
met, not to write new ones," said
Mark Stump, OEPA environmen-
tal supervisor. "We're not going
to leave the sludge out there and
leave it untouched. There are
several more projects to be done
on it, such as growing grass and
mulching."

Marco Kaltofen, president of
Boston Chemical Data Co. and a
witness contacted by residents
opposing the project, said he con-
siders the proposal as a landfill.

"This is an experiment," said
Kaltofen, who had to leave mid-
way through the hearing to re-
turn to Boston. "This is a chance
to find something out. Something
is unknown, so there are guinea
pigs involved."

Other arguments raised during
the hearing included the rates of
sludge being applied, liability in
case something would go wrong
at the site and whether Terry
Logan, an OSU agronomy profes-
sor who helped to develop the
plan, had created a conflict of in-
terest by serving as a consultant
for National N-Viro Tech of To-
ledo, the company manufacturing
the sludge-like material.

The hearing, which stretched
beyond three hours, is part of the
application process for a project
permit. Testimony from the hear-
ing will be considered in the final
determination for granting and/
or altering an application. State
officials said they could not de-
termine when a final decision on
the project application would be
made by OEPA.

ODNR officials said work re-
cently begun on the site involves
reclamation with the topsoil only
and is not considered part of the
project area. The land is owned
by Don Domer of Dover.

Kaltofen, who said he has vis-
ited many sludge application
sites throughout the country,
said Boston pays \$400 per ton to
dispose of its sludge.

"The lucky people of Dover ...
you're actually going to get this
stuff for free," he said.

**an injured
fairgrounds**

18-year-old employee of

See MEETING ... A-5

N-VIRO SOIL'S PART IN THE RECLAMATION OF THE FLEMING ABANDONED MINE SITE

The N-Viro Soil (NVS) or Advanced Alkaline Stabilized Sludge with Accelerated Drying (AASSAD) process is a US and Ohio EPA approved Process to Further Reduce Pathogens (PFRP) and produces an Exceptional Quality Sludge (EQS) product. Dewatered municipal biosolids (sludge cake) are mixed with other alkaline by-products such as lime kiln dust (LKD), cement kiln dust (CKD) or fluidized bed boiler ash (FBA). The resultant mix causes the material to heat up to between 52°C to 62°C (pasteurization temperatures) and the pH is increased to 12. The mixture is stored to maintain these temperatures for at least 12 hrs. After this, the heat treated material is dried (while the pH remains above 12 for at least three days) through intermittent turning of windrows or other drying processes, until the solids levels reach and maintain a minimum of 50%. The mechanisms of pasteurization and the increase in pH causes all pathogens to be destroyed while maintaining the normal soil microbes. It also converts any heavy metals present into insoluble minerals.

N-VIRO PROCESS COMPARED TO OTHERS: Unlike traditional high heat lime pasteurization/sterilization, the N-Viro process does not have to use large dosages of quicklime or maintain the material at pH 12 until land applied. The pH of NVS will decrease through the normal weathering process even in storage with no fear of pathogen regrowth. This is due to the natural soil microbes present in the NVS and the dry, soil-like consistency.

The NVS made in Toledo, Galion, and Circleville, Ohio and throughout the United States, England and Australia all adhere to the company's strong Quality Assurance/Quality Control Program. The N-Viro process and product also has to meet the most stringent State and Federal regulations for the marketing and distribution of an EQS product.

NVS IN THE MARKETPLACE: In Ohio, the largest market for NVS is presently as an agricultural lime substitute. Since 1990, we have sold over 65,000 tons to farmers and another 15,000 tons to other markets such as topsoil manufacturing and landfill cover. Farmers can buy NVS for a price equal to or less than lime and receive the added benefit of the NPK, organic matter, micronutrients and soil microbes present.

NVS AND MINELAND RECLAMATION: In 1988, a project was begun in Hopkins Co., Kentucky in conjunction with the Kentucky Department of Natural Resources that used a NVS product out of Bowling Green KY to reclaim a site that had been surface mined in the 1950's. The pH of the area was 2.5 and consisted of sandy soil and rocks. After NVS was applied, the area was seeded with a standard reclamation mix. No additional fertilizer was applied to the site. After three weeks grasses began to grow and by the following spring the grass was thick and tall with no "weak" spots. Areas which did not receive NVS were stressed by the low pH and showed little or no vegetative growth. The site has been revisited several times since the test and the growth remains strong. Based on the results of this project, the Kentucky Division of Abandoned Mine Lands has placed N-Viro Soil on its list of approved reclamation materials. This allows contractors to use NVS on reclamation projects overseen by Abandoned Lands. The contractors like the NVS because it costs 50-60% less than conventional reclamation materials while providing 75 % better results.

THE FLEMING ABANDONED MINELAND PROJECT: When NVS was proposed for use in mineland reclamation for the first time in Ohio, we wanted to begin with a research project. We know it is important for Ohioans to see and understand how this material will work in their state. At the Fleming mine site NVS will be applied to two, one acre plots at a rate of 250 tons per acre. This is so the lime value of the NVS plots will match the lime value of the plots amended with regular agricultural lime. There is also an eight acre area surrounding the research plots being called a buffer zone that will receive NVS at a rate of 100 tons per acre. Therefore, a total of ten acres will have NVS applied to them.

Comments from N-Viro
Toledo, Ohio

The mined land reclamation areas to be reclaimed require action. They represent one of the best examples for Exceptional Quality Sludge (EQS) beneficial utilization.

- The N-Viro EQS product is by 503 definition, not a "sludge" but essentially a non-regulated product.
- The City of Toledo has just recently (9/93) used an N-Viro Soil blend product to reclaim a park, to be used publicly this fall, at a rate exceeding 8 times the suggested tons/acre rate proposed for this mine reclamation project. See article attached.
- Since 1990 65,000 tons of the N-Viro product was agronomically applied all over northwestern Ohio, as an EQS product, perhaps a better understanding could have been achieved.
- N-Viro Soil had been used for mineland reclamation in Kentucky with no problems. Contractors and the public were more than satisfied. (see attached N-Viro Soil at Fleming information sheet).
- The existing low pH condition not only exaggerates any possible existing lead pollution affects, but every other potential metal problem as well. There could be as much lead in the soil along every mile of major roadway they took to get to the meeting than there will be in the N-Viro product delivered to the project site (especially TCLP extract). Synthetic inorganic fertilizers also contain heavy metals (attached aglime information).
- The high pH metal stabilization quality of the N-Viro product could only help stabilize if not reverse the existing condition.

GREAT LAKES

**N-VIRO SOIL™
ORGANIC AG LIME**

N-Viro Soil™ (NVS) is a substitute agricultural liming material with a guaranteed TNP of 40% (dry basis as calcium carbonate). NVS is a safe, pasteurized product made from municipal biosolids and alkaline by-products such as lime or cement kiln dust and fluidized bed boiler ashes. NVS is also a source of organic matter, macro- and micro-nutrients and natural soil microbes. NVS meets all state and federal guidelines for sludge derived products with regard to pathogen destruction, heavy metal concentrations and odors and vector attraction. ✓

INSTRUCTIONS FOR USE

NVS may be used where soil tests indicate a need for an agricultural liming agent. The rate of application is dependent on the recommended tons of lime per acre needed.

Example: If the NVS TNP is 50% and the soil test indicates a need for 4 tons/acre of ag lime, use 8 tons/acre of NVS

LIMING VALUE

The particle size of NVS is much finer than many agricultural limestones, thus reacts to adjust pH of the soil quickly, within one month. The high pH of NVS is due to the presence of small amounts of calcium hydroxide. NVS contains a large amount of CaCO_3 . When exposed to air, it carbonates within minutes and the pH will be buffered to about 8.0.

Table 1

NUTRIENT	lbs/DT
Nitrogen	14
P ₂ O ₅	27
K ₂ O	10
Calcium	388
Magnesium	161
Sulfur	52
Zinc	0.45
Copper	0.13
Manganese	0.60

NVS METALS ANALYSIS

The heavy metal content of NVS is tested continuously. Metals levels are guaranteed to fall below all state and federal rules regulating their concentration in biosolids derived products. Table 2 compares the concentration of metals in NVS with that of inorganic, synthetic fertilizers and the EPA limits for land application.

SPREADING NVS

NVS can be spread with lime $\frac{1}{2}$ or manure spreaders. Fill hopper approximately $\frac{3}{4}$ of the way to prevent bridging of the material.

PLANT NUTRIENTS

The nitrogen in NVS is almost entirely organic, therefore it acts like a slow release fertilizer. Research indicates that approximately 20% of the nitrogen is available during the first year with continual mineralization yielding another 5% per year. 50% of the phosphorus and 100% of the potash (K) will be available. Table 1 shows an average of the lbs/acre of PK and micronutrients you might find in NVS. These values are based on 1993 analysis and are not guaranteed.

Table 2

HEAVY METALS	1993 AVG NVS CONC.(mg/kg)	EPA/EQS LIMITS	AVG SYN FERT CONC
Arsenic	15.8	41	
Cadmium	1.9	39	13
Chromium	72.4	1200	129
Copper	95.5	1600	55
Lead	65.4	300	36
Mercury	0.4	17	0.1
Molybdenum	10.3	18	
Nickel	120.2	420	81
Selenium	4.6	36	
Zinc	355.9	2800	230

N-VIRO IN THE NEWS

A Reprint From The Toledo Blade 9/24/93

Park to get new look with sludge

A South Toledo park might end up being a little bit greener, thanks to a soil additive that combines sewer sludge with various forms of dust and ash.

For years, farmers have fertilized their land by spreading the sewage by-product on it. Sludge is a moist material formed at the city's sewage plant when the waste stream is treated and many liquids are removed.

One advantage of sludge is that it is more affordable than many fertilizers.

The city has found a way to use it on the northern section of the old River Park on Brookford Drive near the Anthony Wayne Trail, saving money while adding nutrients to the soil, Water Commissioner Whit Van Cott said.

The park has been undergoing a massive face lift since the spring of 1992, an effort that has been aided with grant money from the Ohio National Guard.

The section under reconstruction was the site of a wastewater treatment plant that had huge reservoirs dating back to 1907.

The plant was demolished months ago. The crushed concrete from the plant was left there and covered by about three feet of fill, Mr. Van Cott said.

The dirt was covered by a four-inch layer of Envirosoil, a product developed by Great Lakes N-Viro, a subsidiary of N-Viro Energy Systems of Toledo.

Envirosoil consists of sludge and alkaline by-products, such as dust from lime kilns, cement kilns, and ash, Cindy Drill, product manager for Great Lakes N-Viro, said.

By using the sludge product, the city can save on fertilizer and dirt costs while supporting a local company, Mr. Van Cott said.

The city has spent about \$250,000 on renovation so far, including about \$45,000 for 3,000 cubic yards of envirosoil, he said. It would have

cost about another \$35,000 if the final layers consisted of topsoil, he said.

The sludge-and-dust product has been mixed with existing dirt and clay at the site, and officials expect to find out soon how well the stuff works.

The grass was planted yesterday, Ms. Drill said.

City officials have said the renovation is not expected to be completed for another two to five years. The city still needs to obtain funds for landscaping, and to install new facilities, Mr. Van Cott said. They are working off a master plan drawn up in August, 1991.

Envirosoil is likely to remain more popular on farms.

N-Viro has sold 65,000 tons of Envirosoil to area farmers since 1990, Ms. Drill said. About 15,000 tons have been sold for other purposes, such as landfill cover, she said.

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