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ALTERNATIVES TO LAND BURIAL OF SEWAGE SLUDGE ASH
Inquiry Response No. 150
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INQUIRY: What are the potential alternatives to land burial of sewage sludge ash?

KEY RESOURCES:*

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BACKGROUND: The U.S. produced 9.3 million dry tons of wastewater sludge in 1975, of which 35 percent was incinerated.[1] Currently, the Twin Cities metropolitan area produces 260 dry tons of sludge per day. Each day about 200 tons is incinerated, yielding 50 tons of ash. The rest of the sludge is landspread.[2] The Metropolitan Waste Control Commission (MWCC) currently disposes 17,500 tons of ash per year.

Management of sewage sludge or ash is a major problem for other U.S. metropolitan areas as well. Some areas have chosen to manage it as a waste, disposing of it as cheaply as possible by ocean dumping, incineration, or placing it in landfills, while other areas see it as a resource and use it as a fertilizer or soil conditioner. As a fertilizer it may be spread on cropland as a slurry, at 8 to 10 percent solids, or dewatered and given away or sold for use on lawns or croplands.

The MWCC plans to continue a combined management approach of both incineration and landspreading. An incinerator under construction at the Pig's Eye Treatment facility will have the capacity to incinerate the total amount of sludge produced at that facility. It is expected to be in full operation by 1984. The incinerator will produce dry ash with less lime and iron than in the ash currently produced. Land disposal of ash will require additional landfill sites by 1983 even before completion of the new incinerator. Development of alternative uses for the ash could reduce the need for landfill sites. The site selection process has been started in order to have a location for disposal when the present site is closed.

The Metropolitan Council staff contacted twelve cities to inquire about alternative uses of sludge ash and found that all of them continue to landfill the ash. Other alternatives had been investigated, but none had been implemented.

*A key resource is a person who knows the technical aspects of the topic being considered and has indicated a willingness to answer questions on the topic from legislators.

The problems associated with disposal of 50 tons of ash per day are compounded by the presence of heavy metal contaminants in the ash which can have a toxic effect on plants or animals. A major source of these metals is industrial wastewater. Effluent discharge limits have reduced concentrations of these metals but have not eliminated them altogether. Their presence means that ash must be managed in a way that will not create environmental hazards.

This document will present information on (1) potential hazards associated with management of sludge ash, (2) the similarities and differences between sludge ash and fly ash, (3) uses of fly ash and potential uses of sludge ash in construction materials, (4) evaluation of the potential for the use of sludge ash in construction, (5) feasibility of using sludge ash in asphalt, and (6) sludge ash as a fertilizer additive.

RESPONSE:

1. Potential Hazards of Sludge Ash

Wastewater sludge, a non-hazardous material, is used as a fertilizer because it contains both major nutrients (nitrogen, phosphorus, and potassium) and minor nutrients (copper, manganese, zinc, and boron). Because it also contains heavy metals (cadmium, nickel, lead, and chromium), which are toxic if taken up by plants, the application of sludge to cropland is monitored to prevent toxic metal buildup in the soil. Soil pH is also monitored to prevent uptake of toxic metals, which occurs when the pH is below 6.5. Lime is added to the soil to keep the pH above 6.5 when necessary.

When sludge is incinerated, most of the heavy metals are concentrated in the ash, and a small percentage is lost with stack gases. The concern for ash disposal centers on the movement of toxic metals from the land burial site. When deposited in the landfill, the main concern is for pollution of groundwater. Leaching studies have been conducted to determine the potential for heavy metals leaving a land disposal site. Standards for leaching tests have been set by the U.S. Environmental Protection Agency (EPA) and the State of Minnesota to identify hazardous wastes. MWCC sludge ash that has been analyzed is not classified as a hazardous waste, according to Minnesota Pollution Control Agency (MPCA) rules, including those which apply to leachate characteristics. Leaching tests also provide an indication of the potential of movement of toxic metals from materials in which the ash may be used such as construction materials, asphalt, or as a soil stabilizer in construction.

2. Comparison of Sludge Ash and Fly Ash

Coal ash and sludge ash are produced by the combustion of carbon-containing material. When coal is combusted, about 3 to 30 percent remains as ash, and this varies with the type of coal. The ash content of sludge is around 20 percent.[3] The characteristics of each ash will be compared in this section.

The three types of coal ash produced by power-generating plants are bottom ash, slag, and fly ash. The latter is produced in the largest amounts (65 percent of the total) and is similar to sludge ash in chemical composition. The total nationwide production of coal ash in 1980 was estimated at 78 million tons.[4] Because of the large amounts of fly ash produced, there has been considerable study of its properties in order to find alternative uses for this resource.

Fly ash is primarily produced in power plant boiler furnaces using pulverized coal firing and cyclone firing. Combustion temperatures of about 2700°F are maintained. The fly ash is collected from the exhaust stream before it leaves the exhaust stack. The majority of the ash produced is very light and finely divided (0.01 to 0.1 millimeter in diameter). About 75 percent of the fly ash is fused into spherical glass particles.

In contrast, sludge ash is produced in a multiple hearth furnace that provides for the drying of the ash before combustion. The drying process requires the use of supplemental fuel. Furnace temperatures reach 1700° to 2000°F. Whether or not the particles have been fused has not been determined. The ash ranges in particle size. The large pieces are easily crumbled into fine particles, though these are somewhat coarser than fly ash.

The characteristics of the sludge ash that will be produced in the new MWCC incinerator will not be known until it is in operation. An attempt has been made to produce similar ash by incinerating sludge (without adding lime and iron) in a rotary kiln, and about 100 pounds have been produced for use in preliminary ash evaluation studies.

The major chemical components of sludge ash and fly ash are shown in Table 1.

TABLE 1

Major Chemical Components of Sludge Ash and Fly Ash (percent)

MAJOR CONSTITUENTS	FLY ASH[a]	SLUDGE ASH[b]
Silica (SiO_2)	38-57	32.28
Alumina (Al_2O_3)	15-31	13.74
Ferric oxide (Fe_2O_3)	4.2-5	9.26
Titanium dioxide (TiO_2)	1.5-1.7	Not available
Calcium oxide (CaO)	.86-24	34.50
Magnesium oxide (MgO)	.75-4.7	2.98
Sodium oxide (Na_2O)	.27-.50	.15
Potassium oxide (K_2O)	.04-2.6	.14
Sulfur Trioxide (SO_3)	.22-1.7	3.62

[a]John Ashby, "Utilization of Fly Ash in Concrete," presented to the Seventh Kentucky Coal By-Products Seminar, Lexington, Kentucky, June 12, 1981.

[b]Laboratory Report No. 6-17927, Twin City Testing and Engineering Laboratory, Inc., March 21, 1978, "Pozzolanic Activity Index with Portland at 28 Days."

It should be noted that there is a significant variation in the composition of fly ash from different types of coal. Ash composition affects the ash's usefulness though as yet there is no quick method to determine those properties that affect its usefulness in concrete. Fly ash can be used as a replacement for portland cement in concrete if it acts as a pozzolan. A pozzolan is a material having properties of cement when mixed with both lime and water. Whether or not it has these properties, fly ash or sludge ash can be used as a raw material in the production of cement, because of their silica and iron content. Metropolitan area sludge ash will need to be evaluated for its pozzolanic properties.

3. Fly Ash in Construction Materials

Significant amounts of fly ash are being used in the construction industry at present, but it is still an under-utilized resource. In 1979, 57.5 million tons of fly ash were produced in the U.S., of which only 1.9 million tons were used as an ingredient in concrete, and 830 thousand tons were used as a raw material in the production of cement.[5] In 1978, it was estimated that 13 percent of all fly ash produced was utilized in one fashion or another. Table II indicates the worldwide uses of ash in 1977. These uses exploit one or more of the following properties:

(1) Pozzolanic properties - Cement replacement, addition to cement, and aerated concrete blocks.
(2) Particulate characteristics (finely divided) - Fill material, road stabilizer, blast grit, asphalt filler, and asphalt roofing filler.
(3) Clay replacement - Cement raw material, lightweight aggregate, brick, and ceramics.[6]

TABLE II

World Use of Coal Ash in 1977

USE	10^6 TONS/YEAR	LEADING USERS
Fill material	5.8	England, USA, Canada
Cement replacement	5.6	USA, England, E. Germany
Addition to cement	4.1	France, Spain, W. Germany, Poland, Australia, USA
Road stabilizer	3.1	Poland, England, USA
Aerated concrete blocks	1.8	Poland, England
Blast grit and roofing	1.6	USA, W. Germany
Asphalt filler	1.2	W. Germany, USA
Cement raw material	1.0	USA, France
Lightweight aggregate	0.8	England, USA, E. Germany
Bricks and ceramics	.6	W. Germany, Ukraine, E. Germany
Other	9.6	USA, Poland, E. Germany, W. Germany
TOTAL:	35.2	

SOURCE: John Ashby, "Utilization of Fly Ash in Concrete," presented to the Seventh Kentucky Coal By-Products Seminar, Lexington, Kentucky, June 12, 1981.

The replacement value of fly ash plays a significant role in determining potential uses. It has its highest value when used as a replacement for cement, which costs \$60 to \$70 per ton. It has a lower value when used as an aggregate but can play a significant role when used in areas of the state where aggregate is in short supply. When used in the manufacture of building blocks it has the advantage of producing lighter-weight products. In some areas of the country, it is used as a filler in asphalt pavement.

4. Evaluation of the Use of Sludge Ash in Construction Materials

The previous discussion of fly ash provides the basis for discussing the properties and potential uses of sludge ash. Ash may be combined in the production of concrete products at the following levels: (1) Ash combined with clay and lime and roasted in a furnace to make cement, (2) as a pozzolan to replace some portion of the cement in making concrete, or (3) as a replacement for a portion of the sand or gravel aggregate in the production of concrete or concrete products.

The potential for using ash as a raw material in cement manufacture is dependent on the proximity of cement plants to the ash incinerator, the acceptability of the ash for that use by the cement industries, and promotion by sales representatives for users and specifications writers.

Sludge ash apparently lacks the necessary pozzolanic properties needed for use as a cement replacement in concrete, though the reasons for this have not been determined.[8] The ash may not have been fired to a high enough temperature to fuse the minerals into glass as is required, or the particles may not have been fine enough to be reactive with the lime and water. The sludge ash does contain the appropriated amounts of silica and alumina required of a pozzolan. With the changeover to a new MWCC incinerator, it will be necessary to examine the new sludge ash produced to determine its potential uses. Specific tests for pozzolanic properties are available. The Metropolitan Council is contracting for studies to examine some of these characteristics.

The use of ash in concrete products as an aggregate is dependent on the development of an aggressive sales program to promote the advantages of ash. It makes a lighter-weight product than concrete made with sand and gravel.

Sludge ash needs to be evaluated for its usefulness as a soil stabilizer for road and construction fill. It may be possible to use it alone or with cement or lime in the preparation of stable soil base.

Once satisfactory uses of ash are found, the actual use of ash will require a marketing effort which ensures that the use of ash is written into construction specifications.

In summary, sludge ash has properties that make it useful as an aggregate in construction materials. Testing and evaluation are needed to determine whether it can replace cement in concrete. It will take a concerted effort on the part of the MWCC to develop appropriate uses and to market the material. There is inborn resistance to the introduction of new materials in the manufacturing process for which there may be some increased handling costs. Performance testing will also be needed.

5. Feasibility of Sludge Ash in Asphalt

Testing to determine the effect of adding up to 3 percent by weight of ash to asphalt as a filler has begun. If all of the needed tests are positive, up to 43,000 tons of ash could be used annually as an asphalt extender in the metropolitan area. This would more than utilize all of the ash produced in the metropolitan area. A test area of asphalt was spread by Total Asphalt, Inc. in December 1981. The initial reaction by the company to the mix was positive. An analysis of the mix made by the Minnesota Department of Transportation indicated that the mix was suitable for base material and that additional tests would be needed to determine the suitability for a surface coat.[9]

A feasibility study of sludge ash use in asphalt has been initiated by the Metropolitan Council to examine several issues, including (1) ash collection, storage, and transportation; (2) equipment; and (3) economics.[10]

(1) Ash collection and storage presents a twofold problem. Ash can be transported directly to asphalt plants during the warmer months while asphalt pavement is produced--April to November. During the other months, dry storage or alternative uses of sludge (if not incinerated) or ash are needed.
(2) The 30 asphalt plants in the Twin Cities metropolitan area have not used any filler in asphalt in 14 years, and equipment changes may be needed. Because of the finely divided nature of the ash, air pollution control is a concern.
(3) An evaluation of the economics of using sludge ash in asphalt is needed. Cost reduction from material savings, cost increases from equipment changes, product quality, and quality control of ash and pavement are factors of concern in a proper evaluation of sludge ash.

6. Sludge Ash as a Fertilizer Additive

One of the values that sludge has as a fertilizer is its trace nutrient content. It contains small amounts of elements such as manganese, cobalt, and zinc which are required by plants. These elements are concentrated three- to four-fold in the ash. Depending on the availability of these trace nutrients, the ash is useful as an additive for fertilizer in areas of the country where trace nutrients are in short supply, such as Florida. The ash at the same time can also serve as a fertilizer filler to reduce high concentrations of nitrogen and phosphorus to appropriate levels. A feasiblity study is needed to determine whether shipping costs would prevent the use of ash an economic replacement for other sources of trace nutrients and other fillers.[11]

SUMMARY: Fly ash and sludge ash have similar characteristics and chemical composition. These similarities provide the basis for examining the present uses of fly ash as potential uses of sludge ash. Fly ash is used as a cement replacement, as a raw material for cement, an asphalt filler, and soil stabilizer. Testing procedures used to evaluate the suitability of fly ash can be used to evaluate sludge ash. Some research can take place using the prototype sludge ash now available, while other research may need to wait until the new incinerator is in operation. Such testing and evaluation will determine the extent to which this resource may be used for purposes other than disposal in a landfill.

FOOTNOTES:

1. R. C. Gabler and David Neylan, "Incinerated Municipal Sewage Sludge as a Secondary Resource for Metals and Phosphorus," proceedings of the Third National Conference on Sludge Management and Disposal, December 1976.
2. Consulting Engineers Diversified, Inc./CH2M Hill, Inc., "Residual Solids Management Study," 201 Summary Report Series, Volume II, (St. Paul, MN: Metropolitan Waste Control Commission, June 1980).

FOOTNOTES (continued):

3. Minnesota Pollution Control Agency, An Evaluation of Sewage Sludge Disposal On Land, (Roseville, MN: Minnesota Pollution Control Agency, January 1, 1981).
4. National Ash Association, "Power Plant Ash," (Washington, D.C.: National Ash Association, undated).
5. John Ashby, "Utilization of Fly Ash in Concrete," presentation to the Seventh Kentucky Coal By-Products Seminar, Lexington, Kentucky, June 12, 1981.
6. G. Frohnsdorff and J.R. Clifton, "Fly Ashes in Cements and Concretes: Technical Needs and Opportunities," (Washington, D.C.: Office of Recycled Materials, National Bureau of Standards, March 1981).
7. Ibid.
8. Laboratory Report No. 6-17927, Twin City Testing and Engineering Laboratory, Inc., March 21, 1978. "Pozzolanic Activity Index with Portland at 28 Days."
9. Rich Wolters, Office of Materials Engineering, Minnesota Department of Transportation, St. Paul, MN, statement during telephone conversation, January 13, 1982.
10. David Holt, Director of Engineeirng, Minnesota Asphalt Paving Association, St. Paul, MN, statement during telephone conversation, December 30, 1981.
11. Edgar David, Florida Fertilizer, Inc., (Box 1087, Wauchula, Florida, 33873), statement during telephone conversation, January 13, 1982. He indicated a willingness to provide an opinion on the usefulness of the ash based upon examination of an ash sample.

DWH/jb