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Sewage Sludge Landspreading in Ohio Communities: 1980 Perspective

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Sewage Sludge Landspreading in Ohio Communities: 1980 Perspective

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INTRODUCTION

The primary purpose of this report is to describe the extent of and current practices in Ohio municipal sewage sludge landspreading as of 1980. The extent of landspreading and the characteristics of the sludge are summarized; sludge application rates and the resulting loadings of nutrients and metals to the soil are estimated; the crop acreage receiving sludge is projected, as well as the nutrient value to these crops; landspreading systems are described, and monetary costs of these systems are estimated. Finally, the relationships between landowners receiving the sludge and landspreading municipalities are described. Where possible, comparisons are made to landspreading practices that existed 5 years earlier. Ohio communities were surveyed in 1975 and 1980, and the survey results are the data base used for this analysis.

BACKGROUND

Landspreading in Ohio has a history as long as municipal waste treatment. But in the past decade interest in landspreading increased dramatically. First, there was more sludge for cities to dispose. Federal legislation and subsequent financial assistance caused communities to upgrade their wastewater treatment facilities, to remove more solids from effluents, and to produce more sludge. Second, cities faced a limited number of sludge disposal options, and for most cities, landspreading was the lowest cost alternative. Third, sludge contained plant nutrients which could be used on cropland as substitutes for nutrients from increasingly costly commercial fertilizer. With these incentives, landspreading sludge received increased support from community officials and farmers. However, some warned of potential problems with landspreading sewage sludge.

Concern was expressed that surface water quality might deteriorate due to runoff from landspreading fields, groundwater might receive excessive levels of chemicals from leaching, soils might be permanently damaged due to the accumulation of toxic materials, plants might take

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up and accumulate heavy metals which could be dangerous to plant growth and human health, viruses or other pathogens might create potential health problems, and nuisance odors might result. Extensive research throughout the United States has demonstrated that sludge may be a valuable product for agriculture and landspreading may be a practical disposal option, but also that improper management of sludge may produce pollutants injurious to soil, plants and human health (2, 8, 9).

In 1975, a survey of Ohio landspreading communities was conducted to identify the extent of landspreading and the current methods and practices used. Results indicated that numerous communities landspreading sludge were following less than satisfactory management programs. Sludge was being disposed, not judiciously landspread. Application rates were largely unknown, more than half the communities had no knowledge of the heavy metals content of their sludge, many did not know the nutrient content of the sludge, and most lacked information about the nutrient requirements of the cropland receiving the sludge. In short, landspreading was being conducted on a widespread basis, but the majority of communities were not using management practices which would assure practical, yet environmentally safe programs.

In 1977 an educational program was initiated in Ohio to demonstrate landspreading practices which provided communities an economical method of sludge disposal, provided crop nutrients to farmers, and minimized health and environmental risks. The educational program was funded by the U. S. Environmental Protection Agency and Ohio Farm Bureau Federation. Personnel from The Ohio State University, Ohio Agricultural Research and Development Center, and Ohio Farm Bureau Federation actively participated. Four Ohio communities (Medina, Defiance, Columbus, and Springfield) were the focus of the program.

In each community, field plots were used to demonstrate application practices as well as resulting crop performance. Also, sludge was landspread on numerous farms in each community at application rates which maximized the nutrient value of the sludge (1 to 5 dry tons per acre). Necessary testing and monitoring programs for sludges and soils were employed. In three of the communities, an intensive effort was made to monitor the health of humans and livestock near landspreading sites. Numerous educational meetings were held in these communities as well as many others throughout Ohio. Several groups, including community officials, consulting engineers, government agency personnel, farmers, and the public at large, were target audiences at these meetings. The advantages and disadvantages of landspreading were discussed, as were acceptable landspreading management practices. Also, educational materials were written and distributed, and television and radio presentations were made. In short, an intensive program was conducted to attempt to improve landspreading practices.

This report summarizes current (1980) Ohio landspreading practices. A survey of Ohio landspreading communities was used to gather this information. Where possible, comparisons are made to 1975 practices found in a similar survey. Changes in practices have occurred, of course. Many of these changes may be due to the educational program. However, not all changes can be attributed to this program. U. S. Environmental Protection Agency guidelines and regulations have had an effect on these practices. Also, economic conditions have encouraged the expansion of landspreading and have shaped practices being used.

SURVEY PROCEDURE

District offices of the Ohio Environmental Protection Agency provided the locations of treatment plants which were thought to be conducting landspreading programs. Eighty communities were identified, and a questionnaire was mailed to each of these communities. The questionnaire was to be returned to OFB offices. Another questionnaire was mailed to those communities not responding to the first one. From these two mailings, 63 communities (79%) returned completed questionnnaires. A few of these communities reported that landspreading was not being used and incineration or landfilling was the principal method of disposal. Fifty-six communities completing the questionnaire were identified as landspreading and were used in this analysis.

CHARACTERISTICS OF TREATMENT PLANTS AND SLUDGES

The characteristics of treatment plants using landspreading are shown in Table 1, and the characteristics of the sludges from those plants are shown in Table 2. It is estimated that the total amount of sewage treated in Ohio is 1,373 million gallons per day (MGD) (6). Table 1 indicates the mean flow of the 56 treatment plants to be 6.14 million gallons per day. Thus, landspreading is the sludge disposal method used for at least 344 MGD (25%) of the total flow from all Ohio sewage treatment plants. Undoubtedly, other landspreading communities are not included in these survey results and thus landspreading in Ohio probably accounts for more than 30% of sludge disposal.

The mean amount of sludge produced from each of these landspreading communities is 1,370 dry tons per year. However, a few very large treatment plants skew this distribution. The median sludge production, 760 dry tons per year, provides a better representation of the amount of sludge from the typical plant. Most of this sludge is treated by anaerobic or aerobic digestion.

The characteristics of the sludges (Table 2) are similar to those found in other studies (11, 12). The total nitrogen can be divided into organic and ammonia forms. However, too few cities reported this division to provide meaningful results. Metal concentrations are within the range usually seen in the United States. One community in the sample has unusually high metal concentrations which increased the

TABLE 1.—Sludge Treatment Plant Characteristics for 56 Ohio Landspreading Communities, 1980.

Characteristic	Mean	Median	Number Reporting
Treated Flow (million gallons per day)	6.14	3.0	56
Sludge Production			
Dry tons per day	3.8	2.1	56
Dry tons per year	1,370	760	56
Sludge Treatment Method			
Anaerobic	55.0 %		
Aerobic	38.3		
Lime	4.0		
Heat	1.7		
Other	1.0		
Total	100.0 %		

Source: Survey results.

TABLE 2.—Sludge Characteristics for 56 Ohio Landspreading Communities, 1980.

Characteristic	Mean	Median	Number Reporting
	(%)	(%)	
Solids	6.1	4.5	55
Plant Nutrients			
Nitrogen—TKN	3.1	2.7	23
Phosphorus	1.9	1.9	24
Potassium	0.4	0.3	18
Metals	(ppm)	(ppm)	
Cadmium	49	12	33
Zinc	1,889	1,392	39
Copper	796	540	39
Nickel	304	95	38
Lead	697	250	30

Source: Survey results.

mean substantially. Again, the median concentration is a better reflection than the mean of typical concentrations in Ohio communities.

NUTRIENT AND METAL LOADINGS

For those communities reporting both a) nutrient and metal concentrations and b) sludge application rates, nutrient and metal loading rates were computed. The results are shown in Table 3. Again, a few communities with high sludge application rates produce a relatively high mean annual application rate of 7.6 dry tons per acre. The median annual rate is 3.8 tons per acre. Also, the mean nutrient and metal loadings are much higher than the median loadings due to a few high rates of sludge application.

Most communities are well within existing regulations and guidelines for metal loadings (7, 13). The community with the most extreme metal loadings exceeds the maximum allowed annual cadmium loading. However, all other communities' metal loadings are low enough to prevent any plant toxicity or damage to animal or human health. It appears that Ohio communities are generally spreading sludge in an environmentally safe manner.

Nutrients are being applied at relatively high rates. Both the mean and median phosphorus rates (190 and 140 lb per acre) supply more phosphorus than is typically required by a crop in one growing season in Ohio. Thus, some phosphorus from sludge is carried over to later growing seasons. Available nitrogen supplied by the mean and median

TABLE 3.—Annual Sludge Application Rates; Nutrient and Heavy Metal Loadings for 56 Ohio Landspreading Communities, 1980.

	Mean	Median	Maximum	Number Reporting
		(tons per acre)		
Annual Sludge Application Rate	7.6	3.8	45	35
Nutrient Loadings		(lb per acre)		
Nitrogen—TKN	322	190	1,620	16
Phosphorus	192	140	477	18
Potassium	41	20	252	14
Metal Loadings		(lb per acre)		
Cadmium	0.6	0.2	6.1	22
Zinc	17.4	9.9	56.7	25
Copper	7.0	3.4	48.6	26
Nickel	2.0	1.0	10.2	24
Lead	7.0	2.7	53.8	19

Source: Survey results.

annual loading rates is generally lower than the requirements of corn, but it approximates the requirements of small grains, hay, and pasture. Potassium loading rates are lower than the potassium requirements of most crops. In most cases, supplemental applications of potassium from other sources are required.

BENEFITS OF SLUDGE TO CROPLAND

Acres receiving sludge vary greatly between communities. In some communities, substantial row crop acres are landspread with low (2 dry tons per acre or less) application rates. In other communities, the receiving land remains idle during landspreading, and high application rates are used over a small number of acres. The crop acres affected by landspreading in these 56 communities are:

	Acres	Percent
Corn	11,100	44.8
Soybeans	3,600	14.5
Pasture and Hay	3,500	14.1
Idle	3,000	12.1
Small Grains	2,300	9.3
Other	1,300	5.2
	24,800	100.0

Thus, nearly 88% of the land receiving sludge is in crops during the year of sludge application. These crops utilize the nutrients in the sludge, and the nutrients substitute for commercial fertilizer.

The potential gross fertilizer value of sludge from these 56 communities is $2.3 million annually.[2] To realize all these benefits, communities must spread sludge at rates which supply nutrients in amounts which do not exceed crop requirements. With present application rates, phosphorus is supplied in excess of crop needs, and some benefits are lost in most communities.

LANDSPREADING SYSTEMS

About two-thirds of the surveyed communities own sludge application equipment and spread their own sludge. The other one-third contract landspreading services from commercial haulers. While contract haulers are used by communities of all sizes, they tend to be used by the larger landspreading communities. Communities using contract haulers produce an average of nearly 2,500 dry tons per year, while communities using their own equipment average only 740 dry tons per

[2]Each community spreads an average of 1,368 dry tons per year, or 76,608 dry tons are spread by all communities. The nutrient value of sludge is approximately $30 per dry ton.

year. Contract haulers spread 65% of the sludge landspread in Ohio while community owned systems spread only 35%.

From estimates provided by surveyed communities, landspreading cost functions are estimated. Each community provided the total operating costs (*e.g.*, labor, fuel, maintenance, and contract hauler fees), as well as the capital investment in sludge disposal equipment. This capital investment is converted to annual fixed costs (*i.e.*, depreciation and interest).[3] Total annual costs of landspreading (operating costs plus fixed costs) are divided by the amount of sludge landspread to arrive at the cost per dry ton. For communities contracting hauling services, annual costs are the fees paid by the community to the hauler.

Costs are related to the size of the community by the following:

$$(1)\ \text{Cost per dry ton} = a_0 + a_1 \left[\frac{1}{\text{Annual dry tons}}\right]$$

Coefficients a_0 and a_1 are estimated using regression analyses for both community owned systems and contract hauler systems.[4] Results are

[3]Annual fixed costs are assumed to be equal to 40% of the capital investment (1980 dollars). Equipment life is assumed to be 3 years, and the interest is assumed to be 14% of the mid-life value.

[4]Several regression models were estimated. Generally, these models hypothesized that economies of size were present. Also, distance to landspreading site was incorporated in some of the models but was not found to be statistically significant.

TABLE 4.—Regression Analysis Results for Ohio Community Owned and Contract Hauler Systems, 1980.

	Community Owned (N=24)	Contract Haulers (N=12)
I. Regression Equations		
a. Regression coefficients		
a_0 Intercept	33.79	99.13
a_1 $\frac{1}{\text{Annual dry tons}}$	17,664* (8.20)	65,307** (1.66)
b. R^2	0.75	0.22
II. Annual Sludge Production		
Mean (dry tons)	739	2,466
Median (dry tons)	360	1,224
III. Cost per Dry Ton at		
Mean annual production	$58	$126
Median annual production	$83	$152

Numbers in parentheses are the t-values for the regression coefficients.
*Statistically significant at $<.01$ level.
**Statistically significant at $<.12$ level.

shown in Table 4. Generally, the statistical estimates of equation 1 are better for community owned systems than for contract hauler systems. The R^2 for the estimated relationship for community owned systems was much higher than that for contract hauler systems. Also, the regression coefficient relating cost per ton to community size (a_1) was more statistically significant for community owned systems. For most community sizes, landspreading costs for contract hauler systems are about three times higher than the costs for community owned systems (Table 5).

Using these estimates, sludge landspreading costs these Ohio communities nearly $7.8 million or an average of $101 per dry ton. As previously stated, about $30 per dry ton may be recovered as benefits from nutrients in the sludge. Of course, these benefits tend to be captured

TABLE 5.—Landspreading Cost Estimates by Amount of Annual Sludge Production, Ohio, 1980.

Annual Sludge Production	Community Owned	Contract Haulers
dry tons	$/dry ton	
500	69	230
1,000	51	164
1,500	43	143
2,000	41	132

TABLE 6.—Sludge Analysis Programs Conducted by Ohio Communities, 1980.

	1975 Survey		1980 Survey	
Type of Analysis	Number of Communities	Percent of Communities	Number of Communities	Percent of Communities
No analysis of sludge	9	21	0	0
Minimal analysis of sludge* (e.g., solids content, pH)	16	37	4	7
Thorough analysis of sludge†	18	42	51	93
nutrient content	(N.A.)		(36)‡	
metals content	(N.A.)		(51)	
Communities responding	43	100	55	100

*"Minimal" includes analyses for total solids content and volatile solids in the sludge.

†"Thorough" includes analyses for solids content, volatile solids, some primary nutrients (nitrogen, phosphorus, potassium), and some heavy metals (cadmium, zinc, copper, nickel, boron, chromium, cobalt, manganese, mercury, molybdenum, lead).

‡Five of the communities not analyzing the nutrient content used contract haulers. It is likely that some of these haulers analyzed the sludge for nutrient content.

by farmers receiving sludge rather than the community producing the sludge.

The cost estimates for community owned landspreading correspond closely to estimates in the literature (1, 3, 10). Also, these studies compare landspreading to other disposal options. Generally, they conclude that landspreading is the lowest cost method of disposal.

TESTING AND MONITORING

Most communities have adequate knowledge of the contents of their sludge (Table 6). The survey results indicate that 93% of the communities surveyed know the metals content of their sludge, and most of these communities also know the nutrient content. The remaining 7% of the communities have a minimal analysis which provided the solids content, pH, and a few other characteristics.

These results contrast sharply with the situation 5 years earlier (4). Then only 42% had thorough knowledge of their sludge, and 21% of the communities had no sludge analysis. Generally, landspreading communities are also more knowledgeable of the soils receiving sludge than they were 5 years earlier. About half of the communities conduct soil testing programs prior to sludge application (Table 7). Five years earlier, very few had soils tested prior to application. About half of the communities also monitor the soils after sludge application, which is up sharply from 5 years earlier. Monitoring of plant tissue and water quality at the landspreading site is done by one-third of the communities, which is about the same as 5 years ago.[5]

[5]Estimates of testing and monitoring programs tend to understate the extent of these programs. For example, communities hiring contract haulers may have no soil testing program; however, the hauler may be testing the soils.

TABLE 7.—Soil Testing at Landspreading Site and Monitoring of Landspreading Site, Ohio Landspreading Communities, 1980.

Type of Testing and Monitoring	1975 Survey Number of Communities	1975 Survey Percent of Communities	1980 Survey Number of Communities	1980 Survey Percent of Communities
Testing soil prior to application	4	9	27	49
Monitoring soils after application	8	19	24	44
Monitoring water quality near landspreading site after application	14	33	18	33
Monitoring plant tissue on landspreading site after application	18	42	18	33
Communities responding	43	100	55	100

EQUIPMENT

Most communities use tank trucks to spread sludge with a solids content of less than 10%. Of the 45 communities providing information about equipment, 41 were spreading liquid sludge and only 4 are spreading a dewatered sludge. Of the 45 communities, 19 have spreading vehicles with flotation tires. Flotation tires lengthen the period of time when vehicles have access to fields, and they reduce soil compaction. Another trend in equipment usage is the operation of separate "nurse" trucks to haul the sludge from the treatment plant to the disposal site. Of the 45 communities supplying equipment information, 15 are using nurse trucks.

LAND OWNERSHIP AND CONTRACTED ARRANGEMENTS

Most communities spread sludge on privately owned land (Table 8). A few pay the landowner a rental fee, a few receive payment for the sludge, but most communities use the landspreading site with no payments made by either party. A small proportion of the communities (11%) only use land owned by a governmental unit.

Most communities using privately owned land have an implicit understanding or oral agreement rather than a written contract. Written contracts are used by only 39% of the responding communities. Those that use written contracts typically include a clause specifying the application rate. Other commonly used clauses include: a) specification of the type and frequency of sludge analysis, b) specification of acceptable sludge quality, and c) restrictions on time of application.

CONCLUSIONS

The quality of landspreading programs in Ohio has improved substantially over the past 5 years. Communities are better aware of the contents of their sludge and spread it in a more judicious manner. Ohio communities appear to be landspreading sludge in a manner which provides a low cost disposal option, provides crop nutrients to farmers, and minimizes health and environmental risks.

TABLE 8.—Ownership of Landspreading Sites.

Owner	Number of Communities	Percent
Municipality or other governmental unit	6	11
Private	38	69
Some government owners and some private owners	11	20
Total	55	100

The contents of Ohio sludges are typical of those seen throughout the United States. Application rates are moderate. Loadings of metals are generally well within U. S. Environmental Protection Agency guidelines and regulations. These metal loading rates are low enough to prevent damage to soils, plant toxicity, or impairment of human or animal health. Phosphorus in the sludge is being applied at rates which exceed crop requirements and thus some carryover of phosphorus is occurring. However, phosphorus application rates are not high enough to affect surface or ground water. Communities are conducting testing programs which provide adequate information on the contents of their sludges.

A representative landspreading community has the following program. Anaerobically or aerobically digested liquid sludge (4.5% solids) is landspread by a tank truck on privately owned land within a few miles of the treatment plant. A verbal agreement is reached between the landowner and the community about application rates, time of application, and fields to receive the sludge. Payments are made by neither the landowner nor the community. About 760 dry tons are applied each year by the community at 3.8 dry tons per acre. Land receiving the sludge is primarily cropland, with corn, soybeans, pasture, and hay being the predominant crops. The community is bearing costs of about $57 per dry ton if it does its own landspreading. If it contracts the spreading to a contract hauler, costs are substantially higher. The community tests the sludge and has knowledge of its nutrient and metal content. Soil testing is performed in order to project crop nutrient requirements. Some monitoring of the landspreading site is done after landspreading.

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The Ohio Agricultural Experiment Station, as the Center was called for 83 years, was established at The Ohio State University, Columbus, in 1882. Ten years later, the Station was moved to its present location in Wayne County. In 1965, the Ohio General Assembly passed legislation changing the name to Ohio Agricultural Research and Development Center—a name which more accurately reflects the nature and scope of the Center's research program today.

Research at OARDC deals with the improvement of all agricultural production and marketing practices. It is concerned with the development of an agricultural product from germination of a seed or development of an embryo through to the consumer's dinner table. It is directed at improved human nutrition, family and child development, home management, and all other aspects of family life. It is geared to enhancing and preserving the quality of our environment.

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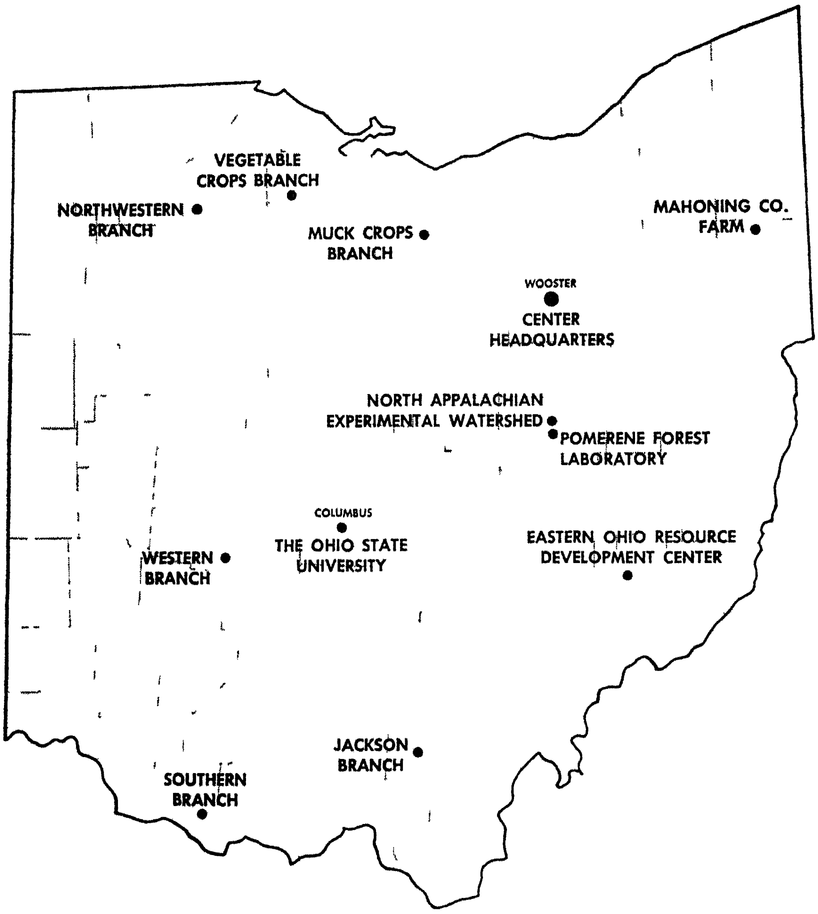

Ohio's major soil types and climatic conditions are represented at the Research Center's 12 locations.

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Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Jackson Branch, Jackson, Jackson County: 502 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with the Science and Education Administration/Agricultural Research, U. S. Dept. of Agriculture)

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Vegetable Crops Branch, Fremont, Sandusky County: 105 acres

Western Branch, South Charleston, Clark County: 428 acres