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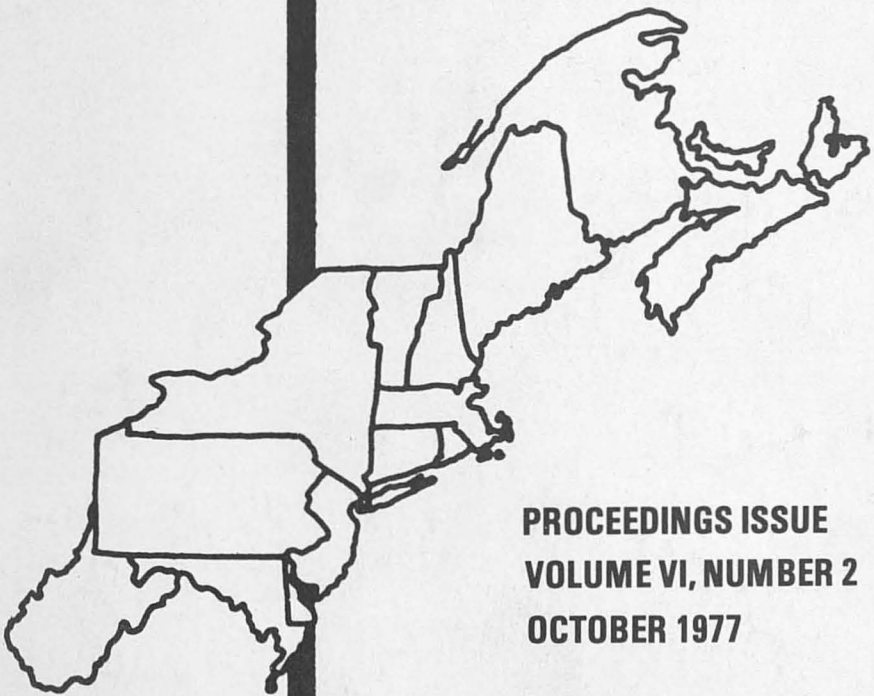

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# AN ECONOMIC IMPACT OF THE USE OF SEWAGE SLUDGE IN FORAGE PRODUCTION

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## Introduction

In 1976 the Massachusetts Commission on Organic Recycling was formed to assess the feasibility of recycling several organic materials. One of the Task Forces operating under the auspices of the Commission was called the Task Force on "The Feasibility of Application of Municipal Sewage Sludge on Agricultural Land in Massachusetts". The Task Force, composed of scientists and technical specialists from several public agencies prepared and submitted a report to the Commission [2].

One of the critical elements of the overall effort was the section on the economic impact on agriculture. This paper summarizes the analysis and results which focused on the use of sludges for the production of corn silage on dairy farms.

Interest in the use of sewage sludge on agricultural land is motivated by the fact that (1) sludge contains basic plant nutrients and (2) Massachusetts farmers need to use substantial quantities of fertilizer materials in crop production. At issue is the economic feasibility of substituting sludge for commercial fertilizer.

## A Review of Selected Literature on Sludge Application

One of the best known studies of economic aspects of sludge application on farmland has been reported by Seitz and Swanson [7] and Seitz [6]. In that case sludge was transported from Chicago, Illinois to Fulton County, Illinois (170 miles southeast of Chicago) and applied on land which had been strip-mined. The net costs of this project, including allowances for crop production aspects and transportation, ranged from 68 dollars per dry ton utilizing rail shipment to 39 dollars per ton for pipeline transport.

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Forster, et al. [3] conducted a survey of 50 to 60 Ohio communities currently applying treated sewage sludge to agricultural land. Estimates of unit sludge disposal costs were developed which included transport and land application. Costs were also related to treatment plant size. A further stage of the study estimated the value of the nutrients using commercial fertilizer prices. The benefits were estimated to be 23 dollars per dry ton while the average cost per dry ton for land spreading was 31 dollars. The net cost, on the average, for the land disposal alternative was estimated to be about 8 dollars per dry ton.

While the above studies were concerned with the broad issue of land application of sewage sludge, a detailed marginal analysis of the impact on the individual farm appears lacking. Economic analysis which focuses on the individual farm situation, involving consideration of labor and machinery use, is necessary to adequately assess this dimension of the agricultural use alternative.

## Dairy Farms as Potential Sludge Receivers

Dairy farms are hypothesized as the most logical potential receiver of sludge for several reasons. First, the physical handling of manures and sludge can be accomplished by essentially similar equipment (as described in another section) already owned by the farmer. Secondly, the dairy farm uses manure in forage crop production and could use sludge for the same purpose. Thirdly, the crops on which sludge would be applied are not used for human consumption but for animal feed (there is scant evidence to show disease transmission through the food chain from animals fed on sludge grown forage). Fourth, the nutrients contained in sludge can be substituted for commercial fertilizer.

Some technical difficulties are apparent. Sludges with low solids contents are amenable for use only on farms with liquid manure handling systems. Sludges with high solids content can be handled with conventional spreading systems. But unless water is added to create a slurry, such filter cake sludges cannot be handled with liquid systems.

Use of sludge in crop production on a commercial farm must be keyed to the farm calendar. That is, unless an irrigation type system is used, sludge cannot be applied during the crop growing season. For corn this means from May through September, while for hay the prohibited period would be somewhat shorter depending on the number of cuttings (it appears advisable to avoid spreading sludge on foliage of crops that will be consumed by livestock).

If sludge is to be immediately incorporated in the soil, a further restriction is imposed by climate. In Massachusetts, the soil is generally frozen from mid-November to March which would preclude tillage operations or soil injection.

In summary, these restrictions would indicate three possibilities: (1) that for small sewage treatment plants the frequency of sludge removal may conceivably be keyed to the spring and fall periods when land application is most feasible, (2) that sludge storage capability be provided either at the plant or at the farm to hold the sludge until field disposal is possible, or (3) that the municipality dispose of sludge to farmers during those seasons when possible and dispose in landfills or other means during other seasons.

Provided the type of sludge produced is compatible with the manure disposal equipment of the farm, costs of sludge application on farmland can be regarded as "marginal costs". Marginal costs are only those additional costs attributable to sludge application. This means that since the farmer already has the necessary equipment, the ownership costs (amortization, depreciation, etc.) would not be attributable to sludge application. Costs attributable to sludge application then become only the variable costs (fuel, repairs, labor, etc.).

Adjustments may be made in this concept to account for minor equipment requirements or the purchase of larger machinery to deal efficiently with higher volumes of material to be distributed on the land. It is also possible, where excess capacity exists, that the added volume of sludge handled will lower the unit cost of disposal for the farm manure handled.

## Estimates of On-Farm Sludge Application Costs and Benefits

The model farm situation was specified as a dairy farm with 150 head of cattle and 200 acres of tillable land. The initial situation specified production of the corn silage needs for the herd assuming the fertilizer nutrients for crop production were supplied by farm manures supplemented by purchases of commercial fertilizer. The cost data developed relate only to manure spreading and fertilizer application. Detailed budgets for manure-sludge handling equipment are contained in tables at the end of this paper.

The situation involving sludge application differed from the initial situation in that sludge was used to supplement manure as the nitrogen nutrient source. No differences in yield were assumed. Those additional costs incurred due to sludge application were computed as well as the reduction in costs of commercial fertilizer application. No price was included for the sludge. Thus, it was assumed to be supplied to the farm as a free resource. Some supplemental applications of commercial fertilizer were found to be necessary to balance the total nutrient requirements.

The net costs/benefits to the farm situation were determined from considering the added costs of sludge application as compared with the reduced costs of commercial fertilizer. Situations were analyzed for

applying sludge with conventional manure handling equipment and with liquid manure handling equipment.

For the conventional system it was assumed that corn silage would be grown on 200 acres with yield target of 20T/acre and that farm produced manure would be used with supplementation from sludge and commercial fertilizer.[1/] This would result in the following nutrient requirements and their sources:

| | N | P | K |
|---|---|---|---|
| Total nutrient requirement (lbs.) | 30,000 | 25,000 | 36,000 |
| Nutrients from manures (lbs.) | 13,500 | 8,100 | 13,500 |
| Nutrient deficit | 16,500 | 16,900 | 22,500 |
| Sludge (295 tons solids) | 16,500 | 17,089[2/] | 2,357 |
| Supplemental fertilizer required | 0 | 3,150 | 20,143 |

The economic results of using sludge are shown in the following partial budget:

| | |
|---|---|
| Added costs associated with sludge application | $1,022 |
| Reduced fertilizer expenses | 7,210 |
| Net benefits accruing to sludge application | $6,188 |
| Net farm value per ton of sludge solids | $20.98 |
| Net farm value per ton of "wet" sludge | $ 3.15 |

All assumptions and basic nutrient balance information for the liquid system are identical with the conventional system described above. However, three times as much total tonnage must be handled. In addition, the liquid manure handling equipment is somewhat more costly than conventional. Balancing these factors to some extent is increased load capacity. When these factors were considered, the net benefits accruing to sludge application for low solids sludge were estimated to be $4,910. Thus, the net farm value per ton of solids (295 tons), therefore, would be $16.64 and the net farm value per ton of "wet" sludge $0.83.

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1/ Assumes that manure will be applied on 90 acres and sludge on 110 acres.

2/ Acreage on which sludge only is applied will receive P in excess of needs. However, acreage on which manure is applied will require supplemental fertilizer application.

Impact on Resource Use

The use of sludge in place of part of the commercial fertilizer needs had an impact on the use of farm labor and machinery. The additional labor requirements and variable costs involved are given in the Appendix.

A summation of the additional labor and machinery time indicates there is a strain during the peak periods for these resources. Additional time for sludge disposal amounts to approximately 120 man-hours. The labor can be absorbed by hiring, but short of buying new equipment proper planning is essential to complete all of the competing activities for the machinery. For example, in the spring the demands on tractor use includes plowing, planting and fertilizer spreading, and manure spreading. In Massachusetts, where the ground is frozen until mid-March, it may be infeasible to consider sludge spreading in the spring. A more reasonable time would be after harvest. Spreading in the fall (before ground freezes in mid-November) will spread out machine use and also reduce the necessity for additional part-time labor, but would require an additional operation to incorporate the sludge into the soil.

Immediate incorporation (within 24 hours) will also strain capital and labor resources. Additional labor and machine time would be approximately 64 hours. One must remember though that this operation would have to be performed in a conventional tillage farming operation, and to coordinate sludge disposal with the initial plowing or harrowing operation would effectively remove it from consideration in the marginal budget of the sludge disposal, at least if spring applications are used.

As stated earlier, careful planning is necessary to avoid delays in other farm operations.

Summary

It is difficult to reach and make general conclusions in a situation where agricultural conditions vary widely and sludge-generating conditions even more so. However, the following points seem clear. First, there are significant benefits in the form of foregone costs of commercial fertilizer associated with the land application option for sludge disposal which should be factored into a serious decision framework. The magnitude of these benefits depends heavily on sludge composition and prices of commercial fertilizers, as well as on cropping systems. To the extent that these commercial fertilizer costs are projected to increase relative to other prices and costs, the estimations of value of these benefits given earlier should be regarded as a lower bound on future benefits.

Perhaps the most critical variable in determining the economic feasibility of the land application alternative is the distance (and cost)

it is necessary to transport the sludge. This is a key reason why the agricultural use alternative is likely to be more economically feasible for small to medium sized communities than for larger metropolitan areas. The transportation costs can increase rapidly with increasing distance. A municipality will limit the distance carried to a point where disposal costs are equal to other alternatives. A farmer, using budgeting processes, can now determine the value of the sludge to the farm and be able to make a more informed decision if asked to defray long distance transportation costs.

The benefits accruing to the farm are in the form of reduced expenditures for commercial fertilizer. Other benefits not explicitly studied are the organic conditioning to the soils. Also, some indirect costs were not dealt with. An implicit cost may be identified as the opportunity cost of labor and machinery employed in sludge application which could be productively employed in other activities. A linear programming analysis, for example, would more effectively deal with these questions.

Finally, while little experience with agricultural use of municipal sewage sludge has been acquired in Massachusetts, largely perhaps due to institutional reasons, there is little reason to believe the critical conditions discussed earlier are substantially different from many other areas in the country.

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# APPENDIX

The following are partial budgets developed for the representative dairy farm operations in Massachusetts. Unit time allotment values were developed from Ashraf [1]. Nutrient values were obtained from Forster, et al. [3], Powers, et al. [5] and Larson [4].

Farm Size: 200 Acres Herd Size: 150

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Operating Costs: Manure Spreading

Labor @ $3.50/hour

| | | |
|---|---|---|
| Scraping: | 180 hours | $ 630.00 |
| *Hauling: | 96.4 hours | 337.40 |
| Loading: | 45.8 hours | 160.30 |
| Spreading: | 48 hours | 168.00 |
| Total | | $1,127.70 |

Tractor @ $3.65/hour - 100 h.p.

| | | |
|---|---|---|
| *Hauling: | 81.94 hours | $ 299.08 |
| Spreading: | 40.8 hours | 148.92 |
| Total | | $ 448.00 |

Tractor @ $2.79/hour - 50 h.p.

| | | |
|---|---|---|
| Scraping: | 153 hours | $ 426.87 |

Spreader @ $0.50/hour

| | | |
|---|---|---|
| Loading: | 38.93 hours | $ 19.47 |
| *Hauling: | 81.94 hours | 40.97 |
| Spreading: | 40.8 hours | 20.40 |
| Total | | $ 80.83 |

Total Operating Costs $2,083.40

Operating Costs: Fertilizer Application Supplement to Manure Remaining Needs After Manure Application

Fertilizer: 10(150-125-180)/acre for approximately 20T/acre silage

| | | |
|---|---|---|
| Nitrogen | 16,500 lbs. @ $.255/# | $4,207.50 |
| $P_2O_5$ | 16,900 lbs. @ $.203/# | 3,430.70 |
| $K_2O$ | 22,500 lbs. @ $.089/# | 2,002.50 |
| Total | | $9,640.70 |

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Labor in application of fertilizer is included in planting. 2/3 of planter loading time spent on loading fertilizer.

Labor @ $3.50/hour

| | |
|---|---|
| Loading: 8 hours | $ 28.00 |

Marginal equipment costs to tractor and planter would be borne in the planting operation regardless of whether fertilizer is applied.

| | |
|---|---|
| Total Operating Costs | $9,668.70 |

Operating Costs: Sludge Application Supplement to Manure

Labor @ $3.50/hour

| | | |
|---|---|---|
| Loading: | 39.2 hours | $ 137.20 |
| *Hauling: | 82.5 hours | 288.75 |
| Spreading: | 41.0 hours | 143.50 |
| Total | | $ 569.45 |

Tractor @ $3.65/hour - 100 h.p.

| | | |
|---|---|---|
| *Hauling: | 70.1 hours | $ 255.87 |
| Spreading: | 34.9 hours | 127.39 |
| Total | | $ 383.26 |

Spreader @ $0.50/hour

| | | |
|---|---|---|
| Loading: | 33.3 hours | $ 16.65 |
| *Hauling: | 70.1 hours | 35.05 |
| Spreading: | 34.9 hours | 17.45 |
| Total | | $ 69.15 |

| | |
|---|---|
| Total Operating Costs: Sludge | $1,021.86 |

Operating Costs: Additional Inorganic Fertilizer Necessary to Supplement Sludge and Manure

| | |
|---|---|
| Nitrogen - 0 | |
| $P_2O_5$ - 3,150 lbs. @ .203/# | $ 639.45 |
| $K_2O$ - 20,142.86 lbs. @ .089/# | 1,792.71 |
| Total | $2,432.16 |

Labor in application of fertilizer is included in planting. 1/3 of planter loading time spent on loading fertilizer.

Labor @ $3.50/hour

| | | |
|---|---|---|
| Loading: | 4 hours | $ 14.00 |

Marginal equipment costs to tractor and planter would be borne in the planting operation regardless of whether fertilizer is applied.

Total Operating Costs of Sludge Application with Supplemental Inorganic Fertilizer: $3,468.02

Operating Costs: Liquid Sludge Application Supplement to Manure

Labor @ $3.50/hour

| | | |
|---|---|---|
| Loading: | 16.3 hours | $ 57.05 |
| *Hauling: | 162.7 hours | 569.45 |
| Spreading: | 97.6 hours | 341.60 |
| Total | | $ 968.10 |

Pump @ $.90/hour

| | | |
|---|---|---|
| Agitation: | 48 hours | $ 43.20 |
| Loading: | 13.9 hours | 12.51 |
| Total | | $ 55.71 |

Tractor @ $3.65/hour

| | | |
|---|---|---|
| *Hauling: | 138.3 hours | $ 504.79 |
| Spreading: | 83 hours | 302.95 |
| Total | | $ 802.74 |

Spreader @ $1.92/hour

| | | |
|---|---|---|
| Loading: | 13.9 hours | $ 26.69 |
| *Hauling: | 138.3 hours | 265.54 |
| Spreading: | 83 hours | 159.36 |
| Total | | $ 451.59 |

Total Operating Costs $2,278.14

Operating Costs: Additional Inorganic Fertilizer Necessary to Supplement Sludge and Manure

| | |
|---|---|
| Nitrogen - 0 | |
| $P_2O_5$ - 3,150 lbs. @ .203/# | $ 639.45 |
| $K_2O$ - 20,140.86 lbs. @ .089/# | 1,792.71 |
| Total | $2,432.16 |

Labor in application of fertilizer is included in planting. 1/3 of planter loading time spent on loading fertilizer.

Labor @ $3.50/hour

| | |
|---|---|
| Loading: 4 hours | $ 14.00 |

Marginal equipment costs to tractor and planter would be borne in the planting operation regardless of fertilizer application.

| | |
|---|---|
| Total Operating Cost of Liquid Sludge Application with Supplement Inorganic Fertilizer: | $4,724.30 |

*Average field distance approximately .5 miles.