United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-80-199 Mar. 1981

Project Summary

Production of Non-Food-Chain Crops with Sewage Sludge

Lilia A. Abron-Robinson, Cecil Lue-Hing, Edward J. Martin, and David W. Lake

A beneficial use for sewage sludge? This study investigated the feasibility of using sewage sludge in cultivating three non-food-chain crops currently sold on the open market or with good potential for marketability. A cost analysis determined how cultivation costs using sewage sludge compared with costs using commercial fertilizer.

Cotton, sod, and energy biomass trees were determined to have the best potential for cultivation using sewage sludge, based on the market values and nutrient requirements for each crop and on the hectares presently under cultivation for production of these crops.

Results indicate that large quantities of sewage sludge can be used, based solely on the nitrogen and phosphorus requirements for the cultivation of these crops. In addition, although the total costs for fertilization using commercial fertilizer are less than the costs for using sewage sludge, the latter would be viewed more favorably if the municipality generating the sludge bore the costs.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH 45268, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Sewage sludge has historically been viewed as a spent by-product of sewage treatment. Recognition of the valuable properties of sludge, including its high concentrations of plant nutrients and organic matter, has led to increasing emphasis on its beneficial uses for reclaiming disturbed lands and fertilizing agricultural soils. The prospect of widespread application on agricultural land has, however, been accompanied by concern over possible accumulations of toxic substances in soils and potential translocation of toxics throughout the human food chain.

The purpose of this study was to evaluate the feasibility and market potential of land application of municipal sewage sludge in the cultivation of non-food-chain crops (NFCC). Using sludge in this manner would realize the advantages of its beneficial properties while circumventing the potential problems associated with the unknown impacts of toxic materials on the human food chain. This study entailed three broad activities: (1) assessing the fertilizer value of sludge, (2) selecting NFCC amenable to cultivation using sewage sludge, and (3) determining land requirements and costs associated with producing NFCC using sludge and comparing these costs to the costs of producing the same crops using commercial fertilizer. The analyses were based on data available in the literature or obtained through personal interviews.

Fertilizer Value of Sludge

The nutrient content of municipal sewage sludge was found to vary with the composition of the influent wastewater and the sewage and sludge treatment processes employed. Municipal sludges were found to have a total nitrogen (N) content of 1% to 6%, a phosphorus (P) content of 1% to 6%, and a potassium (K) content of 0.04% to 6.1%. Because of its low potassium levels, sludge is generally not considered to be a good source of this nutrient.

Based on mean sludge N, P, and K values of 3.2%, 1.8%, and 0.3%, respectively; on inorganic, N, P, and K prices of $0.253/kg ($0.115/lb), $1.37/kg ($0.621/lb), and $0.259/kg ($0.1176/lb); and on a projected 1985 U.S. sludge production rate of 16,012 dry metric tons/day (17,650 dry tons/day), the total daily sludge produced in the United States has an *estimated chemical fertilizer equivalent* market value of $537,000 per day for the year 1985 (based on 1980 dollars). Other benefits of using sewage sludge, such as improvements in tilth and water holding capacity of soils, are difficult to quantify. It is crucial also to consider *that using sewage sludge in place of or* as a supplement to chemical fertilizer avoids or reduces the high energy costs associated with both commercial fertilizer production and sludge incineration.

NFCC Amenable to Sewage-Sludge Cultivation

The next step was to identify NFCC and determine which of these are amenable to cultivation using sewage sludge. Food-chain crops are defined as (1) tobacco; (2) crops grown for human consumption; and (3) pasture, forage, and feed grain for animals whose products are consumed by humans. NFCC are, therefore, the crops that remain. These crops were first identified using the Standard Industrial Code (SIC), to which were added research crops such as *jojoba, euphorbia, guayule, and biomass* crops. Cotton and soybeans were also included because these crops have significant inedible uses, both respond favorably to commercial fertilization, and cotton clearly has a high N demand.

The selection of NFCC feasible for cultivation *using sewage sludge* was based on a developed set of criteria. The most important of these criteria were: (1) the crop must not produce edible matter that could *easily* become a part of man's food chain; (2) the crop must have a demonstrated or a high probability of future market potential; (3) the land used to raise the crop must have a high probability of being continuously used exclusively for production of that crop; and (4) data must be available giving the response of the crop to sludge, or sufficient data must be available for similar crops, to enable a probable response determination using data extrapolation and inference.

Six crop categories composed of 20 crops were studied in relation to the above criteria: timber tracts (five hardwood and three softwood varieties); forest nurseries; flax; horticultural specialties (greenhouse varieties, shrubs, sod and turf grasses, lawn grasses); research crops (jojoba, guayule, euphorbia, energy biomass crops); and oil crops (cotton, soybeans). Using sludge for cultivating hardwood forests was deemed unacceptable because hardwoods are best grown in the open forest environment. These sites are generally remote from sludge generating centers and are only intermittently accessible; also, the impacts of sludge on the open forest environment are poorly understood. *Furthermore, hardwoods have a slow* rotation period and low N and P requirements. Flax was deleted because the market for this crop is declining and a reasonable possibility exists that land used to raise this crop could be used to grow food-chain-crops. *Of the research crops, all were rejected* except biomass crops because not enough data were available to determine feasibility.

Based on the above criteria, crops retained for further study included monoculture timber tract operations using softwood, forest nurseries, sod, and energy biomass trees, and cotton and soybeans. Of these, cotton, sod, and biomass trees were selected for detailed case study analysis. These three crops are currently sold on the open market or, in the case of biomass crops, are being actively researched. Thus, information was readily available describing the preferential climatic condition for the crop, nutrient requirements of the crop, land required, and minimum size of a city that could generate enough sludge to support crop production.

Land Requirements and Costs

Given both the sludge quantities generated and the land currently under harvest for each crop in each state, the following were determined: (1) the maximum amount of land that could be fertilized for each crop in each state, constrained by either the amount of sludge generated in that state or by the land currently harvested; (2) the unit costs (excluding land costs) of using sludge to fertilize this land (by three application modes—injection, surface irrigation, truck spreading); and (3) the unit costs of fertilizing this land using custom application of commercial fertilizer. Application rates of sludge and commercial fertilizer were calculated in two different ways: rates needed to satisfy crop nitrogen requirements and rates needed to satisfy crop phosphorus requirements. Aqueous ammonia containing 30% NH_3 was used as the basic source of commercial N; phosphorus pentoxide containing 40% P was used as the basic source of commercial P. The current cost of commercial fertilizer was determined from the chemical marketing literature, and the costs of transport and custom application were based on information from companies providing these services. The cost of the sludge itself was taken as zero, and the *sludge transportation costs from the* centers of sludge generation to the application sites were considered separately.

Conclusions and Recommendations

The cost comparisons for sludge and commercial fertilizer are compared in Table 1 . Of the three sludge application modes, injection is the most expensive and truck spreading appears to be the cheapest. Using sludge in lieu of com*mercial fertilizer appears to be most cost* effective when applying sludge to biomass crops via truck spreading and surface irrigation at rates sufficient to satisfy nitrogen requirements. Research on the use of sewage as a substitute for commercial fertilizers for *the production of biomass crops should* be encouraged.

Using sludge for sod production is the most feasible beneficial sludge use option at this time. Sod production would conservatively use 5% to 10% of the total sludge generated in the sod *producing states. As stated previously,* biomass crops are still in the research stage. Although most of the cotton being produced is used in part for food-chain products, the possibility does exist whereby a portion of this crop could be grown for non-food-chain purposes only.

It became evident from the case study analysis of the three crops that all of the sewage sludge generated cannot be

Table 1. *Cost Comparisons for Sludge Versus Commercial Fertilizer (Fertilizer Costs Include Both N and P)*

	Average Total Annual Cost ($/ha)								
	Cotton			Sod			Biomass		
Application Mode	*N(S)*	*P(S)*	*Fertilizer*[a]	*N(S)*	*P(S)*	*Fertilizer*[a]	*N(S)*	*P(S)*	*Fertilizer*[a]
Injection	1,229	1,034	290	1,364	1,156	350	1,197	746	432
Surface Irrigation	709	1,127	290	660	1,048	350	255	361	432
Truck Spreading	296	290	290	704	336	350	417	338	432

[a]*All fertilizer costs are custom application.*

used to produce NFCC. Based only on the crops analyzed in this study, however, at least 20% of the sludge generated could be used for NFCC production. This is significant. The problem of generating more sludge than that required for application raises other concerns such as the need for storage facilities and the need for other beneficial sludge use options. These needs should be addressed if the eventual objective is to use and recycle sludge to the greatest extent possible.

Transportation costs from the centers of sludge generation to the application site will have a significant impact on cost. When transport costs are added to the costs presented in Table 1, the difference between costs for sludge and commercial fertilizer become even more pronounced. Clearly, if sewage sludge is to compete with commercial products, the costs for the operation will have to be borne by the municipality generating the sludge. If the municipality were to transport the sludge to the application site and provide the application equipment, the sludge would be a sought-after commodity.

Lilia A. Abron-Robinson and Cecil Lue-Hing are with PEER Consultants, Inc., Rockville, MD 20852; Edward J. Martin and David W. Lake are with Environmental Quality Systems, Inc., Rockville, MD 20852.
***Gerald Stern** is the EPA Project Officer (see below).*
The complete report, entitled "Production of Non-Food-Chain Crops with Sewage Sludge," (Order No. PB 81-125 296; Cost $11.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

☆ U.S. GOVERNMENT PRINTING OFFICE: 1981-757-012/7017

Unit… Env… Age…

Center for Environmental Research

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
Cincinnati, Ohio 45268

Offi… Pen…

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300
AN EQUAL OPPORTUNITY EMPLOYER

Postage and
Fees Paid
Environmental
Protection
Agency
EPA 335

U.S. MAIL

Region 5 Library
U.S. Environmental Protection Agency
230 S. Dearborn St.
Chicago, IL 60604

EPA-353 (Cin) (Rev. 11-80)