United States Environmental Protection Agency

Municipal Environmental Research Laboratory Cincinnati OH 45268

Research and Development

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Project Summary

Application of Municipal Sludges on Energy Crops: A Feasibility Analysis

This study evaluates the feasibility of using treated municipal sludge to grow energy crops on marginal land. The use of sludge on energy crops rather than on agricultural crops avoids most of the problems associated with the presence of heavy metals and other pollutants in sludge. This analysis shows that replacing sludge incineration and/or landfilling with land spreading on energy crops can result in dollar and energy credits to municipalities implementing this alternative. The potential economic advantage of the energy crop approach is, however, very sensitive to local factors such as the value of the credits gained from eliminating incineration or landfilling and the annual yields of the energy crops.

Energy crop production will probably not result in a net revenue for a city, since the costs of spreading the sludge and processing the energy crop are likely to be greater than the dollar value of the crop. And because the present market value of farm products is greater than that of energy crops, sludge disposal on the latter is slightly more costly than on agricultural crops. But energy crops do generate clean, renewable energy, whereas agricultural crops consume energy. The analysis presented here is valid for cities with populations of 50,000 to several million, and it applies essentially to all regions of the United States.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, 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

This study examines the use of sewage sludge for energy crop production, an activity with the potential for solving three societal problems at once: municipal (sewage sludge) disposal, low soil productivity, and energy production. The objectives of the project were as follows:

1. To assess the economic feasibility of using municipal sludge on land devoted to the production of energy crops;
2. To determine the net energy balance of using sludge to generate energy crops; and
3. To assess the potential impact of this sludge disposal method on a national scale.

The term "energy crop" refers to any form of biomass (agricultural, woody, or grass crops) grown specifically for its energy value. The energy may be recovered by direct combustion or through conversion to another form.

Application of municipal sludge to agricultural land or recreational areas is recognized as one of the promising methods for ultimate sludge disposal. Applications of these residues to food crops, however, might create serious problems when the crops become part of the food chain. Disposal on recreational areas also requires caution because of the presence of pathogens.

The approach explored in this study is to apply the urban sludge to land (especially marginal land) and to generate energy crops or crops produced exclusively for their fuel value. Such an approach would essentially eliminate the risk of human or animal contact with heavy metals and other pollutants; it would also generate a renewable source of energy that would reduce the dependence of the local company on outside energy sources. The reclamation of marginal or submarginal land also offers a social benefit, but one that is not included in the economic feasibility study.

The study considered the situation expected in 1985, when most municipalities will have included some form of secondary treatment and sludge management for their wastewater treatment plants. The economics and energy balance of sludge disposal on energy crops are compared with three other methods of stabilized sludge disposal—incineration, landfilling, and application to agricultural crops. The comparison is made for cities with populations of 10,000 to 4 million.

Four classes of energy crops were considered: (1) Fast-growing, short-rotation hardwood plantations, (2) arid region or desert shrubs, (3) sugar crops, and (4) grain crops. In the first two cases, wood chips for fuel or electricity would be the final products generated, whereas in the latter two, ethanol is assumed to be produced from the crops.

The economic evaluation of the energy-crop-from-sludge concept includes the following items: (1) the credits to the municipality for eliminating the standard methods of sludge disposal and for the sales of the energy crop or its product, (2) the costs incurred in transporting the sludge to the plantation, (3) the costs of storing the sludge if needed, (4) the expense of generating and harvesting the energy crop, (5) the price of leasing or buying the necessary crop land, and (6) the costs incurred in marketing the energy crop or its product and hauling to the point of use. The same credits and debits apply to the disposal of sludge on agricultural crops. No credit was taken for improving the land as a result of sludge application.

The energy balance evaluation takes into account the energy credits for eliminating incineration or landfilling and for generating the energy crop. Also considered is the energy consumption associated with transporting the sludge and the energy crop, and with producing and converting the energy crop. The same energy credits and debits apply for agricultural crops, except for the credit associated with the crop's energy value.

The analysis is performed for five climatic regions encompassing the continental United States. Particular emphasis was placed on fast-growing hardwood crops, since in the course of the study these crops appeared to offer the most flexibility and the widest range of applicability.

Methods

The method used here to evaluate the potential of sludge disposal on energy crops for a given municipality is outlined in Figure 1. The municipality is characterized by its population and by the climatic region in which it is located.

The following steps are involved in evaluating the economic feasibility of the energy crop approach. The report follows these steps in developing the cost and/or credit data.

1. Determine the amount of sludge produced annually (based on population) and the rate of sludge production.
2. Determine the credit to the municipalities if incineration or landfilling of the sludge is replaced by sludge disposal on energy crops. Both credits are functions of the population and include operation and maintenance costs for either method of disposal. Capital recovery costs of the inplace systems (i.e., incineration or landfilling) will still be incurred and thus are not considered as credits. Disposal through agricultural crop production will result in the same credits.
3. Choose energy crops suitable to the climatic region and estimate the crop area required to apply the sludge on land. This and the following steps of the method also apply to disposal on agricultural crops.
4. Determine the storage capacity required on the basis of climatic factors. Estimate the cost of storage (a function of population and duration of storage). This and the following steps refer to the energy crop plantation operations.
5. Estimate the cost of applying the sludge to land.
6. Evaluate the production cost of the energy crop excluding the cost of land.
7. Estimate the cost of converting the crop to energy.
8. Estimate the credit resulting from the sale of the energy produced from the crop.
9. Estimate the functional dependence of the sludge transportation cost on the distance from the municipality.
10. Estimate the functional dependence of yearly land costs on the distance from the municipality.

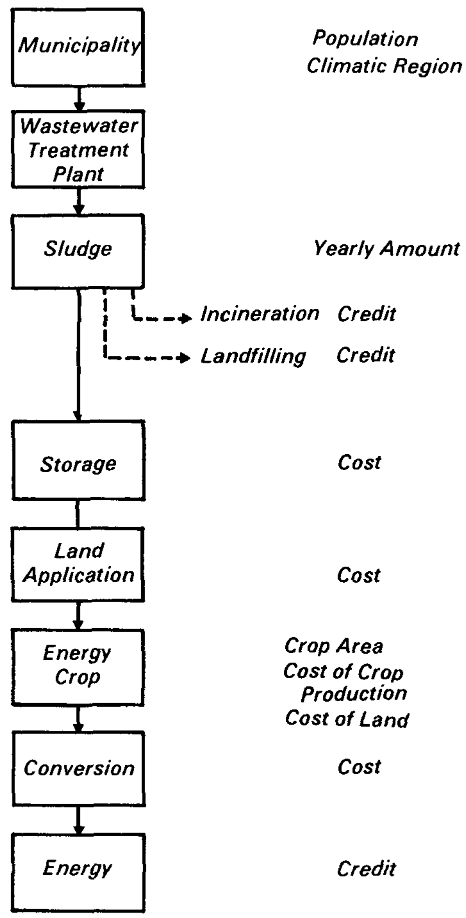

Figure 1. Method for evaluating the potential of sludge disposal on energy crops.

11. Estimate the minimum distance to be traveled from the municipality to find land suitable for sludge disposal.

The energy crop approach will be economically beneficial if the credits received by the municipality are larger than or equal to the sum of the costs incurred in producing the energy crop. Thus

Credit for energy crop + credit for incineration or landfilling $\geq$ costs for energy crop production and and conversion (1)

Identifying the terms involved in the total costs for energy crop production in Equation 1 becomes:

Credit for energy crop + credit for incineration or landfilling - (costs for sludge storage, spreading, crop production, and energy conversion) $\geq$ sludge transportation cost + land cost (2)

Results of the Analysis

The study indicated that the use of sewage sludge on marginal land to produce energy crops is economically feasible, conserves energy, and can improve the environment. Energy and monetary credits may be gained for municipalities by replacing incineration or landfilling with surface applications of sludge for energy crop production. The advantage this disposal method has for a city is determined by local site factors.

Woody Energy Crops for Fuel

In all five regions of the country, cities with a population of 10,000 to 4 million could reduce sludge disposal costs by changing from land-filling to land spreading of sludge to produce woody plants for energy. The cost of disposal through energy crops does not include the cost of processing the crop or the revenue from energy produced.

For all regions and cities with populations larger than about 50,000, disposal costs are less for producing woody energy crops with sludge than for incinerating it—assuming that sludge pretreatment methods for land disposal are in place and in operation. In most cases, disposal through energy crops reduces sludge disposal costs about 50%. But if supplementary pretreatment must be constructed to permit land disposal through energy crops, incineration is more economical for cities with populations up to about 700,000. For larger cities, replacing incineration with disposal through an energy crop results in an annual saving of about 30%.

Electricity from Woody Energy Crops

Because of the high investment costs for small power plants, electricity production from woody crops is economically justified only for operations of 15,000 to 20,000 acres—or specifically, for cities with a population of 2 million or more. For such a population center, the net credit is smaller than for producing wood chips for electricity than for fuel only. But larger cities incur a larger credit when electricity is produced. These results are influenced, however, by the local price of electricity. As in the case of woody fuels, the major portion of a net credit would result from eliminating sludge disposal by landfilling or incineration.

Fuel from Sugar Crops

Ethanol can be produced at competitive costs only from sugar crops in large conversion plants. The production of fuel from sugar crops is limited to a small number of cities in the United States—those that have a population of 5 million or more and available sugar crops in addition to those produced with sludge.

Fuel from Grain Crops

The study showed that economical production of ethanol from grain crops would require sludge from a population of about 50 million. Thus to be feasible for smaller cities, ethanol production from sludge-produced grain would require grain supplements from land not treated with sludge.

Conclusions

- Growing woody biomass for fuel on sludge-treated land is economically more advantageous than landfilling the sludge for cities with populations of more than 10,000. Specifically, the energy crop approach reduces the cost of sludge disposal by about 50% in most cases. In semi-arid regions, adapted species treated with sludge would have to yield an annual 11 dry mt/ha (5 dry tons/acre).
- Growing woody biomass for fuel on sludge-treated land is economically more advantageous than sludge incineration for cities with populations of more than 50,000 if land disposal does not require new pretreatment installations. Specifically, the energy crop approach reduces the cost of sludge disposal by about 50% in many cases.
- Producing electricity rather than fuel from woody energy crops is economically attractive for cities larger than about 2 million. The economic advantage of sludge-produced woody crops may reach 50% or more of the cost of sludge disposal by incineration or landfilling for cities of about 4 million or more. The economic advantage varies locally with the market value of electricity in the region.
- Fuel (ethanol) production from sugar crops is attractive only for cities with populations larger than about 5 million if all the raw material is supplied from sludge-grown energy crops.
- Fuel (ethanol) production from grain crops is attractive only for population centers of about 50 million if all the raw material is supplied from sludge-grown energy crops.
- The investment required for the two most attractive energy crop approaches (i.e., woody fuel and electricity from woody fuel) strongly favors the production of woody fuel.
- The production of woody fuel produces a high energy balance for each unit of sludge applied than does the use of woody fuel to produce electricity. Sludge disposal on energy crops yields a much higher energy credit than does disposal on land producing agricultural crops.
- The economic advantage of sludge disposal through production of energy crops rather than incineration or landfilling is very sensitive to credit values used in the analysis, biomass yields, and the market price of electricity.

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This Project Summary was prepared by staff of InterTechnology/Solar Corporation, Warrenton, VA 21186.
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The complete report, entitled "Application of Municipal Sludges on Energy Crops: A Feasibility Analysis," (Order No. PB 84-101 559; Cost: $16.00, subject to change) will be available only from:
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