Metal	Soil Cation Exchange Capacity (meq/100g) ∠5	5 to 15	≥15
Lead	500	1,000	2,000
Zinc	250	500	1,000
Copper	125	250	500
Nickel	125	250	500
Cadmium	5	10	20

Table 2 Maximum Amount of Metal (lb/acre, cumulative) Suggested for Application to Agricultural Soils

Addressing Project Concerns

Land application of sludge is often opposed by local groups because of concerns over potential odor generation and risks to human health and the environment. These concerns can be addressed by taking the following precautions:

- Use sludges that are well stabilized and that have relatively low concentrations of critical contaminants.
- Apply sludges at rates which meet crop nitrogen or phosphorus requirements.
- Maintain soil pH near neutral.
- Provide adequate monitoring of sludge quality and soils.

For high application rate disposal practices, or when sludges contain relatively high concentrations of critical contaminants and/or sludge stabilization is limited, one or more of the following additional precautions can be helpful:

- Select remote application sites or limit access to the sites.
- Apply sludge to areas used for the production of animal feed or non-food chain crops.
- If needed, provide adequate monitoring of vegetation, surface and ground water.

Current Use

Land application of sludge is currently practiced throughout the country with municipal sludges and many different types of industrial wastes. For biodegradable wastes applied at proper loading rates to suitable sites, the process represents a very efficient and cost-effective sludge treatment and disposal alternative. It is currently estimated that over 40% of the municipal sludge produced in this country is eventually applied to the land in one form or another.

Soil Cation Exchange Capacity (meq/100g)	If Background Soil pH is Below 6.5 (lb Cd/acre)	If Background Soil pH is Above 6.5 or Maintained at 6.5 by Liming (lb Cd/acre)
∠5	5	5
5 to 15	5	10
≥15	5	20

Table 3 Maximum Amount of Cadmium (cumulative) Suggested for Application to Agricultural Soils

Costs

As with most sludge management processes, the construction and operating costs are too site-specific to generalize. Operating costs range from as low as $40/dry ton to over $210/dry ton depending on specific conditions and what is included in the cost estimates. The following factors are typically found to have a major influence on the cost-effectiveness of sludge treatment by land application:

- The purchase or lease price of the land, if necessary.
- The transport distance from the point of sludge generation (sewage treatment plant) to the land application site.
- Climatic constraints (excessively wet or cold weather) which will substantially limit the number of favorable application days and create a need for storage facilities or other methods of sludge utilization and disposal at certain times of the year.

On projects where the above conditions are moderate to favorable, land application of sludge will usually be competitive with other sludge utilization and disposal alternatives.

Summary

Land application of sludge is a process which is not equipment oriented or energy intensive. Because of this, both capital and operating costs often compare favorably against other alternatives for sludge utilization and disposal.

In order for land application of sludge to be used effectively, suitable application sites must be available. The soils and geology of a potential site must be assessed, including an on-site evaluation, prior to judging its suitability. Other factors influencing site suitability will be the availability and cost, if any, of the land, the distance from the sewage treatment plant to the site, and the operating restrictions imposed by local climatic conditions.

Land application of sludge is a widely used process which in many cases offers a practical and cost-effective disposal alternative. To be successful, however, thorough planning is required. A good public education and participation program can usually go a long way towards helping to assure the success of a land application project.

Photos courtesy of Ag-Chem Equipment Co.

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United States Environmental Protection Agency

September 1983

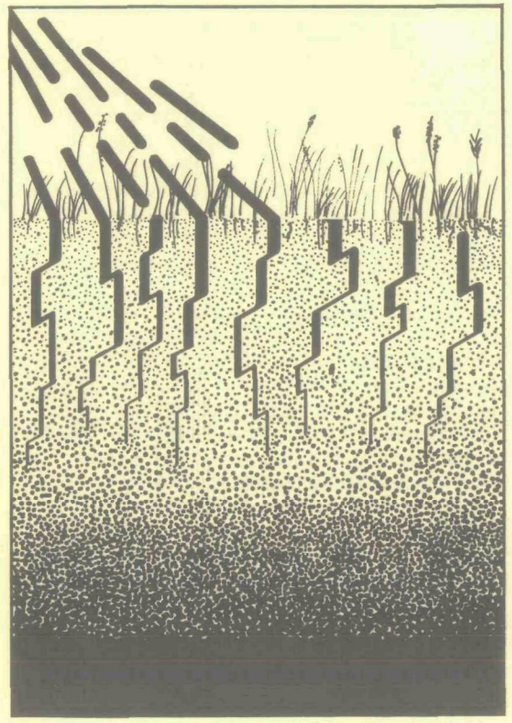
EPA

A Practical Technology

Land Application of Sludge

832R83108

A Viable Alternative



Land Application of Sludge - A Viable Alternative

Needed: Cost-Effective Alternatives
As we provide increased wastewater treatment, we generally remove increased quantities of solids from the wastewater. Handling, treating, and ultimately disposing of these solids (sludge) in an environmentally acceptable, yet cost-effective, manner is often even more complex than the wastewater treatment process itself.

Many of today's traditionally accepted methods of sludge treatment and disposal are equipment oriented and/or energy intensive. Although these processes are reliable alternatives, they can also result in high capital and operating costs. Needed are new approaches which encourage the development of innovative concepts and alternative processes which can favorably compete with conventional options. Sludge utilization and disposal by land application is one such process. Although not a new idea, it offers a practical alternative.

The potential benefits from recycling the organic matter and nutrient resources in municipal sewage sludge through various land application practices have been well demonstrated and have led to an increased use of these practices in many parts of the country. Not only can land application help municipalities by serving as a cost-effective sludge disposal technique, it can also serve the farmer or other land owner by improving soil characteristics, reducing fertilizer costs, and increasing productivity.

The possible presence of pathogens, heavy metals and toxic organics at varying concentrations in different sludges has led EPA and many state regulatory agencies to develop guidelines and regulations. Adherence to the recommendations and requirements that are issued by these agencies should assure both safe and effective sludge utilization. By following carefully planned procedures for dispending the sludge at predetermined application rates and using good management techniques, land application projects can be implemented successfully while avoiding potential problems.

Process Description
Land application of sludge is the controlled application of sludge to a soil. The process is used primarily for the ultimate disposal or recycle of sludge. However, the process also provides additional sludge treatment, as well as disposal in a single operation. Sludge application can be used effectively in agriculture, forestry, and land reclamation. Common to all sludge application systems is the need to provide stabilization and disinfection of the sludge prior to land application. In some cases, the sludge may be stabilized as part of the wastewater treatment system (e.g. aerated lagoons, extended aeration), and the solids need little or no further treatment prior to being applied to the land. In other cases where the sludge is much less stable (e.g., conventional activated sludge), a separate digestion or other stabilization process (e.g., composting, heat treatment, lime stabilization, long term lagooning) is normally required.

Sludge can be applied to the land in many forms and by many methods. It can be applied directly in liquid form, as a dewatered cake, or as composted or dried material. The method of application will vary according to the nature of the sludge, the type of terrain, the vegetation on the site, and the ultimate sludge use. Figures 1 and 2 show two techniques for the application of liquid sludge, while Figure 3 shows a method of applying dewatered sludge.

Site Suitability
If proper steps are taken in designing the system, very few sites are totally unacceptable for land application of municipal sludge. However, there are a number of site-specific factors which should be assessed adequately prior to determining whether a particular site can be used effectively for land application. Table 1 lists major site conditions which should be considered. Since many suitable sites will not be ideal, the planner must carefully consider such factors when choosing actual application sites and designing projects.

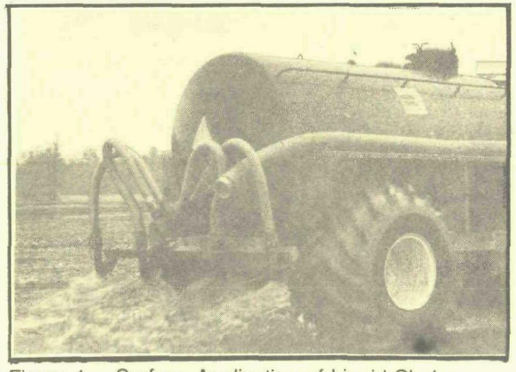


Figure 1 Surface Application of Liquid Sludge

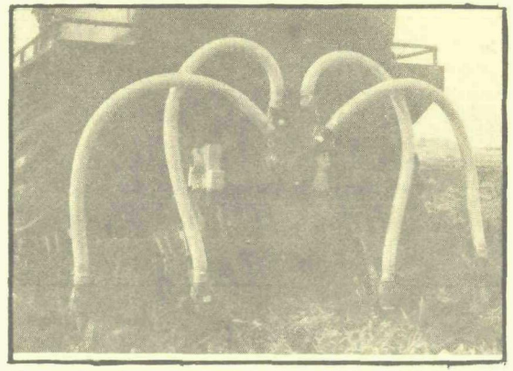


Figure 2 Subsurface Injection of Liquid Sludge

Loading Rate Determination
Once a suitable application site has been selected and the process objectives defined, proper sludge loading rates are determined. This process often involves characterizing the waste for a number of constituents. The following constituents are generally of most concern for municipal sludges: pathogens, phosphorus, nitrogen, cadmium, copper, nickel, lead, and zinc. When sludge is applied at rates to meet the nitrogen requirements of the crops being grown, nitrogen losses in excess of those expected from commercial fertilizer use should not be expected.

- **Soil type**
- **Site susceptibility to flooding**
- **Slope**
- **Depth to seasonal ground water table**
- **Permeability of the most restrictive soil layer**
- **Cropping patterns and vegetative cover**
- **Nutrient and organic matter content**

Table 1 Major Site Conditions for Land Application of Sludge

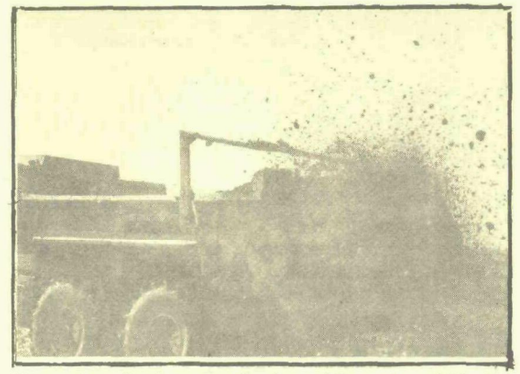


Figure 3 Surface Application of Dewatered Sludge

Regarding heavy metals, the useful life of land application sites can usually be based on the cumulative amounts of the five metals listed above. The recommended limits shown in Tables 2 and 3 should not interfere with crop growth or use of the crops at any future time, while serving to protect human and animal health. Of the metals shown in Table 2, EPA currently regulates only cadmium applications to agricultural soils. However, agency guidance has been issued pertaining to recommended cumulative limits for the other metals shown in the table. The cadmium limit is based on the protection of food chain crops, and is considered by many to be very conservative if used for non-food chain crops. Specific federal, state and local requirements have been issued which restrict the application rates of some sludge constituents such as cadmium and PCBs.

After the allowable loading rate of each constituent has been calculated, the actual sludge loading rate is based on the most limiting constituent of those being considered. Frequently, the most limiting rate is dictated by the nitrogen (or alternatively the phosphorus) loading to meet crop needs. Higher loading rates than those calculated above can be used if: (1) non-food chain vegetation is used; (2) the site is well monitored; (3) required state and local regulatory approvals are granted.