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Project Summary

A Critical Review of Wastewater Treatment Plant Sludge Disposal by Landfilling

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Current landfilling practices are reviewed for the disposal of sludges from wastewater treatment plants (WWTP). Major emphases of the report include (1) assessments of the possible impacts of sludge landfilling on the environment and the public health, (2) available control technologies and management options, (3) sludge treatment processes and the characteristics of WWTP sludges, and (4) design approaches and operational procedures for current sludge landfilling practices.

Codisposal landfills (which dispose of sludge along with refuse or soil) are generally favored over sludge-only methods (which dispose of sludge alone in either trenches or area fills). Advantages of the codisposal landfills are that they are the least costly alternative, they generate the least public opposition, and they provide for more effective land use. However, codisposal sites do have greater potentials for increased odor, aerosol, noise, and public health risks.

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

Disposal of wastewater treatment plant (WWTP) sludge has historically occurred by land burial, ocean dumping, internment in evaporation (or percolation) lagoons and ponds, incineration, agricultural use, and land spreading. But annual increases in sludge production, current bans on ocean dumping of sludge, and the high costs of incineration have intensified the need for sludge landfilling. Recent sludge disposal research assesses the site-specific problems of sludge landfilling as well as the environmental benefits.

Sludge landfilling (with or without the addition of municipal refuse) presents many environmental and public health risks and managerial options. Environmental and public health risks include leachate contamination of water and soil resources, destruction of native fauna and flora, obnoxious odors, aerosol and dust generation, pathogen transmission, and other related nuisances. Management decisions about sludge landfills encompass a range of topics uncommon to conventional refuse landfills, including acceptable types of sludge for landfilling, the degree of sludge stabilization or dewatering required, and appropriate sludge/refuse mixing ratios for codisposal. The degree of environmental and public health risks posed by sludge landfills will be greatly influenced by such management decisions.

This study reviews current landfilling practices for the disposal of sludges from wastewater treatment plants. Major subjects covered in the report are as follows:

1. Sludge treatment processes and the physical, chemical, and microbiological characteristics of WWTP sludges;
2. Design approaches and operational procedures for current sludge landfilling practices;
3. Potential environmental and public health impacts of sludge landfilling procedures; and
4. Available pollution control technologies and management options.

Characteristics of WWTP Sludge

The physical, chemical, and microbiological quality of sludges from municipal wastewater treatment plants depends on the nature of incoming raw wastewater and the effectiveness of the treatment plant process. Most of the sludge is readily biodegradable, though measurable quantities of persistent organics, metals, and minerals are invariably present. The sludge may also contain pathogenic organisms that have survived the wastewater treatment process. Without wastewater pretreatment, industries may be the major source for contributing trace metals, refractory organics, or salts to the WWTP sludges.

WWTP sludge is generally classified according to the stage of wastewater treatment (primary, secondary, or tertiary). In addition, the sludge may be categorized by the various sludge treatment processes, including thickening, stabilization, disinfection, conditioning, dewatering, drying, and high-temperature processing. Within each of these categories are numerous process alternatives that ultimately affect the disposal options for the sludge.

Sludge moisture content and permeability are critical physical characteristics that can have pronounced impacts on leachate generation and sludge engineering properties. Excessive residual moisture will complicate handling and landfill operations and hasten the formation of landfill leachates. Even dewatered sludge has poor engineering properties because it is largely noncompressible and has little bearing strength.

The chemical characteristics of WWTP sludges often impose limitations on sludge disposal options. Though the concentration and mobility of chemical constituents vary greatly, sludge can be highly contaminated. Sludge constituents that are potentially harmful to the environment include nitrogen, phosphorus, trace metals, major inorganic ions, and certain organic compounds. Industrial wastewater can be a particularly important source of trace metals and synthetic organic compounds.

Sludge microorganisms that may be of health concern are bacteria, viruses, parasites, and fungi. Bacteria, viruses, and parasites (including protozoa, helminths, and nematodes) are considered primary pathogens and are incorporated into the sludge during its formation in wastewater processing. Fungi are considered secondary sludge pathogens because they are only numerous in sludge when given the opportunity to grow during some treatment or storage process. The concentrations of these microbes can be diminished through various sludge processing practices such as anaerobic digestion, aerobic digestion, lime stabilization, composting, and heat and radiation treatment. But, the literature reviewed in this study clearly indicates that many pathogens actually survive wastewater and sludge treatment processes. Thus WWTP sludges can pose various health hazards.

Current Sludge Landfill Practices

Current landfilling practices for WWTP sludge disposal fall into three major categories:

- Sludge-only trench
  narrow trench
  wide trench
- Sludge-only area fill
  area-fill mound
  area-fill layer
  diked containment
- Codisposal
  sludge/refuse mixture
  sludge/soil mixture

Each of these landfilling methods can demonstrate site-specific advantages in terms of design approach, operational procedures, or effectiveness in protecting the environment and the public health.

Sludge-Only Trench

Disposal of sludge in a sludge-only trench involves the excavation of a trench into which the sludge is placed. The excavated soil is then placed over the sludge as a cover, thereby eliminating the need for substantial soil import. The practice is usually limited to areas with suitable hydrogeological conditions or in locations where surface application or other alternatives are not viable.

Sludge-only trenching represents potential despoiling of prime agricultur soils, since the nutrient rich topsoil i mixed and buried in a subsoil/surfac soil mixture. Another disadvantage i the occasional need for sludge limin before placement in the trench. Thi approach can have its advantage however, such as reduction of odor immobilization of heavy metals, an reduced pathogen levels.

Methods for sludge-only trenchin are generally designated as wid trenches (greater than 3.0 m, or 10ft) c narrow trenches (less than 3.0 m Variables affecting the depth and lengt of trenches include the followin depth to bedrock, high water table, sc stability, and operational limitatior (i.e., site configuration, equipment, ar physiographic characteristics). Thoug the narrow-trench operation is usual land-intensive, associated enviror mental and public health risks a relatively minimal. Wide-trench sludg disposal often creates a greater potenti for leachate generation, vectors, odor and possible public health impact Liners can minimize the risks of leacha generation. Odors, vectors, and publ health impacts are related to the larg sludge exposure periods and great sludge application rates.

Sludge-Only Area Fill

Sludge-only area fill is a method b which WWTP sludge is disposed above the original ground surfac Three methods may be used for area-f sludge applications—area-fill moun area-fill layer, and diked containmer The sludge-only area fills require mixir with soil as a bulking agent to provi sludge stability. Since sludge-only ar fills are usually located where a hi groundwater table or near-the-surfa bedrock prevails, difficulties often ari in obtaining sufficient onsite soils. common design feature of sludge ar fills is the inclusion of surface wat drainage control measures. Leacha from the sludge and surface runoff fro the site require control measures su as upland runoff diversion ditches a onsite leachate collection systems.

Codisposal

Codisposal is the practice of disposi of sludge in a conventional refu landfill. This method can offer significa cost savings through economies of sc (e.g., additional land acquisition a equipment costs are expected to low). Codisposal landfilling methods a viewed favorably when compared with sludge-only alternatives because of advantages such as lower capital costs, less public opposition, and more effective land use. Conventional codisposal approaches include the use of both sludge with refuse mixtures and sludge with soil combinations. Both practices are increasingly used as viable disposal options.

Municipal refuse can absorb large volumes of sludge moisture and prevent or delay attainment of landfill field capacity. Thus the sludge/refuse mix ratio is a critical operational specification for codisposal practices. A proper mix ratio ensures that water released from the sludge can be intercepted by the refuse without depleting the refuse adsorption capacity. Major factors governing sludge/refuse mix ratios are sludge solids content (or moisture content), refuse composition, and depth of disposal.

In a sludge/soil operation, sludge is mixed with soil and the mixture is applied as a cover for areas of a refuse landfill. In this operation, the sludge is disked or mixed into indigenous soil and later retrieved for use as an intermediate or final cover. Use of sludge/soil mixtures requires greater manpower and equipment and may have greater environmental and public health impacts than mixing sludge with refuse.

Environmental and Public Health Impacts

Various environmental impacts are associated with the landfilling of WWTP sludges. Sludge landfilling can adversely affect leachate composition, leachate volume production, air quality, and land quality. Because of the toxic and pathogenic nature of many WWTP sludges, their placement in a landfill may lead to the formation of highly contaminated leachates or surface runoff that could migrate from the landfill site. But the critical factor influencing environmental impacts is the method of sludge application.

The risk of transmitting disease is of major concern for the various sludge disposal practices. The direct pathways for disease transmission from sludge landfilling operations include aerosols, vector transport, direct contact, groundwater, and surface water runoff. The groundwater and surface water runoff pathways present the greatest risks for disease transmission. Although the potential health effects and virulence of sludge and refuse contaminants have been well documented, no known outbreaks of disease have occurred among persons exposed to sludge landfilling operations.

The literature suggests that good design and operation can mitigate many of the potential environmental and public health problems. For instance, codisposal practices were found to produce weaker leachates than municipal refuse landfills. But the potentials for increased odor, aerosol, and noise are greater at codisposal sites. Possible risks to the public health are also greater because more viable contaminants are available to enter the groundwater. An acceptable sludge disposal

Table 1. *Suitability of WWTP Sludges for Landfilling According to Potential Odor and Operation Problems*

	Sludge Only Landfilling		Codisposal Landfilling	
Type of Sludge	*Suitability*	*Reason*	*Suitability*	*Reason*
Liquid - Unstabilized				
Gravity-thickened primary, WAS and primary, and WAS*	*NS*	*OD, OP*	*NS*	*OD, OP*
Flotation-thickened primary and WAS, and WAS without chemicals	*NS*	*OD, OP*	*NS*	*OD, OP*
Flotation-thickened WAS with chemicals	*NS*	*OP*	*NS*	*OD, OP*
Thermal-conditioned primary or WAS	*NS*	*OD, OP*	*MS*	*OD, OP*
Liquid - Stabilized				
Thickened anaerobic digested primary and primary, and WAS	*NS*	*OP*	*MS*	*OP*
Thickened aerobic digested primary and primary, and WAS	*NS*	*OP*	*MS*	*OP*
Thickened lime stabilized primary and primary, and WAS	*NS*	*OP*	*MS*	*OP*
Dewatered - Unstabilized				
Vacuum-filtered, lime-conditioned primary	*S*	—	*S*	—
Dewatered - Stabilized				
Drying-bed-digested and lime-stabilized	*S*	—	*S*	—
Vacuum-filtered, lime-conditioned digested	*S*	—	*S*	—
Pressure-filtered, lime-conditioned digested	*S*	—	*S*	—
Centrifuged, digested, and lime-conditioned digested	*S*	—	*S*	—
Heat-Dried				
Heat-dried digested	*S*	—	*S*	—
High-Temperature-Processed				
Incinerated dewatered primary and primary, and WAS	*S*	—	*S*	—
Wet—Air Oxidized Primary and Primary, and WAS	*NS*	*OD, OP*	*MS*	*OD, OP*

**Abbreviations: WAS = Waste-activated sludge*
NS = Not suitable
MS = Marginally suitable
S = Suitable
OD = Odor problems
OP = Operational problems

alternative must include measures for minimizing the environmental and public health impacts.

Control Technology and Management Options

Landfilling of WWTP sludge can be an acceptable disposal method, providing environmental and public health impacts are controlled. Control technologies that can be implemented are as follows:

1. Leachate and groundwater control, including collection, treatment, ultimate disposal, and monitoring.
2. Surface water control, including run-on control, and runoff retention and treatment.
3. Air emissions control, including control of gases, odor, dust, and volatile sludge constituents.
4. Erosion control to minimize wind and water erosion.
5. Mud control to prevent equipment from slipping onsite or tracking mud offsite.
6. Vector control to limit vector access and to discourage burrowing animals.
7. Aesthetic considerations, including site closure planning and visual barriers.
8. Noise control to prevent excessive noise.
9. Personal health and safety control for onsite workers and others near the facility.

Management options depend on current WWTP sludge landfill practices, the types of WWTP sludges placed in the fill, related environmental and health impacts, and other special constraints of WWTP sludge landfilling. Appropriate control technologies should be applied for anticipated environmental impacts. Consideration should be given to operational factors such as sludge dewatering and stabilization or special regulatory constraints that exist in most states.

The feasibility of various management options is primarily influenced by the selected landfill method and the type of incoming sludge (Table 1). Additional considerations include cost evaluations, regulatory limitations, and geographical distinctions.

Conclusions

Codisposal landfills are generally favored over sludge-only alternatives because they are the least costly, generate the least public opposition, and provide for more effective land use. The potentials for increased odor, aerosol, noise, and public health risks are greater at codisposal sites.

The need for sludge stabilization depends strictly on the landfill site and the engineering design. Sludge dewatering, however, is imperative for all landfilling operations. Available control technologies such as leachate and methane gas control must be applied at sludge landfill sites to prevent odor and operational problems and to ensure overall public acceptance.

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The complete report, entitled "A Critical Review of Wastewater Treatment Plant Sludge Disposal by Landfilling," (Order No. PB 83-111 518; Cost: $25.00, subject to change) will be available only from:
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