Forest Service Handbook
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Forest Service Handbook 7409.11 – Sanitary Engineering and Public Health Handbook

Chapter 50 - Wastewater

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58.9 - Ultimate Disposal

The need for proper treatment of all residual sludge streams is well recognized and should be provided for in plant design. The methods of final disposal can be broadly categorized as disposal or utilization procedures. Disposal procedures include landfills and ocean dumping as described in the following tabulation.

FINAL DISPOSAL METHODS

Disposal Procedure	Principal Sludge Form	Main Constraints
Sanitary Landfill	Dewatered cake or ash (stabi-lized)	Gas leachate, and runoff control; land availability
Ocean Dumping	Liquid (Thickening)	Oceanic and shore-line pollution

The landfill is one of the major methods for final disposal of sludge and incinerator ash. The amount of sludge that is dumped in the ocean is decreasing because of regulations.

Utilization procedures are receiving increasing attention and are described in the following table. Cropland application and land reclamation are the major sludge utilization methods. Other methods of synthesizing or retrieving useful products by treating sludge with chemicals and/or heat are being studied.

SLUDGE UTILIZATION METHODS

UTILIZATION PROCEDURE	SLUDGE FORM	MAIN CONSTRAINTS
Cropland Applica-tion	Liquid Cake dried, or compost	Application rate, unsatisfactory sludge.
Land Reclama-tion	Liquid or Dewatered	Application rate, unsatisfactory sludge, avail-ability of land

In developing an optimum conceptual design for a wastewater treatment plant, it is increasingly apparent that determination of the method of final sludge disposal is a major consideration. The method of final disposal determines the acceptable form of the sludge residue and thus influences the choice of both sludge and liquid unit processes to be employed.

In selecting a final disposal or utilization process, the method chosen should be in accordance with local, State, inter-State, and Federal requirements. While no sludge residues, grit, ash, or other solids should be discharged into the plant efluent or receiving waters, the procedure chosen

should also not result in any significant degradation of surface or groundwater; air or land surfaces. It is desirable that methods chosen do not cause a health hazard or a nuisance condition; therefore, it is essential that sludges be stabilized prior to spreading on land. The acceptable form of sludge for disposal or utilization is partially determined by the sludge treatment method. The sludge may be in the form of a liquid, dewatered cake, incinerator ash compost product, or dried powder.

58.91 - Hazardous Waste Considerations

Most States are legislating to control hazardous waste products. State regulations should be consulted in this regard prior to selection of a disposal or utilization procedure.

58.92 - Land Application

Land Application of sludge involves spreading wastewater solids on the soil surface or incorporating them into the root zone. Deep trenching or burying of sludge is discussed under "Landfilling." Two distinct rates of application can be considered depending on the system objectives. If the objective is to recycle nutrients or apply sludge at agricultural rates, the nitrogen or heavey metal loadings will usually limit the application rates. Monitoring of soils and crops can be minimized when these rates are used. Higher loadings can be used when (1) detailed monitoring of environmental impacts is conducted, (2) uses such as reclamation of stripp-mined land or application to Forests or sod farms are considered, (3) nonfood chain crops are grown on the site.

The process of planning a land application project begins with collection of basic data on sludge, soils, climate, and regulations and involves selection, design, and operation of the site. Throughout the planning, support of local officials, farmers, and other key individuals must be sustained.

Resistance to land application of sludge can stem from concerns about the adverse impacts of using sludge for agricultural purposes. For example, there may be fear that a sludge may contain concentrations of organic or inorganic substances that could be toxic to plants or accumulate in plants to the detriment of animals or humans. Furthermore, inadequate treatment may produce a sludge that is a potential source of noxious odors or diseases. Acceptance will be more readily forthcoming if local autonomy is assured and if the project has the flexibility to incorporate needed changes.

Any sludge utilization program must begin with basic data on the sludge itself, laws and regulations, climate, soil type, and land use.

Characterization of sludge properties is the first step. Important characteristics include:

1. Current and future sludge generation quantities - cost estimates, land area reguirements, site life, and application rates are all based in part on sludge production quantities.

2. Percent total and volatile solids - total solids content will influence the choice of transportation and application method. Volatile solids content is an important indicator of potential odor problems.

3. Nitrogen, phosphorus, and potassium - provides information on the fertilizer value of sludge. This information can be useful for determining optimum application rates, and the need for supplemental fertilization.

4. Heavy metals (principally cadmium, copper, nickel, lead and zinc) and specific organic compounds - provide information on limiting yearly or total application quantities.

5. Pathogens, parasites and viruses (optional) - evaluation of the above organisms is useful in assessing the degree of sludge stabilization.

The physical factors that are important include topography, soils, geology, climate, surface water hydrology and quality, an ground water hydrology and quality.

The process of characterizing, evaluating and selecting sites is usually iterative in nature. Once the full array of physical characteristics is assembled, the sites can be screened for acceptability, using physical factors, and other criteria, such as, water rights, and requirements of regulations and laws.

The differences in aerobically and anaerobically digested sludges and other sludge types are presented in the following tabulation. The data presented can vary substantially from one sludge to the next. This table should not be substituted for chemical analysis of the sludge.

TYPE OF SLUDGE

Component	Anaerobic	Aerobic	Other[a]	All Sludges
		Percent		
N..........	4.2	4.8	1.8	3.3
P..........	3.0	2.7	1.0	2.3
K..........	0.3	0.4	0.2	0.3
Na.........	0.7	0.8	0.1	0.2
Ca.........	4.9	3.0	3.4	3.9
Mg.........	0.5	0.4	0.4	0.4
Fe.........	1.2	1.0	0.1	1.1
Al.........	0.5	0.4	0.1	0.4
		mg/kg		
Pb.........	540	300	620	500
Zn.........	1,890	1,800	1,100	1,740
Cu.........	1,000	970	390	850
Ni.........	85	31	118	82
Cd.........	16	16	14	16
Cr.........	1,350	260	640	890

aLagooned, primary, tertiary.

Substantial information on sludge application to cropland and forested lands is available in the literature. "Sludge Treatment and Disposal" is recommended as this presents a very thorough study of design consideration and design examples.

Forested sites offer special opportunities for the beneficial use of sludge through improving soil fertility and increasing plant growth. In contrast to many agricultural crops, Forest products are generally not consumed by humans and thus, there is no reason to suspect Forest products grown on sludge treated areas as constituting a human health hazard.

Furthermore, direct human contact in Forests treated with sludge is minimal because of the low population density. However, not all features of Forest land use are favorable. Public resistance may be encountered, accesibililty may be poor, resident species, including wildlife, may be impacted, and special distribution systems may be necessary to overcome rugged and sloping terrain.

58.93 - Sanitary Landfill

Stabilized sludge containing no free water can be satisfactorily disposed in a sanitary landfill, either alone or in a mixture with municipal solid waste. A sanitary landfill must be managed so that wastes are systematically deposited and covered with earth to control environmental impacts within defined limits. This distinguishes a sanitary landfill from an uncontrolled dumping operation. Sludges and solid wastes have in the past been disposed of in dumps not meeting proper landfill specifications. The placement of incinerator ash or stabilized sludge cake in a sanitary landfill can be an acceptable procedure when adequate land is available and site location and operational precautions prevent the creation of nuisance conditions or health hazards. Prior to placing sludge in a landfill it should be sufficiently dewatered to minimize the quantity of free water present. Leachate and runoff from a sanitary landfill should be minimized and, when necessary, collected and suitably treated to prevent pollution of ground and surface waters. Therefore, sound engineering judgement dictates that sanitary landfills not be located in an existing flood plain.

The several alternative methods and sub-methods for sludge landfilling include:

1. Sludge-only trench: narrow trench; wide trench.

2. Sludge-only area fill: area fill mound; area fill layer; diked containment.

3. Codisposal: sludge/refuse mixture; sludge/soil mixture.

Each method is addressed in more detail. The information presented should be valid for the vast majority of sludge landfill applications. However, design criteria should be qualified as being "typical" or "recommended." Variations are employed and may be appropriate in some cases. For example, the range of sludge solids contents recommended for each method in this section may vary somewhat depending on the sludge source, treatment, and characteristics. Specifically, a sludge treated with polymers is more slippery and less stable; consequently, it will require a higher solids content to be landfilled in the same manner as a sludge content treated with polymers. Nevertheless, the criteria suggested by this section can serve as a starting point. An assessment of the suitability of various sludge types has been included in the following tabulation.

SEE PAPER COPY FOR TABULATION

58.93a - Sludge Only Trench

For sludge-only trenches, subsurface excavation is required so that sludge can be placed entirely below the original ground surface. Trench applications require that ground water and bedrock be sufficiently deep so as to allow excavation and still maintain sufficient buffer soils between the bottom of sludge deposits and the top of groundwater or bedrock.

In trench applications, soil is used only for cover and is not used as a sludge bulking agent. The sludge is usually dumped directly into the trench from haul vehicles. On-site equipment is normally used for trench excavation and cover application; it is not normally used to haul, push, layer, mound, or otherwise come into contact with the sludge.

Although in some cases cover application may be less frequent, cover is normally applied over sludge the same day that it is received. Because of the frequency of cover, odor control is optimized; therefore, trench is more appropriate for unstabilized or low-stabilized sludges than other landfilling methods. The soil excavated during trench construction provides quantities which are almost always sufficient for cover applications. Accordingly, soil importation is seldom required in trench applications.

Two sub-methods have been identified under trench applications. These include (1) narrow trench and (2) wide trench. Narrow trenches are defined as having widths less than 10 ft (3.0 m); wide trenches are defined as having widths greater than 10 ft (3.0 m). The depth and length of both narrown and wide trenches are variable and dependent upon a number of factors. Trench depth is a function of (1) depth to groundwater and bedrock (2) sidewall stability, and (3) equipment limitations. Trench length is virtually unlimited, but inevitably dependent upon property boundaries an other site conditions. In addition, trench length may be limited by the need to discontinue the trench for a short distance or place a dike within the trench to contain a low-
solids sludge and prevent it from flowing throughout the trench.

Site condition requirements, design criteria, and advantages an disadvantages of the two sub-methods are described in "Sludge Treatment and Disposal."

58.93b - Sludge-Only Area Fill

For sludge-only area fills, sludge is usually placed above the original ground surface. Because excavation is not required and sludge is not placed below the surface, area fill applications are particularly useful in areas with shallow groundwater or bedrock. The solids content of sludge as received is not necessarily limited. However, because the sidewall containment (available in a trench) is lacking and equipment must be supported atop the sludge in most area fills, sludge stability and bearing capacity must be relatively good. To achieve these qualities, soil is usually mixed with the sludge as a bulking agent. Since excavation is not usually performed in the landfilling area, and since shallow groundwater or bedrock may prevail, large quantities of soil required usually must be imported from off-site or hauled from other locations on-site.

Because filling proceeds above the ground surface, liners can be more readily installed at area fill operations than at trench operations. Of course, because of the likely proximity of groundwater or bedrock to the ground surface, the installation of a liner will often be required at area fills. With or without liners, surface runoff of moisture from the sludge and contaminated rainwater should be expected in greater quantities at area fills, and appropriate surface drainage control facilities should be considered.

In area fills, the landfilling area usually consists of several consecutive lifts or applications of sludge/soil mixture and cover soil. As for any landfill, cover should be applied atop all sludge applications. However, this cover often is applied as necessary to provide stability for additional lifts. Because some time may lapse between consecutive sludge applications, daily cover is usually not provided and stabilized sludges are better suited for area filling than are unstabilized sludges.

Three sub-methods have been identified under area fill applications. These include (a) area fill mound, (b) area fill layer, and (c) diked containment.

The required site conditions, design criteria and advantages and disadvantages for each sub-method are described in "Sludge Treatment and Disposal."

58.93c - Codisposal

A codisposal operation is defined as the receipt of sludge at a refuse landfill. Two sub-methods have been identified under codisposal operations. These include (1) sludge/refuse mixture and (2) sludge/soil mixture.

1. Sludge/Refuse Mixture. In a sludge/refuse mixture operation, sludge is deposited at the working face of the landfill and applied atop refuse. The sludge and refuse are then mixed as thoroughly as possible. The mixture is then spread, compacted, and covered in the usual manner at a refuse landfill. Relevant sludge and site conditions as well as design criteria are presented in "Sludge Treatment and Disposal."

2. Sludge/Soil Mixture. In a sludge/soil mixture operation, sludge is mixed with soil and applied as interim or final cover over completed areas of the refuse landfill. This is not strictly a sludge landfilling method since the sludge is not buried. However, it is a viable option for disposal of sludge at refuse landfills which has been performed and should be used in many cases. Relevant sludge and site conditions as well as design criteria are presented in "Sludge Treatment and Disposal."

3. Advantages. For a variety of reasons, consideration should be given to using codisposal methods for sludge disposal in lieu of sludge-only methods. The advantages of using an existing refuse landfill instead of a new sludge-only landfill include:

a. Shorter time delay. Processing of permits to dispose of sludge at an existing refuse landfill will probably be quicker than processing permits for a new sludge-only site. Also, since most or all of the site presentation required for sludge disposal is in place delays for construction may not occur.

b. Less environmental impact. The environmental impact (odors, traffic, aesthetics, water) of one codisposal site will probably be less than the combined impacts from two separate sites.

c. Less public opposition. The public is less likely to resist an expansion in the operations of one site than it is to resist the operation of a new site.

d. Less costs. Due to economics of scale, the cost of one codisposal site will probably be less than the combined costs of two separate sites.

4. Disadvantages. Obviously, there are several disadvantages for refuse landfill operators to consider when contemplating the receipt of sludge. These include:

a. Odors may increase somewhat depending upon the degree to which the sludge is stabilized.

b. Leachate may be generated sooner (if not already existing) or leachate quantities may increase (if already existing).

c. Operational problems may develop, including equipment slipping or becoming stuck in sludge, or sludge being tracked around the site by equipment an haul vehicle.

5. Other Considerations. Several other items should be considered by a refuse landfill before receiving sludge.

a. Pertinent regulatory authorities should be consulted to ascertain whether sludge receipt is permissible.

b. Leachate collection and treatment systems may have to be enlarged (if existing) or installed (if not existing) to handle any increased leachate quantities.

c. Leachate treatment systems may have to be upgraded to handle any change in leachate quality.

d. A sufficient volume of refuse should be delivered to the site so that sufficient absorption of sludge moisture can occur.

e. Ideally, delivery of sludge and refuse should occur simultaneously. If not, storage capacity must be provided for either sludge or refuse so that sludge can be mixed with refuse when landfilled.

f. Controlled dumping of refuse should occur to maximize its absorptive capacity with sludge. Such control may not be attainable when the public is allowed access to the working face.

58.93d - Landfill Summary

The following tables are compilations of the conditions and criteria presented previously for each landfilling method. They are provided to give guidance during the investigation of alternative sites and landfilling methods. It is important to note that there is no one best method for a given sludge or site. Rather, these considerations and criteria merely

suggest sites and amenable landfilling methods that can simplify and improve the design and operational procedures required for an environmentally safe and cost-effective sludge landfill. Additional information can be obtained from "Sludge Treatment and Disposal."

SEE PAPER COPY FOR ILLUSTRATION

58.94 - Reclamation/Reuse

Properly treated sludge can be utilized for beneficial purposes. The most common uses are as soil conditioners and for land reclamation. The benefits and considerations of both these beneficial uses are addressed in paragraph 58.71 - Composting and in 58.92 - Land Application.

58.95 - Ocean Disposal

Present indications are that ocean disposal will be banned. Designs incorporating sludge disposal to the ocean are not recommended.