United States
Environmental Protection
Agency

Biosolids Technology Fact Sheet

Use of Landfilling for Biosolids Management

DESCRIPTION

Current options for managing wastewater biosolids in the United States include both beneficial reuse technologies (such as land application, landfilling with biogas recovery, and energy recovery through incineration) and non-reuse options, including landfilling. While implementing some type of beneficial reuse is the preferred method for managing wastewater biosolids, this is not always practical. For example, land acquisition constraints or poor material quality may limit beneficial reuse options. In these situations, landfilling of biosolids may be a viable alternative.

Biosolids landfilling options include disposal in a monofill (a landfill that accepts only wastewater treatment plant biosolids), or in a co-disposal landfill (a landfill that combines biosolids with municipal solid waste). Although co-disposal landfilling is more common than monofilling, biosolids typically represent only a small percentage of the total waste in a co-disposal landfill (WEF, 1998).

Landfill disposal of biosolids should not be confused with use of biosolids to amend final cover material at landfills. This practice is a form of land application in which biosolids are added to soil to enhance conditions for growing cover vegetation. The EPA fact sheet *Land Application of Biosolids* addresses the use of biosolids in rehabilitating disturbed lands.

Biosolids Monofilling

Biosolids monofilling consists of preparing the site, transferring the biosolids to the site, and covering the biosolids with a layer of cover material. Depending on the concentration of pollutants in the biosolids, site preparation may include installing a liner to prevent contaminants from migrating downward into the site soil. The three most common methods of monofilling wastewater biosolids are the trench, area, and ramp methods.

Trench monofilling (Figure 1) involves excavating a trench, placing the biosolids in the trench, and then backfilling the trench to return the soil to its original contours. Monofill trenches can be narrow or wide, depending on the solids concentrations of the biosolids to be filled. Narrow trenches (typically less than 3 m [approximately 10 ft] wide) are generally used for disposal of biosolids with a low solids content. Wide trenches (typically greater than 3 m [approximately 10 ft] wide) are used for disposal of biosolids with a solids content of 20 percent or more. If the biosolids contain less than 20 percent solids, they will not support the machinery used to place the cover material over the trench.

Application rates for trenches less than 3 m in width are approximately 2,270-10,580 m^3/ha (1,200- 5,600 yd^3/acre). Typical application rates for wider trenches range from 6,000-27,000 m^3/ha (3,200-14,500 yd^3/acre) (U.S. EPA, 1978).

The trench method provides efficient use of available land space. However, this method is

FIGURE 1 EXCAVATED CROSS-SECTION OF BIOSOLIDS TRENCH

generally not used at sites that require a liner because of the potential to damage the liner during trench excavation.

In the area method, biosolids are placed in a natural or excavated depression, or they are mixed with soil and placed on top of the existing soil layer. Biosolids to be landfilled in this manner are generally stabilized prior to landfilling because these sites do not always apply daily cover. The area method is particularly well suited to areas where bedrock or ground water are shallow, and excavation (as is required for the trench method) is difficult. However, this method requires substantial amounts of soil for fill and results in changes to the local topography.

The ramp method involves spreading and compacting the biosolids along a slope. The soil higher on the slope is pushed over the top of the biosolids as a cover material.

Applicable Regulations

Landfilling of biosolids in monofills is regulated by the Environmental Protection Agency under Subpart C of 40 CFR, Part 503, Standards for the Use and Disposal of Sewage Sludge as surface disposal. The Part 503 Regulations establish maximum concentrations of arsenic, chromium, and nickel in biosolids to be landfilled in a monofill without a liner. The limits vary with distance to property lines as presented in Table 1. If the concentration of any of these pollutants exceeds the criteria, the facility must be lined. The regulations also allow establishment of site-specific pollutant limits at the discretion of the permitting authority.

These regulations also require that biosolids placed in a landfill meet either Class A or Class B pathogen reduction requirements or that they be covered with soil or other material at the end of each operating day.

In addition, many state regulations for monofills have more stringent requirements, which may include installing a liner regardless of pollutant concentrations.

TABLE 1 MAXIMUM POLLUTANT CONCENTRATION FOR SURFACE DISPOSAL OF BIOSOLIDS

	Pollutant Concentration (Dry Weight Basis)		
Distance from Boundary of Active Biosolids Unit to Property Line, m	**Arsenic mg/kg**	**Chromium mg/kg**	**Nickel mg/kg**
0 to less than 25	30	200	210
25 to less than 50	34	220	240
50 to less than 75	39	260	270
75 to less than 100	46	300	320
100 to less than 125	53	360	390
125 to less than 150	62	450	420
Equal to or greater than 150	73	600	420

Source: Part 503 Regulations

Co-Disposal Landfilling

Co-disposal landfilling involves combining wastewater solids with municipal solid waste and placing the mixture in a permitted landfill. Generally, a layer of municipal solid waste is spread near the working face of the landfill. Wastewater solids are then spread over the municipal waste and the two are thoroughly mixed using typical landfill machinery. The ratio of waste to wastewater solids is dependent, in part, on the solids content of the wastewater solids. Ten percent biosolids to 90 percent solid waste (by volume) is common. The mixture is then compacted and covered with a daily cover.

Applicable Regulations

The design and operation of co-disposal landfills is regulated by EPA under Subpart I of 40 CFR, Part 258, Criteria for Municipal Solid Waste Landfills. Standards set forth in the Part 258 Regulations address general requirements, pollutant limits, management practices, operational standards for pathogens and vector attraction, and monitoring, record keeping, and reporting requirements.

Accepting wastewater solids at a co-disposal landfill generally does not add significant regulatory hurdles or permit constraints to the landfill operator. In addition, co-disposal typically does not result in additional operational requirements for the landfill other than the mixing the biosolids and waste prior to placement in the permanent cell.

APPLICABILITY

Landfilling is generally considered for wastewater biosolids management when land application or other beneficial reuse is not possible. Typical scenarios that lead to selection of landfill disposal rather than beneficial reuse include:

- Land acquisition constraints;
- High concentration of metals or other toxins in the biosolids; or
- Odorous material that may create a public nuisance if managed through other options.

Solids concentrations of the biosolids are also a factor in determining whether landfilling is a viable disposal option. For biosolids monofills, the solids concentration should be 15 percent or greater. Although soil may be mixed with biosolids to increase the solids concentration to this level, this may not be cost effective. Biosolids are usually stabilized prior to monofilling.

As a general rule, municipal solid waste landfills will not accept materials with solids content less than about 18 percent. The operator will generally perform a paint filter test on the biosolids prior to allowing them to be deposited due to the regulatory prohibition of materials containing free liquids. The paint filter test is described in detail in EPA publication SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, Method 9095. In addition to the paint filter test for free liquids, a Toxicity Characterization Leaching Procedure (TCLP) must also be performed to verify that the biosolids are non-hazardous. Passing this test is generally not a problem for biosolids. The TCLP method (Method 1311) is defined in EPA SW-846.

Finally, economics also factor into any decision to manage biosolids through landfilling. Landfill tipping fees can be less than the full cost of land application or other reuse options. Because tipping fees change in response to market conditions, a periodic reassessment of solids management decisions is recommended.

ADVANTAGES AND DISADVANTAGES

Advantages

- Landfilling is suitable for biosolids with high concentrations of metals or other toxics.
- Landfills may require smaller land area than land application.
- Landfilling improves packing of solid waste and increases biogas production.
- Landfills may be the most economical biosolids management solution, especially for malodorous biosolids.

Disadvantages

- Landfilling biosolids eliminates their reuse potential and is contrary to the EPA national beneficial reuse policy.
- Landfilling requires extensive planning, including selection of a proposed landfill site, and operation, closure, and post closure care of the site.
- Operation, maintenance, and post closure care of landfills are labor intensive.
- Landfill sites have a potential for groundwater contamination from leachate.
- Decomposition of biosolids in a landfill produces methane gas which must be collected and reused or disposed of by flaring or venting. Energy can be recovered

through methane capture systems to offset the cost of the necessary collection system.

- Landfills have a potential for odor generation.

Environmental Impacts

There are several potential environmental impacts associated with landfilling of wastewater biosolids. Leachate from the landfill may transport nitrate, metals, organics, and/or pathogens to groundwater if the landfill site has not been properly selected or if the liner has been damaged. In addition, rainfall runoff from an active landfill may carry contaminates to nearby surface waters. Specific impacts will vary among landfill locations

Other potential impacts from these landfills include impacts on traffic volume, land use, air quality, public health, aesthetics, wildlife, and habitats of endangered species. Adverse impacts should be mitigated during the site selection process or by specific measures in the design (U.S. EPA, 1979).

DESIGN CRITERIA

Design of monofills and co-disposal landfills includes selecting an appropriate site, evaluating wastewater solids quality, and approving a method of operation. Preliminary planning is followed by detailed design, site development, site operation and maintenance, and closure.

Site Evaluation

Landfill sites must meet the siting criteria established by either the Part 503 (for monofills) or the Part 258 regulations (for co-disposal landfills). Both regulations contain similar requirements, including:

- A landfill shall not be developed if it is likely to adversely affect a threatened or endangered species.

- The landfill cannot be located in a wetland unless a special permit is obtained.

- A landfill cannot restrict the flow of a 100-year flood event.

- The landfill must not be located in a geologically unstable area.

- The landfill must be located 60 m (200 ft) or more from a fault area that has experienced displacement in Holocene time.

- If the landfill is located in a seismic impact zone, it must be designed to resist seismic forces.

- The landfill must be located at least 300 m (1,000 ft) from an airport runway.

Some states have additional siting criteria, including setbacks from property lines, public or private drinking water wells, surface drinking water supplies, and buildings or residences.

Preliminary Planning

The preliminary planning phase for landfill design should include a determination of the biosolids characteristics and an estimate of the average biosolids quantity. Once the biosolids quantity is determined, the area required for the landfill site, as well as its probable lifespan, can be calculated. Generally, a site should provide 10 to 20 years of operational capacity.

Other factors to consider during preliminary planning include haul distance and route from point of generation to the facility; topography; surface water and soils; geology; groundwater; vegetation; meteorology; environmentally sensitive areas; archaeological and historical significance; site access; final site use; and cost. Each of these issues could affect the final location of the landfill.

Site Development

Once the landfill site is determined, initial site development can begin. During the initial development of the landfill site, utilities such as water, sewer, and electricity must be provided for daily operations. In addition, support facilities such as an equipment garage, office building, and leachate pumping stations may need to be constructed.

The landfill design must also include site-specific criteria to meet environmental requirements. These requirements include mitigating the environmental impacts of runoff, infiltration of water through the landfill and into the underlying soil, and gas generation. Depending on regulatory requirements, the landfill may also require a lining. Design considerations for these impacts are discussed below.

Mitigation of Runoff

EPA requires that surface water runoff from an active landfill be collected and disposed of in accordance with NPDES requirements (WEF, 1998). The runoff collection system must be designed to contain a 25-year, 24-hour storm.

Infiltration

As water percolates through a landfill, it may become contaminated as it dissolves various soluble components of the biosolids. The resulting leachate must be contained and treated to eliminate the potential for groundwater pollution and/or public health problems. Methods for controlling leachate include implementing proper drainage, installing a liner, allowing the leachate to attenuate naturally, or collecting and treating the leachate. A leachate collection system may consist of a drainage layer (usually sand or geonet), leachate collection piping, a sump or series of sumps, and manholes.

Gas Generation

The anaerobic decomposition of biosolids in a landfill contributes to the generation of "natural" gas consisting primarily of methane (45 to 55 percent) and carbon dioxide. Methane is explosive in the atmosphere at concentrations of 5 to 15 percent. Either passive or active gas collection systems can be effective in preventing the accumulation and possible migration of landfill gas. A passive collection system consists of perforated collection pipes and header pipes placed just below the landfill cap to collect and vent gas to the atmosphere. Active systems consist of a series of gas wells drilled into the waste or a series of horizontal trenches and a blower to collect the gas. Active gas collection systems are used to control odors at a site and may also be used to recover energy from the methane. If cost effective, the methane recovered from the landfill gas may be used in boilers or space heaters, or in turbines to generate electricity. It may also be upgraded to pipeline-quality gas.

Landfill Liner

Another critical design consideration is facility lining. Three types of materials are typically used for landfill liner systems. They include low permeability soil (clay), geosynthetic clay liners (GCL), and geomembrane liners. The Part 503 regulations require a maximum hydraulic conductivity of 1×10^{-7} cm/s (2×10^{-7} ft/min) for a monofill liner (when a liner is required). The Part 258 regulations require all co-disposal landfills to have a composite liner. The top component of the liner must consist of a minimum 30-mil flexible membrane liner, while the bottom component must consist of at least a 60 cm (2 ft) thick layer of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/s (2×10^{-7} ft/min). The flexible membrane component must be installed in direct and uniform contact with the compacted soil.

Both natural and synthetic liners have advantages and disadvantages. While synthetic liners are virtually impermeable to liquids, they do not have the self-healing characteristics of natural liners. Natural liners have slightly higher permeability than synthetic liners, but are less susceptible to possible subbase changes.

OPERATION AND MAINTENANCE

Each municipal solid waste landfill is required to have an operation and maintenance (O&M) plan that describes its procedures. Monofills are encouraged to maintain a similar plan. Operational considerations addressed in these plans include:

- Hours of operation.
- Material weighing procedures.

- Traffic flow and unloading procedures.
- Cover material excavation (or purchase), stockpiling, and placement.
- Maintenance procedures and schedules.
- Inclement weather operations.
- Environmental monitoring and control practices.

Management and reporting required under the Part 503 and Part 258 regulations include maintaining activity, performance, and cost records, as well as required regulatory reports. Activity records may include equipment and personnel accounts, biosolids receipts, cover material quantities, etc.

Regular O&M activities at a landfill containing biosolids may involve the following: providing periodic cover for the biosolids; capping sections (or "cells") of the landfill once they are full; monitoring the site to ensure that leachate from the landfill does not contaminate groundwater; and closing the landfill site when it has reached its capacity. These O&M activities are discussed in more detail below.

Periodic Cover

Cover materials are used at landfills to manage vectors, control odors, increase compaction, decrease settling, and minimize wind erosion. If the landfill site does not have sufficient available soil, cover material must be obtained off-site and transported to the facility. At the end of each working day 15 cm (6 in) of cover is spread over the compacted waste. An intermediate cover 30 cm (1 ft) thick is applied when the cover material will be exposed for more than one month but less than six months. If the cover material is to be exposed for more than six months, final cover with a minimum thickness of 60 cm (2 ft) is required.

Cell Closure

Landfills are typically developed in phases to minimize the area exposed to rainfall and the rate of leachate production. Based on the site topography and the calculated amount of waste to be landfilled, an area with an expected life of two to five years is developed for each phase. As an active cell nears its capacity, a new cell is constructed.

Site Monitoring

Both the Part 503 and Part 258 regulations stipulate that landfills shall not contaminate an aquifer. Most states require groundwater monitoring at landfill sites. EPA has also established monitoring requirements for methane gas because of the explosive hazard. Monitoring is required during the active life of the landfill and for three years following closure of the landfill.

Site Closure/Capping

When a landfill cell has reached capacity, a final cap is placed to prevent infiltration of rainwater and reduce leachate generation. The layers of the cap, from bottom to top, include the following:

- Subgrade Layer - Used to contour the landfill and provide a base for construction of subsequent layers.
- Gas Control Layer - Transports gas to a venting system.
- Hydraulic Barrier - Limits infiltration of water to the landfilled waste.
- Drainage Layer - Collects and transports water that percolates into the final cover.
- Biotic Layer - Protects the hydraulic barrier from intrusions by animals or plants.
- Filter Layer - Prevents the migration of fines from the vegetative support (surface) layer to the drainage layer.
- Surface Layer - May be either a soil capable of supporting vegetation or an armored protection layer.

The thickness and performance standards for each layer may vary depending on the approving authority. Post closure monitoring of the cap should include monitoring of settlement, cover soil integrity, grading, vegetation conditions, sediment and erosion controls, gas controls, and security fencing.

The Part 503 and Part 258 Regulations require the owner/operator of a landfill to submit a closure plan at least 180 days prior to closure of the facility. The closure plan should describe both closure and post closure activities including maintenance of the leachate collection system, monitoring of methane gas production, and limiting public access to the site, all required for three years following closure.

The final intended use of a closed landfill should be identified during the design phase to ensure that appropriate decisions are made regarding cover material, grading, monitoring, and stormwater management. Typical uses for closed landfills include athletic fields, game courts, golf courses, playgrounds, picnic areas, and open spaces where there is not a need for extensive tree planting.

COSTS

It is difficult to estimate the cost of landfilling biosolids without individual program details. For example, land acquisition costs vary from region to region, and liners may or may not be required. Other factors that impact the cost of landfilling of biosolids include:

- Capacity of landfills serving the area.
- Haul distance.
- Method of leachate treatment and disposal.
- Method of gas collection, disposal or reuse.
- Post closure use.
- Purchase and maintenance of equipment.
- Regulatory compliance, such as preparation of reports, site monitoring, and biosolids analysis.
- Local labor rates.
- Importation of cover material if on-site quantity is insufficient.

In 1994, the municipalities of Las Vegas, Henderson, and the Clark County Sanitation District in Nevada were disposing all biosolids in a privately owned and operated facility 25 miles from the municipalities. The total solids production of 545 wet Mg/day (600 wet tons/day) was mechanically dewatered to a range of 10 to 33 percent solids. The cost for disposing of these solids was approximately \$10/ wet Mg (\$11/ wet ton), including transportation by a contract hauler and landfill tipping fee.

As part of a regional biosolids management plan developed in 1994, the municipalities evaluated the option of building their own biosolids monofill. Potential sites, ranging from less than 16 km (10 mi) to up to 80 km (50 mi) away, were selected based primarily on their distance from the municipalities. Other site evaluation criteria included topography, hydrology, land use, availability of utilities, and other social/environmental concerns. The monofill capacity was estimated at 31 million m^3 (40 million yd^3), based on accommodating the total annual solids production for a period of 30 years. The amount of land required for the monofill and space for solids processing was estimated to be approximately 200 ha (500 acres). The estimated cost for this alternative ranged from \$25.71/wet Mg (\$28.32/wet ton) for the closest site to \$28.32/wet Mg (\$31.20/wet ton) for the most remote site.

REFERENCES

Other Related Fact Sheets

Odor Management in Biosolids Management
EPA 832-F-00-067
September 2000

Centrifugal Dewatering/Thickening
EPA 832-F-053
September 2000

Belt Filter Press
EPA 832-F-057
September 2000

Filter Press, Recessed Plate
EPA 832-F-00-058
September 2000

Alkaline Stabilization of Biosolids
EPA 832-F-00-052
September 2000

Other EPA Fact Sheets can be found at the following web address:
http://www.epa.gov/owm/mtb/mtbfact.htm

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