Leachate Treatment Options and How to Choose Among Them

Landfill leachate treatment remains a potentially costly and troublesome issue facing owners/operators of municipal solid waste (MSW) landfills. The following provides a review of available treatment technologies and a methodology for selecting the best option.

By Tom Myers, Ph.D., P.E. and Bill Wright, P.E.

New or expanding municipal solid waste (MSW) landfills not only face the challenges of developing designs, obtaining permits and constructing the facility, but also must be prepared to pay potentially significant capital and/or operating costs for treating or disposing of the leachate generated. Numerous on-site and off-site leachate treatment options are available, but choosing the appropriate method(s) can be a challenge due to the variability of the leachate stream, including wide ranges of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids, pH and other constituents. Other characteristics unique to each particular landfill (e.g., location, space, funding, state and local regulations) also can play a prominent role in determining the most effective treatment.

Treatment Technologies

Landfill leachate is often high strength, containing both toxic organic and inorganic components, but its character can vary from day to day and month to month. For these reasons, a combination of treatment processes often is required in order to achieve acceptable discharge levels. A recent National Solid Wastes Management Association survey indicates that 68 percent of landfills use a leachate collection system. Of this number, 15 percent employ recirculation for disposal, 17 percent use on-site treatment, 62 percent use off-site treatment and 6 percent employ a combination of treatments.

The options available can be divided generally into a wide range of on-site and off-site treatment systems, depending on the final disposition of the treated leachate.

Off-site leachate treatment is typically performed by a Publicly Owned Treatment Works (POTW) or a private treatment contractor who collects hazardous wastewaters and treats them prior to discharge. In either of these two options, the leachate can be piped, sewered, pumped or transported by truck to the treatment location. It is important to note that under federal pre-treatment guidelines, leachate is classified as an industrial waste. A POTW treating leachate needs to prevent it from interfering with its wastewater treatment process, as the leachate can introduce contaminants that are toxic to the biological treatment process. In addition, the leachate may also degrade the sludge quality, by increasing the heavy metals concentration, or even lead to exceeding the facility's sludge limit.

On-site leachate treatment options include a wide range of treatment levels, from no treatment (e.g., total recirculation) to nearly complete contaminant removal for discharge to surface water. An intermediate level of on-site treatment is usually followed by off-site treatment unless local, state or federal regulations allow for discharge of mildly contaminated wastewater—for instance, into an area with poor groundwater quality due to natural or unavoidable causes such as mine drainage.

Conventional Systems

A conventional leachate treatment system consists of several processes. The leachate will collect and equalize in an equalization (EQ) basin, typically ranging in size from 200,000 to 2 million gallons. Multiple basins can be used, and they must provide a minimum holding capacity or time (e.g. 270 days) depending on state or federal law, whichever is more stringent. The primary factors determining...
Leachate treatment pond—a work in progress at St. Louis County Regional Landfill, St. Louis County, MN.

holding capacity are the amount of precipitation, acreage and seasonal operation. Aeration and mixing of chemicals in the basin(s) can facilitate initial biological treatment for the removal of BOD and ammonia.

Following the aerated equalization basin(s), chemical pretreatment is used in conjunction with a clarifier for removing solids and metals, achieving 80 to 90 percent removal of solids. Sludge from the clarifier will be thickened, dewatered and disposed of on-site at an active portion of the landfill or off-site, if required.

Polishing filters (e.g., sand filters) and granular activated carbon (GAC) are then used for additional solids and metals removal by adsorption. Any remaining phenols and VOCs also can be removed by carbon adsorption. The final processes consist of aeration, to replenish dissolved oxygen, and disinfection, to render fecal coliforms harmless.

Figure 1 illustrates a conventional leachate treatment system. The capital costs associated with a typical system, treating up to 30 gpm (40,000 gpd), range from $350,000 to $600,000, including aerations basins, chemical treatment tanks, clarifier, polishing filters, GAC filters and disinfection. Operating costs can vary greatly but are usually in the $0.03 to $0.06/gallon range.

**Membrane Treatment**

A membrane leachate system, an alternative to the conventional, relies solely on physical filtration rather than chemical treatment and reactions. Prior to entering the treatment unit, the leachate is equalized or stored and then undergoes a pH adjustment in order to increase membrane removal efficiencies and to reduce the possibility of membrane fouling.

Two streams exit the membrane treatment unit; the clean water or permeate is

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
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<tbody>
<tr>
<td>Equalization (EQ) Basin(s)</td>
<td>Flow and mass loadings must be equalized. Provisions to handle fluctuations must be made available either in-line or off-line.</td>
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<tr>
<td>Aeration</td>
<td>The addition of oxygen to the wastewater assists in the cultivation of microorganisms. Aeration is usually added in the EQ basins or in the biological process equipment.</td>
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<tr>
<td>Screening</td>
<td>Removal of large suspended or floating debris.</td>
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<tr>
<td>Flocculation</td>
<td>Chemical addition alters the physical state of dissolved and suspended solids to form &quot;flocs.&quot; Facilitates removal by sedimentation.</td>
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<tr>
<td>Precipitation</td>
<td>Solubility is reduced by chemical addition. Removal of hardness, phosphorus and many metals.</td>
</tr>
<tr>
<td>Clarification/Sedimentation</td>
<td>Settled solids are removed by gravity.</td>
</tr>
<tr>
<td>Flotation</td>
<td>Fine air bubbles float solids to the surface to be skimmed.</td>
</tr>
<tr>
<td>Air Stripping</td>
<td>Air and liquid mixing to remove ammonia, VOCs and other contaminants either in the EQ basins or, more typically, in stripping towers.</td>
</tr>
<tr>
<td>Filtration</td>
<td>Filter bed or microscreen. Removal of suspended solids and turbidity.</td>
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<tr>
<td>Membrane Processes (ultrafiltration, reverse osmosis, etc.)</td>
<td>Dissolved solids are removed by membrane separation.</td>
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<tr>
<td>Natural Evaporation</td>
<td>Leachate is directed to shallow basins which have an impermeable liner. The leachate evaporates at a rate dependent on temperature, precipitation, etc.</td>
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<tr>
<td>Disinfection</td>
<td>Pathogens are destroyed by chemicals or UV light.</td>
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<tr>
<td>Ion Exchange</td>
<td>Removal of inorganics by which ions of a given species are displaced from an insoluble exchange material by ions of a different species.</td>
</tr>
<tr>
<td>Carbon Adsorption</td>
<td>Collection of soluble substances on a suitable interface (e.g., carbon). Removal of BOD, COD, toxic organics and some metals.</td>
</tr>
<tr>
<td>Biological (aerobic, anaerobic, aerobic anaerobic, land treatment)</td>
<td>Microorganisms are cultivated to consume biodegradable organic matter.</td>
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<tr>
<td>Constructed Wetlands</td>
<td>Plant and soil systems are used to filter or destroy organic and inorganic contaminants.</td>
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<tr>
<td>Land Application</td>
<td>Leachate is applied over land to treat the waste by a combination of physical, chemical and biological means (e.g., by spray irrigation).</td>
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routed to a storage tank prior to discharge, and the waste stream or concentrate stream is directed to a concentrate storage tank for recirculation to the landfill or sent off-site for further treatment and/or disposal.

Figure 2 illustrates a typical membrane leachate treatment system. The capital costs associated with this type of system, treating up to 30 gpm (40,000 gpd), range from $600,000 to $2,000,000, including storage tanks as well as the membrane treatment system itself. Operating costs are typically lower than those for a conventional system, ranging from $0.02 to $0.04/gallon, which excludes concentrate treatment, if any.

Spray Irrigation

Spray irrigation, or applying collected leachate over the landfill or other land parcels, is another option for on-site treatment of leachate, typically used with small to medium flow landfills. An impermeably lined pond is necessary to provide storage of the leachate between irrigation periods. The irrigation may occur on closed sections of a lined landfill but is also sometimes used on unlined, undeveloped grasslands. Vaporization during spraying or adsorption by plant life or soils may not remove contaminants from the leachate. Because acceptance of this method is limited, each facility that selects spray irrigation for treatment must acquire approval by regulators.

Capital costs for a system irrigating approximately two million gallons per year (5,000 gpd) of leachate have been estimated to be $300,000, including holding ponds, piping, pumps, spray irrigation equipment and control equipment.

Steps to Selecting Treatment

Choosing the most appropriate leachate treatment option involves the following 11 steps:

1. Information Gathering. Researching the history of the landfill can be invaluable in defining the problem to be solved, both now and in the future. In addition, regulatory agency and POTW contacts should be developed to obtain current and pending regulations which apply to the particular landfill site, other recent landfills permitted in the state and local region and other critical information which would apply to the landfill in question. Accurate assessments of the geology, hydrology, and topography of the site should be available from landfill design studies.

2. Initial Screening of Leachate Treatment Options. Methods that fail to meet one or more of the critical criteria—"musts," such as desired cost per gallon of leachate or desired level of treatment—are removed from consideration. A preliminary discharge agreement should be negotiated with any POTWs involved.

3. Secondary Screening. The technical and economic support team, often an experienced consultant, performs a leachate management assessment study to indicate which of the remaining options are the strongest. A list of "wants" is generated, which can be ranked on a weighted scale. Technical and/or economic decision analysis methods also can be used.

4. First Round of Request for Proposals (RFP-1). RFPs are legally required to be "public noticed" for most publicly owned MSW landfills and must reflect the degree of risk the owner/operator is willing to take for the project—for instance, whether the landfill owner/operator or an outside firm becomes the general contractor. The general contractor is typically responsible for overseeing construction and installation of the leachate treatment system, as well as for performance testing of any onsite system components and development of standard operating procedures.

5. Proposal Evaluation. Again, using a weighted scale for the various criteria can be used to select the top two or three
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proposals. Sales hype should be recognized and should not outweigh previously determined factors critical to the short-term and long-term success of the treatment project.

6. Negotiations with Selected Vendors. If no acceptable proposals are received, often a second RFP (RFP-2) is issued, reflecting changes in responsibility or scope that the owner/operator is willing to accept in order to solicit more favorable proposals. The second round of proposals is reviewed and evaluated—repeating step 5. While two rounds of RFPs are usually sufficient, some projects may require more because of the number of unknowns or changing regulations.

7. System Design and Equipment Orders. The specifications for the design should have been dictated in general in the RFPs, but they can be further refined and reviewed at this time. This step also includes ordering long-lead time equipment and can be undertaken by the vendor and/or the owner/operator. Note that vendor guarantees may be voided if they do not supply all equipment, but this generally does not include force-main piping and structures to house equipment.

8. Construction. This step should be carried out on a preset timetable in order to control costs and timing. While the vendor may or may not be willing to be the general contractor for installation of the equipment, the owner/operator or their representative should be present at critical milestones to monitor the progress and accuracy of the project. Typically, minor and sometimes major design changes must be made in the field in order to overcome unforeseen problems.

9. Equipment Shakedown and Performance Testing. Vendor representatives should be present during this testing to assist in operator training and development of written standard operating procedures. Guidelines for accepting the completion of the treatment facility should be carefully worded, so that the owner/operator has leverage to ensure...
successful completion of this step.

10. Operations and Maintenance. This generally requires state regulatory agency approval beforehand. Due to the variability in leachate flowrate and quality, which can occur both seasonally and over the longer-term operating and post-closure life of the landfill, it is possible that leachate treatment system operations and equipment may change significantly.

11. Decommissioning of the Treatment System. A point eventually is reached when regulations allow leachate collection and treatment to cease. This will likely include removal of all wastes and sludges from the site, cleanup and removal of equipment for sale or scrap and plugging influent and effluent lines as required.

While these steps are not always followed completely or chronologically, they provide the MSW owner/operator with a basis for how to proceed.

References

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Ash Recycling Held Back by State Regulation

Research results gathered over the past three decades prove that ash residues from solid waste incinerators are safe and suitable for reuse, but a patchwork of regulations in many states—not stringent federal guidelines—has kept the material from reaching its recycling potential.

By Marc J. Rogoff and Brian J. Guzzone

Research on the potential for reuse of municipal waste combustor ash was conducted in the early 1960s by the Federal Highway Administration—and almost continuously ever since by a host of other organizations. Despite the effort—and the proof—from recent studies by the U.S. EPA that ash can be used without violating groundwater regulations or impacting human health and the environment, the status of ash from municipal waste combustors (MWCs) has not improved dramatically. MWC ash management remains a political issue and concern—thus, not widely considered as a recyclable commodity.

The Solid Waste Association of North America (SWANA) has conducted two surveys in the past three years to try to provide a baseline of national information on ash management and ash recycling. With the surveys, SWANA hoped to show that ash management practices in the U.S. were sufficient to safeguard the population and the environment—and suitable enough to consider taking steps to convert the material into a useful commodity instead of requiring disposal.

New Federal Rules Have Little Effect on Ash Reuse

SWANA’s first survey, conducted in 1993, showed that the vast majority of states with operating waste combustors had regulations for ash management in place. It indicated that, despite the absence of federal regulations on MWC ash, most of the ash was being tested to determine if it was hazardous and otherwise prudently managed. (See references at the end of this article.)

Despite the obvious record that states had provided sufficient regulatory oversight, the Natural Resources Defense Council pursued a lawsuit seeking more federal regulatory oversight of MWC ash. Ultimately, the U.S. Supreme Court ruled, in mid-1994, that ash is not exempt from testing for hazardous characteristics under regulations supporting the Resource Conservation and Recovery Act (RCRA). EPA followed soon with policy guidance on testing requirements.

EPA issued guidelines requiring waste-to-energy facilities to test their ash residues over a two-week period and to report the results. If one sample failed the test, the facility owners and operators would have to pay to transport all their ash to a hazardous waste landfill. Before EPA initiated this testing program, many facilities installed ash treatment and stabilization systems as well as chemical fixation or immobilization technologies; others already had systems in place that would render ash that could pass the required toxicity tests. Consequently, most facilities passed the mandated EPA toxicity test.

In light of these positive results, EPA re-issued its draft policy guideline in July 1995. This guidance required that all MWC ash would have to be tested to determine if it is hazardous using the EPA’s Toxicity Characteristic Leaching Procedure (TCLP) test. The EPA also ruled that each plant could combine its ash streams into a single stream for testing, as long as it was generated within the confines of the plant enclosure. Ash which fails the TCLP has to be managed as a hazardous waste under RCRA Subtitle C regulations.

While the Supreme Court ruling and new EPA regulations has increased the cost of ash management in the past couple of years, it has resulted in little, if any, real restrictions on ash reuse opportunities. The vast majority of MWC ash streams test non-hazardous, so they should be candidates for beneficial reuse.

So, where is the obstacle to ash reuse? Because the principal hindrance seemed to be state regulations, SWANA recently conducted a new survey of WTE plant owners and operators and state regulators. The focus of the survey was to gauge the current level of interest in and acceptance of beneficial ash reuse.

The survey was sent to 43 state regulatory agency personnel responsible for ash management oversight. The owners and operators of 117 WTE facilities through-

After a long trip by rail, a car dumper is unloading ash at a landfill. More waste combustor ash is traveling farther to reach disposal facilities. SWANA’s ash survey indicated an average one-way distance of 185 miles for ash not disposed on-site or at facilities within the local service area of the waste combustor.

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