DEVELOPMENT OF LEACHATE MANAGEMENT PROCESSES

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Through the active, closure, and post-closure periods of landfill operation, the disposal of leachate can have substantial cost implications for the owner/operator of a site. The selection of a leachate management process should depend on consideration of the problem in several areas. Before selecting a leachate management process areas should be considered, including: regulatory requirements; the nature of the leachate; operational considerations of the landfill site; and available disposal options.

Failure to consider all of these areas can lead to management solutions that are excessively expensive to construct and operate, are difficult to operate, and provide potential compliance problems. Several of these areas involve non-technology issues that are often given cursory consideration in the design of post-generation leachate management systems, but can have the most impact on leachate non-technical management costs.

The following initially discusses the non-technical constraints for leachate disposal. Subsequently, technical considerations for leachate management processes are discussed.

NON-TECHNOLOGY CONSTRAINTS

Non-technology constraints for leachate disposal systems can play a key role in determining system cost and operational requirements.

Regulations on the federal, state, or local level impact leachate disposal systems. In the United States, for example, two substantial federal programs - Resource Conservation and Recovery Act's Subtitle D and the U.S. EPA Clean Water Act program - have significant impact potential.

Subtitle D regulations have caused fundamental changes in the siting, design, and operation of landfills. Leachate management impacts for Subtitle D include a prohibition on liquid disposal (with the notable exception of leachate recirculation for sites meeting specific liner requirements), and the requirement to remove leachate. Individual states vary in their federally approved programs regarding the ability to recirculate leachate.

As part of the Clean Water Act, EPA sets wide, minimum waste water-discharge-quality standards for specific industries. EPA is presently developing such standards for landfill leachates. The standards are projected to be in place by early 1999 and may cause fundamental changes to the way sites handle leachate disposal by establishing minimum discharge limits for leachates. Sites not presently treating leachates either will have to put treatment technologies in place, or find alternative means for managing leachate.

State and local regulations often set requirements in such areas as construction of system and disposal of leachate residues. These requirements often offer opportunities for implementing lower-cost leachate disposal systems that are frequently glossed over in utilizing "standard" post-generation leachate management systems.

NATURE OF LEACHATE

The cost of a leachate management system is heavily dependent on both the quality and quantity of leachate that is generated. Understanding the physical, chemical, geological, and site-related factors that influence leachate generation allows a site to develop management systems that are not excessively over-designed and will operate successfully over a wide range of required conditions.

Important physical factors that influence leachate generation include waste adsorptive tendencies, moisture content, and compaction density. Chemical factors such as the solubilities of waste components, adsorptive/ion exchange capacity of soils and waste, and pH of percolating liquids affect leachate characteristics. Chemical characteristics of the leachate also affect interactions with landfilled wastes, which in turn affect leachate quality.

The types and density of bacterial populations in a landfill, waste degradability/toxicity, and oxygen levels within the landfill are biological factors that produce leachate characteristic effects during the life cycle of a landfill. The leachate produced from an individual cell undergoes quality shifts as the landfill ages. As a cell ages, leachate strength decreases due to maturation of the biological processes within the cell.

Site-related factors also influence leachate characteristics. For example, the climate of a site determines the amount of precipitation and background temperature, which help determine infiltration and the biological environment. A site's hydrogeological characteristics, such as the relative location of groundwater table, soil hydraulic conductivity, and groundwater flow pattern can affect the amount of groundwater flow into a landfill site, which affects the amount of leachate produced. Sites with engineered liners and collection systems are designed to preclude groundwater inflow.

The design/utilization of final/intermediate cover, vegetation systems, and side slopes influence the amount of run-on and infiltration into a landfill. The type of run-off/run-on control, active working face size, use of daily or intermediate cover, and maintenance of cover systems are operational practices that can reduce leachate production. The types of wastes landfilled also affect leachate generation rates and the quality of leachate produced. Other site operating practices such as leachate removal or recirculation can produce changes in leachate character by influencing the biochemical environment of a landfill.

Consideration of the factors involved in shaping leachate quality and quantity, taking into account the aging effects of leachate and staging of site development, can help a site avoid the over-design of a management system. The variability of leachate flow and quality must be taken into account in design/construction of a leachate disposal system. For example, certain technologies vary in response to hydraulic loading. As a result, some leachate disposal systems will require more equalization volume or be sized larger to process the peak flows.

OPERATIONAL AND DESIGN CONSIDERATIONS

Several site operational issues affect leachate disposal system design, construction, and operation, and therefore should be considered in system implementation.

The development of a site (such as a gate receipt rate, phasing plans, and placement of intermediate/final cover) will impact the amount of leachate produced and its overall quality. Evaluating site developmental effects leads to more realistic designs for leachate disposal systems.

Other planned operations at a site, such as composting, landfill gas recovery, or recycling, often can provide economies of scale and scope for leachate disposal operations. These economies can lead to reductions in labor, management, residual management, and technology costs. For example, landfill gas, or recovered heat from landfill-gas-fired generations, can provide energy for use in a leachate disposal system. Automation and control systems can be shared for operations at a landfill site, which can lead to lower costs and better integration of operations.

TECHNICAL CONSIDERATIONS FOR LEACHATE MANAGEMENT SYSTEMS

Disposal options for leachate can be grouped into two categories: off-site and on-site.

Off-site methods of disposal for leachate include off-site shipment to commercial waste treatment (CWT) operations, and shipment/direct discharge to publicly owned treatment works (POTWs). Disposal costs generally are comprised of hauling and user fees. The magnitude of the costs depend on the distance hauled from the site, and market competition factors. The future adoption of categorical treatment standards could severely impact costs for this disposal option by mandating pre-treatment requirements or forcing CWTs to upgrade treatment processes.

On-site leachate disposal methods include:

- Pre-treatment with discharge to POTWs or wetlands;
- Complete treatment with surface, groundwater, or wetlands discharge, or reuse;
- Leachate recirculation;
- Direct wetlands application; or
- Evaporation.

Over the years, myriad technologies have been used to treat/pre-treat/manage leachate. (Table 1 presents a list of many technologies either developed, evaluated, designed, or operated by Rust over the last 14 years.) Individual technologies vary in their ability to adequately dispose of leachate (as measured by compliance, cost, operatability, flexibility, and adaptability). As previously mentioned, selection of an optimum post-generation management technology depends on consideration of all the constraints facing an individual site, not just a technology's performance.

Based on experience gained in operations, design, and evaluation of leachate disposal treatment processes, recent work has centered on process simplification, improving ease of operation, automation, and value-added provision of leachate management processes. This focus has resulted in producing lower-cost management systems that retain desired compliance and adaptability.

The remainder of this paper considers leachate recirculation and leachate treatment technologies.

LEACHATE TREATMENT TECHNOLOGIES DEVELOPED, UTILIZED, AND EVALUATED BY RUST ENVIRONMENT & INFRASTRUCTURE

TECHNOLOGY TYPE	TECHNOLOGY
INORGANIC TREATMENT	▪ Metals, Precipitation Caustics, Lime Sulfide/Organic Sulfur/ Proprietary ▪ Clarification ▪ Ion Exchange ▪ Filtration Granular Media Filter Bag/Pressure Filtration ▪ Stabilization
MEMBRANE TECHNOLOGIES	▪ Reverse Osmosis ▪ Electrodialysis ▪ Ultrafiltration
THERMAL	▪ Evaporation Low Temperature High Temperature
Mechanical-passive	▪ Incineration
BIOLOGICAL (Organic/Nutrient)	▪ Anaerobic/Aerobic Fixed Film Contact Stabilization Sequence Batch Reactor Fixed Film Activated Sludge PAC System
OXIDATION	▪ Peroxide w & wo/UV ▪ Ozone w & wo/UV ▪ Electrolytic
OTHERS	▪ Granular Activated Carbon ▪ Air Stripping Ammonia VOCs Disinfection
LEACHATE RECIRCULATION	▪ Working Face Application ▪ Gravity Wells, Trenches ▪ Infiltration Ponds ▪ Wells Injection
SOLIDS PROCESSING	▪ Dewatering Mechanical Low Temperature ▪ Thermal Incineration Stabilization

LEACHATE RECIRCULATION

Recirculation is a leachate management practice which has been studied for quite some time. It has been a somewhat controversial topic pitting those that believe that the most appropriate landfilling method is to maintain the landfill as a dry tomb against those who believe that the landfill can be operated as a bioreactor to stabilize the landfill more quickly. Much of the reported experience with recirculation has been in the laboratory under very controlled conditions. Full scale recirculation studies have been fewer and more recent in nature. Large scale operational experience is partly available from Europe.

Leachate recirculation has several potential benefits to landfill operation:

> **Attenuation of leachate quantity and quality.** Leachate quantity is reduced by evaporation, and adsorption/confinement of the refuse. Leachate organic strength is reduced by increase contact of the leachate with the biological processes that occur in the landfill. Metals levels are reduced in the recirculated leachate due to adsorption, and because of precipitation that occurs due to destruction of organic materials in the leachate. This leachate attenuation can produce lower leachate management costs for sites.
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> **Increased rate of waste degradation (stabilization).** Laboratory studies have demonstrated that moisture content is the most critical limiting factor in biodegradation of refuse. Additionally, it is thought that moisture transport through the refuse is beneficial to refuse decomposition can take over 30 years in non-recirculated landfills. This period can be reduced by 2-5 times with recirculation. However, refuse moisture levels may have to be raised to 60-70 percent (total weight basis) before degradation rates are stimulated.
>
> **Increased landfill air space and gas generation rates.** These benefits are resultant from the increased rate of landfilled waste degradation, and better waste compaction. If done effectively, leachate recirculation can increase landfill air space by 10-50 percent. Gas production rate increase is roughly proportional the rate of increase of degradation.
>
> **Operation of a landfill as a bioreactor may actually simplify landfill operation.** The bioreactor concept could potentially eliminate the need for other ancillary landfill operations (such as composting and bioremediation piles) and allow for effective co-disposal of select industrial wastes. Leachate recirculation has several potential benefits to landfill operation.

Leachate Recirculation also has some disadvantages.

> **Ponding, seepage, localized accumulation, and severe subsidence caused by short circuiting of leachate.** A landfill is very heterogenous media for liquid movement.

In most cases, excess leachate will be produced which will still require management. Additionally, this leachate may still require additional treatment to meet management restrictions. Alternatively, in arid climates, insufficient recirculation may be produced to facilitate operation of a landfill as a bioreactor. This may require sites change cover practices, or necessitate revisiting (liquid disposal) restrictions imposed by Subtitle D Regulations.

Recirculation may impose limitations or demands on site operators. Recirculation devices may cause landfill traffic concerns, and change waste and cover placement practices. Some recirculation techniques could increase odors and worker's exposure. This is to potential increase the failure of extraction systems due to fouling caused by increased amounts of leachate transported through the system.

LEACHATE RECIRCULATION METHODS

These are several methods for recirculating leachate:

Direct Working Face Application (Either by tanker truck or by hoses)
Drip Irrigation
Vertical Injection Needles
Horizontal Permeable Distribution System
Perforated Piping System
Perforated Manhole
Horizontal Trench

Table 2 contains descriptive information for these methods. Multiple methods are often used at a site to accommodate site operational requirements. For example, a site may use working face application and vertical well and horizontal trenches to distribute leachate to all areas of the site to account for different stages of operation (active, temporarily closed or closed) and different weather conditions.

LEACHATE TREATMENT TECHNOLOGIES

There are several proven technologies for leachate treatment. However, not all technologies are capable of reducing all types of contaminants. Table 3 identifies contaminants that are treated by various technologies. These technologies are further discussed below.

BIOLOGICAL TREATMENT OF LEACHATE

Since dissolved organic constituents, ammonia, and low levels of metals are principal contaminants of leachate, it is not surprising that most existing leachate treatment facilities use biological systems, and considerable evaluation effort has been in the area of biological treatment as biological processes address the previously mentioned contaminants. Biological processes can also remove other contaminants such as oil and grease and nutrients (phosphorous, sulfate, and nitrite/nitrate). Biological processes utilize microorganisms, generally bacteria, to destroy contaminants in leachate. Metal removal is accomplished through adsorption or through the

TABLE 2
LEACHATE RECIRCULATION
COMMONLY UTILIZED METHODS

METHOD	ADVANTAGES	DISADVANTAGES
SURFACE APPLICATION	- Simple Design	- Odor
	- Most evaporation potential	- Weather restrictions (wind, rain)
	- Good coverage	- Health risk
	- Low capital investment	- Surface water contamination risk
	- Least subject to plugging	
	- Easily accessed for maintenance	
VERTICAL WELLS	- Minimal Weather Restrictions	- Poor coverage (without horizontal distribution)
	- No odor	- Susceptible to differential settlement damage (most severe at well location)
	- Simple design	- Subject to plugging
	- Simple implementation	- Repair or maintenance virtually impossible
	- May be easily combined with horizontal distribution lines	- Subject to short circulating of leachate
		- Difficult to maintain vertical levelness
HORIZONTAL WELLS/TRENCHES	- Fair to good coverage	- More sophisticated design, construction requirements
	- Minimal weather restrictions	- Subject to differential settlement damage
		- Repair or maintenance virtually impossible

TABLE 2 (Continued)
LEACHATE RECIRCULATION
COMMONLY UTILIZED METHODS

METHOD	ADVANTAGES	DISADVANTAGES
SPRAY IRRIGATION:		
	- No odor	- Subject to plugging
	- Good coverage	- Sophisticated design, construction
	- Moderate weather restrictions	- Subject to freezing
	- Subject to evapotranspiration (major leachate consumption)	- Subject to surface saturation, odors
	- Easily adjusted for settlement concerns	- Surface water contamination potential
INJECTION NEEDLES		
	- Portable	- Potential crushing of pipes
	- Good coverage	- Subject to freezing
	- Moderate design, construction requirements	- Surface water contamination potential (through pipe leaks)
	- Moderate weather restrictions	- Limited use after capping
	- Easily adjusted and maintained	

Table 3

LEACHATE TREATMENT TECHNOLOGY

TREATMENT PERFORMANCE

TECHNOLOGY	*CONTAMINANT REMOVED/DESTROYED OR CONCENTRATED*									
	SUSPENDED SOLIDS	METALS	RADIONUCLIDES	BOD & COD	OIL & GREASE	AMMONIA	NUTRIENTS	ORGANIC POLLUTANT	CYANIDES	DISSOLVED SOLIDS
A. INORGANIC/PHYSICAL TREATMENT										
Lime Precipitation		X								X
Caustic Precipitation		X								
Ferro/Ferri Precipitation		X							X	
$BaCl_2$ Coprecipitation		X	X							
Sulfide/ org. Sulfide Precipitation		X								
Ion Exchange		X								
Air Oxidation		X								
Clarification	X									
Granular Media Filter	X									
Sand Filter	X									
Bag/Pressure Filter	X									
B. MEMBRANE TECHNOLOGIES										
Reverse Osmosis	X	X	X	X	X	X	X	X	X	X
Electrodialysis	X									X
C. THERMAL TECHNOLOGIES										
Evaporation	X	X	X	X	X	X	X	X	X	X
Ultrafiltration	X				X					
PO*WW*ER	X	X	X	X	X	X	X	X	X	X
Incineration	X			X	X	X		X	X	X

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D. OXIDATION										
Peroxide				X	X			X		
Ozone w/wo UV				X	X			X		
Electrolytic				X	X			X		
E. BIOLOGICAL										
1. Anaerobic										
Fixed Film	X	X	X	X	X		X	X	X	
Sludge Blanket	X	X	X	X	X			X	X	
UASB	X	X	X	X	X			X	X	
Fluidized Bed	X	X	X	X	X			X	X	
PAC	X	X	X	X	X			X	X	
2. Aerobic/Mixed										
Fixed Film	X	X	X	X	X	X	X	X	X	
ASP	X	X	X	X	X	X	X	X	X	
SBR	X	X	X	X	X	X	X	X	X	
MATS	X	X	X	X	X	X	X	X	X	
PAC	X	X	X	X	X	X	X	X	X	
F. OTHER										
Granular Activated Carbon								X		
Air Stripping						X		X		

biological processes involved changing the leachate chemistry by destroying organics and ammonia species which can keep metals dissolved in leachate, thereby allowing the metals to precipitate as hydroxides or carbonates.

Biological processes can be divided into two categories, anaerobic processes and aerobic processes. The processes have two modes of operation: attached growth, and suspended growth. In attached growth the microorganisms involved adhere to a media such as plastic film, carbon, or gravel. In suspended growth operations microorganisms are held in a suspended mixture with the wastewater by mixing. In suspended growth processes, after the biological process is completed the microorganisms are removed by clarification or filtration.

ANAEROBIC PROCESSES

Anaerobic process utilize organisms, generally bacteria, that degrade organic constituents without requiring oxygen. Additionally, anaerobic processes can remove sulfates and nitrites The anaerobic process transforms constituents in leachate to carbon dioxide, methane, nitrogen, hydrogen sulfide, water, and bacteria. (Table 4 provides a list and description of the types of anaerobic processes utilized for treating leachate.) The most common form of anaerobic technology used at leachate treatment facilities is a fixed film reactor.

Anaerobic processes generally require less physical space, and have less capital and operating costs than aerobic processes. However, anaerobic processes do not remove ammonia, and cannot generally treat constituents low levels. Therefore, anaerobic processes for leachate are generally utilized as pretreatment steps for aerobic processes for leachates with high organic strength.

AEROBIC AND MIXED PROCESSES

Aerobic processes utilize organisms that degrade organics and treat ammonia by requiring oxygen. Some technologies utilize both aerobic and anaerobic (anoxic) processes (mixed processes) to allow for complete biological treatment (organics, ammonia, nitrate, nitrite, sulfates). Aerobic processes transform organic contaminants to carbon dioxide, water, and microorganisms. They transform ammonia to nitrate and nitrite (in a process called nitrification). Anoxic (no oxygen) processes convert the nitrite/nitrate to nitrogen (gas - denitrification). Table 5 provides a list and description of the types of aerobic processes utilized for treating leachate.

Aerobic or mixed processes are generally all that is required to treat leachates for discharge to sewage authorities. (These processes provide enough metal removal to meet POTW, and in some cases surface water discharge, requirements). For some surface water discharge situations, additional metals removal (by precipitation) and filtration is required.

Currently, the most common biological technology utilized for leachate is the Sequencing Batch Reactor (SBR). The SBR has high flow and organic strength flexibility and treats leachate to low discharge limits. SBRs are more labor intensive than fixed film processes, but less labor intensive that Activated Sludge Processes (ASP). Fixed Film technologies also provide some (but less) flexibility and less organic loading capacity. Of particular interest for fixed film technologies is a

Table 4

Anaerobic Reactor Types

NAME	DESCRIPTION
Fixed Film	Organisms are grown on a stationary solid surface such as a plastic media, which is kept flooded .
Sludge Blanket	Organisms are present as suspended growth. Mixing is used to keep bacterial and wastewater in contact.
Fluidized Bed	Organisms are grown on a moving surface such as Granular Activated Carbon (GAC). The surface is kept floating or fluidized by pumping or gas production.
Upflow Anaerobic Sludge Blanket (UASB)	Organisms grow on media that is self-constructed by the organism using the carbonate present in the wastewater. The media is fluidized by the methane/carbon dioxide generated by the anaerobic process.
Powdered Activated Carbon (PAC)	Powdered Activated Carbon is added to bacteria to serve as a media for growth and to adsorb "non-biodegradable" or toxic organics.

Table 5

Aerobic or Mixed Reactor Types

NAME	DESCRIPTION
Fixed Film (also MATS)	Organisms are grown on a stationary solid surface such as a plastic media, which is kept flooded .
Activated Sludge Process (ASP)	Organisms are suspended in wastewater in process tank by mixing/aeration. Treated wastewater is separated from organisms by use of clarifier, with organisms either returned to the process tanks or wasted.
Sequencing Batch Reactor (SBR)	A semi-continuous or batch biological process that uses aerobic and aerobic (anoxic) processes to degrade organics and remove nutrients (such as ammonia, nitrite/nitrates, and phosphorous).
Powdered Activated Carbon (PAC) Enhanced Systems	Powdered Activated Carbon is added to bacteria to serve as a media for growth and to adsorb "non-biodegradable" or toxic organics.
Lagoon	A semi-mixed basin that uses aerobic (either forced or natural aeration) and anaerobic (anoxic) process to remove organics and nutrients.

technology called MATS (Microbial and Aquatic Treatment System) which is presently being tested. MATS could provide much better loading and hydraulic flexibility than other fixed film processes. Traditional Activated Sludge Processes have the least hydraulic and loading flexibility, are more difficult to operate than fixed film or SBR processes, and are difficult to use in "mixed" (aerobic and anaerobic) operation.

A variation in SBR and ASP processes is its use powdered activated carbon to enhance treatment. (PAC Process). The PAC process offers no tangible benefits to the vast majority of Municipal Solid Waste leachates. It may be appropriate for some hazardous leachate treatment or if air pollution regulations for biological processes drastically change.

Aerobic (or mixed) biological processes strongest niche for leachate is in POTW discharge situations. Presently, other technologies (R/O, Evaporating incineration) may be cost competitive in surface water discharge or reuse situations where other unit operations may have to be added to biological treatment, particularly when salt (chloride removal) is required.

LEACHATE TREATMENT BY REVERSE OSMOSIS

Various types of membrane processes have been used to treat landfill leachates. These of the most common membrane processes include Reverse Osmosis, Electrodialysis and Ultrafiltration.

Reverse Osmosis (R/O) is a process that is used extensively in Europe and presently making inroads in the U.S. for treatment of leachate. In this process contaminants are removed from a wastewater (like leachate) by pumping the material at high pressure (400 - 3000 psi) through a membrane filter. The filtrate from the process (called permeate) can be discharged but may require additional treatment. The material held back from the membrane (concentrate) can be disposed of through recirculation, stabilization, deep-welling, or a centralized waste treater. The fraction of permeate recovered from the leachate depends on leachate contaminant levels, and the operating pressure and membrane type. Reverse osmosis is the most common membrane technology utilized for leachate treatment.

The types of contaminants that can be removed via reverse osmosis include:

BOD	COD
TSS	Metals
TDS (Chlorides, Sulfates)	Most Priority Pollutant Organics
Radionuclides	Nitrites/Nitrates
Phosphorous Species	Ammonia
Oil & Grease	

Table 6 provides a partial listing of landfill sites in Europe utilizing a specific R/O technologies, including their operational rates and permeate recovery fraction (of total leachate processed).

The quality of the permeate produced depends on the rejection capacity of the membrane for particular constituents. Recent improvements in R/O technology have centered on improving rejection performance for membranes (especially for ammonia and small molecular weight volatile organics), and improving the concentration of the contaminants in the wastewater and therefore decreasing the amount of concentrate that must be managed off-site. Although R/O has improved in treating leachates, additional treatment may be required for the permeate:

- If the permeate will be discharged to surface water, then it requires aeration and passage through a carbonate column prior to discharge.
- If the leachate contains appreciable levels of volatiles (such as Acetone, MEK, methylene chloride), secondary treatment of the permeate may be required. This treatment could include use of a secondary stage of reverse osmosis or air stripping, or chemical oxidation, or biological treatment, or carbon adsorption.

As indicated earlier, various options can be used for concentrate management. The concentrate from a non-hazardous leachate may be recirculated under certain conditions. Site should be aware that the concentrate produced by R/O is probably not stimulatory (and may be in fact inhibitory) to anaerobic processes in the landfill. However, this potential inhibitory may not be enough to actually prevent methanogenesis in a landfill.

The concentrate can be sent off-site for either deep welling or to another Centralized Waste Treater. Otherwise the brine can be stabilized and landfilled. The concentrate produced from an R/O system can be further reduced by additional processing with evaporation of with an additional R/O stage.

<u>The advantages of R/O for treating landfill leachate are:</u>

1. High quality effluent can be produced (especially if relatively low levels of volatiles and phenol are present in the leachate).
2. The operation is relatively simple and requires primarily mechanical maintenance (low operator attention).
3. The R/O units generally come in modules that are relatively easy to install and require smaller footprints when compared to more conventional treatment units.
4. The R/O process is a mechanical operation and can be started and stopped to accommodate intermittent leachate flow.
    (1) Units can be placed into and out of operation in modules to accommodate expansions and shut downs.
    (2) MSW sites with intermittent leachate generation or discharge requirements. The cost advantages for the above sites of R/O are enhanced if the concentrate can be recirculated.

Disadvantages of R/O include:

1. Brine disposal costs can be high in the cases where a site cannot recirculate the leachate or if the leachate is hazardous.

2. R/O Systems do not have as good of volume fluctuation performance (when a leachate generates large quantities of leachate relative to average) and may require more equalization storage or be sized larger to accommodate high leachate generation events at a site.

3. If the concentrate from an R/O system is recirculated, care must be exercised not to overload disposal areas with large amounts of high salt concentrate, as landfill biological activity can potentially be inhibited.

EVAPORATION AND THERMAL TECHNOLOGIES FOR LEACHATE MANAGEMENT

Thermal technologies can be used for leachate management. Generally water is volatilized from the leachate, leaving concentrated contaminants which can be recirculated, solidified, dried to solid state, or deep welled. Evaporation processes used for leachate have been generally either passive (evaporation pond) or mechanical/thermal. Alternatively, leachate can be incinerated.

Evaporation ponds are generally utilized in arid or semi-arid regions to manage leachate. Often an aerator is used to increase the rate of evaporation. Also heating (either using a heat exchanger or passive solar heaters) can also be used to increase the rate of evaporation. Mechanical-Thermal Evaporators utilize a heating source (for which fuel can be supplied by landfill gas) to concentrate leachates. Often the stream (evaporated leachate) produced must be further treated by use of an incinerator or catalytic incinerator or condensed and treated by air stripping, oxidation or granular activated carbon. The steam can be air discharged or condensed and reused on site or surface water discharged.

Leachates can be directly incinerated by use of incineration processes. Leachate can be injected into a gas flare and burned at a high (~ 900°F temperature). Dissolved salts from the leachate may be changed to acid vapor which requires pollution control (scrubbing) from the discharge. Metal fumes from the process may also require pollution control.

Evaporation and Thermal Technologies can be best applied to sites with low leachate flows, arid locations, and relatively low gas volume (where gas recovery and reuse is not economical), or in remote locations where other management options are not available. These processes do not have good hydraulic flexibility and larger (more conservatively sized) storage and process capacity must be provided than other management technologies. Mechanical Thermal Evaporation and Incineration processes may require robust metallurgy construction and may require air pollution controls.

CONCLUSION

By considering all of the constraints for leachate management, both non-technical and technical, sites can produce leachate management systems that are relatively inexpensive, easy to operate, and achieve consistent compliance with regulations.