GEOS 3310 Lecture Notes: Waste Management

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Solid Waste Management

Introduction

Solid waste management is a large and growing industry in the U.S. as waste volume and population continue to increase:

- the average American produces 4.5 lbs of trash per day, which totals 236 million tons per year

- around half of U.S. cities are running out of landfill space

- new landfills are unpopular, and difficult to establish

- ultimately the optimum solution is a combination of source reduction, recycling, composting, landfill and incineration termed *integrated waste management* (Fig. 1)

- integration has also fostered growth of a few large companies that manage much of the waste in the U.S. (e.g. Waste Management, Inc. with 22 million customers and around 300 active landfills)

Urban Waste Composition

TABLE 17.1 Generalized Composition of Urban Solid Waste (by Weight)

Material	Percentage
Paper	38
Yard waste	18
Plastics	8
Metals	8
Food waste	7
Glass	7
Other	14

U.S. Environmental Protection Agency. 1998. Office of Solid Waste. Accessed 10/9/98 at www.epa.gov

Figure 1: Composition of urban solid waste 1998 [Tbl. 17.2, Keller, 2008]. The two largest categories, paper and yard waste can be readily reduced through recycling and composting.

Early Waste Management

Prior to large scale industrialization, relatively simple approaches to waste management were sufficient: [Fig. 17.8, Keller, 2008]

- "*Dilute and disperse*", e.g. disposal of industrial waste directly into rivers. Successful only when few such sites are active

- "*Concentrate and contain*" became the principal approach, moving waste to relatively few sites that could be "controlled"

- in the 1970's it became clear containment was rarely complete, and it was proposed to either apply *resource* *recovery* (convert old wastes into new usable material, only marginally successful) **or**:

- *integrated waste management*
  - emphasizes *reduce, reuse, recycle* for minimization of waste storage in landfills
  - result so far has been to reduce household waste contribution to landfills from 90% to 50%

Disposal of Solid Waste

Disposal of Solid Waste

- *On-site disposal*: transformation of waste, e.g. mechanical grinding or garbage disposal

- *composting*: transformation (decomposition) of organic waste, generating a useful fertilizer. Separation of organics from the general waste stream can be difficult.

- *Incineration*: burning of waste, either solid or liquid
  - useful as an alternative heat source, air pollution a negative
  - reduces waste volume by same amount as reduction/recycling
  - only feasible method for difficult wastes (e.g. chemical weapons)

- *Open Dumps*: uncontrolled surface disposal. Was the standard method until the mid-1970's. Leakage from such dumps is a major source of contaminants [Fig. 17.3, Keller, 2008]

- *Sanitary Landfill*:
  - carefully designed to minimize downward leakage of *leachate* and upward leakage of *methane* gas [Fig. 17.5, Keller, 2008]
  - Case studies:
    * British house explosions adjacent to landfill
    * Belmont Shores Mobile Estates, Los Angeles. Explosion of mobile home with one death. Active monitoring today.
  - site selection:

    - arid regions are best, dry lakebeds often good locations
    - humid regions: leachate is inevitable, so low-perm host sediments are best site
  - Design
    - generally a plastic liner is first, containing a leachate removal system above
    - above that is compacted clay liner
    - when landfill is closed, a clay cap is added to minimize infiltration from above
    - after closure monitoring wells, leachate and methane removal systems are operated for at least 30 years afterward
  - leachate and methane recovery systems (Fig. 2) are now standard on most landfills
    - Texas has 24 active landfill gas projects

$*$ closest is the McCommas Bluff landfill in Dallas

Methane-Leachate Recovery

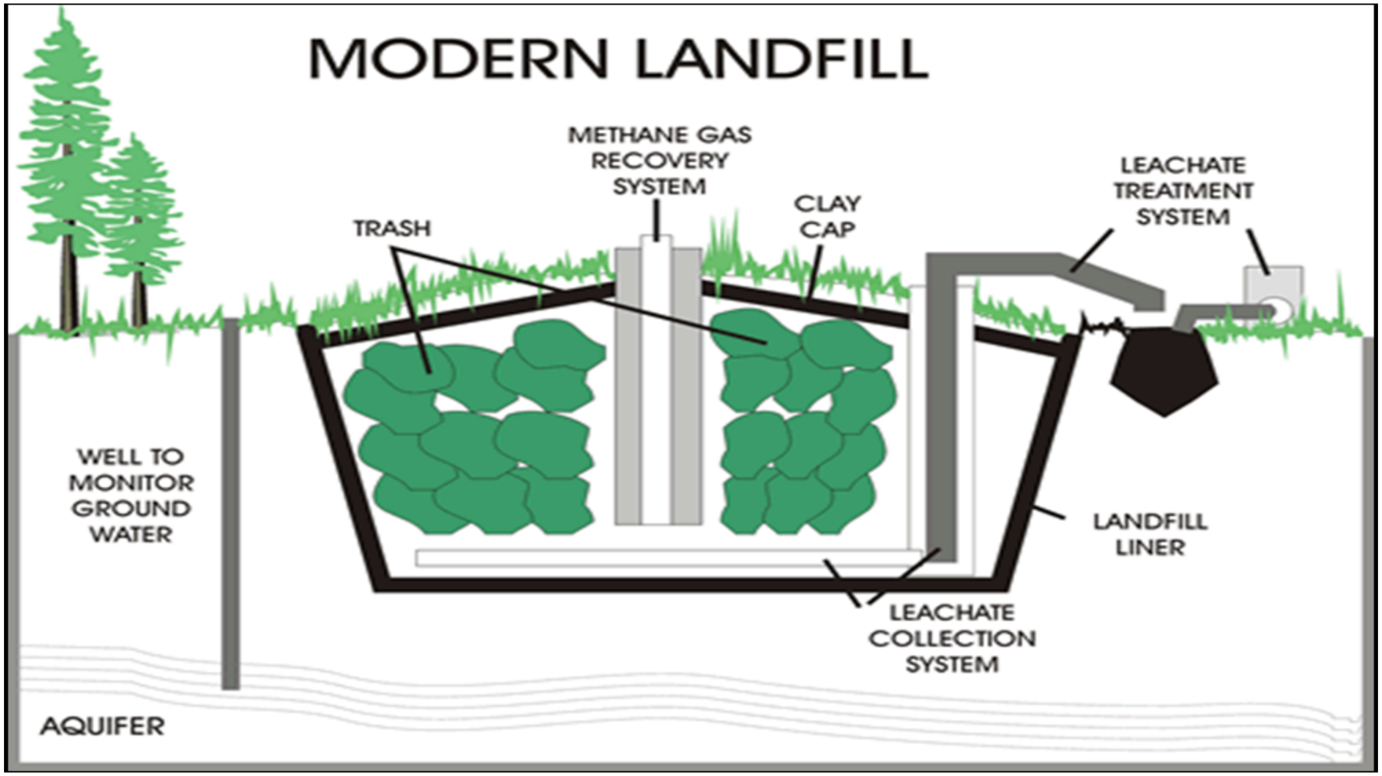

Figure 2: Landfill methane recovery design, as encouraged by EPA. After Utah State University .

Ocean Dumping

- essentially so much waste is produced that offshore dumping is "required"

- EPA allows dumping of materials known not to affect ocean health and expected to be immobile

- these include dredge spoils, solid and construction waste, some industrial wastes

- while continued dumping is undesirable, it is likely to remain a fact of life (as well as ocean pollution) for much of this century

Disposal of Liquid Waste

Hazardous Waste Law

- *hazardous waste* is generally in liquid form, and is heavily regulated in the U.S.

- *RCRA*: Resource Conservation and Recovery Act (1976), "cradle to grave" management of hazardous chemicals to avoid future contamination
  - established controls on the manufacture, distribution and disposal of hazardous waste
  - chemicals are maintained in a chain of custody for most highly toxic, corrosive or explosive/unstable substances

- *CERCLA*, Comprehensive Environmental Response Compensation and Liability Act (1980):

- provided funds for cleanup of earlier contaminated sites
- main program is *Superfund* (now depleted

- *SARA*, Superfund Amendment and Reauthorization Act: limits liability for pre-existing contaminant plumes provided an *environmental audit* is performed prior to commercial real-estate transfer

Hazardous Waste Disposal

A large variety of land-disposal methods are available, none of them perfect Keller [Fig. 17.13, 2008]

- *Secure Landfill*: landfill designed to fully contain or treat high-volume leachate settings [Fig. 17.10, Keller, 2008]

- *Surface Impoundment*: a surface pond. Most common method prior to 1970's, usually leak heavily and evaporate hazardous chemicals

- *Deep-well disposal*: injection deep underground. Good for otherwise-unmanageable wastes (e.g. chemical weapons). Oilfield brines are most common material disposed-of. Also prone to earthquake hazard [Fig. 17.11, Keller, 2008] . Can be prone to leakage, and must be monitored, [Fig. 12.11, Keller, 2000] .

- *Incineration*: combustion at extremely high temperatures, converts waste to carbon dioxide and water. Only option for some “nasty “ chemicals [Fig. 17.12, Keller, 2008] .

Radioactive Waste

Waste Disposal Methods

- two main categories, low and high-level waste
- *Low-Level Waste*: [Fig. 12.15, Keller, 2000] .
  - typically medical wastes, etc.
  - must be kept away from accessible environment for *500 years*
  - typically 2-3 states will form a compact and bury each other's wastes.
  - Texas had a compact with Vermont and Maine which seemed likely to be controversial
    - we would store waste first
    - after about 20 years, Vermont or Maine would store our waste

- High-Level Waste
  - very nasty, must be kept away from accessible environment for *10,000 years* [Fig. 12.14, Keller, 2000] .
  - a few centralized facilities are available
    - WIPP site for defense-related waste in NM
    - Yucca Mountain, NV , still being evaluated
    - Yucca Mountain Repository likely to be abandoned as of Spring 2009
    - Skull Valley, UT proposed for "temporary" surface storage of commercial reactor waste. Viewed as an important potential source of income by a very poor Indian tribe
  - very problematic to try to understand and predict system for that time period:

* WIPP site is in salt, and is experiencing great problems with liquid migrating as isolated pores in the malleable salt [Bredehoeft, 1988]
* Yucca Mountain was found to have 10-100 times more water moving through the proposed repository than predicted [Flint et al., 2001]

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