1. INTRODUCTION

Many different hazardous waste treatment technologies can be used prior to ultimate disposal. Their aims are modification of the physical and/or chemical properties of the waste. They reduce volume, immobilize toxic components or detoxify. The choice of the best practicable way of treating a given waste depends on many factors, including the availability and suitability of disposal or treatment facilities, safety standards, and cost considerations. No disposal route offers absolute safety, and any waste treatment or disposal technology has an associated level of risk.

Selection of a treatment process for a given waste stream is not easy and involves consideration of: the nature of the waste, the desired characteristics of the output stream, the technical adequacy of the treatment alternatives, economic and financial considerations, environmental considerations, energy considerations and the making of an overall evaluation.

Hazardous waste management involves prevention, treatment and disposal. Prevention includes both waste and volume reduction. One aim of any hazardous waste management strategy should be to reduce to a minimum the quantity of hazardous waste that must be managed and that requires disposal. Treatment and disposal techniques render the wastes less hazardous and dispose of them in a manner such that environmental and human health problems do not occur. Land disposal of hazardous waste can be an economically and technically sound management approach but it requires an engineered design to control pollutants. A good understanding of the stringent requirements of proper landfilling is of prime importance for the management of hazardous wastes.

2. TYPICAL TREATMENT TECHNOLOGIES

Some of the treatment processes identified are:

2.1 PHYSICAL TREATMENT

These processes include various methods of phase separation and solidification. At the most basic level, phase separation encompasses lagooning, sludge drying in beds, and prolonged storage in tank processes. All three depend on gravitational settlement, and the first two also allow the removal of liquid by decanting, drainage and evaporation. Lagooning and tank storage are widely used to separate oil and water from mixed wastes, sometimes following preliminary treatment with emulsion breaking agents and occasionally, in the case of tank storage, combined with heating. A development of this last method is the burning of the recovered oil to raise process steam for tank heating.

For example, solidification or fixation processes convert the waste into a insoluble, rock-hard material, and they are generally used as pretreatment prior to landfill disposal. The conversion is achieved by blending the waste with various reactants to produce a cement-like product.
2.2 CHEMICAL TREATMENT

Chemical treatment methods are used both to facilitate the complete breakdown of hazardous waste into non toxic gases and, more usually, to modify the chemical properties of the waste (e.g., to reduce water solubility or to neutralize acidity or alkalinity).

Some examples of chemical treatment are:

- **Neutralization.** Aqueous solutions of mineral acids arise in large quantities from engineering firms and chemical industries. Slaked lime is the cheapest alkali available and is therefore usually chosen for large-scale acid neutralization. Alkaline waste is also arises mainly from engineering and chemical works, but its composition varies much more than of acid waste and recovery of useful materials at disposal sites is even more difficult. For needed acid addition, sulphuric (H2SO4) and hydrochloric (HCl) acids are most commonly used.

- **Heavy Metal Precipitation.** Plating effluents often contain in solution various heavy metals such as copper, nickel or zinc. These are subsequently removed by the addition of an excess of slaked lime or sodium hydroxide to precipitate them as water insoluble compounds.

- **Solvents/Fuels Recovery.** Combustible organic solvents are frequently toxic and their vapours when mixed with air can be explosive. Most of this waste is recoverable and, indeed, often is recovered at the source. Where this is not possible, combustion would usually be the most appropriate method of disposal.

2.3 BIOLOGICAL TREATMENT

Many industrial wastes are treated by biological methods similar to those used for sewage treatment. Hazardous waste is occasionally amenable to such treatment, even though the concentrations of toxic materials present are often lethal to microorganisms. Major industrial users of land treatment have included petroleum refining, industrial organic chemicals, wood preserving, petroleum production, plastics, residues and paints and allied products. The in-plant biological treatment of dilute aqueous effluents is well established, and microorganisms have been developed to selectively degrade specific toxic chemicals. For example:

- Laminate factory effluent Hydrabad Phenol is mixed with domestic waste in ratio of 1:3 and treated with activated sludge with 95 to 98% removal of phenol.

- Trichlorophenol containing liquid effluent is treated entirely by itself with addition of N & P in activated sludge plant with removal efficiency of 95 percent plus.

The natural microbiological activity in toppsili is also used in farming for degrading some organic chemicals, notably oil waste. Composting may also be useful for certain organic chemical products.

2.3 THERMAL TREATMENT

- **Incineration.** It is an ultimate disposal process, applied to certain wastes that can not be recycled, reused or safely deposited in a landfill site. It is a high temperature, thermal oxidation process in which hazardous wastes are converted, in the presence of oxygen in the air, into gases and an incombustible solid residue. The product gases are released to the atmosphere, with or without gas cleaning, and the solid residues are landfilled. However, the risk of causing nuisance and environmental pollution from emission of particulates, acidic gases, unburnt waste and trace quantities of hazardous organic by-products should be appreciated when selecting equipment and siting hazardous waste incineration facilities.

- **Pyrolysis.** It's a system where waste is broken down into less complex materials through the application of heat in the absence of oxygen. Potential advantages include lower support fuel usage and reduced emissions.
# Typical Treatment Technologies

<table>
<thead>
<tr>
<th>PHYSICAL</th>
<th>CHEMICAL</th>
<th>BIOLOGICAL</th>
<th>THERMAL</th>
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<tbody>
<tr>
<td>Adsorption</td>
<td>Calcination</td>
<td>Activated sludge</td>
<td>Incineration</td>
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<td>Centrifugation</td>
<td>Catalysis</td>
<td>Aerated lagoon</td>
<td>Pyrolysis</td>
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<td>Distillation</td>
<td>Neutralization</td>
<td>Anaerobic digestion</td>
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<td>Electrodialysis</td>
<td>Electrolysis</td>
<td>Composting</td>
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<td>Evaporation</td>
<td>Hidrolysis</td>
<td>Enzyme treatment</td>
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<td>Filtration</td>
<td>Precipitation</td>
<td>Waste stabilization pond</td>
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<td>Flocculation</td>
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<td>Ion exchange</td>
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<td>Sedimentation</td>
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<td>Liquid-liquid extracting</td>
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<td>High gradient magnetic separation</td>
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<td>Air stripping</td>
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<td>Suspension freezing</td>
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<td>Refining</td>
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<td>Crushing and Grinding</td>
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<td>Cryogenics</td>
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<td>Dissolution</td>
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<td>Reverse osmosis</td>
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3. DISPOSAL TECHNOLOGY - SECURE LANDFILLS

A landfill is a disposal facility where hazardous wastes are placed into and stored in the soil. Landfills for hazardous wastes frequently are considered a technology of last resort to be used after every effort has been made to reduce or eliminate the hazards posed by the wastes. The intent is to bury or alter the wastes so that they are not environmental or public health hazards.

Landfills are not homogeneous and are usually made up of cells in which a discrete volume of a hazardous waste is kept isolated from adjacent waste cells by a suitable barrier. Barriers between cells commonly consist of a layer of natural soil (clays) which restrict downward or lateral scape of the hazardous waste constituents or leachate.

A hazardous waste landfill must be designed and operated to be a secure permanent burial site for the hazardous waste. The design and construction of such a landfill attempt to prohibit contact between the landfill contents and the surrounding environment. The primary concern at landfills is to prevent groundwater contamination. Design and management emphasize prevention of leachate formation and migration. Prevention methods include: (a) elimination of free liquids (liquid waste should be dewatered or solidified before placement), (b) diversion of surface waters (runon), (c) use of relatively impermeable daily and final cover to minimize infiltration of precipitation, (d) compaction of wastes, (e) use of cells throughout the landfill, (f) collection and treatment of leachate, and (g) groundwater monitoring.

The ideal hazardous waste landfill is one which is underlain by many meters of impermeable clay in a non-seismic zone. Hazardous waste landfill should not be placed above a draining water aquifer. Plans for adequate record-keeping should be made. The location and dimensions of each cell in the landfill should be recorded, as should the contents of each cell. For future needs, the location and dates of each type of waste material placed in the cells should be recorded.

An initial step in developing a secure landfill for hazardous wastes is to determine the type and characteristics of the material that will be placed in it. Information on the estimated waste volume, and the physical and chemical properties of the materials expected to be landfilled is important to the actual design and management, as well as to the determination of area and volume requirements and equipment needs.

REFERENCES

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2. Guidelines for industrial and urban waste disposal in Latin America; K. H. Striegel; State Agency for Water and Waste Northrhine-Westfalia, Dusseldorf, Germany.

3. Guía para el Diseño de Rellenos de Seguridad en América Latina; Striegel, K. H.; Benavides, Livia; CEPIS/PAHO; Draft Paper.
FIGURE 1

HAZARDOUS WASTE MANAGEMENT STAGES

GENERATION OF WASTES

CONDITIONING

SEGREGATION

RECYCLING

STORAGE

TREATMENT

FINAL DISPOSAL

COLLECTION

TRANSPORT

RECYCLING

TREATMENT

FINAL DISPOSAL
TREATMENT OPTIONS FOR HAZARDOUS WASTES

- PHYSICAL
  - SEDIMENTATION
  - SOLIDIFICATION
- CHEMICAL
  - PRECIPITATION
  - OXIDATION
  - REDUCTION
  - NEUTRALIZATION
  - SEPARATION
- THERMAL
  - INCINERATION
  - PYROLYSIS
- BIOLOGICAL
  - ANAEROBIC DIGESTION
  - LAND APPLICATION
TYPICAL PHYSICAL CHEMICAL TREATMENTS

1) SLUDGE THICKENING

PURPOSE
TO REDUCE THE VOLUME OF SLUDGE TO STABILIZE, DEWATER AND DISPOSE OF

METHODS
A) GRAVITY
B) FLOTATION
C) BY CENTRIFUGE
TYPICAL PHYSICAL CHEMICAL TREATMENTS

- **2) SLUDGE DEWATERING**

- **PURPOSE**
  TO REDUCE THE VOLUME OF SLUDGE THROUGH THE EXTRACTION OF WATER.
  SLUDGE CAKE SOLID CONTENT VARIES FROM 20 TO 50%

- **METHODS**
  1) DRYING BEDS
  2) VACUUM FILTRAITION
  3) BY CENTRIFUGE
  4) PRESS FILTERS
TYPICAL PHYSICAL CHEMICAL TREATMENTS

3) NEUTRALIZATION

PURPOSE
PROCESS OF ADJUSTING EITHER AN ACIDIC OR A BASIC WASTE STREAM TO A pH NEAR NEUTRALITY

EXAMPLES OF INDUSTRIES THAT UTILIZE NEUTRALIZATION:
- BATTERIES
- INORGANIC CHEMICALS
- IRON AND STEEL
- EXPLOSIVES
- SOAP AND DETERGENT
- PHARMA CENTICICAL
- TEXTILES
TYPICAL PHYSICAL CHEMICAL TREATMENTS

4) PRECIPITATION

PURPOSE:

TO TRANSFORM SUBSTANCES, MAINLY HEAVY METALS, INTO SOLIDS

EXAMPLES:

- HIDROXIDES M(OH)2
- SULFIDES MS
TYPICAL PHYSICAL CHEMICAL TREATMENTS

» 5) REDUCTION OF CHROMIUM (VI) TO THE RELATIVELY NON TOXIC CHROMIUM (III)

» MAINLY WITH FERROUS SULPHATE

» 6) CONVERSION OF CYANIDE TO CYANATE BY OXIDATION

» OR TO NITROGEN AND CARBON DIOXIDE MAINLY WITH CHLORINE
7) SLUDGE SOLIDIFICATION

PURPOSE:

TO CONVERT THE SLUDGES (WASTES) INTO AN INSOLUBLE, ROCK HARD MATERIAL BY BLENDING IT MAINLY WITH CEMENT OR FLY ASHES TO PRODUCE SOLIDS OF A THAT CAN BE READILY TRANSPORTED COARSE-GRAINED, SOIL-LIKE CONSISTENCY BY TRUCK TO A DISPOSAL SITE
Figure 7.4-11
Rotary Kiln

FIGURE 7.3-3

Schematic of a Hazardous Waste Injection Well

INDUSTRY A
Polluter

SUPPLY

WASTE CLEARING-HOUSE

DEMAND

INDUSTRY B
Potential user of wastes

INFORMATION

WASTE EXCHANGE (negotiations)

INFORMATION
INDUSTRIAL WASTE CLEARINGHOUSE
(WASTE EXCHANGE)

ADVANTAGES:

- WASTE MINIMIZATION
- SAVINGS IN PRODUCTION, TREATMENT AND FINAL DISPOSAL COSTS
- LESS CONSUMPTION OF RAW MATERIALS
- ENVIRONMENTAL AND HEALTH PROTECTION
- NEW TECHNOLOGIES FOR RECYCLING AND RECOVERY OF WASTES (POLLUTION ABATEMENT)
- CREATES JOB OPPORTUNITIES
INDUSTRIAL WASTE CLEARINGHOUSE
(WASTE EXCHANGE)

HOW DOES IT WORK?

- Disseminates information on what wastes are available.

- Identifies the polluters.

- Promotes the exchange of wastes among generators and users.

- Facilitates the transfer and recycling of wastes using a data base.

- Identifies options for wastes and by-products use.
Contaminant Transport from a Land Disposal Site
<table>
<thead>
<tr>
<th>Class of criteria</th>
<th>Hydrology and groundwater protection</th>
<th>Nature reserve</th>
<th>Settlement infrastructure</th>
<th>Mining</th>
<th>Hydrogeology</th>
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<tbody>
<tr>
<td>Large scale</td>
<td>- margin and valleys</td>
<td>- nature reserve</td>
<td>- large construction projects</td>
<td>- artificially drained depressions due to mining influence</td>
<td>- geological formations with permeability k &gt; 1x10^-7 m/s; (large scale)</td>
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<td>- important groundwater reservoirs</td>
<td>- natural forests</td>
<td>- settlements and its surroundings</td>
<td>- future mining areas and raw material deposits</td>
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ANTI-HAZARDOUS TYPE LANDFILL SITE
Schematic Cross-Section of a Secure Landfill
FIGURE 7.1-7

Schematic Diagram of a HSWA* Double Liner System and an EPA Synthetic/Clay Liner for a Landfill

Source: EPA

SCHEMATIC DIAGRAM OF A COMPOSITE DOUBLE LINER SYSTEM FOR A LANDFILL

Source: EPA

SCHEMATIC DIAGRAM OF A HSWA* DOUBLE LINER SYSTEM AND AN EPA SYNTHETIC/CLAY LINER FOR A LANDFILL

*Thickness to be determined by breakthrough time for EPA synthetic/clay liner
Thicknes 2 feet for HSWA* double liner

*Hazardous & Solid Waste Amendments of 1984 (USA)