

Hazardous Wastes Management

Hazardous Waste: A hazardous waste has physical, chemical or biological characteristics which cause potential danger to human beings, other creatures, microorganisms, property or the environment.

In general, hazardous wastes have one or more of the characteristics – corrosivity, ignitability, reactivity, radio activity, toxicity, carcinogenicity, mutagenicity, bioaccumulation and phytotoxicity.

For a hazardous waste to be a risk, a person, animal, or plant must be exposed to it, and exposed in a way that can cause harm. Unless the waste has escaped into the environment, the greatest hazard is usually to the workers handling it.

Corrosive, ignitable, or reactive wastes can also harm materials, as when a corrosive waste “eats” a metal container.

Human Exposure Pathways for Hazardous Wastes

Human population is mainly exposed to hazardous wastes thorough inhalation, ingestion and dermal exposure. The main pathways are shown in below:

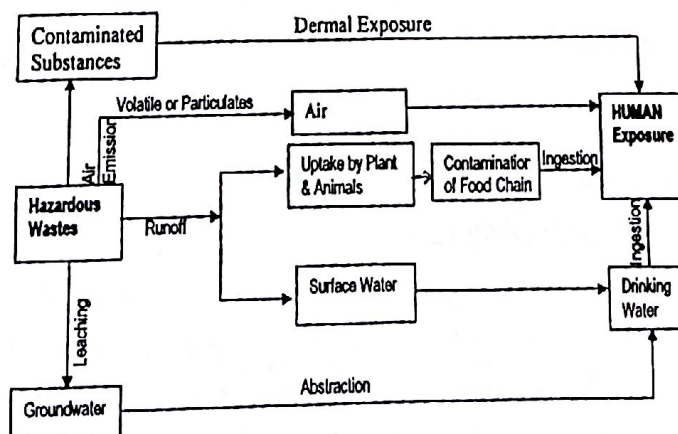
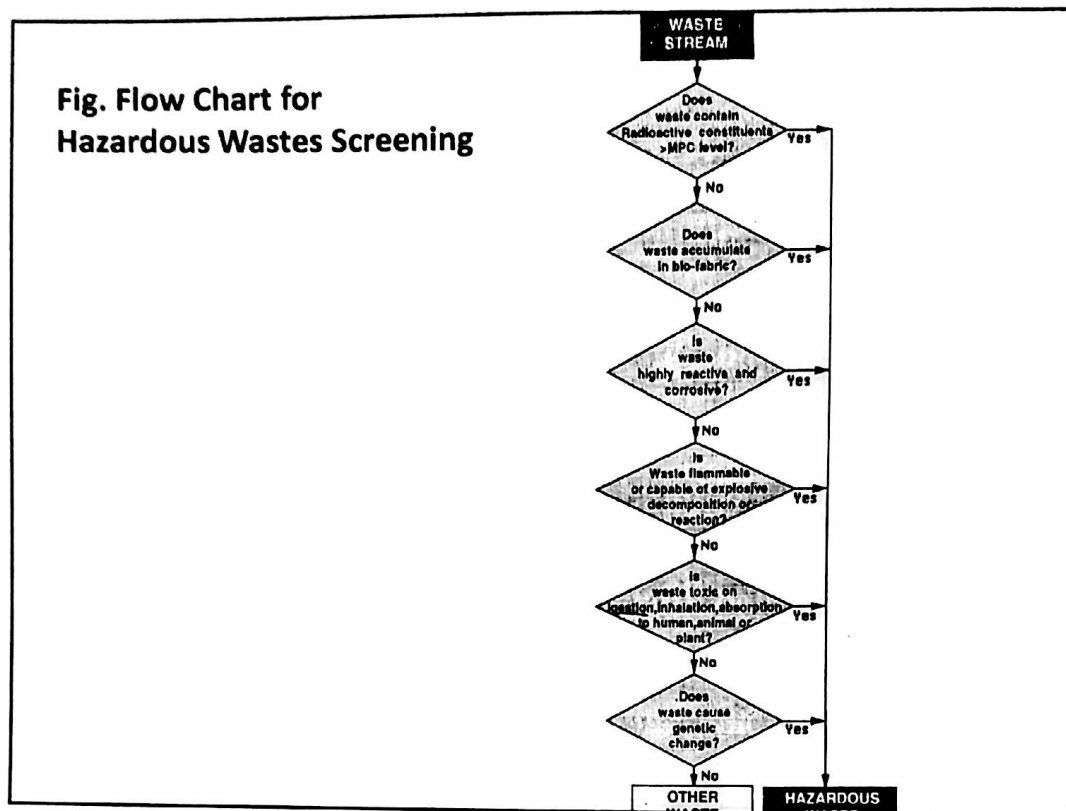


Figure: Pathways of Human Exposure to Hazardous Wastes

**Fig. Flow Chart for
Hazardous Wastes Screening**



Review of Treatment and Disposal Options for Hazardous Wastes

Problems in Hazardous Wastes Treatment and Disposal

- Technological limitations
- Involves some degrees of risk
- Involves cost

Problems in Developing Countries

- Poor control in storage, handling, transportation & disposal
- Scattered in small quantities in units that generate wastes
- Producers are unaware of short and long term effects
- Limited organizational capacity, skills and financial resources
- Many other problems receive attention over hazardous wastes

Five General Categories of Hazardous Wastes

- Radioactive substances
- Toxic Chemicals
- Biological Wastes
- Flammable Wastes
- Explosives

Classification for Processing and Treatment Operations

- Inorganic chemicals of low toxicity
- Inorganic chemicals with toxic metals/compounds
- Organic chemical with low toxicity
- Organic chemicals with toxic metals/chemicals
- Radiological wastes
- Biological wastes
- Flammable wastes
- Explosives

Hazardous Waste Minimization

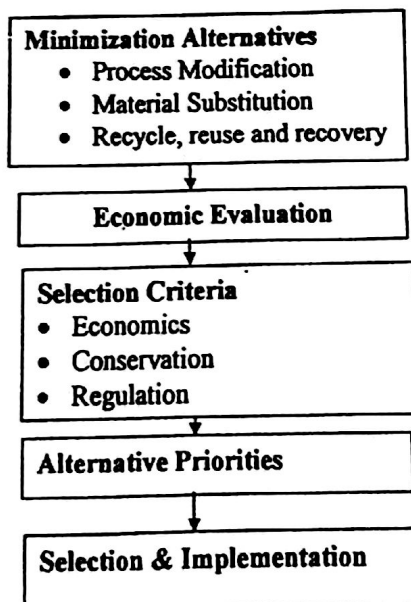


Fig. : Selection Process of Hazardous Wastes Minimization

Potential Management Priorities for Hazardous Wastes

1. Comply with laws and regulation
2. Reduce disposal cost and resource commitment
3. Reduce short-term liabilities during waste processing, transportation and storage
4. Eliminate long-term landfill liabilities
5. Ensure reliability of the technology
6. Protect environment and human health
7. Provide employee incentives
8. Provide organizational incentives
9. Improve public and community relations
10. Enhance corporate image

Potential Process and Operation Alternatives for Waste Minimization

1. Exhaust Pollution Prevention Alternatives
2. Education and training of employee Improve house keeping
3. Assure quality materials procured
4. Improve handling and distribution of materials
5. Substitute materials that are likely to generate wastes
6. Modify process operating conditions
7. Improve process control and operating conditions
8. Recycling wastes to other processes
9. Recover wastes for other uses
10. Modify maintenance procedure
11. Modify process equipment
12. Modify materials of construction
13. Modify product specification
14. Treatment of waste to reduce quantity
15. Treatment of wastes to reduce risk of hazards
16. Treatment of wastes to render it nonhazardous

The above mentioned potential management priorities and potential process and operation alternatives can be used as a checklist for the development, implementation and control of successful waste minimization program.

Table 1: Treatment Processes Suitable for Different types of Wastes

Operations/Processes	Functions Perform	Type of Wastes	Forms of Wastes
PHYSICAL TREATMENT			
Solidification/Encapsulation	St	1, 2, 3, 4, 5, 6	L, S
Aeration	Se	1, 2, 3, 4	L
Carbon Absorption	Vr, Se	1, 3	L, G
Stripping	Vr, Se	1, 2, 3, 4	L
Sedimentation/Flotation	Se, Vr	1, 2, 3, 4, 5, 7	L
Centrifugation	Se, Vr	1, 2, 3, 4, 5	L
Flocculation/Settling	Se, Vr	1, 2, 3, 4, 5	L
Filtration	Se	1, 2, 3, 4, 5	L
Reverse Osmosis	Se, Vr	1, 2, 3, 4, 6	L
Evaporation	Se, Vr	1, 2, 3, 4, 5, 6, 7, 8	L
CHEMICAL TREATMENT			
Neutralization/Precipitation	De	1, 2, 3, 4	L
Coagulation/Sedimentation	Se, De	1, 2, 3, 4, 5	L
Ion exchange	Se, De	1, 2, 3, 4	L
Chlorination/Ozonation	De	1, 2, 3, 4	L
Reduction	De	1, 2	L

Operations/Processes	Functions Perform	Type of Wastes	Forms of Wastes
BIOLOGICAL TREATMENT			
Waste Stabilization Ponds	De	3	L
Aerated Lagoon	De	3	L
Activated Sludge	De	3	L
Trickling Filters	De	3	L
Anaerobic Digestion	De	3	L
Anaerobic Filtration	De	3	L
THERMAL TREATMENT			
Incineration	Vr, De	3, 4, 5, 6, 7	S, L, G
Pyrolysis	Vr, De	3, 4, 6	S, L, G

Functions: De - Detoxification; Se - Separation; St- Storage; Vr- Volume reduction
Waste type: 1. Inorganic chemicals of low toxicity 2. Inorganic chemicals with toxic metals/compounds; 3. Organic Chemicals of low toxicity; 4. Organic Chemicals with toxic metals/compounds; 5. Radiological. 6. Biological; 7. Flammable; 8. Explosive.
Waste forms: S-Solids; L-Liquids; G-Gaseous

Table: Advantages, Disadvantages and Limitations of Physical Processes

Process	Advantages	Disadvantages	Limitations
Solidification/ Encapsulation	Application to many solid, semi-solid and liquid wastes	Not completely immobile and nonreactive	Not effective for all wastes
Carbon Absorption	Very effective, application to many organics & inorganics that do not respond to other treatment	Regeneration & disposal of spent carbon required, high operation and maintenance costs	Many inorganics and some organics are poorly absorbed
Stripping	Well understood and effective	Air control required	Application only to relatively volatile organic contaminants
Sedimentation/ Centrifugation/ Floatation	Well understood, inexpensive	Generates sludge & scum for disposal	Not applicable for soluble and colloidal solids
Filtration	Low cost	Requires pretreatment	Not effective for many constituents
Reverse Osmosis	High removal potentials	Pretreatment Required, produces sludge for removal, expensive	Waste flow and composition affect performance
Flocculation- Settling	Low cost	Produces sludges for disposal	Not effective for many constituents
Evaporation	Applicable for all waste types	Energy intensive	Solar evaporation is weather dependent

Table : Advantages, Disadvantages and Limitations of Chemical and Thermal Treatment Processes

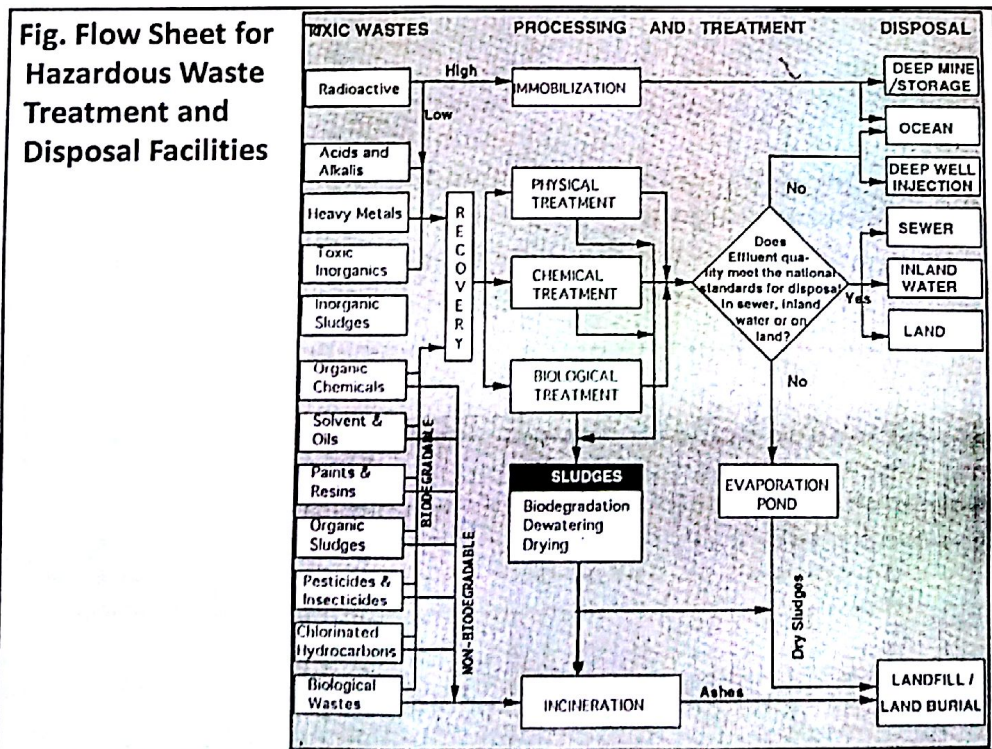
Process	Advantages	Disadvantages	Limitations
Neutralization/ Precipitation	Wide range of application, low cost	Produce hazardous sludge for disposal	Complexing agents reduces effectiveness
Coagulation/ Flocculation/ Sedimentation	Low cost	Generate hazardous sludges disposal, sometimes adjustment needed	Not effective for all constituents
Ion exchange	Can recover metal at high efficiency	Expensive pretreatment required	Not effective for all constituents
Wet air Oxidation	Good for wastes too dilute for incineration, too concentrate or toxic for biological treatment	Oxidation not complete, may produce new hazardous waste and require pretreatment	Moderate efficiency, poor destruction of many chemicals

Process	Advantages	Disadvantages	Limitations
Chlorination	Well understood, widely used, cause complete destruction of many chemicals	Produces chlorinated hydrocarbons	Interfering wastes limits application and effectiveness
Ozonization	Can destroy many organics	Oxidation not complete, can produce new hazardous products, high capital cost	Not effective for many wastes
Incineration	Destroy all organics	Generates toxic residues for disposal, causes air pollution, high cost	Requires moisture control, additional fuel for wet wastes or superheating for destruction of some toxic chemicals

Table : Advantage, Disadvantages and Limitations of Biological Treatment Processes

Process	Advantages	Disadvantages	Limitations
Enzyme Treatment	Can degrade many chemicals	Prohibitively high cost	Limited Commercial application
Waste Stabilization Ponds	Low cost	Ground water pollution from unlined ponds	Toxic elements/ compounds limit biodegradation
Aerated Lagoon	Low cost treatment of same hazardous wastes	Produces sludge for disposal	Toxic elements or compounds may inhibit bacterial activity
Activated Sludge	Used to detoxicate some hazardous wastes	Gaseous emissions may be hazardous, produces excess biological sludges	- do -

Process	Advantages	Disadvantages	Limitations
Trickling Filter	Used to detoxicate some hazardous wastes	produces humus sludge for disposal	Toxic elements or compounds may inhibit bacterial activity
Anaerobic processes	Low energy requirements	Produce sludges for disposal	Limited to few wastes, toxic wastes inhibit the processes
Absorption/adsorption on plants	Effective for heavy metals and toxic dyes removal	Requires safe disposal of plants	Use in experimental stage



Options for the disposal of processed, treated and untreated hazardous wastes

- On land, in sewer and inland waters
- Ocean dumping
- Engineering storage
- Deep well injection
- Deep mine storage and disposal
- Land burial or landfill

Future demand is for more land disposal option by landfill or land burial method but there are problems for

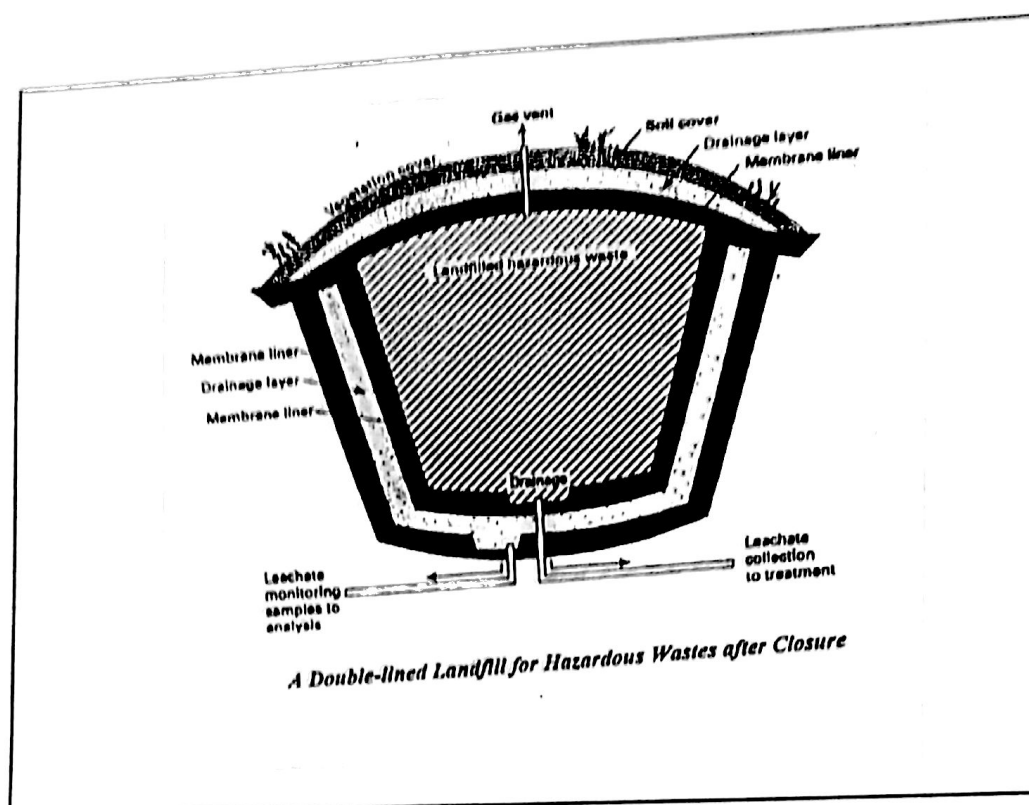
- Percolation of toxic liquid wastes into groundwater
- Dissolution of solid hazardous wastes by acid leachate and percolation into ground water
- Undesirable reaction leading to explosion and release of toxic gases
- Volatization of hazardous wastes leading to release of toxic and explosive vapors to atmosphere
- Corrosion of containers holding hazardous wastes

Consequently some special criteria will be required for

- Selection of landfill sites
- Engineering design of landfills
- Operation of landfills

Landfill for final Disposal of Hazardous Wastes

A landfill for final disposal of hazardous waste should be doubly lined with impermeable materials to prevent leakage of hazardous substances in the soil and groundwater. A secure doubly lined landfill for hazardous waste is shown in the following figure.



Factors to be Considered for Sitting Landfills for Hazardous Wastes

- Groundwater
- Floodplain
- Surface water
- Air quality
- Operational Safety
- Disease Transmission
- Impact of food chain and crop land
- Endangered species

Design Considerations of a Hazardous Waste Landfill

- 1. Type and volume of hazardous and nonhazardous wastes to be landfilled**
- 2. Expected active operating period of the landfill**
- 3. Topography and soil characteristics at the site and the vicinity**
- 4. Climatic conditions throughout the year**
- 5. Surface water and groundwater levels in the vicinity**
- 6. Soil cover requirement for individual containment cells**
- 7. Anticipated quality and volume of leachate**
- 8. Collection and treatment of leachate**
- 9. Monitoring of surface and groundwater**
- 10. Collection and treatment of gaseous products**
- 11. Selection of flexible membrane and other impermeable liners**
- 12. Environmental Monitoring Plan**
- 13. Closure and post closure plan**
- 14. Final cover of the landfill**
- 15. Alternative uses during post closure period**
- 16. Possible effect on human health and environment**