Land disposal:

- After treatment, the hazardous wastes are converted into suitable form for disposal. Immobilization, stabilization, fixation, and solidification are some of the popularly used techniques for preparation of waste for disposal.

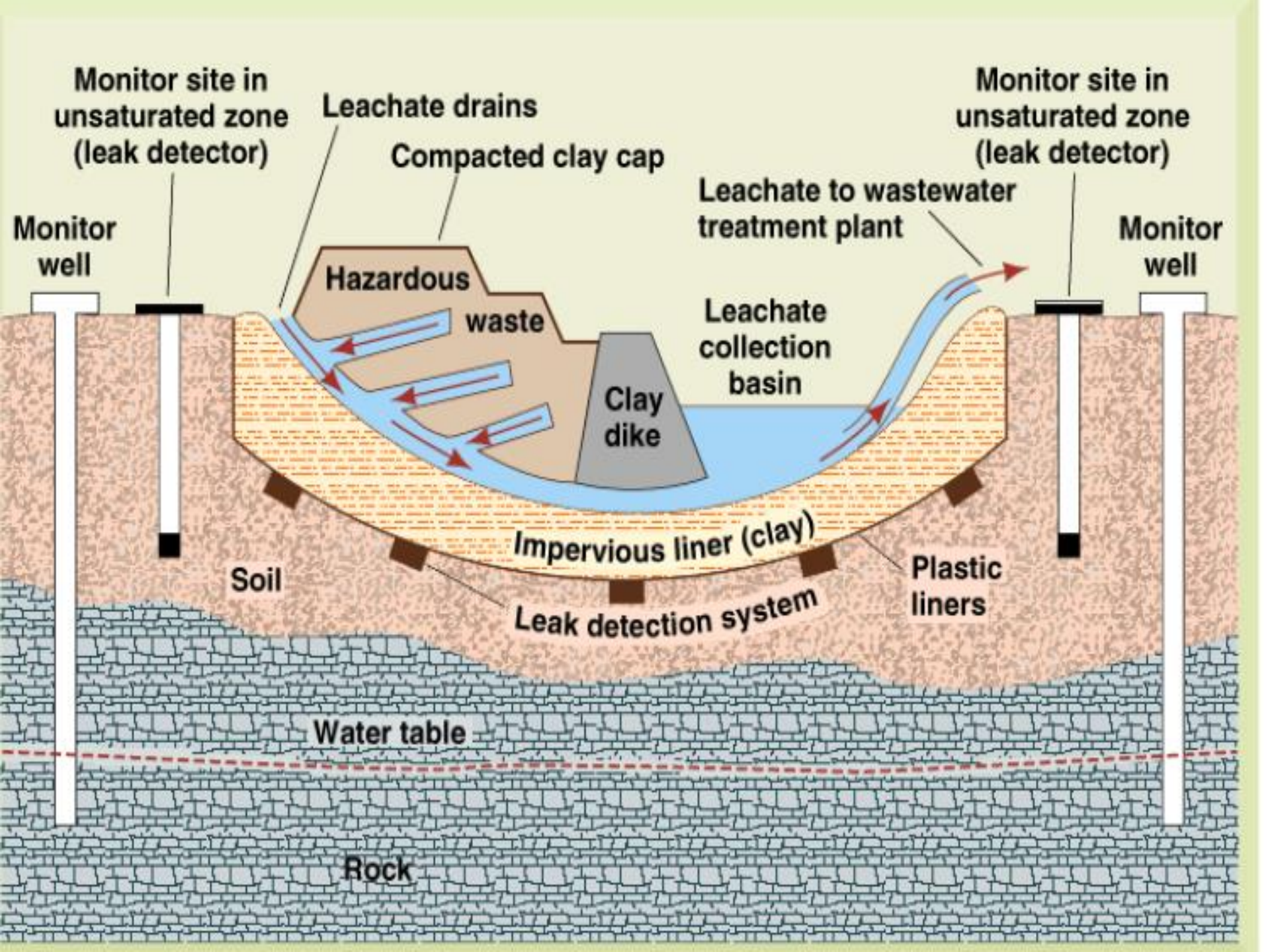
Land disposal techniques include

- Landfills,
- Surface impediment
- Underground injection wells.
- Land farming

- The most common hazardous waste disposal practice is placement in a land disposal unit such as a landfill, surface impediment waste pile, land treatment unit, or injection well. Land disposal is subject to requirements under EPA's Land Disposal Restrictions Program.
- Underground injection wells are the most commonly used disposal method for liquid hazardous waste. Because of their potential impact upon drinking water resources, injection wells are also regulated under the Safe Drinking Water Act (SDWA) and by the Underground Injection Control (UIC) Program.

Landfills:

- In order to protect public health and environment the design of hazardous waste landfills should be adequate. Figure 2 shows the typical cross section of a hazardous waste landfill.


Monitor site in unsaturated zone (leak detector)
Leachate drains
Compacted clay cap
Monitor site in unsaturated zone (leak detector)
Leachate to wastewater treatment plant
Monitor well
Monitor well
Hazardous waste
Leachate collection basin
Clay dike
Impervious liner (clay)
Soil
Plastic liners
Leak detection system
Water table
Rock

- The liner system, waste emplacement and cover system are the three components of landfills.
- Liners should be impermeable and avoid the contact between waste and the surrounding environment.
- Leachate collection system, drains and leak detectors too form an integral part of the landfill system.
- They ensure that leachate does not leave the disposal site.
- Hazardous wastes are contained in secured landfills provided with double liner system.
- The liner system consists of natural (clay), synthetic material (polymers), and a leachate collection.
- The primary barrier is a synthetic polymeric flexible membrane with a separation layer of thin geotextile or polymeric material (HDPE, LDPE, PVC etc). Secondary barrier is composed of clay, bentonite enhanced soil or geosynthetic clay

- A leachate collection tubes are layered between the waste and the protection layer.
- It channelizes the leachate to a pumping station where they are removed and taken up for further treatment.
- An intermediate high permeability drainage layer is incorporated between primary and secondary barrier.
- This layer is for the collection of leachate and gas. Every barrier is separated by geotextile fabric. The landfill is sloped to avoid infiltration of water and run off associated with it.

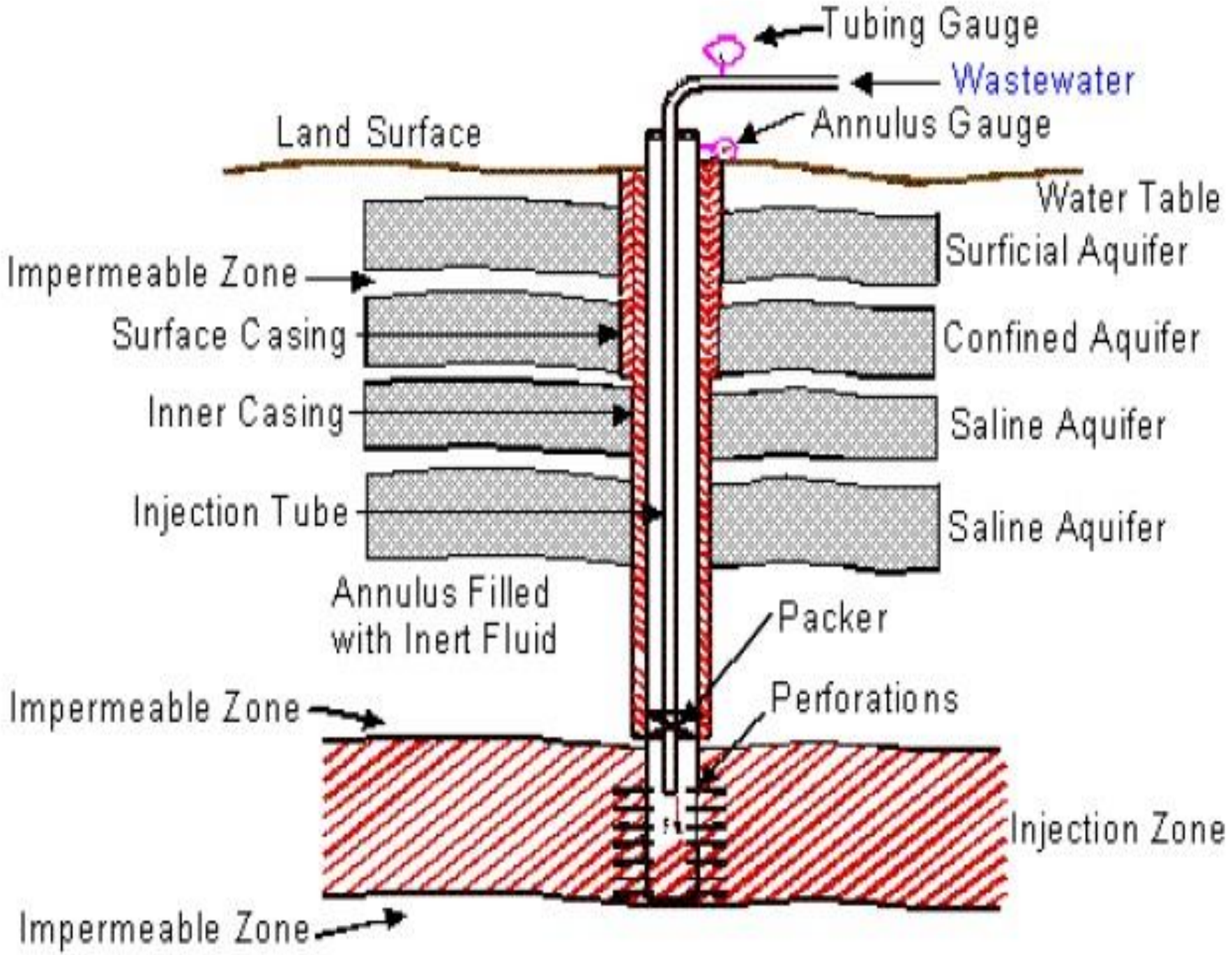
- The leachate that is collected is treated by (1) passing it through a column containing sorbent material such as carbon or flyash. (2) subjected to suitable physical-chemical units such as chemical addition, flocculation, sedimentation, pressure filtration, pH adjustment, and reverse osmosis to remove the dissolved waste.
- The secondary leachate collection system acts as back up system which will be useful during failure of primary leachate system. Continuous monitoring of ground water from the wells will help us to determine the failure of primary and secondary liner system.
- Waste is loaded inside the landfill after preliminary treatment (i.e) solidification, stabilization etc. The cover or capping is also essential component of the waste landfill.
- The purpose of the landfill cover is to protect the waste, prevent the entry of rain and surface water into the waste, control the release of landfill gas, to prevent ingress of air and enable the growth of short rooted plant when covered with top soil.
- Landfills are allowed with sufficient vent points so that if methane is generated, it may be burned off continuously.

Surface impoundments/ Surface impediment:

- A surface impoundment is a man-made excavation, diked area, or natural topographic depression designed to hold an accumulation of liquid wastes.
- The construction is similar to landfill where the bottom walls function like a liner which is impermeable to liquids.
- The surface impoundments are also provided with provision for leachate collection.
- Surface impediment: encapsulation, fixation, or containment of the waste. This method involves arresting or demobilizing the movement or migration of the waste by containing it in a hard core: clay soil, thermoplastics polymers, non-corrosive metallic containers (carbon-steel tanks), cement, lime, fire glass, rocks

Underground injection: Deep well injection

- A special kind of drilled well is prepared for such purposes. Brine (40% salt solution) is usually disposed in this manner. Precautions for water pollution need to be a concern.
- Underground injection or deep-well disposal is a method by which the hazardous waste materials are injected into underground strata under pressure.
- The underground strata must be impermeable and separated from the aquifers. During this process, the chance of chemical reactions with waste constituent and mineral is possible.
- This will result in corrosion, clogging problems.
- The main concern with underground injection is the potential for contaminating underground drinking water supplies, if the disposal well is not properly cased or if it is damaged


Tubing Gauge
Wastewater
Annulus Gauge
Land Surface
Water Table
Impermeable Zone
Surficial Aquifer
Surface Casing
Confined Aquifer
Inner Casing
Saline Aquifer
Injection Tube
Saline Aquifer
Annulus Filled
with Inert Fluid
Packer
Impermeable Zone
Perforations
Injection Zone
Impermeable Zone

Applicability and limitation

- The target contaminant groups for deep well injection are VOCs, SVOCs, fuels, explosives, and pesticides. However, existing permitted deep well injection facilities are limited to a narrow range of specific wastes.
- Injection will not be used for hazardous waste disposal in any areas where seismic activity could potentially occur.
- The waste generator may be required to perform physical, chemical, biological, or thermal treatment for removal of various contaminants or constituents from the waste to modify the physical and chemical character of the waste to assure compatibility.
- High concentrations of suspended solids (typically• >2 ppm) can lead to plugging of the injection interval.

Land Farming Facility

- Land farming is the preferred technology for the treatment of oily sludge and hydrocarbon contaminated soils, which constitute the main component of hazardous organic wastes to be treated at the HWTC

Land Farming Facility (cont'd)

- Compounds to be treated at the land Farming Facility:
- Volatile Organic Compounds (VOCs): benzene, ethylbenzene, toluene, xylenes;
- Semi-Volatile Organic Compounds (SVOCs): phenols, creosol, naphthalene, phennathrene, benzo(a)pyrene, flourrene, anthracene, chrysene; and
- Heavy Metals: chromium, cyanides, lead and nickel

Hazardous wastes Management and handling Rules, 1989

Various Acts, rules and regulations have been enacted in India from time to time to manage the solid waste. The municipal act is the first legislation in the post-independence India which deals with environmental pollution caused by municipal solid wastes.

The Delhi municipal corporation act, 1957 contains the following sections relevant to solid waste management in Delhi

- Regulations under the Act describing threshold levels and control details are expected to be promulgated late in 1998.

- The Act only applies to hazardous substances which are imported or manufactured in NewZealand.

- It will not necessarily provide controls for hazardous waste.

- A Government programme, currently under way by the Ministry of the Environment, is directed at introducing measures under the Resource Management Act 1991 to clearly define hazardous waste, outline responsibilities for its management and to introduce a system for tracking and reporting.

Legislation

Hazardous Materials Transportation Act – 1975 – required ID plaques, monitors haz transport

Resources Conservation and Recovery Act – 1976 – control of haz waste "cradle to grave" ; encourages states to handle non hazardous municipal/hazardous waste – prohibit open dumping

Toxic Substances Control Act – 1976 - gave EPA authority to track and control industrial chemicals

Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) – 1980 - create tax for clean up, allows federal government ability to respond directly for haz clean-up, provides liability guidelines, trust fund for clean – up

Nuclear Waste Policy Act – 1982 – set up federal government to provide site for nuclear waste

ENVIRONMENTAL LEGISLATION

- The Environment (Protection) Act, 1986
- The Biomedical Waste (Management & Handling) Rules, 1998
- The Municipal Solid Waste (Management & Handling) Rules, 2000
- The Hazardous Waste (Management & Handling) Rules, 1989
- The National Environmental Tribunal Act, 1995
- The Air (Prevention and Control of Pollution) Act, 1981

Hazardous Substances Legislation

In 1996 the Hazardous Substances and New Organisms Act was passed by the New Zealand Parliament. Under this act the Environmental Risk Management Authority is established and the laws controlling hazardous substances are updated and consolidated. Hazardous substances are defined as:

"any substance which exceeds a threshold level of one or more of the following intrinsic hazardous properties:

- an explosive nature

- flammability

- an oxidising nature

- toxicity

- corrosiveness

- ecotoxicity with or without bioaccumulation

- evolving substances with one or more of the above properties on release into the environment"

Hazardous waste (management and handling) rules of Govt of India (current version 2016)

The draft rules, namely the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, were published by the Government of India in the Ministry of Environment, Forest and Climate Change (MOEFCC) in July 24, 2015.

The earlier version of the hazardous waste (management, handling and transboundary movement) rules of 2008, is now updated, as on 2016.

The official gazette does not include:

a. wastewater, exhaust gases or

b. the wastes arising out of the operation from ships beyond five kilometers of the relevant baseline

c. radioactive wastes

d. biomedical wastes

e. municipal solid waste

- All these are dealt with specific regulations guiding their management and handling strategies. The key definition of hazardous waste, as used in the official gazette refers to any waste which by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances, and should include:
- waste specified under column (3) of Schedule I;
- waste having equal to or more than the concentration limits specified for the constituents in class A and class B of Schedule II or any of the characteristics as specified in class C of Schedule II; and
- wastes specified in Part A of Schedule III in respect of import or export of such wastes or the wastes not specified in Part A but exhibit hazardous characteristics specified in Part C of Schedule III;

Management of Hazardous Waste:

- Waste minimization.
- Waste treatment.
- Waste disposal.

For hazardous waste the hierarchy is as follows:

- Eliminate the production of hazardous waste
- Where elimination is not possible apply methods to reduce the quantity or hazard involved
- Minimise amount of waste for disposal by recycling, reuse and/or recovery.

  This includes the recovery of energy which may be available from the waste.
- Treat waste to stabilise, immobilise, contain or destroy hazardous properties.
- Dispose of residues with a minimum of environmental impact.
- Appropriately contain, isolate and store hazardous waste for which no acceptable treatment or disposal option is currently available.

Waste Minimisation

Examples of ways in which waste minimisation can be achieved include:

- substituting a hazardous material used in a process with a non-hazardous material process changes
- reducing the amount of hazardous materials used
- recovering and reusing materials

Examples of Waste Minimisation Practices

Practice	Industry	Activity
Substitution	Leather production	Replacement of ammonium salts by carbon dioxide in dehairing operations
Process Change	Manufacture of plastic containers	Labels moulded into lids eliminating need for glues containing organic solvents
Reduction of Waste Quantity by Recycling/ Recovery and Reuse	Wire manufacturing	Recycling by sulfuric acid use for pickling mild steel
	Timber treatment	Recover of copper, chromium and arsenic and/or boron from sludges and reuse in wood treatment process

Waste Treatment:

- All the waste products whether from manufacturing process or treatment facility must be treated for the impurities hazardous to the nature to render them harmless to the environment.
- **The various treatment procedures can be classified as:**
- 1. Physical.
- 2. Chemical.
- 3. Biological.
- 4. Thermal.
- Usually a combination of the techniques is employed, to developed the most cost-effective and environmentally acceptable solution. Description of each one of the treatment processes is not the scope of this paper and hence only an overview is given here to have an understanding of these processes.

3. Waste Disposal:

- This is an ultimate option with every industry. Depending upon the characteristics of the wastes, two types of disposal methods can be used for hazardous wastes.
- **The predominant method for hazardous wastes disposal after treatment and reuse are:**
- 1. Landfill.
- 2. Incineration.
- **Landfill:**
- Landfills are necessary because one cannot totally eliminate generation of hazardous waste and treatment technologies produce residues

TABLE 4 : Disposal Options for Management of Hazardous Waste

S. No.	Type of Waste	Disposal
1.	Cyanide bearing	Sludge for land-fill
2.	Heavy metal bearing.	Land-fill.
3.	Non-halogenated or halogenated hydrocarbon including solvents.	Thermal treatment and ash for land-fill.
4.	From paint, pigment, glue, varnish, ink industry.	Thermal treatment and ash for land-fill.
5.	From dyes and intermediate containing inorganics.	Land-fill.
6.	From dyes and intermediate containing organics.	Thermal treatment and ash for land-fill.
7.	Waste oil and emulsions.	Sludge for incineration and then ash for land-fill.
8.	Tarry waste and residues from refining, cracking.	Thermal treatment and ash for land-fill.
9.	Sludge from treatment plants.	Land-fill.
10.	Phenols.	Sludge for land-fill.
11.	Asbestos.	Land-fill.
12.	Wastes and residues from pesticides.	Thermal treatment, land-fill.
13.	Acid/alkali slurry.	Sludge for land-fill.
14.	Off-spec. products.	Ash and sludge for land-fill.
15.	Discarded containers and liners.	Containers for land-fill and liners for incineration.

Hazardous Waste Management Guidelines

- Guidelines for Generator of Hazardous Waste

1. To keep a complete record of the types, quantities and characteristics of waste.
2. To segregate hazardous waste from non-hazardous waste at source.
3. To transport hazardous waste only through the specified and registered transporters.
4. To fulfill the pre-transport requirements before transporting hazardous waste.
5. To dispose of hazardous waste only at the notified disposable facilities.
6. The regulatory authorities shall ask the occupier or generator to submit quarterly reports.
7. The authorities should ensure that the occupier/generator sends a copy of the manifest to them as soon as the hazardous wastes is shipped for ultimate disposal.