Hazardous Waste Management

1.1 General

Hazardous wastes that are disposed off causes potential hazard to human health or the environment (soil, air, and water) when it is not properly managed.

They are non-biodegradable, persistent in the environment and are deleterious to human health or natural resources.

The management of hazardous waste is a process which includes the collection, recycling, treatment, transportation, disposal, and monitoring of wastes disposal sites.

In the current scenario of developing countries, hazardous wastes are often disposed directly into the environment posing health and environmental risk. On the other hand, governments and international agencies are taking steps for controlling the growing problem of hazardous substances in the environment which appears to be a difficult process because the wastes are from many sources. Toxic and hazardous substances from these sources contaminate the land, air, and water. The potential health risk associated with these substances vary from minor, short term discomforts, such as headaches and nausea to serious health problems, such as cancers and birth defects, to major accidents that cause immediate injury or death . It is therefore important to take necessary steps in managing the waste.

In view of this, management of hazardous wastes including their disposal in an environment friendly and economically viable way is very important and therefore suggestions are made considering the waste types and states

Classification of solid wastes

Solid waste are classified into different types based on their source as shown in Figure 1

2.1 Non-hazardous waste

Non-hazardous waste is any waste that does not cause harm to people or the environment, and regulations for safe disposal of non-hazardous waste.

2.2 Hazardous waste

Hazardous waste is waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, sludge's, discarded commercial products (e.g., cleaning fluids or pesticides), or the by-products of manufacturing processes.

Classification of hazardous wastes

According to EPA more than 450 listed wastes which are known to be hazardous are grouped as F-List, K-List, P-List and U-List

2.2.1.1 F-list

The F-list contains hazardous wastes originated from a nonspecific source that includes various industrial processes leading to generation of these wastes. The list mainly incudes the solvent used in degreasing, metal treatment baths and sludge's, wastewaters from metal plating operations and dioxin containing chemicals or their precursors. The F-list are categorized depending upon industrial operations generating the wastes.

They can be divided into seven groups depending on the type of manufacturing or industrial operation generating the waste.

- Solvent wastes
- Metal finishing wastes
- Dioxin-contaminated wastes
- Chlorinated aliphatic hydrocarbons production
- Wood preserving wastes
- Waste from petroleum refinery
- Multisource leachate.

2.2.1.2 K-list

The K-list contains hazardous wastes generated as a result of specific industrial processes and are considered as source-specific wastes. The classification of K-listed hazardous waste must fit into one of the 13 categories mentioned below

- Wood preservation
- Organic chemicals manufacturing
- Pesticides manufacturing
- Petroleum refining
- Veterinary pharmaceuticals manufacturing
- Inorganic pigment manufacturing
- Inorganic chemicals manufacturing
- Explosives manufacturing
- Iron and steel production
- Primary aluminum production
- Secondary lead processing
- Ink formulation
- Coking (processing of coal to produce coke)

2.2.1.3 P and U lists

The unused chemicals of pure and commercial formulations that are being disposed come under P and U lists. For a P- or U-listed waste it requires the following three criteria:

- The waste must contain one of the chemicals listed on the P or U list
- The chemical in the waste must be unused
- The chemical in the waste must be in the form of a commercial chemical product.

3. Characteristics of hazardous waste

3.1 Ignitability

A waste is considered to be an ignitable hazardous waste if its flash point is less than 60°C, readily catches fire and burns vigorously as a hazard; or is an ignitable compressed gas or an oxidizer. Ex: Naphtha, lacquer thinner, epoxy resins, adhesives, and oil based paints etc.

3.2 Corrosivity

Any type of liquid waste whose pH is less than or equal to 2 or greater than or equal to 12.5 is considered to be corrosive hazardous waste. Sodium hydroxide (High pH) and hydrochloric acid (Low pH) is often used in many industries to clean or degrease metal parts. Prior to painting disposed solvents without any treatment contributes to corrosive hazardous waste.

3.3 Reactivity

A material is considered as reactive hazardous waste, if it is unstable, reacts violently with water, and generates toxic gases when exposed to water or corrosive materials, or explodes when exposed to heat or a flame.

Examples of reactive wastes would be waste gunpowder, sodium metal or wastes containing cyanides or sulphides.

3.4 Toxicity

Toxicity of a hazardous waste can be determined by taking a representative sample of the material and subjected to a test conducted in a certified laboratory and toxic characteristics can be determined.

4. Categories of hazardous wastes

4.1 Radioactive substance

Radioactive waste is the type of hazardous waste that contains radioactive material. Radioactive waste is a by-product of various nuclear technology processes, industries based on nuclear medicine, nuclear research, nuclear power, manufacturing, construction, coal and rare-earth mining and nuclear weapons reprocessing. Any substances capable of emitting ionizing radiation are said to be radioactive and are hazardous because prolonged exposure often results in damage to living organisms. Radioactive substances attract special concern because they

persist for a long period and disposal depends upon half-life period of the radioactive substance. For example, uranium compounds have half-lives that range from 72 years for U232 to 23,420,000 years for U236.

4.2 Chemicals

The hazardous chemical wastes can be categorized into five group's namely synthetic organics, inorganic metals, salts, acids and bases, and flammables and explosives. Some of the chemicals are hazardous because they threaten human lives.

4.3 Bio-medical wastes

The main sources of hazardous biological wastes are from hospitals and biological research facilities. The biological waste has the capability of infecting other living organisms and has the ability to produce toxins. Biomedical waste mainly includes malignant tissues discarded during surgical procedures and contaminated materials, such as hypodermic needles, bandages and outdated drugs.

4.4 Flammable wastes

The hazardous waste category also includes flammable wastes. This grouping is necessary because of risk involved in storage, collection and disposal of flammable wastes. The flammable wastes may be of solid, liquid or gaseous form. Examples of flammable waste include organic solvents, oils, plasticizers and organic sludge's.

4.5 Explosives

Explosive hazardous wastes are mainly ordnance (artillery) materials. Explosives also involve high potential for hazard in case of storage, collection and disposal. These types of wastes may exist in solid, liquid or gaseous form.

Hazardous waste management

Hazardous waste management is the general term associated with procedures and policies of hazardous waste management that it does not cause any potential threat to man and the environment. Traditionally, hazardous wastes are disposed by dumping in open space and burning. Open dumping results in soil and water pollution and open burning and incineration contribute to air pollution in the form of particulates, nitrogen oxides, noxious odors, and other constituents. After solid waste residues disposed leads to water pollution. Municipal incineration with sophisticated energy recovery systems were popular in large European and American cities at the turn of the century, but became extinct due to high operating costs. In recent years, for hazardous solid waste management incineration has become less popular because of risk associated with increased air pollution control requirements. Because of rapid industrialization the concern of hazardous waste management is increasing. The waste generated from various industrial and domestic activities can result in severe health hazards and also leads to negative impact on the environment.

The following procedure illustrates the standard waste management strategy in a developed society. Various steps involved in hazardous waste management was shown in Figure 2 .

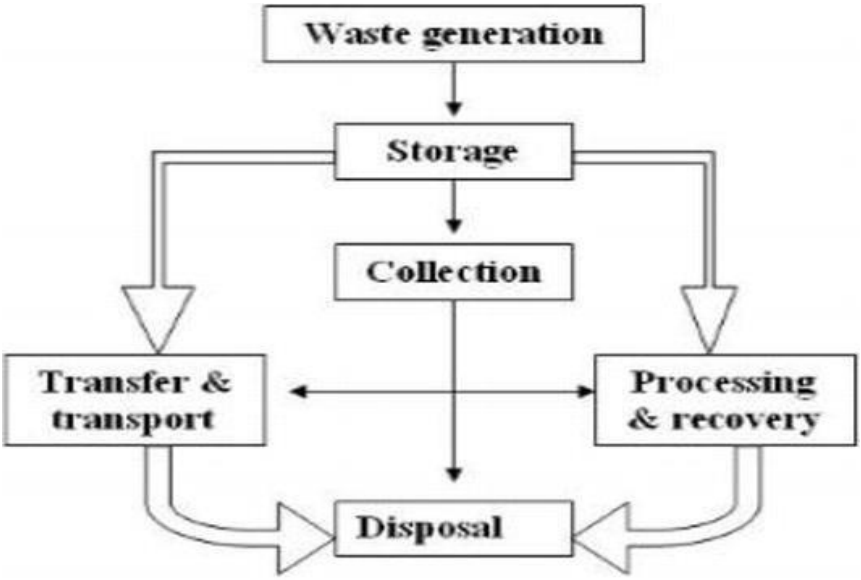

Figure 2.

Steps involved in hazardous waste disposal.

Storage and collection

Onsite storage practices are a function of the types and amounts of hazardous wastes generated and the period over which generation occurs. Usually, when large quantities are generated, special facilities are used that have sufficient capacity to hold wastes accumulated over a period of several days. When only a small amount is generated, the waste can be containerised, and limited quantity may be stored. Containers and facilities used in hazardous waste storage and handling are selected on the basis of waste characteristics. For example corrosive acids or caustic solutions are stored in fibreglass or glass-lined containers to prevent deterioration of metals in the container. Great care must also be exercised to avoid storing incompatible wastes in the same container or locations.

The waste generator, or a specialised hauler, generally collects the hazardous waste for delivery to a treatment or disposal site. The loading of collection vehicles is completed in either of the following ways: (i) Wastes stored in large-capacity tanks are either drained or pumped into collection vehicles; (ii) Wastes stored in sealed drums or sealed containers are loaded by hand or by mechanical equipment onto flatbed trucks.

5.2 Handling of hazardous wastes

Persons handling hazardous wastes are advised to have protective precautions to protect themselves from health effects. Exposure of hazardous waste leads to dermatitis in the skin, asthma on long exposure, eye irritation and also tightening of the chest.

5.3 Transport of hazardous waste

Hazardous waste generated often requires transport to a particular site for an approved treatment, storage, or disposal facility (TSDF). Because of potential threats to public safety and the environment, transport is given special attention by governmental agencies to avoid any occasional accidental spill [8].

Treatment facilities use various processes (such as incineration or oxidation) to alter the character or composition of hazardous wastes. Some treatment processes enable waste to be recovered and reused in manufacturing settings, while other treatment processes dramatically reduce the amount of hazardous waste.

Storage facilities temporarily hold hazardous wastes until they are treated or disposed of.

Disposal facilities permanently contain hazardous wastes. The most common type of disposal facility is a landfill, where hazardous wastes are disposed of in carefully constructed units designed to protect groundwater and surface-water resources.

The treatment, storage, and disposal facility (TSDF) follows the generator and transporter in the chain of waste management activities

5.4 Disposal

Disposal of hazardous waste is the final stage of a hazardous waste management system. The different waste disposal methods includes secure landfill, deep well and bedrock disposal [9].

5.4.1 Secure landfill

Disposal of some hazardous wastes in regular landfills resulted in unfavorable amounts of hazardous materials seeping into the ground. These chemicals eventually enter natural hydrologic systems. So to prevent the chemicals entering the soil, landfill requires a barrier for collecting hazardous substances that may remain in the disposed waste. Now, hazardous wastes are stabilized and made into solid and placed in landfill and this process depends upon the type of hazardous waste. A landfill is a disposal facility where hazardous wastes are placed into and stored in the soil [10]. An example of a recommended design is shown in Figure 3 . The wastes are dumped in sealed drums before disposal. The hazardous-waste landfill setup consists of two impermeable liners and also includes leachate collection systems. Double leachate collection system is made up of network of pipes placed above each liner. The upper layer reduces the accumulation of leachate trapped in the fill, and the lower layer acts as a backup. The leachate collected is transferred to treatment plant for further process. An impermeable cap or cover is placed over a finished landfill is placed to reduce the amount of leachate in the fill and minimize the potential for environmental degradation.

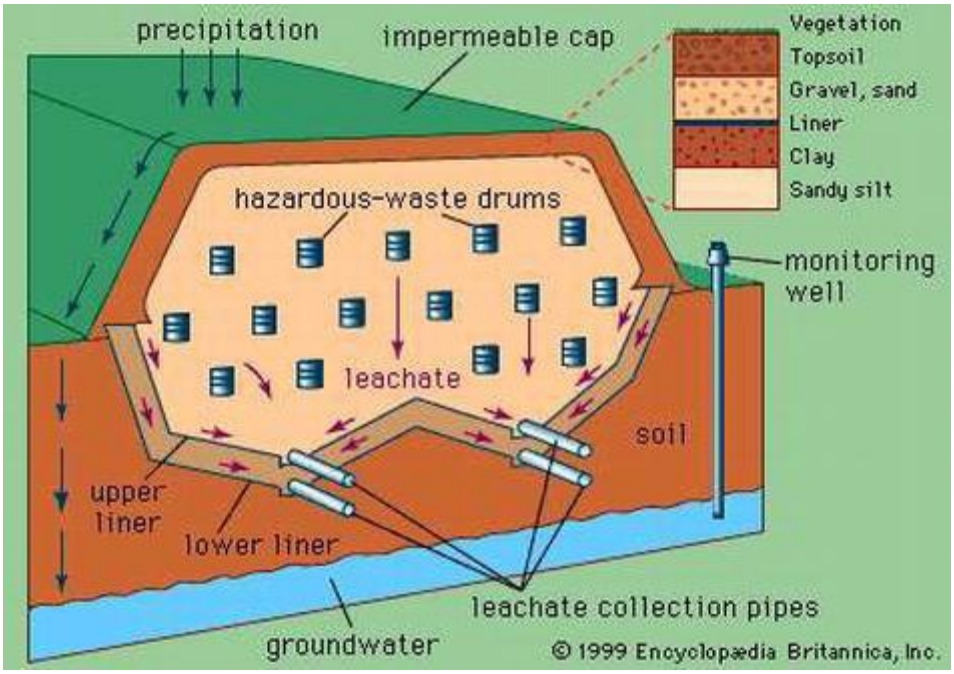

Figure 3.

Secure land fill method.

The main components in the leachate from landfill sites are grouped as follows

- Major elements and ions such as calcium, magnesium, iron, sodium, ammonia, carbonate, sulphate and chloride.
- Trace metals such as manganese, chromium, nickel, lead and calcium
- Wide variety of organic compounds
- Biological agents

Hazardous waste mainly from industries will give rise to leachate. Heavy metals concentration in the leachate is of greater concern compared to other components of leachate.

5.4.2 Deep well disposal

Another alternative disposal of liquid industrial waste is injection into deep well as shown in the Figure 4 . Deep well injection is a liquid waste disposal technology. This alternative uses injection wells to place treated or untreated liquid waste into geologic formations that have no potential to allow migration of contaminants into potential potable water aquifers. In order to force the liquid into the pores and fissures of the rock, high pressures are applied. The rock unit selected are of porous and permeable (commonly, sandstone or fractured limestone), and must be separated by low permeability layers (for example, shale) above and below. Deep-well injection is a cost effective and requires little or no pretreatment of the waste, but it poses a danger of leaking hazardous waste and eventually polluting underground water resources.

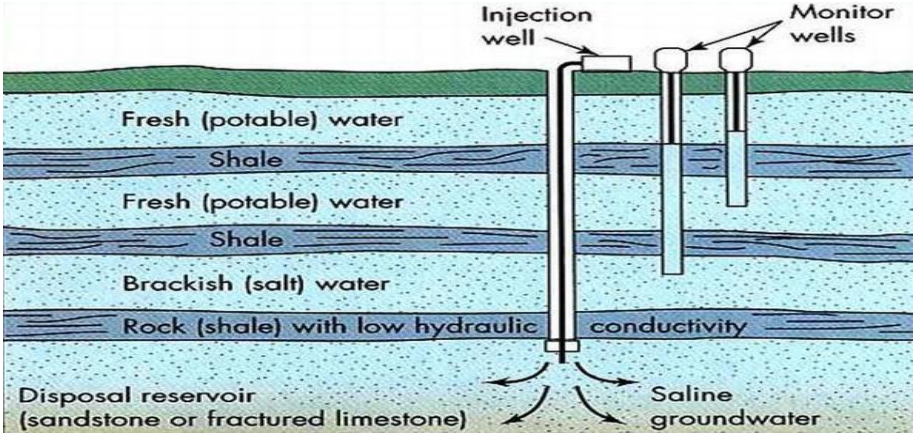

Figure 4.

Deep well disposal method.

5.4.3 Bedrock disposal

Bedrock disposal is mainly meant for solid hazardous waste and a variety of bed rock types are being investigated as host rocks. The design of a bedrock disposal site or repository for hazardous wastes is shown in Figure 5 . It is based on the multiple barrier (or multi barrier) concept: surrounding solid hazardous waste sealed with several different types of materials to prevent waste leakage or invasion by ground water. A major concern is the nature of the host rock as well as some potential drawbacks. The method is widely used for high-level radioactive wastes. Sealed into stainless steel canisters, or spent fuel rods encapsulated in corrosion resistant metals such as copper or stainless steel and buried in stable rock structures deep underground. Many geological formations such as granite, volcanic tuff, salt, thick basalts such as the Columbia River plateau basalt or shale will be suitable [11].

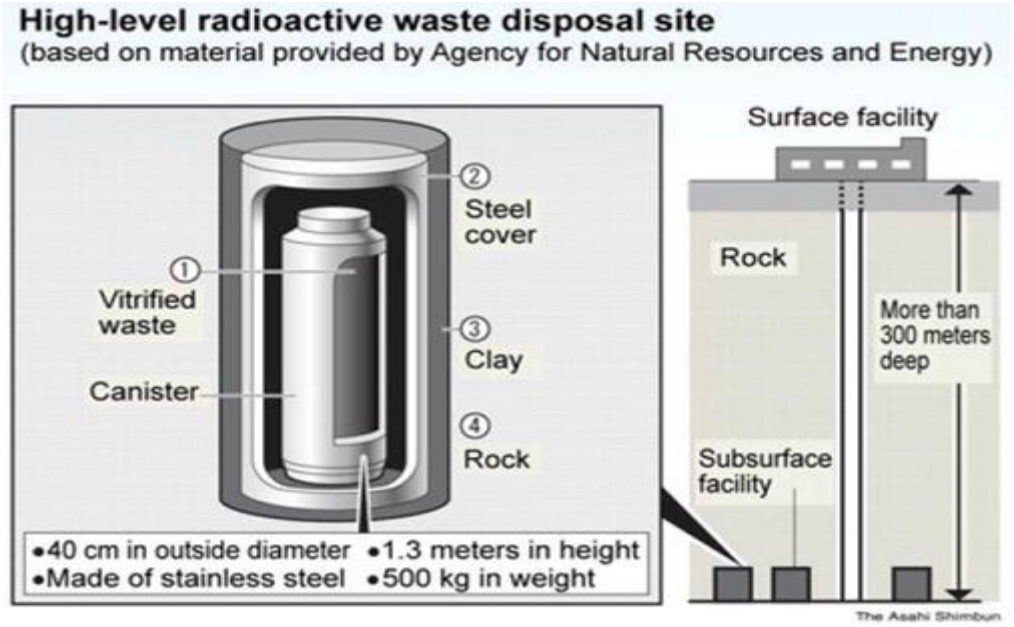

Figure 5.

Bedrock disposal method.

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