A Review on Hazardous wastes and its Management

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Abstract— Hazardous wastes refer to wastes that may, or tend to, cause adverse health effects on the ecosystem and human beings. These wastes pose present or potential risks to human health or living organisms as they are non-degradable or persistent in nature, can be biologically magnified and are highly toxic and even lethal at very low concentrations. Prime sources of hazardous waste include hospitals, timber treatment, petrol storage, metal finishing, paint manufacture, vehicle servicing, tanneries, agriculture/horticulture, electricity distribution and dry cleaning. Such wastes can be treated chemically, physically, thermally and biologically. They require appropriate management throughout their life cycle to minimize adverse effects on public health and safety or to the environment generally after treatment, waste is deposited in the landfills. This research paper deals with the discussion on various hazardous waste, its handling methods and treatment.

Key words: Hazardous waste, Landfills, Horticulture, Waste Management

I. INTRODUCTION

Most of the materials used or produced in chemical processes possess hazardous and are threat to human health and require appropriate management throughout their life cycle to minimize adverse effects on public health and safety or to the environment generally. Hazardous wastes pose present or potential risks to human health or living organisms as they:

- are non-degradable or persistent in nature;
- can be biologically magnified;
- are highly toxic and even lethal at very low concentrations
- Hazardous wastes are determined based on toxicity, phytotoxicity, genetic activity and bio-concentration. These are secondary materials, generally classified into six categories as inherently waste: like materials, spent materials, sludges, by-products, commercial chemical products and scrap metals. Solid wastes form a subset of all secondary materials and hazardous wastes form a subset of solid waste.

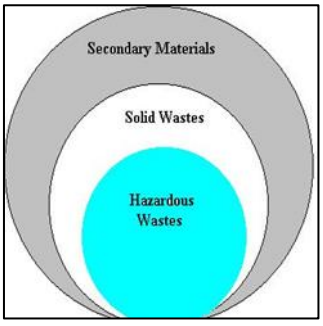

Fig. 1: Secondary Materials, Solid and Hazardous Wastes: Relationship

II. HAZARDOUS WASTE: IDENTIFICATION

By using the following criteria, we can identify whether the waste is hazardous or not:

- The list provided by government agencies declaring that substance as hazardous.
- Characteristics such as ignitibility, corrosivity, reactivity and toxicity of the substance.

III. HAZARDOUS WASTES: CHARACTERISTITICS

The following are the characteristics of hazardous wastes:

1) Ignitability: A waste is an ignitable hazardous waste, if it has a flash point of less than 60 C; readily catches fire and burns so vigorously as to create a hazard; or is an ignitable compressed gas or an oxidizer. Example: Naphtha, Epoxy Resins.
2) Corrosivity: A waste is an ignitable hazardous waste, if it has a flash point of less than 60 C; readily catches fire and burns so vigorously as to create a hazard; or is an ignitable compressed gas or an oxidizer. Example: Sodium Hydroxide, Hydrochloric acid.
3) Reactivity: A material is considered a reactive hazardous waste, if it is unstable, reacts violently with water, generates toxic gases when exposed to water or corrosive materials, or if it is capable of detonation or explosion when exposed to heat or a flame. Example: Gunpowder, Sodium metal & wastes containing cyanides or sulphides.
4) Toxicity: A representative sample of the material must be subjected to a test conducted in a certified laboratory to determine whether the waste is toxic or not.

A useful listing of hazardous characteristics is that provided by the United Nations (1989) as part of recommendations relating to the transport of dangerous goods. Examples from this listing are given in table below:

U.N. Class Number	Hazardous Characteristic
1	Explosive
3 – 4	Flammable
5	Oxidizing
6	Poisonous/Infectious
7	Radioactive
8	Corrosive
9	Toxic (Delayed or Chronic)/Ecotoxic

Table 1: Examples of Hazardous Characteristics: Extracted From U.N. Listing (1989)
Source: Environment-B-Hazardous Waste-3

IV. HAZARDOUS WASTES: CLASSIFICATION

The hazardous wastes are classified in five general categories, they are:

1) Radioactive substance: Substances that emits radiation are radioactive. Such substances are hazardous because

prolonged exposure to radiation often results in damage to living organisms. Example: Uranium.

2) Chemicals: Chemicals can be classified into four groups: synthetic organics, inorganic metals, salts, acids and bases, and flammables and explosives. Some of the chemicals are hazardous and are highly toxic to life forms.
3) Biomedical wastes: The principal sources of hazardous biological wastes are hospitals and biological research facilities. This group mainly includes malignant tissues discarded during surgical procedures and contaminated materials, such as hypodermic needles, bandages and outdated drugs
4) Flammable wastes: Most flammable wastes are also identified as hazardous chemical wastes. These wastes may be liquid, gaseous or solid, but most often they are liquids. Typical examples include organic solvents, oils, plasticizers and organic sludges.
5) Explosives: Explosive hazardous wastes are mainly ordnance (artillery) materials, i.e., the wastes resulting from ordnance manufacturing and some industrial gases. They are highly flammable in nature and may exist in solid, liquid and gaseous forms.
6) Household hazardous wastes: Household wastes such as cleaning chemicals, batteries, nail polish etc. Batteries contain mercury which are alkaline which is dangerous enough to kill people.

V. HAZARDOUS WASTE GENERATION SOURCES

Table below presents a list of hazardous waste generation sources:

Waste Category	Sources
Radioactive Substance	Biomedical research facilities, colleges and universities, hospitals, offices, nuclear power plants etc.
Toxic Chemicals	Agricultural chemical companies, battery, laboratories of school and colleges, chemical shops, construction companies, hospitals & clinics, nuclear power plants, newspapers & photography solutions, pest control agencies etc.
Biological waste	Biomedical research facilities, drug companies, hospitals & clinic etc.
Flammable wastes	Dry Cleaners, petroleum reclamation plant, petroleum refining, service station, tanker trucks etc.
Explosives	Construction companies, dry cleaners, industrial wastes, ammunition production facilities etc.

Table 2: Common Hazardous Wastes: Community Source
Source: Tchobanoglous, et al., (1977 and 1993)

VI. MANAGING HAZARDOUS WASTE

A. *The Waste Management Hierarchy*

The best method for managing any waste there is a hierarchy for decision making which addresses issues such as sustainability, cleaner production, health, safety, and environmental protection.

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
- Minimize 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 stabilize, immobilize, 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.

B. *Cleaner Production*

It refers to a precautionary approach which targets the goal of preventing the generation of hazardous waste. Minimizing the amount of hazardous waste produced would be one of the objectives of a cleaner production programme.

C. *Waste Minimization*

Waste minimization can be achieved as follows:

- Substituting a hazardous material with a non-hazardous material
- Process change
- Reducing the amount of hazardous materials used
- Recovering and reusing materials

Table below gives examples of waste minimization in industries:

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.
	Dry cleaning	Improved recovery of Perchloroethylene
	Vehicle servicing	Recovery of used lubricating oils for -refining and reuse -use as a supplementary source of fuel in cement kilns

Table 3: Examples of Waste Minimization Practices
Source: XIV-Environment-B-Hazardous Waste-6

VII. TREATMENT OF HAZARDOUS WASTES

The purpose of treating hazardous waste is to convert it into nonhazardous substances or to stabilize or encapsulate the waste so that it will not migrate and present a hazard when released into the environment. Treatment methods can be generally classified as chemical, physical and/or biological which are discussed as below:

A. Chemical Methods

1) Neutralisation

Waste acid with an alkali e.g. sulfuric acid with sodium carbonate:

$$H_2SO_4 + CO_3^{2-} \rightarrow SO_4^{2-} + CO_2 + H_2O$$

2) Oxidation

Using common oxidizing substances such as hydrogen peroxide or calcium hypochlorite e.g. cyanide waste with calcium hypochlorite:

$$CN^- + OCl^- \rightarrow OCN^- + Cl^-$$
$$OCN^- + H_3O^+ \rightarrow CO_2 + NH_3$$

3) Reduction

Used to convert inorganic substances to a less mobile and toxic form e.g. reducing Cr(VI) to Cr(III) using ferrous sulphate:

$$14H^+ + Cr_2O_7^{2-} + 6Fe^{2+} \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$$

4) Hydrolysis

Decomposition of hazardous organic substances e.g. decomposing certain organophosphorus pesticides with sodium hydroxide.

5) Precipitation

Particularly useful for converting hazardous heavy metals to a less mobile, insoluble form prior to disposal to a landfill e.g. precipitation of cadmium as its hydroxide using sodium hydroxide:

$$Cd^{2+}(aq) + 2OH^- \rightarrow Cd(OH)_2(s)$$

B. Physical Methods

1) Encapsulation

Immobilizing hazardous materials by stabilization and incorporation within a solid matrix such as cement concrete or proprietary organic polymers prior to and filling. e.g. encapsulating beryllium in concrete.

2) Filtration/Separation

Physically separating phases containing hazardous substances from other nonhazardous constituents e.g. separation of oils from ship bilge waters.

3) Biological Methods

These involve the use of microorganisms under optimized conditions to mineralise hazardous organic substances e.g. the use of pseudomonas under aerobic conditions break down phenols.

4) Thermal Methods

These are the treatment processes which involve the application of heat to convert the waste into less hazardous forms. One of the most important type of thermal method is High Temperature Incineration method most commonly used to destroy hazardous organic wastes, including organochlorines such as polychlorinated biphenyls (PCBs). There is a high temperature incinerator for the destruction chemical waste as shown in fig.

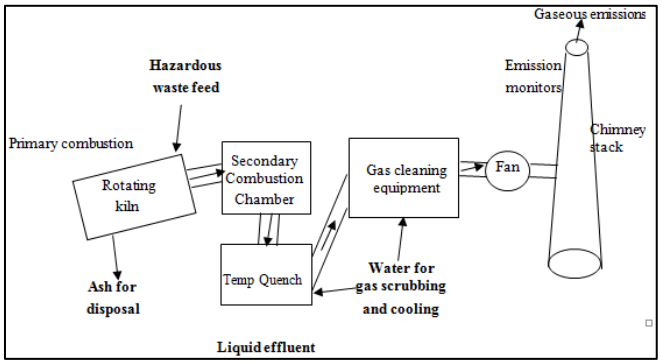

Fig. 2: High Temperature Incineration method
Source: XIV-Environment-B-Hazardous Waste-8

Incineration is the controlled combustion process which can be used to degrade organic substances. For a simple hydrocarbon, involving complete combustion, the chemical reaction can be illustrated as follows:

$$C_xH_y + (x + ¼y)O_2 \rightarrow xCO_2 + ½yH_2O$$

Combustion of organics occur in two stages. In the primary stage, volatile matter is driven off leaving the remainder to burn to ash. The volatiles are combusted in the secondary stage. High temperatures are required, for most wastes 800-900ºC is sufficient but for materials with high thermal stability 1100ºC or higher is required. This temperature must be maintained for sufficient time to allow for complete combustion. Also, sufficient air must be provided to supply the oxygen required for combustion.

VIII. CONCLUSION

Some of the waste currently produced by industrial chemical processes possess hazardous properties and require special attention in respect to disposal. A hierarchy to assist decision making is available to promote sustainability from waste management and this places emphasis on the elimination or minimization of the production of hazardous waste.

Established chemical, physical, and or biological methods are available to stabilize or break down most hazardous waste to a form which will have minimal adverse effect on health, safety and or the environment.

The quantities and types of hazardous wastes arising in and the methods available for elimination, minimization, treatment and disposal of residues are such that, with proper management, hazardous waste need not present a long term problem in the future.

IX. FUTURE SCOPE

- Use of modern landfills in disposal of residuals from treatment process.
- Implementation of stricter norms for disposal of hazardous waste.
- Creating awareness among masses regarding handling and disposal of hazardous wastes.

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