Hazardous Waste Management

Introduction

According to EPA (Environmental Protection Agency), hazardous waste is simply defined as a waste or substances that have the potential to threaten human health or the environment. Hazardous waste is generated from different sources such as industrial manufacturing processes, batteries which are released in the form of liquids, solids, gases and sludge.

For the identification of hazardous waste, EPA has developed a regulatory framework that includes specific guidelines and processes to identify a substance. EPA encourages waste generators to identify the nature of their produced wastes based on a series of question which is shown below;

The first step in identifying hazardous waste includes determining the state of the waste (solid, liquid, gas). The rest of the steps follow as shown in the figure above (EPA, 2017).

Sources, Characteristics and Classification of Hazardous Waste

Sources of hazardous wastes includes industrial manufacturing process (asbestos, PCBs), agricultural fields (pesticides), motor vehicles (mercury), etc. According to US EPA (Environmental Protection Agency), any waste that exhibits the following characteristics is labeled as a hazardous waste. The characteristics of hazardous waste include;

- Corrosivity - Refers to something that can rust or corrode. Corrosive substances like hydrochloric acid, nitric acid have the ability to eat through containers resulting in the leakage of harmful materials.
- Ignitability - Related to something flammable. It refers to wastes that can easily catch on fire and sustain combustion.
- Reactivity – Refers to wastes that are unstable in normal conditions which can result in explosion, toxic fumes or gases under the pressure of heat or compression.
- Toxicity - Wastes those are harmful or fatal when ingested or absorbed such as mercury, lead containing products (Geisheker, 2019).

The Resource Conservation and Recovery Act of 1976 classify hazardous waste into four categories/lists as follows;

1. F-List (Non-Specific Source Wastes)

These are the wastes which are generated from several non-specific sources. Most of these wastes include the byproducts of various manufacturing and industrial processes. They consist mostly of solvents that are used for cleaning and degreasing.

2. K-List (Source Specific Waste)

Waste that falls under the category of K-List are being generated from 13 different specific

industries such as pesticides manufacturing, petroleum refining, explosives manufacturing, iron and steel production, secondary lead processing and ink formulation. Wastewater and sludge from these industries form the K-List (Singh, 2015)

3. P-List and U-List(Discarded Commercial Chemical Products)

Includes chemical products that were discarded without being used. In order to identify the wastes falling under P and U-List, following criteria is considered;

I. The waste has unused chemicals.

II. The waste has a chemical listed on the P or U list.

III. The waste has c chemical in a form that meets EPA's definition of a "commercial chemical product" which refers any chemical which is 100% pure and is sole active ingredient in a chemical formulation.

The P and U lists include commercial chemicals and manufacturing chemical intermediates, off-speciation products, container residues and spill residues. However, the P and U list do not apply to manufacturing process wastes but only to unused chemical that become wastes. P list identifies hazardous wastes from discarded commercial chemical products while P list focus acute hazardous wastes from discarded chemical products (Mueller, 2007).

4. M-List (Discarded Mercury containing Products).

This list includes discarded products or wastes containing mercury. Some of the examples include mercury switches, fluorescent lamps and mercury- containing things.

Hazardous Waste Management Strategy

Hazardous waste management converts the waste material into less harmful chemicals by biological, chemical and thermal processes, followed by disposal of wastes.

Since hazardous wastes come in different forms (solid, liquid, gas), they must be handled according to their characteristics;

- I. Waste Minimization
- II. Detoxification and neutralization of waste by treatments
- III. Destruction of combustible waste by incineration
- IV. Disposal of residue in landfills

Waste Minimization

- Helps in the resource conservation, economic efficiency and environmental protection.
- Concentration on operations, processes, procedures and production units that generate wastes.
- Strategies include
    - a. Source reduction- product modification, minimize consumption

    - b. Recycling- returning material to the original process, solvent reclamation

Detoxification and neutralization of waste by treatments

- Includes physical, chemical and biological treatment

1) Physical Treatment

It includes screening, sedimentation, adsorption, flocculation which is as similar to wastewater treatment.

2) Chemical Treatment

Reduces the hazard of the particular waste and it ensures the complete breakdown of hazardous waste into nontoxic form. It also helps in recovering the by-products from hazardous wastes. Some of the methods used are neutralization, precipitation, oxidation and reduction reactions.

Neutralization - carried out when the wastes contain high/excessive levels of acid or alkali.

Precipitation - it is the process of creating solids from solution. Metals precipitate at different pH levels depending on ion which results in the formation of an insoluble salt which is later neutralized.

Oxidation - used in the destruction of toxic cyanide molecules with oxidizing agents.

Reduction - used for heavy metals. E.g. Conversion of hexavalent chromium to trivalent chromium (Mondal, n.d.).

3) Biological Treatment

Different types of microorganisms are used for degradation of specific compounds. Microorganisms that are found to attack specific compounds are injected into the waste. PCBS can be degraded using pseudomonas and flavor bacterium.

Treatment with activated sludge involves exposing waste to a biological sludge. In an aerated lagoon method, waste is agitated with air in large enclosure to increase aerobic biological oxidation. In treatment using trickling filters, wastes are made to trickle through a bed of rocks that are coated with microorganism. Another method includes water stabilization in which wastes are allowed to decompose over a long period of time (Nimmi, 2018)

Destruction of combustible waste by incineration

Incineration can destroy toxins present in a hazardous waste. A typical hazardous waste incinerator consists of a rotary kiln, an afterburner and APC. Both solid and liquid wastes are incinerated at temperature higher than 1800°F. The kiln rotates slowly to ensure that wastes are being perfectly combusted. Incineration of hazardous waste decreases the amount of waste in landfills and prevents harmful materials from leaching and polluting the environment. Wastes

can be safely and efficiently discarded through incineration (Cooper, 2015)

Disposal of residue in landfills

Disposal of hazardous wastes that are not destroyed by incineration or other chemical processes needs a proper consideration whereby landfill is mostly preferred. Hazardous wastes must be deposited in secure landfills which must be at least 3metres away from the groundwater table. The landfill must have two impermeable liners and leachate collection systems so that it doesn't pollute the ground water. In addition, an impermeable cover should be placed over the landfill to minimize potential environmental damage (Nathanson, 2016).

Remedial Action

Hazardous waste will still pose threat to human health and environment despite proper disposal in the landfill, lagoons, etc. So, it is necessary to remediate those sites such as landfills, lagoons, etc. One method could be complete removal of all the waste materials from the site and transporting it to another location for treatment and proper disposal. This method is known as off-site solution which is the most expensive one. Another option which is on-site remediation reduces the production of leachate and reduces the probability of groundwater contamination. On-site remediation includes temporary removal of hazardous wastes, treatment of contaminated groundwater. An alternative such as full containment of the waste implies placing an impermeable cover over the hazardous waste site, and blocking the flow of groundwater (Nathanson, 2016).

Case Study of Hazardous Waste Management in Germany

Germany has seen the growth in environmental movements since the 1960s. The German Waste Management Act regulates not only the import but also the export and the transit of wastes. 750, 000 tons of hazardous waste are combusted annually in 27 incineration plants with 18 additional incineration plants in progression. Dumping of diluted acids in the North Sea was completely stopped by the end of 1989. Also, the incineration of chlorinated hydrocarbons on German ships was ceased in 1989. The most common disposal process is the sanitary landfill. The safest disposal is the deep underground deposition in salt mines (Shin,1992).

The Circular Economy Act sets out the main provisions on waste handling, prevention, preparation for reuse, recycling and disposal. Since Germany is not rich in resources, emphasis is placed on the conservation of its natural resources. Waste handling in Germany is an integral part of sustainable production and helps to avoid waste production and promote the reuse of resources. The Circular Economy Act requires that recycling is promoted and includes an obligation to collect different types of wastes separately. The goal is to improve recycling and reuse measures (Enderle & Müller-Gschlößl, 2018).

The Ordinance on Hazardous Substances regulates the handling of hazardous substances that are flammable, toxic, explosive, corrosive or carcinogenic. In Germany, some of the policies in relation to HWM are the precautionary principle whose purpose is to create an impetus to take decisions notwithstanding scientific uncertainty about the nature and the extent of risk and also the polluters' pay principle. The implementation of the 'Duty of Care' principle allows producers, carriers, importers and processors of hazardous waste to manage the waste

correctly by proper storage, transferring to appropriate people and ensuring safe recovering without any implications on the environment.

Most of the times, Black Forest Solutions (an organization) look after the handling of the hazardous wastes. Germany has imposed strict legislation amendments in 2005 and afterwards on the HWM which have led the people to dispose their hazardous waste properly. Penalty fees for wastes generators are imposed. The cross-border shipment of waste is regulated by EU law, which requires comprehensive documentation and notification of the relevant state authorities (Kasih, 2017).

Case Study of Hazardous Waste Management in Bangladesh

Bangladesh generates about 12,271 tonnes of hazardous wastes per year of which 15% is recycled and treated. The lack of regulatory control for hazardous waste management has led to unscientific and unsustainable disposal of wastes throughout the country, posing serious threats to public health and the environment. The Acid handlers and suppliers industry in Bangladesh which deals with nitric acid, hydrochloric acid, etc has been attributed to the increased amount of hazardous wastes followed by textile industry. As long as the existence of the industries, the HWM framework has never been implemented since its documentation in1992.

In order to implement the policies of HWM, discussions among the government officials and stakeholders workshop were conducted in Dhaka in March and May, 2009 where they witnessed the strengths and weaknesses of HWM. The strategy of PPP for off site management was preferred by the stakeholders. The policy was to help raise awareness on the management of hazardous wastes. Some of the objectives of the policy included the practice of 3Rs, off-site management, promotion of CDM (Clean Development Mechanism) and investment in HWM.

This led to the establishment of HWMC (Hazardous Waste Management Cell) which served as a focal point for HWM and the promotion of cleaner production practices. The HWMC responsibilities included identification of hazardous wastes, implementation of 3Rs, and policies to reduce and control pollution from re-use of hazardous waste.

Waste avoidance and minimization was preferred first. Recovery of resources such as solvents, other reagents was highly encouraged. Industries were made to explore options for implementation of 3Rs for hazardous waste in an environmentally sound manner. Establishment of Waste Exchange Banks was sensitized to provide information on wastes and promote the principles of 3Rs. Introduction of payback scheme as a part of extended corporate responsibility further led to the effective management of waste (Asian Development Bank, 2010).

Recommendations

In order to have an effective HWM in Bangladesh, government intervention is very important. Moreover, strict polices such as polluter pays principle should be implemented taking Germany as a role model. Industries should be fined if the amount of hazardous wastes produced exceeds the given limit. There should be strict monitoring on the import and export of wastes to and from the country.

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