HAZARDOUS WASTE MANAGEMENT: A UNITED STATES PERSPECTIVE

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Contents

Summary

Hazardous waste pollution, hazardous waste terminologies, various on-site, off-site, in-situ and ex-situ environmental remediation technologies, and case histories are presented in detail in this section. The topics of soil remediation technologies covered here include: excavation, stabilization, solidification, vapor stripping, vacuum extraction, thermal desorption, incineration, starved air combustion, pyrolysis, hot air

enhanced stripping, steam enhanced stripping, thermal extraction, subsurface volatilization and ventilation, vitrification, soil surfactant flushing, soil washing, soil bioremediation, bioventing, slurry bioreactor, chemical treatment, KPEG treatment and natural attenuation. The topics of groundwater decontamination technologies covered here include: air stripping, ultraviolet radiation, oxidation, carbon adsorption, groundwater bioremediation, sewer discharge, liquid/liquid (oil/water) separation, free product recovery, in-situ flushing, trenching, containerizing and dissolved air flotation.

If the hazardous substances at industrial, commercial and agricultural sites were properly handled, stored, transported and/or disposed of, there would be no environmental pollution and no need to execute any site remediation. With this concept in mind, the goal of in-plant hazardous waste management is to achieve pollution prevention and human health protection at the source of hazardous substances. The In-Plant hazardous Waste Management section begins with hazardous waste terminologies and characteristics. Special emphasis is placed on the manifest system, hazardous substances storage requirements, underground storage tanks, aboveground storage tanks, hazardous substances transportation, hazardous waste handling, and disposal.

1. Hazardous Waste Characteristics

Most hazardous wastes are produced in the manufacturing of products for domestic consumption or further industrial application. Rapid development and improvement of various industrial technologies, products and practices frequently increase the generation rate of hazardous substances (including both useful materials and waste materials).

These hazardous substances, which can be in the forms of gas, liquid or solid, must be properly handled in order to protect the plant personnel, the general public and the environment. The term "hazardous substance" refers to any raw materials, intermediate products, final products, spent wastes, accidental spills, leakages, etc. that are hazardous to human health and the environment. Technically speaking, all ignitable, corrosive, reactive (explosive), toxic, infectious, carcinogenic and radioactive substances are hazardous.

According to USA Resource Conservation and Recovery Act (RCRA) of 1978, a waste is considered hazardous when it poses a threat to human health or the environment. Under RCRA regulations, all hazardous wastes are solid wastes regardless of their actual physical form, whether gas, liquid, solid or sludge, because they must be properly stored for handling and disposal.

In the past twenty five years, industry, government and the general public in industrially developed as well as developing countries have become increasingly aware of the need to respond to industrial hazardous substance problems.

Some hazardous wastes or mixtures of hazardous wastes (such as cyanides, hydrogen sulfide and parathion) are extremely or acutely hazardous because of their high acute toxicity. These extremely hazardous wastes, if human exposure should occur, may result in disabling personal injury, illness or even death.

Although the properties of hazardous substances may sound alarming, the managerial skills and technologies used to handle, store or treat hazardous substances are available. Modern technology exists to build and maintain environmentally sound industrial facilities that effectively produce useful products and at the same time render hazardous waste inert. Environmental laws, rules, regulations and guidelines also exist to ensure that modern technology will be adopted by the owners or plant managers for industrial facilities.

2. Industrial Site Management

This section is intended to help the plant owner, the plant engineer/manager, their contractors, their consulting engineers and the general public. The first step of site management is to determine whether or not the waste generated or the accidental release (i.e. spill or leak of chemical/biological substances) is hazardous. Accordingly, waste characterization becomes a critical step in determining how a waste should be handled in bulk or in packaged form. Common hazardous wastes are: (1) waste oil; (2) solvents and thinners; (3) acids and bases/alkalis; (4) toxic or flammable paint wastes; (5) nitrates, perchlorates and peroxides; (6) abandoned or used pesticides; and (7) some wastewater treatment sludge. Special hazardous wastes include: (1) industrial wastes containing the USEPA priority pollutants; (2) infectious medical wastes; (3) explosive military wastes; and (4) radioactive wastes or releases.

In general, there are two ways a waste or a substance may be identified as hazardous: it may be listed in the Federal and/or the State regulations or it may be defined by its hazardous characteristics. Specifically, under RCRA, a hazardous waste may be a designated waste or a characteristic waste.

A **designated waste** (listed hazardous waste) in USA is one that is specifically listed by USEPA as hazardous (such as hydrogen cyanide). A **characteristic waste** is one that exhibits any one of the characteristics of ignitability (easily catches fire, flash point below 140 ^{O}F), corrosiveness (easily corrodes materials or human tissue, very acidic or alkaline, pH of < 2 or > 12.5); reactivity (explosive, produces toxic gases when mixed with water or acid), extractive procedure (EP) toxicity (can leach toxic chemicals as determined by a special laboratory test), or radioactivity.

At the U.S. Federal government level, an **ignitable waste** is defined as any liquid with a flash point of less than 60 ^{O}C (140 ^{O}F), any non-liquid that can cause a fire under certain conditions or any waste classified by the U.S. Department of Transportation (USDOT) as a compressed ignitable gas or oxydizer. A **corrosive waste** is defined as any aqueous material that has a pH less than or equal to 2, a pH greater than or equal to 12.5, or any material that corrodes SAE 1020 steel at a rate greater than 0.25 in/year (1 in. = 2.54 cm). A **reactive waste** is defined as one that is unstable, changes form violently, is explosive, reacts violently with water, forms an explosive mixture with water, or generates toxic gases in dangerous concentrations. A toxic waste is one whose extract contains concentrations of certain constituents in excess of those stipulated by the Safe Drinking Water Act (SDWA). The hazardous waste identification regulations that define the characteristics of toxicity, ignitability, corrosivity and reactivity, as well as the tests for these characteristics, can vary. In the State of California, USA, for

example, a waste or a material is defined as hazardous or extremely hazardous because of its toxicity if it has one of a variety of LD50, LC50, bio-accumulative, persistent, reactive or carcinogenic properties, among others. In addition, concentration limits for particular chemicals that are common to hazardous wastes may be set forth. Since different countries and jurisdictions within them have their own criteria for defining hazardous wastes, the plant manager of an industrial site handling hazardous substances should contact local environmental authorities for details. In order to find out if the waste on the site is hazardous, or even acutely hazardous, a plant manager may also check with: (1) the supplier of the product (request a hazardous material safety data sheet); (2) laboratories; (3) trade associations; and/or (4) environmental consulting engineers and scientists. Besides this, self-reviewing the State and/or Federal hazardous waste regulations for the purpose of verification is always required.

The best available disposal techniques for disposal of hazardous solid wastes are listed in Table 1 (A and B), which is recommended by the Massachusetts Department of Environmental Management, Bureau of Solid Waste Disposal, U.S.A.

3. Manifest System, Storage and Transportation

3.1 Government Regulations

In general, two activities determine the generator category of an industrial plant: the rate at which the plant generates and how much the plant stores (accumulates). Under new, more flexible regulations in USA, the amount and length of time an industrial plant can accumulate wastes may vary according to the type of waste. Generator status is designated according to categories, as is demonstrated by the following Massachusetts guidelines:

1. Large Quantity Generator (LQG): generates more than 1000 kilograms (2200 lbs.) of hazardous waste in a month; once the first 1000 kilograms has been accumulated, the waste must be shipped within 90 days; there is no limit to the amount that can be accumulated;
2. Small Quantity Generator (SQG): generates less than 1000 kilograms of hazardous waste in a month, and/or less than 1 kilogram of acutely hazardous waste (acutely hazardous waste is listed in the State regulations), and
3. Very Small Quantity Generator (VSQG): generates less than 100 kilograms of hazardous waste in a month and generates no acutely hazardous waste.

There are different waste management requirements for each generator status.

3.2. Manifest System

Hazardous waste and waste oil documentation may use a manifest approved by the government. For instance, as a generator an industrial plant in USA always retains responsibility for hazardous waste. If the plant's waste is dumped or disposed of improperly, the plant manager and the owner will be held responsible. It is therefore important that the plant manager or the owner knows where the plant's waste is going and whether or not it is handled properly and safely.

U.S. Federal law (the Resource Conservation and Recovery Act of 1976, known as RCRA) requires a national "cradle to grave" tracking system for hazardous waste. In the State of Massachusetts, for instance, every shipment of hazardous waste by a large or small generator must be transported by a licensed hauler and sent to a licensed treatment, storage or disposal facility (TSD) or to a permitted recycling facility, and must be accompanied by a multi-part shipping document called the Uniform Hazardous Waste Manifest.

Manifests must be delivered within time limits designated by the rules of the receiving state. For all generators, copies of all manifests and any records of tests and analyses done of the hazardous waste must be kept for at least 3 years, and for the duration of any enforcement action. The most common problems in completing the manifest are clerical. For clarity, because this is a multiple carbonless copy form of about 8 pages, typing is strongly recommended. The generator should check for legibility of all copies before transferring the manifest to the transporter at the time of shipment. The generator must ensure that all information is complete and accurate. To transport wastes for disposal, a generator in USA must have a program to reduce the volume and toxicity of waste generated, which is intended to encourage good management practices. Large quantity generators are required to report how they are reducing waste in their annual reports.

3.3 Transportation of Hazardous Wastes

Shipping Hazardous Waste must be handled carefully and legally by environmental engineers and managers. In USA, all hazardous waste must be transported in containers that are labeled with the words HAZARDOUS WASTE, the name of the waste, the type of hazard (i.e. toxic, flammable, etc), and the generator's name, address and USEPA ID number. Many transporters are authorized to assist the plant manager in preparing the plant's hazardous waste for shipment.

The following is a summary of recommended procedures for shipping hazardous wastes from an industrial plant to another location:

1. Selecting a licensed transporter and a hazardous waste facility that will receive the plant's waste;
2. Identifying the waste based on a licensed engineer's testing or certified laboratory testing prior to shipping the waste;
3. Obtaining an identification number
4. Obtaining a manifest for a shipment of waste destined for disposal; and
5. Shipping the plant's waste in accordance with transportation regulations.

3.4 Standards for an Accumulation Area for Hazardous Waste Storage

The accumulation or storage area of an industrial plant (i.e. a generator) must meet certain following conditions for both containers and tanks in accordance with the home State regulations in USA. The hazardous waste regulations in force in Massachusetts are listed below as a reference:

1. Above-ground tanks and containers must be on a surface which does not have any cracks or gaps and is impervious to the hazardous wastes being stored;
2. Area must be secured against unauthorized entry;
3. Area must be clearly marked (i.e. by a visible line or tape, or by a fence) and be separate from any points of generation;
4. Area must be posted with a sign: "HAZARDOUS WASTE" in capital letters at least one inch high (1 inch = 2.54 centimeters);
5. An outdoor area must have secondary containment, such as a dam or dike, that will hold any spill or leaks at: (a) 10% of the total volume of the containers or (b) 110% of the volume of the largest container, whichever is larger; and
6. Any spillage must be promptly removed; in general, if the hazardous waste being stored has no free liquids, no pad or dam is required provided that the accumulation area is sloped or the containers are elevated.

3.5 Standards for Waste Containers and Tanks

General U.S. Massachusetts standards for waste containers and tanks in accordance with the same Massachusetts hazardous waste regulations are given below as a reference:

1. Each container and tank must be clearly and visibly labeled throughout the period of accumulation with the following:

   (a) The words "HAZARDOUS WASTE,"
   (b) The name of the waste (e.g. waste oil, acetone),
   (c) The type of hazard(s) (i.e. ignitable, toxic, dangerous when wet, corrosive), and
   (d) The date on which the accumulation began;

2. Each container must be in good condition;
3. Wastes of different types must be segregated; for example, this includes not mixing waste oil or used fuel oil with other wastes; be careful not to put incompatible wastes in the same container or in unwashed containers that previously stored incompatible wastes;
4. Separate containers of incompatible wastes by a dam, dike or similar structure;
5. Each container holding hazardous wastes must be tightly closed throughout the period of accumulation, except when the waste is being added or removed;
6. Containers holding ignitable or reactive wastes must be at least 15 meters (50 ft) away from the property line; if this is not possible or practical, the plant manager representing the generator must store such containers in compliance with all applicable local ordinances and by-laws, and
7. Inspect the accumulation area at least once a week for any leaking or deterioration of all containers; there must be enough aisle space between the containers to allow for inspections.

Specific rules and regulations also cover requirements for underground storage tanks, underground and on-ground piping, and above ground storage tanks for hazardous wastes. These regulations require thorough, regular inspections and testing.

4. Hazardous Wastes Handling and Disposal

4.1 Disposal of Large Quantities of Hazardous Solid Wastes

When disposed of improperly, hazardous solid wastes may contaminate air, soil and/or groundwater, and may increase the risk of human disease and environmental contamination. Inevitably, some hazardous solid wastes generated at an industrial site must be discarded. Rusted, old containers or equipment might be targets for plant wide-cleaning, as well as some industrial materials or products, such as half-used cans of paint or chemicals. The owner or the plant manager also might want to dispose of some products that are too old to be sold or building materials (such as asbestos) that are too hazardous for everyday use.

Large quantities of any hazardous solid wastes can only be properly transported or disposed of by licensed or certified environmental professionals. Small quantities of hazardous wastes, however, can be handled by a plant manager.

4.2 Disposal of Small Quantities of Hazardous Solid Wastes

Right now there is no easy way to dispose of a very small quantity of hazardous household products, such as pesticides, batteries, outdated medicines, paint, paint removers, used motor oil, wool preservatives, acids, caustics, etc. There are no places that accept such small quantities of wastes generated by a small industrial or commercial site. For now, the best disposal techniques are listed in Table 1, which is recommended by the Massachusetts Department of Environmental Management, Bureau of Solid Waste Disposal.

PRODUCT	Take to a hazardous waste collection site (or store until available)	Wrap in plastic bag, put in trash and alert the collector	Wash down drain with lots of water	Take to a special recycling center (not paper recycling)	Give to a friend to use, with careful instructions	Return to the manufacturer or the retailer
ACIDS (STRONG)	Best	Never	Never	Unavailable	Impractical	Impractical
ACIDS (WEAK)	Best	4th Best	3rd Best	Unavailable	2nd Best	Impractical
BANNED PESTICIDES	2nd Best	Never	Never	Never	Never	Best
BATTERIES	3rd Best	Never	Impractical	Best	Never	2nd Best
CAUSTICS	Best	3rd Best	4th Best	Unavailable	2nd Best	Impractical
PESTICIDE CONTAINERS	Best	2nd Best	Impractical	Unavailable	Impractical	Impractical
FLAMMABLES	Best	3rd Best	Never	Unavailable	2nd Best	Impractical
OUTDATED MEDICINES	Best	3rd Best	2nd Best	Never	Never	Impractical
PAINT	2nd Best	3rd Best	Never	Unavailable	Best	Impractical
PAINT REMOVER	Best	Never	Never	Unavailable	2nd Best	Impractical
PESTICIDES	Best	3rd Best	Never	Unavailable	2nd Best	Impractical
USED MOTOR OIL	3rd Best	Never	Never	Best	Never	2nd Best
WOOD PRESERVATIVES	Best	2nd Best	Never	Unavailable	3rd Best	Impractical

Note: Strong acids include battery acid, murintic acid, and hydrochloric acid. Weak acids include acetic

acid, toilet bowl cleaner, and lactic acid. Banned pesticides include Silvex, Mirex, Aldrin, Chlordane, DDT, and Heptachlor. Caustics include oven cleaner and drain cleaner. Flammables include alcohol, acetone, turpentine, lacquer, and paint thinner. Pesticides include rodent poisons, insecticides, weed killer, and other herbicides and fungicides. Pesticide containers should be triple-rinsed, and the contents sprayed on crops or yard, before discarding.

Table 1. Methods for disposal of small quantities of common hazardous wastes

Small quantities of hazardous solid wastes (such as potassium dichromate, lead nitrate, silver nitrate, asbestos, etc.), liquid chemicals (such as chloroform, PCB, methylene chloride, etc.), petrochemicals (such as gasoline, No.2 fuel oil, etc.), or pure metals (such as mercury, sodium, etc.), which are stored in bottles or cans, however, are not considered to be hazardous "household products." Accordingly, these non-household hazardous solid wastes, even in small quantities, can only be properly disposed of by licensed or certified environmental professionals.

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