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HAZARDOUS WASTE MANAGEMENT

Hazardous waste management, the collection, treatment, and disposal of waste material that, when improperly handled, can cause substantial harm to human health and safety or to the environment. Hazardous wastes can take the form of solids, liquids, sludges, or contained gases, and they are generated primarily by chemical production, manufacturing, and other industrial activities. They may cause damage during inadequate storage, transportation, treatment, or disposal operations. Improper hazardous-waste storage or disposal frequently contaminates surface water and groundwater supplies as harmful water pollution and can also be a source of dangerous land pollution. People living in homes built near old and abandoned waste disposal sites may be in a particularly vulnerable position. In an effort to remedy existing problems and to prevent future harm from hazardous wastes, governments closely regulate the practice of hazardous-waste management.

Waste management includes the activities and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment and disposal of waste, together with monitoring and regulation of the waste management process.

Waste can be solid, liquid, or gas and each type has different methods of disposal and management. Waste management deals with all types of waste, including industrial, biological and household. In some cases, waste can pose a threat to human health. Waste is produced by human activity, for example, the extraction and processing of raw materials. Waste management is intended to reduce adverse effects of waste on human health, the environment or aesthetics.

Waste management practices are not uniform among countries (developed and developing nations); regions (urban and rural areas), and residential and industrial sectors can all take different approaches.

Proper management of waste is important for building sustainable and liveable cities, but it remains a challenge for many developing countries and cities. Effective waste management is quite expensive, usually comprising 20%–50% of municipal budgets. Operating this essential municipal service requires integrated systems that are efficient, sustainable, and socially supported. In view of this, the World Bank finances and advises on solid waste management projects using a diverse suite of products and services, including traditional loans, results-based financing, development policy financing, and technical advisory. World Bank-financed waste management projects usually address the entire lifecycle of waste right from the point of generation to collection and transportation, and finally treatment and disposal. A large portion of waste management practices deal with municipal solid waste (MSW) which is the bulk of the waste that is created by household, industrial, and commercial activity.

Hazardous Waste Characteristics

Hazardous wastes are classified on the basis of their biological, chemical, and physical properties. These properties generate materials that are either toxic, reactive, ignitable, corrosive, infectious, or radioactive.

Toxic_wastes are poisons, even in very small or trace amounts. They may have acute effects, causing death or violent illness, or they may have chronic effects, slowly causing irreparable harm. Some are carcinogenic, causing cancer after many years of exposure. Others are mutagenic, causing major biological changes in the offspring of exposed humans and wildlife.

Reactive wastes are chemically unstable and react violently with air or water. They cause explosions or form toxic vapours. Ignitable wastes burn at relatively low temperatures and may cause an immediate fire hazard. Corrosive wastes include strong acidic or alkaline substances. They destroy solid material and living tissue upon contact, by chemical reaction.

Infectious wastes include used bandages, hypodermic needles, and other materials from hospitals or biological research facilities.

Principles of waste management

Waste hierarchy

The waste hierarchy refers to the "3 Rs" Reduce, Reuse and Recycle, which classifies waste management strategies according to their desirability in terms of waste minimisation. The waste hierarchy is the cornerstone of most waste minimisation strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of end waste; see: resource recovery. The waste hierarchy is represented as a pyramid because the basic premise is that policies should promote measures to prevent the generation of waste. The next step or preferred action is to seek alternative uses for the waste that has been generated i.e. by re-use. The next is recycling which includes composting. Following this step is material recovery and waste-to-energy. The final action is disposal, in landfills or through incineration without energy recovery. This last step is the final resort for waste which has not been prevented, diverted or recovered. The waste hierarchy represents the progression of a product or material through the sequential stages of the pyramid of waste management. The hierarchy represents the latter parts of the life-cycle for each product.

Life-cycle of a product

The life-cycle begins with design, then proceeds through manufacture, distribution, and primary use and then follows through the waste hierarchy's stages of reduce, reuse and recycle. Each stage in the life-cycle offers opportunities for policy intervention, to rethink the need for the product, to redesign to minimize waste potential, to extend its use. Product life-cycle analysis is a way to optimize the use of the world's limited resources by avoiding the unnecessary generation of waste.

Resource efficiency

Resource efficiency reflects the understanding that global economic growth and development cannot be sustained at current production and consumption patterns. Globally, humanity extracts more resources to produce goods than the planet can replenish. Resource efficiency is the reduction of the environmental impact from the production and consumption of these goods, from final raw material extraction to the last use and disposal.

Polluter-pays principle

The polluter-pays principle mandates that the polluting party pays for the impact on the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the unrecoverable material.

Transport Of Hazardous Waste

Hazardous waste generated at a particular site often requires transport to 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. In addition to the occasional accidental spill, hazardous waste has, in the past, been intentionally spilled or abandoned at random locations in a practice known as "midnight dumping." This practice has been greatly curtailed by the enactment of laws that require proper labelling, transport, and tracking of all hazardous wastes.

Transport vehicles

Hazardous waste is generally transported by truck over public highways. Only a very small amount is transported by rail, and almost none is moved by air or inland waterway. Highway shipment is the most common because road vehicles can gain access to most industrial sites and approved TSDFs. Railroad trains require expensive siding facilities and are suitable only for very large waste shipments.

Hazardous wastes can be shipped in tank trucks made of steel or aluminum alloy, with capacities up to about 34,000 litres (9,000 gallons). They also can be containerized and shipped in 200-litre (55-gallon) drums. Specifications and standards for cargo tank trucks and shipping containers are included in governmental regulations.

The manifest system

In the United States and other countries a key feature of regulations pertaining to waste transport is the "cradle-to-grave" manifest system, which monitors the journey of hazardous waste from its point of origin to the point of final disposal. The manifest system helps to eliminate the problem of midnight dumping. It also provides a means for determining the type and quantity of hazardous waste being generated, as well as the recommended emergency procedures in case of an accidental spill. A manifest is a record-keeping document that must be prepared by the generator of the hazardous waste, such as a chemical manufacturer. The generator has primary responsibility for the ultimate disposal of the waste and must give the manifest, along with the waste itself, to a licensed waste transporter. A copy of the manifest must be delivered by the transporter to the recipient of the waste at an authorized TSDF. Each time the waste changes hands, a copy of the manifest must be signed. Copies of the manifest are kept by each party involved, and additional copies are sent to appropriate environmental agencies.

In the event of a leak or accidental spill of hazardous waste during its transport, the transporter must take immediate and appropriate actions, including notifying local authorities of the discharge. An area may have to be diked to contain the wastes, and efforts must be undertaken to remove the wastes and reduce environmental or public health hazards.

Treatment, Storage, And Disposal

Several options are available for hazardous-waste management. The most desirable is to reduce the quantity of waste at its source or to recycle the materials for some other productive use. Nevertheless, while reduction and recycling are desirable options, they are not regarded as the final remedy to the problem of hazardous-waste disposal. There will always be a need for treatment and for storage or disposal of some amount of hazardous waste.

Treatment

Hazardous waste can be treated by chemical, thermal, biological, and physical methods. Chemical methods include ion exchange, precipitation, oxidation and reduction, and neutralization. Among thermal methods is high-temperature incineration, which not only can detoxify certain organic wastes but also can destroy them. Special types of thermal equipment are used for burning waste in either solid, liquid, or sludge form. These include the fluidized-bed incinerator, multiple-hearth furnace, rotary kiln, and liquid-injection incinerator. One problem posed by hazardous-waste incineration is the potential for air pollution.

Biological treatment of certain organic wastes, such as those from the petroleum industry, is also an option. One method used to treat hazardous waste biologically is called landfarming. In this technique the waste is carefully mixed with surface soil on a suitable tract of land. Microbes that can metabolize the waste may be added, along with nutrients. In some cases a genetically engineered species of bacteria is used. Food or forage crops are not grown on the same site. Microbes can also be used for stabilizing hazardous wastes on previously contaminated sites; in that case the process is called bioremediation.

Surface storage and land disposal

Hazardous wastes that are not destroyed by incineration or other chemical processes need to be disposed of properly. For most such wastes, land disposal is the ultimate destination, although it is not an attractive practice, because of the inherent environmental risks involved. Two basic methods of land disposal include landfilling and underground injection. Prior to land disposal, surface storage or containment systems are often employed as a temporary method.

Temporary on-site waste storage facilities include open waste piles and ponds or lagoons. New waste piles must be carefully constructed over an impervious base and must comply with regulatory requirements similar to those for landfills. The piles must be protected from wind dispersion or erosion. If leachate is generated, monitoring and control systems must be provided. Only noncontainerized solid, nonflowing waste material can be stored in a new waste pile, and the material must be landfilled when the size of the pile becomes unmanageable.

A common type of temporary storage impoundment for hazardous liquid waste is an open pit or holding pond, called a lagoon. New lagoons must be lined with impervious clay soils and flexible membrane liners in order to protect groundwater. Leachate collection systems must be installed between the liners, and groundwater monitoring wells are required. Except for some sedimentation, evaporation of volatile organics, and possibly some surface aeration, open lagoons provide no treatment of the waste. Accumulated sludge must be removed periodically and subjected to further handling as a hazardous waste.

Many older, unlined waste piles and lagoons are located above aquifers used for public water supply, thus posing significant risks to public health and environmental quality. A large number of these old sites have been identified and scheduled for cleanup, or remediation, around the world.

Secure landfills

Landfilling of hazardous solid or containerized waste is regulated more stringently than landfilling of municipal solid waste. Hazardous wastes must be deposited in so-called secure landfills, which provide at least 3 metres (10 feet) of separation between the bottom of the landfill and the underlying bedrock or groundwater table. A secure hazardous-waste landfill must have two impermeable liners and leachate collection systems. The double leachate collection system consists of a network of perforated pipes placed above each liner. The upper system prevents the accumulation of leachate trapped in the fill, and the lower serves as a backup. Collected leachate is pumped to a treatment plant. In order to reduce the amount of leachate in the fill and minimize the potential for environmental damage, an impermeable cap or cover is placed over a finished landfill.

A groundwater monitoring system that includes a series of deep wells drilled in and around the site is also required. The wells allow a routine program of sampling and testing to detect any leaks or groundwater contamination. If a leak does occur, the wells can be pumped to intercept the polluted water and bring it to the surface for treatment.

One option for the disposal of liquid hazardous waste is deep-well injection, a procedure that involves pumping liquid waste through a steel casing into a porous layer of limestone or sandstone. High pressures are applied to force the liquid into the pores and fissures of the rock, where it is to be permanently stored. The injection zone must lie below a layer of impervious rock or clay, and it may extend more than 0.8 km (0.5 mile) below the surface. Deep-well injection is relatively inexpensive and requires little or no pre treatment of the waste, but it poses a danger of leaking hazardous waste and eventually polluting subsurface water supplies.

Conclusion

Disposal of hazardous waste in unlined pits, ponds, or lagoons poses a threat to human health and environmental quality. Many such uncontrolled disposal sites were used in the past and have been abandoned. Depending on a determination of the level of risk, it may be necessary to remediate those sites. In some cases, the risk may require emergency action. In other instances, engineering studies may be required to assess the situation thoroughly before remedial action is undertaken.

One option for remediation is to completely remove all the waste material from the site and transport it to another location for treatment and proper disposal. This so-called off-site solution is usually the most expensive option. An alternative is on-site remediation, which reduces the production of leachate and lessens the chance of groundwater contamination. On-site remediation may include temporary removal of the hazardous waste, construction of a secure landfill on the same site, and proper replacement of the waste. It may also include treatment of any contaminated soil or groundwater. Treated soil may be replaced on-site and treated groundwater returned to the aquifer by deep-well injection.

A less costly alternative is full containment of the waste. This is done by placing an impermeable cover over the hazardous-waste site and by blocking the lateral flow of groundwater with subsurface cutoff walls. It is possible to use cutoff walls for this purpose when there is a natural layer of impervious soil or rock below the site. The walls are constructed around the perimeter of the site, deep enough to penetrate to the impervious layer. They can be excavated as trenches around the site without moving or disturbing the waste material. The trenches are filled with a bentonite clay slurry to prevent their collapse during construction, and they are backfilled with a mixture of soil and cement that solidifies to form an impermeable barrier. Cutoff walls thus serve as vertical barriers to the flow of water, and the impervious layer serves as a barrier at the bottom.