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Unit - 3

Hazardous Waste And Its Management: Introduction to hazardous waste management issues, classification; Magnitude of problem; Risk assessment; Environmental Legislation; Characterization and site assessment; Waste minimization and resource recovery; Storage and Transportation of Hazardous wastes; Hazard in processing and treatment; Physical, Chemical, Thermal and Biological processes.

Introduction:

Hazardous wastes are those that may contain toxic substances generated from industrial, hospital, some types of household wastes. These wastes could be corrosive, inflammable, explosive, or react when exposed to other materials. Some hazardous wastes are highly toxic to environment including humans, animals, and plants.

With increasing manufacturing processes, solid, liquid, and/or gaseous emissions generate as by-products. Some of these wastes are potentially harmful to human health and environment and thus need special techniques of management.

Wastes are classified as hazardous if they exhibit one or more of ignitability, corrosivity, reactivity, or toxicity. According to Resource Conservation and Recovery Act (RCRA), hazardous wastes are defined as any waste or combination of wastes which pose a substantial present or potential hazard to human health or living organisms because such wastes are non-degradable or persistent in nature or because they can be biologically magnified, or because they can be lethal, or because they may otherwise cause or tend to cause detrimental cumulative effects.

The management of hazardous wastes has become a specialized discipline because of the complex nature of the problem and the solutions available to humanity. The mismanagement examples of hazardous wastes causing disastrous human and environmental consequences are numerous. The management process is based on the definition and classification of the different wastes, and their toxic effects on human and taking in consideration the application of risk management to control human health and environmental impacts of hazardous waste. Hazardous waste management, therefore, deals with minimizing harmful effects on humans and environment by applying special techniques of handling, storage, transportation, treatment, and disposal of hazardous wastes.

Hazardous characteristics:

A useful listing of hazardous characteristics is that provided by the United Nations as part of recommendations relating to the transport of dangerous goods as illustrated in below TABLE.

UN class number	Hazardous characteristic
1	Explosive
3, 4	Flammable
5	Oxidizing
6	Poisonous/infectious
7	Radioactive
8	Corrosive
9	Toxic (delayed or chronic)/ecotoxic

Industrial wastes:

Waste generated from industrial sources can have non-hazardous and hazardous components, with non-hazardous waste usually representing the greater part of the volume. The hazardous component of this waste is relatively small in volume.

This type of waste was identified as hazardous waste when proceeds toxicity test, corrosively test, ignitability test, and some special character test. As a hazardous pollutant, it may impose serious impacts on surrounding environment and such impacts should be quantitatively examined to assess the influence on human health.

Household waste:

Households generate small quantities of hazardous wastes such as oil-based paints, paint thinners, wood preservatives, pesticides, insecticides, household cleaners, used motor oil, antifreeze, and batteries. It has been estimated that household hazardous waste in industrialized countries such as the United States accounts for a total of about 0.5% (by weight) of all waste generated at home, while in most developing countries, the percentage probably is even lower.

Biomedical waste:

There are some of hazardous medical and dental wastes that, when disposed improperly, could cause harm to the environment. It also presents an occupational health hazards to the healthcare personnel who handle these wastes at the point of generation and those involved with their management, that is, segregation, storage, transport, treatment, and disposal.

Healthcare waste that is capable of producing injury or disease including many sorts of hazardous wastes such as:

- **Infectious waste: Which contain pathogens namely bacteria, viruses, fungi, or parasites in concentrations sufficient to cause disease in susceptible hosts. Cultures and stocks of infectious agents from laboratory work; tissues and dressing generated from autopsies, surgeries, and treatment of infected patients and animals; materials or equipment in contact with blood and infected body fluids.**
- **Pathological waste: Including tissue, organs, body parts, human fetuses, and animal carcasses, blood and body fluids.**
- **Sharps: It comprise syringes, needles, scalpels, saws, infusion sets, knives, blades, broken glass, or other items that can cause cut or puncture wounds.**
- **Pharmaceutical waste: It covers expired, unused, spilt, and contaminated pharmaceutical products, drugs, vaccines, and sera that are no longer required and need to be disposed of in appropriate manner.**
- **Geotaxis waste: This type combines cytostatic drugs, vomit, urine, or feces from the patients treated with cytotoxic drugs, chemicals, and radioactive materials. Genotoxic waste has mutagenic, teratogenic, and carcinogenic properties.**
- **Chemical waste: Discarded solid, liquid, or gaseous chemicals should be considered as hazardous if it is toxic, corrosive, inflammable, or reactive.**
- **Waste with high content of heavy metals: Mercury (thermometers, blood pressure gauges, amalgam), cadmium (discarded batteries), and lead (reinforced wood panels for radiation proofing in radiology department) generated from hospitals could be represented as a subcategory of hazardous chemical waste.**
- **Radioactive waste: The use of radioisotopes in vitro analysis of body tissues and fluids, in vivo organ imaging, tumor localization, and treatment and various clinical studies involving certain radionuclides need to be specially managed in a centralized treatment facility for radioactive wastes.**

Radioactive waste:

Nuclear applications have been rapidly developed recently, and several nuclear power plants started to work throughout the world. The potential impact of released radioactive contaminants into the environment has received growing attention due to nuclear accidents. Contamination of soil and water by radionuclides due to natural processes, global fallout from nuclear weapon testing, discharges from nuclear installations, disposal of nuclear waste, and occasional nuclear accidents (i.e., Chernobyl in 1986 and Fukushima in 2011) poses serious problems to biological systems. Radioactive waste includes a variety of radionuclides and occurs in a variety of physical and chemical forms.

It can be generally classified as low-/intermediate-level radioactive waste and high-level radioactive waste .

Radioactive waste, arising from civilian nuclear activities as well as from weapon activities, poses a potential problem for handling and saving the environment for coming generations.

Radioactive waste includes a variety of radionuclide and occurs in a variety of physical and chemical forms. It can be generally classified as low-/intermediate-level radioactive waste and high-level radioactive waste. Nuclear research establishments include, for example, waste containing different organic components, toxic or chemically aggressive constituents, radionuclide with specific properties (high mobility, high chemical activity, volatile elements, etc.), waste difficult for treatment and not appropriate for direct immobilization (e.g., spent organic ion exchange resins and spent liquid scintillation cocktails). For such waste, application of conventional treatment and conditioning options may not be efficient and appropriate in terms of economy, safety, and performance characteristics. In many cases, such wastes are stored awaiting an appropriate treatment and conditioning solution.

The primary sources of radioactive wastes in a country without nuclear fuel cycle activities are nuclear research, production of radioisotopes, application of radioisotopes, and decontamination and decommission of nuclear installations.

Hazardous and radioactive wastes management:

Waste management is an important component of environmental policy all over the world. Priority of hazardous solid waste for environmental protection is formulated on source reduction and reuse, recycling, treatment, and land filling .

Hazardous Waste Management Problems:

Although there are hazardous waste management difficulties everywhere due to their health and safety risks, less developed countries face a unique set of additional problems. Many hazardous substances are produced by technologies from the developed world, so less developed countries certainly face some of the same problems experienced by developed countries. Compared to economically developed countries, however, developing nations do not possess the advanced technology necessary for adequate hazardous waste management. Severe financial constraints often prevent these countries from acquiring the necessary technologies, and many are dependent upon donors for technology acquisition. This is exacerbated by the fact that a variety of other problems resulting from economic difficulties make hazardous waste management a low priority compared to other more immediate concerns. In addition to economic constraints, hazardous waste management deficiencies in developing countries are also a result of the general lack of awareness among citizens. In Tanzania, for example, as well as many other developing countries, hazardous waste management has not received sufficient public attention (see Case Study 1: Hazardous Waste Management in Tanzania: Retrospection and Future Outlook). Many less developed countries suffer from waste dumping and mismanagement because they lack legislative provisions or enforcement mechanisms necessary for proper hazardous waste management. The current trend of economic liberalization can exacerbate such a situation by resulting in the increase of the types and quantity of hazardous wastes. Economic liberalization can also lead to the growth of industries and other economic establishments that produce hazardous wastes in areas that were previously reserved for other

uses, for example in residential areas or near water sources. High population growth accompanied by economic development has also caused a massive increase in the production of solid waste, including hazardous wastes. When coupled with the hazardous waste problems already faced by less developed countries, including safety and health issues, ignorance, legislative deficiencies, enforcement laxity, technological deficiencies, and poverty, it is no wonder that this has triggered discussions aimed to avert the potential public health and environmental catastrophe that could occur as a result of the additional waste production. The true picture regarding health and environmental effects of hazardous wastes in developing countries cannot be accurately judged from the available statistics. This is due to the following reasons:

- Low awareness concerning the effects of hazardous waste exposure masks pertinent cases that have health and environmental consequences
- Poor data collection and record keeping implies that documented exposure effects are just the tip of the iceberg and that many more effects go undocumented.
- Poor medical services both in terms of quality and availability imply that many cases of hazardous waste exposure effects may not be properly diagnosed and documented or may not be treated at all.
- The lack of a culture of undergoing regular medical check-ups, makes it difficult to expose cause-effect correlation
- Diverse locations and types of sources of hazardous wastes make identification and follow-up difficult.
- Financial constraints at the national and individual level sometimes lead to practices that can increase human exposure to hazardous wastes. For example, the use of pesticides that are banned in developed countries is sometimes due to a lack of an alternative option. Also, in extreme cases, poverty and famine have been known to force people to wash the pesticide coating off grain seeds and eat the seeds even when people know that this can expose them to ill-effects or death.

Hazardous Waste Sources:

As is the case in developed countries, industry is a major source of hazardous waste in less developed countries, but industrial hazardous waste sources in developing countries present more risks than in developed countries because of poor management and obsolete technologies. Notably, multinational companies often shift their plants to less developed countries and use technology banned in their home countries. The accident at the Bhopal plant in India, which belonged to Union Carbide of USA, is a prime example of this situation. A number of hazardous waste sources are specific to less developed countries. Transporters and disposal facilities for hazardous waste, for example, create greater hazards in developing countries due to less strict management standards. Another unique problem to developing countries is that hazardous wastes or wastes contaminated with hazardous wastes are often reclaimed and recycled by scavengers. Household sprays and insect repellents, which are in widespread use in hot climates, can also present higher risks in developing countries. Contaminated sites, spills and abandoned

industries are often never remediated or restored to their original conditions, as is the case in Tanzania, so they continue to be sources of pollution to groundwater and soil through leachate, to air by volatilization and to surface water by surface run-off. Developing countries possess a mix of industrial and less developed country-specific hazardous waste sources. The major sources of hazardous solid wastes in Tanzania, for example, are industrial activities, agriculture and agro-industry, medical facilities, commercial centers, households and the informal sector. The informal sector, the part of the urban economy in less developed countries that has small, competitive and labor-intensive businesses that are not regulated by the government, is a unique source of hazardous solid waste that is currently recognized as a major problem in many developing countries. Problems involving mismanagement of hazardous agrochemicals in particular are more serious in developing countries, especially in Africa and Latin America, than in the developed world. Agro-industry encompasses farming activities (including urban agriculture), livestock production (including processes that are pertinent to the processing of livestock products), and agro-produce processing activities. Common wastes from these sources include crop residues, grain bran, and animal carcasses. These waste fractions are generally re-used and recycled at a high rate as soil amendment agents in addition to being reused as animal feed or as raw materials for animal feed production. The hazardous agro-industry waste fractions include pesticides, industrial fertilizers, veterinary products, and animal carcasses. These components are of concern because of their health and environmental impacts and the fact that they are not properly managed. Notably, in Tanzania many stocks of obsolete and unwanted pesticides as well as veterinary products are poorly managed. Both fertilizers and pesticides find their way into ground and surface water sources with resultant impacts.

Risk assessment at hazardous waste contaminated sites with variability of population characteristics:

The extent to which it is desirable to remove or otherwise contain hazardous substances present at waste disposal sites should be a function of the risk to health and the environment that may remain under various remedial action plans. This paper provides, in Part I, a discussion of the elements of human health risk assessment long in use to evaluate toxic chemicals in other contexts. The discussion is largely non-technical, and is designed to provide an introduction to the subject for those from other disciplines involved in remedial action planning and implementation. Part II contains the essential elements of a risk evaluation scheme that might be used to select the most cost-effective remedial action plan for a given site, where effectiveness is measured by the degree of long-term health protection achieved.

Risk assessment is considered to be an effective scientific tool which enables decision makers to manage hazardous waste-contaminated sites in a cost-effective manner while preserving public health. However, the current risk assessment framework proposed by the US Environmental Protection Agency (US EPA) has limitations in addressing the true variability of population characteristics. This study proposed a methodology that is different from the existing framework by accounting for the true variability of population characteristics. The key differences of the proposed methodology and the existing framework are the

(1) Use of the transient exposure concentration;

(2) use of the entire population rather than a representative ideal individual;

(3) use of age- and gender-based population subgroups to represent population characteristics;

(4) Use of a population growth model to represent growth dynamics; and

(5) Presentation of risk through a risk profile with risk summarized through a single indicator, potential cancer incidences (PCI).

The proposed methodology was applied in a ground water contamination scenario due to benzene to determine its applicability. The results of the study showed that age-based variability of population characteristics is important in predicting the population risk while gender played a small role. The existing US EPA methodology and its variation using age-independent variability of population characteristics overestimate the risk given by PCI substantially, and therefore, the decisions can lead to costly cleanup goals. Population risk is not a single value but a distribution due to the contribution from different individuals of the exposed population. Hence, the decision criterion proposed in this study, PCI, is found to be a useful indicator to describe population carcinogenic risk to the society under a variety of conditions and scenarios.

ENVIRONMENTAL LEGISLATION:

The awareness and consideration for environment covers several environmental issues such as pollution of water, air and soil, land degradation, industrialization, urbanization, depletion of natural resources etc. Environmental Law plays a very crucial and important role in regulating the use of natural resources and in protecting the environment. The success of environmental legislations mainly depends on the way they are enforced. Legislation also serves as a valuable tool for educating masses about their responsibility in maintaining healthy environment. Numerous legislations have already been put forth at national and international levels. In this lesson, you will learn about some important environmental legislations. Indian legislations are called Acts where as the international legislations are in the form of conventions, protocols and treaties.

Objective of Hazardous waste:

After completing this lesson, you will be able to:

- describe the constitutional provision for environmental protection and conservation in India;
- list and describe the various Indian environmental laws along with their objectives;
- describe the various pollution related acts such as water, air and environment act;
- explain the various global conventions and their objectives in the field of environment.

ENVIRONMENTAL LEGISLATION:

Environmental legislation is the collection of laws and regulations pertaining to air quality, water quality, the wilderness, endangered wildlife and other environmental factors. The umbrella of environmental legislation covers many laws and regulations, yet they all work together toward a common goal, which is regulating the interaction between man and the natural world to reduce threats to the environment and increase public health.

As you might imagine, environmental legislation is a broad topic, mainly because the natural environment encompasses so many different aspects. So, environmental laws need to consider everything, from the air we breathe to the natural resources we rely on to the plants and animals that share this world with us.

To better understand environmental law, let's look at an example. Let's say that an energy company wants to build a coal-burning power plant to create electricity for the community. Where this power plant should be built? What type of pollutants might result from the coal burning, and what measures will need to be taken to control harmful emissions? If the power plant is built at the edge of town to lessen air pollution for the human population, how will this impact lesser species that inhabit the land downwind of the plant? These are all considerations to be evaluated within the scope of environmental law.

The genesis of various legislations in the country lies in the environmental problems. There should be effective legislations to protect the environment or else the need for resources by the growing population will create havoc on the environment. The other important aspect is enforcement of these laws. To safeguard our environment from further degradation and pollution these must be enforce laws forcefully and effectively.

Need for legislation:

In the recent past, numerous environmental problems have become threatening for human welfare. An important aspect of environmental problems is that their impact is not confined to the source area but spills over far and wide area. Effective legislation is needed in order to prevent misuse and degradation of the environment. To curb the destructive practices of unscrupulous people, forest mafia groups, poachers, polluters and over exploitation of environmental resources, effective legislation is necessary. Pollution is an important factor and it does not observe political territories or legislative jurisdictions. Thus environmental problems are intrinsically global in nature. Therefore, to prevent such problems environmental legislation is not needed only at the national level but also at the international level.

Hazardous Waste Site Characterization:

Hazardous waste site characterization provides the information needed to identify site hazards and to select worker protection methods. The more accurate, detailed, and comprehensive the information available about a contaminated site, the more the protective measures can be

tailored to the actual hazards that workers may encounter. The person with primary responsibility for Hazardous Waste Operations and Emergency Response (HAZWOPER) site characterization and assessment is the Project Team Leader. In addition, outside experts, such as chemists, health physicists, industrial hygienists, and toxicologists, may be needed to accurately and fully interpret all the available information on site conditions.

Site characterization generally proceeds in three phases:

- Prior to site entry, conduct offsite characterization: gather information away from the site and conduct reconnaissance from the site perimeter.
- Next, conduct onsite surveys. During this phase, restrict HAZWOPER site entry to reconnaissance personnel.
- Once the site has been determined safe for commencement of other activities, perform ongoing monitoring to provide a continuous source of information about site conditions.

It is important to recognize that HAZWOPER site characterization is a continuous process. At each phase of site characterization, information should be obtained and evaluated to define the hazards that the site may pose. This assessment can then be used to develop a safety and health plan for the next phase of work. In addition to the formal information gathering that takes place during the phases of site characterization described here, all site personnel should be constantly alert for new information about site conditions.

What is the Process of Minimizing Waste?

Every year, millions of tons of waste is generated from both households and building construction, most of which ends up in landfills with a small percentage being recycled. Thus, there is a great need for waste minimization as this will not only have a huge environmental impact but also present substantial economic and social benefits.

Waste minimization entails limiting the amount of waste that is generated thereby helping to eliminate the production of persistent and harmful wastes effectively supporting efforts that promote a society that is sustainable. Thus, waste minimization involves a change of societal patterns that relate to production and consumption as well as redesigning products to eliminate the generation of waste.

"Waste Minimization is reduction in the quantity of hazardous wastes achieved through a conscientious application of innovative or alternative procedures. Simple adjustments to a process producing wastes (e.g. a teaching lab experiment, a vehicle cleaning operation, etc.) may be the only requirement to achieve some results. However, looking at the broader picture in the University environment, it is often difficult to recognize waste reductions due to the complex and changing growth patterns within the campus community. Reductions are often offset by increased staff and student growth and/or building construction."

Benefits of Waste Minimization:

While it is obvious that waste minimization supports sound business and economic practices in addition to protecting the environment, other benefits include the following:

- **Improved product quality – New technological practices and innovation will not only reduce generation of waste but also contribute to improved input quality that translates to improved products.**
- **Economic benefits – Efficiency in product use translates to reduced costs when purchasing materials thus significantly affecting financial performance.**
- **Efficiency of production practices – Waste minimization will attain more output of the product for every part of raw material.**
- **Environmental responsibility – eliminating or minimizing generation of waste will make it easy for you to achieve environmental policies, standards and regulations.**
- **Public image – Embracing waste minimization will boost the reputation of your company, as it is a reflection of proactive movement in the quest to protect the environment.**

3 R's of Waste Minimization:

Waste minimization revolves around three R's as follows:

A. Reduce:

This calls for using resources that are just enough to cater to your needs for instance building a smaller house. This is an effective way of conserving resources as it also lowers the costs. This can be achieved through attaining accuracy when ordering to ensure that there is no waste or no material is sitting on the site for long periods that it is damaged.

B. Reuse

Here, you will do well to reuse existing materials and buildings effectively reducing the need for resources while lowering waste volumes and saving money. A huge percentage of resources are incorporated in the construction of homes owing to the mixed materials that are used yet the end destination for most of them are landfills. Thus, renovating a house is a much better option than bringing it down to put up another one because a negligible fraction of the old house may be reused/recycled.

C. Recycle

Using left over resources or those resources that have reached the end of their life minimizes the need for new materials as well as lowers the volume that ends up in landfills. Thus, it is advisable to use materials that are recyclable as this creates a market for the resources that are recycled while also raising the price that recyclers pay for resources that are recovered even as the recycling viability increases.

Waste Minimization Techniques:

1. **Optimization of resources:**
   In order to reduce the quantity of waste that is produced by individuals or organizations calls for the optimization of raw materials used in production. For

instance, a dressmaker will do well to arrange the pieces of pattern in a certain way along the length of the fabric to use a small portion of the fabric.

2. Scrap metal reuse:
   Incorporating scraps into the initial stages of manufacturing is a surefire way of ensuring that they do not end up in landfills as waste products. A majority of industries embrace this process effectively returning rolls that are damaged to the initial production line and in the manufacturing of off cuts, plastic items so that scrap is re-incorporated in the new commodities.

3. Quality control improvement and process monitoring:
   Measures can be put in place to control the number of rejects and ensure it is at a minimum. This may be achieved through increased frequency of inspection as well as increasing the number of inspection points. For instance, installation of continuous monitoring device that is automated will help in identifying production problems before they get to an advanced stage.

4. Exchange of Waste:
   Here, the waste products from one process are used as raw materials for other processes. Exchange of waste is another means of minimizing waste disposal volumes especially for waste that may not be eliminated.

5. Shipping to the point of use:
   Here, raw materials as well as other components are directly delivered at the point of assembly or manufacturing plant ostensibly to minimize handling and use of enclosures and protective wrappings.

Zero waste:

This systems approach is designed to eliminate waste from the source as well as at every point of the supply chain to ensure that no waste is produced. This design philosophy places emphasis on waste prevention and not waste management at the end of production line.

Waste Minimization for Households:

Households can practice waste minimization by employing various techniques. One of the ways to achieve this is through purchasing adequate sizes and amounts of food. Purchasing large containers of paint when taking small decorating jobs or purchasing large volumes of food than you need will result in wastage. In instances where cans or packs may be thrown the remains of the containers should be removed to allow for recycling of the container.

Home composting, thoughtful use of electricity as well as reducing the number of car journeys is also a great way of waste minimization. Generally, buying fewer products or products that last longer, mending worn or broken equipment or clothing can also minimize household waste. Additionally, households can also minimize wastage of water and cycle or walk to various destinations as opposed

to using cars thereby saving on fuel. Overall, personal waste reduction will have an effect on the general waste volumes. Consumers may also shun products without eco-labeling.

Waste Minimization in Building Construction:

An assessment of streams of waste shows that energy savings may be achieved at minimal cost or no cost within the construction sector. Consequently, the environmental impact of materials may be reduced significantly with reuse.

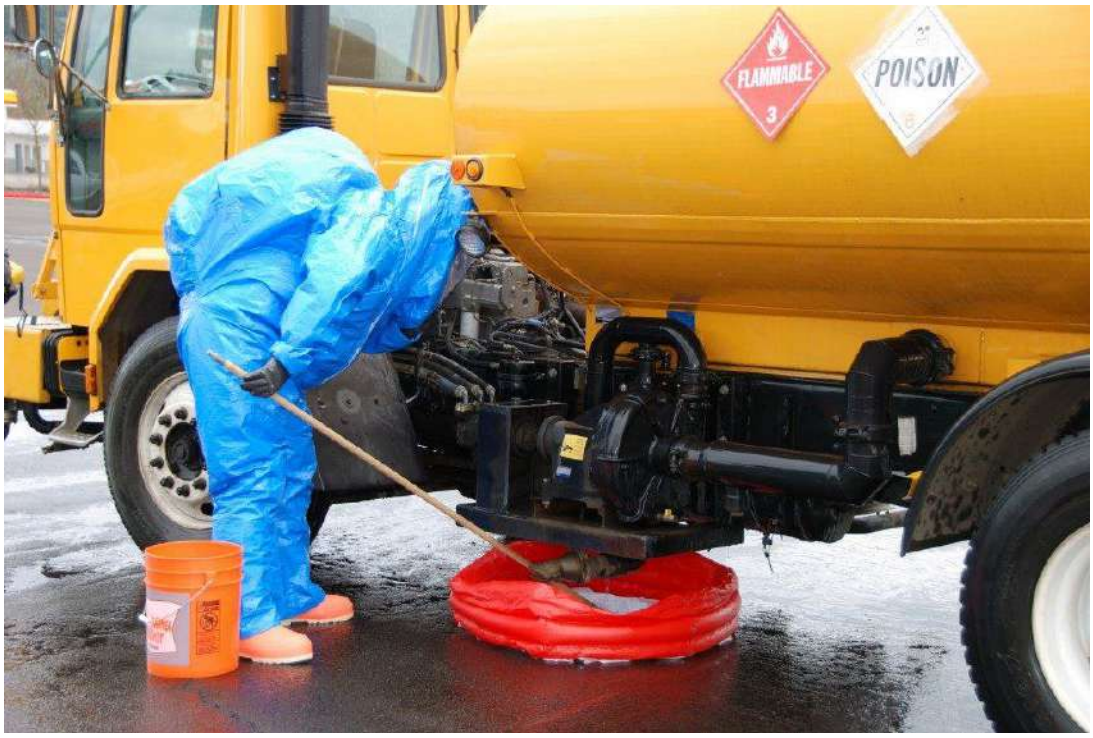
While at it, it is important to ensure you work with the concerned authorities that include local councils, regional waste authorities, landfill operator or waste recycling contractors. Some of the construction materials that may be recycled include steel, aluminum, gypsum plasterboard, timber, concrete, glass, carpet, plastics as well as bricks and tiles.

Why is Waste Minimization Important?

Waste minimization is important because it helps protect the environment and it makes good business sense. In fact, businesses can simultaneously manage both business and environmental objectives by focusing on waste minimization. For example, companies have discovered that waste minimization:

Saves money through avoided disposal and raw materials purchase costs;

- Reduces regulatory burdens and compliance costs;
- Builds better community relations;
- Minimizes short and long term liability;
- Creates safer working conditions for employees;
- Protects human health and the environment;
- Demonstrates environmental leadership;
- Improves competitiveness through greater efficiencies and deceased overhead costs.



How Hazardous Materials Are Disposed And Transported:

Handling and transporting hazardous materials is an essential part of an efficient waste management system. Industrial companies seek the help of hazmat transportation companies in Utah to move hazardous waste and dangerous materials. Some specialized professionals are skilled at handling this risky task.

Many of the items are not dangerous on their own, but they may contain harmful substances, which pose dangers to the public and the environment if not handled properly. Transporting them from one point to another involves risk of damage in transit, theft or loss, explosion, fire, spills and leaks.

Disposal of Hazardous Waste:

The company's responsibilities do not end after using hazardous materials. There are legal and social obligations to ensure that these wastes are recovered or disposed of properly to prevent harming people and the environment.

Risk assessment should include careful consideration of the treatment, recovery, disposal and transportation process of hazardous wastes. Companies using these materials have a legal duty to manage waste properly. It only means that the business using these kinds of materials is responsible until the waste is disposed of or is fully recovered.

There are additional requirements for the waste treatment and disposal as well as the containers that must be used for materials with hazardous qualities. Generally, these chemicals and hazardous materials are accompanied by information and safety data sheet to determine their proper classification, specific handling, transportation or disposal.

Transportation of Hazardous Waste:

There are special regulations to follow when transporting goods classified as hazardous or dangerous. The risks involved must be primarily identified in the classification of the goods. Waste management companies need people who are trained specifically in handling these materials. The load must be secured and the weight evenly distributed. Vehicles carrying hazardous materials and waste must be equipped and marked with suitable warning signs.

Some examples of hazardous materials that waste management companies transport and dispose of are asbestos, oily sludge, chemicals wastes, lead-acid batteries, solvents or solvent-based substances, used engine oils and filters, fluorescent light tubes and pesticides.

When transporting hazardous materials via road or railways, these guidelines must be followed:

- Using appropriate packaging and labels so that everyone who makes contact with it can take necessary precaution.
- Using suitable containers, vehicles, wagons or tanks depending on the classification of the goods.
- Displaying specific information about the goods on the container and the vehicle.
- Following the proper procedure in loading and unloading the goods.

Road transport:

Vehicles carrying hazardous materials must have safety equipment such as fire extinguishers in case of accidents, explosion or fire. The company is required to have a qualified dangerous good safety adviser. Drivers must also be professionally trained, not just in driving but also on the proper handling of dangerous materials and on what to do if an incident occurs

Waste management companies transporting hazardous wastes need to register with the government environmental agency as a waste carrier, and the drivers need a special license registration for this type of work. When transporting the same via sea, air, road or waterways, the company must comply with other international regulations as well.

Transporting hazardous waste:

Proper handling and transporting of hazardous waste can reduce the possibility of accidental spills.

When bringing hazardous waste to household hazardous waste collection services, take the following precautions:

- Don't mix products.
- Keep products in their original containers. (At the Factoria household hazardous waste drop-off site, gasoline containers are not returned to customers.)
- Label products that aren't in their original containers.
- Secure products so they can't tip over and/or leak. Transport similar containers in cardboard boxes NOT garbage bags/bins, etc.
- Secure the Load (external link) in the vehicle or trailer. Vehicles arriving at public or private transfer stations in King County with unsecured loads can be charged an unsecured load fee
- Store products away from the passenger compartment and separate waste products from those that will be retained.
- Owners must unload their own vehicles, except at the Auburn Waste mobile and traveling Waste mobile.

How to Treat Hazardous Waste: Physical, Chemical and Biological Treatment:

There are various alternative waste treatment technologies, for example, physical treatment, chemical treatment, biological treatment, incineration, and solidification or stabilization treatment.

These processes are used to recycle and reuse waste materials, reduce the volume and toxicity of a waste stream, or produce a final residual material that is suitable for disposal. The selection of the most effective technology depends upon the wastes being treated.

Physical Treatment of Hazardous Waste:

This includes processes that separate components of a waste stream or change the physical form of the waste without altering the chemical structure of the constituent materials. Physical treatment techniques are often used to separate the materials within the waste stream so that they can be reused or detoxified by chemical or biological treatment or destroyed by high-temperature incineration.

These processes are very useful for separating hazardous materials from an otherwise non-hazardous waste stream so that they may be treated in a more concentrated form, separating various hazardous components for different treatment processes, and preparing a waste stream for ultimate destruction in a biological or thermal treatment process.

Physical treatment processes are important to most integrated waste treatment systems regardless of the nature of the waste materials or the ultimate technologies used for treatment or destruction.

The physical processes that are commonly used in waste treatment operations are as follows:

1. **Screening is a process for removing particles from waste streams, and it is used to protect downstream pre-treatment processes.**

2. Sedimentation is a process for removing suspended solid particles from a waste stream. Sedimentation is usually accomplished by providing sufficient time and space in special tanks or holding ponds for settling. Chemical coagulating agents are often added to encourage the settling of fine particles.

3. Flotation is a process for removing solids from liquids by floating the particles to the surface by using tiny air bubbles. Flotation is useful for removing particles too small to be removed by sedimentation.

4. Filtration is a process for separating liquids and solids by using various types of porous materials. There are many types of filters designed to achieve various levels of separation.

5. Centrifugation is a process for separating solid and liquid components of a waste stream by rapidly rotating a mixture of solids and liquids inside a vessel. Centrifugation is most often used to dewater sludge's.

Chemical Treatment of Hazardous Waste:

Chemical treatment processes alter the chemical structure of the constituents of the waste to produce either an innocuous or a less hazardous material. Chemical processes are attractive because they produce minimal air emissions, they can often be carried out on the site of the waste generator, and some processes can be designed and constructed as mobile units.

The five chemical treatment operations commonly used in treating wastes are as follows:

1. Neutralization is a process for reducing the acidity or alkalinity of a waste stream by mixing acids and bases to produce a neutral solution. This has proven to be a viable waste management process.

2. Precipitation is a process for removing soluble compounds contained in a waste stream. A specific chemical is added to produce a precipitate. This type of treatment is applicable to streams containing heavy metals.

3. Ion exchange is used to remove from solution ions derived from inorganic materials. The solution is passed over a resin bed, which exchanges ions for the inorganic substances to be removed. When the bed loses its capacity to remove the component, it can be regenerated with a caustic solution.

4. De-chlorination is a process for stripping chlorine atoms from chlorinated compounds such as polychlorinated biphenyls (PCBs). One of the processes uses a metallic sodium reagent to break the chlorine bond.

5. Oxidation-reduction is a process for detoxifying toxic wastes in which the chemical bonds are broken by the passage of electronics from one reactant to another.

Biological Treatment of Hazardous Waste:

Biological waste treatment is a generic term applied to processes that use micro-organisms to decompose organic wastes either into water, carbon dioxide, and simple inorganic substances, or into simpler organic substances, such as aldehydes and acids.

Typically, the micro-organisms used in a biological process are present in the incoming waste. In some instances, micro-organisms that were developed to attack specific compounds are injected into a waste stream.

The purpose of a biological treatment system is to control the environment for micro-organisms so that their growth and activity are enhanced, and to provide a means for maintaining high concentrations of the micro-organisms in contact with the wastes.

Since biological treatment systems do not alter or destroy inorganic substances, and high concentrations of such materials can severely inhibit decomposition activity, chemical or physical treatment may be required to extract inorganic materials from a waste stream prior to biological treatment.

There are five principal types of conventional biological treatment. Treatment with activated sludge involves exposing waste to a biological sludge that is continuously extracted from the clarified waste stream and recycled.

In the aerated lagoon method, waste is agitated with air in large enclosures to increase oxygen-dependent biological oxidation. In treatment using trickling filters, wastes are allowed to trickle through a bed of rocks coated with micro-organisms that alter the waste components by using them as food.

Disposal of Hazardous Waste:

Ultimately, after all treatment is completed, there remains an inorganic valueless residue that must be disposed of safely.

There are five options for disposing of hazardous waste as follows:

- **(i) Underground injection wells are steel and concrete-encased shafts placed deep below the surface of the earth into which hazardous wastes are deposited by force and under pressure. Some liquid waste streams are commonly disposed of in underground injection wells.**
- **(ii) Surface impoundment involves natural or engineered depressions or dike areas that can be used to treat, store, or dispose of hazardous waste. Surface impoundments are often referred to as pits, ponds, lagoons, and basins.**

(iii) Landfills are disposal facilities where hazardous waste is placed in or on land. Properly designed and operated landfills are lined to prevent leakage and contain systems to collect potentially contaminated surface water run-off. Most landfills isolate wastes in discrete cells or trenches, thereby preventing potential contact of incompatible wastes.

(iv) Land treatment is a disposal process in which hazardous waste is applied onto or incorporated into the soil surface. Natural microbes in the soil break down or immobilize the hazardous constituents. Land treatment facilities are also known as land application or land farming facilities.

(v) Waste piles are non-containerized accumulations of solid, non-flowing hazardous waste. While some are used for final disposal, many waste piles are used for temporary storage until the waste is transferred to its final disposal site.

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