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Building Sustainability Edge through Institutional Strategy Solid Waste/ Hazardous Waste/ Toxic Waste Management

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ABSTRACT

Hazardous-waste management, is defined as 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. Proper management and control can greatly reduce the dangers of hazardous waste. There are many rules for managing hazardous waste and preventing releases into the environment. Even so, a lot can go wrong when we try to contain hazardous waste. Even the most technologically advanced landfills we build will leak someday. Tanks used for storing petroleum products and other chemicals can leak and catch fire; underground storage tanks weaken over time and leak their hazardous contents. Transportation accidents, such as train crashes and overturned trucks, can occur while transporting hazardous substances. There are also cases of intentional and illegal dumping of hazardous waste in sewer systems, abandoned warehouses, or ditches in remote areas to avoid the costs and rules of safe disposal. This paper discusses the importance of hazardous waste management, outlining legal requirements and the need to comply with standards; Environmental concerns surrounding hazardous waste management, characteristics of hazardous waste. The paper reflects on some major sources of hazardous wastes; Routes of transport of hazardous waste to the environment and exposure to humans, Health and Environmental impacts of industrial hazardous waste; Treatment of hazardous waste categorizing the four major methods: the physical including encapsulation, wetting and physical separation, the chemical, the biological including biodegradation, bioremediation (in-situ and ex-situ) and the thermal methods. The paper also provides faith-based reflections on waste and waste management issues and suggests various waste management techniques outlining various activities that can be practiced at the personal, home and institutional level in sustainable waste management. The paper emphasizes that waste and especially hazardous waste is not only a local issue; other countries all over the world have to deal with this challenge in order to achieve sustainable development. Participants are encouraged to take part in world events that address waste issues such as; World Environment Day (June 5th), Earth Day (April 22nd), World Health Day (April 7th), World Standards Day (October 14th), and International Coastal Clean-up Day (September 20th)

Introduction

Hazardous-waste management, is defined as 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. Proper management and control can greatly reduce the dangers of hazardous waste. There are many rules for managing hazardous waste and preventing releases into the environment. Even so, a lot can go wrong when we try to contain hazardous waste. Even the most technologically advanced landfills we build will leak someday. Tanks used for storing petroleum products and other chemicals can leak and catch fire; underground storage tanks weaken over time and leak their hazardous contents. Transportation accidents, such as train crashes and overturned trucks, can occur while transporting hazardous substances. There are also cases of intentional and illegal dumping of hazardous waste in sewer systems, abandoned warehouses, or ditches in remote areas to avoid the costs and rules of safe disposal.

Importance of Hazardous Waste Management

Legal Requirement

It is the sole responsibility of the waste generator to handle their waste management especially their hazardous waste. Many local governments provide consultations and recommendations to organizations on the appropriate ways of handling their waste. More than ever, there need to be consequences to companies that do not take waste management seriously. Part of this includes reducing harmful emissions into the environment over a period of time and correctly disposing of waste materials.

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Comply with Standards

Countries have terms and conditions about what is acceptable in terms of waste management. Today, more than ever, industries know their impact of manufacturing on smog levels and the escalating cost of managing their waste. More industrial leaders are showing their accountability for the environment. Citizens need to support companies whose business practices include Hazardous waste management.

Environmentally Conscious and Responsible Conditions

Environmental protection acts encourage and reward companies who do their part to more effectively manage waste and work with environmental agencies to maximize efforts to minimize the impact on the environment. Improper handling of hazardous waste may result in serious health problems for those who consume contaminated water, air or food. Problems can include cancer, nerve damage and birth defects. Hazardous waste that makes its way into the water table may be nearly impossible to remedy. Clean-up and remediation costs to the responsible parties and the public may run into the millions and even billions of dollars.

Environmental Concerns Surrounding Hazardous Waste Management

1. Cause of mass life and material damage and loss (disability, death, fire, explosion);
2. Cause of environmental damages: potential water, solid, and air pollution (underground and surface drinking water);
3. Cause of potential increased chemical bioaccumulation that is hard for biodegradability (chlorine containing chemicals);
4. Cause of long term irreversible health risks (mutagenicity, teratogenicity, and carcinogenicity);
5. High concern of trans-boundary movement of toxic wastes;
6. Cause of massive toxic health damages.

Classification of Hazardous Wastes

Hazardous wastes are classified according to:

I. Characteristics

II. Health effects

Characteristics of Hazardous Waste

The Environmental Protection Agency of America (EPA) defines the characteristics of hazardous waste as:

Flammability and Ignitability

Flammable substances have the potential to catch fire readily and burn in air. A flammable liquid itself does not catch fire; it is the vapours produced that burn. Two important properties of flammable liquids need to be considered while storing and handling them. The first is flash point, which is the lowest temperature, determined by standard tests, at which a liquid gives off vapour in sufficient concentration to form an ignitable mixture with air near the surface of the liquid within the vessel. The most hazardous liquids are those that have flash points at room temperature or lower. The second is the ignition temperature of a substance, which is the minimum temperature required to initiate self-sustained combustion independent of a heat source. Materials susceptible to spontaneous combustion include rags saturated with linseed oil, organic materials mixed with strong oxidizing agents (e.g., nitric acid, chlorates, permanganates, peroxides, and persulfates), alkali metals (e.g., sodium and potassium), finely divided pyrophoric metals, and phosphorus.

Reactivity

Reactive wastes are chemically unstable and react violently with air or water. They cause explosions or form toxic vapours. Such incidents can also occur when the waste is mixed with other chemicals producing the same effect. Wastes containing unstable chemicals are also in this category. Examples: Cyanide plating wastes, wastes containing strong oxidizers such as chlorine, ozone, peroxides, permanganates, Hydrochloric acid, etc.

Toxicity

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. A waste that is likely to produce mass acute and chronic poisoning; long-term health effects (mutagenicity, teratogenicity, carcinogenicity).

Infectivity

Means any wastes or combination of wastes that include cultures and stocks of infectious agents and associated biologicals, human blood and blood products, and substances that were or are likely to have been exposed to or contaminated with or are likely to transmit an infectious agent or zoonotic agent, including all of the following:

(1) Laboratory wastes;

(2) Pathological wastes;

(3) Animal blood and blood products;

(4) Animal carcasses and parts;

(5) Waste materials from the rooms of humans, or the enclosures of animals, that have been isolated because of diagnosed communicable disease that are likely to transmit infectious agents.

(6) Sharp wastes used in the treatment, diagnosis, or inoculation of human beings or animals;

(7) Any other waste materials generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals, identified as infectious wastes after determining that the wastes present a substantial threat to human health when improperly managed because they are contaminated with, or are likely to be contaminated with, infectious agents.

Radioactivity

Radioactive wastes emit ionizing energy that can harm living organisms. Because some radioactive materials can persist in the environment for many thousands of years before fully decaying, there is much concern over the control of these wastes. However, the handling and disposal of radioactive material is not a responsibility of local municipal government. Because of the scope and complexity of the problem, the management of radioactive waste—particularly nuclear fission waste—is usually considered an engineering task separate from other forms of hazardous-waste management. Such wastes are mainly from biomedical training and research institutes. Wastes may include radioactive elements of uranium, molybdenum, cobalt, iodine.

Bioaccumulation Effect

Wastes that are not easily degraded when exposed with the environment. Examples: polychlorinated biphenyls (PCB), dioxin. Classification according to Health effect Health effects that accrue as a result of exposure to hazardous waste depend on:-

Dose - the amount of exposure, as in a millilitre or a gallon.

In general, the larger the dose, the less time it will take to produce an injury.

Duration and frequency- how long and how frequent is the exposure.

In general, the longer the duration of the exposure, the more severe the injury will be. The frequency of the exposure can affect the type, time of onset, extent, and severity of the toxic effect. Some chemicals cause injury only after long-term exposure (they are chronically toxic) while others cause injury after a single exposure (they are acutely toxic).

Route how the exposure takes place. Toxic substances can enter our bodies in any of four ways, called routes of entry. These are:

a. Absorption
b. Ingestion
c. Injection
d. Inhalation

Absorption (through the skin or eye)

If an individual were to walk barefoot through contaminated soil, the contaminant would contact the skin of the foot. This could cause mild skin irritation, or more serious problems like burns, sores, or ulcers on the outer layers of the skin. Contact with a substance may also occur by spilling it on the skin or brushing against a contaminated object. When an individual uses a material that bears instructions recommending the use of gloves, this is to prevent skin contact or absorption through the skin (also called dermal exposure). When an individual works with chemicals, it is particularly important never to put your hand to your eye. Eyes are particularly sensitive to toxic substances: since capillaries are near the surface, the substance can enter the bloodstream more readily. Eye contact with toxic substances can cause irritation, pain, or even blindness.

Injection

The most familiar example of injection is that of shots given to administer medicine, in which the skin is punctured with needles so that a substance can enter the body. Injection can also occur accidentally. For example, if the skin were cut by a contaminated can or a piece of glass that had been in contact with a contaminant, the contaminated substance could be injected into the body. This is a very powerful means of exposure because the contaminant enters the bloodstream immediately.

Ingestion

If an individual ingests a substance that contains a harmful material, that substance enters the body by means of the digestive system. An example of inadvertent ingestion is a battery factory employee who eats lunch in the work area and ingests inorganic lead that has contaminated a sandwich. A more common instance is the child who puts a toxic substance in his or her mouth out of curiosity. Residue from chemicals that have been added to food to kill germs or parasites may also be ingested.

Inhalation

It is also possible to be contaminated by toxic substances by breathing them into the lungs. The amount of air inhaled in a workday can be extremely large, so if an individual works or lives in a contaminated area, he or she can be exposed to significant quantities of a substance in this way.

Health Effects of Hazardous Wastes

Some chemicals have excellent warning properties that let us know when they are in the atmosphere. There is the well-known "rotten egg" smell of hydrogen sulphide, for example. But at high concentrations of this gas, our sense of smell is quickly lost. Many toxic substances, such as carbon monoxide, are both colourless and odourless, providing us with no sensory clues that the exposure is anything unusual.

Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may become evident only after a long latency period. Chronic toxins are particularly insidious because they may have no immediate harmful effects. Asbestos is a mineral-based material that is resistant to heat and corrosive chemicals. Although asbestos is often bonded or woven when manufacturing asbestos containing materials, it can eventually wear down (become friable), releasing fibres into the air. Asbestos exposure may cause lung cancer, pleural mesothelioma (a cancer of the lining of the lungs), peritoneal mesothelioma (a cancer of the lining of the abdominal cavity), and cancer of the digestive system. All types of asbestos can cause diseases like cancer and asbestosis.

Developmental and Reproductive Toxins

Reproductive toxins cause adverse effects on the male or female reproductive systems. They include substances that cause chromosomal damage (mutagens) and substances with lethal or teratogenic (malformation) effects on foetuses.

Table 1. Sources and Impacts of Hazardous Wastes

Hazardous Waste	Health /Environmental impact	Industrial sector
Waste xylene	• eyes and mucous membranes irritation, • disturbances of liver and kidney function	pulp and paper, textile, paints
Waste benzene	• cancer • blood disorder • skin irritation	paints, paper, leather
Peroxides waste	• eye and skin irritation • lung irritation • irritation and inflammation of nose, throat and respiratory tract	pulp and paper, textile
Waste containing lead	• neurological dysfunction in adults and children • high blood pressure in adults • affects blood chemistry, kidney and nervous system • bioccumulates in some shellfish such as mussels.	lead smelting, inorganic chemical industry, iron and steel, pigments, paint
Waste containing cadmium	• causes cancer • kidney damage • de-calcification of bone tissues • toxic to human	textile, leather, inorganic chemical industry, iron and steel, wood preserving, dyes and pigments
Waste containing chromium VI	• causes cancer • chronic irritation of the respiratory tract	metal finishing, leather fur, textile, paper printing, tanning steel, chemicals manufacturing
Waste containing arsenic	• can cause cancer • skin, eye and respiratory irritations • bioaccumulates in aquatic organisms	pigments, paints, wood preserving, inorganic chemicals, lead metallurgy
Waste containing cyanide	• toxic, can cause prompt death due to respiratory arrest • can cause blindness, and damages to optic nerves and retina. • affects the central nervous system • toxic to animals and aquatic organisms	dyes and pigments, metal treatment and coating
Waste sulphuric acid	• irritating to skin, eyes and mucous membrane	textile, inorganic chemicals, printing inks, secondary lead smelting, metal treatment
Waste sodium hydroxide	• irritating to the upper respiratory system • causes skin irritation	textile, metal treatment
Waste halogenated solvents (e.g. dichloromethane)	• probable human carcinogen • affects central nervous system, liver, kidney or respiratory system	organic chemical industry, textile, pesticide, dyes and pigments, paint, inks

Corrosive Substances

It is the ability of the waste to cause skin and mucosal membrane damages: burns and erosions, and dissolves or corrodes metallic surfaces. Any substance that causes visible destruction or alterations in living tissue by chemical action should be classified as corrosive. Major classes of corrosive substances include strong acids (e.g., sulphuric, nitric, hydrochloric, and hydrofluoric acids), strong bases (e.g., sodium hydroxide and potassium hydroxide), dehydrating agents (e.g., sulphuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide), and oxidizing agents (e.g., hydrogen peroxide, chlorine, and bromine).

Irritants

Irritants are noncorrosive chemicals that cause reversible inflammatory effects on living tissue at the site of contact by a chemical.

Systemic toxins

Substances included in this category include hepatotoxins (substances that produce liver damage, such as nitrosamines and carbon tetrachloride); nephrotoxins (agents causing damage to the kidneys, such as certain halogenated hydrocarbons), neurotoxins (substances that produce their primary toxic effects on the nervous system, such as mercury, acrylamide, and carbon disulphide); agents that act on the hematopoietic system (such as carbon monoxide and cyanides that decrease haemoglobin function and deprive the body tissues of oxygen); and agents that damage lung tissue, such as asbestos and silica.

Asphyxiants

These are chemicals that prevent the cells of the individual from receiving life-giving oxygen. Carbon monoxide is a well-known asphyxiant, which chemically "ties up" the haemoglobin in the blood so that the body's metabolism slows and stops.

Central Nervous System (CNS) depressants

They affect the nervous system. This broad category includes vapours from most anaesthetic gases, depressants, and organic solvents (a general category that includes many paints, glues, adhesives, and alcohol). Some CNS depressants produce a feeling of dizziness or giddiness. More severe effects (including death) can also result.

Allergens

An allergen is a substance that produces an allergic reaction after repeated exposure. Remember, there is considerable individual response to allergens, and some people may be more susceptible than others.

Treatment of Hazardous Wastes

The purpose of treating hazardous waste is to convert it into non-hazardous substances or to stabilise or encapsulate the waste so that it will not migrate and present a hazard when released into the environment. Hazardous waste treatment is categorised into four types:

A. Physical
B. Chemical
C. Biological
D. Thermal

Physical Methods

A waste is subjected to physical methods or processes so as to contain the hazard, to immobilize the hazardous component(s) or substance(s) and/or to prepare it for further treatment, recycling or landfill. Physical methods don't convert wastes into non-hazardous forms; instead, they change them into forms that are easier to treat further or to dispose. Traditional physical methods include carbon adsorption, filtration, flocculation, distillation, reverse osmosis and ion exchange.

Encapsulation

Encapsulation involves immobilizing or reducing the toxicity of hazardous materials by either containerization or stabilization and incorporation within a solid water-resistant matrix such as Portland cement, asphalt or proprietary organic polymers prior to land filling. E.g. Double bagging of asbestos waste, Sulphur polymer stabilisation/ solidification of mercury compounds (also forms highly insoluble HgS), encapsulating beryllium in concrete, Stabilisation of metal hydroxide sludge, sulphuric acid plating waste and oily metal sludge with a sludge mixture of lime, fly-ash and bentonite, Encapsulating beryllium or polychlorinated biphenyls (PCBs) in concrete blocks and Contaminated soil mixed into asphalt. There are two types of encapsulation procedures: thermal and microencapsulation.

Thermal Encapsulation

Thermal encapsulation is the term used when heat is applied to melt encapsulation products like asphalt, plastics or waxes in the encapsulation process.

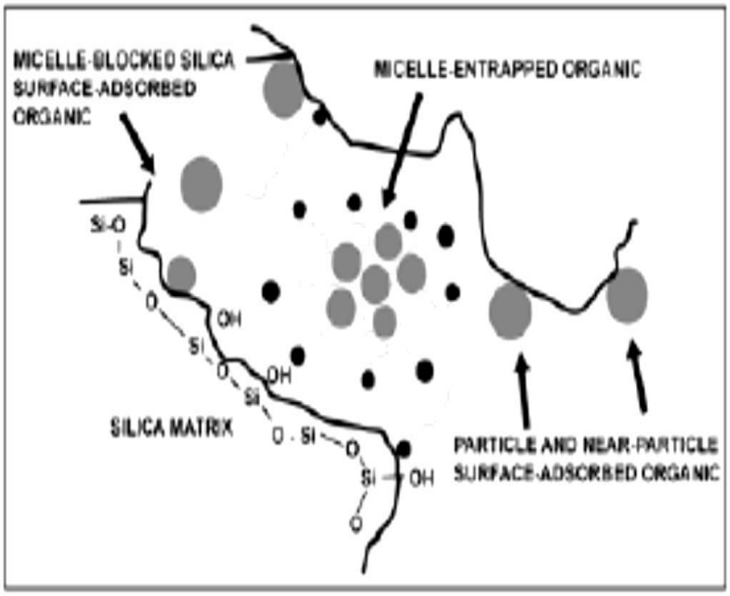

Figure 1. Illustration of Micro-encapsulation

Micro-encapsulation

Micro-encapsulation entails the permanent encapsulation (trapping) of hazardous molecules within the molecular structure of an inert material like silica. In Silica Micro Encapsulation (SME), hydrocarbon, chemical, heavy metal and/or radioactive contaminants are encapsulated (trapped / stabilised) within an impervious silica matrix, thereby completely and permanently isolating it from the environment. This essentially means permanently locking contaminants up in very small grains of sand. Silica is one of the most inert natural substances and with the hazardous contaminant being entrapped in the silica matrix contaminants are prohibited from migrating or leaching out. The silica grain typically does not degrade and generally strengthens over time. This method has been used in the treatment of heavy metals (such as chromium, copper and zinc), metalloids (such as arsenic), and radionuclides (such as uranium). It can be applied to wastewaters, sediments, sludges, soils, mine tailings, and other complex media.

Wetting

Wetting is a method whereby water is used to suppress the spreading of hazardous dust or fibers. In some cases chemicals, such as detergents, are added to the water to enhance the wetting of the substance. E.g. Wetting of asbestos fibers, Sprinkler systems on ash waste piles and mine tailings dams.

Physical Separation - Filtration/Centrifuging/ Distillation/ Reverse Osmosis/ Ion Exchange and flocculation

This approach involves physically separating phases which contain hazardous substances from other nonhazardous constituents which form part of the waste stream. E.g. Separation of oils from ship bilges waters, Wastewater treatment (e.g. ion exchange treatment of perchlorate contaminated waters.)

Mechanical Breaking/ Shredding/ Ripping/ Pelletising

Such methods are used to physically break-up the waste to either prepare it for further treatment or recycling; to reduce the physical hazard; and/or to reduce the volume of waste for airspace and cost saving purposes. E.g. Waste tyres are shredded and pellitised into small rubber pellets for shipment to a rubber recycler, Neon light tubes are broken under controlled condition to render it physically safe and release or recover the mercury containing substances.

Filtration/Centrifuging/Separation

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

Biological Treatment of Hazardous Wastes

Biological treatment, which in the context of hazardous waste treatment is more commonly referred to as bioremediation, is a process whereby waste materials are biologically degraded under controlled conditions. Biological processes are in general, the most cost effective techniques for treating aqueous waste streams containing organic constituents. The physical and chemical properties of the compound influence its biodegradability.

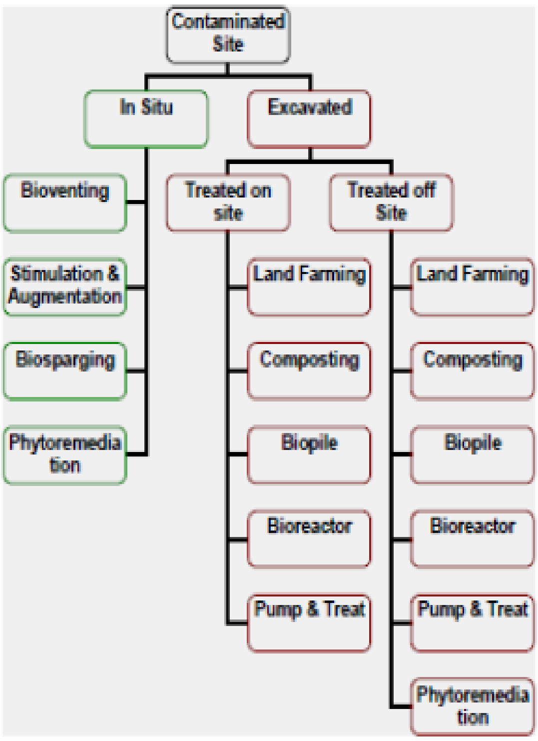

Figure 2. Illustration of Biological Methods of Hazardous Waste Treatment

Since bioremediation involves the use of biological species to break down the hazardous substances, it is important that the growth medium includes the necessary nutrients. Essential nutrients include nitrogen (N) and phosphorous (P). Biodegradation rates can be increased by adding nitrogen fertilizers. Bioremediation can be broadly categorised into 'in-situ' and 'ex-situ' processes.

In situ Bioremediation

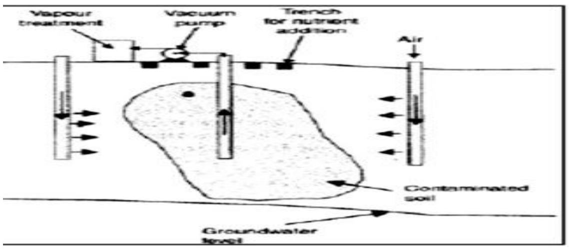

Figure 3. Illustration of In situ Boiventing

Bioventing

Bioventing is an in-situ treatment which combines an increase of oxygen (O2) (and nutrients) with vapour extraction.

Bioaugmentation

Bioaugmentation refers to the addition of naturally occurring microbes to contaminated materials and sites in order to achieve bioremediation. The process ensures that the correct microbes are added in sufficient quantities.

Biostimulation

Biostimulation refers to the modification of contaminated areas to enhance the growth of indigenous microbes already present. This process may include utilizing fertilizers and other nutrients to stimulate the microbes. This method presumes that the correct microbes are present.

Biosparging

This approach aims to increase biological activity of the soil by increasing the O2 supply. Air is initially injected through wells, where after pure O2 is injected

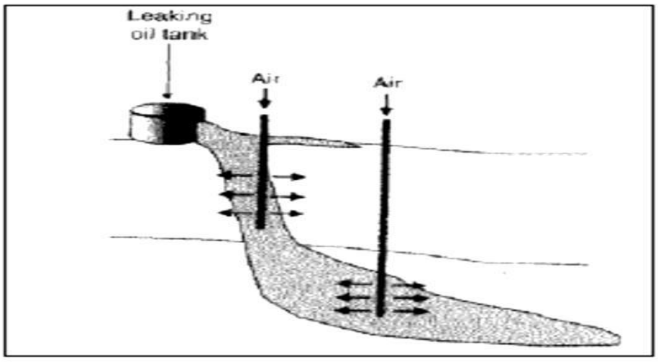

Figure 4. Illustration of Biosparging

Fixed Biobarriers / Biowalls

Fixed biobarriers use either solid or viscous amendments placed across the flow path of contaminated groundwater to form a permeable reactive barrier. Groundwater flows to, through, and past the fixed amendment. The water can either be manually directed past the biowall via engineered trenches or via direct-push injections." In situ enhanced bioremediation in the form of a fixed biobarrier is a suitable technology for large plumes having poorly defined, widely distributed, or inaccessible source areas

Phytoremediation

Phytoremediation is the use of plants for removal of contaminants from soil or water. Contaminants are fixed in the ground, accumulated in the plant tissue or released to the atmosphere. An example of this is constructed wetlands. Constructed wetlands have been used for decades for the management and treatment of many wastewaters, including municipal, acid mine drainage, agriculture, petrochemical and textile industries, and storm water.

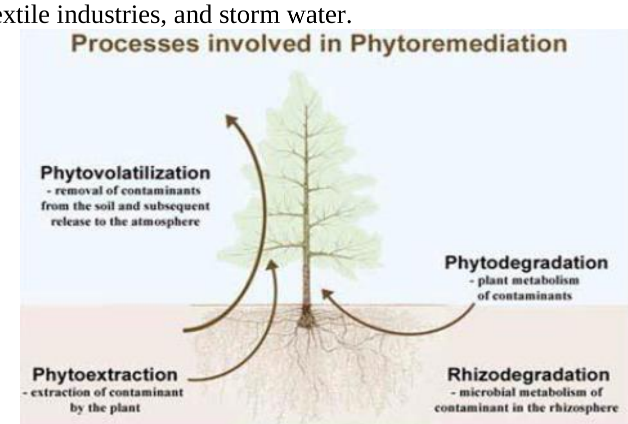

Figure 5. Illustration of Phytoremediation

The trend toward increased use of constructed wetland technology relates to the low capital and operating and maintenance costs associated with this mostly passive technology. Wetlands are usually constructed using limestone drains aid in neutralizing acid from acid mine drainage.

Ex-situ remediation

Landfarming

Landfarming refers to a ‘low tech’ biological treatment which involves the controlled application and spread-out of a more-or-less defined organic bioavailable waste on the soil surface, and the incorporation of the waste into the upper soil zone. It is typically used for biological removal of petroleum products from contaminated soil. Land treatment differs from landfills in that with land treatment, the assimilative capacity of the soil is used to detoxify, immobilize, and degrade all or a portion of the applied waste. Landfills are containments that store hazardous wastes and control the migration of wastes or by-products from the land fill sites. Liners are not required with land treatment.

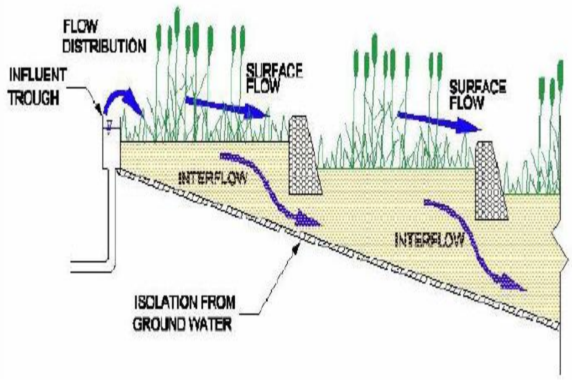

Figure 6. Illustration of Ex-situ Remediation

Hazardous wastes should not be placed in a land treatment site unless the waste can be made less hazardous or nonhazardous by the reactions occurring in the soil. Important microorganisms like bacteria, including those from the genera, agrobacterium, anthrobacter, bacillus, flavobacterium, and pseudomonas are involved in biodegradation. In addition actinomycites and fungi are all involved in the biodegradation of wastes. Land treatment is applicable to petroleum refining wastes, biodegradable organic chemical wastes including organochlorine compounds. However it is not suited to the treatment of waste containing acids, bases, toxic inorganic compounds, salts, heavy metals and excessively soluble volatile and flammable organic compounds.

Composting

Due to its common use for household garden waste, this is the well known controlled biological decomposition of organic material in the presence of air to form a humus-like material. Methods of composting include, mechanical mixing and aerating, ventilating the materials by dropping them through a vertical series of aerated chambers, or placing the compost in piles out in the open air and mixing it or turning it periodically.

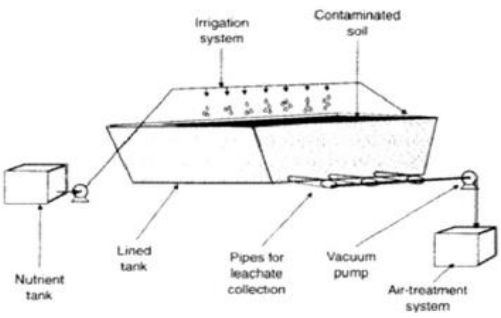

Figure 7. Illustration of Biopiling

Biopile / Biocells / Bioheaps

Biopiles are essentially heaps of contaminated soil placed on lined areas to prevent leaching. They are typically covered with plastic and liquid nutrients are applied. Aeration is improved by applying suction to the base of the pile. Leachate is collected by pipes at the base.

Illustration of ex-situ anaerobic bioremediation in bags at an industrial site

Figure 8. Ex-situ Anaerobic Bioremediation in Bags at an Industrial Site

Bioreactors

A bioreactor refers to any device, container or system that supports a biologically active and controlled environment for bioremediation. This ex-situ biological treatment process depends on maintaining a high active biomass concentration in the reactor. Bioremediation reactors can be classified as follows:

• Suspended-growth reactors – active biomass is suspended as free organisms or microbial aggregates (i.e. Continuous Stirred Tank Reactors (CSTR))

• Supported-growth or fixed-film reactors – growth occurs on or within solid medium or a biomass granule or pellet (i.e. Fluidised Bed Reactors (FBR) and Packed Bed Reactors (PBR).

CSTRs are typically used for treatment of high strength contaminated wastewater at low flow rates and are as such often used for treating industrial wastewater streams. In turn, FBRs and PBRs find their application in treatment of lower strength streams at high flow rate such as may be required for groundwater and water treatment.

Bioleaching

In bioleaching, bioremediation of heavy metal contaminated soil is achieved using acidophilic bacteria that oxidize reduced sulphur compounds to sulphuric acid. The process makes use of either a slurry or a heap leaching system.

Faith Based Reflections on Waste and Waste management

The world’s major religions also point towards sustainable management of waste. Key among these include: Christianity, Hinduism and Islam.

Christianity

There is a major emphasis on waste management in the Christian faith, especially on the collection of remnants for re-use, as when Jesus fed the 5, 000: “When they were all full, he said to his disciples, “Gather the pieces left over; let us not waste any. So they gathered them all up and filled 12 baskets with the pieces left over from the five barley loaves which the people had eaten.” (John 6: 12-14). Waste that cannot be reused or recycled should be disposed of in the right way. Human activity is seen as the major producer of waste. Christians are encouraged to keep the environment free of waste so that it is fit for everyone to live in – including God. In Numbers 35: 34, God says: “Do not defile the land where you are living, because I am the Lord and I live among the people of Israel.” Christians are warned against hoarding, which often produces waste, as not everything can be kept fresh. When the Israelites were in the desert, God sent manna everyday for them to eat, but if they hoarded it, not trusting that God would supply more the next day, it rotted. This is why in the Lord's Prayer we ask that God "give us day by day the food we need" (Luke 11:4). In March 2008, the Vatican added seven new sins for the age of globalization. The list now includes polluting and causing social injustice.

Hinduism

According to Hinduism, when Paramatma (the Supreme Soul) created nature, he made the environment self-sustaining. Human beings destroy the environment by polluting it, through building factories, releasing chemicals, creating rubbish and other activities. Hindu teachings tell us that because we are not separate from nature, when we destroy the environment by polluting it, we also harm ourselves. Hindus believe that our actions affect our karma. Karma, a central Hindu teaching, holds that each of our actions creates consequences – good and bad – that determine our future fate. So our environmental actions will have consequences on our future lives, and because we have free will, we can choose to protect the environment. Hindu sacred texts contain many teachings on environmental matters and environmental activists have drawn much inspiration from them. A well known Hindu teaching from the Isa Upanishad – "Tain tyakten bhunjitha"- has been translated as: "Take what you need for your sustenance without a sense of entitlement or ownership." Or, as the great Indian leader Mahatma Gandhi said: "Nature provides enough for everybody's need but not enough for even one person's greed."

Islam

Muslims are taught to consider that others may be bothered and the natural beauty of nature spoiled by their littering. They consider it a requirement for being a mature believer to avoid littering the shells of seeds and nuts after eating, or bottles, cans, papers, packaging materials and other items that could be harmful to people and animals in the street, school compounds and other public places. Disposing of waste so carelessly on the environment could be considered a form of corruption of the Earth which Allah created. The Qur'an warns us: "Do not spread corruption on the Earth after it has been so well ordered" (Qur'an 7:85), and warns against anyone who "strives throughout the land to cause corruption therein and destroy crops and animals. And Allah does not like corruption" (Qur'an 2:205). "Waste not by excess for Allah loveth not wasters" (Qur'an 7:31). In this way, Muslims are warned to use resources carefully. Yet there are signs of waste all around us. The Hajj is a once-in-a-lifetime experience of pilgrimage for Muslims. It's the annual pilgrimage to Saudi Arabia and one of the pillars of Islam. However, even at the Hajj, an estimated 100 million plastic bottles are left behind each year. Muslim environmentalists are working to combat this.

Conclusion

Waste is not only a local issue; other countries all over the world have to deal with the challenge in order to achieve sustainable development. We can take part in this global agenda at all levels; home, school and work; in our own small way by actively taking part in world events that address waste issues. Some of the global events addressing waste include: World Environment Day (June 5th), Earth Day (April 22nd), World Health Day (April 7th), World Standards Day (October 14th), International Coastal Clean - up Day (September 20th) among others. Therefore it is imperative that these values of Stewardship, responsibility for the environment, humility, accountability and wise use of resources as depicted in the various religions are inculcated in all our curricula to enhance sustainable waste management. These should in essence involve the four "R's" of proper waste management:

Reduce – Reducing the amount of waste that we produce each day reduces our challenge of handling large volumes of waste and is the first choice in dealing with the waste stream.
Reuse – The next best way to reduce waste is to reuse something before we either recycle it or throw it away.

Recycle – The process of taking a product at the end of its useful life and using some or all of it to make another product.
Recover – This refers to getting back materials or energy from waste that cannot be reused or recycled. Recovering energy from waste materials is a growing technology.

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