HAZARDOUS WASTE MANAGEMENT: A REVIEW OF PRINCIPLES AND METHODS

C.C. AMADI, O.C. OKEKE & D.C. AMADI
Department of Geology,
Federal University of Technology, Owerri, Imo State, Nigeria
Chichindu14@yahoo.com

ABSTRACT

Hazardous Waste Management entails procedures and policies carried out to deal with hazardous waste in a way that will not pose problems to man and the environment. A sustainable hazardous waste management system involves waste control from cradle to final disposal and even pollution monitoring. This paper summarizes principles of different waste disposal methods namely: Secure landfill, Deep-well injection and Bedrock disposal.

Keywords: *Hazardous Waste, Toxic substances, Health Risk, Disposal Methods*

1.0 INTRODUCTION

Industry has become an essential part of modern society, and hazardous waste production is an inevitable outcome of developmental activities. A material becomes waste when it is discarded without expecting to be compensated for its inherent value (Misra, 2015). These wastes may pose a potential hazard to human health or the environment (soil, air, water) when improperly managed.

Hazardous wastes are wastes or combination of wastes that pose a substantial present or potential hazard to humans or the environment, in part because they are not degradable, persistent in the environment and are deleterious to human health or natural resources (RCRA, 2016).

Hazardous Waste Management is a process that involves the collection, recycling, treatment, transportation, disposal, and monitoring of wastes disposal sites. Currently, in most developing and transition countries, hazardous wastes often are disposed off indiscriminately posing health and environmental risk. Increasingly, governments and international agencies are attempting to control the growing problem of hazardous substances in the environment which proves difficult because there are so many sources through which they are released.

So many toxic and hazardous substances emanate from these sources either purposefully or accidentally contaminating, the land, air, and water (Enger, 2004). The potential health effects of these substances range from minor, short term discomforts, such as headaches and nausea to serious health problems, such as cancers and birth defects (that may not manifest themselves over years), to major accidents that cause immediate injury or death.

According to Roger et al., (1989), proper control of hazardous wastes does cost money, but experience in a number of developed countries suggests that cleaning up the "sins of the past" is much more expensive in the long term. For instance, in the United States, cleanup of improperly managed wastes has been estimated to cost 10-100 times as much as proper early management. It is therefore important that all developing countries institute controls over hazardous wastes to avoid excessive costs in the future.

In view of this, management of hazardous wastes including their disposal in environment friendly and economically viable way is very important and therefore suggestions are made considering the waste types and states (Solid or liquid).

2.0 **SOURCES OF HAZARDOUS WASTES AND THEIR EFFECTS ON THE ENVIRONMENT.**

2.1 SOURCES OF HAZARDOUS WASTES

Most hazardous wastes are produced from a wide range of sector mainly in the manufacturing of products for consumption or further industrial application. These include and not limited to: Agricultural land and agro industry, domestic/household, mines and mineral processing sites, health care facilities, commercial sites, institutional, industrial, solid waste disposal sites, contaminated sites, building materials and activities that involve radioactive elements.

Table 1 shows the widespread distribution of hazardous wastes. Many sectors of the economy are victims of hazardous wastes production whether directly or /and indirectly. Some industries lack the capacity and capability to properly handle these wastes; they resort to indiscrimate disposal as the only way to avoid costs and procedures associated with proper management.

Table 1: Some hazardous wastes sources (Modified from Roger et al., 1989).

Sector	Source	Hazardous Wastes
Agricultural land and agro-industry	Farms	Pesticides,fertilizers, and hazardous veterinary product wastes
Health care centers	Hospitals,clinics and medical laboratory	Pathological wastes,infectious needles,contaminated blood.
Commercial wastes	Gasoline stations, dry cleaners and automobile repair and servicing shops (workshops),airports,municipal parks,Electrical transformers	Waste oils,hydraulic fluids,halogenated solvents,polychlorinated Biphenyls.
Industrial Hazardous Wastes	Petroleum fuel	Refining products (fuels and tar), impurities like phenol and cyanides in the waste stream, and sludge flushed from the storage tanks.
Small scale industry	Metal treating(electro-plating,etching,anodizing,galvanizing), Photofinishing Textile processing Printing Leather tanning.	Acids,heavy metals Solvents,acids,silver Cadmium,mineral acids Solvents,inks and dyes Solvents,chromium.
Large Scale industry	Bauxite processing Oil refining Petrochemical manufacture Chemical/pharmaceutical manufacture Chlorine production	Red muds Spent catalysts Oily wastes Tarry residues, solvent Mercury.
Building and Roofing Industries	Building and roofing materials	Materials made of asbestos and copper
Mines and Mineral processing, Electricity generating companies	Uranium mining and processing	Spent reactor rods,cloths,rags and wood

Some of these substances are classified as probable human carcinogens and are associated with increased tumor rates, organ damage and even death in man.

2.2 EFFECTS OF HAZARDOUS SUBSTANCES ON THE ENVIRONMENT

2.2.1. GENERAL STATEMENT

Today, because of increased urbanization and industrialization, some communities are threatened with pollution caused by improper disposal of hazardous wastes (solid/liquid), and these wastes can adversely affect the physical, mental and social health of the inhabitants (Etim,2003).

2.2.2 EFFECTS ON LAND

Pollution resulting generally as a result of man's activities affects both crops, animal and human health, and also the quality of the whole environment. Thus it is any process carried out by man which leads to an adverse change in terrestrial environment. The dumping of refuse could be termed the defacement of land and subsequent rendering of the soil non-productive and polluted. Hazardous wastes dumped on land sites, when it rains, the leachates from such refuse dumps contain various contaminants, the most harmful being heavy metals, dissolved organic compounds, and nitrogen.

Deteriorating soil quality and decrease in vegetation abundance are also grave consequences of open waste dumping which have resulted in growing public concern (Dawsin, 2000).

Figures 1 and 2 show indiscriminate ancient disposal methods called "open dumps". Open dumps in addition to other effects mentioned earlier lead to deteriorating soil quality and decrease in vegetation abundance.

Environmental contamination by components of refuse such as heavy metals like cadmium, lead, zinc and copper has been of great concern in the last decades because of their health hazards to man and other organisms; when accumulated within a biological system. The response of plants to pollutants is especially important since many of these plants are more sensitive than the organisms.

Figure 1: Open dumps-Mixed wastes. (John, 2013)

Figure 2: Open dumps-empty used oil drums. (Anderson, 2011)

This is why plants usually serve as the most sensitive indicators as prolonged exposure to them may destroy a large number of plants communities. Toxicity can result from a high concentration of an element nutrient intake and can also give rise to abnormal growth, disease or even death.

Also refuse dumps serve as breeding places for diseases-causing organisms such as rats and flies which are the major disease vectors associated with garbage (Figures 1 &2). Rats, with the assistance of flies are known to be involved in the spread of bubonic plague and urine typhoid fever to humans. Rats may contaminate food with their urine,transmitting leptospirosis, lasa fever and infectious hepatitis. They can transmit salmonella and other intestinal organisms.

Also, hazardous wastes spoil the natural beauty of the land and may interfere with recreational activities. Hazardous solid wastes can also produce unpleasant smell. The free flow of traffic along our streets could also be hindered by the indiscriminate dumping of solid hazardous wastes and can occupy land space that could have been used for other purposes as seen in figures 1&2. Solid waste has the potential to cause sickness and even death. Therefore proper waste management in any society is a matter of urgent attention.

Inherent changes in the application of industrial sludge to land due to contaminations with heavy metals and possible presence of pathogens in raw sludges cause its prohibition in agricultural lands. Chronic cadmium poisoning causes damage to kidney and heart. Prolong exposure also results in loss of calcium from the bones,which then become brittle and easily break. In japan for example, a whole village was striken by cadmium poisoning-known as "Itai-Itai" disease after effluents contaminated rice supplies. Other heavy metals and hazardous substances of interest are Copper, Chromium, Zinc, Lead, Arsenic, and Mercury and Selenium, etc and their effects on man are shown on table 2 below

Table 2: Effects of heavy metals and substances on the Environment (Modified after Fordyce, 2000)

Heavy Metals/Substances	Source	Toxicity
Cadmium (Cd)	Textile Processing	Renal and heart diseases, weakens bones and tumors.
Lead (Pb)	Mines and mineral processing companies	Neurological disorders, convulsions, kidney and brain damage
Mercury (Hg)	Chlorine Production	Neurological disorders, irritability and liver damage
Arsenic (As)	Metal treating(electro-plating, etching, anodizing, galvanizing	Cancer, skin diseases and poisoning
Zinc (Zn)	Building and roofing materials	Enzymes and skin disorders
Copper (Cu)	Building materials made of copper	Gastrointestinal irritant, liver damage
Selenium (Se)	Photographic devices, gun cleaning solutions, plastics, paints, anti-dandruff shampoos, vitamin and mineral supplements, fungicides and some types of glass.	Hair loss, nervous disorders.
Vinyl chloride	Plastics manufacturing. Air or water at contaminated sites	Acute effects: dizziness, headache, unconsciousness, death Chronic effects: liver, lung, and

		circulatory damage.
Polychlorinated biphenyls (PCB)s	Eating contaminated fish, Industrial exposure	Probable carcinogens; acne and skin lesions
Benzene	Industrial exposures. Glues, cleaning products, gasoline	Acute effects: drowsiness, headache, death at high levels. Chronic effects: damage to blood-forming tissues and immune system; also carcinogenic
Benzo[a]pyrene	Product of combustion of gasoline or other fuels. In smoke and soot	Probable carcinogen; probable birth defects
Polycyclic aromatic hydrocarbons	Exposure to smoke from a variety of sources	Probable carcinogen; possible birth defects
Benzo[b]fluoranthene	Product of combustion of gasoline and other fuels inhaled in smoke	Probable carcinogen
Chloroform	Contaminated air and water. Many kinds of industrial settings	Affects central nervous system, liver, and kidneys; probable carcinogen
DDT	From food with low levels of contamination. Still used as pesticide in parts of world	Probable carcinogen, possible long term effect on liver; possible reproductive problems.
Trichloroethylene	Used as a degreaser, evaporates into air	Dizziness, numbness, unconsciousness, death
Dibenz[a,h]anthracene	Product of combustion in smoke	Probable carcinogen

2.2.3 EFFECTS ON WATER

It is a generally accepted fact that the developed countries suffer from problems of chemical discharge into water sources mainly groundwater, while developing countries face problems of agricultural run-off in water sources. On top of these concerns, contamination of water is a big concern after a natural disaster (e.g., tsunamis, earthquakes, hurricanes, floods, and volcanoes) and can influence water quality on a grand scale (Okeke and Udoka, 2014).

Secure landfills may not be totally secure even if conscientiously designed. Carefully compacted clay may be very low in permeability but is probably never completely impermeable, especially over long time intervals (Montgomery, 2000). Chemical and biological reactions in the wastes and leachate can rupture or decompose plastic, and the stress caused by the weight of wastes and cover can fracture a clay liner. Leakage from 'secure' toxic waste dumps, in which hundreds or thousands of barrels of concentrated toxic liquid chemicals are stored, has far more potential for harm. Leakage of at least certain volatile organic compounds deemed high priority toxic pollutants like benzene, toluene, vinyl chloride and chloroform have been detected by monitoring wells, e.g 'Mount Trashmore' Landfill in Evanston, Illinois. These pollutants have been confirmed to cause adverse health problems to man. Prevalent high rainfall and shallow water table accentuate problems of pollution from landfills.

Our water supply is threatened with the presence of asbestos particles, heavy metals like Lead, Cadmium, Arsenic, nitrates and sodium, a variety of chemicals that are known to be carcinogens. Almost all the millions of tons of chemicals improperly disposed off on land will sooner or later find their way to the underground water aquifers if they are fully biograded. These chemicals include toxic synthetic organic chemicals developed with the explosive growth of chemicals and petrochemicals since World War 11 such as Trichloroethane, tetrachloroethane, venylchloride, 1,1,2 - trichloroethane, carbon tetrachloride, benzene, xylene, toluene, and methylene chloride.

Some of these substances are essential to the body in trace amounts, mainly for synthesizing enzymes, but it can be toxic in large amounts. According to the "Doctor's complete guide to Vitamins and minerals, "the tolerable upper intake level of selenium is set at 400mcg daily, with 800mcg daily potentially causing toxicity and a dose of 5mg considered lethal for most people. Selenium poisoning has no known antidote, so recognition of the signs and symptoms is essential for survival (Bond, 2016).

Most of these chemicals are petroleum based and are found in gasoline (petrol) septic tank cleaners, deodorants, plastics, spot removers, household cleaners, disinfectants, paints and varnish removers, dry cleaning fluids and degreasing agent etc. These polluting chemicals find their ways to the ground water in many ways-principally by seeping into aquifers from landfills and waste dumps where chemicals are routinely dumped. They also come from septic tanks of sub-urban, urban and rural homes and from ruptured homes, underground petrol and fuel oil storage tanks. There is no easy solution to the polluted aquifers. Restoration is almost impossible; once contaminated, the ground water remains so. Once the chemicals reach the deep recesses of aquifers, they congeal together and their pollutants grow in size and height yearly depending on the shape and composition of the geological structures in the aquifer.

The solution to this problem is that of drilling into deeper less contaminated aquifer. There is no guarantee that the toxic substances in aquifer near the surface will not reach the lower ones. Aeration of the water is another method. Hence the contaminated water is drawn up from the aquifers, passed through a cooling tower and then sprayed by nozzles into the air. In this way, many of the volatile toxic chemicals evaporate before the water hits the ground again and seeps into the aquifer.

Cancers, arthritis, skin irritation, heart disease, damage to the central nervous system, skin rashes, kidney problems and bronchitis etc are the diseases associated with water pollution by chemicals. The amount of contaminated water that can cause sickness to its consumer depends on concentration and composition of the contaminant chemicals.

2.2.3.1 WATER-BORNE DISEASES/HEALTH HAZARDS OF WATER POLLUTION

Water-borne diseases are infectious diseases spread primarily through contaminated water. Though these diseases are spread either directly or through flies or filth, water is the chief medium of spread of these diseases and hence they are termed as water borne diseases.

Many areas of underground and surface water are now contaminated with heavy metals, POPs (persistent organic pollutants), and nutrients that have an adverse effect on health. Water- borne diseases and water-caused health problems are mostly due to inadequate and incompetent management of water resources.

Generally, exposure to polluted water can cause diarrhea and infections to intestine, respiratory problems, and increases incidence of tumour ,ulcers due to nitrate pollution, skin disorders/irritations due to contact with pollutants, and increased incidence of constipation. Blue baby caused by methane globinemia, reduced activity of immune system, loss of memory and reduced sharpness, jaundice, hepatitis etc will be more prevalent. Eating animals that are high in the food chain can increase exposure to xenoestrogens. For example, eating large fish that survived by eating smaller ones. This is because, microscopic creatures eat algae already been contaminated with the chemicals from polluted water, so they accumulate the chemicals in their bodies. Xenoestrogens accumulate in fatty tissues, which means that each animal in the food chain substantially increases its xenoestrogen levels by eating smaller animals. Since we are on top of the food chain, we are most likely to be affected.00000

2.2.4 EFFECTS ON AIR

Apart from health problems caused by contamination of drinking water, toxins can seep into buildings built above hazardous wastes sites, causing indoor air problems, respiratory diseases and chemical sensitivity. Incinerating hazardous wastes can introduce mercury and dioxin pollutants into the environment which can affect the lungs.

2.3 HAZARDOUS WASTE EXPOSURE PATHWAYS

The different ways a person can come into contact with hazardous chemicals are called exposure pathways. One exposure pathway is inhalation, while others are ingestion and skin contact. Exposure can occur when people breathe in hazardous chemical vapour or air that is contaminated by hazardous chemicals or dusts. Ingestion is taking something in by mouth. Skin contact occurs when something comes in direct contact with the skin. Ingestion can be a secondary exposure pathway after skin contact has occurred, if you put your hands in your mouth and transfer the chemical from your hands to your mouth. People can be exposed to hazardous chemicals through the food they eat. Food contamination can occur if the food has come into contact with hazardous chemicals. It can also occur further down the food chain such as through eating contaminated fish (Duan, et al., 2011).

3.0 PRINCIPLES AND METHODS OF HAZARDOUS WASTE MANAGEMENT

3.1 PRINCIPLES

Hazardous waste management is the general term given to the procedures and policies carried out to deal with hazardous waste in a way that will not pose problems to man and the environment.

Originally, hazardous wastes were commonly disposed of by open dumping, open burning, or incineration. Open dumping can contribute to land litter and water pollution, and the end products of open burning and incineration can contribute to air pollution in the form of particulates, nitrogen oxides, noxious odors, and other constituents. In addition, the burning process can produce solid residues which when ultimately disposed can contribute to water pollution and even help to create some small amounts of methane gas. Municipal incineration with sophisticated energy recovery systems were popular in large European and American cities at the turn of the century, but became extinct due to high operating costs. Similarly, in former years, garbage was reclaimed for hog feed; animal wastes were rendered for fats to manufacture soap and other products. These practices have become less popular because of public health requirements to sterilize garbage, and because of the economies of mixed refuse collection. However, the recovery of paper, metals, and other solid wastes continues to be practiced by scrap dealers whenever economically feasible. In recent years, hazardous solid waste incineration has become less popular because of greatly increased air pollution control requirements.

According to Iyyanki and Vali (2017), hazardous waste management is a major challenge in urban areas throughout the world. Without an effective and efficient waste management program, the waste generated from various human activities both industrial and domestic, can result in health hazards and have negative impact on the environment.

The following procedure forms a standard waste management strategy in a developed society. Each step play a very important role in ensuring that waste disposal which is the final stage in the management process is achieved without threat to man and the environment.

3.2 HANDLING OF HAZARDOUS WASTES:

Persons handling hazardous wastes are advised to wear respiratory protection, hand and skin protection, eye protection and protective clothing to reduce the effect of contact. Hazardous wastes can cause dermatitis to the skin, some cause asthma on long exposure, others cause the eyes to smart and run and also tightening of the chest.

3.3 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 labeling, transport, and tracking of all hazardous wastes (Jerry, 2015).

When hazardous wastes are transported off-site for disposal, the waste generator prepares a shipping document called a manifest. This form must accompany the waste to its final destination and used to track the waste's movements from 'cradle to grave'.

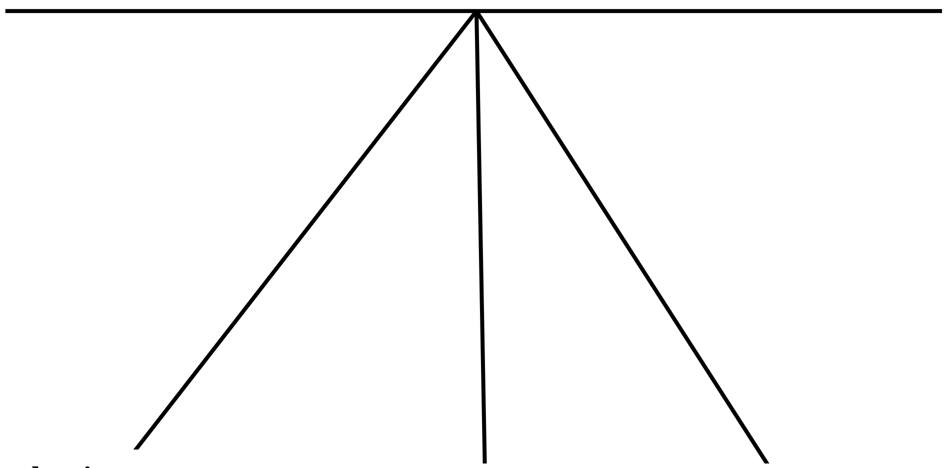
In the event of a leak or accidental spill of hazardous waste during its transport, the transporter must take immediate and appropriate actions, including notifying local authorities of the discharge. An area may have to be diked to contain the wastes, and efforts must be undertaken to remove the wastes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

3.4 . WASTE MINIMIZATION, TREATMENT AND DISPOSAL.

3.4.1 WASTE MINIMIZATION/REDUCTION AND RECYCLING

Waste minimization is a very important hazardous waste management strategy in developing countries. The concept of waste minimization can best be illustrated by means of Figure 3 which subdivides the strategy into three headings: Source reduction, recycling, and treatment.

HAZARDOUS WASTE GENERATION PROCESS(ES)



Source Reduction
Any activity that reduces or eliminates the generation of hazardous waste within a process

Recycling
Any activity that reduces volume and /or toxicity of hazardous waste with attendant generation of a valuable material which is subsequently utilized

Treatment
Any activity that reduces volume and /or toxicity of hazardous waste without attendant generation of a valuable material

(a) Volume reduction –preferable accomplished without an increase of toxicity
(b) Toxicity reduction-preferable accomplished by means other than dilution

Figure 3: Hazardous Waste Control through Reduction. (Modified from Roger,et al., 1989).

RECYCLING AND RECOVERY: Viewed generically "recycling" encompasses both re-use and reclamation activities. Many hazardous wastes can be recycled into new products. Examples might include lead-acid batteries or electronic circuit boards, where there are heavy metals, after burning, these types of ashes go through the proper treatment, they could bind to other pollutants and convert them into easier-to- dispose solids, or they could be used as pavement filling. Such treatments reduce the level of threat of harmful chemicals, like fly and bottom ash while also recycling the safe product.

Hazardous waste recycling is divided into two namely; materials recovery as well as energy recovery .A recycler's decision as to how to treat a waste is principally determined by the character of specific waste streams or waste mixtures. Where treatment should take place (either onsite or offsite however, is a function of a generator's management practices which include:

- Proximity to offsite recycling facilities
- Economic costs related to the transportation of wastes
- The volume of wastes available for processing, and

- Costs related to storage of waste onsite to offsite.

Recycling is characterized by three major practices:

1. Direct use or re-use of a waste in a process.
2. Recovery of a secondary material for a separate end use such as the recovery of a metal from a sludge
3. Removal of impurities from a waste to obtain a relatively pure re-usable substance

Although recycling of selected wastes is practiced to a considerable degree by certain industries, only a small percentage of the hazardous waste is being recycled. A greater percentage of wastes are being recycled onsite. Offsite recycling however has become increasingly common with the advent of commercial recyclers and direct transfer of waste from generators to others who can re-use the wastes. Most flammable materials can be recycled, used as industrial fuel. Some materials with hazardous constituents can be recycled, lead acid batteries are one example.

Recycled wastes are used as feedstocks in production processes or as substitutes for commercial chemical products. Examples include:

- The re-use of solvents for equipment cleaning;
- The recycling of collected pesticide dusts at pesticides formulators; and
- The re-use of ferric chloride wastes from titanium dioxide manufacturing as a wastewater conditioner in water treatment.

In the 1981 U.S. survey, data indicate that recycling for materials recovery and re-use appears to be more popular than fuel use or energy recovery. Reasons are, first, some wastes that could be recycled for energy recovery can also be reclaimed and re-used over and over. Energy recovery in contrast destroys the inputs. Only when the waste is too ”dirty” (contaminated from repeated re-use) do operators consider energy recovery a desirable option. The 1981 data may not, however, provide a completely accurate picture of current practices because of recent developments in energy recovery technology. Many technologies were not available in 1981, and others are only beginning to be commercially available today. Solvents tend to be used for energy recovery because they can possess high energy values. Increasing quantities of high calorific wastes are being used by cement plants and lime kilns.

3.4.2. WASTE TREATMENT AND DISPOSAL

3.4.2.1. TREATMENT

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 before the final disposal of some amount of hazardous waste. Hazardous waste can be treated by chemical, thermal, biological, and physical methods.

Hazardous waste is the most difficult waste to manage, since in the treatment process, heavy metal and dioxin among others are obtained. The outcome elements are dangerous not only for the environment but also for public health (Couto, et al., 2013).

3.4.2.2. DISPOSAL

Disposal of hazardous waste is the final stage of a hazardous waste management system. Almost all possible disposal methods necessitate proper pre-treatment, in order to have secure disposal facilities (Visvanathan, 1996). Summaries of selected principles of different waste disposal methods are emphasized in this work namely: ***Secure landfill, Deep well and Bedrock disposal.***

(a) SECURE LANDFILLS

Historically, some hazardous wastes were disposed of in regular landfills. This resulted in unfavorable amounts of hazardous materials seeping into the ground. These chemicals eventually enter natural hydrologic systems. Many landfills now require countermeasures against groundwater contamination, an example being installing a barrier along the foundation of the landfill to contain the hazardous substances that may remain in the disposed waste. Currently, hazardous wastes must often be stabilized and solidified in order to enter a landfill and many hazardous wastes undergo different treatments in order to stabilize and dispose of them.

A landfill is a disposal facility where hazardous wastes are placed into and stored in the soil. Landfills for hazardous wastes are frequently considered a technology of last resort to be used after every effort has been made to reduce or eliminate the hazards posed by the waste. The intent is to bury or alter the wastes so that they are not environmental or public health hazards.

For some years, waste disposal specialists have believed that, in principle, it is possible to design a secure landfill site for hazardous liquid wastes. An example of a recommended design is shown in Figure 4. The wastes are put in sealed drums before disposal. A secure hazardous-waste landfill must have two impermeable liners and leachate collection systems.

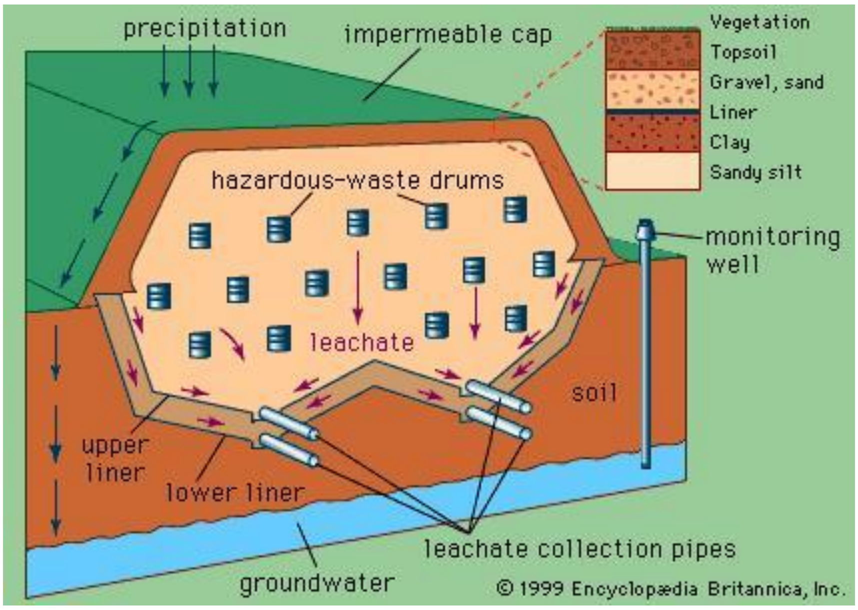


Figure 4: A secure landfill design for hazardous waste disposal (Encyclopedia Britannica, 2016)

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.

In view of the above precaution to prevent leachates from accumulating in landfills, there isn't any complete guarantee that leachate would not accumulate no matter how secure the landfill is engineered.

The main components in the leachate from landfill sites may be conveniently grouped into four classes, as follows:

a) Major elements and ions such as calcium, magnesium, iron, sodium, ammonia, carbonate, sulphate and chloride.
b) Trace metals such as mangenese, chromium, nickel, lead, and calcium;
c) a wide variety of organic compounds which are usually measured as Total Organic Carbon (TOC) or Chemical Oxygen Demand (COD); individual organic species such as phenol can also be of concern; and
d) Microbiological components

All hazardous waste and most industrial waste will give rise to leachate.

Heavy metals have been of greater concern compared to other leachate components; this is as a result of its persistent and bio-accumulative nature in the food chain. Fossil fuel combustion, metallurgical industrial activities and industrial wastes generation are the main sources of heavy metals' wastes generation, and also poor management by generators over years have accentuated their unwarranted release to the environment.

(b) **DEEP-WELL DISPOSAL:** Another alternative disposal of liquid industrial waste is injection into deep wells (Figure 5).Deep well injection is a liquid waste disposal technology. This alternative uses injection wells to place treated or untreated liquid waste into geologic formations that have no potential to allow migration of contaminants into potential potable water aquifers. This method has been practiced since World War 11 and 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 rock unit selected to receive the waste must be relatively porous and permeable (commonly, sandstone or fractured limestone), and it must be isolated by low-permeability layers (for example, shale) above and below. The subsurface geology must be known in sufficient detail that there is reasonable confidence that the disposal stratum remains isolated for some distance from the well site in all directions. Information about that geology may be derived from many sources: direct drilling to obtain core samples that provide a vertical section of the rock units present; geophysical studies that provide data on depths to and thicknesses of different rock layers, and on distribution of ground water; geologic mapping on the basis of cores, surface outcrops, and geophysical data to interpolate between points sampled directly.

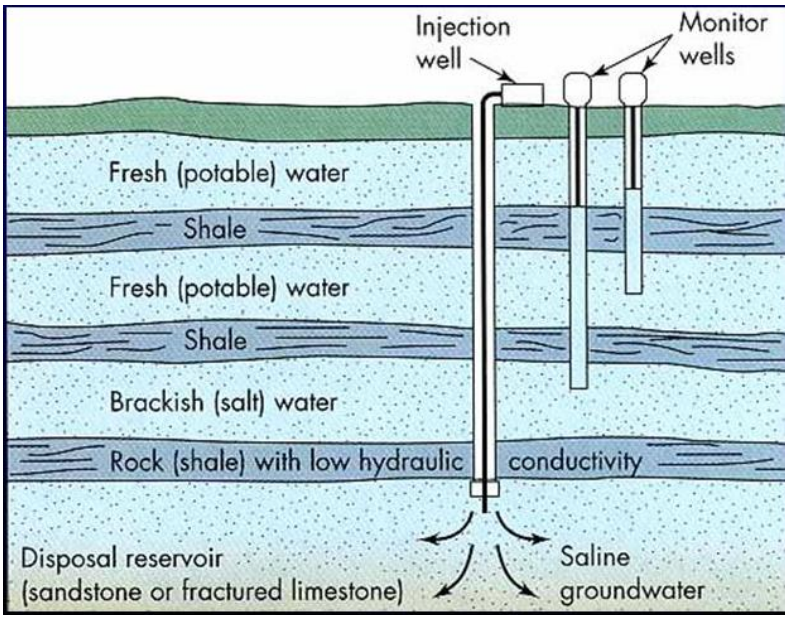


Figure 5: Deep well disposal method (Source; Linday, 2012)

These disposal wells are hundreds to thousands of meters deep, far removed from the surface, and below the regional water table. The pore water in the disposal stratum should be brackish or saline water not suitable for a water supply. Where the well intersects any shallower aquifer that are or might be used for water supply, it must be snugly lined (cased) to prevent leakage of the wastes into those aquifers. Local well water is monitored to detect any accidental leaks promptly.

Movement of deep ground water is generally slow, and the assumption is that, by the time the toxic chemicals have migrated far enough laterally to reach a usable aquifer or another body of water, they will have become sufficiently diluted not to pose a threat. This presumes knowledge of the toxicity of the chemicals in low concentrations. When the wastes are more or less dense than the ground water, they displace and not miscible with it, folds or other geologic structure may help to contain them and slow their spread, as oil traps contain petroleum. The behaviour of chemicals that dissolve in pore water is much less well understood. They can diffuse through the water more rapidly than the water itself moves, so that even if deep ground water transport is slow, contaminant migration may not be.

Deep-well injection is relatively inexpensive and requires little or no pretreatment of the waste, but it poses a danger of leaking hazardous waste and eventually polluting subsurface water supplies.

(c) BEDROCK DISPOSAL

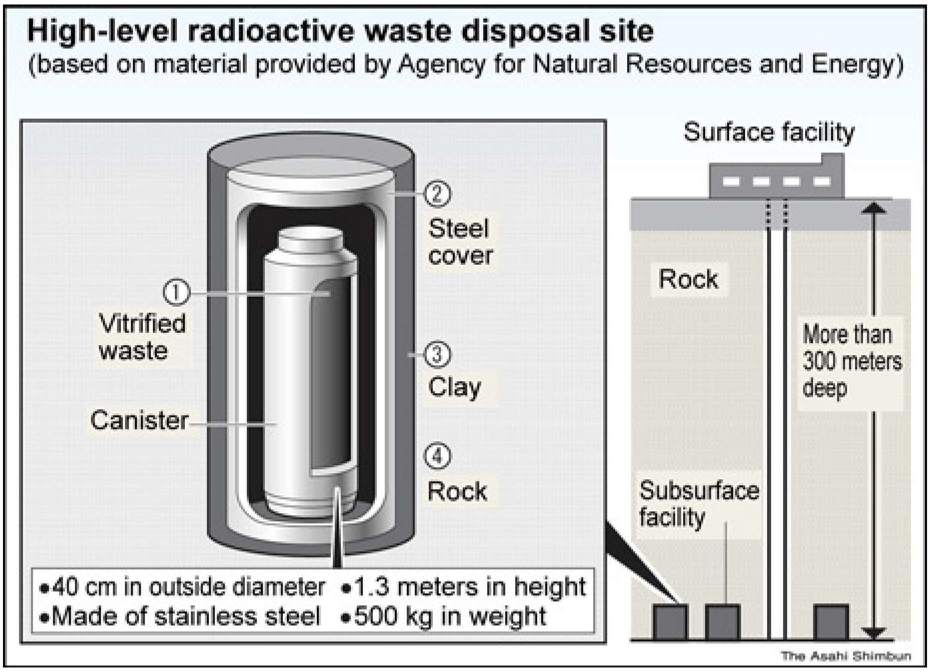


Figure 6: Bedrock disposal of solid hazardous wastes (Source: Rajakumar, 2016)

A variety of bedrock types are being investigated as host rocks for solid hazardous waste. The general design of a bedrock disposal site or repository for such wastes is shown in Figure 6. It involves the multiple barrier (or multi barrier) concept: surrounding solid waste with several different types of materials to create multiple obstructions to waste leakage or invasion by ground water. A major variable is the nature of the host rock as well as some potential drawbacks. The waste forms envisaged for disposal are vitrified high-level radioactive wastes sealed into stainless steel canisters, or spent fuel rods encapsulated in corrosion resistant metals such as copper or stainless steel. The most widely accepted plans are for these to be buried in stable rock structures deep underground. Many geological formations such as granite, volcanic tuff, salt, thick basalts such as the Columbia River plateau basalt or shale will be suitable (Salma, 2012).

4.0 CONCLUSION

The fundamental goal of hazardous waste management program is to change the behavior of those who generate hazardous waste so that they routinely store, transport, treat, and dispose of them in an environmentally safe manner. The focus comes in an effort to address more immediate threats to public health, such as safe drinking water.

Hazardous waste management must move beyond burying and burning. Industries need to be encouraged to generate less hazardous waste in their manufacturing processes. Although toxic wastes cannot be entirely eliminated, technologies are available for minimizing, recycling, and treating wastes. It is possible to enjoy the benefits of modern technology while avoiding the consequences of a poisoned environment. The final outcome rests with governmental and agency policy makers, as well as with an educated public.

REFERENCES.

Anderson,B.(2011).A formular for provision or perversion of Municipal Solid Waste management. Retrieved from http://www.clearimpression.wordpress.com/page/5.

Bond,O.(2016). Signs and symptoms of selenium poisoning. Retrieved from www.livestrong.com/article/367955-signs-symptoms-of-selenium-poisoning/

Couto, N., Silva, V., Monteiro, E., & Rouboa, A. (2013). Hazardous waste management in Portugal: An overview. In *Energy Procedia* (Vol. 36, pp. 607–611). https://doi.org/10.1016/j.egypro.2013.07.069

Dawsin,D.A.(2000). Alternative measures to Waste Disposal. Journal of Hazardous Substance,*12(1-2),79-91*.

Duan,V.,Chen,Q.,Ye et al(2011). Hazardous Incidents. Journal of Hazardous Materials, *186(2—3), 1489-1494*.

Encyclopedia Britannica,2016.Hazardous Waste Disposal.Retrieved from https://www.britannica.com/technology/hazardous-waste-management

Enger, E.D & Smith, B.F.(2004). A study of interrelationships. Environmental Science. Edward E. Bartell. Carlifornia,USA:

Etim, I.U. (2003). Basic Principles of Environmental Science. Etiliew International Publishers.Uyo,Nigeria.

Fordyce, F.(2000). Geochemistry and Health. Geoscience and development,No 6 pp.6-88. GESAMP(IMO)/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP.1982. Joint Group of Experts on the Scientific Aspects of Marine Pollution: The Health of the Oceans. Rep.Stud.,GESAMP,(15): 108p and UNEP Reg.Seas Rep.Stud.16,108pp.

Iyyanki,V.M., & Vali, M.(2017). Science and Engineering for industry. Thailand:Elservier Inc.

Jerry, A.N., (2015). Encyclopedia Britannica, Hazardous Waste management.

John,V.(2014).Smelly and contaminated,the World's open dumps are growing.Retrieved from https://www.thestar.com.my/lifestyle/features.htm.

Linday, D. P.(2012).Deep Well Injection Waste Disposal technology. Retrieved from http://www.theguardian.com.

Misra, V., & Pandey, S. D. (2005). Hazardous waste, impact on health and environment for development of better waste management strategies in future in India. *Environment International*. https://doi.org/10.1016/j.envint.2004.08.005

Montgomery, C.W. (2000). Environmental Geology (5th Ed.).Edward E. Bartell.Carlifornia,USA.

Okeke, O.C.& Udoka, U.P. (2014). Handbook of Geologic Methods *Vol.2*. Platinum Global Ventures Press. Port Harcourt,Nigeria.

Rajakumar, J.(2016). Solid and Liquid waste management in smart cities-phase 2. Retrieved from https://www.slideshare.net/Jayanth-R/solid-and-liquid-waste-management-in-smart-cities-phase-2

Roger, B., James, E.S., & David, D. (1989).The safe disposal of Hazardous wastes: The special needs and problems of developing countries, A world Bank Technical paper *1 (93)154* Washington D.C: World Bank.

Roger, B., James, E.S., & David, D.(1989). The safe disposal of hazardous wastes: The special needs and problems of developing countries. A world Bank Technical paper *2(93) pp 270-276,448-470)* Washington D.C: World Bank

Salma,2012.Is zero waste possible? Retrieved from http://www.global.britannica.com/topic/secure-landfill.

The Resource Conservation and Recovery Act(RCRA)(2016). Hazardous wastes regulations, Chapters 10 through 32 of Division 4.5 of Title 22 of the California Code of Regulations .Retrieved from http://www.dtsc.ca.gov/HazardousWaste/upload/HWMP_DefiningHW111.pdf

Visvanathan, C. (1996). Hazardous waste disposal. In *Resources, Conservation and Recycling* (Vol. 16, pp. 201–212). https://doi.org/10.1016/0921-3449(95)00057-7