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EFFECT OF HAZARDOUS WASTE MATERIAL ON SURROUNDINGS AND THEIR EXECUTIVE STRATEGIES

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Abstract

Hazardous waste has emerged as an issue of major concern that has negative impact both on human health as well as on the environment. Hazardous and infectious agents are handled in daily routine in biomedical laboratories. Their effects are increasing continuously in the environment. Hazardous waste includes solid, liquid, sharp and pathological waste. Workers in hospitals and health care, agricultural and fishing occupations are at particular risk of exposure to hazardous biological agents. Recently, more systematic and strict steps have taken by the Indian government regarding the public concern to prevent the proliferation of hazardous waste and its improper disposal. However, management of waste are still not well promoted. So, to intercept the build-up of biohazards into the environment, waste from biohazardous operations must be disposed or treated appropriately in a special way and it also intends to create awareness amongst the personnel involved in these sectors to develop and implement hazardous waste management and mitigation strategies.

Keywords: Hazardous waste, types and management, disposal, awareness.

1. Introduction

Industries play a vital role in the economic aspect of modern society and hazardous waste production is an inevitable outcome of developmental activities and industrialization. A material becomes waste when it is discarded without expecting to be compensated for its inherent valueⁱ. Over the past two decades, hazardous waste has become a serious issue of concern in many countries including India. Hazardous waste has negative impact on human kind and the surrounding due to mismanagement during storage, transportation and disposal. Itin holds biological agents (bacteria, viruses, prions, fungi, protozoans, tissue cultures, toxins, recombinant DNA (rDNA), transgenic animals, body fluid and tissue etc) as well as chemicals (potentially toxic) used in daily routine in research and educational institutes, industries (e.g., carcinogenic, mutagenic and teratogenic) and in household that may confer danger to the living beings if discharged in the umbworld.

Hazardous waste not only contaminates the environment but also perilous for human beings, animals and plants by another means. Hazardous waste can be classified on the basis of physical, chemical and infectious properties of the waste and their risk of injury during its

handling and disposal. People working in laboratories and medical centers are at particular risk of exposure to hazardous agents. There is growing observations that many professions including agriculture, textiles, wood work, sewage and compost plants harbor the potential for various forms of hazardous waste. Every day millions of tons of waste are being produced by in definite numbers of hospitals and other medical and research institutions of our country. On the other hand, governments and international agencies are taking steps for controlling the growing problem of hazardous substances in the environment which appears to be a difficult process because the wastes are from many sources. Toxic and hazardous substances from these sources contaminate the land, air, and waterⁱⁱ.

Further more people involved in storage, transport, treatment and disposal of these waste are also susceptible and at high risk. Besides this, a huge amount of health care wastes such as saline bottles, disposable syringes, I.V. fluid bottles etc. are picked up by rag pickers all over the country and recycled back into the market without any sterilization or disinfection. The potential health risk associated with these substances vary from minor, short term discomforts, such as headaches and nausea to serious health problems, such as cancers and birth defects, to major accidents that cause immediate injury or deathⁱⁱⁱ. These wastes harm the surrounding even at low concentration and its management all over the world is still in its infancy. So it becomes mandatory to take preventive steps for the proper treatment and safe disposal of the waste, to raise awareness for constant watchfulness and to provide some counseling or guidance towards the handling of hazardous waste existing in the environment.

It is therefore important to take necessary steps in managing the waste. In view of this, management of hazardous wastes including their disposal in an environment friendly and economically viable way is very important^{iv-vi}.

2. Sources of Hazardous Material

Although city solid waste has allured the concern of environmentalists and social administrators, but still there is lack of attention for certain sources of waste and its proper management. One such waste is biohazardous waste. According to the US Center for Disease Control and Prevention^{vii}"any microorganism, cell culture, or human endoparasite, including genetically modified organisms, which may cause infection, allergy toxicity or create a hazard to human health are biohazards." A huge amount of hazardous material is churn out from the hospitals, nurshing homes, veterinary hospitals, animal houses, blood banks, research institutes and related laboratories^{viii}.

Other sources which are associated with biohazards are industries, household and education institutes can badly hit human welfare. United Nation categorized hazardous waste as unsafe goods for shipment that comprises medical waste and all the substances transferable to humans and animals. So from the obtainable proofs it can be concluded that hazardous agents may survive in almost any profession. Human may be affected by biohazards, either by contact with animals through transmission of zoonotic agents (e.g. brucellosis) or by direct contact of causative agent (e.g. a bite from a venomous snake). Some can transfer directly or indirectly (e.g. toxoplasmosis). Some diseases like leishmaniasis (protozoan parasite is transmitted by the bite of phlebotomine sandflies), dengu (virus is transmitted by *Aedesspp*. mosquitoes) and malaria (protozoan parasite is transmitted by *Anopheles* spp. through mosquito bites) by inter mediate host vector or insects as they require human host to complete their life cycle and the diseases (e.g. leishmaniasis, malaria and dengu) that may spread through organ donation and infected blood is known as anthroponoses.

3. Types of Hazardous Material

Many organizations are associated with hazardous waste production but the most prominently involved organizations are health care establishments, industries, educational and research centers and their related laboratories. Based on their concentration, quantity, physical and chemical properties hazardous waste can be categorized as bio-hazardous waste and chemical waste.

3.1 Bio-hazardous Waste: Different types of biological agents^{ix} which are experienced by the people working in research and clinical work are categorized as follow:

3.1.1 Infectious Waste: Infectious waste are believed to contain waste from hospitals, industrial, educational, clinical and research laboratories including culture and stock of microorganisms, human and animal cell cultures, waste from infected patients (dressings soiled wit h blood and other body fluids, excreta), catheters, intravenous sets, cultural flask s, dishes, and other devices used to inoculate, mix and transfer cultures^x.

3.1.2 Pathological Waste: It includes human blood, blood products, tissues, organs, fetus, body parts and body fluids (synovial, pleural, amniotic, peritoneal fluid), animal carcasses etc. This category should be regarded as subcategory of infectious waste^{xi}.

3.1.3 Sharps Contaminated with Biological Agents: Objects that have been in contact with biological materials including needle, blades, scalpels, scissors, serological pipettes, Pasteur pipettes, broken glass, slides and other discarded sharps are considered as bio-hazardous material.

3.2 Chemical Waste: It includes the chemicals used in hospitals, industry, educational and research institutions and disposed of by households are categorized as follows:

3.2.1 Household and Laboratory Chemical Waste: Chemical waste include discarded solid, liquid and gaseous chemicals, various smaller-scale solvents, unused oils, paints, reagents and cleaners (e.g., bleach, toilet cleaner, floor polish and wax), photographic chemicals, insecticides, pesticides, fertilizers. Chemicals used in routine research and education experiments such as spent acid and bases, acrylamide, bis-acrylamide, ethidium bromide, 2-mercaptoethanol, chloramphenicol, chloroform, formaldehyde, trypan blue etc are also included under chemical waste^{xii}.

3.2.2 Pharmaceutical Waste: Pharmaceutical waste contains unused, expired and contaminated pharmaceutical products such as drugs, vaccines that are no longer required. Moreover it includes discarded items used during handling and manipulation of pharmaceuticals, such as gloves, mask, gowns, vials, bottles and bags with residues^{xiii}.

3.2.3 Genotoxic Waste: These are highly hazardous waste of ten used in cancer treatment with mutagenic, carcinogenic and teratogenic properties. It includes cytotoxic or antineoplastic drugs used during chemotherapy and radiotherapy treatment^{xiv}.

3.2.4 Waste with Heavy Metals: It represents wastes such as cadmium waste from discarded batteries, mercury from broken thermometers, blood pressure gauges, lead in radiation proofing of X-ray^{xv}.

3.2.5 Radioactive Waste: Radioactive waste comprises of solid, liquid and gaseous substances impured with radionuclides. These are produced by various activities like *in-vivo* tumor localization, body organ imaging and by *in-vitro* analysis of body fluids and tissues. Various radioactive elements (³²P, ¹⁴C, ³H, ⁸⁵Kr, ¹³³Xe and ³⁵S) are routinely used in Molecular biology laboratory, unused liquid from radiotherapy, absorbent paper, contaminated glassware, (large volumes of waste wit h low radioactivity) used in research and medical laboratory, urine and excreta of patients treated with sealed and unsealed radionuclides and unused liquids from radiotherapy and research works^{xvi}.

3.2.6 Sharps Contaminated With Chemicals: They include glasswares (flasks, beakers, bottles, graduate cylinders, test tubes etc) that have been contaminated with chemicals.

3.2.7 Pressurized Containers: These waste include gases (anaesthetic gases, compressed air, oxygen, ethylene oxide etc) used in research work and health care centers, which are stored in aerosol cans, cartridges, pressurized containers^{xvii}.

4. Mode of Transmission

Preliminary step in hazardous waste management is to identify the possible ways for transmission of diseases. Potential routes between hazardous materials and population are:

- Direct contact
- Indirect contact

Indirect contact is further categorized like:

- Contact through vector
- Air born contaminants
- Food and water born toxins

Every type of hazardous waste has the ability to cause different risks. In order to minimize the risks it is very essential to interrupt the channels of transmission^{xviii}.

5. Impact of Hazardous Elements on Environment

Mismanagement of hazardous waste can cause severe threat to the environment and results in the pollution of land, air and water, which ultimately affect human and other living organisms. Hazards related to this are more threatening than those caused by the poor management of municipal waste. Mainly the people working in these occupations are at a particular risk to this. So the pollutants responsible for this are categorized into biological, chemical and radioactive. Impact of hazardous elements on air, water, land, radio activities and health^{xix}.

5.1 Air Pollution: There are different pollutants chiefly named as biological, chemical and radioactive responsible for the air pollution. Which have severe effects on both indoor and outdoor atmosphere? The pollutants which are responsible for the air pollution are categorized as biological, chemical and radioactive pollutants.

5.2 In-Door Air Pollution: Different pathological and laboratory wastes are the primary source of indoor pollution. Pathogens, present in the waste can enter in the environment and stay as a spore for a prolonged duration. Fumigation or sterilization of rooms can reduce the load of pathogens. Other indoor air pollutants like tobacco smoke which can be identified by their smell are the complex mixture of pollutants and remain associated with air pollution and adversely affect human health^{xx}. Other factors like Air velocity, temperature and humidity also affect t he indoor environment.

5.3 Out-Door Air Pollution: Dumping of clinical or laboratory wastes in an open area without pretreatment also provides a passage for the pathogens to enter in the atmosphere and to cause infections. Open burning of these waste products toxic gases like furans and dioxins^{xxi}. When inhaled cause serious health issues related to respiratory system. Other sources responsible for outdoor pollution are power generation, industrial activity, transportation, biomass burning and domestic cooking and heating.

5.4 Water Pollution: For proper management of waste, landfills are being constructed. To protect nearby groundwater and soil from contaminationlandfills are layered by best materials. But some how improper waste disposal becomes thereason of water pollution. Any sharp material dumped into landfill can easily tear into covering and during the rainy season, any contaminant in theland fill may enter in to the soil due to which groundwater gets polluted. Liquid waste generated during various activities, when discharged into river or fresh water in untreated for m can also lead to water pollution^{xxii}. Due to which proper ties of water like pH, BOD, COD etc. get altered.

5.5 Soil Pollution: Biomedical waste containing expired drugs, cultural waste, chemicals, insecticides, metals, building materials, industrial waste and other wastes are the major cause of soil pollution. Waste containing excess amount of trace elements and heavy metals such as mercury, cadmium, lead etc enters to the soil which is dangerous for the health of plant, animal and human. So pre-treatment before disposal and waste minimization is the only route of waste reduction^{xxiii}.

5.6 Radioactive Pollution: In hospitals different types of diagnostic tools is being used. They may be disposable as well as radioactive. During radio-immunoassay activity radioactive gases are generated in small amount. These gases must be evacuated straight to the outside and should be monitored^{xxiv}. Direct disposal of these agents in the environment is very much harmful for the health of human as well as for environment.

5.7 Occupational Hazards: It has been demonstrated that the individuals within the health care establishments like medical doctors, nurses, researchers, workers in waste handling (who generate, handle and process hazardous waste), and those outside these sources such as waste pickers, drug addicts (Scavangers of used needles and disposed medicines), children (playing nearby waste) etc are at greatest risk to direct exposure of infections (e.g. HIV/AIDS, Hepatitis B and C). Infections occur directly through accident al inhalation of aerosol or cut by contaminated sharps (mainly by hypodermic needle). Illness acquired through the handling of infectious waste has been reported^{xxv}. Proper management of waste can solve the problem of occupational hazards to a large extent.

6. Impact on General Public Health

General public is indirectly associated with transmission of disease, because they are not exactly exposed to the infectious waste or the reservoir body. To facilitate indirect transmission, infectious agents must have the potential to survive outside to its source for prolong duration with an opportunity to affect a susceptible host. According to a study conducted by WHO in 1996 states that everyday >50,000 people die because of infectious diseases.

Population residing in the vicinity of hazardous waste was found to be observed with reproductive disorders (spontaneous abortion, fetal and infant mortalitiy and low birth weight) and birth defects.Dumping of bio-medical waste in open spaces, water objects and municipal dustbins etc. causes spread of diseases. Emission of toxic gases from open burning of waste can cause respiratory diseases and cancer^{xxvi}.

Scavenging on openly dumped plastic waste can choke animals. Some diseases that transmited through infectious waste or vectors are tetanus, pneumonia, diarrhea, tuberculosis, whooping cough, leishmaniasis and malaria etc.^{xxvii}.

7. Risk Minimization

The primary step for minimizing the risk is eradication of vectors (e.g. such as birds and protozoans and who act as vector for psittacosis, leishmaniasis, malaria and dengu) elimination of hazardous agents (e.g. radioactive substances responsible for tumor and cancer, pesticides that kill pests)^{xxviii}.

8. Seperation, Storage and Transportation of Hazardous Waste

Before the final disposal, all the waste must be properly segregated, stored, disinfected and transported to the related disposal sites. This practice should be done in order to prevent contamination of normal waste by infectious and pathological waste so that the waste can be easily transported.

8.1 Separation: It is the primary and mandatory process and mainly depends on the composition and quantity of waste generated at the source that helps in minimizing the risks and cost of handling and disposal. It is theresponsibility of the waste producer to segregate the waste at its source. Segregation alone can help in effective waste management. Effective segregation prevents mixing of laboratory and medical waste (e.g. sharps and infectious waste) with the general municipal waste, reuse of certain components of medical waste like needles, syringes etc. It helps in recycling components of medical wastes like plastic materials after complete disinfection. That can be used for nonfood grade applications. The best mode for segregation of hazardous waste is sorting the waste into color-coded bins and plastic bags^{xxix}.

8.2 Storage: The hazardous waste must be collected in different types of containers or bags from various sources of biomedical wastes like operation theatre, wards, research and educational laboratory, animal houses, corridor, etc. The container or bin should have the international symbol with the word BIOHAZARD underneath.

The containers for collection of the wastes should be leak proof and must have lids with them. Cardboard boxes should not be used for collection because they disintegrate very soon. It is recommended that sharp waste must always be collected in puncture proof containers to protect the workers handling them from injuries and infections. After Storage the waste should not be stored for more than 24 hours. In addition, red or red/ orange biohazard bags should be used for the disposal and/or autoclaving of biohazardous waste.

8.3 Transport: The waste must be transported for further treatment by means of trolleys, carts or containers so as to prevent access to, transportation operators, public and scavengers. Manual loading of waste should not be used in practice. Bags and containers having hazardous waste should be tied properly before transportation. The transporting vehicles should be clean daily and dried on regular basis.

9. Disposal Technique

To protect the environment from the risk of hazardous waste they must be treated and/or disposed of in a special way. Disposal of hazardous waste is the final stage of a hazardous waste management system. The different waste disposal method include deep well injection and secure landfill^{xxx}.

9.1 Deep-Well Injection Technique: Deep well injection is a liquid waste disposal technology. Liquid waste is injected into a well that has been created in the porous rock deep below the water table. Around nine billion gallons of hazardous waste are injected into deep-well each year in the United States. Although this method of hazardous waste disposal is designed to be long-term and ground water, sometimes the wells leak or are damaged and waste contaminates the water supply^{xxxi}.

9.2 Secure Landfill Technique: A secure landfill is a carefully engineered area that is used to deposit waste products. Typically, a secure landfill is a hole in the ground, but may also be built above ground. If the depression is in the ground, it must provide a 3 meter (10 foot) separation between the bottom of the landfill and the underlying bedrock or groundwater table. The purpose of a secure landfill is to prevent any waterborne connection between the waste products and the surrounding natural environment. It is especially imperative that groundwater does not cause run off onto the surrounding landscape. Hazardous wastes are disposed of by burial in secure landfills, though they are sometimes placed underground in deep well injection systems^{xxxii}.

10. Training and Awareness Program

Promotion of proper handling and disposal of various types of hazardous waste is necessary for public health and every member of the public must be aware of the potential health risks. Training and awareness programs should be developed by the government agency for all category of personnel including medical, paramedical, researchers and administrative and it should be suit able for every organization including government, private hospitals, health care centers, polyclinics, research institutions and laboratories^{xxxiii}. The main objectives of the training programs should be:

> To grow awareness regarding hygiene and waste management in hospitals and research institutes^{xxxiv}.

> To inform the general public about the health risks (mainly HIV/AIDS and Hepatitis B and others) linked to health care and hazardous waste^{xxxv}.

To prevent exposure from health-care and hazardous waste and related health risks^{xxxvi}.

11. Conclusions

The main prospective of hazardous waste management program is to change the way of managing hazardous waste so that they can be stored, transported and dispose in an environmentally safe manner. The focus of managing hazardous waste comes in an effort to address potential threats to public health and environment. Hazardous waste management must have an initiative beyond disposing directly into the land surface. Industries are encouraged to generate less amount of hazardous waste as a part of manufacturing process. Because the toxic wastes cannot be completely eliminated and only possible way is to minimizing, recycling and treating wastes. So steps should be taken to use the modern technology without causing any threat to environment.

12. Future Perspectives

There is only one Earth, our fuel and energy resources will eventually be exhausted in coming years. Wastes are in fact mispositioned resources, so there is a need to construct new waste recycling plants and landfills, modernization of existing waste recycling plants and increasing waste processing depth at existing stations, construction of a pilot plant for hazardous waste treatment, equipping waste trucks with navigation systems for better control on waste disposal. Further incineration plants play major role in the management of highly hazardous substances, so it is important to increase the number of incineration plants near the industrial areas. More importantly energy released from these plants can be recycled using the advanced technology to promote the economic development so that recyclable and reprocessed wastes that did not provide economic benefits will become useful resource in the future.

A sustainable source of resources and a sustainably protected environment are the ultimate targets of our efforts in resource recycling.

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