SHORT REVIEW

DOI: 10.54392/irjmt2233

INTERNATIONAL RESEARCH JOURNAL OF
MULTIDISCIPLINARY TECHNOVATION

Asian Research Association

Treatability study of Carcinogenic Waste and its Assessment of Environmental Risk

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DOI: https://doi.org/10.54392/irjmt2233
Received: 18-04-2022; Revised: 20-05-2022; Accepted: 22-05-2022; Published: 25-05-2022

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Abstract: Carcinogenic as well as chemotherapeutic waste is potential hazard to the environment because it is a type of toxic waste according by EPA (Environmental Protection Agency). The procedure of disposal of carcinogenic waste inside hospital, chemical industry and pharmaceutical industry is important concern for our society. The contribution from the Indian Judiciary in its own way to bring effective legal control of these hazardous substances and waste. Moreover, the problems related to judicial issues in tackling the technical issues and the executive inaction make it inevitable to have a separate system of administration of environmental justice and supervisory system so that our environment will be protected. The present paper investigates the treatability study of carcinogenic waste and its assessment of associated environmental risk according to the Indian hazardous substances and waste laws.

Keywords: Carcinogenic Waste, Treatability Study, Handling of Waste, Disposal Methods, Risk Assessment, Environmental Sustainability

1. Introduction

A type of hazardous trash is carcinogenic garbage. It must be handled in an environmentally appropriate manner, including storage, recycling, and disposal, in order to avoid negative effects on human health. Waste containing substances with genotoxic property, highly hazardous substances that are mutagenic, carcinogenic [1, 2] and cytotoxic used in cancer treatment. Items used in chemotherapy, could be contaminated with bulk number of chemotherapeutic drugs which includes, disposable gloves, ppes, bags and tubes, bandage and dressing. According to HWP (Hazardous Waste Permitting) rules [3, 4], more than 3% of the drugs remains carcinogenic properties are called bulk chemotherapeutic waste, if amount is less than a 3% then it is called trace amount [5-7]. Hazardous wastes that aren't suitable for burning will have to be disposed of properly. In that case, two basic methods - landfills and underground injection, are mandatory. Before disposal, surface storage system is used as temporary method. This type of facilities consists of open waste piles, ponds, and lagoons. New rubbish heaps must be created with care over an impervious base and must meet regulatory standards similar to landfills. The piles must be shielded from erosion and wind dispersion. There must be monitoring and control procedures in place if leachate is created. Only non-containerized solid, non-flowing waste material can be stored in a fresh garbage pile, and when the mound becomes unmanageable, the material must be land filled.

A lagoon is a type of temporary storage facility for hazardous liquid waste. Lagoons are built of impervious clay soils and flexible membrane liners to protect groundwater. Between the liners and the groundwater monitoring wells, leachate collection systems will be installed. Except for some sedimentation, evaporation of volatile organics [8,9], and possibly some surface aeration, open lagoons provide no treatment of the waste. The sludge which is accumulated, must be removed periodically otherwise hazardous waste will be generated. Around the world, a considerable number of these historic sites have been discovered and slated for repair.

2. Objective

The objective of this review article is the treatability study of carcinogenic waste along with environmental risk assessment related to disposal methods of waste. This paper also represents briefly the environmental impact of carcinogenic waste and adverse consequences of handling and disposal methods.

3. Hazardous Wastes Rules

The Hazardous Wastes (Management, Handling, and Transboundary Movement) Rules stipulate that incorrect handling or disposal of hazardous waste will result in environmental contamination [10-13]. According to that rule, the facility's occupier, importer, transporter, and operator are all responsible for environmental damage caused by inappropriate hazardous waste handling or disposal. The occupier and operator of the facility, according to the second rule, are obliged to pay financial penalties imposed by the State Pollution Control Board for any breach of the terms of these Rules. Hazardous Waste Management Rules are published to ensure that hazardous waste is handled, processed, treated, packaged, stored, transported, reprocessed, collected, converted, offered for sale, destroyed, and disposed of safely. [14-16].

4. Carcinogenic Waste

4.1 Source of Carcinogenic Waste

Manufacturing waste, home care waste, and contaminated materials from drug manufacturing and delivery are all examples of cytotoxic waste (expired medicines, left-over drugs, returned drugs, syringes, needles, gauzes, vials, packaging, samples such as urine, feces, and vomit from patients). Genotoxic waste (including cytostatic or radioactive chemicals) can account for up to 1% of total health-care waste in specialised oncological institutions. These are classified by the International Agency for Research on Cancer's working groups [18, 19].

4.2 Types of Carcinogenic Waste

4.2.1 According to HWP (Hazards Waste Permitting by RCRA) there are 2 types of waste

- More than 3% of the residual drug remains called bulk chemotherapeutic waste, which can be disposed only in black RCRA (full form) container.
- Less than 3% then it is called trace chemotherapeutic waste.

4.2.2 Types according to CFR

If a trash is specifically included on one of four lists (the F, K, P, and U lists) in part 261 of chapter 40 of the Code of Federal Regulations (CFR), it is considered hazardous waste [20-22].

- The F-list, which can be found in 40 CFR section 261.31, identifies hazardous wastes from common manufacturing and industrial activities. Because the methods that generate these wastes might occur in a range of sectors, the F list wastes are classified as wastes from non-specific sources. They can be classified into seven groups depending on the sort of manufacturing or industrial operation: Wood preserving wastes, Petroleum refinery wastewater treatment sludges, and Multisource leachate.
- Hazardous wastes from various industries and manufacturing sectors are identified on the K-list (source-specific wastes). A waste must fit into one of the 13 categories on the list and match one of the comprehensive K list waste descriptions in 40 CFR section 261.32 to qualify as a K-listed hazardous waste. Wood preservatives, organic chemicals, pesticides, petroleum refining, inorganic pigment manufacturing, inorganic chemicals manufacturing, explosives manufacturing, iron and steel production, primary aluminum production, secondary lead processing, ink formulation, and coking are some of the industries that can generate K list wastes (processing of coal to produce coke).
- Hazardous waste pure and commercial grade formulations of certain discarded compounds are marked on the P and U lists. The following three conditions must be met for a waste to be classified as P- or U-listed:

The waste must contain one of the compounds on the P or U lists, must be unused, and must be in the form of a commercial chemical product.

A commercial chemical product, according to the EPA, is one that is either 100 percent pure, technical (e.g., commercial) grade, or the single active component in a chemical composition. The P-list identifies pollutants that are extremely harmful as a result of the disposal of commercial chemical goods. The P-list is found in 40 CFR section 261.33. The U-list identifies hazardous wastes from abandoned commercial chemical goods. Section 261.33 of the 40 CFR contains the U-list wastes. The federal government's executive departments and agencies publish general and permanent rules in the Federal Register, which are codified in the Code of Federal Regulations (CFR).

4.3 Minimization of Carcinogenic Waste

Waste minimization is a critical first step toward safely, responsibly, and cost-effective waste management. The ideas of reducing, reusing, and recycling are used in this management process.

4.4 Storage of Carcinogens

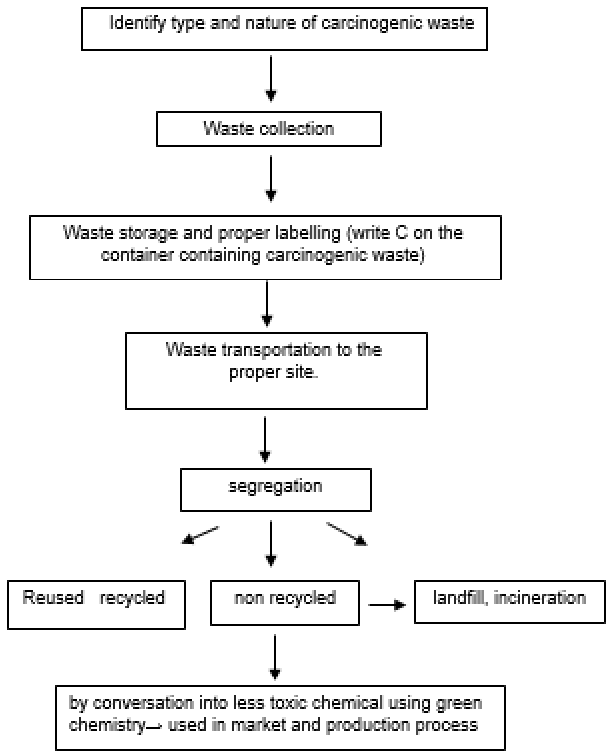
- Records: Each laboratory should keep a separate inventory of carcinogens on hand. Estimates of the actual quantity present are suggested but not necessary at this time.
- Location: Carcinogens should not be stored alongside other chemicals. Separate spaces in

the refrigerator, lab, and freezer should be made aside for carcinogen storage.

- Containers: There should be two levels of containment applied. The first depicts the compound's container, which is a bottle. The best container for the second level of containment is paint can. Several bottles of carcinogens, as well as desiccant, can be stored in a paint can. A label with a list of the carcinogens should be placed on the product.

4.5 Treatability Study of Carcinogenic Waste

4.5.1 Flow Chart



4.5.2 Various Processes

There are different methods used for the treatment of carcinogenic waste, which is mentioned below:

- Chemical processes
- Physical processes
- Thermal processes
- Mechanical processes
- Irradiation processes
- Biological processes
- Encapsulating
- MOF Technologies

4.5.2.1 Chemical process

These procedures make use of disinfection chemicals. Sodium hypochlorite, dissolved chlorine dioxide, per acetic acid, hydrogen peroxide, dry

inorganic chemical, and ozone are examples of such compounds. Most chemical processes use a lot of water and require neutralizers. Ion exchange, precipitation, oxidation-reduction, and neutralisation are examples of chemical procedures [23]

4.5.2.2. Physical Process

Evaporation, sedimentation, flotation, filtering, and solidification are examples of physical processes.

4.5.2.3. Thermal Process

- Heat is used to sterilize these processes. Based on the temperature at which they operate, low-heat and high-heat systems have been split into two types. Low-heat systems (93-177oC) heat and disinfect waste using steam, hot water, or electromagnetic radiation. Low-heat systems include the autoclave and microwave.
- Autoclaving is a low-heat thermal procedure that disinfects waste with steam. There are two types of autoclaves, depending on how they remove air pockets. There are two types of autoclaves: gravity flow and vacuum.
- Microwaving is a method for disinfecting rubbish that uses moist heat and steam created by microwave energy.

To decontaminate and destroy waste, high-heat systems use combustion and high-temperature plasma. For the disposal of carcinogenic waste, incineration may be the only viable option. Not all incinerators, however, are suitable for this use. The gas-fired version is anticipated to be the most efficient, with a first-stage combustion with a less-than-stoichiometric air:fuel ratio followed by a second stage with additional air.

4.5.2.4. Mechanical processes

These procedures change the waste's physical form or properties, either to make it easier to handle or to process it in conjunction with other treatment steps. The following are the two basic mechanical processes:

- Compaction: This is a technique for reducing the volume of garbage.
- Shredding: This is a method of destroying plastic and paper waste in order to prevent it from being reused. In a shredder, only disinfected garbage is used.

4.5.2.5. Irradiation Processes

In these processes, waste is exposed to UV or ionizing radiation in an enclosed chamber. To make the trash unidentifiable, these methods require post-shredding.

4.5.2.6. Biological Processes

Medical waste is treated with biological enzymes [24]. It is claimed that biological reactions will not only clean the rubbish but will also destroy all organic substances, leaving just plastics, glass, and other inert materials behind.

- **Encapsulating**

Solidification is the most important procedure, which can be accomplished by encasing the trash in concrete, asphalt, or plastic. This procedure produces a solid mass of material that resists leaching. The rejected material is combined with lime, fly ash, and water to create a solid, cement-like product.

- **MOF Technology (Metal Organic Framework)**

Metal-organic frameworks, in general, have the highest surface areas per gramme, with a highly organized pore structure that is comparable to one gramme of MOF, just like a FIFA soccer pitch. That equates to up to 7000 square metres of surface area per gramme of MOF material. They have more room for chemical reactions and molecule adsorption because of the huge surface area. Aside from that, there are a variety of other factors driving industry and academic interest in metal-organic frameworks.

4.6. Carcinogenic Waste Disposal

All sorts of carcinogenic waste should be maintained to a minimum, and fewer tests should be undertaken to reduce the amount of solid and/or liquid waste produced. All carcinogenic waste containers should be labeled with the name of carcinogen following all safety guidelines. There is no specific method which can 100% nullify the effect of carcinogenic waste and also not specific disposal method applicable for all types of carcinogenic waste. Some methods are very needful to treat some carcinogenic waste, some methods expose potential hazards to the environment, for example incineration method releases some toxic fumes, in chemical method extraction of chemical is problematic, leachate and land fill method produce soil as well as water pollution. Land fill method also increases the issue to destroy plastics**.** Therefore, the essential concern is that to prevent the exposure of toxic and hazardous vapours from different processes.

4.7. Chemical Characteristics

- Weaker oxidative agents, such as a saturated solution of potassium permanganate in acetone, appear to be suitable for destroying hydrazine or molecules having isolated carbon-carbon double bonds. As an oxidising agent, 50 percent aqueous sodium hypochlorite can be employed.
- Alkylating, arylating, and acylating substances can be eliminated by reacting with nucleophiles such water, hydroxyl ions, ammonia, thiols, and thiosulfate. The reactivity of various alkylating agents varies significantly, and it is also affected by the agent's solubility in the reaction media.
- For the completion of reaction, it is suggested that the agents be dissolved in ethanol or similar solvents.
- No chemical technique on a carcinogen should be used until it has been properly studied for efficacy and safety.

4.8 Risk Assessment

The most significant potentially carcinogenic substances detected in a state-of-the-art clinical waste incinerator (CWI) and vehicle emissions were polychlorinated dibenzo-p-dioxins, polycyclic aromatic hydrocarbons (PAHs), benzene, 1-butadiene, arsenic, cadmium, chromium, and nickel. The long-term exposures of a hypothetical maximum exposed individual (MEI) in the surrounding environment, as well as aggregate emissions from clinical waste transit, were computed. The CWI's PAH mass emission rates to air were compared to estimates of CWI bottom ash mass emissions to land previously published. The total emissions from clinical waste transportation by road were comparable to incineration stack emissions. PAH emissions to landfills typically exceeded those from stack emissions in large amounts. The CWI's emissions contribute just a small amount to the overall cancer risk posed by PAHs and other toxins. The uncertainty in the quantitative risk calculations presented here is assessed in light of these findings.

4.9. Environmental Sustainability

Despite having a good recycling programmed, the best method to ensure environmental sustainability is to extract chemicals from garbage and convert hazardous waste into less dangerous waste. The amount of jobs created by reusing, composting, and recycling our trash can be significant, and it can lead to new enterprises focused on converting trash into treasure. Many countries may help and encourage recycling enterprises by locating them in eco-industrial parks and other such locations.

5. Conclusion

The universal reality is that incineration, as opposed to land filling, is more efficient at disposing of vast amounts of waste than reusing, recycling, and composting. Some hazardous pollutants that cannot be burned or processed chemically must be disposed of immediately. Oxidation with potassium permanganate and sodium hypochlorite solution is the most extensively used method. Furthermore, many waste compounds are completely degraded and inactivated by oxidation followed by nucleophilic substitution. A solution of sodium dichromate in strong sulphuric acid (chromic acid solution) also helpful destroys organic waste compounds. Though there are several successful recycling programs for recovery of chemicals from carcinogenic wastes, the transformation of hazardous waste into less toxic waste is considered as one of the best ways for environmental sustainability. The main concern is to minimize the pollution.

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Conflict of interest

The Authors has no conflicts of interest to declare that they are relevant to the content of this article.

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