International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 11s, 2025
https://www.theaspd.com/ijes.php

Environmental And Healthcare Issues Of Medical Waste

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Abstract
This article investigates medical waste issues, covering typical sources, regulating regulations, and methods of processing and disposal. Many advanced economic countries have medical waste regulations, but there is no advice on whether things are contagious or not. However, there are fewer regulations concerning medical waste in developing countries. Because of this ambiguity, categorising medical trash has become inefficient, which results in rise in volume of trash treated for pathogens, which is typically done by incineration. Review highlights the scenario of medical waste generation, waste segregation and collection methods, health care waste disposal techniques, and medical waste impact assessment on the environment. This analysis demonstrates that incorrect methods of sorting, transporting, treatment of disposal, and untrained workers lead to effects on environmental indicators that cause harmful effects on the environment, human health, and healthcare worker accidents. That will ultimately increase unfavorable environmental consequences. The review concludes that improved medical professional training and systematic categorizing of healthcare waste streams are critical pathways for effective medical waste management at hospitals and clinics and standard environmental assessment of medical waste is a must to give the best scenario of medical waste treatment.

***Key words:** Healthcare, Medical waste, Environment assessment, Incineration, Incinerator emissions*

1. Introduction

The healthcare sector is now a days is one of the leading sectors of economic growth and innovation in developing countries like India. Developed countries significantly use single-use disposable instruments, which results in a huge amount of waste. These resulting emissions impact directly and indirectly on public health, which includes respiratory health as well as climate change or global warming. Largely, its impact is more on developing countries like India, where economic and conditions make it harder to counter the effects due to emissions from the production of materials or electronic waste treatment, which result in climate change and the emission of toxic compounds, heavy metals and air particulates that affect human health [1)]. Climate change exerts considerable effects on coastal as well as marine regions, including rise in sea level, increased risks associated with maritime activities, floods in coastal regions and erosion, economic repercussions, rise in intensity of tropical storms, harm to marine ecosystems, and ocean acidification[2)].

A type of economic system known as the "circular economy" aims to minimise the cost of materials, products and resources, throughout the process. Waste reduction is a significant area of focus for EU initiatives, which entails the creation of sustainable low-carbon technologies and the resources of a competitive and efficient economy. In the past, it was thought that environmental sustainability and economic harm were intimately associated. However, the circular economy model views waste reduction and cost containment as path to economic, social, and environmental sustainability[3-6)].

Despite the huge amount of hazardous solid waste, effluents produced at medical care units have been the focus in several studies from years, mainly because of their increase in volume day-by-day[7)]. Now a days healthcare industrial waste impact is analyzed in terms of the carbon footprint of the hospital[8)]. Besides, the contribution to global warming waste/patient is significantly increasing, from 0.76Kg/bed per day in India to 6Kg/bed in Germany[9)].

Particularly in nations where economy is in transition phase and regulations regarding medical waste is insufficient, as it seen that demand for use and disposal of medical waste is increased after COIVD-19, particularly the discarded PPP (personal protective equipment) and the single-use plastics. This creates a serious problem for strategic management, and waste disposal[10,11]. Due to insufficient recycling as well as municipal garbage services, the COVID-19 pandemic's highly effects the environment and public health have already been felt globally[12,13].

Hospital waste should be handled in accordance with the solid waste management (SWM) hierarchy (prevent/minimise/recover/incinerate/landfilling) or a healthier and better environment. People's health and lives are at risk due to the buildup of municipal solid waste (MSW) and medical waste, particularly poisonous or possibly dangerous waste[14].
The majority of medical waste produced in healthcare facilities is neither more nor less hazardous than regular home waste[15]. The kind of medical waste that represents varying degrees of health risk, however, determines this. For instance, 15% to 25% of all medical trash is infectious waste, which includes things like sharp objects, body parts, poisonous or outdated medications, and waste that is radioactive or cytotoxic[16,17].
For the above objective of waste management, different tools and techniques are available which is usefull. Environmental life cycle assessment (LCA) is a systems analysis tool[18]. LCA has recently emerged as an essential methodology for decision-making in policy contexts that can influence entire sectors or societies[19].
LCA is mainly used in the comparison of two competitive products having the similar functions and to evaluate the modification that has been made in product to make it more sustainable. It is generally implemented to make changes in any part of the system[20].
In this methodology, we consider the right from waste collection to transport, handling of waste, and disposal. The collected data will be analyzed using GaBi and Ecoinvent database [21] for the calculation of human toxicity, freshwater aquatic Eco toxicity as well as terrestrial Eco toxicity potential and global warming. It is seen that open burning and incineration of medical waste lead to global warming and human toxicity potential, whereas the landfilling disposal method results in contributions to freshwater aquatic Eco toxicity categories and Terrestrial Eco toxicity potential[22].

It is required to design incinerator and incineration technology in such a way that the impacts of Healthcare Waste Management (HCWM) can be reduced. Incineration of health care waste having a 30% recovery in energy showed the lesser environmental impact among all impact categories, whereas dioxin emissions contribute 10% to human toxicity without recovering energy[20].

This paper will provide an overview of medical waste issues in the environment and healthcare facilities. First, the content and origins of biological waste will be handled in various courts across the globe. Following that, a debate on both the obligatory law and waste treatment and disposal standards in these areas will take place. Following that, present medical waste disposal procedures will be discussed, with a particular emphasis on internal collections, segregation, transport, and disposal methods. Typical incinerator disposal techniques will be addressed, followed by alternative treatments available and the need to reduce the amount of non-infected medical waste in the contagious medical effluents. Lastly, suggestions for improvement methods will be made, including improved education for healthcare staff as well as standardizing in-facility trash receptacles. This review will demonstrate how enhanced point-of-disposal,waste sorting, standardization of landfill disposal processes, and teaching and education of health staff may decrease the quantity of infectious waste generated and the related damage caused.

2. Medical waste generation

The extent in which different healthcare units generating medical is of great interest and lots of studies are being conducted on it. The quantity and composition of generated medical waste depends on many factors. According to a study, it is found that 52% of the total medical waste generated comes from rehabilitation of short-term patients, followed by analytical laboratories, surgeries, dialysis, and first aid with 23%, 14%, 7%, and 4%

contributions respectively. According to a similar study conducted in Taiwan, infectious medical waste, intensive care unit(ICU), emergency care unit, and outpatient clinic each contribute 23%, 17%, and 12% [23,24].
HCW can be classified into pathological waste (example-human tissues, body parts, foetus etc.), chemical waste (example- reagents, solvents etc.), sharp waste (example- hypodermic needles, scalpels etc.), pharmaceutical waste (example-expired medications etc.), infectious waste (example- blood and body fluids etc.), Genotoxic waste (example- genotoxic chemicals and cytotoxic drugs), pressurized containers (example- batteries, thermometers etc.) [25].

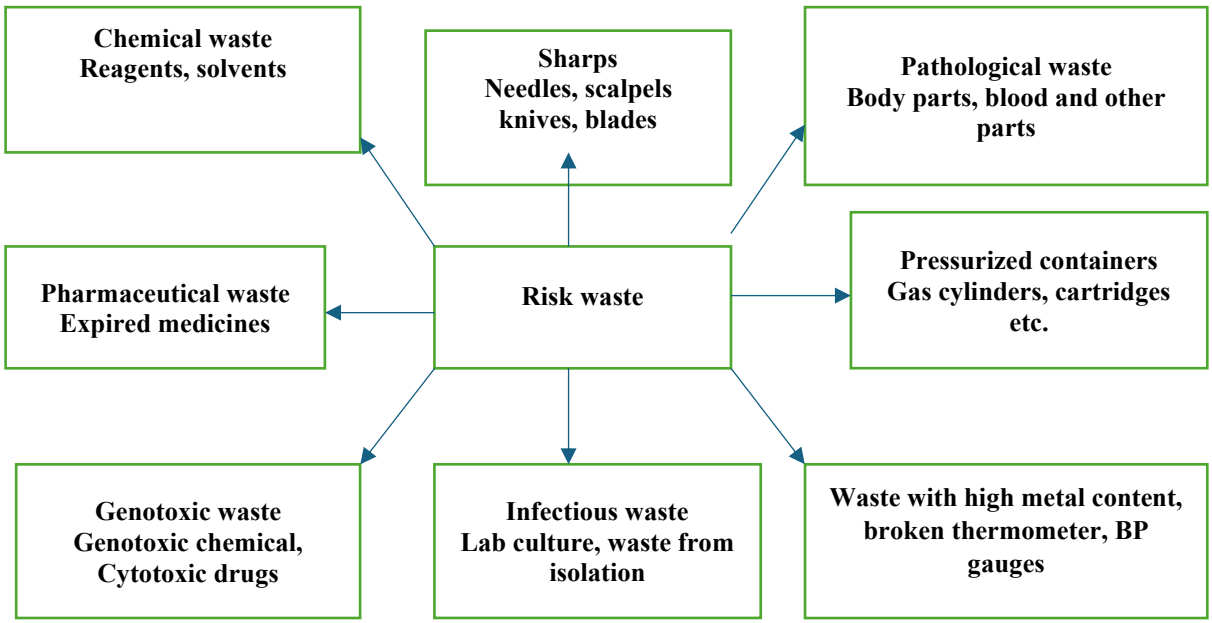

Figure 1 Categories of hazardous medical waste[25]

3. Current legislation in India

According to the gazette notification from the Government of India in 2016, biomedical waste shall be treated and disposed of according to table 1 and compliance with the standards provided in table2. It is a must for the operator to establish a biomedical waste treatment facility with equipment like an incinerator, microwave or autoclave, an effluent treatment plant, and a shredder.

Table 1. Types of medical waste and waste disposal methods as per Government of India[26]

Category	Type of Waste	Types of Bag or Container to be used	Treatment and disposal options
Yellow	(a) Human anatomical waste	Yellow non chlorinated bags of plastic	Incineration /Plasma Pyrolysis/ deep burial
	(b) Animal anatomical waste		Incineration or deep burial or Plasma Pyrolysis
	(c) Soiled waste		In above facilities not available then autoclaving or micro-waving/ hydroclaving
	(d) Expired or discarded medicines		Returning it back to the manufacturer/ supplier for incineration at temperature more than 1200°C
	(e) chemical waste		
	(f) Microbiology, Biotechnology and other clinical laboratory waste	Autoclave safe bags of plastic	Disposed of by incineration / Plasma Pyrolysis / Encapsulation in hazardous waste treatment, storage and disposal facility Pre-treat to sterilize with nonchlorinated chemicals

Red	Contaminated waste (recyclable)	Red non chlorinated bags of plastic or container	Autoclaving/ micro-waving/ hydroclaving then shredding or mutilation or combinly sterilize and shredding
White	Waste sharp including metals	Leak proof container	Autoclaving or Dry Heat Sterilization then shredding/ mutilation/encapsulation in metal container/cement concrete
Blue	(a) Glassware (b) Metal body implants	Blue color cardboard boxes	Disinfection /autoclaving/microwaving/ hydroclaving followed by recycling.

Table 2. Emission standards for medical waste disposal in India[26)]

S.No.	Parameter	Standards	
		Limiting concentration in mg Nm^3 unless stated	**Sampling duration (Minutes)**
1	Nitrogen Oxides NO and NO2	400	30 minutes for online sampling /grab sample
2	Total Dioxins and Furans	0.1ngTEQ/ Nm^3 (at 11% O_2)	8 hours or 5 Nm^3 of sample volume depends on which one is more
3	Particulate matter	50	30 minutes or 1 Nm^3 of sample volume, depends on which one is more
4	HCl	50	30 minutes or 1 Nm^3 of sample volume, depends on which one is more
5	Hg and its compounds	0.05	2 hours or 1 $Nm^3$of sample volume, depends on which one is more

4. Waste Segregation and Collection Method

Special attention should be needed in handling the solid waste of the hospital. Improper handling may result in a rise in airborne pathogenic microorganisms, which affects environment of hospital and human health. The medical waste should be segregated by colour coding of bags and containers, which may be paper, metal, or plastic according to the current legislation. According to a survey conducted, only 93 % of hospitals use the segregation method, whereas 7% of hospitals are still not using the same[27)]. 40% of workers in India are injured while handling medical waste, including skin, eye, and musculoskeletal disorders[28)].

Developing countries like India are also facing disease outbreaks due to the illegal disposal of infectious medical waste by third party firms. Firms receive the medical waste from the different healthcare units and resell it on the black market for reuse. In a study done in 2004, it was found that 10% of the health facilities sell their used syringes to the waste pickers, who manually search for any item that is there for reuse and sell it to healthcare centers. All these practices increase infection transmission[23)].

Biomedical waste shall not be mixed with other waste without treatment, according to government of India rules. The occupier will add the global positioning system and bar code. There are guidelines on not storing untreated human and animal anatomical waste, biotechnological waste, and solid waste for more than 48 hours. Clinical and microbiological waste shall be pretreated by sterilization as per WHO guidelines before packing and transporting it to the treatment facility.

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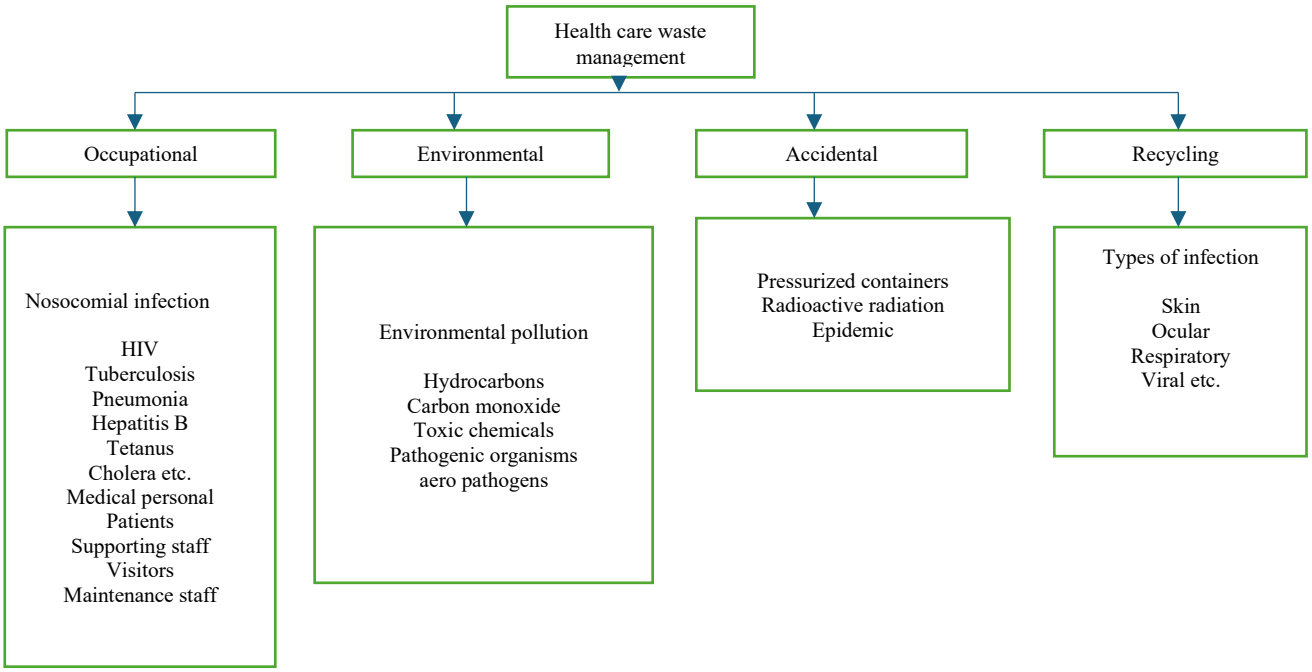

Figure 2. Hazards associated with medical waste management[29)]

5. System Boundaries for HCW

The system of the study starts from the segregation of the solid waste according to their harmful effects and their nature by putting them in different colour

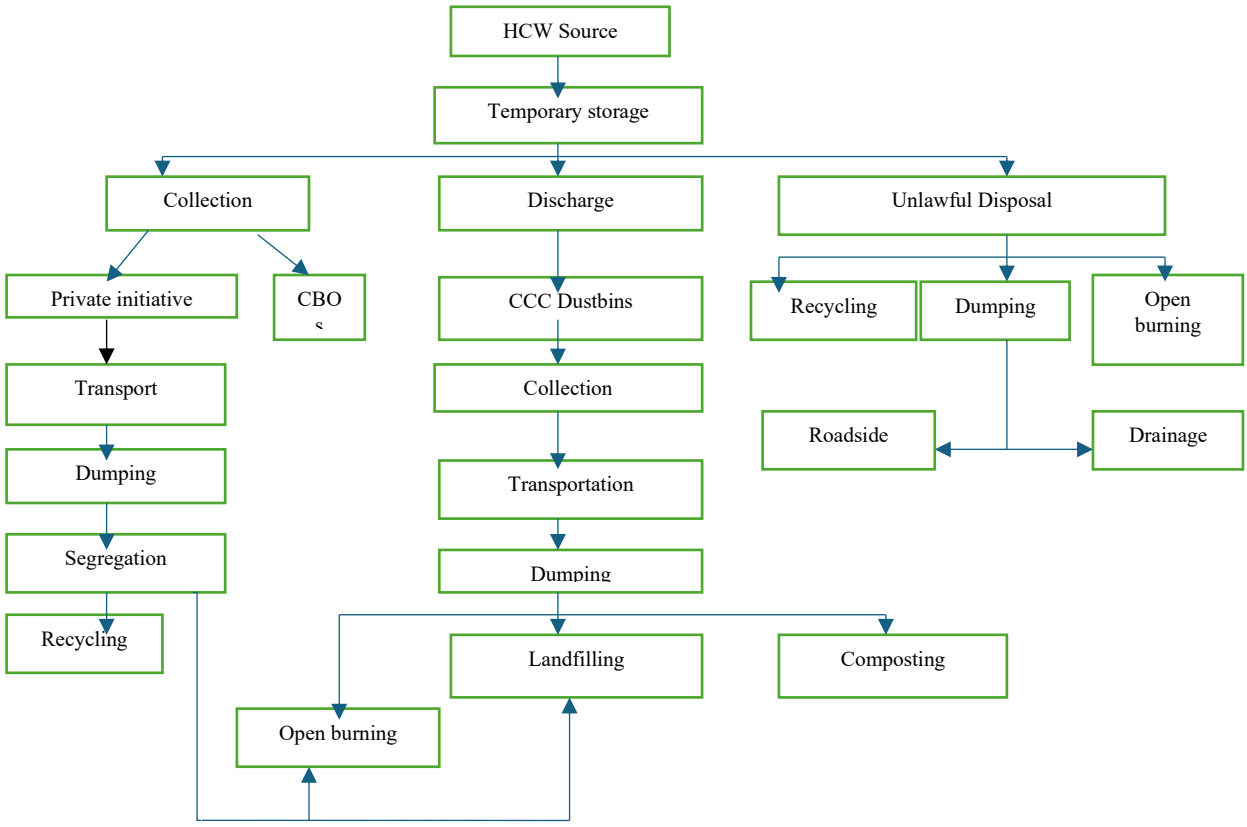

Figure 3. Health care waste management system [20)]

coded bags or bins. From their it is transported to the waste treatment area (recycling, composting, autoclaving, incineration and landfilling). Figure 3 showing the flow chart of health care waste management.

6. Health Care Waste Disposing Techniques

It is very important to use proper methods of disposing medical waste so that it will not affect the environment and human health. The two most widely used techniques for managing medical waste globally are incineration and sanitary landfills [30]. Prior to 1997, over 90% of medical waste in the US was burned, making it the third largest source of dioxin emissions into the atmosphere[31]. This prompted the Environmental Protection Agency (EPA) to establish strict emission guidelines for medical waste incinerators under the Hospital Medical Infectious Waste Incinerator guidelines, which were authorised in May 2013 after more than ten years of strong government enforcement[32]. More than 90% of medical waste ends up in open landfills or is burned without the use of abatement devices, which capture pollutants like dioxins and heavy metals after the waste is burned[33]. Nevertheless, incinerators continue to be the primary method of treating medical waste in the majority of nations with transitional economies. Although autoclaving most popular alternate method for treating medical generated waste, its use is currently restricted to a small number of nations due to its economic viability and the way the treated waste looks[34,35]. Autoclaving is a safe, effective, and heat-based treatment process. Landfills and other solid waste disposal facilities are confused because autoclaved trash is so hard to distinguish[36]. Furthermore, it should be mentioned that unlike incineration, the amount of garbage is not decreased.

6.1 Incineration

Incineration is an engineering process in which thermal decomposition of the organic waste takes place via thermal oxidation at a high temperature, usually 900 °C[37] or above, to destroy the organic fraction of the waste[38].

Medical waste incinerators (MWIs) are basically classified into three categories according to their waste burning process: Small incinerators have a capacity of up to 90 kg/hr, medium-sized incinerators have a capacity of between 90 kg/hr and 225 kg/hr, whereas incinerators having a capacity of more than 225 kg/hr are considered large[38,39]. Figure 4 shows the incineration system. Human toxicity is the most severe impact of incineration[40], followed by marine eco-toxicity and acidification [22].

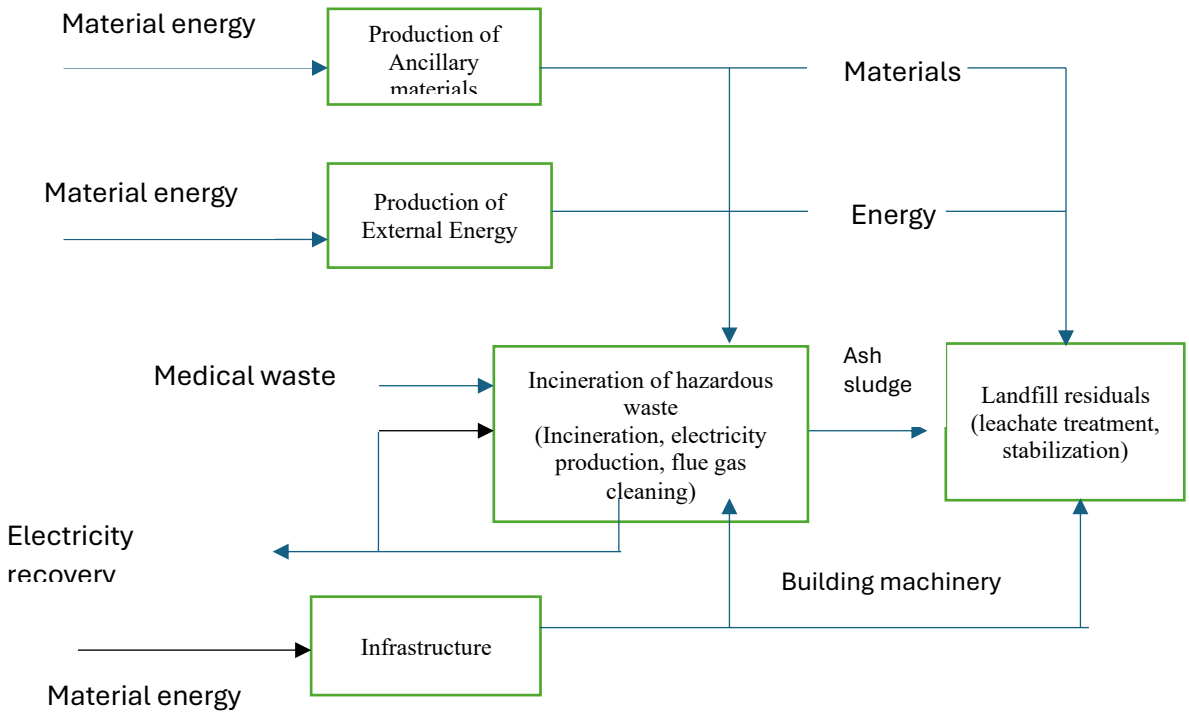

Figure 4. Hazardous waste incineration system[41]

6.2. Autoclave

Many researchers and firms find that a new alternate treatment method for incineration is autoclaving. It is a process in which steam and dry heat is used to raise the temperature from 121 °C to 163 °C [18] in such a manner that microbial contamination is killed by the infectious waste. After treatment, autoclaved waste is taken to the landfill sites and disposed of in the same manner as noninfectious waste [23].

6.3 Landfilling

The sanitary landfilling method is favourite disposal methods for medical generated waste. Its basic principle is to bury garbage or medical waste in the ground results in decompose it into harmless substances over a long period of time by microorganisms [42] .But it is very necessary to have an anti-seepage system for the medical waste system, else various poisonous substances, pathogens ,radioactive substances, etc. will infiltrate the soil during rainwater and harmful substances will affect the human body via the food chain [43,44].

7. Environmental Impact Assessment of Medical Waste

The analytical values of environmental indicators, such as Eutrophication Potential (EP), Global Warming Potential (GWP), Human Toxic Potential (HTP), Ozone Layer Depletion (OZD), Acidification Potential (AP), Abiotic Depletion Potential (ADP), Marine Aquatic Ecotoxicity Potential (MAEP), and Terrestrial Ecotoxicity Potential (TEP), demonstrate the importance of medical waste treatment and its impact on the environment. The method we are using for medical waste disposal directly affects the above environmental indicators. Higher values mean more pollution, and the way we are treating or disposing of it is not appropriate. So, accordingly, we must modify or change the method for the treatment of medical waste.

8. Conclusion

Health care waste management or disposal methods is a field which requires further studies to meet the global demands. The current disposal system is not up to the mark in comparison to the production of medical waste. Methods of sorting, transporting, treatment of disposal and untrained workers lead to effects on environmental indicators, which cause harmful effects on the environment, human health and healthcare worker accidents.

The best way to overcome its impact is to produce less waste, and it must be taken care of that only and only infectious medical waste should be sent for treatment. Better training for healthcare workers is a must. The government should have very strict regulations for the disposal of infectious materials, and priority should be given to research in this area.

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