Medical Waste Management in Developing Countries

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A growing awareness of the need for safe management of medical waste (also known as biomedical waste or healthcare waste) is being witnessed all over the world, especially in developing countries. Globally, the healthcare sector is growing at a very rapid pace, which in turn has led to tremendous increase in the quantity of medical waste generation by hospitals, clinics and other medical establishments. The growing amount of medical wastes is posing significant public health and environmental challenges in cities around the world.

The situation is exacerbated by improper medical waste disposal methods, lack of infrastructure and financial resources and lack of research on healthcare waste management in the developing world. Mismanagement of medical wastes from hospitals, clinics and other medical facilities pose occupational and public health risks to patients, health workers, waste handlers, waste haulers and the general public, besides damage to the environment and natural ecosystems.

1. Sources and categorization of medical wastes in developing countries

Any waste generated during diagnosis, treatment or immunization of human beings or animals in termed as medical waste. Such wastes are generated from a wide array of medical facilities, including hospitals, nursing homes, veterinary hospitals, clinics,

dispensaries, blood banks, animal houses and research institutes. Medical waste can be categorized based on the risk of causing injury and/or infection during handling and disposal. According to the World Health Organization, 85 % of medical wastes are non-hazardous, around 10 % are infectious and approximately 5 % are non-infectious but hazardous wastes [6].

The quantity of medical waste produced in a typical developing country depends on a wide range of factors and may range from 0.5 to 2.5 kg per bed per day [6]. For example, India generates as much as 500 tons of medical wastes every day while Saudi Arabia produces more than 80 tons of healthcare waste daily [7].

The typical composition of waste from healthcare facilities in developing countries is given in the table below [2]:

Waste category	Percentage
bandages, lines and other infectious wastes	30 – 35
plastics	7 – 10
disposable syringes	0.3 – 0.5
glass	3 – 5
general waste	40 – 45

Table 1: Composition of medical waste in India

Medical waste can be further divided into the following categories:

- Infectious waste (lab cultures, wastes from isolation wards, tissues, used dressings)
- Pathological waste (body parts, human foetuses, placentas, blood, other body fluids)
- Pharmaceutical waste (unwanted drugs, expired drugs)
- Chemical waste (chemicals from diagnostic work, cleaning materials)
- Sharps (needles, blades and broken glass)
- Radioactive waste (radioactive substances from radiotherapy and lab work)
- Pressurised containers (gas cylinders, cartridges and aerosol cans)
- High heavy metal content (batteries, broken thermometers, blood pressure gauges)

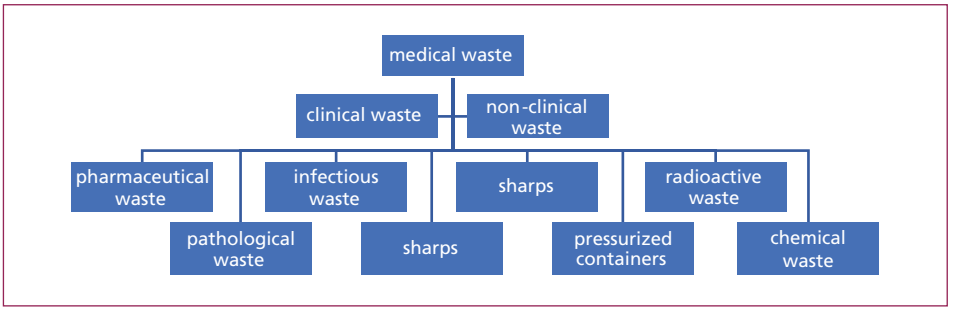

Figure 1: Classification of medical waste

2. Impact of inadequate medical waste management

The inadequate management of medical waste has direct impacts on the community, individuals working in medical facilities and the natural environment. Medical wastes have high degree of potential to infect hospital patients, personnel and the general public. Therefore, it is essential to have safe handling, segregation, storage, destruction and disposal of medical waste to mitigate and minimise environmental pollution, growth and multiplication of vectors which may lead to transmission of diseases like typhoid, cholera, hepatitis and AIDS through direct contact with infected items such as used needles, discarded dressings and human tissues [3]. Other potential dangers of medical wastes include the risk of cancer, burns and skin irritation from radioactive waste or toxic chemicals.

In addition, due consideration should also be given to the impact of medical wastes on the environment, especially its potential to pollute water bodies, soil and air as well as natural habitats in developing countries. In the absence of a sound medical waste management system, the informal recycling community in many low-income countries collects disposable medical items, such as syringes, and resell them leading to outbreak of dangerous diseases [1].

3. Medical waste management in developing countries

Management of medical waste is an integral part of infection control and hygiene programs across healthcare facilities. In recent years, the generation of hospital wastes has increased significantly owing to an increase in population, the number of healthcare facilities and the use of disposable medical products. However, the management of medical waste is still unorganized in most of the developing countries worldwide due to lack of awareness, weak implementation of laws, lacklustre stakeholder participation and lack of financial and technical capabilities. However, medical waste management has been attracting greater attention in recent years due to increase in public awareness.

According to World Health Organization (WHO), around 75 to 90 % of the waste generated in medical facilities can be considered as non-hazardous while the remaining 10 to 25 % consist of infectious, radioactive, toxic or genotoxic items which require special treatment procedures. Safe and scientific management of medical waste has become very important when it comes to environmental conservation and public health [4]. The preliminary step in the management of healthcare waste is its segregation into general waste, infectious waste, sharps waste etc, followed by its treatment and disposal in a scientific manner, according to local waste management regulations of the concerned country.

Worldwide, developing countries are facing enormous challenges in coping with the proper disposal of medical waste with hundreds of tonnes of medical wastes still being dumped openly in waste dumps and natural environments every year. A serious cause of concern is the rampant re-use of disposable syringes and needles in African, Asian

and Central and Eastern European countries. In addition, large-scale scavenging at waste dumps and manual sorting of infectious waste at healthcare establishments is posing a serious risk to public health. Incinerators are the main tool to dispose medical waste in the developing world.

Though WHO and national health organizations of respective countries have issued clear guidelines for the disposal of medical wastes these guidelines are, by and large, not followed. Mixing of medical waste with the municipal waste is a common practice in low-income countries.

3.1. Situation in India

In India, the government passed the Biomedical Waste Management and Handling Rules, 1998, which outlines how hospitals should collect and transport waste, as well as appropriate disposal methods. The Bio-medical Waste Management Rules, 2016 restricts occupier for establishment of on-site or captive bio-medical waste treatment and disposal facility, if a service of common bio-medical waste treatment and disposal facility is available within a distance of 75 kilometres.

Despite this legislation, most of the medical waste in India is dumped in the open and collected with the general waste. The medical waste management situation in India highlights typical problems faced in handling medical wastes in developing countries:

- staff are exposed to potential infections from poor quality equipment used for handling the medical waste (such as repeated use of single-use gloves)
- laboratories do not segregate waste according to the required colour-coded system, but put all types of waste in one bag (including sharp items)
- waste storage areas are not secure (flies, rodents and dogs could access the area).

3.2. Situation in Africa

Most of the African countries lack legislation for medical waste management. For example, Eritrea, Lesotho, and Ghana have no legislation for health care waste management, while Kenya, Nigeria, and Gambia are signatories to the Stockholm Convention with few relevant laws. The lack of sanitary landfills has led to the increased use of crudely designed incinerators. Gambia, Ghana, Lesotho, Nigeria, Senegal, Tanzania have no sanitary landfills while Kenya and Zambia only have crude dumpsites. It is estimated that there are more than 1,000 incinerators in Africa but many of them are inoperative or operating below standards [5].

The biggest risk is posed by the reckless disposal of sharps (needles, scalpel blades, blood vials, glassware, etc) that are in contact with infectious germs. Scavenging of syringes, needles and glassware at waste dumps is a common sight in many Africa nations which is a serious public health issue.

4. Treatment technologies used in developing countries

The predominant medical waste management method in the developing world is either small-scale incineration or landfilling. However, in recent years, alternative and non-thermal technologies like steam sterilization, microwave treatment, dry heat sterilization, alkaline hydrolysis and plasma gasification are also getting good traction.

4.1. Incineration of medical wastes

Incineration is a thermal process that transforms medical wastes into inorganic, incombustible matter thus leading to significant reduction in waste volume and weight. The main purpose of any medical waste incinerator is to eliminate pathogens from waste and reduce the waste to ashes. However, certain types of medical wastes, such as pharmaceutical or chemical wastes, require higher temperatures for complete destruction.

Table 2: Categories of medical wastes and treatment options in developing countries

Waste class and description	Treatment and disposal options
human anatomical wastes, (human tissues, organs, waste body parts)	incineration / deep burial
animal wastes (Wastes consisting of animal tissue, organs, body parts, carcasses, body fluid, blood and blood products, items contaminated with blood and fluids, wastes from surgery treatment and autopsy and wastes of experimental animals used in research, waste generated by veterinary hospitals, colleges, animal houses and livestock farms)	incineration / deep burial
microbiology & biotechnology waste (wastes from laboratory, culture stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biological dishes and devices used for transfer of cultures)	autoclaving / microwaving / incineration
waste sharps (Needles, syringes, scalpels, blades, glass, etc that are capable of causing puncture and cuts. This includes both used and unused sharps)	disinfection using chemical treatment / autoclaving / microwaving and mutilation. shredding and disposal in landfill / recycling (for PVC, plastics and glassware)
discarded medicines (Wastes comprising of outdated, contaminated and discarded medicines)	incineration or destruction and disposal in landfills
soiled wastes (Wastes generated from soiled cotton, dressings, plaster casts, linens, beddings, material contaminated with blood including the packaging materials)	incineration/autoclaving/microwaving
solid wastes (Wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc.)	disinfection by chemical treatment / autoclaving / microwaving and mutilation/shredding
liquid waste (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)	disinfection by chemical treatment and discharge into drains.
incineration ash (ash from incineration of any biomedical waste)	disposal in municipal landfill
chemical waste (Chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.)	chemical treatment and discharge into drains for liquids and secured landfill for solids

Medical waste incinerators typically operate at high temperatures between 900 and 1,200 °C. Developing countries of Asia and Africa usually use low-cost, high-temperature incinerators of simple design for stabilization of healthcare wastes. The most reliable and predominant medical waste incineration technology is pyrolytic incineration, also known as controlled air incineration or double-chamber incineration. The pyrolytic incinerator comprises a pyrolytic chamber and a post-combustion chamber.

Medical waste is thermally decomposed in the pyrolytic chamber through an oxygen-deficient, medium-temperature combustion process (800 to 900 °C), producing solid ashes and gases. The gases produced in the pyrolytic chamber are burned at high temperature (900 to 1,200 °C) by a fuel burner in the post-combustion chamber, using an excess of air to minimize smoke and odours.

Small-scale decentralized incinerators used in hospitals, of capacity 200–1,000 kg/day, are operated on demand in developing countries, such as India. On the other hand, off-site regional facilities have large-scale incinerators of capacity 1–8 tonnes/day, operating continuously and equipped with automatic loading and de-ashing devices. In recent years, mobile incinerators are getting attraction in developing world as such units permit on-site waste treatment in hospitals and clinics, thus avoiding the need to transport infectious waste across the city.

However, the WHO policy paper of 2004 and the Stockholm Convention, has stressed the need to consider the risks associated with the incineration of healthcare waste in the form of particulate matter, heavy metals, acid gases, carbon monoxide, organic compounds, pathogens etc. In addition, leachable organic compounds, like dioxins and heavy metals, are usually present in bottom ash residues. Due to these factors, many industrialized countries are phasing out healthcare waste incinerators and exploring technologies that do not produce any dioxins. Countries like United States, Ireland, Portugal, Canada and Germany have completely shut down or put a moratorium on medical waste incinerators.

4.2. Steam sterilization (or autoclaving)

Steam sterilization (or autoclaving) is a popular alternative medical waste treatment method in low-income countries. Steam sterilization is done in closed chambers where both heat and pressure are applied over a period of time to destroy all microorganisms that may be present in healthcare waste before landfill disposal. Among alternative systems, autoclaving has the lowest capital costs and can be used to process up to 90 % of medical waste and are easily scaled to meet the needs of any medical organization.

Autoclaving is an efficient wet thermal disinfection process whereby pressurized steam at a temperature of around 121 °C heat infectious wastes without causing air emissions that are characterised by incineration-based processes. Moisture in medical waste increases heat transfer which effectively penetrates the waste load, thus reducing the time needed to achieve disinfection.

The growing popularity of autoclaves in the developing world is because of the fact they are less polluting that incinerators and other high-temperature thermal processes. Volatile and semi-volatile organic compounds, cytotoxic waste, mercury, other

hazardous chemical waste, and radioactive waste should not be treated in an autoclave. Segregation of different medical waste streams is essential to prevent emission of alcohols, phenols, formaldehyde, and other organic compounds in the air which may pose health risks to the autoclave operators, waste workers and hospital staff. The treated waste from an autoclave will retain its physical appearance and shredder or compactor may be used to reduce the volume. In fact, shredding infectious waste before it has been autoclaved increases the surface area exposed to the heat and steam and will lead to more complete disinfection.

Advanced autoclaves or advanced steam treatment technologies combine steam treatment with vacuuming, internal mixing or fragmentation, internal shredding, drying, and compaction thus leading to as much as 90 % volume reduction. Advanced steam systems have higher capital costs than standard autoclaves of the same size. However, rigorous waste segregation is important in steam sterilization in order to exclude hazardous materials and chemicals from the waste stream.

It is to be noted that autoclaves require a reliable source of electricity in order to maintain the pressurization and temperatures necessary to properly disinfect infectious waste. Nowadays, hybrid or integrated autoclaving technologies are also being used in developing countries to improve heat transfer to waste, achieve more uniform heating of waste, altering the physical appearance of medical waste, and making autoclaving a continuous process.

4.3. Microwave treatment

Microwave treatment is an emerging technology in which treatment occurs through the introduction of moist heat and steam generated by microwave energy. A typical microwave treatment system consists of a treatment chamber into which microwave energy is directed from a microwave generator. Some microwave systems use temperatures around 97 to 100 °C with long exposure times while in other systems, steam under pressure is used to achieve temperatures as high as 140 °C.

In a microwave treatment unit, a loading device transfers the wastes into a shredder, where it is reduced to small pieces. The waste is then humidified, transferred to the irradiation chamber, which is equipped with a series of microwave generators, and irradiated for about 20 minutes. Most microorganisms are destroyed by the action of microwaves at a frequency of about 2,450 MHz and a wavelength of 12.24 cm. The water contained within the wastes is rapidly heated by the microwaves and the infectious components are destroyed by heat conduction. After irradiation, the waste is compacted inside a container and can be mixed with the municipal waste stream.

The microwave process is widely used in many countries and is becoming increasingly popular. However, relatively high costs coupled with potential operation and maintenance problems has hampered its large-scale deployment in developing countries. Microwave units generally have higher capital costs than autoclaves and can be batch or semi-continuous.

4.4. Plasma gasification

Plasma gasification is a state-of-the-art solution for sustainable management of medical waste in developing countries. A plasma gasifier is an oxygen-starved reactor that is operated at the very high temperatures which results in the breakdown of wastes into hydrogen, carbon monoxide, water etc.

The main product of a plasma gasification plant is energy-rich syngas which can be converted into heat, electricity and liquids fuels. Inorganic components in medical wastes, like metals and glass, get converted into a glassy aggregate.

5. Conclusion

Medical waste management in developing countries, though improving steadily, is still a matter of grave concern. Around 15–25 % of the medical waste stream contains hazardous materials in biological, chemical, radiological or other forms. The cost and complexity of medical waste management has been aggravated by lack of public awareness, weak legislation, indifferent attitude of hospital operators and lack of financing. The segregation of medical waste between hazardous and general waste can significantly reduce dangerous risks associated with medical wastes. The large-scale deployment of alternative waste treatment technologies, such as microwave and steam sterilization will also have a long way in improving medical waste management situation in the developing world.

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