Department of Biosystems and Agricultural Engineering
MICHIGAN STATE UNIVERSITY

Biomedical Waste Management

Lauren Falzarano, Catherine Christenson, Mitchell Wojtowicz, Anna Burgess, Claire Kolar

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Dr. Safferman

Introduction

Biomedical waste refers to anything disposed of that was created during the diagnosing, treating, and immunization of patients. This waste can come from a variety of sources including hospitals, laboratories, blood banks, and veterinary clinics. Although most medical waste is considered nonhazardous as seen in figure 1, there is still a portion that poses a threat to the public and the environment. Infected specimens, bandages, needles, and body fluids are considered hazardous, and there are several regulations that help to ensure these are properly decontaminated; however, the processes are costly, and it is important that institutions are aware of their options in disposal [1]. Strategies used currently are incineration, the use of radiation or microwaves, autoclaving, or chemical methods to neutralize hazards [2].

The purpose of this poster is to investigate the possible effects of the mismanagement of biomedical waste on people and the environment along with effective techniques for proper disposal.

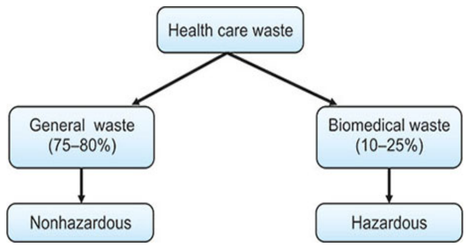

Figure 1: Breakdown of medical waste [1]

Process Description

Medical waste can potentially cause health risks to the public if improperly handled due to the various potentially infectious materials that it contains. Therefore, the life cycle of medical equipment, including medical waste, is observed and must meet the requirements for medical waste management. The processes include:

1. Production
2. Distribution: Packaging and transportation to various healthcare facilities, medical laboratories, or biomedical research facilities
3. Medical use
4. Collection of waste: Collection of waste from common storage and transportation outside of health facility as seen in Figure 2
   - Segregation of hospital waste [4]:
     - General waste
     - Infected plastics
     - Glassware
     - Sharps
5. Treatment of waste:
   - Treatment technology methods [3] :
     - Landfilling
     - Microwave
     - Chemical disinfection
     - Incineration
     - Shredding
     - Compacting
     - Steam sterilization
6. Final disposal depending on type of waste as seen in Figure 3

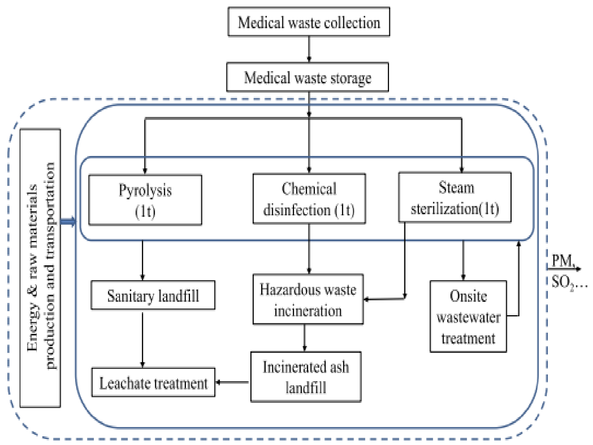

Figure 2: Life cycle analysis of medical waste [3]

Potential Impact on Ecosystem Services

Given the multiple sources of biomedical waste and the varying methods of disposal, there is the increased possibility that some will unwantedly escape as a pollutant into the environment, via air, water, or land. Also, there's the added risk that some of these practices will have negative impacts on the environment themselves.

Biomedical waste can be sorted in two ways each with their own treatment methods:

- Hazardous (infectious) waste is sorted to be incinerated or, more commonly, autoclaved, which is a type of steam cleaning.
- Non-hazardous (non-infectious) waste is typically treated as municipal waste and moved to landfills.

Incineration: Since most medical facilities around the world must come up with their own resources, not all are able to afford pollution control equipment for source exhausts, allowing more pollutants to escape. Incinerators may emit, "suspended solids, metals, acid gases, nitrogen oxides, carbon monoxide and organic compounds."[12] Those of most concern include dioxins, furans, and mercury.[11]

- Dioxins have a half-life of 7-11 years, are highly carcinogenic, and can cause reproductive harm - furans having similar characteristics[11]
- In 2000, the 6,000+ incinerators in the U.S. accounted for 27% of the anthropogenic dioxin emissions.[11]
- "In Canada, infectious medical waste incinerators are estimated to account for 9 percent of annual atmospheric mercury emissions"[11].

Autoclave/Landfill: After the autoclaving process is complete, waste that was hazardous is no longer so. Due to this, it could be compressed moved to a landfill with other municipal waste.

- According to a study of Isfahan hospitals, plastic accounted for 40.28% of infected waste and 17.02% of non-infected waste[12].
  - Plastic takes 100's of years to decompose

Even though autoclaving is no health concern to humans, it sill poses a threat to many ecosystems. Plastics often escape landfills and interfere with certain wildlife.

Sensitive Unit

The most common cause of failure in biomedical waste disposal is a lack of resources, both physical and financial [5]. Regulations and monitoring are normally conducted at the state level instead of at national or global levels, making biomedical waste treatment very different depending on location and resources available [6]. Worldwide, the improper disposal of biomedical waste, specifically because of a lack of resources or awareness, is and has been a huge problem. Simple tasks like properly separating waste like in Figure 3 are often looked over for convenience.

- Only 58% of countries have an adequate system of biomedical waste disposal [7].
- In the 1990s, it was estimated that about 10% of hospital deaths in developing countries were due to the mismanagement of biomedical, or infectious, waste [7].
- According to a 1992 study done in Japan, more than 400 cases of biohazards from cyto-toxic drugs being improperly discarded, along with more than 1,000 cases of infections or intoxications due to medical waste, were reported [7].

Much of this lack of resources is due to financial reasons. The two most commonly used biomedical waste systems in the United States are incineration and autoclaving [8]. These systems, while effective at sterilizing waste from possible biomedical contaminates, are very expensive. A full-sized incinerator system costs anywhere upwards of $41 million, depending on size [9]. Although autoclaving systems are much more reasonably priced, the cost of water alone can be almost $100,000 over 20 years [10]. Especially in countries with limited financial resources, these systems cannot be implemented and used effectively. Without them, however, biomedical waste will continue to impact both environmental and human health.

Figure 3: Segregation of hospital biomedical waste and disposal accordingly [4]

Research

The area of this topic that requires further investigation is determining the quality of current practices and the impact of a lack of financial resources on different facilities. The set up below would provide more insight into whether current practices are enough or if more needs to be done to manage biomedical waste.

Question: Are the current methods of biomedical waste disposal adequate to prevent hazardous waste from entering the environment?

Hypothesis: If facilities have the proper equipment and financial resources, then current methods of disposal are adequate in protecting the environment from hazardous waste.

Protocol:

- Select a variety of facilities that produce biomedical waste: Some that have proper equipment and some that do not. (At lease 10 of each)
- After each place has treated waste using their methods, the waste will be collected and tested to determine how much is still hazardous.
- Hazardous components that remain will be analyzed for their effect on the environment.

Analysis:

- The two sources of waste will be analyzed on how well they neutralize hazards and how harmful the remaining waste is on the environment.
- Results will be compared to determine if access to resources impacts the quality of biomedical waste management and if places with proper resources do enough to limit contaminants.

References

1. Hegde, V., Kulkarni, R. D., & Ajantha, G. S. (2007). Biomedical waste management. Journal of Oral and Maxillofacial Pathology, 11(1), 5. https://www.jomfp.in/article.asp?issn=0973-029X;year=2007;volume=11;issue=1;spage=5;epage=9;aulast=Hegde
2. Mathur, P., Patan, S., & Shobhawat, A. S. (2012). Need of biomedical waste management system in hospitals-An emerging issue-a review. Current World Environment, 7(1), 117. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.402.6967&rep=rep1&type=pdf
3. Hong, Jingmin, et al. (2018). Life-Cycle Environmental and Economic Assessment of Medical Waste Treatment." Journal of Cleaner Production, Elsevier, www.sciencedirect.com/science/article/abs/pii/S0959652617325155?via%3Dihub.
4. Guidelines Implementation Must for Proper Management of Medical Waste. (2020). Aawaaj News - Guidelines Implementation Must for Proper Management of Medical Waste, https://aawaajnews.com/social/medical-waste-management-at-kathmandu-hospitals/
5. Padmanabhan, K.K., Barik, D. (2018). Health hazards of medical waste and its disposal. Energy from Toxic Organic Waste for Heat and Power Generation. 99-118. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7152398/
6. US EPA,OLEM. (2016). Medical Waste | US EPA. US EPA. https://www.epa.gov/rcra/medical-waste
7. Borowy, I. (2020). Medical waste: the dark side of healthcare. História, Ciências, Saúde-Manguinhos. 27(1). 231-251. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-59702020000900231
8. Biomedical Waste Services. (2018). Types of biomedical waste disposal. https://bwaste.com/resources/the-knowledge-center/articles-insights-and-updates/types-biomedical-waste-disposal
9. Waste to Energy International. (2015). Cost of incineration plant. https://wteinternational.com/cost-of-incineration-plant/
10. Consolidated Sterilized Systems. (n.d.). Understanding steam autoclave ownership costs: acquisition cost vs operating costs. https://consteril.com/understanding-steam-autoclave-ownership-costs-acquisition-vs-operating/
11. Brooks, Marianne Su-Ling. "Medical Waste Management – A Review." Journal of Environmental Management, Edited by Elliott Steen Windfeld, vol. 163, 1 Nov. 2015, pp. 98–108., https://www-sciencedirect-com.proxy1.cl.msu.edu/science/article/pii/S0301479715302176
12. Ferdowsi, Ali, et al. "Incineration or Autoclave? A Comparative Study in Isfahan Hospitals Waste Management System (2010)." Materia Socio-Medica, AVICENA, D.o.o., Sarajevo, Mar. 2013, www.ncbi.nlm.nih.gov/pmc/articles/PMC3633376/