



## **MEDICAL SOLID WASTE MANAGEMENT PRACTICES IN SELECTED HOSPITALS IN THE DUTSE LOCAL GOVERNMENT AREA, JIGAWA STATE, NIGERIA**

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**Abstract:** This study assessed the medical solid waste management methods in Dutse General and Sambo hospitals in Dutse, Jigawa State. However, medical solid wastes expose health workers, patients, waste handlers, and the general public to health risks. The method employed use of questionnaire administration, in-depth interviews, and observation as the techniques for data collection to capture medical solid waste management methods in selected hospitals in Dutse including the types of medical solid waste generated in these hospitals, the current medical solid waste management methods, and the effect of medical solid waste among waste handlers, patients, and caregivers in the study area. A total of 94 copies of the questionnaire were used. Purposive sampling was used to select waste handlers. Results on medical solid waste show that sharp/infectious waste is the most common medical solid waste generated in the two study areas. This study aimed to determine the availability of storage containers and separations of sharps/infectious materials, absence of color coding, central storage facilities, and recycling of medical waste in Dutse General Hospital (DGH). In both study areas, incineration, burning, and burying were adopted as waste treatment methods. Waste transportation was mainly performed using carts at SHL and open vehicles at DGH. Medical solid waste disposal methods are primarily by open dumping and burning at both DGH and SHL. Similarly, healthcare/waste workers are at risk of injuries from sharp objects (needles, broken bottles, etc.) as the effect of medical solid waste which has the highest mean value at DGH and is ranked first. At SHL, psychological impacts (stress and anxiety) and allergies are the effects of medical solid waste with the highest mean value and are ranked first. In conclusion, General and Sambo hospitals have been conducting solid waste management practices. It is recommended that better modern techniques should be introduced in the selected hospitals by the management to protect the management, health care workers, and public health from diseases. In addition, the management of the two hospitals should improve their medical solid waste disposal methods. However, further study on the effects of the medical solid waste from the two hospitals on the environment (soil, water, and air) is recommended.

**Keywords:** Management, Practices, Hospitals, Medical Waste, Solid Waste.

## 1. INTRODUCTION

Environmentalists and informed residents in Nigeria voice considerable apprehension regarding insufficient waste management in hospitals and other health care facilities. Hospitals are health care institutions that deliver medical services, whereas health care establishments directly manage public health through patient care. It also guarantees a sanitary and healthful environment for employees and community members. In other words, health care activities protect the environment, cure patients, and save lives. However, during their operations, they generate medical solid waste, 20% of which puts humans at risk of infections, trauma, chemical or radiation exposure, and occasionally even death (WHO, 2018). Radar et al. (2018) described several hospital waste, including sharps, human tissues, body parts, and other disposable but infectious materials referred to as "Medical Solid

Waste." The problem of improving the management of medical solid waste is receiving increasing attention worldwide because health care institutions generate tons of medical solid waste each year.

According to Bhangu et al. (2023), wastes are materials that individuals would wish to get rid of, even if doing so costs money. Waste is a necessary byproduct of human activity, but it is also the outcome of ineffective production methods, the ongoing creation of which depletes key resources. Any material that is rejected by society's material flow pattern is considered solid waste, whereas management is the prudent use of a means to an end. With the increasing urbanization of the world, the possible health risk of improper waste disposal is a serious concern (WHO, 2018). We refer to all wastes created during medical or diagnostic procedures as "medical waste." Between 75% and 90% of hospital waste is equivalent to garbage from homes or businesses and poses no unique risks. Refuse from health care centers can be collected, recycled, and processed in the same way as domestic waste. Particular or hazardous medical waste refers to the remaining 10%–25%. This type of waste raises health concerns (World Health Organization, 2018).

Healthcare institutions of all kinds define medical solid waste as any waste they produce during the diagnosis, treatment, or immunization of humans or animals, as well as related biological research, production, or testing (2020). According to the World Health Organization (WHO, 2020), medical solid waste is any waste produced while providing healthcare services and can include a wide range of items, such as radioactive materials, body parts, soiled dressings, used needles and syringes, diagnostic tests, and medical gadgets.

The production of harmful sulfide and methane gases via open-air storage, the formation of heavy metals in landfill leachate through leaching (You et al., 2020), and the release of carcinogenic polychlorinated biphenyls and dioxins during incineration (Minoglu et al. 2020) are all associated with the inappropriate disposal of medical solid wastes (Emenike et al. 2017).

Medical solid waste management (MSWM) in developing countries has become an issue of global significance (Sanjeev et al., 2020). With the outbreak of the COVID-19 pandemic, we have learned how fragile medical and solid waste management chains are and how this could lead to an increasing environmental pollution scenario (You et al. 2020). Sanjeev et al. (2020) noted a surge in the creation of medical solid waste from positive cases. Nigeria and other developing countries focus on two interconnected but crucial issues: waste management and sanitation (Singh et al., 2022). Medical solid wastes are hazardous because they contain radioactive materials, dangerous chemicals, and pathogenic microbiological elements (Khan et al. 2019). They may also change microbial ecology, resulting in resistance to antibiotics. (Onu et al., 2023).

Unfortunately, practical information about the implications of inadequate management of medical solid wastes is lacking. Coker et al. (as cited in Isyaku, 2015) reported a near-total absence of institutional arrangements for medical solid wastes in Nigeria.

Population growth in the Dutse Local Government Area has led to a rising demand for medical services. Consequently, this surge is increasing the generation of medical solid waste, raising the potential for environmental and human harm. Therefore, it is crucial to assess the medical and solid waste management practices in hospitals located within the Dutse Local Government Area, Jigawa State.

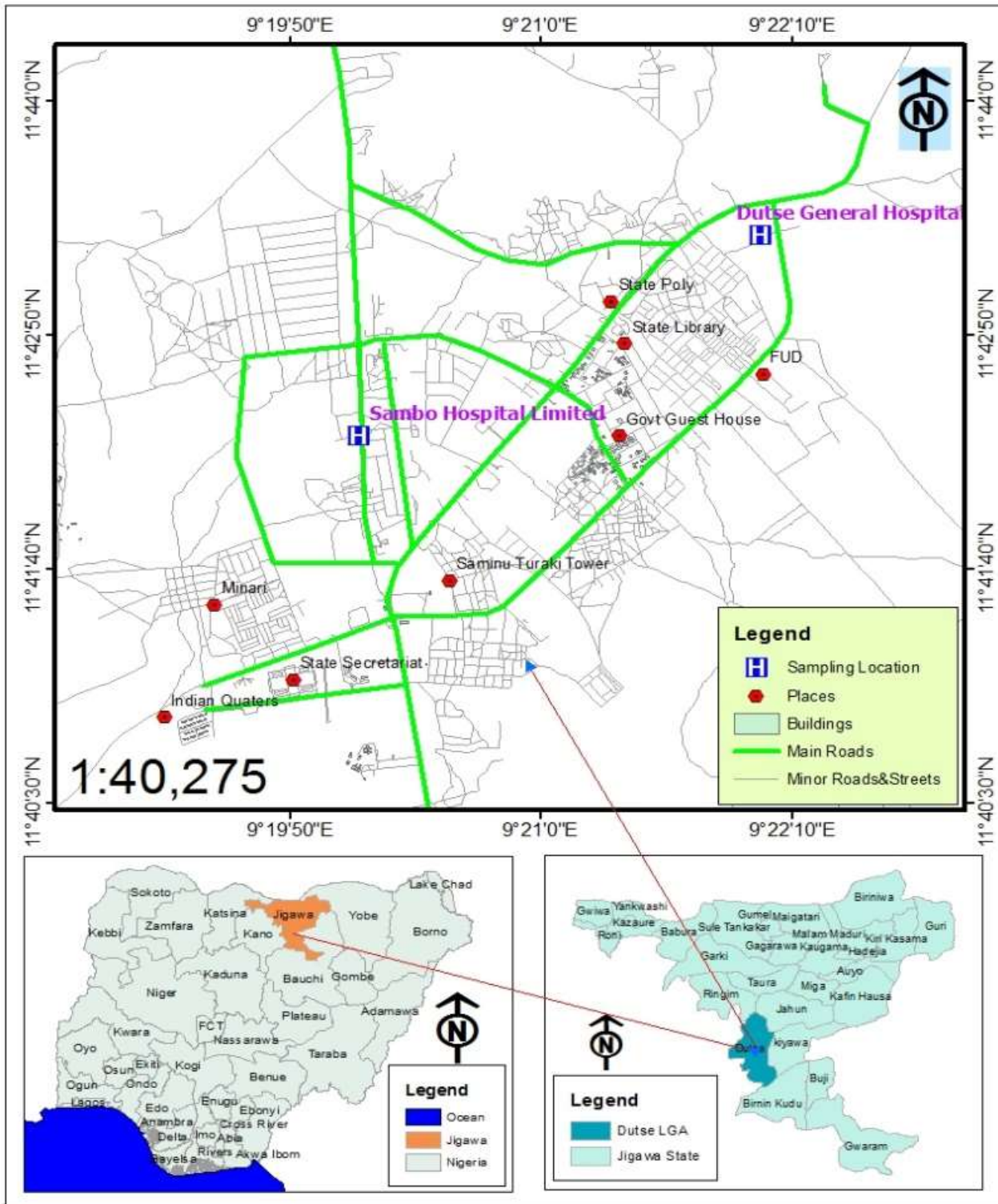
## **MATERIALS AND METHODS**

### ***Study Area***

The study area is Dutse, the capital city of Jigawa State, Nigeria. The map indicates that the study area is situated between 11°43'20"N and 11°43'28"N and 9°18'40"E and 9°23'20"E (Figure 3.1). It covers an area of approximately 420 square miles (1,089-kilometre square (Kura et al., 2023). This area is primarily urban, with several key landmarks and facilities, including Dutse General Hospital, a major healthcare facility in the region, Sambo Hospital Limited, another healthcare center providing medical services, and Saminu Tower, a notable landmark in the area. State Library, Federal University Dutse, and a State Secretariat, which is an administrative building. The study area is well-connected by main roads and minor roads/streets, making it accessible for transportation and waste management activities (Kura et al., 2023).

The dump sites are within the same general area, as shown in the second map. The dump site coordinates are approximately 9°21'44"E to 9°22'8"E and 11°43'20"N to 11°43'28"N. The dump sites are relatively close to the study area, likely within a 1-2 km radius, based on the map scale (1:51,245). It is accessible via minor roads connect it to the main roads leading to the study area. The proximity of the dump sites to the study area raises concerns about potential environmental and health impacts, especially if waste management practices are inadequate.

The study area includes Dutse General DGH and Sambo Hospital SHL, which are critical public health facilities. Improper waste management in the area could pose risks to these facilities, such as infection spread or contamination of medical supplies. Improper waste disposal could affect the Indian Quarters and other residential zones near the study area, leading to health risks such as respiratory issues, water contamination, and vector-borne diseases. The proximity of the dump site to the study area raises concerns about air pollution (from burning waste), water contamination (if waste leaches into groundwater or nearby water bodies), and soil degradation. The presence of minor roads near the dump site that waste transportation might pass through populated areas, increasing the risk of littering and environmental pollution. The proximity of the dump site to health care facilities, residential areas, and educational institutions underscores the importance of addressing waste management challenges to protect public health and the environment.



**Figure 1: Map of Dutse**

Source: Extracted from the Administrative Map of Jigawa State.

## 2. METHOD OF DATA COLLECTION

### ***1. Reconnaissance survey***

A reconnaissance survey was conducted to familiarize the researcher with the study area. The researcher also used this avenue to establish a good relationship with the hospital's staff, cleaners, and sanitary workers and solicit their support for the research.

### ***2. Research design***

This study employed a descriptive survey design, which is a type of non-experimental research design aimed at systematically collecting and analyzing data to describe a specific population's characteristics, behaviors, or attitudes. This study focused on assessing medical solid waste management practices in selected hospitals in Dutse, Jigawa State, Nigeria. The descriptive survey design was an appropriate choice for this study, as it allowed the researcher to systematically collect and analyze data on medical solid waste management practices in the selected hospitals (Creswell, 2014). By combining quantitative and qualitative methods, this study provided a detailed and nuanced understanding of the types of waste generated, current management practices, and their effects on patients, waste handlers, and caregivers. This design laid the foundation for actionable recommendations to improve hospital waste management practices.

### ***3. Instrument used for data collection***

#### ***a. Questionnaire***

A questionnaire is a research tool made up of a set of questions intended to elicit information from respondents (McLeod, 2018). The questionnaire used in this study was adopted from Isyaku (2015), a previous study on medical solid waste management. However, the study was modified to align with the specific objectives of this research and the unique context of the selected health care facilities. Some questions were adjusted to reflect the current waste management practices in the study area.

#### ***b. In-depth interview***

In-depth interviewing is a qualitative research method that entails conducting detailed individual interviews with a limited number of participants to gain insights into their views on a specific concept, program, or situation (Boyce, 2016). The interview participants were five (5) patients and five caregivers (5) to the two hospitals to ensure a balance between obtaining a broad range of perspectives and managing the depth of each interview. A total of 10 participants were interviewed.

### ***4. Sample size and sampling technique used***

The objective of this study is to assess the methods of managing medical solid waste in Dutse. A public general hospital and a private commercial hospital were considered for a comprehensive understanding. Dutse General Hospital and Sambo Hospital Limited were used.

Purposive sampling was used in this study. Sometimes referred to as judgmental, selective, or subjective sampling, it depends on the researcher's judgment in choosing the study units (individuals, cases/organizations, events, or data points) (Pandey et al. 2021).

Data for the study were analyzed using Statistical Package for the Social Sciences version 22.0. The analysis was conducted according to the following objectives.

## **3. RESULTS AND DISCUSSIONS**

### **1 Demographic characteristic of the respondents at Dutse General Hospital and Sambo Hospitals Limited.**

This section presents the demographic and socioeconomic characteristics of the respondents in the two selected hospitals. Table 1 presents the demographic characteristics of the respondents based on gender, age, marital

status, educational status, and years of experience in waste handling. The majority (71.25% and 64.29%) of the respondents were males, while the least (28.75% and 35.71%) were females at both DGH and SHL, respectively. This implies that more men are employed in the two hospitals than their female counterparts. This could mean that no gender equality or balance exists in the employment of waste managers in the two hospitals. If there is a gender imbalance among the employed waste managers, it could be attributed to the tedious nature of the work or its hazardous nature. Hospital waste handling roles often involve physical labor and exposure to various hazards, such as biohazardous materials and chemicals. Historically, societal perceptions of strength and suitability for manual labor have led males to predominantly occupy these roles.

**Table 1 Demographic characteristics of the respondents**

Hospitals	Use General Hospital	Percentage %	Sambo Hospital, Ltd.	Percentage%
Gender	Frequency	Percentage %	Frequency	Percentage%
Male	57	71.25	9	64.29
Female	23	28.75	5	35.71
<b>Total</b>	<b>80</b>	<b>100.00</b>	<b>14</b>	<b>100.00</b>
<b>Age</b>				
20-30	11	13.75	4	28.57
31-40	48	60.0	7	50.0
41-50	18	22.50	3	21.43
51 and above	3	3.75	0	0.00
<b>Total</b>	<b>80</b>	<b>100.00</b>	<b>14</b>	<b>100.00</b>

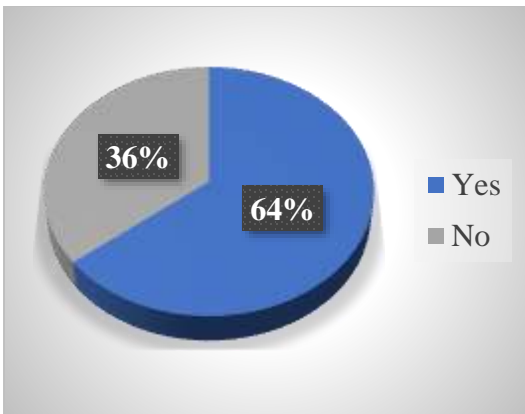
Source: Field survey conducted in 2024

## 2. Medical Solid Waste Management Method

This section presents findings on the knowledge, attitude, and current practices of MSWM in the selected hospitals. The questionnaire was administered to the waste workers to examine the involvement, knowledge, and current practices of medical solid waste management, including the availability of storage containers, color coding, separation, and central waste storage facility.

### *Waste handlers are involved in the handling of medical waste*

Figure 2 shows how the waste handlers are involved in handling medical waste. Many studies have proved that in some hospitals, waste handlers are not fully involved in the handling of waste. However, in the case of Dutse General Hospital and Sambo Hospital Ltd, the majority (64%) of the respondents ticked Yes, implying or agreeing that they are fully involved in waste handling. This provided the basis for further analysis of the study objectives.



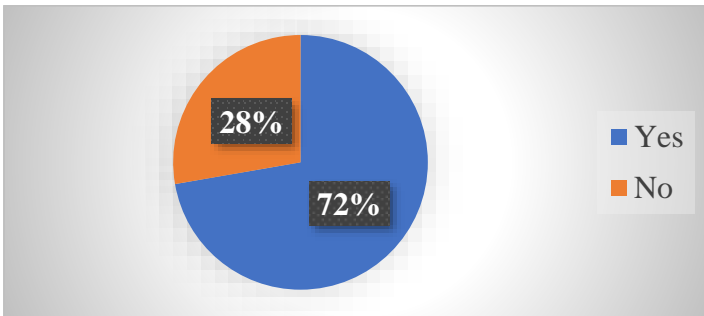
**Figure 2 Involvement in waste handling**

Source: Field Survey (2024)

***Knowledge of medical solid waste management***

There is also the issue of knowledge of medical solid waste management, which is presented in Figure 2. Because of the occupation that involves medical solid waste, there is a need for waste handlers to know about medical waste management, which would make them carry out management practices effectively. The sources of this knowledge could be experience about waste handling, seminars, and training. The majority (72%) of the respondents ticked Yes, indicating that they know about waste management. Only 28% ticked “No,” implying that

They do not know medical waste, which is insignificant compared with the majority’s opinion.

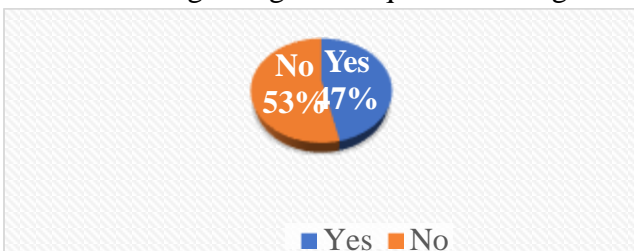


**Figure 3 Knowledge of medical waste management**

Source: Field Survey (2024)

***Self-acquired training and knowledge***

Self-acquired training and knowledge were important to this study, in which the respondents provided information regarding self-acquired training and knowledge. This is presented in Figure 4.



**Figure 4 Self-Acquired Training and Knowledge**

Source: Field Survey (2024)

The majority (53%) ticked No, meaning that acquired knowledge and training regarding handling waste is not self against the least (47%) that ticked Yes. Waste handling is a sensitive aspect of medical waste that requires training by hospital management to avoid mishandling of medical waste. Therefore, the majority has a valid opinion regarding self-acquired training and knowledge of medical waste management.

***Availability of storage containers, color coding, separation, and central waste storage facility at both the DGH and the SHL***

Table 2 shows the availability of storage containers, container coding, waste separation, and central storage facility. All the respondents in both DGH and SHL 80 and 14, representing 100%, attested that the health care facilities have waste storage containers in different units/departments. This implies that there is a high level of compliance with the provision of containers in the healthcare facility, which prevents the indiscriminate dumping of medical solid wastes in wards and clinics.

Observations around the facilities also confirmed this, as every facility visited has one form of container or the other for waste collection, and this falls within the acceptable standards recommended by the WHO (2018). Some health care facilities in Nigeria also use inappropriate containers, such as plastic bags, paper bags, or cardboard, to collect medical waste (Coker, 2009). This statement was also the same in the study area, where plastic bags, paper bags, and nylon were used to collect medical solid waste.

The table also shows that all the respondents representing 100% reported that the containers have color coding at SHL and DGH, respectively, indicating that there were no color coding practices for receptacles in their hospitals for medical waste management as the majority of the respondents (78.75%) reported that no such practice is done in their healthcare facility. The report shows a low level of compliance with color-coding practices at the DGH.

This is confirmed by Olubukola's (2009) findings in Lagos that healthcare waste management practices are marred with poor color-coding practices and a lack of instructive posters on waste segregation and disposal of general wastes in Nigerian public hospitals. According to Ndidi et al. (2009) and Abah and Ohimain (2011), the segregation of waste in marked color-coded receptacles would result in a clean medical waste stream that could be easily, safely, and cost-effectively managed through recycling, composting, and landfilling.

**Table 2 Storage container availability, color coding, separation, and central waste storage facility**

Hospital	YES		NO	
	Frequency	Percentage %	Frequency	Percentage %
DGH	80	100.00	0	0.0
SHL	14	100.0	0	0
<b>Color coding</b>				
DGH	17	21.25	63	78.75
SHL	14	100.0	0	0
<b>Waste separation</b>				
DGH	73	91.25	7	8.75
SHL	14	100.0	0	0
<b>Central waste storage</b>				
DGH	0	0.00	80	100.0
SHL	14	100.0	0	0.00

**Source: Field survey conducted in 2024**

The table further revealed that 91.25% and 100% of the respondents from DGH and SHL, respectively, indicated that there were separations of waste for sharps or infectious materials in their hospitals. This study reveals that the facility has a high regard/compliance for the segregation of sharps/infectious waste. Coker et al. (2009) reported that there was no proper segregation in the Ibadan healthcare facilities in Nigeria. The study team had to implement waste sorting and segregation at the source by providing coded separate receptacles for each identified medical waste component. Improperly disposed of hazardous HCW (such as syringes and needles in the absence of sterilization) can cause Hepatitis B, C, and HIV infections (WHO, 2002) and pose indirect risks to humans through direct environmental effects by contaminating soil and groundwater (Abah and Ohimain, 2011).

From the observations around the facility, containers of varying sizes existed, and it was observed that anatomical waste, such as human body parts, organs, aborted fetuses, placenta, and tissues, was prevalent in the facility surveyed, but the separation was not done using the right color-coded containers/receptacles. The facility also engaged in the source separation of sharp objects, including needles, scalpels, and operating blades that are segregated in the health care facility. Sharp/injection boxes are used in various wards, clinics, and laboratories.

Table 2 further shows that 100% of the respondents reported that there is a central waste storage facility at SHL, while 100% of the respondents reported that there was no central waste storage facility at DGH, where all gathered wastes from all the units/departments are stored before transportation to the final destination for disposal. This implies that the DGH lacks a good waste collection strategy to tackle the medical waste menace. This could be because it is government-owned, and most government health care facilities face the challenges of inadequate infrastructural facilities. In addition, for research, the DGH may see the need to put all hands-on desks toward their medical solid waste management. Coker et al. (2009) reported insecure and inadequate central storage facilities in Nigeria. Most hospitals in Nigeria had no special place for the storage of medical waste (Coker et al., 2009). Algo and Kocasoy (2008) also reported the unsecured location of storage depots at the Ibn-Nafis Hospital in Istanbul, Turkey. It has limited access; it is easily accessible to personnel responsible for waste handling.

***Treatment of Medical Solid Wastes at Dutse General Hospital and Sambo Hospital Limited***

Table 3 presents the waste treatment methods adopted at both DGH and SHL before disposal. This reveals that the autoclaving of waste is not done at health care facilities. Autoclaving is a pretreatment practice used to treat samples from highly infectious patients before disposal. Treatment of medical waste using autoclaving at DGH and SHL is absent because none of the respondents (0.0%) reported the existence of autoclaving in their health care facilities. This implies that this practice is very poor or absent in the facility, exposing the laboratory staff and other waste handlers to a high risk of contact with highly infectious wastes. Isyaku (2015) also reported that autoclaving is still in its infancy in Zaria.

The table also shows that 85.0% of the DGH and 100% of the SHL respondents reported that the practice of incinerating waste exists in the hospitals, whereas 15.0% of the DGH and 0.0% of the SHL respondents reported that it is absent. This result shows that incineration as a practice is present at both DGH and SHL due to the high response from the respondents. As a result, incineration prevents the waste handlers and medical staff from exposure to infections through contact with hazardous waste.

Healthcare waste incineration was found to be a common practice in the surveyed healthcare facilities. Most of the incineration technologies in healthcare facilities were found to be in obsolete condition and operated in a rudimentary fashion or were simply nonfunctional. Incinerators are poorly designed and often have operational problems (Coker et al., 2009).

**Table 3 Method of Waste Treatment at both DGH and SHL**

Hospitals Treatment Method	DGH				SHL			
	YES Frequency	%	No Frequency	%	YES Frequency	%	NO Frequency	%
Autoclaving	0	0.00	80	100.0	0	0.00	14	100.0
Incinerating hazardous waste	68	85.0	12	15.0	14	100.0	0	0.00
Burying	72	90.0	8	10.0	0	0.00	14	100.0
Use of chemical disinfectants	0	0.00	80	100.0	9	64.28	5	34.71

**Source: Field survey conducted in 2024**

***Transportation of Medical Solid Wastes for Disposal at Dutse General Hospital and Sambo Hospital Limited***

Table 4 presents the waste transportation method for final disposal. Ogbonna et al. (2010), Ogbonna (2011), Oke (2008), and Olubukola (2009) argued that the method of transporting waste of all kinds to the final destination is an integral part of achieving proper and sustainable waste management. The authors specifically pointed out the effect of hazardous waste if it is not transported using proper methods. The effect could be on both the surroundings and healthcare workers, especially waste handlers, who are at the highest risk of occupational injuries.

Table 4 shows that the use of open vehicles is the most dominant and common method of transporting medical waste at DGH to its final destination for disposal, with 54 representing (67.50%) of the respondents. Only occasionally (25.0%) did the respondents report that carts are used to transport medical solid waste for disposal at DGH.

This implies that the hospital is at risk of environmental pollution and occupational health risks due to the poor transportation of medical solid waste. This finding is in agreement with that of Isyaku (2015), who reported that 80% of all waste in Nigeria is transported using carts and other open means due to inadequate waste transportation facilities in Nigerian healthcare centers. The author attributed this to a corrupt government system at all levels and in most Nigerian government establishments.

**Table 4: Method of transporting medical solid waste for disposal at both DGH and SHL**

HOSPITALS Transportation method	DGH		SHL	
	Frequency	Percentage %	Frequency	Percentage %
Open Vehicles	54	67.50	3	21.43
Trucks	6	7.50	0	0.00
Carts	20	25.00	11	78.57
Trolleys	0	0.00	0	0.00

Enclosed compaction	0	0.00	0	0.00
<b>Total</b>	<b>80</b>	<b>100.00</b>	<b>14</b>	<b>100.00</b>

**Source: Field survey conducted in 2024**

The table further shows that the use of carts (78.57%) is the most dominant and common method of transporting medical solid waste at SHL to its final destination for disposal. Only a few respondents (21.43 %) reported that open vehicles are also used to transport medical solid waste for disposal at the SHL. This implies that the hospital is not at risk of environmental pollution due to poor transportation of medical solid waste. This finding is in agreement with that of Saidu (2018), who reported that 70% of medical solid waste in Nigeria is transported using open vehicles and carts but not the recommended enclosed compaction vehicle.

***Method of Medical Solid Waste Disposal at Dutse General Hospital and Sambo Hospital Limited***

The method of medical waste disposal is presented in Table 5. It was reported that the method employed by DGH for medical solid waste disposal shows that according to (73.75%) of the respondents was open dumpsite, burning (22.5), and burying (3.75). Burning (78.57) and open dumping (21.43) are the final waste destinations at SHL.

**Table 5: Method of Medical Solid Waste Disposal at both DGH and SHL**

Hospitals Method of waste disposal	DGH		SHL	
	Frequency	Percentage %	Frequency	Percentage %
Open dumping	59	73.75	3	21.43
Landfill	0	0.00	0	0.00
Shredding	0	0.00	0	0.00
Burying	3	3.75	0	0.00
Burning	18	22.5	11	78.57
<b>Total</b>	<b>80</b>	<b>100.0</b>	<b>14</b>	<b>100.0</b>

**Source: Field survey conducted in 2024**

This implies that open dumping and burning are the most common waste disposal practices at DGH, while burning and open dumping are the most adopted methods at SHL. The results highlight the complexity and diversity of opinions regarding waste disposal methods. These findings are consistent with those of Isyaku (2015), who affirmed that open dumping and burial are the most common methods of medical waste disposal at ABUTH and ABUHS. Oke (2008) also confirmed that most healthcare establishments in Nigeria use open disposal as the final disposal method. This result also supports the findings of Ogbonna (2011), who reported that open dumping and burning are the most common waste disposal practices in Nigeria, regardless of whether the waste is hazardous or not.

An in-depth interview with a patient was conducted on the methods of waste transport and disposal. The discussant said,

*P1, 2, 5,9,10 “What I see mostly done to remove waste is burning.” This is related to medical waste that can be burned. Other waste, such as broken bottles and syringes, I don’t know what they will do with them. However, I believe they have a method of removing such solid medical waste”*

Similarly, a caregiver commented on the same issue regarding the method of medical solid waste transportation and disposal. He said,

P3, 4, 8: "When the incinerator is filled up, I see trucks moving the waste away. I think they have places where they dump the waste or bury it." I have no in-depth knowledge of this.

#### 4. Conclusion

According to the study, the most common type of trash generated at DGH is sharp/infectious waste, whereas at SHL. There were efforts to separate infectious materials or sharps and the presence of storage containers, and serious flaws were found, such as a lack of color coding, centralized storage facilities, and recycling programs. This observation underscores the urgent need to improve waste segregation and waste management practices in health care settings to reduce health risks.

The primary disposal methods used by DGH and SHL for waste treatment were incineration, burying, and landfilling, with open dumping and burning being the most common. This emphasizes a reliance on simple and sometimes dangerous waste management techniques, which could seriously endanger both the environment and human health. The study highlights the need for urgently updated, safer waste treatment and disposal techniques in health care settings.

This study found that medical solid waste poses serious health risks, especially to trash handlers and health care personnel. Sharp object injuries were the most frequent health risk at the DGH, but psychological effects (stress and anxiety) and allergies (with the highest mean value of 4.33) were more common at the SHL. These findings highlight the risks to occupational health of healthcare workers and support better safety procedures and preventative measures to protect their health and welfare.

#### REFERENCES

- Abah, S. O., & Ohimain, E. I. (2010). Dumpsite rehabilitation potential assessment using the integrated risk based Approach: A case study of Enugu, Nigeria *World Appl Sci J*, 8(4), 436-442.
- Abah, S. O., and E. I. Ohimain. 2011. Health care Waste Management in Nigeria: A Case Study of Ibadan Teaching Hospital. *Journal of Public Health and Epidemiology*, 3(3), 99-110. <https://doi.org/10.1016/j.jphe.2013.09.010>.
- Abdisalam, H. (2018). Medical waste disposal methods in Hargeisa Public Hospital, Somaliland *International Journal of Social Science and Humanities Research*, vol. 6, no. 4, pp. 1144-1167. Retrieved from [www.researchpublish.com](http://www.researchpublish.com) Assessed on 18 July 2024
- Abubakar, I. R., Maniruzzaman, K. M., Dano, U. L., AlShihri, F. S., AlShammari, M. S., Ahmed, S. M. S., & Alrawaf, T. I. (2022). Impacts of solid waste management practices on environmental sustainability in the global South *International Journal of Environmental Research and Public Health*, 19 (19), 12717. doi:10.1016/j.ijep.2007.07.017.
- Adegbite, M. A., Nwafor, S. O., Afon, A., Abegunde, A. A., & Bamise, C. T. (2010). Assessment of dental waste Management in a tertiary hospital in Nigeria *Waste Management and Research*, 28, 769-777.
- Adeoye, A. O., Akande, E. A., & Lateef, A. (2018). Impacts of hospital waste management on health and Environment of the Ogbomoso area, Oyo state, Japan. *Hospital and Palliative Medicine International Journal* 2(6), 386-389.

- AGENDA for Environment and Responsible Development. (2009). *Needs assessment of hospitals in Africa countries regarding infectious waste treatment: Final report-Demonstrating and promoting best techniques and Practices for reducing health care waste to avoid dioxin and mercury environmental releases*. Dar es Salaam, Tanzania.
- Ahsan, A., Alamgir, M., El-Sergany, M. M., Shams, S., & Rowshon, M. K. (2014). Assessment of the municipal solid Waste management system in developing countries. *Chinese Journal of Engineering*, 1, 1-11.
- A. Al-Khatib, C. Sato, M. S. Ali-Shtayeh (2009). Solid Healthcare Waste Management: Status of Healthcare Centers in the West Bank Palestinian Territory *Journal of Waste Management*, Vol. 29, pp. 2398-2403.
- Al-Khatib, I. A., Ali-Shtayeh, M. S., & Al Qaroot, Y. S. (2005). Management of health care waste in circumstances of limited resources: A case study of public health centers in Iran *Waste Management and Research*, 27(4), 305-312.
- Aseweh Abor, P. and Bouwer, A. (2008). Medical waste management practices in a hospital in Southern Africa *International Journal of Health Care Quality Assurance*, 21(4), 356-364. <https://doi.org/10.1108/09526860810880153> July, 2024
- Azuike, E. C., Adinma, E. D., Nwabueze, S. A., Zrike, E. D., and V. A. Mbanuzuru. 2015. Health care waste management: What do the health workers in a Nigerian tertiary hospital know and practice? *Sci J Public Health*, 3, 114-118.
- Bako, S. M., & Ali, A. F. (2022). Assessment of Compliance with medical waste management practices in selected hospitals in the urban Bauchi, Nigeria. *Use Journal of Pure and Applied Sciences*, 8, 166-173.
- Babanyara, Y. (2013). *An assessment of medical Waste management practice(s) at ABUTH, Zaria, Nigeria* (unpublished M.Sc. thesis). Abubakar Tafawa Balewa University, Bauchi, Nigeria.
- Change, S., Provost, F., & Caduff, C. (2023). Introduction to qualitative research methods One. *Perspectives in Clinical Research*, 14(1), 39-42.
- Bassey, E. B., Benka-Coker, M. O., & Aluyi, H. S. A. (2006). Characterization and Management of solid medical wastes in Abuja, Nigeria, the Federal Capital Territory. *African Health Sciences*, 6(1), 58–63.
- Boyce, C. (2016). *Conducting in-depth interviews: A guide for designing and conducting Depth interviews for evaluation input*.
- Brinkhoff, T. (2017). Ogawa (State, Nigeria): Population statistics, chart, and map *National Population Commission of Nigeria (web)*, *National Bureau of Statistics (web)*. Retrieved from <https://www.citypopulation.de.php> (Accessed on March 14, 2023).
- Brady, E., & Prior, J. (2020). Esthetics: A synthetic review *People and Nature*, 2(2), 254-266.

- Borowy, I. (2020). Medical waste: The dark side of health care. *História, Ciências, Saúde –Manguinhos*, 27, 231-251.
- Coker, A. O., & Sridhar, M. K. C. (2010). Increase in health care facilities and rapid environmental degradation: A technological paradox in urban centers in Nigeria *African Journal of Environmental Science and Technology*, vol. 4, no. 9, pp. 577-585.
- Coker A, Sangodoyin A, Sridhar M, Booth C. and Olomolaiye, P. (2009). Medical Waste Management in Ibadan, Nigeria: Obstacles and Prospects *Journal of Waste Management and Environmental Research*, 29, 804-811.
- Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods* (4th ed.). SAGE Publications.
- R. R. A. Data (2020). Medical waste management market size, share, demand, analysis, by waste type (sharps), by treatment site (on-site), by treatment type (chemical), by service type (recycling), by nature of waste (hazardous and non-hazardous), by waste generator (hospitals), and segment forecasts to 2027. *Reports and Data*. 2023. <https://www.reportsanddata.com/report-detail/medical-waste-management-market>
- B. Dida, J. Gomez, R. Conroy, M. Seid, Michaels, J. (2002). San Francisco safe needle disposal program from 1991 to 2001. *Journal of the American Pharmaceutical Association*, 42, 62-77.
- Devi, A., Ravindra, K., Kaur, M., Kumar, R. (2019). Evaluation of the biomedical waste Management practices in public and private healthcare facilities in India. *Environmental Science and Pollution Research*, 26, 26082-26089.
- European Union (EU). (2008). Guideline on Interpreting the key provisions of directive 2008/98/EC on waste. *European Commission*. <http://ec.europa.eu/environment/waste/framework> (Assessed on August 18, 2024).
- Emenike, P. C.; Tenebe, T. I.; Omeje, M.; Osinubi, D. S. (2017). Health risk assessment of heavy metal variability in water sachets sold in Ado-Odo Ota, South-Western Nigeria *Environmental Monitoring and Assessment* 189: 480.
- El-Amaireh, N. A. A., Al-Zoubi, H., & Al Khashman, O. A. (2023). Hospital waste incinerator ash: Characteristics, treatment techniques, and applications *Journal of Water and Health*, 21(11), 1686-1702.
- Ezeudu, O. B., Ezeudu, T. S., and Ugochukwu, U. C., Tenebe, I. T., Ajogu, A. P., Nwadi, U. V., & Ajaero, C. C. (2022). Health care Waste Management in Nigeria: A Review *Recycling*, vol. 7, no. 6, 87.
- Fadaei, A. (2023). Comparison of the medical waste Management methods in different countries: A systematic review *Review of Environmental Health*, 38(2), 339-348.

- Franklin-Wallis, O. (2023). *Wasteland: The dirty Truth about what we throw away, where it goes, and why it matters*. Simon and Schuster.
- Fernando, R. L. S. (2019). Solid waste Management of local governments in the Western Province of Sri Lanka: An implementation analysis *Waste Management*, 84, 194-203.
- Ferraz, A. and Afonso, S. A. V. (2003). Incineration of different types of medical wastes: Gaseous emissions emission factors *Atmospheric Environment*, vol. 37, pp. 5415-5422.
- Garba, Y. I., Gano, U. T., Yusuuf, M. S., & Musa, D. M. (2018). Assessment of Physicochemical and microbiological quality of borehole water in Dutse Metropolitan Jigawa State, Nigeria. *Science World Journal*, 13 (3), 1-5.
- S. Gupta, R. Boojh, A. Mishra, and H. Chandra (2009). Rules and management of biomedical waste at Vivekananda Polyclinic: A case study *Waste Management*, vol. 29, pp. 812–819.
- M. Gauthier, L. Simard, W. Jean-Philippe, (2011). Public Participation in Strategic Environmental assessment (SEA): A critical review and the Quebec (Canada) approach *Environmental Impact Assessment Review*, 31, 48-60.
- HCWH. (2020). Health care waste management and sustainable development goals. *Health care without harm*. (Accessed on July 09, 2023). <https://noharm-global.org/issues/global/health-care-waste-management-and-sustainable-development-goals> Accessed February 11, 2024.
- Hale, B., Light, A., & Lawhon, L. A. (Eds.). (2023). *The Routledge companion to Environmental ethics*. Routledge.
- Angulo, L. and Akintola, O. (2017). Health care Waste management in community-based care: Experiences of community health workers in low-resource communities in South Africa. *BMC Health Res.* 2017; 17:436-448.
- Hassan M, Ahmed S, Rahman K, Biswas T. (2018). Pattern of medical waste Management: Existing scenario in Dhaka City, Bangladesh. *BMC Public Health*, 8, 36. <https://doi.org/10.1016/j.bmcph.2012.09.010>.
- Hey, C. (2019). *Municipal capillary biosolids barrier covers for reactive mine tailings* [Doctoral dissertation, Carleton University].
- R. Hollal, B. Darshan, N. Sorake, Unnikrishnan, B., & Thapar, R. (2015). Knowledge and practices regarding biomedical waste management among health care professionals in tertiary care hospitals in Mangalore, India. *International Journal of Environmental Resource and Waste Management*, 2, 656-659.
- Hossain, M. S., Rahman, N. N., Balakrishnan, V., V. R. Puvanesuaran, M. Z. Sarker, et al. (2013). Infectious risk assessment of unsafe handling practices and clinical solid waste management *International Journal of Environmental Research and Public Health*, 10, 556-567.

- Isyaku, F. 2015. *Assessment of the medical waste management practices in Ahmadu Bello University Teaching Hospital and Ahmadu Bello University Health Services, Zaria, Nigeria*. Department of Geography, Ahmadu Bello University
- Jahan, S. (2005). Epidemiology of the needle stick injuries among health care workers Secondary care hospital in Saudi Arabia. *Annals of Saudi Medicine* 25: 233-238.
- Jang, Y. C., Lee, C., Yoon, O. S., & Kim, H. (2006). Medical waste management in Korea *Journal of Environmental Management, Vol. 80, pp. 107-115*.
- Johannahessen, L., Dijkman, M., Bartone, C., Hanrahan, D., Boyer, M. G., & Chandra, C. (2000). *Health care waste management guidance note: Health nutrition and population*. World Bank.
- Klangsin, P., & Harding, A. K. (1998). Medical Waste treatment and disposal methods used by hospitals in Oregon, Washington, and Idaho. *Journal of the Air and Waste Management Association, 48(6)*, 516-526.
- Khan, B. A.; Cheng, L.; Khan, A. A.; Ahmed, H. (2019). Health care waste management in developing Asian countries: A mini-review *Waste Management and Research, 37(9)*, 863-875.
- Krejcie, R. V., & Morgan, D. V. (1970). Determining the sample size for research activities. *Educational and Psychological Measurement, 30*, 607-610.
- Kura, N. U.; Usman, S. U.; Khalil, M. S. (2023). Assessment of flood vulnerability in a semi-arid region: A case study of Dutse in Jigawa State, Nigeria *Journal of Environmental Issues and Climate Change, Vol. 2, No. 1, pp. 20-29*.
- Kuo, H., Shu, S., & Wu, C. (1999). Characteristics of medical waste in Taiwan. *Water, Air, and Soil Pollution, 114*, 413-425.
- Longe, E. O., & Williams, A. (2006). A Preliminary study of medical waste management in the Lagos metropolis, Nigeria *Iranian Journal of Environmental Health Science & Engineering, 3(2)*, 133-139.
- Mansur, A., & Muhammad, M. U. (2016). Use change in a developing urban area of the Dutse metropolis, Jigawa State, Nigeria. *Annals of Agricultural and Environmental Sciences, 1(1)*, p....
- A. Mesdaghinia, K. Naddafi, A. H. Mahri, Saeedi, R. (2009). Waste management in Primary health care centers in Iran. *Waste Management Reviews, 27*, 354–361. <https://doi.org/10.1016/j.wasman.2009.04.003><https://doi.org/10.1016/j.wasman.2009.04.003>
- Mokuolu, O. A., & Timothy, R. S. (2009). Circular economy and waste management actions during the COVID-19 pandemic in Nigeria *Journal of Human Environment and Health Promotion, 7(1)*, 1–5 (2005).

- Mmerekhi, D., Baldwin, A., Li, B., & Liu, M. (2017). Health care Waste Management in Botswana: Storage, Collection, Treatment, and Disposal System *Journal of Material Cycles and Waste Management*, 19,351–365. <https://doi.org/10.1007/s10163-015-0429-0> (Accessed on February 11, 2024).
- Minoglou M, Gerassimidou S, Komilis D. (2017). Health care waste generation Worldwide and its dependence on socio-economic and environmental factors. *Sustainability*, 9(2), 220.<https://doi.org/10.3390/su9020220> (Accessed on February 11, 2024).
- Mmerekhi, D., Baldwin, A., Li, B., Liu, M., 2017. Health care waste management in the Botswana: storage, collection, treatment, and disposal system. *Journal of Material Cycles and Waste Management*, 19,351–365. <https://doi.org/10.1007/s10163-015-0429-0> (Accessed on June 28, 2024).
- Martin, M., Williams, I. D. and Clark, M. (2006). Sociocultural and structural influences on household waste recycling: A case study *Journal of Resources, Conservation and Recycling*, 48, 357–373. <https://doi.org/10.1016/j.resconrec.2005.09.010> (Accessed on February 11, 2024).
- McLeod, S. (2018). Questionnaire: Definition, Examples, design, and types. *Simply Psychology*, 78, 350–365.
- National Bureau of Statistics. (2022). Population estimates for Nigeria: 2022 report. <https://nigerianstat.gov.ng> (Accessed February 2024).
- Nigeria Basic Health Care Provision Fund (BHPPF) Project. (2018). Health care waste management plan (HCWMP) draft report prepared in compliance with the World Bank environmental assessment requirements on projects for World Bank financing. 12-64.
- Nuebling, M., & Hofmann, F. (2001). Profile and risk of occupational hepatitis: An infection in sewerage workers. *International Archives of Occupational and Environmental Health*, 74,589–593. <https://doi.org/10.1007/s004200100229>
- A. Nema, A. Pathak, P. Bajaj, H. Sigh, Kumar, S. (2011). Case study: Biomedical waste Management at a city hospital in Himachal Pradesh. *Sage Publications*, 29, 669–673.
- N. Ngwuluka, N. A. Ochekepe, P. O. Odumoso, and S. A. John (2009). Waste management in healthcare establishments within Jos, Nigeria *African Journal of Environmental Science and Technology*, 3(12), 459–465.
- Nkhuwa, D. C. W.; Kafula, T.; Ahmed, A. H. (2008). Preliminary inventory of hazardous medical waste disposal systems and their influence on Lusaka’s groundwater quality *Medical Journal of Zambia*, 35(4), 129–138.
- Nemathaga, F., Maringa, S., & Chimuka, L. (2008). Hospital Solid Waste Management Practices in Limpopo Province, South Africa: A Case Study of Two Hospitals *Waste Management Journal*, 28, 1236–1245. <https://doi.org/10.1016/j.wasman.2007.09.019>

- Niemiec K, Fitrzyk A, Grabowik C. (2021). Manufacturing methods and innovations in steel aerosol production *International Journal of Modern Manufacturing Technologies (IJMMT)*, Vol. 13
- Olukanni, D. O., Lazarus, J. D., & Fagbenle, E. (2022). Health care Waste Management Practices in Nigeria: A review In *Health Care Waste Management and COVID-19 Pandemic: Policy, Implementation Status and Vaccine Management*, pp. 197–218, Springer.
- Onu, M. A., Ayeleru, O. O., Oboirien, B. Olubambi, P. A. (2023). Challenges in wastewater generation and management in sub-Saharan Africa: A review *Environmental Challenges*, 11, 100686. <https://doi.org/10.1016/j.envc.2023.100686> (Accessed January 28, 2024)
- Oke, I. A. (2008). Immunization management Solid wastes in Kano, Nigeria. *Waste Management Journal*, 28, 2512–2521. <https://doi.org/10.1016/j.wasman.2008.01.014>
- Olubukola, B. O. (2009). Comparative analysis of health care waste management practices in two general hospitals in Nigeria. Available at: <http://www.ecoweb.com/edi/index.htm>. (Accessed January 28, 2024).
- Ogbonna, D. N., Amangabara, G. T., and Ekere, T. O. (2011). Urban solid waste generation in the Port Harcourt metropolis and its implications for waste management *International Journal of Environmental Quality Management*, 18(1), 71-88.
- Ogbonna, D. N. (2011). Characteristics and medical waste management practices in health care institutions in Port Harcourt, Nigeria *Journal of Soil Science and Environmental Management*, 2, 132-141.
- Ogbonna, D. N.; Chindah, A.; Ubani, N. (2012). Waste management options for health care wastes in Nigeria: A case study of hospitals in Port Harcourt *Journal of Public Health and Epidemiology*, 4, 156-169.
- Ogbonna, D. N., & Udotong, I. R. (2021). An Appraisal of the waste crisis, urban floods, and municipal solid waste management in Port Harcourt City, Nigeria. *Open Access Journal of Waste Management & Xenobiotics*, 4, 000156.
- R. Oweis, M. Al-Widijan, and O. Al-Limon (2005). Medical Waste Management in Jordan: A Study of the King Hussein Medical Center. *Waste Management*, 25, 622-625.
- Patil, G. V., & Prakesh, K. (2005). Solid waste management in an Indian hospital: A case study *Waste Management*, 25(6), 592-599.
- Pandey, P. and Pandey, M. M. (2021). Methodology tools and techniques. Bridge Center.
- A. Pachauri, P. Shah, B. C. Almroth, Sevilla, N. P., & Narasimhan, M. (2019). *Safe and sustainable waste management of self-care products* BMJ, 365. <https://doi.org/10.1136/bmj.1129> (Accessed January 28, 2024).

- J. Peng, X. Wu, R. Wang, C. Li, Q. Zhang, Wei, D. (2020). Medical waste management Practice during the 2019–2020 novel coronavirus pandemic: Experience in a general hospital American Journal of Infection Control, 48(8), 918–921. <https://doi.org/10.1016/j.ajic.2020.05.035> (Accessed January 28, 2024).
- Prüss-Ustün, A., Giroult, E., & Rushbrook, P. (1999). Safe waste management from health care activities WHO.
- Quadar, J., Bhat, A. H., & Gurdekar, D. K. (2018). Quantitative characterization of the biomedical Waste generated from some health care units in Rewa City. *International Journal of Engineering Science Invention*, vol. 7, no. 9, pp. 85-87.
- A. Rajora, M. Xaxaa, R. Mehta, R. Kunala, (2012). An overview of characterization, Utilization and leachate analysis of biomedical waste incinerator ash. *Journal of Environmental Management*, Vol. 108, pp. 36-41.
- Rao, P. H. (2008). Hospital Waste Management awareness and practices: A study of the three states In India. *Waste Management and Research*, 26, 297-303.
- Rocheteau, M. (2023). *Medical waste management for more resilient humanitarian organizations* (Master's thesis). Banken School of Economics.
- Rushbrook, P. H., Chandra, C., & Gayton, S. (1999). *Healthcare waste management in medical institutions: A practical approach* WHO Healthcare Practical Information Series No. 1.
- Saad, S. A. (2013). Hospital management Solid waste in the state of Khartoum. *Environmental Monitoring and Assessment*, 185(10), 8567-8582.
- Sa'idu, H. D. (2018). *Assessment of medical Waste management practices in Ahmadu Bello University Health Services, Zaria, Nigeria*. Department of Geography, Ahmadu Bello University
- R. Sanjeev, S. Kuruvilla, R. Subramaniam, Prashant, P., & Gopalakrishnan, M. (2018). Knowledge, attitude, and practices about biomedical waste management among dental health care personnel in dental colleges in Kothamangalam: A cross-sectional study *Health Sciences*, 1, 1-12.
- Sawalem, M., Selic, E., & Herbell, J.-D. (2009). Hospital Waste Management in Libya: A Case Study *Waste Management*, vol. 29, no. 4, pp. 1370-1375.
- Kavita, K. L., & Joseph, T. J. (2018). Of Hospital Waste Management in Kerala: An Analysis Based on Hospital Ownership
- Singh, A., Singh, A., & Maurya, N. K. (2019). Healthcare waste management *International Journal of Scientific Research Review*, 16 (6), 1060.

- Singh, N., Ogunseitan, O. A., & Tang, Y. (2022). Medical waste: Current challenges and future opportunities for sustainable management *Critical Reviews in Environmental Science and Technology*, 52(11), 2000-2022.
- Singh, N., Tang, Y., & Ogunseitan, O. A. (2020a). Environmentally sustainable management of used PPE *Environmental Science & Technology*, 54(14), 8500-8502. DOI: 10.1021/acs.est.0c03022. Accessed August 28, 2024.
- N. Singh, Y. Tang, Z. Zhang, and C. Zheng (2020b). COVID-19 waste management: Effective and successful measures in Wuhan, China. *Resources, Conservation, and Recycling*, 163, 105071. <https://doi.org/10.1016/j.resconrec.2020.105071> (Accessed August 28, 2024).
- Smith, A., & Lee, B. (2022). Effects of medical Waste management practices on patient health outcomes. *Journal of Health care Environment Management*, 45(2), 120-135.
- Soliman, S. M., & Ahmed, A. I. (2007). Biomedical waste management in selected governorates in Egypt: A pilot study *Waste Management*, 27, 1920-1923.
- Sridhar, M. K. C., & Coker, A. O. (2009). Treatment of disposable health care wastes in *Health care Management: A Handbook for Developing Countries* (pp. 91-117). University Press, Ibadan.
- Stephen, (2011). School of Spatial Distribution Mapping and analysis of the solid waste disposal sites in Minna. *Geographic Information System, Environmental Technology and Science Journal*, 1(1), 86-91.
- Sushma R, Naganandini S, Nagabhu S, & Shana, D. (2013). The global scenario of hospital waste management *International Journal of Environmental Biology*, 3(3), 143-146.
- Sweta, P., & Anil, K. (2016). Infections through hospital waste: A review. *Journal of Of Public Health and Epidemiology*, 3(3), 99-110.
- Silva, C. E., Hoppe, A. E., Ravanello, M. M, & Mello, N. (2005). Medical waste management in southern Brazil *Waste Management*, 25, pp. 600-605.
- Owned, B., & Vallini, I. (2008). Waste management: The global paradox *Waste Management and Research*, 26, 215-216.
- Toyobo, A. E., Baba, A. O., & Oyeniya, A. B. (2012). Appraisal of University Teaching Hospital Medical Waste Management in Nigeria: Case Studies of University College Hospital (UCH) Ibadan and Obafemi Awolowo University Teaching Hospital (OAUTH) Ile-Ife *Universal Journal of Education and General Studies*, 1(9), 290-297.
- Tsai, W. T. (2021). Analysis of the medical waste Management and impact of COVID-19 its generation in Taiwan. *Waste Management and Research*, 39(1\_suppl), 27-33.

- Sofia, E. A., & Nriagu, J. (2013). Healthcare Waste in Africa: A silent crisis? *Global Health Perspectives*, 1(1), 3-10.
- United Nations Development Program (2009). *Needs assessment of infectious waste treatment in hospitals in African countries: Final report*
- United Nations Statistical Division (2001). *Environmental statistics glossary* Series No. 67. Available at <http://unstats.un.org/unsd/environmental/> Accessed August 28, 2024.
- United Nations Environment Program (UNEP) (UNEP)/SBC and the WHO (2005). Preparation of National Health care Waste Management Plans in Sub-Saharan countries Guidance Manual. Geneva, Switzerland: WHO document production services.
- Wirojanagud, W. (2020). Environmental Legislation: Asia. In *managing human and social systems* (pp. 321-344). CRC Press.
- Williams, M., Gower, R., Green, J., Whitebread, E., Lenkiewicz, Z., & Schroder, P. (2019). *No time to waste: Tackling the plastic pollution crisis before it is too late.*
- World Health Organization. (1994). *Managing medical waste in developing countries: Report of a consultation on medical wastes management in developing countries, Geneva, 1994.* Available at [http://whqlibdoc.who.int/hq/1994/WHO\\_PEPRUD\\_94.1.pdf](http://whqlibdoc.who.int/hq/1994/WHO_PEPRUD_94.1.pdf) (Accessed August 28, 2024).
- World Health Organization. (1999). *Safe waste management from health care activities.* In A. Prüss, E. Giroult, and P. Rushbrook (Eds.). Geneva, WHO. Available at [http://www.who.int/watersanitation\\_health/Environmental\\_sanit/MHC\\_WHhandbook.htm](http://www.who.int/watersanitation_health/Environmental_sanit/MHC_WHhandbook.htm) (Accessed August 19, 2024).
- World Health Organization. (2002). *Waste from health care activities.* Fact Sheet No. 231. Available at <http://www.who.int/mediacentre/factsheets/fs231/en/> (Accessed August 19, 2024).
- World Health Organization. (2004). *Assessment of small-scale incinerators for health care waste* In S. Batterman, R. Stringer, and E. Giroult (Eds.). Geneva, WHO. Available at <http://whqlibdoc.who.int/hq/2004/a85187.pdf> (Accessed August 19, 2024).
- World Health Organization. (2014). *Safe waste management from health care Activities (2nd ed.)*. Chartier, Y., Emmanuel, J., Pieper, U., Prüss, A., Rushbrook, P., Stringer, R., Townend, W., Wilburn, S., & Zghondi, R. (Eds.). (Accessed August 18, 2024). [http://www.who.int/water\\_sanitation\\_health/healthcare\\_waste/en/](http://www.who.int/water_sanitation_health/healthcare_waste/en/)
- World Health Organization. (2015). *Water, sanitation, and hygiene in health care facilities: Status in low- and middle-income countries and the way forward for the future.* World Health Organization. Accessed August 18, 2024. <http://who.int/news-room/fact-sheets-/detail/health-care-waste>

- World Health Organization. (2018). *Fact sheet on health care waste management*. Available at <http://who.int/news-room/fact-sheets-/detail/health-care-waste> (Accessed on August 18, 2024).
- World Health Organization and UNICEF (2015). *Water sanitation and hygiene (WASH) in healthcare facilities: Global plan*. Available at: [http://www.who.int/water-sanitation health/facilities/healthcare/wash-in-hcf-global-action-plan-2016-03-16.pdf](http://www.who.int/water-sanitation_health/facilities/healthcare/wash-in-hcf-global-action-plan-2016-03-16.pdf) (Accessed on August 18, 2024).
- WHO. (2020). *Application of the treatment and disposal methods for health care waste categories*. Available at [https://www.who.int/water\\_sanitation\\_health/medicalwaste/113to129.pdf?ua=1](https://www.who.int/water_sanitation_health/medicalwaste/113to129.pdf?ua=1) (Accessed on August 18, 2024).
- You S, Sonne, C., & Ok, Y. S. (2020). COVID Nineteen's unsustainable waste management. *Science*, 368. <https://doi.org/10.1126/science.abc7778> (Accessed on February 11, 2024).