ANALYSIS OF MEDICAL WASTE MANAGEMENT PRACTICES IN PRIMARY HEALTHCARE CENTERS IN ZARIA LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

BY

KAUTHAR MIKA'IL ABUBAKAR
P16PSGS8070/ P18PSGS8697

(MSC. ENVIRONMENTAL MANAGEMENT)

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT,
FACULTY OF PHYSICAL SCIENCES,
AHAMADU BELLO UNIVERSITY,
ZARIA

MAY, 2022

DECLARATION

I hereby declare that this dissertation was written by me and it is a true record of my research work. It has not been presented in any previous application for a higher degree. All the sources of information are duly acknowledged by means of references. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution.

Kauthar ABUBAKAR Mikail

. ...

Signature Date

CERTIFICATION

This dissertation titled **ANALYSIS OF MEDICAL WASTE MANAGEMENT PRACTICES IN PRIMARY HEALTHCARE CENTERS IN ZARIA LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA** by KAUTHAR ABUBAKAR MIKAIL meets the regulations governing the award of the degree of MSc in Environmental Management of the Ahmadu Bello University Zaria and is approved for its contribution to knowledge.

.....	……..	.....……..
Dr. Shehu Abbas	Signature	Date
Chairman, Supervisory committee		

.....	.....	……..
Prof. Binta Abdulkarim	Signature	Date
Member, Supervisory committee		

.....	.....	…….
Dr. Shehu Abbas	Signature	Date
Head of Department		

DEDICATION

I dedicate this work to Almighty Allah, for making this research work a reality and strengthening me all the way. I dedicate this dissertation to my beloved parents, I say thank you for your support, care and love. I also dedicate this dissertation to my husband and kids for their patience, encouragement, endurance and perseverance. May Allah reward you abundantly Ameen.

ACKNOWLEDGEMENT

My sincere gratitude goes to Almighty Allah for His mercy, protection and guidance in the course of my academic journey. I would like to express my sincere gratitude and appreciation to my supervisors Dr. S. Abbas and Prof. Binta Abdulkarim for their excellent advice, guidance, support, encouragement and contribution in improving the quality of this research. To the entire academic staff and non-academic staff of Geography and Environmental Management department, I thank you all for your support. To my parents, I say a big thank you for your love care and support. To my husband (Shitu Muhammad Sani) I also say thank you for your love, patience, encouragement and endurance. I want to thank my friends and well-wishers, who in one way or the other contributed in making this research a success, the likes of Shamsuddeen Mohammed Giwa, Fauziyya Shehu Dahiru, Na'ima Usman Hauwa'u S. Bala, Mansur Alharans Ismail Abubakar and others.

TABLE OF CONTENTS **Page**

Declaration……...i

Certification…….....ii

Dedication……iii

Acknowledgements……..iv

Abstract…….v

Table of contents……..vii

CHAPTER ONE: Introduction……….. 2

1.1 Background to the Study……2

1.2 Statement of the Research Problem……...……6

1.3 Aim and Objectives……8

1.4 Hypothesis……..9

1.5 Scope of the Study……...……..9

1.6 Significance of the Study……..……9

CHAPTER TWO: Conceptual Issues and Literature Review…….…...11

2.1 Conceptual Issues……11

2.1.1 Concept of wastes…….11

2.1.2 Concept of medical waste…….12

2.1.3. Sources of medical waste…….13

2.1.4. Types of medical waste……13

2.1.5 Classification of Health Care Wastes……..…….……16

2.1.6 Potential risks associated with medical waste……..……17

2.1.7 Risks associated with waste disposal……..….18

2.1.8 Micro-organisms associated with medical waste……19

2.1.9 Disposal methods……20

2.1.10 Global perspectives of the hazardous medical waste management……..22

2.1.11 Proper management of medical waste……..23

2.1.12 Benefits of proper medical waste management……26

2.2 Literature Review……..26

2.2.1 Types of Medical Waste Generated……27

2.2.2 Amount of Medical Waste Generated…….28

2.2.3 Methods of collection and disposal of waste Generated…….31

2.2.4 Challenges of Medical Waste Management……33

CHAPTER THREE: Study Area and Methodology ……34

3.1 Study Area……34

3.1.1 Location…….34

3.1.2 Climate and Vegetation…….34

3.1.3 Soil…….35

3.1.4 People and Population……36

3.1.5 Healthcare Facilities……38

3.2. Methodology……..40

3.2.1 Reconnaissance survey……..40

3.2.2 Types of data…….40

3.2.3 Sources of data……..40

3.2.4 Sampling size and sampling technique…….41

3.2.5. Methods of data analysis……42

CHAPTER FOUR: Results and Discussion……..……..44

4.1 The Types of Medical Waste Generated…….……..…44

4.2 Quantity of Medical Waste Generated at the Primary Healthcare Centers…….….47

4.3 Comparison in the Amount of waste generated by the PHCs…….…….49

4.4 Method of Medical Waste Collection and Disposal…….....…..50

4.4.1 Methods of Waste Disposal…….……...……...…55

4.4.1.1 Existence of Incineration Practice……..55

4.4.1.2 Burying of Medical Waste in the PHCs…….……56

4.4.1.3 Chemical Disinfection Practice…….…….57

4.4.1.4 Method of Waste Transportation within the PHCs…….…….58

4.5 Challenges faced by the PHCs…….……..59

CHAPTERFIVE: Summary of findings, Conclusion and Recommendations.…….....62

5.1 Summary of Major Findings……..…….……...62

5.2 Conclusion…….……63

5.3: Recommendations…….…….64

REFERENCES…….…….67

APPENDIX …….…….…….…….77

LIST OF TABLES **Page**

Table 2.1: UNEP/WHO Classification of Healthcare Waste…….17

Table 3.1: Distribution of Primary Healthcare Facilities……41

Table 4.1: Types of Medical Waste Generated by the PHCs…….…….45

Table 4.2: Quantity of Medical Waste Generated by the PHCs……..47

Table 4.3: ANOVA Results of the Differences in Medical Waste Generation……..49

Table 4.4: Availability of Colour Coding for Medical Waste Collection……51

Table 4.5: Burying Method Practiced by the PHCs…….56

Table 4.6: Challenges Faced by the PHCs……..59

LIST OF FIGURES **Page**

Figure 4.1: Availability of Receptacles/Storage Containers……50

Figure 4.2: Distribution on Segregation of Sharps or Infectious Material……...…52

Figure 4.3: Waste Collection Personnel in the PHCs……..53

Figure 4.4: Waste Dumping Outside the PHCs……54

Figure 4.5: Incineration Practice by the PHCs…….55

Figure 4.6: Chemical Disinfection Practice in the PHCs……..57

Figure 4.7: Transportation of Waste within the PHCs…….58

Figure4.8: Location of Primary Healthcare Centers……..61

ABSTRACT

Healthcare services are aimed at improving a healthy environment and wellbeing and preventing potential human health risks and environmental hazards. In the course of doing this wastes generated could really be harmful. Lack of proper management of these medical wastes exposes the health workers, patients, waste handlers and the general public to health risks. Thus, this study focused on the assessment of medical wastes management practices at Zaria Local Government Area of Kaduna State. A set of questionnaire was administered to all the waste handlers in the PHC amounting to a total of 44 copies. The common types of medical waste as collected include; food debris, sharps, dressing swaps, body fluids. Group A (Non- Risk Medical Waste) were found to be the most common across the PHCs. The group A consists of waste material such as packaging; food debris etc and they were prevalent as a result of activities of patients, visitors and also the health care workers. Furthermore, intravenous set needles and broken vials were classified as B2, Swabs, body fluids and bandages (C1), spilt medicine and disinfectant (B3), Packaging, food scraps and papers A1 all of these were found in inpatient wards. Similarly, medical waste material found in outpatient wards were categorize as waste paper, food debris (A1), Hand gloves and swabs. For outpatient wards (C1), hand gloves and swabs including needles and syringes (B2) all of which are non risk medical waste. That of labor ward is as follows; needles, scalpel and blades (B2) and can be classified as risk medical waste. In the laboratory sharps and needles (B2) are common waste found and are risk medical wastes. Then in pharmacy unit, most commonly found medical waste are packing, papers and empty containers (A1) which can be classified as non risk medical wastes. Waste generated in all the PHCs was categorized according to the UNEP/WHO classification. The results show that among the PHCs, Gyallesu PHC had the highest recorded waste generation of 399.8kg/week. With

regards to the difference in amount of wastes among the PHCs, statistical test of ANOVA indicated the difference in amount of waste among the PHCs at $p \leq 0.05$ significant levels. Therefore, the amount of waste generated among the PHCs is statistically significant. Similarly, on waste collection, the finding also revealed that Anguwan Fatika, Anguwan Alkali and Babban Dodo had the highest (100%) who confirmed that they have available storage equipment. With regards to color coding of waste collection, the study showed that Kake, T/wada, Panmadina, Durumin mai Garke, Babban Dodo and Tukur-Tukur (10.5%) had the highest respondents confirming the availability of colour coding in their PHCs respectively. In addition to the findings of this study, majority (68%) of the respondents confirmed segregating sharp or infectious waste in the PHCs is being practiced in their PHCs. On the issue of waste disposal, the study revealed that, Dambo and Tukur-Tukur had the highest number of respondents (9.0%) that confirmed dumping of waste outside their PHCs. Again, the highest number (59%) of the PHCs practice incineration method of waste disposal while respondents (13.7%) confirmed that burying of medical waste is being practiced in the PHC. Tukur-Tukur had the highest number (80%) that carry out chemical disinfection of waste as a practice. In the same vein, respondents at Kake, Dambo, Anguwan Fatika, and Durumin mai Garke confirmed that transportation of medical waste is commonly done by wheel barrow. All the PHCs were facing challenges of medical waste management and the highest challenges faced in the following PHCs; Panmadina, Anguwan Liman and Tukur-Tukur were the problem of no equipment for collection and disposal of wastes which accounted for (33.3%) respectively. It was recommended that management of the PHCs should endeavor to provide adequate medical waste facilities as well as training of waste handlers in order to achieve optimum results. It is advisable to bury infectious waste. This

however, means that PHCs that exposed their waste are posing threat to the environment and the public so the PHCs should desist from doing that.

CHAPTER ONE

1.1 Background to the Study

Waste management has continually generated global concern. Cities spend increasing resources to improve the waste management practice. Waste management continues to be a rising challenge as population grows along with the industrial development of countries. The existing methods of waste treatment include; landfills gasification, ocean dumping, incineration and recycling. There has always been the need for man to dispose-off the waste generated in the course of his daily activities, and medical waste is part of the total waste streams generated in the built environment. Wastes are being disposed indiscriminately in our surroundings, on the streets and in the drains from houses. While industries discharge wastes without pre-treatment are disposed into streams and farmlands and this affects the natural environment. Hospitals and other health-care facilities are not left out of this obnoxious act Coker *et al*., (1998).

According to Uwa (2008) waste management is the proper disposal of garbage that is generated by the various industries, human settlements, institutions and other places where activities of production and consumption of products and services take place. Furthermore, Uwa (2008) categorized wastes as solids, liquids, and abattoir, domestic, industrial, agricultural, commercial, radioactive, hazardous, and medical wastes. Although, medical waste represents a relatively small portion of the total waste generated in a community, medical waste management is considered an important issue worldwide because of the danger that is associated with it.

Cheng *et al*.(2009).

Medical Waste is defined as the waste generated from health-care establishments, such as hospitals, primary healthcare centers, private clinics, research facilities, laboratories used in diagnosis, monitoring, and prevention activities (Massrouje, 2001; Silva *et al.,* 2002)**.** Medical waste is a public health issue that attracts attention all over the world (Miyazaki *et al.*, 2005**)**. According to World Health Organization (WHO,2006) Primary Health Care is a whole of societal approach to health that aims at ensuring the highest possible level of health and well being and their equitable distribution by focusing on people's needs and as early as possible along the continuum from health promotion and disease prevention to treatment and rehabilitation. In some developing countries, most hazardous and toxic wastes are placed on landfills with few safeguards to protect nearby inhabitants and water sources from contamination (Bartlett.*et a.,l* 2001). The World Health Organization (WHO) estimates that each year there are 8-16 million cases of hepatitis B Virus, 2.3-4.7 million cases of hepatitis C Virus and 80,000-160,000 cases of HIV due to unsafe injections and mostly due to very poor medical waste management system (WHO, 1999; Townend and Cheeseman, 2005). Unregulated clinical waste treatment and disposal has been linked to several public health threats. In addition, hazardous waste includes sharp, infectious waste, pharmaceutical waste, pathological and genotoxic waste, pressurized containers and high and radioactive waste as well, which has the potential to pose a variety of environmental and health risks. Healthcare activities generate a lot of waste, especially from the frequently used consumables, which are harmful for in-patients and healthy population (WHO, 2014).The waste products that are generated by healthcare activities have higher potential to spread infection and injuries than municipal wastes. Inadequate or incorrect handling of medical waste may cause serious public health issues such as HIV, tuberculosis, hepatitis, and other bacterial diseases and also have irreversible impact on the environment (WHO, 2014).

Effective medical waste management is crucial for environment and health protection. According to Remy (2001) waste generated in the process of health care consists of variety of materials including hypodermic needles, scalpels, blades, surgical cottons, gloves, bandages, clothes, discarded medicine and body fluids, human tissues and organs, chemicals and others. These are the most environmentally sensitive health-care by products that need greater attention and should be monitored. Various strategies were adopted by national and international bodies on the development and implementation on education and training programs for medical staff and patients emphasizing on proper medical waste management. Several studies have been conducted on Medical waste management.

Improper healthcare waste management have resulted to human health problems and environmental pollution, unpleasant odours, and growth of insects, rodents, and worms; which may lead to transmission of various diseases like cholera, typhoid and hepatitis through injuries from sharp objects contaminated with human blood (Yong *et al*., 2009). In recent decades, the management of the healthcare waste is an evolving issue due to the lack of proper resources like training, awareness, and finance to support solutions (Abdulla *et al.,* 2008).

Furthermore, the public concern has been stirred with regard to whole systems such as generation, in-house storage, transportation, treatment, and disposal of the healthcare waste including infectious and toxic materials (Birpınar *et al.,* 2009). Appropriate management systems for handling and safe disposal of healthcare wastes are of great importance, in order to minimize the risk to both public health and the environment.

Solberg (2009) reported that 240 people in Indian State of Gujarat contacted hepatitis B after receiving medical care with previously used syringes acquired through the illegal trade of clinical wastes. The improper disposal of medical wastes constitutes a problem in most

developing countries. There have been numerous instances where medical wastes have been dumped in residential areas. The illegal dumping of medical wastes in residential areas has resulted in situations where children have been found playing with medical waste materials such as syringes. Waste from medical facilities poses serious risk to healthcare workers, patients and the local communities (Singh & Prakash, 2007).

Medical waste has equally received very little attention in Nigeria in contrast to the management of other types of solid waste, as medical waste management was in a deplorable state with less or no provision for health-care waste disposal (Coker *et al*., 1998). Unfortunately, practical information on this important aspect of healthcare management is inadequate and research on the public health implications of inadequate management of healthcare wastes are few and limited in scope. According to Mahmood *et al.,* (2003) it is believed that several hundreds of tones of healthcare waste are deposited openly in waste dumps and surrounding environments, often alongside with nonhazardous solid waste, this problem has no geographical boundary; it has cut across all the states and Local Governments in Nigeria.

It is ironic that the healthcare delivery system, which is established to provide treatment and safeguard the health of the people against illnesses, becomes a source of infection and means of spreading diseases in the process of healthcare delivery. Healthcare institutions/facilities generate different types of infectious and/or hazardous medical waste that poses enormous risk to patients, healthcare providers, waste pickers, and the community at large, if their disposal is not comprehensively and scientifically managed (Rao, 2008; & Babanyara, 2012). It is well known, that hospitals, clinics, nursing homes, laboratories, veterinary clinics and many more establishments have to dispose of waste materials that have been generated in the process of medical care and treatment. Medical wastes (MW) constitute a larger portion of infectious

wastes, which are potentially dangerous, because they may be resistant to treatment and possess high ability to cause disease (Manyele, 2015). Medical waste is also a source of contamination of land and water sources if not rendered harmless before its burial on land or disposal in water. Furthermore, medical waste emits harmful gases, which leads to atmospheric pollution, when treated in open burning or burning in incinerators. These emissions can cause respiratory and skin diseases or even cancer, if precautionary protocols are ignored (Edmund, 2012).

Over the decade, the growth of the medical sector around the world combined with an increase in the use of disposable medical products has contributed to the large amount of medical waste generated (Edmund, 2012). As such, poor medical waste management causes environmental pollution, unpleasant smell, growth and multiplication of insects, rodents and worms, and may lead to transmission of diseases like typhoid, cholera, and hepatitis through injuries from sharps contaminated with blood (Coker & Sridhar, 2010, Yitayel *et al.,* 2012). In developing countries such as Nigeria, where health concern are competing with limited resources medical wastes have not received sufficient attention and the priority it deserves (Abah & Ohimain, 2011,Ibijoke *et al.,* 2013). Hazardous and medical wastes are still handled and disposed- off together with domestic wastes, thus creating a great health risk to municipal workers, the public, and the environment (Silva *et al.,* 2005, Ogbonna *et al.,* 2012; Ibijoke *et al.,* 2013). The Primary Healthcare Centers (PHC) in the study area are no exception in this regard. Based on this, the study tries to analyse medical waste disposal practices by the PHCs in Zaria Local Government Area (LGA) of Kaduna State.

1.2 Statement of the Research Problem

Most of the PHCs in Zaria LGA are located very close to local population clusters. There is thus, serious concern regarding primary health care waste which is often not been properly managed.

There is inadequate training of primary health care workers on waste management practices, nonexistent segregation of medical wastes and risky disposal system, dumping sites are open and uncontrolled. Those managing the waste do not disinfect the waste before disposing it. The way and manner that scavengers and children are seen handling or playing with this kind of wastes at dumpsites is a source of concern, as it could have far-reaching health and environmental effects. The waste handling behavior of the people itself is risky. They dispose off their wastes as cheaply and as quickly as possible without considering the hygienic way of doing it. Also, the frequent incineration of wastes at such dumpsites poses serious threats, considering the harzardous nature of some of the medical wastes.

Joshua et al (2014) conducted a study on hospital wastes management as a potential hazard in selected primary healthcare centres in Zaria. A cross-sectional descriptive study was carried out between October 2012 and march 2013 using staff of the PHCs. Majority of the PHCs personnel were nurses (37%) and the knowledge score of all the staff was 5 out of 10 (50%) about 73% had training on hospital waste management 31% had reported injury by sharps medical wastes. Also, 66% use protective hand gloves while doing their work. Wheel barrow was the commonest method of transporting waste and open burning was the final method of waste disposal by the PHCs.

Ishiyaku (2015) in a research on medical waste management practices in Ahmadu Bello University Teaching Hospital (ABUTH) and Ahmadu Bello University Health Service (ABUHS) found that the total quantities of waste generated were 845kg and 77kg per day for Ahmadu Bello University Teaching Hospital and Ahmadu Bello University Health Service respectively. The study also revealed that the waste collection in the two hospitals was in receptacles and in strategic locations and disposal methods were incineration and open dumping. The result also

shows that poor management of health care wastes exposes the health worker, patients, waste handlers and the general public to health risk.

Studies on medical waste management practices in primary health care centers have been scanty. To the best knowledge of the author, the gap between the study conducted by previous study and this present one is that, the former is concerned with waste as a potential hazard in some selected PHCs while the latter is trying to analyze the medical waste management practices within the PHCs in Zaria local government area. It is against this that the present study tries to fill the gap in the existing literature by analyzing medical wastes management practices in the study area.

Therefore, the research tries to answer the following questions:

1. What are the types of medical waste generated in the PHCs?
2. What is the amount of medical waste generated in each ward by the PHCs?
3. What is the comparison in the amount of waste generated by the PHCs?
4. What are the methods of medical wastes collection and disposal in the PHCs?
5. What are the challenges of medical wastes management in the PHCs?

1.3 Aim and Objectives

The aim of the study is to analyze the Medical Waste Management practices in Primary Healthcare Centers of Zaria Local Government area of Kaduna State. The specific objectives are to:

i. identify the types of medical waste generated in the study area;
ii. determine the amount of waste generated in each PHC within the wards in the study area;
iii. determine the comparison in the amount of waste generated by the PHCs in the study area

iv. examine the methods of collection and disposal of waste by the PHCs in the study area;

v. examine the challenges of medical waste management in the PHCs.

1.4 Hypothesis

The study tested the following null hypotheses at $p \leq 0.05$ significant levels.

H0: There is no significant difference in the amount of medical wastes generated by the PHCs in the study area. It is when the variation is known, and then the volume of waste generated by the PHCs will now be properly managed.

1.5 Scope of the Study

Waste management is too wide to be effectively covered in a research study; this is because a lot of time and material resources would be required, waste comes in different forms and is generated from different sources. In line with this, study focused on the types of waste generated in the PHCs, amount of waste generated, method of waste collection and disposal and the challenges faced by the PHCs in the study area and the study is limited to Primary Healthcare centers within Zaria Local Government area of Kaduna State. The study also focused on Medical solid waste management practices in the thirteen Primary Healthcare centers, which apart from posing health threats to the existence of human and animals, has direct and indirect impact on the socio-political and economic development of the surrounding communities. On the temporal scope, the study covered the period from September 2019 to April 2022, current situation and practices within the study area in order to provide solutions to contemporary issues.

1.6 Significance of the Study

Improper handling of solid waste in the PHCs may increase the airborne pathogenic bacteria, which could adversely affect the PHC's environment and the surrounding community, and has

serious impact on human environment. Apart from risk of water, air and soil pollution, it has considerable impact on human health due to aesthetic effects (Slack, Gronow and Voulvoulis, 2004). The research provided the PHC staffs and general public of Zaria Local Government area the health risk of poor waste management practice. It suggested to Government and policy makers of Zaria Local Government on the need to employ the necessary manpower and strategies on waste collection, storage, treatment and disposal, which will be beneficial to the community. And also to advise medical health practitioners on the need to ensure proper collection, storage, and final disposal of Medical waste.

CHAPTER TWO

CONCEPTUAL ISSUES AND LITERATURE REVIEW

2.1 Conceptual Issues

2.1.1 Concept of Wastes

Waste is generated daily by households, hospitals, commercial establishments, industries, governmental organizations and virtually every element of the society. Waste is generally taken to include all gaseous, liquid waste generated from a large range of community activities, i.e. trash, rubbish and garbage (Longe and Williams, 2006).In USA, waste includes refuse, garbage, slurries and all materials that are normally discarded after use and also by-products of manufacturing or mining activities that are normally discarded (Longe and Williams, 2006). According to the European Economic Community (EEC) defined waste as "Any substance or object the holder disposes of or is demanded to dispose of pursuant to the provisions of the national law in force (commission of the European communities, 1992)." According to Uwa (2008), a waste is any substance for which the owner or the generator has no further use and which he discards. Waste may be solid, semi-solid, liquid or gaseous, and in each case may be toxic or non-toxic, combustible or non-combustible. Everywhere in the world waste is often discussed according to some criteria which include; The source of waste e.g domestic, commercial, industrial, hospital and agricultural, The method of disposal e.g incineration, landfill, tipping, composting and pulverization, and the degree of risk for human health and environment e.g toxic, infectious, hazardous, non hazardous waste.

2.1.2 Concept of medical waste

Medical waste (MW) has been defined as any waste generated in the diagnosis, treatment or the immunization of human beings and animals. In related research, this includes the production or

testing of biological materials from all types of healthcare institutions, including hospitals, clinics, doctor's offices (including dental and veterinary) and medical laboratories (WHO, 1999, 2005). The common method or practice is the co-disposal/improper segregation of MW with municipal solid waste MSW at the point of production/disposal. Sound MSW management continues to be a challenge in Nigeria, as in most developing countries. Though MW constitutes a small fraction of MSW, the potential environmental and health hazards could be deleterious if not handled properly (Blenkham, 1995; Pruss *et al.,* 1999).

Medical waste is considered as one of the major hazards that affect the environment and the health of human beings, since improper management of this waste may pose health hazards through transmission of diseases, the contamination of soil and groundwater and poisonous emissions from improper burning of medical waste (Ja'al, 2003). In the long term, medical waste not only impairs the quality of life of the community, but also affects the welfare of the entire population and the national economy (Massrouje, 2001). However, in developing countries, medical wastes have not received sufficient attention. In many of these countries hazardous and medical wastes are still handled and disposed of together with domestic wastes, thus creating a great health risk to municipal workers, the public and the environment (Silva *et al.,* 2005).

Medical waste management (MWM) has become a critical issue as it poses potential health risks and damage to the environment (Adnane *et al.,* 2013). It is also of greater importance due to its potential environmental hazards and public health risks with high propensity to result into epidemics (Dehghani *et al.,* 2008). It continues to be a major challenge, particularly, in most healthcare facilities of the developing countries where it is hampered by technological, economical, social difficulties and inadequate training of staff responsible for handling of the waste (Alagoz & Kocasoy, 2008). Poor conduct and inappropriate management and disposal

methods exercised during handling and disposal of medical waste (MW) is an increasing significant health hazards and environmental pollution/hazards due to the infectious nature and unpleasant smell of the waste (Chua, Puziah & Subramaniam, 2010). Despite the fact that current medical waste management (MWM) practices vary from hospital to hospital, the problematic areas are similar for all healthcare units and at all stages of management.

2.1.3. Sources of Medical Waste

The main sources of medical waste are hospitals and other healthcare facilities (dispensary, outpatient departments and offices, facilities for blood transfusion or dialysis, emergency team, autopsy facilities), as well as laboratories and research institute (Palanisamy *et al.,* 2011). With the proliferation of blood borne diseases, more attention is being focused on the issue of infectious medical waste and its disposal. Health care institutions must be aware of the potential risk in handling infectious waste, and adhere to the highest standards of disposal and transport (Toyobo, 2012). Education of the staff, patients and community about the management of the infectious waste is crucial in today's health care arena.

2.1.4. Types of Medical Waste

(Shinee *et al.,*2008) documents that; there are two types of medical waste.

a) Non-hazardous or non-risk waste; approximately 75-90% of the waste generated in healthcare establishment is nonhazardous. This includes waste comprising of food remnants, paper cartons, fruit peels, packaging materials wool, kitchen wastes, etc, that does not pose any special handling problem or hazard to health or the environment. Non-hazardous waste is generated in the patients' ward areas, out-patient-department (OPD), kitchens, offices, etc.

b) Hazardous or risk medical waste; the remaining 10-25% of medical waste is hazardous and can be injurious to humans or animals and deleterious to the environment. The hazardous waste

portion includes pathological, infectious sharps and chemical wastes. Hazardous wastes are normally produced in labor wards, operation theatres, laboratories, etc. It is important to note that if both these types are mixed together then the whole waste becomes harmful.

2.1.4.1 Categories or Classification of Hazardous Medical Waste

According to World Health Organization (WHO) 2012, medical waste is classified as Sharp waste(e.g., hypodermic needles, scalpels etc.), Chemical waste (e.g., reagents, solvent etc.), Pathological waste (e.g., human tissues, body parts, fetus, etc.), Infectious waste (e.g., blood and body fluids etc.), Pressurized containers (e.g., gas cylinders, aerosol etc.), Pharmaceutical waste (e.g. out-dated medications, etc.), Genotoxic waste (e.g., cytotoxic drugs and genotoxic chemical) and Waste with high heavy metal content (e.g., batteries, thermometers etc.)

a) Sharp Waste:

These are items that can cause cuts or puncture wounds (e.g needle stick injuries). They are considered as highly hazardous instrument and potentially infectious waste (Hayashi and Shigematsu 2000). World Health Organization 2012 opined that globally; Injections with contaminated syringes caused 21 million hepatitis B infections (32% of all new infections), 2 million hepatitis C infections (40% of all new infections) and 260,000 HIV infections (5% of all new infections). Furthermore, Rao, (2008) document that, in India, 2 million, new Hepatitis B, 400,000 Hepatitis C and 30,000 HIV positive cases occur in a year due to needle prick injuries. More specifically medical waste has a high potential of carrying micro organisms that can infect people who are exposed to it, as well as the community at large if it is not properly disposed of (Manyele & Anicetus, 2011). Many of these infections were avoidable if the syringes had been disposed of safely. The reuse of disposable syringes and needles for injections is particularly common in certain African, Asian and Central and Eastern European countries. In developing

countries, additional hazards occur from scavenging at waste disposal sites and the manual sorting of hazardous waste from health-care establishments. These practices are common in many regions of the world. The waste handlers are at immediate risk of needle- stick injuries and exposure to toxic or infectious materials.

b) Infectious Waste:

Infectious wastes are suspected to contain pathogens in sufficient quantities to cause diseases to other host or person. It includes discarded materials or equipment used for the diagnosis, treatment and prevention of disease as dressings, swabs, and others. This group also includes liquid waste such as urine, blood and sputum or lung secretions (WHO, 1999).

c) Pathological and Anatomical Waste:

Pathological wastes consist of organs, tissues, body parts or fluids such as blood. Anatomical waste is a sub-group of pathological waste and consisting in recognizable human body parts (WHO, 1999; Hayashi and Shigematsu, 2000).

d) Pharmaceutical Waste:

Pharmaceutical waste includes expired, unused, spilt and contaminated pharmaceutical products, drugs and vaccines (WHO, 1999)

e) Chemical Waste:

Chemical wastes consist of discarded chemicals (solid, liquid or gaseous) that are generated during disinfecting procedures or cleaning processes (WHO, 1999).

f) Waste with a high content of Heavy Metals:

Wastes with high contents of heavy metals are highly toxic (e.g. cadmium or mercury from thermometers or manometers). They are considered as a sub-group of chemical waste but they should be treated specifically (WHO, 1999).

g) Pressurized Containers:

It consist a full or emptied containers or aerosol cans with pressurized liquids, gas or powdered materials (WHO, 1999).

h) Highly Infectious Waste:

They include body fluids of patients with highly infectious diseases, microbial cultures and stocks of highly infectious agents from Medical Analysis Laboratories (WHO, 1999).

i) Genotoxic / Cytotoxic Waste:

Genotoxic waste derives from drugs generally used in oncology or radiotherapy units that have a high hazardous mutagenic or cytotoxic effect, vomit or urine from patients treated with cytotoxic drugs or chemicals should be considered as genotoxic (WHO, 1999).

j) Radioactive Waste:

Radioactive waste includes gas, liquids and solids contaminated with radio-nuclides whose ionizing radiations have genotoxic effects. The use of radiation sources in medical and other applications is widespread throughout the world. Occasionally, the public is exposed to radioactive waste, which originates from radiotherapy treatment, which has not been disposed of properly. Serious accidents have been documented in Brazil in 1988 (where four people died and 28 had serious radiation burns), Mexico and Morocco in 1983, Algeria in 1978 and Mexico in 1962.

2.1.5 Classification of Health Care Wastes

Health care wastes are generated by hospitals, animal research facilities and laboratories all of which can be represented in hospitals. The most accepted and recognized is that by the UNEP/WHO. Table 2.1 shows the United Nations Environmental Programme/World Health Organization classification of Health Care Waste (HCW) (UNEP/WHO, 2005).

Table 2.1: UNEP/WHO Classification of Health Care Waste (HCW)

Main Group	Sub Group I	Sub Group II
A: Non Risk Waste	A1: Recyclable waste A2: Biodegradable waste A3: Other non-risk waste	
B:HCW requiring special attention	B1: Human anatomical waste B2: Sharps B3: Pharmaceutical waste	B31: Non-hazardous Pharmaceutical waste B32: Potentially hazardous Pharmaceutical waste B33: Hazardous Pharmaceutical waste
C: Infectious and highly infectious waste	B4: Cyto-toxic pharmaceutical waste B5: Blood and body fluids C1: Infectious waste C2: Highly infectious waste	
D: Other hazardous waste		
E: Radioactive waste		

2.1.6 Potential Risks Associated with Medical Waste

It has been established that, worldwide, about 5.2 million people (including 4 million children) die each year from waste related diseases (Akter, 2011). The hazards of exposure to hospital waste can range from gastro-enteric, respiratory, and skin infections to more deadly diseases such as HIV/AIDS, and Hepatitis (Rao, 2008 & Baban yara, 2012). Additionally, medical waste contains potentially harmful micro-organisms which can infect hospital patients, health-care workers and the general public. Other potential infectious risks may include the spread of drug resistant micro-organisms from health-care establishments into the environment. Waste and by-products can also cause injuries, for example: Radiation burns, sharps-inflicted injuries, Poisoning and pollution through the release of pharmaceutical products, in particular, antibiotics and cytotoxic drugs, Poisoning and pollution through waste water; and Poisoning and pollution

by toxic elements or compounds, such as mercury or dioxins that are released during incineration.

2.1.7 Risks Associated with Waste Disposal

Although treatment and disposal of medical waste reduces risks, indirect health risks may occur through the release of toxic pollutants into the environment through treatment or disposal (Patil & shekdar, 2011). Specifically the risks associated with waste disposal are as follows:-

A. Risks of Landfills

Landfills can contaminate drinking-water if they are not properly constructed. Occupational risks exist at disposal facilities that are not well designed, run, or maintained.

B. Risks of Incineration

Incineration of waste has been widely practiced but inadequate incineration or the incineration of unsuitable materials results in the release of pollutants into the air and of ash residue. Incinerated materials containing chlorine can generate dioxins and furans, which are human carcinogens and have been associated with a range of adverse health effects. Incineration of heavy metals or materials with high metal content (in particular lead, mercury and cadmium) can lead to the spread of toxic metals in the environment. Dioxins, furans and metals are persistent in the environment. Materials containing chlorine or metal should therefore not be incinerated.

C. Occupational and Public Health Risks

During handling of wastes, the medical and ancillary staff as well as the sanitary labourers can be injured if the waste has not been packed safely. In that respect, sharps are considered as one of the most dangerous category of waste. Many injuries occur because syringe needles or other sharps have not been collected in safety boxes or because these have been overfilled. The general public can be infected by Medical waste either directly or indirectly through several routes of

contamination. Dumping medical waste in open areas is a practice that can have major adverse effects on the population. The «recycling» practices that have been reported, particularly, the reuse of syringes is certainly the most serious problem in a number of countries. The WHO estimates that over 23 million infections of hepatitis B, C and HIV occur yearly due to unsafe injection practices (reuse of syringes and needles in the absence of sterilization). There is also a public health risk linked to the sale of recovered drugs in the informal sector when the elimination of expired drugs isn't properly controlled and monitored.

D. Indirect Risks via the Environment

Finally, the dumping of Medical waste in uncontrolled areas can have a direct environmental effect by contaminating soils and underground waters. During incineration, if no proper filtering is done, air can also be polluted causing illnesses to the nearby populations. This has to be taken into consideration when choosing a treatment or a disposal method by carrying out a rapid environmental impact assessment (EIA).

2.1.8 Micro-Organisms Associated with Medical Waste

Presence of various microorganisms such as pathogenic viruses and bacteria have been investigated by both cultivation and by (RT)-PCR assays. A number of (opportunistic) pathogenic bacteria, including Pseudomonas spp., Lactobacillus spp., Staphylococcus spp., Micrococcus spp., Kocuria spp., Brevibacillus spp., Microbacterium oxydans, and Propionibacterium acnes, were identified and reported from the various medical wastes. In addition, pathogenic viruses such as noro viruses and hepatitis B virus have been also detected in human tissue wastes. Commonly identified bacterial and viral pathogens such as Pseudomonas spp., Corynebacterium diphtheriae, Escherichia coli, Staphylococcus spp., and respiratory

synctial virus (RSV) have been reported to be part of the medical wastes. Medical waste should be carefully controlled and monitored to prevent Nosocomial infection associated with the exposure to these wastes. Health service waste gives rise to controversy regarding its importance for human, animal and environmental health (Nascimento *etal*; 2014). Furthermore, occurrences of multi-resistant strains support the hypothesis that health service waste acts as a reservoir for resistance markers, with an environmental impact. The lack of regional legislation concerning segregation, treatment and final disposal of waste may expose different populations to risks of transmission of infectious diseases associated with multi-resistant microorganisms (Emery *et al*; 2016).

Steps towards Improvement of medical waste management Improvements in health-care waste management rely on the following key elements:

1. Building a comprehensive system, addressing responsibilities, resource allocation, handling and disposal. This is a long-term process, sustained by gradual improvements.
2. Raising awareness of the risks related to medical waste, and of safe and sound practices.
3. Selecting safe and environmentally-friendly management options, to protect people from hazards when collecting, handling, storing, transporting, treating or disposing of waste.

Government commitment and support is needed for universal, long-term improvement, although immediate action can be taken locally.

2.1.9 Disposal Methods

According to Farzardkia & Jorfia, (2016), different methods are used for the disposal of medical waste and are discussed below:

A. Incineration

It is a controlled combustion process where waste is completely oxidized and harmful microorganisms present in it are destroyed under high temperature. Medium- and high-temperature incineration devices require a capital investment and an operations and maintenance budget. They operate on fuel, wood, or other combustible material and produce solid ashes and gases. Pollutants are emitted to varying degrees. The ash is toxic and must be buried in a protected pit. Combustible waste is reduced to incombustible waste with a decreased volume. The high temperatures kill microorganisms.

Medium-temperature incinerators, commonly a double- chamber design or pyrolytic incinerator, operate at a medium-temperature combustion process (800°-1,000°C).

High-temperature incinerators, recommended by WHO, treat health care waste at a temperature >1,000°C.

B. Autoclaving

Autoclaving is a low-heat thermal process where steam is brought into direct contact with waste in a controlled manner and for sufficient duration to disinfect the wastes. For ease and safety in operation, the system should be horizontal type and exclusively designed for the treatment of medical waste. For optimum results, pre vacuum based system is preferred against the gravity type system. It shall have tamper-proof control panel with efficient display and recording devices for critical parameters such as time, temperature, pressure, date and batch number etc.

C. Microwaving

Microbial inactivation occurs as a result of the thermal effect of electromagnetic radiation spectrum lying between the frequencies 300 and 300,000 MHz Microwave heating is an inter-molecular heating process. The heating occurs inside the waste material in the presence of steam.

D. Hydro claving

This is similar to autoclaving except that the waste is subjected to indirect heating by applying steam in the outer jacket. The waste is continuously tumbled in the chamber during the process.

E. Shredder

Shredding is a process by which waste are de-shaped or cut into smaller pieces so as to make the wastes unrecognizable. It helps in prevention of reuse of bio-medical waste and also acts as identifier that the wastes have been disinfected and are safe to dispose of. A shredder is to be used for shredding in medical waste with minimum requirements.

2.1.10 Global Perspectives of the Hazardous Medical Waste Management

Environmentally sound management involves taking all practical steps to protect human health and the environment from hazardous wastes, like medical waste. In an ideal world, this would mean reducing the generation of hazardous wastes to zero. In practice, environmentally sound management means strictly controlling the storage, transport, treatment, reuse, recycling, recovery and final disposal of wastes (Semwal & Dharmendra, 2016). When segregated and properly managed, medical waste streams are usually very small in quantity. In addition, most waste generated in the healthcare facilities can be treated as regular municipal solid waste except for a varying portion needing special attention such as sharps, pathological wastes, and other potentially infectious wastes, pharmaceutical, biological and hazardous chemical wastes, collectively known as “Special healthcare wastes” and requires proper packaging, storage,

transportation and disposal (Code & Christen, 2015). The lack of segregation between hazardous and non-hazardous waste, an absence of rules and regulations applying to the collection of waste from the hospital wards and the on-site transport to a temporary storage location, lack of proper waste treatment, disposal of medical waste along with municipal garbage, insufficient training of personnel, insufficient personal protective equipment and lack of knowledge regarding the proper use of such equipment are among the problems highlighted in literature are prominent factors contributing to poor medical waste management (PRISM Bangaladesh, 2013) . In Africa, the situation of poor medical waste management is similar in South Africa, Mozambique, Swaziland, Kenya and Tanzania (Charlie *et al*; 2014). Illegal dumping is a serious problem in most developing countries. Almost all the countries recognized poverty as a basic factor that dwarfed the success of African efforts in the area of environmentally sound management of hazardous waste. An additional challenge was the state of the medical waste incinerators of the low operating temperatures (~200°C), resulting in excess generation of toxic gases like HCl, CO, co organics, dioxins and furans. Since the locations of these facilities (in hospitals) are usually located in very close proximity of communities, the emissions from the incinerators present a serious health risk to the same community which the hospital is meant to serve (Manyele, 2015).

2.1.11 Proper Management of Medical Waste

The best medical waste management practice for medical waste is to prevent and minimize the generation of waste (Jang *et al*, 2006). The management of waste must be consistent from the point of generation ("cradle") to the point of final disposal ("grave"). According to WHO (1999), WHO (2000), and WHO (2004**)**, the path between these two points can be segmented schematically into these steps.

a) Waste Minimization:

This first step comes prior to the production of waste and aims at reducing as much as possible the amount of HCW that will be produced by setting up an efficient purchasing policy and having a good stock management (WHO, 1999).

b) Waste Generation:

Waste generation is the point where wastes are generated. Biomedical waste should be collected in containers that are leak-proof and sufficiently strong to prevent breakage during handling. Containers of biomedical waste are marked with a biohazard symbol. The container, marking, and labels are often red. Discarded sharps are usually collected in specialized boxes, often called needle boxes. Minimal recommended equipment includes a fume hood and primary and secondary waste containers to capture potential overflow.

c) Segregation and Containerization:

The segregation must be done at the point of generation of the waste. To encourage segregation at source, (reusable) containers or baskets with liners of the correct size and thickness must be placed as close to the point of generation as possible (WHO, 2000). They should be properly codified by color-coded (yellow or red for infectious waste) and have the international infectious waste symbol clearly marked. When they are 3/4 full, the liners must be closed with plastic cable ties or string and placed into larger containers (WHO, 2000).

d) Intermediate Storage:

In order to avoid both the accumulation and decomposition of the waste, it must be collected on a regular daily basis to the area where the larger containers are kept before removal to the central storage area (WHO, 2004).

e) Internal Transportation:

Transportation to the central storage area is usually performed by using a wheelie bin or trolley. Wheelie bins or trolley should be easy to load and unload, have no sharp edges that could damage waste bags or containers and they should be easy to clean. Ideally, they should be marked with the corresponding coding color (WHO, 2004).

f) Centralized Storage:

The central storage area should be sized according to the volume of waste generated as well as the frequency of collection. The facility should not be situated near food stores or food preparation areas. Its access should be always limited to authorized personnel, also it should be easy to clean, have good lighting and ventilation, designed to prevent rodents, insects or birds from entering. Storage time should not exceed than 24-48 hours especially in countries that have a warm and humid climate (WHO, 2004).

g) External Transport:

External transport should be carried out by using dedicated vehicles. They should be free from sharp edges, easy to load and unload by hand, easy to clean and disinfect, and fully enclosed in order to prevent any spillage in the hospital premises or at the road during transportation (WHO, 2004). The transportation should be always properly documented and all vehicles should carry a consignment note from the point of collection to the treatment facility (WHO, 2004).

h) Treatment and Final Disposal:

There are a number of different treatment methods and options to deal with medical waste including incineration, steam sterilization (sanitation), microwave sanitation, chemical disinfection, dray heat disinfection, and disinfection with superheated stem (WHO 2004). The goals of biomedical waste treatment are to reduce or eliminate the waste's hazards, and usually to

make the waste unrecognizable. Treatment should render the waste safe for subsequent handling and disposal.

2.1.12 Benefits of Proper Medical Waste Management

Proper hospital waste disposal is important for many reasons from protecting public health and the environment to keeping your patients and coworkers safe. It also protects your healthcare facility from fines and a bad reputation. The World Health Organization (2004) has made a huge effort to encourage proper hospital waste disposal around the world. These include;

1. Minimizes the spread of infections & reduces the risk of accidental injury to staff, patients, visitors & the community,
2. Reduces the likelihood of contamination of the soil or ground water with chemicals or micro-organisms,
3. Attracts fewer insects and rodents and does not attract animals,
4. Helps to provide an aesthetically pleasing atmosphere.

Measures to ensure the safe and environmentally sound management of health care wastes can prevent adverse health and environmental impacts from such waste including the unintended release of chemical or biological hazards, including drug-resistant microorganisms, into the environment thus protecting the health of patients, health workers, and the general public.

2.2 Literature Review

2.2.1 Types of Medical Waste

According to Remy (2001) waste generated in the process of health care consists of variety of materials including hypodermic needles, scalpels, blades, surgical cottons, gloves, bandages, clothes, discarded medicine and body fluids, human tissues and organs, chemicals and others.

These are the most environmentally sensitive health-care by products that need greater attention and should be monitored

Longe and Williams (2006) carried out a research on medical waste management practices and their implications to health and environment in metropolitan Lagos using 4 hospitals with a range of 40-600 beds. The study established that the average generation rate of medical waste was 0.56kg/bed.

Ogolowa, (2013) In a study 'Biomedical waste disposal and Environmental Aesthetics of Tertiary Healthcare centers'. The results from the type and categories of BMW showed in both hospitals are generated by all irrespective of age and socioeconomic or status because of their numerous uses. The respondents agreed that all the listed items; Papers Bandages Cotton swabs Used diapers and tissue. Non Degradable; syringes and needles, broken bottles, used blades plastics are generated as waste in the hospitals. This is concluded because all the items met the cut-off point of 1.0 and above. This therefore implies that all the listed items are forms of waste generated in the two hospitals. Further, all degradable wastes are known for their offensive odour and often constitute toxic leachate from the decomposed materials that ends up contaminating both soil and ground water.

Ishiyaku, (2015), in a research on medical waste management practices in Ahmadu Bello University Teaching Hospital (ABUTH) and Ahmadu Bello University Health Service (ABUHS) found that at the ABUHS, the respondents said all the waste categories according to UNEP/WHO classification were present except radioactive wastes, other hazardous wastes and human anatomical wastes are not present. The categories and sub-sets of healthcare waste yielded by the exercise comprise: Recyclable wastes, Biodegradable wastes, sharps, non-hazardous pharmaceutical wastes, potentially hazardous pharmaceutical wastes, cyto-toxic

pharmaceutical wastes, blood and body fluids, Infectious wastes, highly infectious wastes, other hazardous wastes and radioactive wastes.

2.2.2 Amount of Medical Waste

Generation of wastes differs not only from country to country, but also within country (WHO, 1999). The amount of waste generated in hospitals depends on various factors, like the number of beds, types of health services provided, economic, social and cultural status of patients, and the general conditions of the locality where the health-care facility is situated Ascarian et al, (2004). Medical activities generate waste that should always be discarded at the point of generation WHO, (1999). The quantity of medical waste generated should always be minimized and precautions must be taken during their handling. A study Gias, (2008) reported the rapid increase of these institutions exert tremendous impact on human and on the environment due to production of huge amount of hazardous and non-hazardous waste".

The amount of hospital waste generated in US hospitals is approximately 6,670 tons per day. The per- patient- per day generation rate of 15 pounds reported in a US hospital survey conducted in 1987-1988 Rutala et al, (1989) is about 15% higher than the amount reported in a North Carolina hospital survey (13 pounds perpatient-per day) conducted in October 1980 Rutala ,& Sarubbi, (1983). A study shows that about 3,500 metric tons of garbage was generated per day in the Dhaka city, 200 tons of which are generated by the healthcare establishments, 20% of which were infectious wastes The Bangladesh Observer (2000). The number was rising day by day. The Bangladesh University of Engineering and Technology (BUET) conducted a study in some hospitals in Dhaka city in 1999.The total study was limited to the generation

of solid wastes per bed per day. It was found that an average solid waste produced was 1.00 kg/ bed/day The Bangladesh Observer (2000)**.** The University conducted another study in Dhaka city in 1997 Rabbani, (1997) to assess different technological options for improvement of the present situation. It was found that the rate of waste generation was about 1.6 kg/bed /day and hazardous waste was 0.169 kg/bed/day. The contribution of infectious, sharps and pathological wastes were about 10.5%, 3.5% and 1.5% respectively compared to solid waste of 3,000 tons/day in Dhaka city. It was also reported that careful sorting, handling and storage of wastes inside the hospital was the key factor of maintaining the hospital hygiene. A survey was conducted by Professor Mushfique in (2003) on 71 healthcare institutions in the city including Rajshahi Medical College hospital. Total amount of medical waste generated in Rajshahi City was found to be 999.76 kg/day of which general wastes was 712. 35 (71.3%), non-sharp infectious was 255.45 kg/day (25.6%), sharps was 31.95 kg/day (3.2%). Minor amount of genotoxic waste (0.01 kg/day) was generated only in the Radiotherapy and Oncology Department of Rajshahi Medical College Hospital. A number of studies have indicated that the inappropriate handling and disposal of hospital waste poses health risks to health workers who may be directly exposed and to people near health facilities, particularly children and scavengers who may become exposed to infectious wastes and a higher risk of diseases like hepatitis and HIV/AIDS Adegbita ,Nwafor, Afon, Abegunde and Bamise, (2010) ;Coker,2009;PATH,2009;WHO,(1999). In effect, various methodologies have been used all over the world to assess and quantify hospital waste. They include the use of physical observation, questionnaire administration and quantification (Adegbita et al., (2010); Olubukola, (2009); Phengxay et al., (2005), as well as checklists (Townend and Cheeseman, (2005) and private and public records Coker et al (2009).

Recent studies in Nigeria has estimated waste generation of between 0.562 to 0.670 kg/bed/day (Longe and Williams, (2006) and as high as 1.68kg/bed/day

Longe and Williams (2006) carried out a research on medical waste management practices and their implications to health and environment in metropolitan Lagos using 4 hospitals with a range of 40-600 beds. The study established that the average generation rate of medical waste was 0.56kg/bed. Only two of the hospitals undergo treatment of infectious and waste before final disposal. Abah and Ohiman (2011) in their study on healthcare waste management in Nigeria, focused on the quantity, evaluation of waste segregation practice and determination of awareness of healthcare workers regarding healthcare waste management. The findings revealed that the amount of healthcare waste was 0.62kg/person/day. The proportion of respondents who had received training was 11% and the number of respondents who understood the importance of management of healthcare waste in the provision of safety to the public was 46%.

Ishiyaku (2015) in a research on medical waste management practices in Ahmadu Bello University Teaching Hospital (ABUTH) and Ahmadu Bello University Health Service (ABUHS) found that the total quantities of waste generated were 845kg and 77kg per day for Ahmadu Bello University Teaching Hospital and Ahmadu Bello University Health Service respectively. The findings also revealed that the waste collection in the two hospitals was in receptacles and in strategic locations and disposal methods were incineration and open dumping.

Ibijoke.I. *et al;* (2013) in their study assessed the medical waste management practice in two hospitals in Lagos. The cross-sectional study involved the use of questionnaires, in-depth interviews, focused group discussions and participant observation strategies. It also involved the collection, segregation, identification and weighing of waste types from wards and units in the representative facilities in Lagos, Nigeria, for qualitative and quantitative analysis of the MW

streams. The findings indicated that the selected Nigerian healthcare facilities were lacking in the adoption of sound MW management (MWM) practices. The average MW ranged from 0.01 kg/bed/day to 3.98 kg/bed/day. Moreover, about 30% of the domestic waste from the healthcare facilities consisted of MW due to inappropriate co-disposal practices. Multiple linear regressions was applied to predict the volume of waste generated giving a correlation coefficient (R2) value of 0.99 confirming a good fit of the data. This study revealed that the current MWM practices and strategies in Lagos are weak, and suggests an urgent need for review to achieve vital reversals in the current trends.

2.2.3 Methods of Collection and Disposal of Medical Waste

A study in Port Harcourt shows that only 1% of Primary Health Care Centers had a transport vehicle also 8% of PHCs had an established dumpsite (Stanley, et al 2011). More than 90% of the hospital waste generated in Nigeria is directly disposed on land in an unsatisfactory manner (Vivian, Blama, Ezemokwe, Okafor and Bawa, 2012).

As primitive as open dump method of solid wastes disposal is, Johanessen and Boyer (1999) observed that it remains the predominant means in developing countries. Rush brook and Pugh (1999) considered the open dump method of solid waste disposal as both “naïve and dangerous” because of the leaching effects of chemicals and biological contaminants in the wastes, which constitutes a direct route for transmission of communicable diseases. Although, incineration is not an unclean process of disposing wastes, it is still the most effective method of treating HCW because it involves the application of combustion process under controlled condition at high temperature, converting wastes containing stocks of infectious agents and pathological materials to inert mineral residues and gases (Omotoso, Faluyi and Iyanda, 2007).However, incineration is regarded as the most expensive waste management option because it requires capital intensive

plant, highly skilled personnel and careful maintenance (Onipede and Bolaji, 2004) and it to the production of dioxins, furans or other toxic pollutants as emissions and residues. Improper HCW disposal method like open air burning, land filling, dumping into water bodies is common in developing countries, constitutes environmental threats, increased vulnerability for potential transmission of communicable diseases and natural disasters.

In developing countries like Nigeria, where many health concerns are competing for limited resources, it is not surprising that the management of healthcare wastes has received less attention and the priority it deserves. Although reliable records of the quantity and nature of healthcare wastes and the management techniques to adequately dispose of these wastes has remained a challenge in many developing countries of the world, it is believed that several hundreds of tons of healthcare waste are deposited openly in waste dumps and surrounding environments, often alongside with non-hazardous solid wastes (Abah and Ohimain, 2010). Unfortunately, practical information on this important aspect of healthcare management is inadequate and research on the public health implications of inadequate management of healthcare wastes are few and limited in scope.

Latch *et al*., 2003 andSherer, 2006). Specifically, Castensson (2008) and Kummerer (2009) identified the burying of pharmaceutical waste as being improper for environmental reasons because it is implicated in the leaching of waste into groundwater and surface water. Indeed, HCW management literature in support of the occurrence of pharmaceutical waste in waste water as well as in surface ground and drinking waters abound in studies carried out in developed countries. They include the studies by Herberer (2002); Jones *et al.* (2002); Zuccato *et al.* (2006); Castensson (2008); Kiel *et al.* (2008); and Kummerer (2009). Ngwuluka *et al.* (2011) noted, on the contrary, that while developed countries have been monitoring and determining

pharmaceutical wastes, there exists no apparent indication that Nigeria is monitoring it. They went on to assert as evidence the little awareness in Nigeria about the hazards of 23 pharmaceutical wastes as an emerging contaminant as a result of limited number of actors who are aware of the requirements of regulatory authorities.

2.2.4 Challenges of Medical Waste Management.

Despite all the effort made by different stakeholders in the country with regard to managing waste in the country, there has been inadequacy that still prohibits the state and country from managing medical wastes in a scientific and more-coordinated way. The risks of medical waste are beyond comparison to the risks of general non-hazardous wastes. Incineration of hazardous wastes leads to the emission of dioxin, furans, and even mercury is produced. This poses environmental degradation and induces health risks as well. This is a serious challenge to sanitation workers, as the virus can persist for up to a day on cardboard and for longer on metal and plastic surfaces, according to one study of the virus in lab conditions. Despite all the sensitization and advocacy campaign by government officials using various media houses, traditional and religious leaders, there are quite a number of people who still do not believe that the infectious waste exist. The enforcement of policy regulations is usually slow because of our usual ways of doing things in the State and country at large. Naturally the enforcement team is supposed to include mobile courts where offenders are tried on the spot and if any is convicted, and then the law takes it course. So the poor enforcement leads to ineffective management of infectious waste in the state.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 Study Area

3.1.1 Location

Zaria is located between Latitudes $11^0$3`N and$11^0$15`N of the equator and Longitude 70^0 33`E and $70^0$45`E of the Greenwich Meridian. Zaria is located in the central plains of the northern Nigeria highland standing at an average height of 670m above sea level and is about 83km North of Kaduna town along Kaduna-Kano Highway. It is the second largest city in Kaduna State. It is drained by three major rivers namely; Kubanni River, Saye River and Galma River.

3.1.2 Climate and Vegetation

The climatic characteristics are that of the tropical savannah (Hore, 1970) Zaria experiences a tropical continental climate, which is characterized by distinct wet and dry seasons. Analysis of the long term records of rain fall from the Institute of Agricultural Research and the meteorological station at the Nigerian College of Aviation Technology shows that the area enjoys mean annual rainfall of about 1060mm. The seasonality in climate is largely determined by the movement of inter-tropical convergent zone (ITCZ) across the country. This ITCZ is the zone where the two dominant air masses the tropical continental (TC) from the North-East and the tropical maritime (MT) from the South-West meets (Ayoade, 1987). Also the high mean daily maximum temperature rises gradually from a low temperature of about 26.6^0C in January to a major peak of 390C in April or October the dry season starts from November to February. The relative humidity falls from 69^0 to 36^0 whilst the harmattan wind becomes steady and contains particles with associated poor visibility.

In terms of vegetation, Zaria lies within the Northern Guinea Savannah type of vegetation which implies that it has a woodland vegetation type. Through the clearing of vegetation for cultivation, firewood, as well as overgrazing the natural or climate vegetation of Zaria have been changed to that of derived savanna type which is characterized by shrubs, stems and trees along with some tuft covers and some clusters of trees along river course (Alkali, 2009). Trees species here include here include *Magnifera indica* dotting everywhere, *Parkia clappertoniana, Tamarinda indiana, Butyrispernum spp* and several others which are found to be useful to man. During the rainy season, the vegetation is thick and greenish but is dry and brownish during the dry season with little of these plants retaining their leaves. The dominant shrubs around the area is *Isoberlina doka* with an average height of 50 cm. other less frequent shrub species include: *Pilliostigma spp., Terminacea avicennides*

The common grass communities in the study area are mostly *Andropogan spp.* (Kwabe, 1987), which are almost completely absent during the long dry season. However, the grasses sprout during rainy season, but no sooner than rainy season ceased than they become dry. In this same Savannah zone there is the presence of *Isobelina doka, tomentoss and Vapaca togoensis* with a well-developed grass layer. Jackson,(1970).

3.1.3 Soil

The soil in Zaria is lateritic formed from drift deposit which mantles the solid rudimentary and Precambrian baseman rocks. The soil types identified in the study area are loamy and alluvial soil suitable for wide range of crop cultivation. The region is capable for cultivation of cereals, perennial and root crops which are of economic value. The undulating terrain has advantage for mechanized farming.

3.1.4 People and Population

Zaria local government area consists mainly of the Hausa-Fulanis, though there are many other ethnic groups. The Indigenes are majorly Muslims who practice Islam. Cultural practices in this area can hardly be separated from the religious practices for example, seclusion (Purdah) is linked to both cultural and religious traditions. It means women are restricted to the home and can only move out with their husband's permission. In these communities the men are known as both the provider (breadwinner) and the decision makers

Families in the Zaria area can be divided into two types of units, a simple unit consisting of an individual married adult and his children and a composite unit which is also known as economic unit. It consists of two or more male adult usually married staying together in a compound setting, in some cases they cooperate to secure income from a farm. In order of decision- making power, the subordinate have minor rights and basic decisions are taken by the head of the units (Nwachukwu, 1990). The population of Zaria Local Government Area has increased exponentially over the years. Presently, the current metro area population of Zaria in 2023 is **766,000**, a **2.27% increase** from 2022.The metro area population of Zaria in 2022 was **749,000**, a **1.77% increase** from 2021.The metro area population of Zaria in 2021 was **736,000**, a **1.38% increase** from 2020.The metro area population of Zaria in 2020 was **726,000**, a **0.97% increase** from 2019. Nigerian Metro Area Population, (1950-2023).

Based on this, it is important to state that the increasing population growth is bound to have an association with the number of people that patronizes primary health healthcare centers in the study area. This has also enhance the level of medical waste generation in the selected PHCs;

with a high risk of environmental hazards because when medical waste are not proper handled or managed it could be disastrous on the environment and the general public.

Healthcare Facilities

According to ZAICON DIGITAL TECH there are three-tier system of health care in Nigeria, depending on the facility infrastructure, personnel and the type of care they offer.

The Tertiary Healthcare System is managed by the federal government through their Federal Ministries of Health. Examples of tertiary healthcare clinic are the Federal Medical Centres, Federal Neuro-Psychiatric Hospitals, University Teaching Hospital, National Laboratories, and some "top" private high-level specialist hospitals.

The Secondary Healthcare System is managed by the states government through their state ministries of health.
They handle all cases that are "too big" for Primary Health Care" to handle.
Examples of secondary healthcare clinic are the general hospitals, comprehensive health center, district hospital, specialist and "big" private hospitals
The Federal Ministry of Health (FMOH) operated institutions handle the policy-making, technical support, national health management, and health services delivery. The Tertiary Health Care System also helps to coordinate the activities of the other lower healthcare tiers such as secondary and primary healthcare.

Primary Health Care (PHC) are health centres at the community or ward level, and is the first point of contact for patient. Most of the healthcare providers in the PHC are nurses, community health workers, and sometimes, a doctor who practices general medicine. A person is most likely being referred to a secondary or tertiary health care centers if the need be. Primary Health

Care is managed by the Local Government. Typically, the size of a healthcare facility can be measured based n the number of beds, facility level and services offered. The Primary Healthcare centers in Zaria Local government offer the following Services Offered: Antenatal Care (ANC), Immunization, HIV/ AIDS Services, Tuberculosis, Non Communicable Diseases, Family Planning, Intensive Care Services, Communicable Diseases, Hepatitis, Child Survival, Accidents and Emergency, Nutrition, Health Education and Community Mobilization, Maternal and new born care gynecology and obstetrics. Their facility level is that they are PHCs in Zaria Local Government. Their number of beds ranges from 12 above.

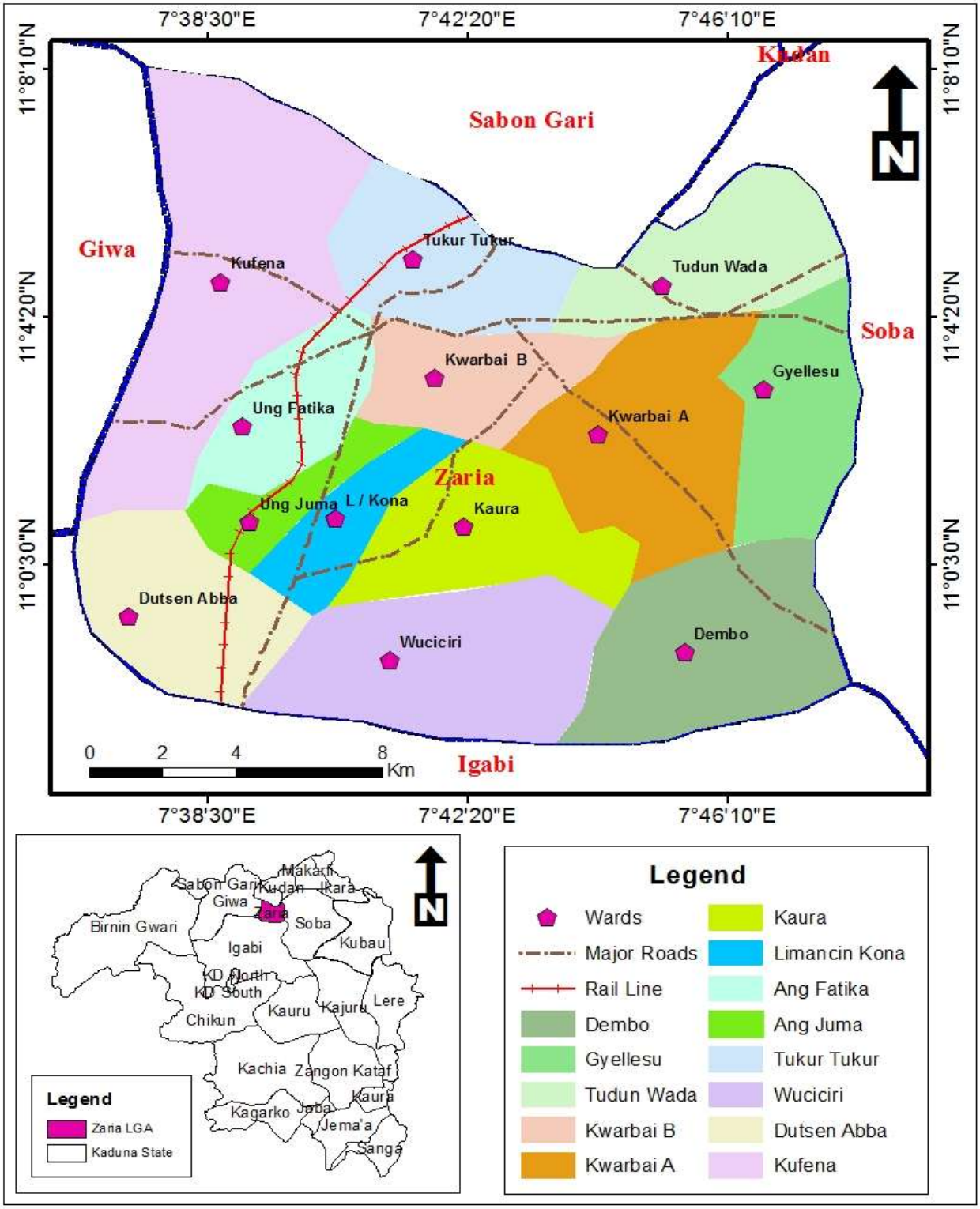


Figure 3.1: Zaria Local Government Area MAP Source: GIS and Remote Sensing Software Arc Map 10.1 Department of Geography ABU, Zaria.

3.2. METHODOLOGY

3.2.1 Reconnaissance survey

A reconnaissance survey was carried out by the researcher in the area, which provided the researcher with good knowledge of the study area. The survey revealed that there are 32 primary healthcare centers within the study area but 29 of them are functional, 2 are not in existence and 1 is not functional. There are 13 wards within Zaria local government. There seems to be indiscriminate dumping of medical waste where general wastes are dumped. There is also inadequate equipment in handling medical waste and there are also different disposal methods practiced within the study area.

3.2.2 Types of Data

The types of data required for this research include:

i. Quantity of waste generated in the PHCs
ii. Co-ordinates of the PHCs
iii. Names and number of the existing Primary Healthcare Centers (PHCs)
iv. Different Methods of Medical Waste Collection and Disposal,
v. Challenges faced by the PHCs.

3.2.3 Sources of Data

Data for the study were collected using primary and secondary sources.

Primary Source of Data

Different methods of Medical waste collection and disposal: Pictures of the waste dumpsite, waste bins using camera. The nature of medical waste, methods of medical waste collection and disposal and the challenges faced by the PHCs was collected using questionnaire.

Quantity of waste generated in the PHCs: Amount of waste generated per week from each of the PHC within the wards. The amount was measured using sack as a measuring tool.

Co-ordinates of the PHCs: this was gotten using mobile topographer.

Name and number of the existing Primary Health care Centers (PHCs): This is gotten from Zaria Local Government Health Department.

Secondary Source of Data

Secondary data sources included information on Primary Healthcare Centers and their activities from Zaria Local Government Health Department; Kaduna State Environmental Protection Agency (K.E.P.A) is also gathered in order to achieve the stated objectives.

3.2.4 Sampling Size and Sampling Technique

For the purpose of this study, Random Sampling Technique was used to select respondents in the PHCs. The respondents are the cleaners (in charge) in each of the PHCs. So a set of questionnaire was administered to the cleaners within the PHCs in the study area. A total of forty-four (44) copies questionnaire were administered to medical waste handlers and questionnaires were recovered at the end of the field work and were used for the analysis. Descriptive statistics was used which include presentation of results in tabular form, frequencies, percentages, pie charts, and bar charts.

Table 3.1: Distribution of Primary Health Care Facilities by Wards in Zaria LGA

Wards	Number of PHCs	Selected PHCs	No of Cleaners
Kufena	4	Ang.Dankali, Gabari, **Kake** & Danmagaji	3
Tudun Wada	2	**Tudun wada** &Dandutse	4
Gyallesu	2	**Gyallesu** & Kaku	4
Dambo	1	**Dambo**	2
Dutsen Abba	3	Dutsen Abba **Pammadina** & Dorayi	5
Wucciciri	4	Wucicciri, **Aba**, Dakace &Rubuci	3
Anguwan Fatika	2	**Anguwan Fatika** & Kofar Kibo	2
Kwarbai A	3	Ang. Magajiya Amaru & **Ang. Liman**	4
Kwarbai B	1	**Anguwan Alkali**	2
Anguwan Juma	2	**Durumin mai Garke** & Anguwan Iya	3
Limancin Kona	4	**Babban Dodo**, Salmanduna, Ang. Zakara & Kusfa	4
Kaura	2	**Anguwan Bishar** & Rimin Doko	3
Tukur-Tukur	2	**Tukur-Tukur** & Tudun Jukun	5
Total	**32**		**44**

Source: Department of Health, Zaria LGA (2019)/Author's Compilation

3.2.6. Methods of data analysis

Objective I: Identify the Class of solid Medical Waste Generated

This was achieved by analyzing the data from the questionnaire using descriptive statistics; frequency table. The identified medical waste was categorized according to the UNEP/WHO classification. It was observed that the common types of medical waste as collected include, food debris, sharps, dressing swaps, body fluids, Group A (Non- Risk Medical Waste) were found to be the most common across the PHCs. The group A consists of waste material such as packaging; food debris etc and they were prevalent as a result of activities of patients, visitors and also the health care workers.

Objective II: Determine the Amount of Waste Generated.

This was achieved by quantifying the amount of waste generated per week in each PHC in the study area. The weighing balance was used to determine the quantity of medical waste in kg/bed/day, kg/day and kg/week. Average waste generated in kg/week was derived by dividing waste per kg/day and total daily waste generated for the thirteen PHCs and multiplying it by 100.

Objective III: Determine the Comparison in the Amount of Medical Waste

Hypothesis was tested at $p \leq 0.05$ significant level using statistical test of ANOVA. ANOVA is an analysis tool used in statistics that splits an observed aggregate variability found inside a data set into two parts: systematic factors and random factors. It is used to determine the influence that independent variable have on the dependent variable in a regression study.

Objective IV: Determine the Methods of Collection and Disposal of Medical Waste

This was achieved by analyzing the responses of the interviews conducted with the personnel (cleaners) of the PHCs on the method used in collecting and disposal of waste. The collected

data from the questionnaire were analyzed using descriptive statistical techniques, including frequency counts, percentages and tables.

Objective V: Examine the Challenges of Medical Waste Management

The result obtained from questionnaire help to know the challenges faced by each PHC. Tables, frequency counts, percentages were used to presents the results. The collected data from the questionnaire were analyzed using descriptive statistical techniques.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter contains the analysis based on research objectives and interpretation of results from questionnaire administered to the respondents.

4.1 Types of Medical Waste Generated by the PHCs in Zaria Local Government

The types of medical waste generated in the surveyed Primary Health Care Centers are shown in Table 4.1.The various types of medical waste generated in all the PHCs are categorized according to the UNEP/WHO classification. The common types of medical waste as collected include, food debris, sharps, dressing swaps, body fluids, Group A (Non- Risk Medical Waste) were found to be the most common across the PHCs. The group A consists of waste material such as packaging; food debris etc and they were prevalent as a result of activities of patients, visitors and also the health care workers.

Furthermore, intravenous set needles and broken vials were classified as B2, Swabs, body fluids and bandages (C1), spilt medicine and disinfectant (B3), Packaging, food scraps and papers A1 all of these were found in inpatient wards. Similarly, medical waste material found in outpatient wards were categorize as waste paper, food debris (A1), Hand gloves and swabs.

Table 4.1: Types and Nature of Waste Generated at the PHCs

Wards/Units	Types of Waste	Classification Codes
Inpatient ward	Intravenous set Needles, broken vials	B2
	Swabs,Body fluids, bandages	C1
	Spilt medicine, Disinfectants	B31
	Packaging, Food Scraps, Papers	A
Outpatient Ward	Waste paper, food debris	A1
	Hand gloves, Swabs,	C1
	Needles and Syringes	B2
Labour Ward	Needles, Scalpels, Blades,	B2
	Placenta, Blood and Body Fluids	C1
	Gloves, masks, split disinfectant	B31
	Packaging	A
Laboratory	Sharps and Needles,	B2
	Culture, Stocks, tissue and	C1/D
	Containers	B31
	Methanol, methylene and other Solvent,	A1
	Packaging, Papers, Empty containers	A1
Pharmacy	Expired drugs, spilled drugs,	B31
	Packaging, Papers and empty container	A1

Source: Field Survey, 2021

For outpatient wards, hand gloves and swabs including needles and syringes (B2) all of which are medical waste requiring special attention. That of labor ward is as follows; needles, scalpel and blades (B2) and can be classified as risk medical waste. In the laboratory sharps and needles (B2) are common waste found and are risk medical wastes. And then in pharmacy unit, most commonly found medical waste are packaging, papers and empty containers (A1) which can be classified as non risk medical wastes. These results are supported by the study of Ishiyaku, (2015), in a research on medical waste management practices in Ahmadu Bello University Teaching Hospital (ABUTH) and Ahmadu Bello University Health Service (ABUHS), all the

waste categories according to UNEP/WHO classification were present except radioactive wastes, other hazardous wastes and human anatomical wastes are not present. The categories and sub-sets of healthcare waste yielded by the exercise comprise: Recyclable wastes, Biodegradable wastes, sharps, non-hazardous pharmaceutical wastes, potentially hazardous pharmaceutical wastes, cyto-toxic pharmaceutical wastes, blood and body fluids, Infectious wastes, highly infectious wastes, other hazardous wastes and radioactive wastes.

Akaeta and Danny (2013) had the highest diversity of wastes, most of which are classified as categories B and C. Categorization of waste in the facilities showed that all 12 (100.0%) facilities generated sharps , infectious and general waste, 6 (50.0%) generated pharmaceutical waste, 4 (33.3%) generated pathological waste . Neither radioactive, chemical nor genotoxic waste was generated in any facility. Ogolowa, (2013), in a study 'Biomedical waste disposal and Environmental Aesthetics of Tertiary Healthcare centers'. The results from the type and categories of BMW showed in both hospitals are generated by all irrespective of age and socioeconomic or status because of their numerous uses. The respondents agreed that all the listed items; Papers Bandages Cotton swabs used diapers and tissue. Non Degradable; syringes and needles, broken bottles, used blades plastics are generated as waste in the hospitals. This is concluded because all the items met the cut-off point of 1.0 and above. This therefore implies that all the listed items are forms of waste generated in the two hospitals. Further, all degradable wastes are known for their offensive odour and often constitute toxic leachate from the decomposed materials that ends up contaminating both soil and ground water.

4.2 Quantity of Medical Waste Generated at the Primary Healthcare Centers

Table 4.2 shows the quantity of waste generated by the PHCs found in the thirteen wards of Zaria Local government.

Table 4.2: Quantity of Waste Generated by the PHCs in Zaria LGA

PHCs	Number of Beds	Total waste generated (kg/day)	Average waste generated (kg/week)	Generation rate (kg/bed/day)
Kake	5	4.2	29.4	0.84
Tudun wada	9	7.03	49.1	0.78
Gyallesu	8	57.1	399.8	7.14
Dambo	8	4.13	29.1	0.52
Panmadina	5	2.34	16.5	0.47
Aba	4	2.03	14.3	0.51
Ang. Fatika	5	6.01	42.0	1.20
Ang. Liman	4	3.01	21.0	0.75
Ang. Alkali	4	3.25	22.7	0. 81
Durumin mai Garke	3	2.13	14.9	0.71
Babban Dodo	5	3.25	22.8	0.65
Ang Bishar	5	4.25	29.8	0.85
Tukur-tukur	9	7.13	49.8	0.79
Total	74	105.9kg	741.2kg	16.02

Source: Author's field Survey, 2021

It shows that the average waste generated (kilogram/week) in the selected PHCs, the highest recorded waste generation was found in Gyallesu (399.8kg/week) while the least waste generation is found in Durumin mai Garke and Aba (14.3kg/week) respectively. The difference between the highest waste generation and the lowest is attributed to the higher number of patients, at Gyallesu compared to Durumin mai Garke and Aba PHCs. It was observed that other PHCs have disparity in waste generation which means the weekly quantity of waste generation in these PHCs vary because of differences in the number of beds for patients.

In support of these results, is the study of Ishiyaku (2015) Assessed medical waste management practices in Ahmadu Bello University Teaching Hospital and Ahmadu Bello University Health

Services Zaria. The study established the total quantities of HCW generated at ABUTH and ABUHS as 845kg and 77kg per day respectively; which translates to 1.18kg and 1.54kg per day per bed at ABUTH and ABUHS respectively. This result is contrary to that of this study because it has a higher waste generation per bed/per day.

The reason is because primary health care centers are not as standard as university teaching hospital and university healthcare services. But another study on assessment of medical healthcare waste management practices in primary health care facilities in Edo state, Nigeria by Akaete and Danny, (2013) is in support of the findings of this study which revealed the average amount of health care waste generated from all the facilities over the 7 day period was 0.21kg/bed/day. Average amount generated from the out-patient unit and treatment rooms was 0.023 + 0.001 kg/person/day, and 0.012 kg+ 0.001 /bed/day in the inpatient wards. The Labour ward generated the most waste, 0.03 + 0.002kg/person/day However, from the results of this study; the number of beds in each PHC is a determinant for the quantity of waste generated per week.

4.3 Comparison in the Amount of Medical Waste Generated by the PHCs

To determine the differences in waste generation among the various PHCs, Analysis of variance (ANOVA) statistical technique was employed at 0.05 significant levels. The result for the hypothesis is presented in Table 4.3

Table 4.3. ANOVA Test Results of Differences in Waste Generation among the PHCs

		Sum of Squares	Df	Mean Square	F	Sig.
W	Between Groups	5273.003	12	439.417	.	.
	Within Groups	.000	26	.000		
	Total	5273.003	38			
NB	Between Groups	13.026	12	1.085	5.292	.000
	Within Groups	5.333	26	.205		
	Total	18.359	38			

Source: Author's Field Survey, 2022

NB- Number of beds. **W**- Waste generation

H0: There is no significant difference between the amounts of medical wastes generated by the PHCs in the study area. The study tested the null hypotheses at $p \leq 0.05$ significant level. However, the result shows that there is a significant difference in the amount of waste generation by statistical test of ANOVA. It is established that P-value = 0.00 with degree of freedom df = 12. This therefore, means that P-value is less than 0.05 significance level. This is strong evidence against the null hypothesis and we accept the alternative that there is significant difference between the amounts of waste generated across the PHCs in Zaria.

4.4: Method of Medical Waste Collection and Disposal

This section tries to analyze the third objective of the study on method of medical wastes collection and disposal. It was achieved by the use of bar charts.

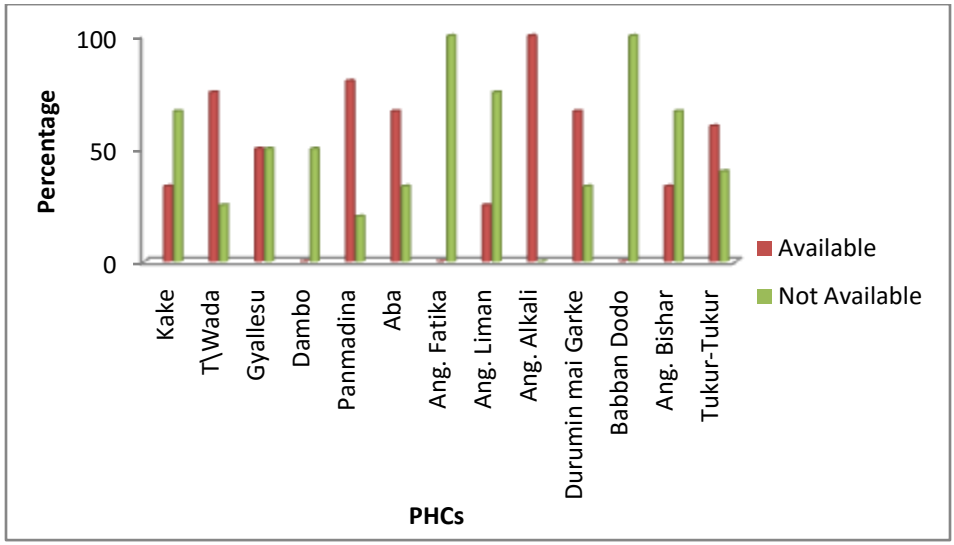


Figure 4.1: Availability of Receptacles/ Storage Containers by PHCs

Source: Author's Field Survey, 2021

Figure 4.1 show that Anguwan Fatika, Anguwan Alkali and Anguwan babban Dodo have the highest (100%) of respondents that confirmed availability of receptacles and storage equipment. The least being Anguwan Liman has 4 (25%). This is because apart from the highest three PHCs with available receptacles and storage equipment, Anguwan Liman has very minimal receptacles and storage equipment. Furthermore, observations around the PHCs with receptacle and storage containers was confirmed during a visit to these PHCs which have one form of container or the other for collection of medical waste as recommended by WHO (2005) In addition, this results is supported by that of Afolabi et al (2018), that (79.2%) stored their waste in dustbins.

Also (Coker et al 2009) reported the use of receptacles and container in healthcare centers in Nigeria such as plastic bags, paper bags or card boards. In addition, (79.2%) stored their waste in dustbins Afolabi et al (2018).

Table 4.4: Availability of Color Coding for Medical Waste Collection by the PHCs

PHCs	Yes		No	
	Frequency	Percentage	Frequency	Percentage
Kake	2	10.5	1	4
T/ wada	2	10.5	2	8
Gyallesu	1	5.3	3	12
Dambo	1	5.3	1	4
Panmandina	2	10.5	3	12
Aba	1	5.3	2	8
Anguwan Fatika	1	5.3	1	4
Anguwan Liman	1	5.3	3	12
Anguwan Alkali	1	5.3	1	4
Durumin mai Garke	2	10.5	1	4
Babban Dodo	2	10.5	2	8
Anguwan Bishar	1	5.3	2	8
Tukur-Tukur	2	10.5	3	12
Total	19	100	25	100

Source: Author's Field Survey, 2021

The finding in Table 4.4 shows Kake 2(10.5%), T/wada 2(10.5%), Panmandina 2 (10.5%), Durumin mai Garke 2 (10.5%), Babban Dodo 2(10.5%) and Tukur-Tukur 2 (10.5%) highest (10.5%) of respondents confirming the availability of colour coding in their PHCs respectively while the least was found at Gyallesu, Dambo, Aba, Anguwan Fatika, Anguwan Liman, Anguwan Alkali and Anguwan Bishar 1 (5.3%) respectively.

The reason for having a higher percentage in terms of usage of colour coding in waste collection by the six above mentioned PHCs is that they have a strong community participation in developing their health center, thus they were able to afford colour coding in medical waste

management practice. This implies the total percentage of the use of color coding and receptacles across all the PHCs studied is very low and there is need to further enhance the practice of using color coding and receptacles for medical waste materials in those PHCs with deficiency. In essence color coding helps the staff to easily identify which container to put the waste into, so that segregation can be maintained during transport, storage, treatment and disposal. This observation is in agreement with the study of Afolabi et al, (2018), assessed waste management practices among health care professionals at privately owned health facilities in Ife Central L.G.A. Only 25.0% reporting that they colour coded sorted medical waste and it indicate a low response.

SEGREGATION OF SHARPS OR INFECTIOUS MATERIALS

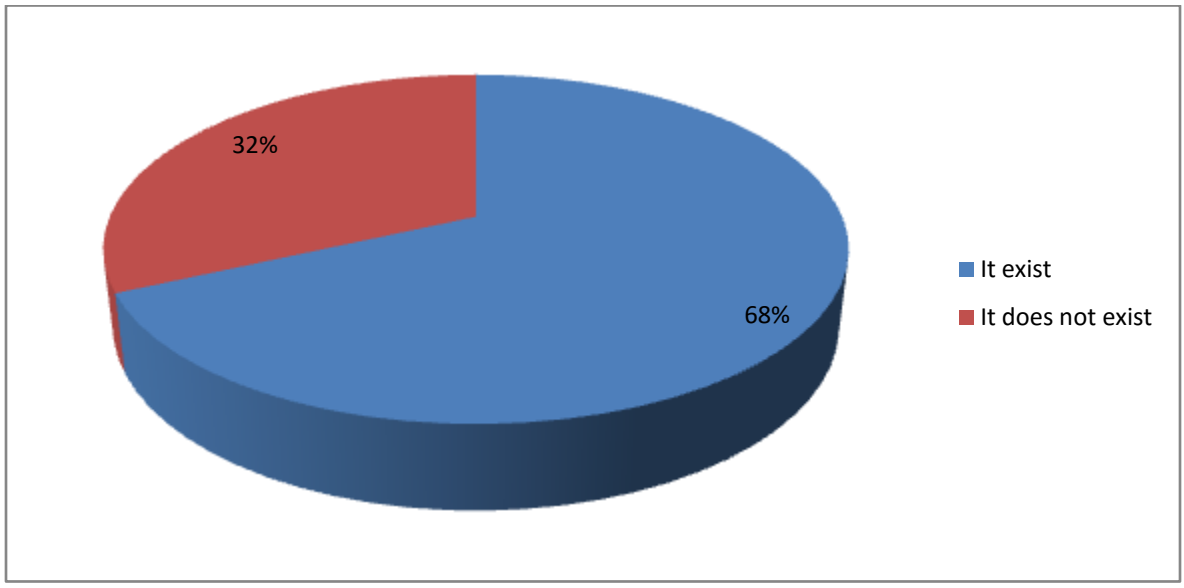


Figure 4.2 Distributions on Segregation of Sharps or Infectious Materials in the PHCs

Source: Author's Field Survey, 2021

The question of whether segregation sharps or infectious materials during waste collection exist is revealed in Figure 4.2 and it shows that majority 68% of the respondents

confirmed segregating sharp or infectious waste in the PHCs while the least 32% of the respondents had a contrary opinion as they do not segregate sharp or infectious wastes.

The reason for majority of the PHC practicing segregation of sharp or infectious wastes is because the state government and the communities are not putting in their contribution towards enhancing proper waste management when compared to others that do not practice segregation of sharps or infectious materials. These results are in line with that of Ndiaya et al (2012) that recorded absence of sorting, of medical waste at source to have (53.0%) and is regarded as high. However, Sengodan (2014) noted that effective segregation protocols significantly reduced biomedical waste generated from 2011 to 2012 in India.

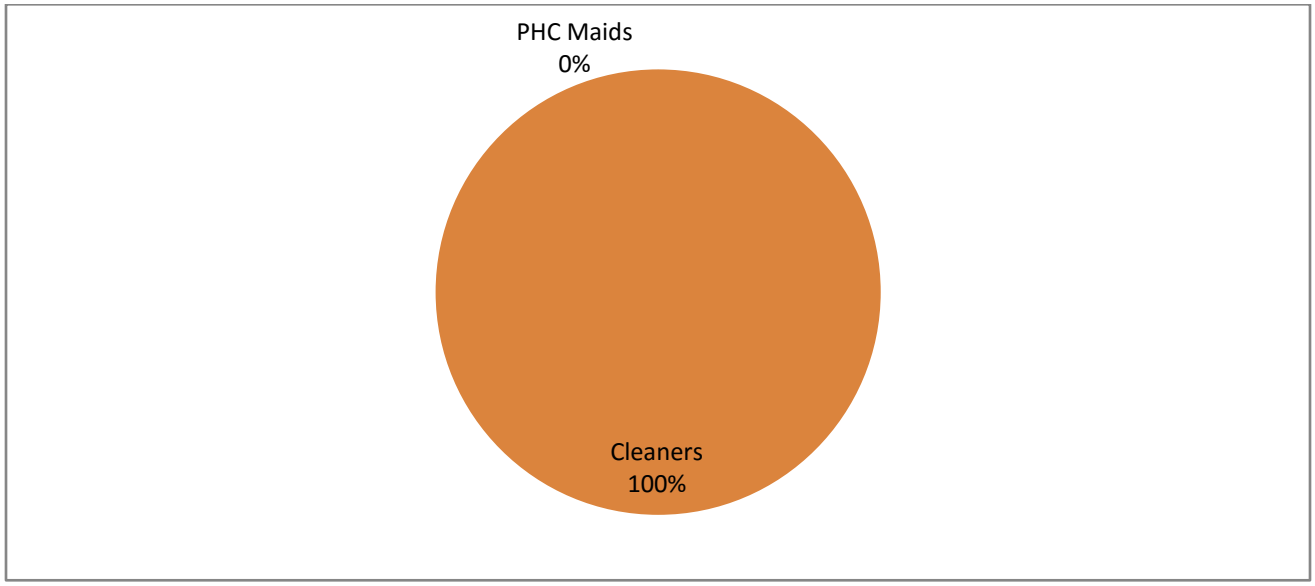


Figure 4.3: Waste Collection Personnel across the PHCs in Zaria LGA.

Source: Author's Field Survey, 2021

Figure 4.3 revealed 100% of respondents who were waste collection personnel. This means no other personnel of the PHCs are saddled with the responsibility of medical waste management practices except the cleaners and so they are at high risk of disease contamination.

This is to further say that, if the cleaners are well trained have equipments to handle waste management practices in the PHCs they would do it effectively. This could minimize hazards that non waste handlers are likely to face when they engage in waste handling because they do not have any form of training on waste handling.

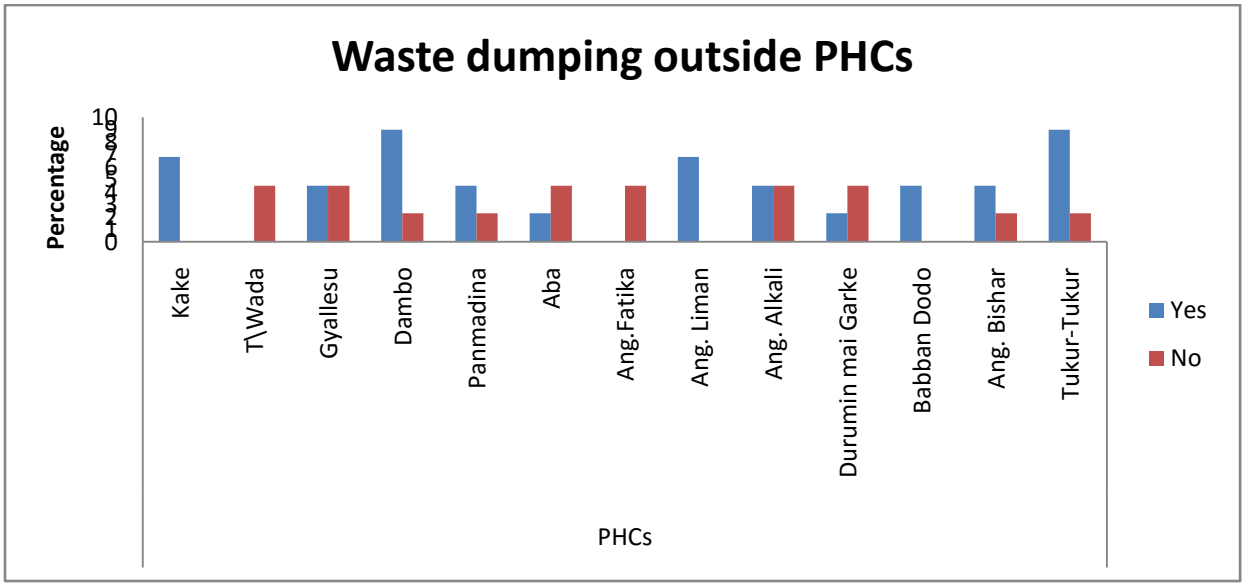


Figure 4.4 Waste Dumping Outside the PHCs in Zaria LGA

Source: Author's Field Survey, 2021

The reports obtained from respondents on the distribution of dumping of waste outside the PHC in Figure 4.4 shows that Dambo and Tukur Tukur have the highest number of respondents 4 (9.0%) that confirmed dumping outside their PHCs respectively while the least 1 (2.3%) was found at Aba and Durumin mai Garke PHCs. Waste dumping outside PHCs is a primary concern of the management of the PHCs and the waste handlers, therefore, the practice of waste dumping outside PHCs is generally poor as many of the PHCs do not practice it, which could pose treat to patients, health personnel and general public. This is consistent with (Kuroiwa et al., 2004). Dumping outside the facility premises poses health risks to patients and people residing close to healthcare facilities

4.4.1 Methods of Waste Disposal

4.4.1.1 Existence of Incineration Practice

Incineration as a practice, serve as a treatment practice to reduce the harmful effect of waste generated. The existence of incineration practice in the PHCs is shown in Figure 4.3.1.1.

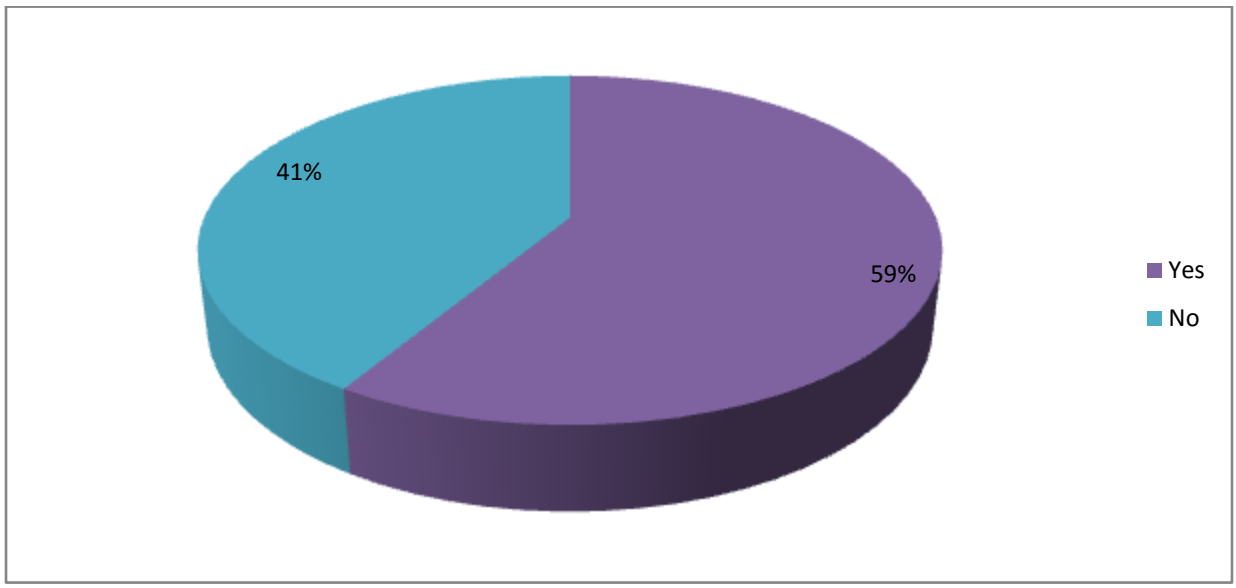


Figure 4.5: Incineration Practice across the PHCs in Zaria LGA

Source: Author's Field Survey, 2021

From the Figure 4.5 above, the highest 59% of the PHCs practice incineration method of waste disposal while the least 41% do not practice incineration method of waste disposal. The reason for not adopting incineration practice by 41% of the PHCs is because the PHCs do not have incinerators to store and burn waste generated in their PHCs.

Having majority of the PHCs practicing incineration method of waste disposal will promote a healthy environment free of health risks in those PHCs. It is in line with the work of Joshua et al (2014). The commonest method of treatment of hospital waste available in selected PHCs in Zaria was by incineration.

Table 4.5: Burying of Medical Waste in the PHCs

PHCs	Yes		No	
	Frequency	Percentage	Frequency	Percentage
Kake	2	6.8	1	6.6
T/wada	3	10.3	1	6.6
Gyallesu	2	6.8	2	13.3
Dambo	1	3.4	1	6.6
Panmandina	4	13.7	1	6.6
Aba	2	6.8	1	6.6
Ang. Fatika	1	3.4	1	6.6
Ang. Liman	2	6.8	2	13.3
Ang. Alkali	2	6.8	0	6.6
Durumin Mai Garke	1	3.4	2	13.3
Babban Dodo	3	10.3	1	6.6
Ang. Bishar	3	10.3	0	0.00
Tukur-Tukur	3	10.3	2	13.3
Total	19	100	15	100

Source: Author's Field Survey, 2021

Table 4.5.revealed that majority of the respondents 4 (13.7%) confirmed that burying of medical waste is being practiced in the PHC while the least 1 (3.4%) of respondents at Dambo, Anguwan Fatika, and Durumin mai Garke PHCs agreed that they do not bury their medical waste, respectively. The reason for this differences is that the PHC that bury its wastes found the practice as very important while others that do not bury medical wastes did not see waste burying as very important issue. However, other PHCs in the study area do not bury their waste completely which is shown in the table 4.3.2. Aside all these facts, it was noticed that some of the PHCs that do not bury their waste engage in burning the wastes. Both practices are good because waste could be infectious and part of environmental hazards. These results conform to that of Afolabi (2018) that claimed 20.8% buried the medical waste as a means of disposal.

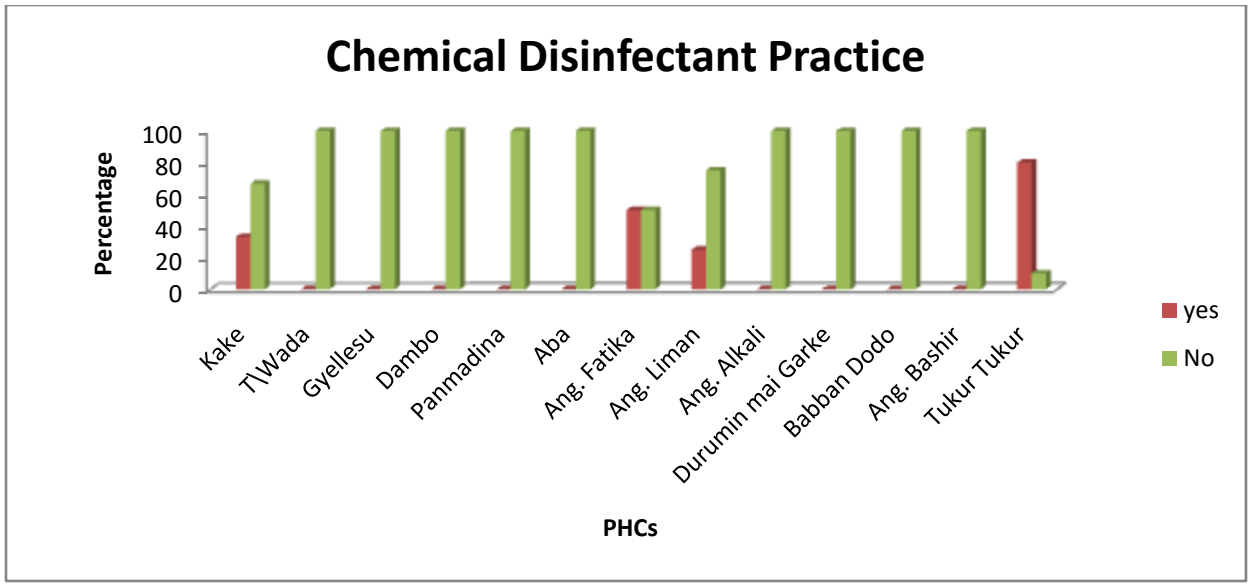


Figure 4.6 Chemical Disinfection Practice in the PHCs

Source: Author's Field Survey, 2021

Based on the report in Figure 4.6, Tukur Tukur was found the highest PHC (80%) that carryout chemical disinfection of waste as practices while the least (20%) was found at Anguwan Liman. Tukur-Tukur does this practice because the PHC is well developed and can afford the means to purchase chemicals to disinfect their waste. Anguwan Liman does not have this capacity except in their near future. However, as indicated, more than fifty percent (50%) of the PHCs in the study area does not practice chemical disinfection of waste. Since some of the medical waste is infectious, chemical disinfections of waste reduces the risk of getting contaminated particularly after disposal as they often do. Hence, lack of this practice could be disastrous to the PHCs and even the public health.

A similar study posited that treatment of healthcare waste before disposal or use of scientific methods of disposal are largely lacking in Nigeria as other developing countries due to lack of the fund to acquire the needed facilities (Ogbonna 2002).

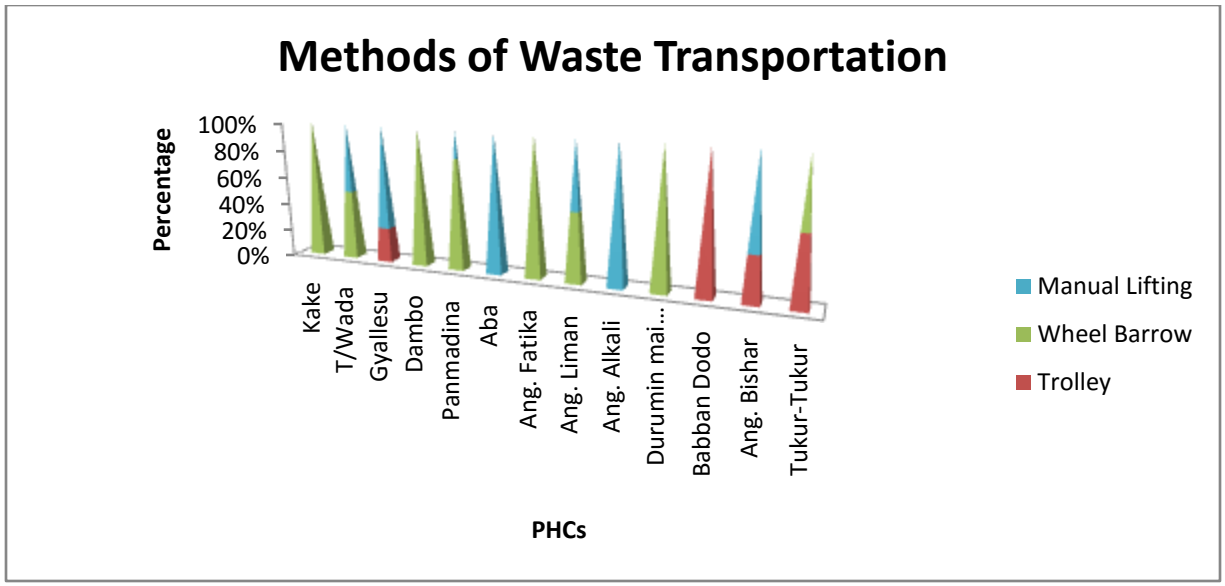


Figure 4.7 Transportation of Waste Disposal within the PHCs

Source: Author's Survey, 2021

In assessing the movement of medical waste from the source of generation to final disposal, Figure 4.7 revealed that that majority of the respondents at Kake 3 (100%), Dambo 4 (100%), Anguwan Fatika 2 (100%) and Durumin mai Garke 3 (100%) confirmed that transportation of medical waste by wheel barrow was the most used equipment respectively. The least (20%) in terms of using wheel barrow to transport medical waste was found at Tukur Tukur. Also, in terms of use of Trolley to move waste, the PHC with the highest usage of this equipment is Babban Dodo (66.6%) while the least is Tukur-Tukur with 3 (20%). Also, for manual lifting of waste, the highest was 2 (100%) and was found at Anguwan Alkali while the least 5(20%) was found at Panmandina. The variation in medical waste movement by the various PHC depend on their capacity to purchase better equipment such as trolley, vans etc. This observation conform with the study of Joshua, et al (2014) claimed that 66% confirmed wheel barrow as the commonest method of transporting medical waste in some selected primary healthcare centres in

Zaria. Transportation of medical waste is important thus, provision of mechanical means of transportation should be adopted by all the PHCs in the study area.

4.5 Challenges Faced by the PHCs

The challenges faced by the PHCs is presented in Table 4.5.1

Table 4.6: Challenges Faced by Primary Health Care Centers

PHCs	No equipment		release to toxins gases		sharp take Longer period		waste are mixed	
	Freq.	%	Freq.	%	Freq	%	Freq	%
Kake	0	0	1	33.3	0	0	2	66.6
T/wada	2	50	0	0	0	0	2	50
Gyallesu	3	75	0	0	1	25	0	0
Dambo	0	0	1	50	0	0	1	50
Panmadina	1	20	3	60	0	0	1	20
Aba	3	100	0	0	0	0	0	0
Ang. Fatima	0	0	0	0	0	0	2	100
Ang.Liman	1	50	1	25	2	50	0	0
Ang. Alkali	0	0	0	0	0	0	2	50
Durumin Mai Garke	3	100	0	0	0	0	0	0
Babban Dod	1	25	2	50	0	0	1	33.3
Ang. Bishar	0	0	0	0	1	33.3	2	66.6
Tuku Tukur	0	0	4	80	0	0	1	20

Source: Author's Field Survey, 2021

On the distribution of the challenges faced by the PHC, 0% of the respondents did not commented on the issue of no equipment but 33.3% indicated release of toxic gases as a challenge and sharp take longer period constituted 0% as 66% went for waste are being mixed. At Dandutse PHC 50% confirmed no equipment while 0% indicated no response. Again, 0% constituted no response for sharp take longer period and 50% went for wastes are mixed. 75% were for no equipment, 0% indicates no response, 25% were for sharp take a longer period while 0% indicates no response all at Gyallesu PHC. For Dambo PHC 0% indicates no response 50%

went for release of toxic gases. 0% indicates no response while 50% were for wastes are mixed. 20% were for no equipment while 60% went for release of toxic gases as 0% indicates no response; 20% were for wastes are mixed at Panmadina. At Aba, 100% were for no equipment, 0% no response, 0% for sharp take longer period and 0% did not respond at Aba. Similarly, 0% revealed no response for no equipment, 0% also revealed no response for release of toxic gases, 0% no response for sharp take long, 0% no response for sharp take longer period and 100% were for waste are mixed all at Anguwan Fatika. For Anguwan Alkali 0% indicate no response for no equipment, 0% no response towards release of toxic gases, 0% means no response for sharp take longer period while 50% were for waste are mixed. 100% were for no equipment, 0% indicates no response for release of toxic gases, 0% also indicates no response for sharp take longer period as 0% also showed no respondent responded on the challenge faced by PHC with regards to waste are mixed all at Durumin mai Garke. 25% were for no equipment, 50% for release of toxic gases, 0% indicates no responses while 33.3% were for waste are mixed at Babban Dodo. At Anguwan Bishar, 0% is for no response on no equipment, 0% too were for release of toxic gases, 33.3% confirmed sharps take longer period while 66.6% were for waste are mixed. Similarly, 0% indicates no response on no equipment, 80% indicates release of toxic gases, 0% no response on sharps take longer period as in the case of 20% that were for waste are mixed at Tuku Tukur.

The various challenges faced by the PHCs in the study area differ from one another because of location and capacity to overcome medical waste challenges. All the challenges can be overcome with a proper waste handling management. The results are in line with that of Ajimotokan and Aremu (2009), in a study titled “case study evaluation of health-care waste challenges in Hospitals within Ilorin metropolis”, found out that about 177.67Kg of waste was generated daily and the average waste generated per bed/per day was 1.56Kg. They further reported that the

management of the waste was often poor, with a mixture of potentially infectious and non-infectious waste being a common sight in the hospital waste bins and hospital environment.

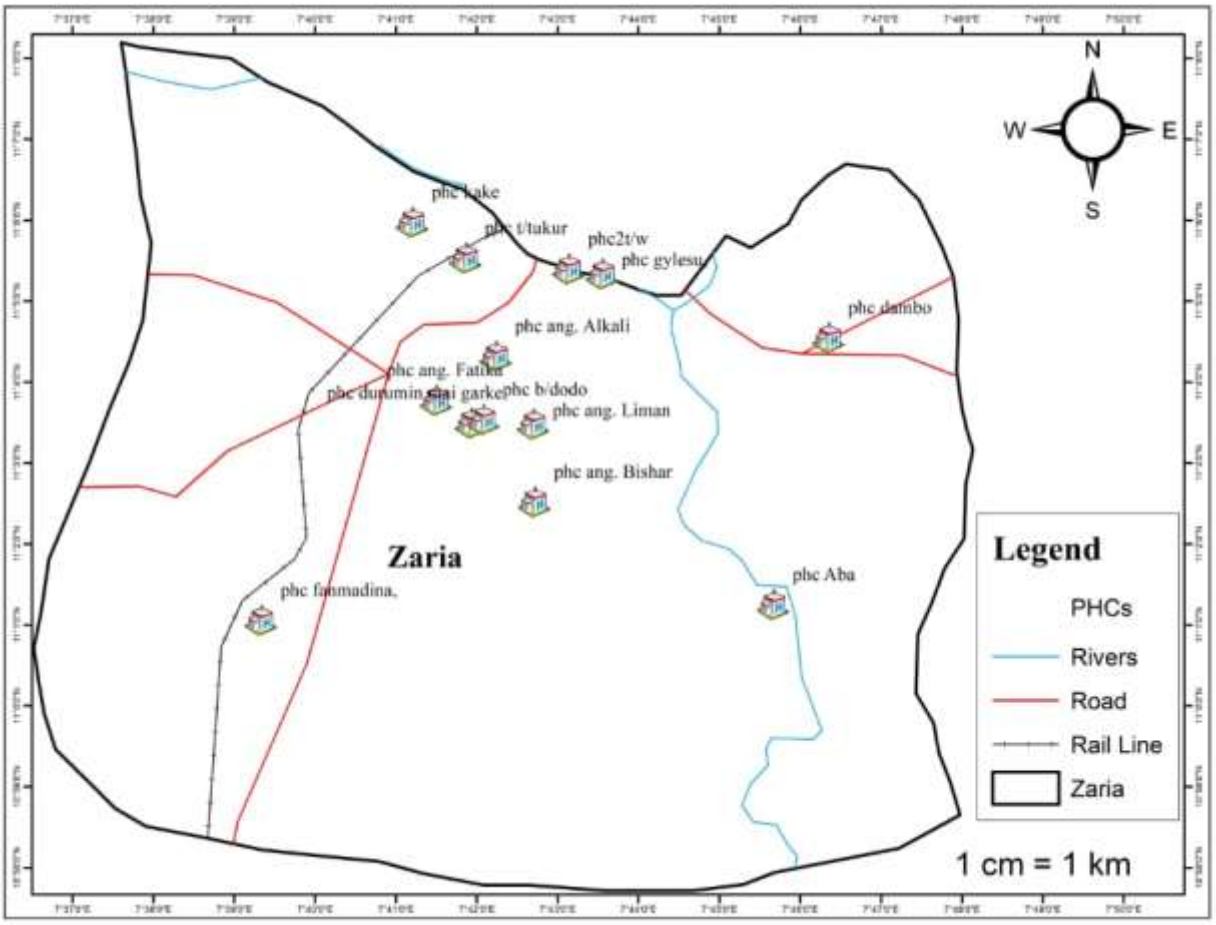


Figure 4.8: Shows the Location of the Primary HealthCare Centers in Zaria LGA

Source: Author's Field Survey, 2021

The Coordinates of the Primary Healthcare Centers selected at Zaria local government Area

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Major Findings

The study aimed at analyzing medical waste management practices in primary health care centers in Zaria Local Government Area of Kaduna State, Nigeria. One PHC was selected from each of the thirteen wards in the local government, making a total of thirteen PHCs. From the findings, types of medical waste generated in all the PHCs were categorized according to the UNEP/WHO classification. Group A (Non- Risk Medical Waste) were found to be the most common across the units/ wards. Group B2 include the risk medical waste.

The findings show that among the PHCs, Gyallesu PHC had the highest recorded waste generation of 399.8kg/week. And with regards to the difference in amount of wastes among the PHCs, statistical test of ANOVA indicated the difference in amount of waste among the PHC since $p \leq 0.05$ significant levels. However, the result shows that there is a significant difference in amount of waste generated by the PHCs based on ANOVA.

Similarly, the finding also revealed that Anguwan Fatika, Anguwan Alkali and Babban Dodo have the highest (100%) of respondents that confirmed they have available storage equipment. With regards to color coding of waste collection, the study showed that Kake, T/wada, Panmandina, Durumin mai Garke, Babban Dodo and Tukur-Tukur (10.5%) have the highest respondents confirming the availability of colour coding in their PHCs respectively.

In addition to the findings of this study, majority (68%) of the respondents confirmed segregating sharp or infectious waste in the PHCs is being practiced in their PHCs. (100%) of the respondents were waste collection personnel. Apart from that, Dambo and Tukur-Tukur had the highest number

of respondents (9.0%) that confirmed dumping of waste outside their PHCs. Again, the highest (59%) of the PHCs practice incineration method of waste disposal while majority of the respondents (13.7%) confirmed that burying of medical waste is being practiced in the PHC. Tukur-Tukur was the highest (80%) who confirmed chemical disinfection of Medical waste as a practice at the time of disposal. In the same vein, majority of the respondents at Kake, Dambo, Anguwan Fatika, Durumin mai Garke confirmed that transportation of medical waste is commonly done by wheel barrow. All the PHCs were facing challenges of medical waste management and the highest challenges faced in the following PHCs which are Panmandina, Anguwan Liman and Tukur-Tukur is the problem of no equipment for collection and disposal of wastes which accounted for 33.3% respectively.

5.2 Conclusion

Proper collection, segregation, colour coding and treatment of medical waste are important. There is no enough information on medical waste management technologies and its impact on public health and environment. Proper medical waste disposal and management practice is also inadequate. However, there is need for raising awareness about medical waste and its related issues. Proper monitoring and evaluation of medical waste management interventions should be implemented and also the need for medical waste management planning to facilitate the implementation of necessary measures to improve the present medical waste management situation.

CONTRIBUTIONS TO KNOWLEDGE BASED ON THE RESEARCH QUESTIONS

1. Medical wastes have been categorized based on UNEP/WHO classification and quantity of waste within the PHCs was determined using ANOVA. Tukur tukur PHC had 399.8kg per week of waste generation when compared with other PHCs, because there is disparity

in the number of patients visiting the PHCs. There is significant difference in the amount of waste generated by the PHCs at P = 0.000

2. The research was able to categorize the PHCs based on the method of waste collection and disposal. 68% confirmed segregation of sharp or infectious objects, and 13.7% confirmed that incineration is practiced in their PHCs.
3. All the PHCs were facing challenges of medical waste management and one of the major challenges faced by some PHCs is the problem of no equipment for collection and disposal of waste which accounted for 33.3%.

5.3: Recommendations

The following recommendations are proffered to the management of the PHCs for optimum performance level:

I. Adequate awareness should be created on associated health hazards to the people as a result of unsafe disposal of medical waste. There is also need for creation of more awareness and devotion of more resources to the management of medical waste among Primary Healthcare Centers in Zaria Local Government and in Kaduna State in general.

II. The weekly quantity of waste generation in the PHCs is attributed to the number of beds in the PHCs. This means there is need for procurement of more beds which will result to a higher generation of waste in the PHCS.

III. Training of staff: There is need for adequate budgeting in relation to training of staff on appropriate management of medical waste. There should be appropriate channels for educating medical staff on the acceptable ways of handling and disposing medical waste, these may include use of posters and other audio visual materials. Training of health

workers through attending conferences, seminars and workshops in order to increase their knowledge about medical waste, its risks and sanitation is very vital.

IV. There is need for improvement in the use of receptacles and storage containers so that a comprehensive system will address the issue of medical wastes handling, storing, transporting, treating or disposing of waste to prevent health risk of personnel, patients and the general public.

V. Ensuring waste separation, colour coding, to avoid mixed up of hazardous non hazardous and infectious waste and treatment of medical of medical waste should be done to minimize the release of toxic gases and also improve in segregation of sharps or infectious materials so as to enhance a better management of waste by waste handlers in the PHCs by the management

VI. Since more than half of the PHCs adopted incineration practice, there is need for others to do the same. The capacity to do that may not be available which calls for the attention of ministry of health to assist the PHCs with funds to enable them build incineration for a safe and healthy environment.

VII. It is advisable to bury infectious waste. This however, means that PHCs that exposed their waste are posing threat to the environment and the public so the PHCs should desist from doing that.

VIII. Movement of waste appears to be done with wheel barrow by most of the PHCs. This is not good enough compared to use of trolley and vans. The management of the PHCs should channel their complaint to the government about the inadequate waste transport system so that waste can easily and safety be transferred to dumpsites.

IX. There is need for the State government to provide the PHCs with modern waste disposal systems and equipment for effective management of medical waste because final disposal of waste using wheel barrows that usually do not have covers is dangerous and could aid in the spread of infections. Safety boxes should be evacuated as soon as possible, protective clothing and other materials should be provided and there should be employment of more health workers for cleaning of the PHCs.

X. There is also the need for the State government to enforce environmental sanitation by employing more health workers, and support them with materials and equipment for the day-to-day operation in environmental cleaning exercise in the state. There is need for proper enforcement of medical guidelines in relation to safety and efficient service delivery.

XI. Given the importance of the challenges faced by the PHCs and the current unsustainable level of performance, it is important to investigate the challenges further so as to proffer comprehensive solutions to the challenges.

XII. Further research should be carried out to analyze the effect of medical waste on water quality in the surrounding area. Another research can be carried out on Analysis of medical waste management on Secondary Healthcare Centers and also on Private Clinics

REFERENCES

Abdullah F, Qdais HA, Rabi A. (2008). Site investigation on medical waste management practices in northern Jordan. *Waste Management, 28 (2): 450-458...*

Abah SO.and Ohimain, EI." Healthcare waste management in Nigeria: A case study" *Journal of Public Health and Epidemiology* March, 2011, Vol. 3(3), pp. 99-110,

Adegbita, M. A. Nwafor S. O. Afon A. Abegunde A. A. Bamise CT (2010). Assessment of dental waste management in a Nigerian tertiary hospital. *Waste manag. Res., 28: 769-777.*

Adnane MI, Belkacem K, Abdelkarim E, Mohamed B. Medical Waste Management: A case study of the Souss-Massa-Drâa Region, Morocco. *J Environ Prot. 2013; 4:914–9. http://dx.doi.org/10.4236/jep.2013.49105 Published Online September 2013 (http://www.scirp.org/journal/jep).*

Afon, A.O. (2005). Solid waste management in selected cities of Oyo State, Nigeria. *Unpublished Ph.D. Thesis, Department of Urban and Regional Planning, Obafemi Awolowo University, Ile Ife, Nigeria, pp: 289-306*

Afolabi et al (2016) perception of healthcare workers in private healthcare facilities in an urban community in Nigeria. African Journal of Environmental Science and Technology

. Ajimotokan, H.A. and Aremu, S.A. (2009). *Healthcare waste management*. First annual civil engineering conference university of Ilorin, Nigeria, 26-28.

Akeate and Danny (2013) Health care waste management practice in Primary Healthcare Edo State, Nigeria.

Akter N. (2011). Medical waste management: A review, *international Journal of Science and Pharmaceutical Educational Research.1 (1);53-61*

Alagoz AZ, Kocasoy G. Improvement and modification of the routing system for the health-care waste collection and transportation in Istanbul. *Waste Manag. 2008;28:1461–71.*

Babanyara, YY. " An assessment of medical waste management practice(s) of Ahmadu Bello university teaching hospital (ABUTH) Zaria. Nigeria."2012. *Unpublished M.Sc. Thesis. Abubakar Tafawa Balewa University, Bauchi, Nigeria.*

Bartlett J.E.11, Kotrilik J.w, Haggings (2001) Organizational research; Determining appropriate sample size for survey research performance *Journal; 19 (1) 43-50*

Bassey B. E. Ben-Coker M. O. Aluyi H. S. (2006). Characterisation and Management of Solid Medical waste in Federal capital Territory, Abuja Nigeria. *Journal of African Health Sciences 6;6(1): 65-67*

Birpınar, Mehmet Emin, Bilgili, Mehmet Sinan, Erdogan, Tugba. (2009). Medical waste management in Turkey: A case study of Istanbul. Waste Management 29, 445–448.

Blenkham JI (1995) The disposal of clinical wastes. *Journal of Hospital Infection 30: 514–520.*

Code, A. and Christen, J "How are we managing our healthcare wastes? St. Gallen, 2015, Switzerland: SKAT.

Coker, A. and Sridhar, M. K. C. "Increase in healthcare facilities and rapid environmental degradation: A technological paradox in Nigeria's urban centers", *African Journal of Environmental Science and Technology. September, 2010 .Vol. 4(9), pp. 577-585.*

Cheng, Y.W. Sung, F.C, Yang, Y, Lo, Y.H.. Chung, Y.T and Li, K.C. (2009). Medical waste production at hospitals and associated factors. *J. Waste Manage., 29: 440-444.*

Chua T. Puziah A.L. Subramaniam A. K. Medical waste management in private medical clinic Taipin, Perak. *International conference on Ecological Environmental and Bio science. (2012).*

Coker, A.O. Sangodoyin A.Y. and Ogunlowo, O.O. (1998). Managing Hospital Wastes in Nigeria. *Proceedings of the 24th Annual Conference of Water Engineering and Development Centre (WEDC), Loughborough University, U.K., pp:70-72.*

Coker (2009). Medical waste management in Ibadan, Nigeria: Obstacles and Prospects. February 2009. *Waste Manag., 29(2): 804-811.*

Da Silva CE, Hoppe AE, Ravanello MM, Mello N (2005). Medical waste management in the south of Brazil. *Waste Manage., 25: 600-605.*

Dehghani MH, Azam K, Changani F, Dehghani EF. Assessment of medical waste management in Educational Hospitals of Tehran University Medical Science. Iran *J Environ Health Sci Eng. (2008);5(2):131–6.*

Diaz LF, Savage GM, Eggerth LL. (2005). Alternatives for the treatment and disposal of health care wastes in developing countries. *Journal of waste management; 25; 626-637*

Draft of the National Health Care Waste Management Plan in Nigeria (2007). *Prepared for the Federal Ministry of Environment (FMENV). In collaboration with John Snow Incorporation Nigeria (JSI).*

Edmund JJ. (2012) "Characterization and analysis of medical solid waste in Osun State, *African Journal of Environmental Science and Technology*. *December (2012), Vol. 5(12), pp. 1027-1038*

Emery, V. David JR. Wenchao, J Mmereki, D. John, Y. Heriniaina. F. (2016). Health Care Waste Management Practices in Liberia: An Investigative Case Study. World Academy of Science, Engineering, and Technology; *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering 10:1*

Farzardkia, M. Jorfia, S. (2016). Hospital waste management practices; A case study in Iran. World Academy of Science, Engineering, and Technology; *International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering, 10;2*

Hayashi Y. Shigematsu, M. (2000). Proper disposal management of medical wastes infection prevention and waste management *(Clean Hospital Project) at Hiroshima City, Asa Hospital. Rinsho Byori (Suppl. 112), 26–31.*

Health-Care Without Harm, (HCWH), (2001). Waste Minimization, Segregation and Recycling in Hospitals Health Care Without Harm on the Web *at World-Wide Web www.noharm.org. This version: October 15, 2001. Washington, DC 20009*

Ibijoke, I Babajide, A. Williams A. and Rafid, AK. " Profile of medical waste management in two healthcare facilities in Lagos,.Nigeria" *Waste management and research,(2013). Vol.31.pp494-501*

Ishiyaku (2015) Assessment of Medical Waste Management Practices in ABU Zaria Teaching Hospital and ABU University Health Service: An unpublished thesis

Joshua I.I. A. Joshua1, *, S., S. Mohammed2, Makama3, W., W. I. Joshua4, Audu, Nmadu 6, J., J. B. Ogboi (2014) Hospital Waste Management as a Potential Hazard in Selected Primary Healthcare Centres in Zaria, Nigeria. Nigerian Journal of Technology (NIJOTECH2014, pp. 215 – 221 vol.33, No. 2, April 2014, pp. 215 – 221

Kane, A. Lloyd, J. Zaffran, M. & Kane M. Ref. (1999) In Focus Unsafe injections in the developing world and transmission of blood borne pathogens. *No. 0058 789 Bulletin of the World Health Organization, 77 (10) 801-807.*

Kuroiwa C, Suzuki A, Yamaji Y, Miyoshi M (2004). Hidden reality on the introduction of auto-disable syringes in developing countries. Southeast Asian J. Trop. Public Health, 35: I0-1023.

Longe E. O. Williams A. A. (2006). A Preliminary study of medical waste management in Lagos Metropolis, Nigeria. Iran *journal of environmental health science;3(2):133-139*

Manyele, SV. (2015) "Effects of Improper Hospital Waste Management on Occupational Health and Safety", *African Newsletter on Occupational Health and Safety, Vol.14 pp30-33*

Manyele, SV. and Anicetus, H. (2011) "Management of medical waste in Tanzanian hospitals" *Tanzania Health Res. Bull,* 2011, Vol. 8(3) pp177-182

Massrouje, H.T.N. - Nov. (2001) Medical waste and health care workers in Gaza governorates. *Eastern Mediterranean Health Journal, volume7 No.6 (1017-1024).*

Miyazaki, M., Une, H., (2005). Infectious waste management in Japan: *A revised regulation and management process in medical institutions. Waste mange. 25,616-621*

Manohar, D. Reddy, P.R. and Kotaih, B. (2016). "Characterization of solid waste of a super specialty Hospital: a case study". *Ind. J. Environ. Health,* Vol, 40, pp. 319-326.

Mahmood SS, Malik R, Azim W. (2003) A Study of waste generation, collection and disposal in a tertiary hospital in Pakistan. *Journal of medical research; 24(4):13-17*

Mortimore, M.J. (1970). "Historical Development". In Mortimore M.J. (Ed), *"Zaria and Its Region".*Occassional Paper No.4. Geography Department. A.B.U Zaria

Nwachukwu, I.C. (1990). "The Role of Education in the Development of Rural Zaria." Unpublished M.Sc. Thesis, Department of Geography, A.B.U Zaria.

Nascimento, TC. Januzzi, WA. Leonel, M. Silva, VL. and Diniz, CG. (2014) "Occurrence of clinically relevant bacteria in health service waste in a Brazilian sanitary landfill and antimicrobial susceptibility profile". *Rev. Soc. Bras. Med. Trop.* 2014, Vol., 42(4) pp., 60-79.

Nigeria Metro Area population(1952-2022)

Ngwuluka, N. Ochekpe, N Odumosu, P. and John, S A. " Waste management in healthcare establishments within Jos Metropolis, Nigeria" *African Journal of Environmental Science and Technology,* 2009 .Vol.3 (12), pp., 459-465.

Ogbonna, DN. Chindah, A and Ubani, N. "Waste management options for health care wastes in Nigeria: A case study of Port Harcourt hospitals" *Journal of Public Health and Epidemiology*. June 2012Vol. 4(6), pp.156-169

Ogbonna DN. "Characteristics and Waste Management Practices of Medical Waste in HealthCare Institutions in Port Harcourt, Nigeria". Journal of Soil Science and Environmental Management, 2002, 2(5): pp132-141

Ogolowa Marcel ogie, "Biomedical Waste disposal and Environmental Aesthetics of Tertiary Healthcare Centers in Federal capital Territory, Abuja: An Unpublished Thesis 2013

Olubukola, B. O. "Comparative Analysis of Health Care Waste Management Practice in Two General Hospitals in Nigeria". Available at; www.ecoweb.com/edi/index.htm.,Accessed, August 10, 2012.

Oke IA. (2008). Management of immunization solid wastes in Kano state, Nigeria. *Waste Manage., 28: 2512-2521*.

PRISM Bangladesh, (2013). Survey on Quantitative and qualitative assessment of medical waste generation and management in Dhaka North City Corporation and Dhaka South City Corporation, *(Unpublished survey report), Dhaka*.

Patil, A. D., and Shekdar, A.V. (2011). "Health-care waste management in India". *Journal of Environmental Management, 2011.Vol. 63, pp, 211– 220.*

Palanisamy, P. Sivaraman, S. Babu, S P. and Athimoolam, A. (2011), Biomedical waste management for health care industry" *International Journal of Biological & Medical Research.*2011, Vol. 2(1) pp. 472-486

Pruss A, Giroult E, Rushbrook D (1999). Safe management of waste from healthcare activities. Geneva: *Word Health Organization.*

Prüss, Annette Giroult, Eric Rushbrook Philip, (1999). Safe management of wastes from health-care. *ISBN 92 4 154525 9 (NLM classification: WA 790).WHO.*

Rao, HP. "Report: Hospital waste management- awareness and practices: a study of three states in India. *Waste management and Research, (2008), Vol.26, pp297-303.*

Remy L. (2001). Managing Hospital Waste is a Big Nasty Deal, *Great Western Pacific Coast.*

Semwal, R., Dharmendra. (2016). Environmental concern and threat investigation due to malpractices in biomedical waste management: a review. *Proceedings of IRF International Conference, Goa, India, ISBN:* 978-93-85973-54-3

Sengodan (2014), "Segregation of biomedical waste in an South Indian tertiary care hospital," *Journal of Natural Science, Biology and Medicine*, vol. 5, no. 2, pp. 378–382, 2014.

Solberg KE (2009). Trade in Medical waste causes deaths in India. *The lancet onlineRetrieved16-05-2013 http//www.thelancet/journals/lancet/articles/11;140-6736(09)60632-2*

Silva, C.E. Hoppe, A.E. Ravanello, M.M. and Mello, N. "Medical waste management in the south of Brazil" *Waste Management, (2005), Vol. 25(6) pp. 600–605.*

Silva, C.E., Hoppe, A. E., Ravanello, M. M., Mello, N. (2002). Medical waste generation in the Vacaca ´ river basin - RS. In: *Proceedings of the Sixth National Seminar on Solid Wastes. Gramado, RS, Brazil, pp. 1-4.*

Singh S.Prakash V. (2007) Toxic environmental releases from medical waste incineration: *A review of environmental monitoring; 132:67-31. Retrieved 15-05-2013. http://www.ncbi.nlm.nih.gov/pubmed.*

Shinee, E. Gombojav, E. Nishimura, A. Hamajima, N and Ito, K. "Healthcare waste management in the capital city of Mongolia", *Waste Management, (2008) Vol. 28, 435–441.*

Toyobo, A. E. Baba, A. O. & Oyeniyi, 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,* September, 2012 Vol. 1(9) pp. 290-297.

Taru, P. Kuvaraga A. j. (2005) Solid waste management: The case of Palirenjatwa hospital Zimbabwe*, Rev biomedical journal ; p16:157-158*

Townend, WK, Cheeseman CR (2005). Guidelines for the evaluation and assessment of the sustainable use of resources and of wastes management at healthcare facilities. *Waste Manage. Res., 23: 398-408.*

Tudor, TL,Townend WK, Cheeseman CR, Edgarv JE.(2009) An overview of Arising and large scale treatment technologies for healthcare waste in the united Kingdom. *The Journal of the international solid wastes and public cleansing association; 27 (4):374*

UNEP, (United Nations Environment Program) "Minimizing Hazardous Wastes": *A Simplified Guide to the Basel Convention; France, 2000. GE 04-03062.*

Uwa, C.U. (2008). Assessment of healthcare waste management in tertiary health facilities in Enugu metropolis, *PhD Thesis, Centre for Environmental Management and Control, University of Nigeria, Enugu campus, Nigeria*

Umar, A. B. & Mohammed Nura Yahaya (2014). Hospital Waste Management Practices: A Case Study of Primary Health Care Centers, In Fagge Local Government Area, Kano State. *IOSR Journal of Nursing and Health Science (IOSR-JNHS) e-ISSN: 2320–1959.p-ISSN: 2320–1940 Volume 3, Issue 6 Ver. II (Nov.-Dec. 2014), PP 26-33 www.iosrjournals.org*

World Health Organization (WHO), (1999) "Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies," *WHO/EDM/PAR/99.2. Geneva: WHO. 2000.*

World Health Organization (WHO), 2004 "Health-care Waste Management". *policy paper, Department of Protection of the Human Environment Water, Sanitation and Health20. Geneva 27, Switzerland.*

WHO (2002). Wastes from healthcare activities. *Fact sheet no 231, April 2002. Available at (http://www.who.int/mediacentre/factsheets/fs231/en/). Accessed 12 September, 2009.*

WHO (World Health Organization) (2005) Understanding and simplifying bio-medical waste management. *A training manual for trainers. Available at: http://www.noharm.org/detailcfmID=1197andtype=documentwater_sanitation_health/medicalwaste/decisionmguiderev221105.pdf (accessed December 2012)*

WHO, (2006) a global perspective of definition of primary healthcare centers.

Yong, Zhang, Gang, Xiao, Guanxing, Wang, Tao, Zhou, Dawei, Jiang (2009). Medical waste management in China: A case study of Nanjing. *Waste Management 29, 1376–1382.*

Yitayel, S. Tamrat, A. and Adane, M. (2012),"Sharps injuries and exposure to blood and bloodstained body fluids involving medical waste handlers." *Waste management and Research, 2012.Vol. 30, pp. 1299-1305.*

ZAICON DIGITAL TECHNOLOGIES LTD copyright2022. *(Hospital Book by facility)*

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT

FACULTY OF PHYSICAL SCIENCE

AHAMADU BELLO UNIVERSITY, ZARIA

Msc Environmental management

Dear respondent,

I am currently carrying out a study on the **ANALYSES OF MEDICAL WASTE MANAGEMENT PRACTICES OF PRIMARY HEALTH CARE CENTERS IN ZARIA LOCAL GOVERNMENT, KADUNA STATE.** This study is an academic research giving to the award of Master of Science Degree in Environmental Management in the above named institution. All information and data gathered in the course of this study shall strictly be used for academic purposes. Therefore your responses will be treated with confidentiality.

Thank you.

Kauthar Abubakar Mikail

Msc /PsGs8070/2016-2017

For how long have you been acquainted with the PHC? a)2years-4years b)5years-8years c)9years and above

Do you have waste bin in your PHC?

Yes or N0

What are the types of solid waste generated in the PHC?

_____

_____

_____

How are they distributed?

_____

How is waste collected and transported within the PHC? a) using wheel barrow b)using cart c)using bare hands d)others_____

How is waste transported off-site?

cart b) wheel barrow c)vehicles d) others_____

Who are those responsible for the transportation? a) Trained staff b)private company c)Govt. agency d)others_____

Does infectious waste labeled at the time of disposal? Yes or No

Is there any form of treatment done to the infectious waste before disposal? Yes or No

If yes, what do you use in treating the waste? a) chemical disinfectants b)Auto clave and retort treatment c) micro wave treatment d) others____

For how long is waste stored before disposal? a) 1-12hours b)13-24hours

25-48hours d) others_____

What is the quantity of syringe generated per week in your PHC ? a) less than 200 b) 201-400 c) 400- 600 tons d) more than 600

How many times do you dispose your waste? a) once a week b)twice a week c)trice a week d) others_____

Where do you dispose your medical waste? a) authorized HCW collection site b)House to house waste collection site c)municipal waste disposal site d)others_____

What type of protective clothing does your PHC used in medical waste disposal? a) hand gloves b) boots c) apron d) others_____

Is there any waste management programme or policy being implemented in your PHC? yes or No, if yes state_____

Are there specific personnel assigned to the management of medical waste in the PHC? Yes or NO

Is there any training programme for the personnel? Yes or No

Which method of waste disposal does your HCC practiced? a) incineration method b) deep burying method c) open dumping method d) others____

What are the challenges faced in managing Medical waste in your PHC?

_____

_____

_____

How effective is the management of Medical waste in your PHC?

_____

_____

APPENDIXES



Plate 4.1 Primary Healthcare center located at Babban Dodo Zaria city

Source: Author's Field Survey, 2021



Plate 4.2 Deep Burying dumpsite located at Tudun Wada Primary health care center

Source: Author's Field Survey, 2021



Plate 4.3 An Open Dumped site located at Dambo Primary Healthcare center

Source: Author's Field Survey, 2021



Plate 4.4 Safety Box

Source: Author's Field Survey, 2021



Plate4.5: A waste bin at Durumin Mai Garke PHC

Source: Author's Field Survey, 2021



Plate4.6: An open dumped site at Aba PHC

Source: Author's Field Survey, 2021