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**Department Environment and Natural Resource Management**

**AN ASSESSMENT OF THE EFFECTIVENESS OF MEDICAL WASTE  
MANAGEMENT IN THREE HEALTH CARE CENTERS IN BUEA, CAMEROON**

A Thesis Submitted to the Department Environment and Natural Resource Management, in  
Partial Fulfilment of the Requirements for the Award of a Master of Science (M.Sc.)  
degree in Environment and Natural Resource Management

**BY**

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**BUEA, AUGUST 2015**

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## **DEDICATION**

This work is dedicated to my dear parents,  
Mr. Azeh John Muma and Mrs. Lum Gladys Azeh.

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## **LIST OF ABBRIVATIONS**

|                |                                        |
|----------------|----------------------------------------|
| <b>SBS</b>     | Sick Building Syndrome                 |
| <b>US</b>      | United States                          |
| <b>HIV</b>     | Human Immune Virus                     |
| <b>AIDS</b>    | Acquired Immune Deficiency Syndrome    |
| <b>HCRW</b>    | Health Care Related Waste              |
| <b>POP</b>     | Persistent Organic Pollutants          |
| <b>UNEP</b>    | United Nations Environmental Programme |
| <b>FAO</b>     | Food and Agriculture Organisation      |
| <b>PIC</b>     | Prior Informed Consent                 |
| <b>HCC</b>     | Health Care Centre                     |
| <b>HYSACAM</b> | Hygiene et Salubrité du Cameroun       |

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## **ABSTRACT**

This study, aimed at assessing effectiveness of medical waste management, was carried out in the South West Region, Cameroon, with objectives to: identify medical waste management systems in three healthcare centres/hospitals in Buea; assess methods of waste management systems and compare these management systems with WHO standards. Health care centres were selected based on availability and closeness to the area of study. Scientific knowledge and know-how on concepts of modern medical waste management were tested. All aspects and equipment used in medical waste management were examined. Results revealed that medical wastes produced from different departments of the three healthcare centres were poorly managed. Separation was applied only for sharp wastes, collected in special sharp boxes after use. Waste storage time (in plastic and metal containers with or without plastic lining and biohazard symbols) was less than 48 hrs. Collection was done first by medical staff, and then transported, with other waste by cleaners. Waste bags were constantly subject to tear and consequently spilling of the waste. 27% of the respondents were aware of a temporal storage site, 33% had no idea and 27% were ignorant about a storage site in the hospitals. Training courses and awareness programs on medical waste management for health care providers and workers at hospitals were limited or not provided. Medical wastes management was not judiciously planned; hence they were not treated and disposed of in accordance with Schedule I, and not in compliance with the standards prescribed in Schedule V of WHO standards. However, the health care centres have set up some requisite bio-medical waste treatment facilities (in accordance with time-schedule), like incinerator, autoclave, microwave system for treatment of waste, and ensure requisite treatment of waste at a common waste treatment facility or any other waste treatment facility. Bio-medical waste is not segregated into containers/bags at point of generation in accordance with Schedule II prior to storage, transportation, treatment and disposal.

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## **ABSTRAIT**

Cette étude a pour but l'évaluation de l'efficacité de la gestion de déchets médicaux. Elle a été menée dans la région du Sud-Ouest, Cameroun, avec pour objectifs : l'identification des systèmes de gestion de déchets médicaux de trois centres hospitaliers à Buéa ; l'évaluation des méthodes des systèmes de gestion de déchets et la comparaison de ces systèmes de gestion selon les normes de l'OMS. Les centres de santé ont été choisis en fonction de leur disponibilité et proximité au champ de l'étude. La connaissance scientifique et le savoir-faire sur les concepts modernes de la gestion de déchets médicaux ont été testés. Tous les aspects et équipements utilisés dans la gestion de déchets médicaux ont été examinés. Les résultats ont révélé que les déchets médicaux produits par les différents services de trois centres de santé étaient mal gérés. Seuls les déchets tranchants étaient séparés et collectionnés après usage dans des boîtes spéciales pour objets tranchants. Le temps de stockage de déchets (dans des contenants en plastique et en métal avec ou sans revêtement plastique, ni symboles de danger de contamination) étaient de moins 48 heures. La collecte était d'abord effectuée par le personnel médical, puis transportée avec les autres types de déchets par les agents d'entretien. Les sacs à rebut étaient constamment déchirés et par conséquent, les déchets se répandaient. Parmi les répondants, 27% étaient au courant d'un site de stockage temporel, 33% n'en avaient aucune idée et 27% ignoraient l'existence d'un site de stockage dans les hôpitaux. Les cours de formations et les programmes de sensibilisation du personnel de centre de santé et des employés d'hôpitaux sur la gestion de déchets médicaux étaient limités ou non existants. La gestion de déchets médicaux n'était pas planifiée de manière judicieuse ; donc, les déchets n'étaient pas traités et jetés selon Annexe I, et la gestion n'était pas en accord avec les normes prescrites dans Annexe V des normes de l'OMS. Toutefois, les centres de santé se sont équipés de quelques matériels pour le traitement de déchets biomédicaux (selon temps-Annexe) comme l'incinérateur, l'autoclave, le système micro-onde pour le traitement de déchets, et s'assurent du traitement de déchets requis à l'installation du traitement de déchets ordinaire ou toute autre installation de traitement de déchets. Les déchets biomédicaux ne sont pas séparés dans des contenants/sacs au point de génération selon Annexe II avant le stockage, transport, traitement et ramassage.

## CHAPTER ONE

### INTRODUCTION

#### **1.1. Background of the study**

Over the years, the world has witnessed a rapid population growth in different patterns which has equally led to extraordinary waste generation. In many developed and developing countries, collection, transportation, treatment and disposal of waste are the major challenges for government, organizations and other institutions (WHO, 2012).

Medical waste or clinical waste is classified as one of the most hazardous wastes in the world. Clinical waste refers to any waste that is generated during medical activities such as diagnosis, monitoring, and immunization or treatment of human beings or animals (Rutala and Mayhall, 1992). It includes viruses and bacteria that potentially cause diseases which are produced by hospitals, clinics, and other types of healthcare institutions. Medical care is vital for our life, health and well-being.

The waste generated from these medical activities can be hazardous, toxic and even lethal because of their high potential for diseases transmission. These wastes also present additional risks to staff of healthcare facilities, patients and the community if the wastes are not managed properly (Baveja et al, 2000; Silva, 2005). The risk results from poor handling, improper disposal of medical waste which include open dumping and uncontrolled burning which increases the risk of spreading infections and of exposure to toxic emissions from incomplete combustions. According to Hakim et al, 2014 medical waste management has recently emerged as an issue of major concern not only to hospitals, primary health-care centres and nursing home authorities but also to the environment. Advances in medical facilities and the development of more sophisticated instruments have increased the waste generation per patient in health-care units worldwide. According to the World Health Organization (WHO, 2012), high-income countries generate on average up to 0.5 kg of hazardous waste per hospital bed per day. Although the figure for low-income countries is only 0.2 kg per hospital bed per day, healthcare waste is often not separated into hazardous or non-hazardous wastes, making the real quantity of hazardous waste potentially much higher. Hakim et al, 2014 also said clinical solid waste is a particular challenge in most health-care facilities of the developing world. Poor handling practices and inappropriate disposal of hospital waste is an increasing health hazard in these countries. For example, hazardous and medical wastes are handled and disposed of together with domestic wastes, thus creating a health risk to municipal workers, domestic animals, the general public and

the environment. In developing countries where some efforts have been made to tackle the problem, waste disposal options are limited, and small-scale incinerators are used as an interim solution.

#### **1.1.1. DESCRIPTION OF STUDY AREA**

Buea is the capital of the South West Region of Cameroon. The town is located on the eastern slopes of Mount Cameroon and has a population of about 90,088 as of the 2005 census.

#### **1.1.2. Geographical location and topographic situation**

Geographically, Buea lies between latitude 4.15 N and longitude 9.24E. It has coordinates by time N 4° 9' 9" and E 9° 14' 27". Buea is 870 meters above sea level and lies on the Eastern slope of Mount Cameroon, with a steady slope toward the mountain. The soil type is of volcanic origin hence rich in volcanic ash.

#### **1.1.3 Physical characteristics**

##### ***1.1.3.1 Climate***

Buea is found at the foot of the Mount Cameroon and because of this location the climate tends to be humid, with neighbourhoods at higher elevation enjoying cooler temperatures while the lower neighbourhoods experience a warmer climate. Extended periods of rainfall, characterized by incessant drizzle, which can last for weeks, are common during the rainy season( from Mid-March to Mid-November) as well as damp fogs rolling off the mountain into the town below.

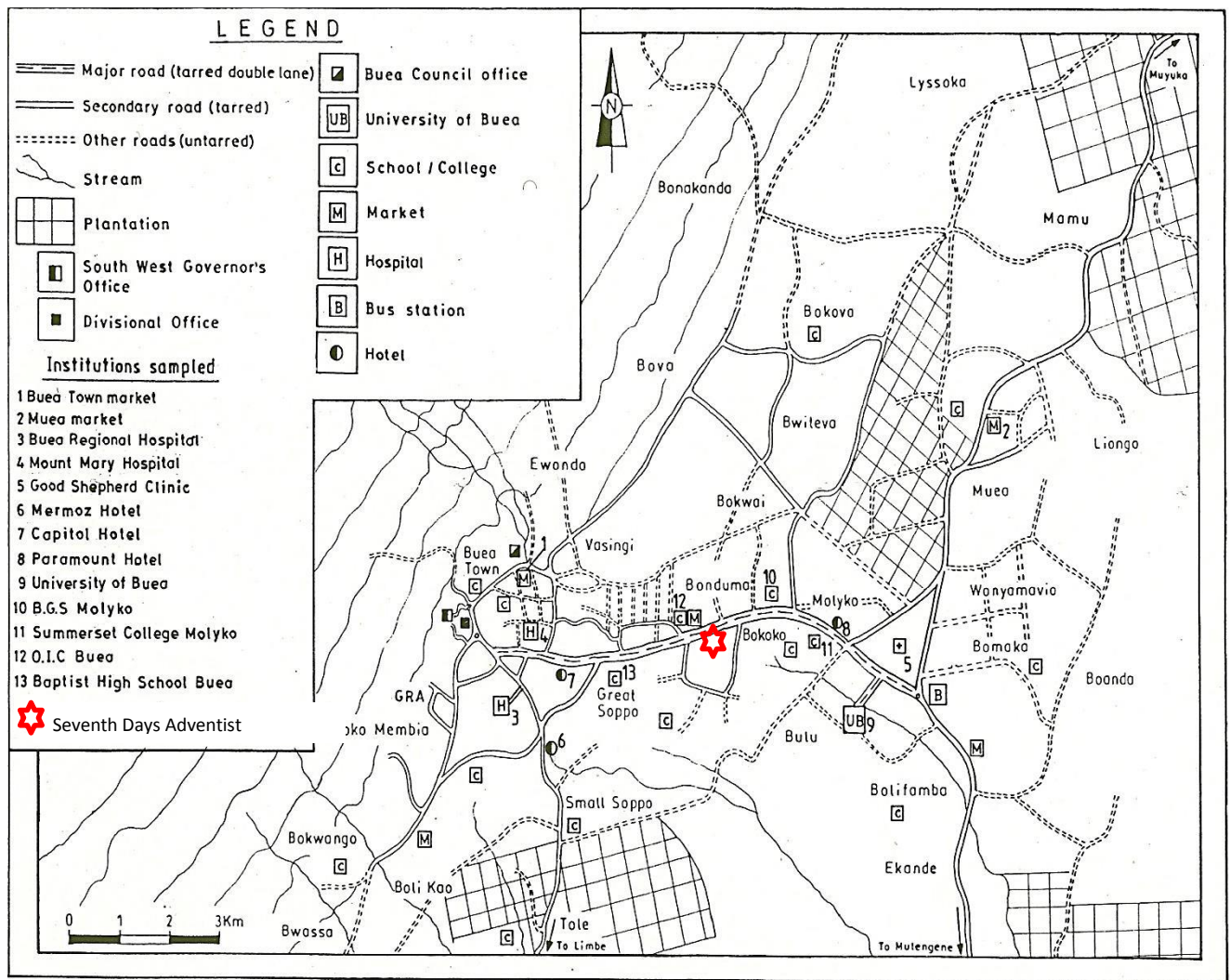


Figure 1: Map showing the location of the study area.

#### 1.1.3.2 Socio economic status

The population of Buea, which is also the capital of the South West Region is composed of people from all the regions of Cameroon and other African countries mostly Nigerians. The Bakwer are the indigenes. Due to the cosmopolitan nature of Buea there are different cultures and traditions which give a perfect mix to the approximate 90,088 inhabitants as per the 2005 census. It can be said that all the ten regions of Cameroon are represented in this area for example North Westerners and Westerners having a majority. Being an academic centre the student population is high, followed by business men and women, traders, religious men and women and government officers. These people make use of the various services provided by the hospitals and clinics in Buea.

### **1.1.3.3 Infrastructural evolution**

Buea being the capital of the South West Region has in the recent past noticed an increase in permanent infrastructure development with many new buildings and hotels adding to the beauty of the town. Buea is linked to Limbe, Douala, and Kumba by tarred roads making the town accessible from many other parts of Cameroon.

#### **A) BUEA REGIONAL HOSPITAL**

The Buea Regional Hospital annex is found in Buea town, Fako Division of the South West Region of Cameroon. It is about 2km away from the main motor park commonly known as 'mile 17' Motor Park. It is situated between the delegations of education and the army barracks, along the highway to Bokwango neighbourhood. The hospital is made up of many units/departments/centres as follows: the medical unit (male and female), the surgical unit, the paediatrics unit, the maternity unit, the HIV/AIDS unit, the Laboratory unit, the X-ray unit, the haemodialysis centre, the Tuberculosis centre, the Diabetes Centre, the theatre department and the Outpatient department. Each of the Unit/Department/Centre is headed by a specialist doctor (Surgeons, Gynaecologist, Paediatrician, etc.). But control of the wards is done by the ward charges like senior nurses and midwives.

The hospitals also have nurses (Nursing assistants, State Registered Nurses, Higher National Diploma Nurses, Bachelor, Master's degree holders). The hospital is headed by a medical doctor (Director) assisted by the general supervisor who supervises the activities of the technical staff, there is an accountant who is in charge of finances, and other administrative staff. The Buea Regional Hospital serves clients from all over Buea and its environments. These clients either come to the hospital for consultation and treatment or they are referred from other health centres and clinics. It admits patients for on an out-patient and in-patient bases and this is greatly influenced by the economic situation which determines their stay and how fast they recover. It also carries out minor and major surgeries. In the year 2003, the Chinese government renovated the entire hospital and equipped some units with modern equipment.

#### **b) MOUNT MARY CLINIC**

Situated in the South-West Region (Buea) at the foot of Mount Cameroon, this small hospital has the capability and facility for quick and moderate costing major surgeries. It is performing and playing an important role in patients care. It was founded by Catholic diocese Buea in 1967. The total catchment area is about 50,000 (though there are other hospitals

within that area) it has so many wards and beds for their patients. It has resident medical doctors with two theatres for surgery. Other services offered include: maternity, anti-natal, vaccination and HIV/AIDS. Presently, the management is improving on its infrastructure and equipment.

**c) BUEA SEVENTH DAY ADVENTIST**

Buea Seventh day Adventist hospital is a maternal, child and reproductive health centre located in Soppo neighbourhood. This health centre is situated along the main road to the Buea municipal council and therefore it is easily accessible. The hospital opens Mondays to Thursdays from 8 am to 3 pm and Fridays from 8 am to 1 pm. The services provided by this hospital include general consultation, gynaecology and paediatric (specialist consultation), cervical cancer screening, family planning, wound care and dressing. The hospital also carries out minor surgeries like incision and drainage, lymphomas and other skin problems, circumcision, dilation and curettage. It also has a maternity and a pharmacy. The hospital has a few beds and offices for the medical staff.

With the increase in population more hospitals and small clinics are opening their doors to serve the needs of the people. This also increases the amount of waste produced and more problems for the community.

## **1.2. PROBLEM STATEMENT**

In the past, the quantity of medical waste produced in health care centres in Buea was barely managed without a major call for concern. However, the rapid increase in population in recent years correlates with an increasing number of patients (Ikome, 2011) without a collaborative increase in technological development of medical waste management, hence presenting the problem of improper medical waste management. If patients are to receive health care and recover in safe surroundings, medical waste must be disposed of safely (WHO, 2012). The paradox here is that the healthcare delivery system, which is established to provide treatment and safeguard the health of the people against illnesses, has become a source of infection and means of spreading diseases in the process of healthcare delivery. Health care institutions/facilities generate different types of infectious and/or hazardous medical waste that poses enormous risk to patients, healthcare providers, waste pickers, the environment and the community at large.

In Buea medical waste management in health care centers has not been well documented and it is not clear how these medical wastes are being managed. Therefore it is very important to know how these hospitals, clinics and health care centers in Buea manage/handle the medical wastes they produce before it presents a threat to the population health of Buea. A successful management of medical waste must be understood and addressed by everyone working in the health care services from those washing the floor to senior administration.

### **1.3. OBJECTIVE OF STUDY**

#### **1.3.1. Main objective**

The main objective of this study is to assess the effectiveness of medical waste management in three healthcare centres/hospitals in Buea, namely: Regional Hospital, Mount Mary Clinic and the Buea Seventh Day Adventist.

#### **1.3.2. Specific objective**

The specific objectives of this study are as follows:

- 1) To identify the methods of waste management systems in three healthcare centres/hospital in Buea.
- 2) To assess the methods of waste management systems in three healthcare centres/hospital in Buea.
- 3) To compare these management systems with the WHO standard for medical waste management.

### **1.4. RESEARCH QUESTIONS**

- What waste management systems are practiced by these hospitals?
- What is the technological level of the waste management in these healthcare facilities?
- What are the differences between the international standard of medical waste management given by the WHO and those of these hospitals in Buea?

### **1.5. SIGNIFICANCE OF THE STUDY**

#### **1.5.1. Research level**

The study will contribute to the background knowledge on medical waste management in Buea Cameroon, and will spur up further research on the impact of the current waste management practices (methods and technological management) on natural resources as well as human health within the study/related area.

### **1.5.2. Policy level**

By understanding of the on-going waste management practices in healthcare and clinical facilities, policy makers may introduce and/or formulate better policies to improve on the current situation. And this will serve as a base for those who are in charge of formulating policies on natural resources management and legislative frameworks that are being elaborated in the country.

### **1.5.3. Community level**

By understanding of the potential impacts of unconventional medical wastes management methods the community is sensitized on the dangers of these wastes. They will be informed on the community-level actions to protect their health and the environment

### **1.5.4. Staff**

It will help the hospital staff to know how to best manage and dispose of their waste in order to reduce the dangers of harm and the amount of pollution emitted from these wastes.

### **1.5.5. Waste pickers (Scavengers)**

It will enable scavengers and other pickers to understand the risk associated with their activities and may encourage them to take extra care.

## **1.6. Scope of the study area**

There are so many hospitals, clinics and health centres in Buea. This study is centred just on three of these clinics which are, the Regional Hospital, Mount Mary Clinic and Seventh Day Adventists Clinic.

## **1.7. ORGANIZATION OF STUDY**

The study is structured into five chapters. In chapter one, a brief background of the study has been covered starting with an introduction, stating the objectives of the research, the problem statement and information of the study area. Chapter two presents relevant literature on medical waste management and it illustrates the importance of medical waste management in Cameroon and the role of hospitals and clinics to put in place concrete measures to effectively manage medical waste. Chapter three gives a description of the methods used in collecting and analysing data of the study. In chapter four, the findings of the research are

presented and discussed. Chapter five gives the summary, conclusions and recommendations of the study.

## **1.8. Definition of Terms**

### **1.8.1. Medical Waste**

The world health organization (WHO) defines medical waste as ‘any waste that is generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining there to or in the production or testing of biological components’ (DC Healthcare without Harm, 2000)

### **1.8.2. Hospital Waste**

Hospital waste refers to all wastes, biological or non-biological, that are discarded and not intended for further use (WHO, 2014).

### **1.8.3. Infectious Waste**

Infectious waste refers to the portion of medical waste that could transmit an infectious disease, also infectious wastes are wastes that contain microorganism in sufficient quantity which could result in multiplication and growth of microorganism in the host and they cause infectious diseases (Rutala and Mayhall, 1992).

### **1.8.4. Healthcare Waste**

Healthcare waste includes all wastes generated by healthcare establishments, research facilities and laboratories. In addition it includes the waste originating from minor or scattered sources such as those produced in the course of healthcare undertaken in homes. In general medical waste, medical waste and healthcare waste contain both non-infectious and infectious wastes.

## **CHAPTER TWO**

### **LITERATURE REVIEW AND THEORETICAL FRAMEWORK**

#### **2.1. Literature Review**

Medical waste is generated while reducing the health problems and eliminating potential risk to people's health. Manyela and Lyasenga( 2010) states that hospital services inevitably create waste that may itself be hazardous to health. The waste produce in the course of healthcare activities carries a higher potential for infection, injury and pollution due to improper handling and disposal. Where ever medical waste is generated, safe and reliable methods for its handling are therefore essential. Inadequate and inappropriate handling of medical waste may have serious public health consequences and significant impact on the environment. Sound management of medical waste is thus crucial component of the environment and health protection. Medical waste differs from other types of hazardous waste such as industrial waste in that it comes from biological sources or is used in the diagnosis, prevention or treatment of diseases. Common producers of medical waste include hospital, healthcare clinics, nursing home, medical research laboratories, and offices of physicians, dentists, veterinarian's home and funeral homes.

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 (Manyela and Lyasenga, 2010). The type of medical waste establishment and waste management capacity at hospital has been recognized as an important factor in waste treatment. The WHO (2011) suggests that around 80% of clinical wastes are non-hazardous (comparable to domestic waste), 15% are infectious (cultures and stocks of infectious agents, wastes from infected patients, wastes contaminated with blood and its derivatives, discarded diagnostic samples, infected animals from laboratories, and contaminated materials and equipment) and anatomic (recognizable body parts and carcasses of animals) wastes and the remaining 5% is made-up of sharps (1%), toxic chemicals and pharmaceuticals (3%) and genotoxic and radioactive waste of 1% (WHO, 2011). These estimates, according to WHO (2011) are not consistent for many developing countries. According to the WHO (2012) 25% of clinical waste produced in Pakistan is hazardous, 26.5% in Nigeria and 2-10% in other sub-Saharan Africa countries. Manyela and Lyasenga(2010) state that urban health centres in Tanzania generate 50% of the country's clinical hazardous waste. Sakar et al(2006) identified higher clinics and diagnostic centres as being responsible for 36.03% of hazardous

clinical waste produced in Bangladesh. According to Ikome(2011) recording daily hospital averages of clinical waste, including the specific amount produced per bed/day and factoring this amount in to relative mathematical equations is a major way of quantifying the amount of clinical waste produced in hospitals. But since health care establishments differ in ways previously mentioned, including size of medical staff and proportion of reusable items used in the establishment, such a technique produces results relative to each healthcare establishment .US hospitals generate an estimated 6,670 tons of clinical waste per day (Rutala and Mayhall, 1992), 3,8 kg/bed/day in Portugal (Alvim Ferraz et al, 2000) and 1 kg/bed/day is generated in Thailand (Kerdsuwan, 2000). It is important to bear in mind that only a fraction of healthcare institutions contribute to the aforementioned figures as data from private physicians offices, dentists, veterinarians, medical clinics, laboratories, long-term care facilities and free standing care blood banks are unreliable and often unavailable (Rutala and Mayhall, 1992). Determining which portion or components of clinical waste is infectious is challenged by its inherent heterogeneous nature and definitional problems (OTA, 1998). No tests currently exist to objectively determine whether waste is infectious or not (Rutala and Mayhall, 1992).

The U.S. EPA and Centres for Disease Control, despite their discrepancies in clarifying the term infectious waste, have designated pathological waste, blood and blood products, contaminated sharps (scalpels, needles and blades) and microbiological waste (cultures and stocks) as infectious (OTA, 1998). In general, for waste to be infectious, it has to contain enough virulence capable of causing an infectious disease including a portal of entry in a susceptible host (Peter Ikome, 2011)

Poor management of health care waste potentially exposes health care workers, waste handlers, patients and the community at large to infection, toxic effects and injuries, and risks polluting the environment. It is essential that all medical waste materials are segregated at the point of generation, appropriately treated and disposed of safely (WHO, 2011). Healthcare waste is a by-product of healthcare that includes sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive materials.

WHO Program activities include developing technical guidance materials for assessing the quantities and types of waste produced in different facilities, creating national action plans, developing national healthcare waste management guidelines and building capacity at national level to enhance the way healthcare waste management is dealt with in low-income countries.

According to WHO (2012) classification of Health Care wastes shows that

1. Of the total amount of waste generated by health-care activities, about 80% is general waste.
2. The remaining 20% is considered hazardous material that may be infectious, toxic or radioactive.
3. Every year an estimated 16 000 million injections are administered worldwide, but not all of the needles and syringes are properly disposed of afterwards.
4. Health-care waste contains potentially harmful microorganisms which can infect hospital patients, health-care workers and the general public.

### **2.1.1. Groups of medical waste**

#### **2.1.1.1. *Infectious group of medical waste***

These are wastes that are contaminated with blood and its by-products, cultures and stocks of infectious agents, waste from patients in isolation wards, discarded diagnostic samples containing blood and body fluids, infected animals from laboratories, and contaminated materials (swabs, bandages) and equipment (such as disposable medical devices); are considered as infectious waste, all wastes that are susceptible to contain pathogens (or their toxins) in sufficient concentration to cause diseases to a potential host. Examples of infectious waste include discarded materials or equipment, used for the diagnosis, treatment and prevention of disease that has been in contact with body fluids (dressings, swabs, nappies, blood, bags). This group also includes liquid waste such as faeces, urine, blood or other body secretions (such as sputum or lung secretions) (WHO, 2012).

#### **2.1.1.2. *Pathological group of medical waste***

Recognizable body parts and contaminated animal carcasses; Pathological waste consists of organs, tissues, body parts or fluids such as blood. Even if pathological waste may contain healthy body parts, it has to be considered as infectious waste for precautionary reasons. Anatomical waste is a sub-group of pathological waste and consists in recognizable human body parts, whether they may be infected or not. Following the precautionary principles, anatomical waste is always considered as potential infectious waste (WHO, 2012).

#### **2.1.1.4. *Pharmaceutical group of medical wastes***

Expired, unused, and contaminated drugs and vaccines; Pharmaceutical waste includes expired, unused, spilt and contaminated pharmaceutical products, drugs and vaccines. In this group are also included discarded items used in the handling of pharmaceuticals like bottles, vials, connecting tubing. Since various ministries of health or their equivalents usually put

in place specific measures that will reduce the wastage of drugs, Health care facilities should deal only with small quantities of pharmaceutical wastes. This group also includes all the drugs and equipment used for the mixing and administration of cytotoxic drugs. Cytotoxic drugs organo-toxic drugs are drugs that have the ability to reduce/stop the growth of certain living cells and are used in chemotherapy for cancer. Cytotoxic waste is dealt with under a separate heading (WHO, 2012).

#### **2.1.1.5.        *Genotoxic group medical waste***

Highly hazardous, mutagenic, teratogenic or carcinogenic cytotoxic, such as drugs used in cancer treatment and their metabolites; Genotoxic waste derives from drugs generally used in oncology or radiotherapy units that have a high hazardous mutagenic or cytotoxic effect. Faeces, vomit or urine from patients treated with cytotoxic drugs or chemicals should be considered as genotoxic. In specialised cancer hospitals, their proper treatment or disposal raises serious safety problems (WHO, 2012).

#### **2.1.1.6.        *Radioactive group of medical waste***

Such as glassware contaminated with radioactive diagnostic material or radio therapeutic materials; radioactive waste includes liquids, gas and solids contaminated with radionuclides whose ionizing radiations have genotoxic effects. According to the WHO the ionizing radiations of interest in medicine include X- and  $\gamma$ -rays as well as  $\alpha$ - and  $\beta$ - particles. An important difference between these types of radiations is that X-rays are emitted from X-ray tubes only when generating equipment is switched on whereas  $\gamma$ -rays,  $\alpha$ - and  $\beta$ - particles emit radiations continuously. The type of radioactive material used in HCF results in low level radioactive waste. It concerns mainly therapeutic and imaging investigation activities where Cobalt 60Co, Technetium 99mTc, Iodine 131I and Iridium 192Ir are most commonly used. With the noticeable exception of Cobalt 60Co, their half-life is reasonably short (6 hrs for 99mTc, 8 days for 131I and 74 days for 192Ir) and the concentrations used remain low. A proper storage with an appropriate retention time is sufficient to prevent radioactivity spillage in the environment. Infectious and anatomic wastes together represent the majority of the hazardous waste, up to 15% of the total waste from health-care activities. Sharps represent about 1% of the total waste but they are a major source of disease transmission if not properly managed. Chemicals and pharmaceuticals account for about 3% of waste from health-care activities while genotoxic waste, radioactive matter and heavy metal content account for around 1% of the total health-care waste (WHO, 2012).

### **2.1.2. Sources of medical waste**

According to Rutala and Mayhall, (1992) there are different sources of medical waste. These include Hospitals and other health-care establishments, Laboratories and research centres, Mortuary and autopsy centres, Animal research and testing laboratories, Blood banks and collection services and Nursing homes for the elderly.

The WHO states that high-income countries generate on average up to 0.5 kg of hazardous waste per bed per day; while low-income countries generate on average 0.2 kg of hazardous waste per hospital bed per day. However, health-care waste is often not separated into hazardous or non-hazardous wastes in low-income countries making the real quantity of hazardous waste much higher.

### **2.1.3. Potential effects of medical waste**

Poor management of health care waste potentially exposes health care workers, waste handlers, patients and the community at large to infection, toxic effects and injuries, and risks polluting the environment. It is essential that all medical waste materials are segregated at the point of generation, appropriately treated and disposed of safely.

However in most countries including Cameroon, such wastes are not given appropriate treatment, thus it is impacting negatively on the environment

According to WHO (2012) pathogen present in medical waste can enter and remain in the air within the hospital for long period, in the form of spores or pathogens. This can result in hospital acquired infections. Patients and their attendants also contract infections caused by airborne pathogen or spores. All individuals exposed to medical waste are potentially at risk of being injured or infected, they include;

- Medical staff; doctors, nurses, sanitary staff and hospital maintenance personnel
- In and out patients receiving treatment in healthcare facilities
- Visitors of hospital
- Workers in support service linked to healthcare facilities such as laundries. Waste handling and transportation services
- Workers in waste disposal facilities, including scavengers.
- The general public and more specifically the children playing with the items they can find in the waste outside the healthcare facilities when it is directly accessible to them.

### **2.1.3.1. Environmental Hazards**

Inappropriate treatment and disposal of medical waste contributes to environmental pollution, uncontrolled incineration causes air pollution. Azage and Kumie (2010) say dumping in valleys, tanks and along the river bed causes water pollution and unscientific land filling causes soil pollution.

#### **a) Air pollution**

The UN states that air pollution can be caused in both indoor and outdoor atmosphere. Medical waste that generated by air pollution are been classified in three types namely biological, chemical and radioactive.

#### **b) Indoor air pollution**

According to Askarian and Baveja (2000) pathogens present in the waste can enter and remain in the air for a long period in the form of spores or as pathogens. Segregation of waste, pre-treatment at source etc., can also reduce this problem to a great extent. Sterilizing the rooms will also help in checking the indoor air pollution biologically. The indoor air pollution caused due to the above chemicals from poor ventilation can cause diseases like sick building syndrome (SBS). Proper building design and well maintained air conditioners can reduce SBS. Chemicals should be utilized as per prescribed norms. Over use of chemicals should be avoided

#### **c) Outdoor air pollution**

Outdoor air pollution can be caused by pathogens. Medical waste without pre- treatment if transported outside the institution, or if it is dumped in open areas, pathogens can enter into the atmosphere. According to Bdour(2004)Chemical pollutants that cause outdoor air pollution have two major sources open burning and incinerators. Open burning of medical waste is the most harmful practice. When inhaled can cause respiratory diseases. Certain organic gases such as dioxins and furans are carcinogenic. The design parameters and maintenance of such treatment and disposal technology should be as per the prescribed standards (Bdour, 2004)

#### **d) Radioactive emissions**

Research and radio immunoassay activities may generate small quantities of radioactive gas. Gaseous radioactive material should be evacuated directly to the outside. The use of such device requires maintenance of the trap and monitoring of the off gas (Malviga, 1999)

#### **e) Water pollution**

The liquid waste generated when let into sewers can also lead to water pollution if not treated properly. Water pollution can alter parameters such as pH, BOD, DO, COD etc. There are instances where dioxins are reported from water bodies near incinerator plants. Dioxins enter the water body from the air (Chitins et al, 2000; Saini and Dadhwal, 1995)

#### **f) Radioactive effluent**

Radioactive waste in liquid form can come from chemical or biological research, from body organ imaging, from decontamination of radioactive spills, from patient's urine and from scintillation liquids used in radioimmunoassay. Under normal circumstances, urine and faces can be handled as no radioactive waste so long as the patient's room is routinely monitored for radioactive contamination (Shah et al, 2001)

#### **g) Land pollution**

Soil pollution from medical waste is caused by infectious waste, discarded medicines, chemicals used in treatment and ash and other waste generated during treatment processes. Heavy metals such as cadmium, lead, mercury etc., which are present in waste will get absorbed by plants and can then enter the food chain. Nitrate and phosphates present in leachates from landfills are also pollutions. Excessive amounts of trace nutrient elements including heavy metals in soil are harmful to crops and are also harmful to animals and human beings (Mehta, 1998). Minimizing the waste and proper treatment before disposal on land are the only ways of reducing this kind of pollution (Silva, et al. 2005)

#### **2.1.3.2. Occupational Hazard**

Occupational hazard refers to the risks involve to all those who generate, collect, segregate, handle, package, store, transport, treat and dispose of medical waste. Occupational exposure to blood can result can result from percutaneous injury (needle stick or other sharps injury), muco-cutaneous injury (splash of blood or other body fluids into the eye, nose or mouth) or blood contact with non-intact skin. The most common form of occupational exposure to blood and the most likely to result in infection is needle stick injury. The most cause of needle stick is two handed recapping and the unsafe collection and disposal of sharps waste. Over 20 bloods bone diseases can be transmitted but particular concern is the threat of spread of infectious or communicable diseases like AIDS, hepatitis B and C, cholera, tuberculosis, diphtheria etc. Waste such as chemicals, radioactivity and heavy metals etc. are hazardous to health (US Department of Energy, 1996). There are however numerous other diseases

which can be transmitted by contact with infectious medical wastes. During the handling of waste, injuries occur when syringes, needles or other sharps have not been collected in puncture proof containers. Inappropriate design and or overflow of existing sharps containers and moreover unprotected pits increase risk exposure of the healthcare workers, waste handlers and of the community at large.

#### **2.1.3.3.        *Public Health Hazards***

The reuse of infectious syringe represents a major threat to the public health. The WHO estimated that in the year 2000 worldwide, immunization undertaken with contaminated syringes caused 23 million infections of hepatitis B, C and HIV, such situations are very likely to happen when medical waste dumped on an uncontrolled site where it can be easily accessed by the public. Children and rag pickers are particularly at risk to come in contact with infection waste. Worldwide, each year, the overuse of injection and unsafe injection practices combine to cause an estimated 8 to 16 million hepatitis B virus infection and 80000 to 160000 HIV infections (USEPA, 1998). Among unsafe practices, the reuse of syringes and or needles without sterilization is of particular concern.

Plastic waste can choke animals, which scavenge on openly dumped waste. Injuries from sharps are common feature affecting animals. Harmful chemicals such as dioxins and furans can cause serious health hazards to animals and birds. Certain heavy metals can affect the reproductive health of animals (Code and Christic, 1999)

#### **2.1.4.    *Risks associated with waste disposal***

Although treatment and disposal of health-care waste reduces risks, indirect health risks may occur through release of toxic pollutants into environment through treatment or disposal.

- 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.
- 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. According to the WHO 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 and bio-

accumulate in the environment. Materials containing chlorine or metal should therefore not be incinerated.

- Only modern incinerators operating at 850-1100 °C and fitted with special gas-cleaning equipment are able to comply with the international emission standards for dioxins and furans. Alternatives to incineration are now available, such as autoclaving, microwaving, steam treatment integrated with internal mixing, and chemical treatment.

#### **2.1.5. World Health Organization talks on medical waste**

The first global and comprehensive guidance document, Safe management of wastes from health-care activities, originally released by WHO in 1999, addresses aspects such as regulatory framework, planning issues, waste minimization and recycling, handling, storage and transportation, treatment and disposal options, and training.

It is aimed at managers of hospitals and other health-care establishments, policy makers, public health professionals and managers involved in waste management. It is accompanied by a Teacher's guide, which contains material for a three-day workshop aimed at the same audience.

Additionally, WHO guidance documents on health-care waste are now available including the following:

- A monitoring tool
- A cost assessment tool
- A rapid assessment tool
- A policy paper
- Guidance to develop national plans
- Management of waste from injection activities
- Management of waste at primary health care centres
- Management of waste from mass immunization activities
- Management of waste in emergencies.

#### **2.1.6. Medical waste in UK, Nigeria and America**

##### **2.1.6.1. *United Kingdom***

In the UK, clinical waste and the management of this waste is closely regulated by applicable legislation which includes the environmental protection act 1990 and the Hazardous Waste Regulations (England & Wales) 2005, as well as the Special Waste Regulations in Scotland.

#### **2.1.6.2.        *United States***

In 1988 the Federal government passed The Medical Waste Tracking Act which set the standards for governmental regulation of medical waste. After the Act was repealed in 1991, States were given the responsibility to regulate and pass laws concerning the disposal of medical waste. All fifty states vary in their regulations from no regulations to very strict. Disposal of this waste is an environmental concern, as many medical wastes are classified as infectious or bio-hazardous and could potentially lead to the spread of infectious disease. Examples of infectious waste include blood, potentially contaminated "sharps" such as needles and scalpels, and identifiable body parts. Sharps include used needles, lancets, and other devices capable of penetrating skin. Infectious waste is often incinerated. The most common method of sterilization is an autoclave. The autoclave uses steam and pressure to sterilize the waste. Additionally, medical facilities produce a variety of hazardous chemicals, including radioactive materials. While such wastes are normally not infectious, they may be classified as hazardous wastes, and require proper disposal.

In the United States, there are three main methods for medical waste generators to dispose of their waste: On-site, truck service, and mail-back disposal. On-site treatment involves the use of very expensive equipment, and is generally only used by very large hospitals and major universities who have the means to afford such equipment. Truck service involves hiring of a medical waste disposal service whose employees are trained to collect and haul away medical waste in special containers (usually cardboard boxes, or reusable plastic bins) for treatment at a facility designed to handle large amounts of medical waste. Mail-back medical waste disposal is similar, except that the waste is shipped through the U.S. postal service instead of by private hauler. Although currently available in all 50 U.S. states, mail-back medical waste disposal is limited to very strict postal regulations (collection and shipping containers must be approved by the postal service for use) and only available by a handful of companies.

#### **2.1.6.3.        *Healthcare waste in Nigeria***

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 (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 (Abah and Ohimain, 2010). 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 waste (Alagoz and Kocasay, 2007; Abah and Ohimain, 2010).

A near total absence of institutional arrangements for HCW in Nigeria has been reported by others (Coker et al., 1998). Various methodologies have been used all over the world to assess and quantify HCW. 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 (Abah and Ohimain, 2011) and as high as 1.68 kg/bed/day (Abah and Ohimain, 2011). As reported in the literature, there may not be much of a difference in the way and manner wastes generated in various health care institutions are managed in Nigeria. A good example is given by the findings of the study in Lagos by Olubukola which reported the similarity in waste data and HCW management practices in two General hospitals, characterized by a lack of waste minimization or waste reduction strategies, poor waste segregation practices, lack of instructive posters on waste segregation and disposal of HCW with general waste (Olubukola, 2009). The mismanagement of healthcare waste poses health risks to people and the environment by contaminating the air, soil and water resources. Hospitals and healthcare units are supposed to safeguard the health of the community. However, healthcare wastes if not properly managed can pose an even greater threat than the original diseases themselves (PATH, 2009).

## **2.2. THEORETICAL FRAMEWORK**

### **2.2.1. WHO standardfor medical waste management**

Medical waste is classified according to the WHO guidelines into various categories depending on the methods of treatment and disposal. This helps to facilitate the management of the medical waste. These categories can be seen in table 1.

### 2.2.1.1. SCHEDULE I

Table 1: Categories of bio-medical waste

| Option         | Waste Category                                                                                                                                                                                                                                                                                                                                                       | Treatment & Disposal                                                                         |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| CATEGORY NO. 1 | <b>Human Anatomical Waste</b> (human tissues, organs, body parts)                                                                                                                                                                                                                                                                                                    | Incineration @/deep burial*                                                                  |
| CATEGORY NO. 2 | <b>Animal Waste</b> (animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospitals, animal houses)                                                                                                                                | Incineration @ / deep burial*                                                                |
| CATEGORY NO 3  | <b>Microbiology &amp; Biotechnology Waste</b> (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures) | local autoclaving / micro-waving / incineration@                                             |
| CATEGORY NO 4  | <b>Waste sharps</b> (Needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)                                                                                                                                                                                                                   | disinfection (chemical treatment @ 01/autoclaving / micro- waving and mutilation/ shredding" |
| CATEGORY NO 5  | <b>Discarded Medicines and Cytotoxic drugs</b> (wastes comprising of out-dated, contaminated and discarded medicines)                                                                                                                                                                                                                                                | Incineration @/destruction and drugs disposal in secured landfills drugs disposal in secured |

|                 |                                                                                                                                                                               |                                                                                                                |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| CATEGORY NO 6   | <b>Solid Waste</b> (Items contaminated with blood, and body fluids including cotton dressings, soiled plaster casts, lines, beddings, other material contaminated with blood) | Incineration @ autoclaving /micro-waving                                                                       |
| CATEGORY NO. 7  | <b>Solid Waste</b> (Wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc.).                                    | disinfection by chemical treatment @@ autoclaving/micro-waving and mutilation/shredding##                      |
| CATEGORY NO. 8  | <b>Liquid Waste</b> (waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities)                                                        | Liquid Waste(waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities) |
| CATEGORY NO. 9  | <b>Incineration Ash</b> (ash from incineration of any bio-medical waste)                                                                                                      | disposal in municipal landfill                                                                                 |
| CATEGORY NO. 10 | <b>Chemical Waste</b> (Chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.)                                                    | chemical treatment @@ and discharge into drains for liquids and secured landfill for solids                    |

@@ Chemicals treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection.

## Mutilation/shredding must be such so as to prevent unauthorized reuse.

@ There will be no chemical pre-treatment before incineration. Chlorinated plastics shall not be incinerated.

- Deep burial shall be an option available only in towns with population less than five lakhs and in rural areas.

#### **2.2.1.1.        *SEGREGATION OF MEDICAL WASTE***

Creating a system for segregation of waste is the first step of medical waste management. Segregation at source is the separation of the different types of medical waste and their appropriate storage or disinfections, sterilization, etc. would ensure that infection wastes do not get mixed with non-infectious waste as this would infect the entire waste. Only a small fraction of waste generated by healthcare institution is actually infectious or hazardous.

Segregation of waste into infected or contaminated waste and non-infected waste is mandatory and is a prerequisite for safe and hygienic waste management. Segregation at source makes it easier to prevent spread of infection, help it easier to choose among the options of disposal, and can reduce the load on the waste treatment system and prevent injuries (Bailey and Scotts, 2002)

There are certain directions regarding segregation and storage to ensure safe and hygienic handling of infectious and non-infectious waste. The segregation of waste into various categories and stored in four different coloured containers is done taking into account the treatment and disposal facilities available. The medical waste will be segregated into containers or bags at the point of generation in accordance with its storage, transport, treatment and disposal methods. Apart from the medical waste the general waste or the garbage generated in healthcare establishments such as office waste, food waste and garden waste is advisable to be stored in one container. The locals are duty bound to collect such general waste stored in this containers.

Clinical and general waste must be segregated at source and placed in colour coded plastic bags and the containers of definite specifications prior to collection and disposal. The container comprises of an inner plastic bag of a varied colour depending on the type of waste. The container should be of minimum gauge of 55micron (if of low density) or 25 micron (if of high density), leak proof and puncture proof, and should match the chosen outer container.

The outer container is a plastic bin with handles, and must match the chosen outer container colour. The outer container is a plastic bin with handles, and of a size which will depend on the amount of waste generated. The inner polythene bag must fit into the container with one-fourth of the polythene bag turned over the rim. Labelling has been recommended to indicate the type of waste, site of generation, name of generating hospital or facilities. This will allow the waste to be traced from the point of generation to the disposal area. The containers are

then to be transported in closed trolleys or wheeled containers that are designed for easy cleaning and draining. If for any reasons, it becomes necessary to store the waste beyond such period, permission from the prescribed authority (established by the government of every state and union territory) must be taken, and it must be ensured that it does not adversely affect human health and the environment. Once collection occurs, then medical waste is stored in proper place. No untreated medical waste will be stored beyond a period of 48 hours. Segregated waste of different categories needs to be collected in identifiable containers. The duration of storage must not exceed for 8-10 hours in a big hospitals and 24 hours in other healthcare institution. Each container may be clearly labelled so that it may be necessary to trace the waste back to its source. Besides this, storage area should be marked with a caution sign (USEPA, 1994).

#### 2.2.1.2. SCHEDULE II

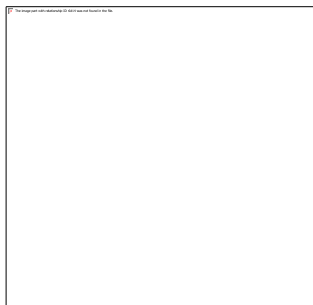
Table 2: Colour coding and type of container for disposal of bio-medical wastes

| Colour Coding          | Type of Container -I                 | Waste Category                         | Treatment options according to Schedule I                             |
|------------------------|--------------------------------------|----------------------------------------|-----------------------------------------------------------------------|
| Yellow                 | Plastic bag                          | Cat. 1, Cat. 2 and Cat. 3, Cat. 6.     | Incineration/deep burial                                              |
| Red                    | Disinfected container/plastic bag    | Cat. 3, Cat. 6, Cat.7.                 | Autoclaving/Microwaving/ Chemical Treatment                           |
| Blue/White translucent | Plastic bag/puncture proof Container | Cat. 4, Cat. 7.                        | Autoclaving/Microwaving/ Chemical Treatment and destruction/shredding |
| Black                  | Plastic bag                          | Cat. 5 and Cat. 9 and Cat. 10. (solid) | Disposal in secured landfill                                          |

#### 2.2.1.3. SCHEDULE III

##### 2.2.1.3.1. Label for Medical Waste Containers/Bags

Each container may be clearly labelled with the biohazard symbol (figure 2) so that it may be necessary to indicate the potential impact it may cause. In addition, storage areas should be marked with a caution sign (USEPA, 1994).



*Figure 2: Label for medical waste*

#### **2.2.3.2.        *Storage of Medical Waste***

The storage area will be inside the hospital. The waste in bins and containers must be stored in a room or an area appropriate to the quantities of waste generated. Cytotoxic waste must be stored separately from the other wastes. The storage room must be in the ground floor near the entrance so the transportation van can easily get access to it. The room can have a storage capacity for at most 2 days. No untreated waste should be stored for more than 48 hours.

#### **2.2.3.3.        *Treatment of Medical Waste***

##### **a)        Thermal treatment**

In contrast to incineration, some thermal treatment methods can use the high water content of medical waste to advantage. Water can provide an effective heat transfer medium, to help distribute heat throughout the mass of the waste.

One problem with water as a heat transfer medium is that the temperature at which water boils at normal atmospheric pressure is not sufficiently high to kill some of the hardier microorganisms (spore-forming species, for example). One common solution is to carry out the treatment in a pressure chamber. As the pressure is raised, the boiling point of water increases. At a pressure twice as high as normal atmospheric pressure, the boiling point of water increases by about 36°F, to 240°F (i.e. by about 20°C, to 120°C), which is sufficient to kill most organisms of concern. Systems using steam under pressure are called *autoclaves*, and are among the most common alternatives to incineration for medical waste treatment.

Another thermal treatment system that takes advantage of the properties of water uses *microwaves* as the energy source. In a microwave system, the waste is subjected to high intensity radio waves, tuned to a frequency that is readily absorbed by water molecules. It is an efficient way to deliver the energy where it is most needed for sterilization purposes. The other side of that coin is that microwave heating will be inefficient if the waste is too dry. Microwaves will penetrate bulk materials to some extent, but the heating will proceed more efficiently if the waste is shredded and mixed in the chamber during the process (for much the same reason that many kitchen microwave ovens use a rotating platform).

An advantage to both autoclaves and microwave systems is the fact that air does not have to move through the systems while they operate. Emission of volatiles only occurs during loading and unloading, and can be minimized with proper design and operation.

Autoclaves and microwave systems are effective, but the necessary equipment is somewhat expensive (pressure chambers and microwave generators, respectively). In contrast, *dry heat systems* use less demanding equipment, but typically require higher temperatures and longer exposure times to ensure that the heat supplied by the system penetrates to the centre of the waste. Rather than directing the heat into the mass of the waste, evaporating water carries a substantial quantity of the heat away. On the other hand, the drying of the waste has some advantages, including substantial weight and volume reduction and easier handling of the residue.

Since dry heat systems do not involve combustion, unwanted reactions such as dioxin formation are not an issue. But if air moves through the system, it can carry volatiles and pathogens. The exhaust stream is typically filtered before release, but the potential for release always exists.

One disadvantage with all of these systems, stemming from the fact that they operate at substantially lower temperatures than incinerators, is that they require a certain minimum contact time to ensure that all pathogens have been destroyed. Higher temperatures are required to process large quantities of waste in a shorter time. To obtain a higher throughput while avoiding the problems associated with ordinary combustion, some large scale systems use advanced heating methods to create very high temperatures with a minimum of air passing through the system. One method to produce the desired temperature uses a plasma arc an electric discharge producing intense heat in the absence of combustion. Other types

of heating, such as induction, may also be used. In any case, the heat is sufficiently high to cause the organic molecules in the waste to break down to simpler compounds, even though no combustion is occurring. (This kind of heat breakdown with minimal oxygen present is generally called "pyrolysis".) Unfortunately, those simpler compounds include a significant proportion of gases (including carbon monoxide), which are somewhat harder to handle than solid residue. Since they must flow out of the pyrolysis chamber as the reaction proceeds, the advantage of not having to flow combustion air through the system is somewhat nullified. The off-gases are burned in an oxidation chamber. The volume of air that must be treated is somewhat less, but all the contaminants present in an incinerator exhaust stream are there as well, and must be filtered out or they will be emitted from the system.

## **b) Chemical treatment**

The obvious disadvantage of chemical treatment systems is that they consume chemicals. In addition, even if they are effective in rendering the waste non-infectious, the products of the chemical reactions they undergo are present in the waste, and may pose problems of their own. However, chemical treatment systems are convenient, and may be suitable in some situations, particularly when small quantities of waste are involved.

One of the most common constituents of chemical treatment systems is chlorine, either in the form of sodium hypochlorite solution (common bleach), or as the more powerful (and correspondingly more hazardous) gas, chlorine dioxide. These compounds are relatively cheap and effective. However, in the course of reacting with organic compounds, they tend to form objectionable by-products such as chloroform and other persistent toxins.

The chlorine compounds work by "oxidizing" (stripping electrons from) organic compounds, including the constituents of pathogenic microorganisms. The original "oxidizer" is, of course, atmospheric oxygen. Although it is, in fact, a fairly powerful oxidizing agent, ordinary oxygen is not harmful to, but is in fact essential for the survival of many organisms, including most of the pathogens in medical waste. However, when oxygen ( $O_2$ ) is converted to ozone ( $O_3$ ), a much stronger oxidizer, it becomes toxic to most life forms. Ozone can readily be generated by passing an electric arc through ordinary oxygen gas. When used in a medical waste treatment system, ozone acts as an effective sterilizer, without the tendency to generate the types of by-products found with chlorine compounds. The major problem

encountered with ozone systems is the need to avoid exposure to anyone in the vicinity of the treatment system, since ozone is highly injurious to lungs.

Alkaline agents are also used in medical waste treatment, either in highly corrosive form (sodium hydroxide, or lye), or in somewhat milder form (calcium oxide, or quicklime). Alkali tends to hydrolyse (decompose) proteins, among other effects. Apart from the cost of the reagents, the major disadvantage is the risk of contact, since alkaline solutions damage skin and lungs.

#### **2.2.4. SCHEDULE V**

#### **STANDARDS FOR TREATMENT AND DISPOSAL OF BIO-MEDICAL WASTES**

##### **2.2.4.1. Standards for Incinerators**

All incinerators shall meet the following operating and emission standards

##### **a) Operating Standards**

1. Combustion efficiency (CE) shall be at least 99.00%.
2. The Combustion efficiency is computed as follows:

$$C.E = \frac{\%CO_2}{\%CO_2 + \%CO} \times 100$$

3. The temperature of the primary chamber shall be  $800 \pm 50$  °C
4. The secondary chamber gas residence time shall be at least one second at  $1050 \pm 50$  °C, with minimum 3% Oxygen in the stack gas.

##### **b) Emission Standards**

Emission standards are shown below.

Table 3: Emission standards

| <b>Parameters</b> | <b>Concentration mg/Nm<sup>3</sup> at (12 % CO<sub>2</sub> correction)</b> |
|-------------------|----------------------------------------------------------------------------|
|-------------------|----------------------------------------------------------------------------|

|                                   |                        |
|-----------------------------------|------------------------|
| Particulate matter                | 150                    |
| Nitrogen Oxides                   | 450                    |
| HCl                               | 50                     |
| Minimum stack height              | 30 m above ground      |
| Volatile organic compounds in ash | not be more than 0.01% |

**Note:**

- Suitably designed pollution control devices should be installed/retrofitted with the incinerator to achieve the above emission limits, if necessary.
- Wastes to be incinerated shall not be chemically treated with any chlorinated disinfectants.
- Chlorinated plastics shall not be incinerated.
- Toxic metals in incineration ash shall be limited within the regulatory quantities as defined under the Hazardous Waste (Management and Handling Rules,) 1989.
- Only low sulphur fuel like L.D.0dLS.H.S.1Diesel shall be used as fuel in the incinerator.

#### **2.2.4.2. Standards for Waste Autoclaving**

The autoclave should be dedicated for the purposes of disinfecting and treating bio-medical waste,

a) Gravity Autoclave:

When operating a gravity flow autoclave, medical waste shall be subjected to:

- a temperature of not less than 121 C° and pressure of 15 pounds per square inch (psi) for an autoclave residence time of not less than 60 minutes; or
- a temperature of not less than 135 C° and a pressure of 31 psi for an autoclave residence time of not less than 45 minutes; or
- a temperature of not less than 149 C° and a pressure of 52 psi for an autoclave residence time of not less than 30 minutes.

### **b) Vacuum Autoclave**

When operating a vacuum autoclave, medical waste shall be subjected to a minimum of one pre-vacuum pulse to purge the autoclave of all air. The waste shall be subjected to the following:

- i. A temperature of not less than 121 °C and pressure of 15 psi for an autoclave residence time of not less than 45 mins; or
- ii. A temperature of not less than 135 °C and a pressure of 31 psi for an autoclave residence time of not less than 30 mins;

### **c) Autoclave standards**

Medical waste shall not be considered properly treated unless the time, temperature and pressure indicators indicate that the required time, temperature and pressure were reached during the autoclave process. If for any reasons, time temperature or pressure indicator indicates that the required temperature, pressure or residence time was not reached, the entire load of medical waste must be autoclaved again until the proper temperature, pressure and residence time were achieved.

### **d) Recording of operational parameters**

Each autoclave shall have graphic or computer recording devices which will automatically and continuously monitor and record dates, time of day, load identification number and operating parameters throughout the entire length of the autoclave cycle.

### **e) Validation test**

#### **Spore testing:**

The autoclave should completely and consistently kill the approved biological indicator at the maximum design capacity of each autoclave unit. Biological indicator for autoclave shall be *Bacillus stearothermophilus* spores using vials or spore Strips; with at least  $1 \times 10^4$  spores/ml. Under no circumstances will an autoclave have minimum operating parameters less than a residence time of 30 mins, regardless of temperature and pressure, a temperature less than 121 °C or a pressure less than 15 psi.

#### **f) Routine Test**

A chemical indicator strip/tape that changes colour when a certain temperature is reached can be used to verify that a specific temperature has been achieved. It may be necessary to use more than one strip over the waste package at different location to ensure that the inner content of the package has been adequately autoclaved

#### **2.2.4.3. Standard for Liquid Waste**

The effluent generated from the hospital should conform to the limits found in table 2.

Table 4: parameter standard for liquid waste

| PARAMETERS       | PERMISSIBLE LIMITS                                       |
|------------------|----------------------------------------------------------|
| pH               | 63-9.0                                                   |
| Suspended solids | 100 mg/l                                                 |
| Oil and grease   | 10 mg/l                                                  |
| BOD              | 30 mg/l                                                  |
| COD              | 250 mg/l                                                 |
| Bioassay test    | 90% survival of fish after 96 hours in<br>100% effluent. |

These limits are applicable to those, hospitals, which are either connected with sewers without terminal sewage treatment plant or not connected to public sewers. For discharge into public sewers with terminal facilities, the general standards as notified under the Environment (Protection) Act, 1986 shall be applicable.

#### **2.2.4.4. Standards of Microwaving**

- 1 Microwave treatment shall not be used for cytotoxic, hazardous or radioactive wastes, contaminated animal carcasses, body parts and large metal items.
2. The microwave system shall comply with the efficacy test/routine tests and a performance guarantee may be provided by the supplier before operation of the limit.
3. The microwave should completely and consistently kill the bacteria and other pathogenic organisms that is ensured by approved biological indicator at the

maximum design capacity of each microwave unit. Biological indicators for microwave shall be *Bacillus subtilis* spores using vials or spore strips with at least  $1 \times 10^1$  spores/ml.

#### **2.2.4.5. Standards for Deep Burial**

1. A pit or trench should be dug about 2 m deep. It should be half filled with waste then covered with lime within 50 cm of the surface, before filling the rest of the pit with soil.
2. It must be ensured that animals do not have any access to burial sites. Covers of galvanised iron/wire meshes may be used.
3. On each occasion, when wastes are added to the pit, a layer of 10 cm of soil shall be added to cover the wastes.
4. Burial must be performed under close and dedicated supervision.
5. The deep burial site should be relatively impermeable and no shallow well should be close to the site.
6. The pits should be distant from habitation, and sited so as to ensure that no contamination occurs of any surface water or ground water. The area should not be prone to flooding or erosion.
7. The location of the deep burial site will be authorized by the prescribed authority.
8. The institution shall maintain a record of all pits for deep burial.

#### **2.2.5. Recycling/Reuse**

Medical and other equipment used in a hospital may be reused provided that it is designed for the purpose and will withstand the sterilization process. Reusable items may include certain sharps, such as scalpels and hypodermic needles, syringes, glass bottles and containers, etc. After use, these items should be collected separately from non-reusable items, carefully washed (particularly in the case of hypodermic needles if infectious droplets could be trapped in them), and may then be sterilized. Although reuse of hypodermic needles is not recommended it may be necessary in establishments that cannot afford disposable syringes and needles. Plastic syringes and catheters should not be thermally or chemically sterilized, they should be discarded for recycling industries. Long-term radio nuclides conditioned as pins, needles or seeds used for radiotherapy may be reused after sterilization.

Special measure must be applied in the case of potential contamination with the causative agents of transmissible diseases. Care should be taken while opting for recycle or reused materials, medical and other equipment. Ensure that effective sterilization is attained. Sterilization can be achieved by thermal sterilization and chemical sterilization.

#### **2.2.6. Waste transportation**

Untreated medical waste shall be transported in specific vehicles into a storage house within the hospital. The transportation can be done in trolleys or in wheelbarrows. Manual loading of medical waste should be avoided if possible to reduce risk of infections. The medical waste can be put in bags which should be accompanied by signed documents by a doctor or nurse mentioning the date, quantity and destination.

Off-site transport should be done in special vehicles so as to prevent access to, and direct contact with the waste by the transported operators, the scavengers and the public. The transport containers should be properly enclosed so as to reduce the risk if any accident should occur. The effects of accidents should be considered when designing the vehicles that transport medical waste. The driver should be well trained in the processes they must follow in case of an accidental spillage. It should also be possible to wash the interior of the transport container after the waste has been dumped. The untreated waste is been transported carefully to disposal sites.

#### **2.2.7. SCHEDULE IV**

##### **LABEL FOR TRANSPORT OF BIO-MEDICAL WASTE CONTAINERS/BAGS**

Day .....Month .....

Year .....

Date of generation .....

Waste category No .....

Waste class

Waste description

**Sender's Name & Address**

PhoneNo .....

TelexNo ....

Fax No .....

ContactPerson .....

**Receiver's Name & Address**

PhoneNo .....

TelexNo .....

Fax No .....

Contact Person .....

**In case of emergency please contact**

Name &Address :

Phone No.

Note : Label shall be non-washable and prominently visible.

## **2.3. International agreements and principles on health care management**

### **2.3.1. Basel convention**

This convention is a global agreement, ratified by some 178 member countries to address the problems and challenges posed by hazardous waste. The Secretariat, based in Geneva (Switzerland) is administered by UNEP. It facilitates the implementation of the Convention and related agreements. It also provides assistance and guidelines on legal and technical issues and conducts training on the proper management of hazardous waste. The key objectives of the Basel Convention are:

- To minimize the generation of hazardous wastes in terms of quantity and hazardousness;
- To dispose of them as close to the source of generation as possible;
- To reduce the movement of hazardous wastes.

A central goal of the Basel Convention is “environmentally sound management” (ESM), the aim of which is to protect human health and the environment by minimizing hazardous waste production whenever possible. ESM means addressing the issue through an “integrated life-cycle approach”, which involves strong controls from the generation of a hazardous waste to its storage, transport, treatment, reuse, recycling, recovery and final disposal.

Health Care Related Wastes (HCRW) is one of the categories of hazardous wastes covered by the Convention. It was adopted in 1989. During its first decade, the Convention’s principal focus was the elaboration of controls on the “trans-boundary” movement of hazardous wastes that is the movement of such wastes across international frontiers and the development of criteria for environmentally sound management of the wastes. More recently

the work of the Convention has emphasized full implementation of treaty commitments, promotion of the environmentally sound management of hazardous wastes, a lifecycle approach, and minimization of hazardous waste, generation. The Convention entered into force 5 May 1992 (HCWC, 2007).

The Basel Convention (Article 4) requires each Party to minimize waste generation and to ensure, to the extent possible, the availability of disposal facilities within its own territory. The Conference of the Parties at its sixth meeting in December 2002 adopted a Strategic Plan for the implementation of the Basel Declaration to 2010 building on and using the framework of the 1999 Ministerial Basel Declaration on Environmentally Sound Management. Hazardous wastes are those wastes that are: explosive, flammable, poisonous, infectious, corrosive, toxic, or eco-toxic.

### **2.3.2. The Stockholm convention on persistent organic pollutants**

This Convention is a global treaty to protect human health and the environment from persistent organic pollutants (POPs). POPs are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms and are toxic to humans and wildlife. Persistent Organic Pollutants (POPs) circulate globally and can cause damage wherever they travel. In implementing the Convention, Governments will take measures to eliminate or reduce the release of POPs into the environment.

The countries that have signed these conventions are Afghanistan, Albania, Algeria, Andorra, Angola, Antigua and Barbuda Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia, and Herzegovina, Botswana, Brazil, Brunei, Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Rep, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Cote d'Ivoire, Croatia, Cuba Cyprus, Czech Republic, Dem. Rep. of Korea, Dem. Rep. of the Congo, Denmark, Niger, Nigeria and many more other countries.

The Stockholm Convention was adopted in 2001. POPs are chemicals that are highly toxic, persistent, bio-accumulate and move long distance in the environment. The Convention seeks the elimination or restriction of production and use of all intentionally produced POPs (i.e. industrial chemicals and pesticides). It also seeks the continuing minimization and, where feasible, ultimate elimination of the release of unintentionally produced POPs such as dioxins and furans. The Convention entered into force 17 May 2004 (HCWC, 2007).

### **2.3.3. The Rotterdam convention**

The Rotterdam Convention was adopted in 1998. In the 1980s, UNEP and FAO developed voluntary codes of conduct and information exchange systems, culminating in the Prior Informed Consent (PIC) procedure introduced in 1989. The Convention replaces this arrangement with a mandatory PIC procedure and information exchange mechanism on hazardous chemicals and pesticides. The Convention entered into force 24 February 2004.

The Rotterdam Convention (Article 5) obliges Parties to notify the secretariat of final regulatory actions taken in respect of banned or severely restricted chemicals, for the information of other Parties and possible listing under the Convention. Developing countries and countries with economies in transition may also propose the listing of severely hazardous pesticide formulations (Article 6).

The Rotterdam Convention applies to any chemical that is banned or severely restricted by a Party. The Prior Informed Consent procedure applies to the following 28 hazardous pesticides: 2,4,5-T, aldrin, binapacryl, captafol, chlordane, chlordimeform, chlorobenzilate, DDT, 1,2-dibromoethane (EDB), dieldrin, dinoseb, DNOC and its salts, ethylene dichloride, ethylene oxide, fluoroacetamide, HCH, heptachlor, hexachlorobenzene, lindane, mercury compounds, monocrotophos, parathion, pentachlorophenol and toxaphene, plus certain formulations of methamidophos, methyl-parathion, monocrotophos, parathion, phosphamidon and a combination of benomyl, carbofuran and thiram. It also covers 11 industrial chemicals: asbestos (actinolite, anthophyllite, amosite, crocidolite, tremolite), polybrominated biphenyls (PBBs), polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCTs), tris (2,3-dibromopropyl) phosphate and tetraethyl lead (TEL) and tetramethyl lead (TML).

## **2.4. Health care waste management concepts**

### **2.4.1. Duty of care principle**

This principle stipulates that any organization that generates waste has a duty to dispose of the waste safely. Therefore it is the HCF that has ultimate responsibility for how waste is containerized, handled on-site and off-site and finally disposed of.

### **2.4.2. Polluter pays principle**

According to this principle all waste producers are legally and financially responsible for the safe handling and environmentally sound disposal of the waste they produce. In case of an

accidental pollution, the organization is liable for the costs of cleaning it up. Therefore if pollution results from poor management of health-care waste then the HCF is responsible. However, if the pollution results because of poor standards at the treatment facility then the HCF is likely to be held jointly accountable for the pollution with the treatment facility. Likewise this could happen with the service provider. The fact that the polluters should pay for the costs they impose on the environment is seen as an efficient incentive to produce less and segregate well.

#### 2.4.3. Precautionary principle

Following this principle one must always assume that waste is hazardous until shown to be safe. This means that where it is unknown what the hazard may be, it is important to take all the necessary precautions.

#### 2.4.4. Proximity principle

This principle recommends that treatment and disposal of hazardous waste take place at the closest possible location to its source in order to minimize the risks involved in its transport. According to a similar principle, any community should recycle or dispose of the waste it produces, inside its own territorial limits.

### The Waste Hierarchy

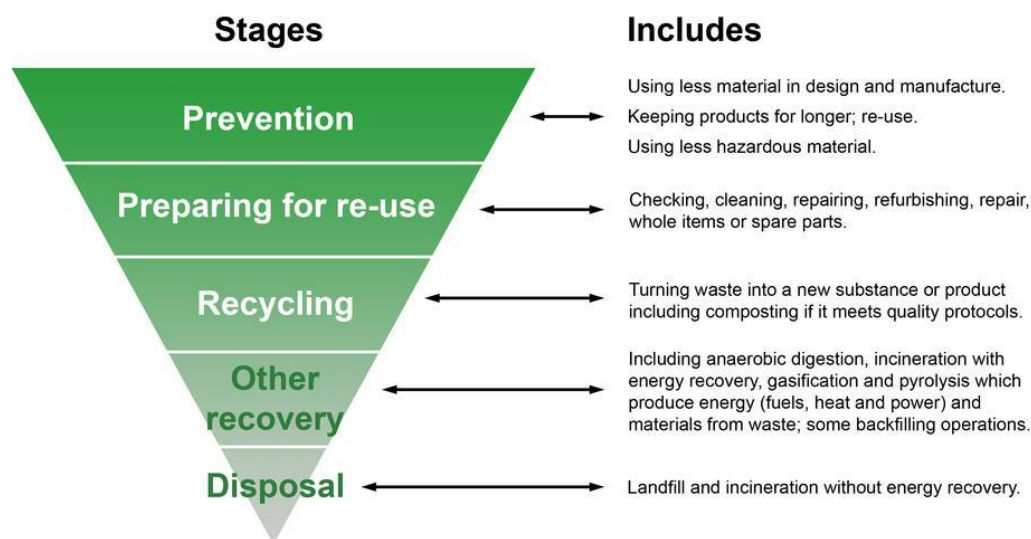


Figure 2: Waste management hierarchy.

## **CHAPTER THREE**

### **METHODOLOGY OF THE STUDY**

#### **3.1. Model Specification**

The model used in this study was based on comparing the existing medical waste management practices carried out in three different health care centres to the requirements put forward by the World Health Organisation guidelines for good practice. Figure 3.1 represents a schematic flow chart of the model used in this study.

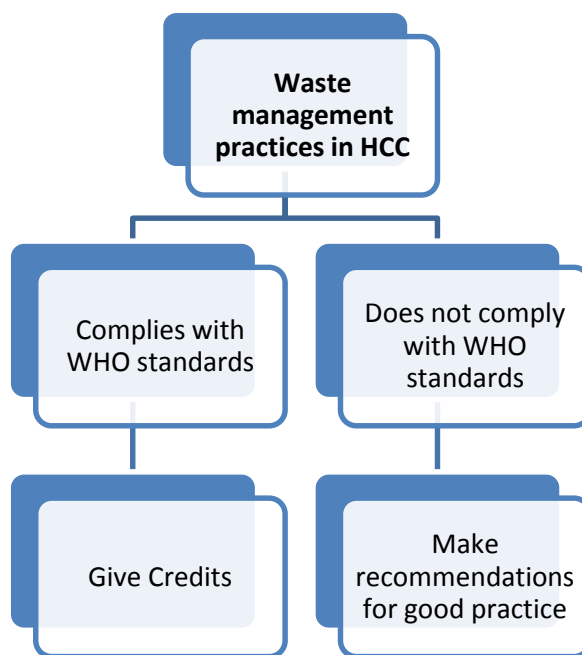


Figure 3: Schematic representation of model used in this study

### 3.2. Study Design

The study was both exploratory and descriptive in nature. The study targeted healthcare centres in Buea. Although, Buea has a number of healthcare centres, only three of these centres were purposively selected because they were most prominent in Buea in terms of familiarity with capacity, equipment facilities and professionals in the field of medicine. In addition, they were noted to produce a considerable amount of medical waste. The study population here include: midwives, nurses, cleaners and doctors because they were involved in one way or another, in the generation and management of medical waste in these healthcare centres. Amongst these target groups, 120 individuals were randomly selected for questionnaire administration. The questionnaires contained open and closed-ended questions. In addition, observations were made to document first-hand information on the existing medical waste practices. Furthermore, a total of 25 key informant interviews were conducted to get information from the different individuals working at these healthcare centres.

In general, the methodology adopted for this study followed that used by Oweis et al (2005). This includes a two stage strategy.

- 1) Examine the rules, procedures and regulations set forth by the hospitals directory to be followed by the personnel regarding the management of medical generated in the hospital
- 2) Spending enough time in the different departments of the hospital recording observations and writing notes in the critical manner about the practices of the medical waste management by the staff responsible for waste management.

Regular visits were made to general medical wards, maternity wards, surgical and critical care wards and semi operation theatres. To complement primary data, books, journals, articles, academic thesis, reports and website publication were also consulted. The results obtained were discussed to ascertain the extent to which the medical wastes are handled in the light of written policies and the established international standards in this regard. Data for the analysis was extracted from the interview and questionnaire administered.

### **3.3. Analytical approach**

Qualitative and quantitative analysis were used to get results. In the qualitative analysis, results were obtained from interview and observation. Descriptive analysis was used to describe what was observed in these hospitals. Questionnaires were used to collect data for the quantitative analysis. The results obtained were compared against the international standards required by WHO for medical waste management.

### **3.4. Validation of results**

There is a general standard on how medical waste should be handled. In this regards, the results from this research can be generalized because it was triangulated and conformed to other research findings generated by different data collection methods. More so, the medical waste management assessment and comparisons were in accordance to the WHO guidelines for medical waste management. Moreover, the researcher took necessary measures to ensure the reliability of the data collection instruments, the validity of data collected, the appropriateness of data analysis procedures and correctness in the interpretation of data analysis results. To ensure the reliability of the data collection instruments i.e. questionnaires, pretesting was carried out. At the end of this pre-test, some questions were added, some rephrased to reduce ambiguity, while others were discarded completely. Also, all of the variables captured in the questionnaires have been used extensively in studies of similar nature). Finally, the variables chosen were directly related to the objectives of the study.



## CHAPTER FOUR

### PRESENTATION AND ANALYSIS OF DATA

#### 4.1. Medical Waste Management Systems in the Three Healthcare Centers

Generally the different types of wastes that were identified from the three health care centres included, medical and non-medical wastes. Non-medical waste produced consisted of food waste, paper and cardboard waste and grass cuttings. These waste types are similar to the household wastes from the Buea municipality. In addition, the amount of waste generated in these health centres depended upon various factors such as number of beds, types of health services provided, economic, social and cultural status of the patients and the population in the area where the hospital is situated. For example, in hospitals located in low socioeconomic areas of cities, most of the non-medical waste consists of residues from fruits which are voluminous and abundant, whereas in those located in high socioeconomic area of the city, most of the waste consists of flowers, cans and single used containers for food (Askarian et al,2004). On the other hand, the medical wastes consisted of used sharps (needles, syringes and blades), cotton, plaster, drugs, used drip sets and plastic containers.



Figure 3: Complex mixture of medical and non-medical waste produced and stored in a pit

In all the healthcare centres, different kinds of therapeutic practices and procedures existed and these influenced the type of medical waste produced. However, the results show that there was no data on the quantity of medical waste produced in all the three healthcare centres.

#### **4.1.1. At the Regional Hospital, Buea**

##### **4.1.1.1. *Hospital facilities and MWM practice***

The Buea regional hospital is one of the main hospitals in Buea. It has good infrastructure and equipment facilities. The hospital adopts the following waste management procedures:

##### **a) Segregation**

Medical waste is produced from the different department in the regional hospital. Segregation is usually improperly done at source for most of the department especially the laboratory and the theatre. This is because the wastes collected in the bins from the different departments were composed of a mixture of materials (plastics, gauze, metals, etc.). The following descriptions explain the practices observed in the different departments of the hospital visited:

##### **Laboratory**

Waste contaminated with blood is separated from others and stored in different plastic bags. Sharps are placed in a different container too, as well as gloves while waste like used bottles or containers to collect stool and urine are place in another container. These containers for stool and urine are usually sterilized and reused for sample collection. Whereas containers in which blood is collected together with the blood are autoclaved, the blood is disposed of and the containers are kept for incineration.

##### **Wards**

All the waste produced here are stored in one container (fig 5b). There is no separation of the waste at the wards. The wastes here include blood contained substances like cotton, plaster, cloth and food waste of the patients. Interestingly, the sharps and syringe needles used for intravenous or intramuscular infusions, plastic waste, gloves and drip set are not emptied in the bin located around the wards; rather they are collected and stored in the laboratory bin described above.



a

b

Figure 4: a) Metal bin used in the hospital wards, b) plastic bin used in the hospital around the wards.

### **Labour room**

All the wastes from here are put in the same container except for the body parts such as placental that is given to the family member for burial. Also sharps are placed in another container as described in the case with the laboratory.

### **Maternity**

The waste here is similar to the waste produce at the other wards which include blood contaminated items and food waste. The wastes are also emptied in the metal and plastic bins described in the case on the other wards above.

### **Radiology department**

The waste is separated at source into solid radioactive waste and liquid radioactive waste. These wastes are put in polythene bags.

### **Dental department**

The waste is separated into mercury contained waste, silver containing waste, waste containing blood and teeth.

All the wastes from all the different department of the hospital are stored in bins. These bins do not follow the standard dimension of bins that medical wastes should be stored in it. The bins used in the wards are made of different materials; some metals and others plastic. In some cases a plastic bag is put first into the bin before the medical waste is put in it while in

other cases no plastic bag is used. Furthermore, some of these plastic bags do not have the biohazard symbol while others do. This impedes the safety of workers.

#### **b) Storage**

All the wastes are stored in these containers for about 24 hrs in their various department of origin. There is no waste storage room available in this healthcare centre. Mercury is stored in a mercury container and it is usually mixed with silver to make it less reactive. Silver containing waste is directly disposed of down the septic tank. It is mixed together with the liquid waste which is usually washed down the drains. Solid radioactive waste is store in bins lined with polythene bags and liquid radioactive waste is also stored in bins lined with polythene bags.

#### **c) Transportation**

##### **Onsite transportation**

There was no use of trolleys or trucks to transport waste around the hospital. The cleaners do the transportation manually by hand carrying to the incinerator, laboratory or to the pit.

##### **Off-site transportation**

This is mostly done by HYSACAM, the waste management company in Cameroon. Usually, only a small quantity of waste that is collected in a metal bin outside the hospital gate is given to HYSACAM for disposal (fig 6).



Figure 5: Waste collected at the gate of the general hospital and given to HYSACAM

This waste usually comprises only of food waste, plastic bottles, plastic bags, papers and grass cuttings.

#### **d) Treatment**

The main form of medical waste treatment here is through various means of sterilization including chemical treatment (using bleaching agents), autoclaving and/or microwaving. Wastes such as sharps are microwaved or autoclaved. These two treatment processes are mostly done in the lab and only small amount of the waste can be treated since the hospital does not have a modern autoclave machine. Some of the wastes such as wastes from wards and maternity are taken to the pit to be burn with little or no treatment. After microwaving or autoclaving, the sharp wastes are then incinerated. Incineration is done within the hospital in an incinerator. The specific temperature of the incinerator has not been noted. The plastic cups used for collection of urine and stool are sterilized by boiling and treated with bleaching agents.

#### **e) Reuse**

The most common waste that is reused in the general hospital is the plastic containers that were initially used for the collection of stool and urine samples. These containers are treated as explained in the treatment process above and later on reused.

#### **f) Disposal**

The main methods of disposal here are deep burial and burning (in a pit or an incinerator). A very deep pit is dug and the waste is dumped in it for a certain period of time until almost halve full and the covered with soil to bury the wastes. Cardboards, used cottons, plasters, gauze, gloves and syringes are usually incinerated.

#### **4.1.2. AT The Mount Mary HOSPITAL, Buea**

##### **4.1.2.1. *Hospital facilities and MWM practice***

The Mount Mary healthcare centre also has different departments but from inception, its infrastructure and equipment facilities tailor it to best handle cases with child delivery. However, it currently accommodates diverse therapeutic treatment processes with new technological facilities. In this regards, the Health Care centre adopts its own waste management procedures. The following description explains the practices observed in the different departments of the hospital visited:

##### **a) Segregation**



Figure 6: Labelled waste bins, located around the wards in the healthcare centre

Generally, segregation is done at the source especially in the laboratory and in the theatre. The entrance of the hospital has two separate bins put in front of it. One of the bins is labelled “perishable” and the other is labelled “non-perishable”. The perishable bin has waste that can easily decay and can be disposed of in farms near by the hospital. The non-perishable bin as the name explains has waste that cannot easily decay. These wastes are usually burnt in an open pit.

##### **Ward and maternity**

The wastes produced from these two sections of the hospital are similar. They include food waste, blood contaminated cotton, baby diapers, plastics, gloves etc.

##### **Lab**

Separation of waste here is done at source. Blood containing waste, cotton, tissues are separated from sharps. Blood, urine and stool used to carry out test are washed down directly into the drains.

### **Labour room**

The waste here is also separated. The body parts are given to the family for burial while the sharps and waste containing blood are stored in another container. All the wastes are put in the same container. There is no distinction in the colours of the containers as recommended by the WHO.

#### **b) Storage**

There is no storage house for the temporal storage of medical wastes. The wastes are stored in pits or in the bins for 24 hrs before disposal.

#### **c) Treatment**

The treatment methods used in this centre are autoclaving and microwaving. Sharps and other waste are microwaved before incinerated. They are also autoclaved.

#### **d) Reuse**

Some containers are put in detergent to be reused.

#### **e) Transportation**

- i. ***On site transportation:*** The cleaners carry the waste to the incinerator or pit.
- ii. ***Off-site transportation:*** The waste is given to HYSACAM.

#### **f) Disposal**

The methods for disposal here were similar to those of the general hospital and it includes: deep burial and burning (in a pit or an incinerator).

### **4.1.3. Medical Waste Management in Seventh Days Adventist Hospital, Buea**

#### **4.1.3.1. *Hospital facilities and MWM practice***

The Seventh Days Adventist health care centre is a paediatrics centre with limited infrastructure and equipment facilities, designed to best handle cases with child delivery and maternal care. However, it currently accommodates the treatment of common communicable diseases like malaria. In this regards, the health care centre adopts its own waste management procedures based on its capacity. The following description explains the practices observed:

### **a) Segregation**

#### **Ward and maternity**

The wastes produce here include cotton, plaster, and blood contaminated material, diapers and food waste. All these wastes are put into the same container.

#### **Laboratory**

Here, segregation practice is very minimal in the laboratory; in this case, the sharps are put in different containers, while blood containing substances are put in another container.

#### **Labour room**

Waste here is also separated drip sets and sharps are placed in one container while blood containing substances are placed in others. Body parts are given to the family member. The wastes from all the different hospital units are stored in plastic bins but they are not coloured according to the category of waste and they do not have the biohazard symbol for medical waste.

### **b) Storage**

There is no temporal storage site for the medical and non-medical wastes. In fact, these wastes are collected and stored in a pit (fig 9) pending burning.



Figure 7: Pit used for waste burning in the Seven Days Adventist healthcare centre in Buea

### **a) Treatment**

Here the medical wastes are not treated before burning or disposal but chemical detergents are used to disinfect some wastes which can be reused.

### **b) Reuse**

Here, detergents are used to disinfect some waste containers which can be reused. This process takes place in the laboratory.

### **c) Transportation**

- i. **Onsite transportation:** The waste is transported to the pit by the cleaners.
- ii. **Offsite transportation:** The waste collected (fig 10) and transported to the dumpsite at Musaka, by HYSACAM on daily bases.



Figure 8: Waste collected outside the Seventh Days healthcare centre

### **d) Disposal**

The waste is put in a pit and burnt. Wastes to be incinerated are given to the Mount Mary hospital

It was noted that the healthcare services were provided via a public (Regional Hospital Annex) and two private institutions (Mount Mary and the Seven days Adventist hospitals). The Ministry of Public Health is the umbrella organization responsible for maintenance of all public health services while the Catholic Church and Seven Days Adventist church are responsible for maintenance of the other two respective private healthcare services under this study, in Buea and in Cameroon at large. The results show that the effectiveness of the medical waste management in the three healthcare centres in Buea varies. The variations are suggested to be tied down to institutional and policy issues. In fact, it was noted that effectiveness depended on the educational status of the staff, infrastructural and equipment facilities. As explained by Gabriel and Peter (2013), when public health care infrastructure is expanded and other services included as a means to cope with such pressure, it leads to an increase in the amount of generated clinical waste. Local, regional and national authorities are thus faced with challenges to safely collect; treat and dispose the waste in a manner that

is compatible with international standards. Anríquez and Stloukal (2008) explained that the typical economic and political problems in such countries as Cameroon take the blame for insufficient social and educational resources and infrastructure, which in turn contribute towards failures in effective clinical waste management.

#### 4.1.2. Assessment of Medical Waste Management

Table 5: General Assessment on Medical Waste Management

| Questions                                    | Answers   | Regional hospital (%) | Mount Mary (%) | Seventh Days Adventist (%) | Total (%) |
|----------------------------------------------|-----------|-----------------------|----------------|----------------------------|-----------|
| gender                                       | male      | 28                    | 12             | 32                         | 24        |
|                                              | female    | 72                    | 88             | 68                         | 76        |
| position                                     | doctor    | 30                    | 20             | 15                         | 22        |
|                                              | nurse     | 48                    | 56             | 66                         | 56        |
|                                              | cleaners  | 22                    | 24             | 19                         | 22        |
| department                                   | lab       | 12                    | 9              | 8                          | 10        |
|                                              | ward      | 55                    | 60             | 66                         | 60        |
|                                              | maternity | 33                    | 31             | 26                         | 30        |
| Practice waste management?                   | yes       | 83                    | 75             | 60                         | 73        |
|                                              | no        | 15                    | 10             | 30                         | 18        |
|                                              | No idea   | 2                     | 15             | 10                         | 9         |
| Segregate medical waste?                     | yes       | 35                    | 20             | 23                         | 26        |
|                                              | no        | 40                    | 56             | 45                         | 47        |
|                                              | No ideal  | 25                    | 24             | 32                         | 27        |
| Differentiate bins for the different wastes? | yes       | 25                    | 15             | 10                         | 17        |
|                                              | no        | 70                    | 79             | 55                         | 68        |
|                                              | No idea   | 5                     | 6              | 35                         | 15        |
| Treat wastes?                                | yes       | 45                    | 49             | 45                         | 46        |

|                                 |               |     |     |     |     |
|---------------------------------|---------------|-----|-----|-----|-----|
|                                 | no            | 30  | 27  | 25  | 27  |
|                                 | No ideal      | 25  | 24  | 30  | 27  |
|                                 | yes           | 25  | 35  | 20  | 27  |
| Temporal storage?               | no            | 45  | 30  | 45  | 40  |
|                                 | No idea       | 30  | 35  | 35  | 33  |
|                                 | yes           | 49  | 30  | 46  | 42  |
| Reuse some wastes?              | no            | 20  | 40  | 35  | 32  |
|                                 | No idea       | 31  | 30  | 19  | 26  |
|                                 | yes           | 10  | 15  | 5   | 10  |
| Had waste management training?  | no            | 70  | 70  | 88  | 76  |
|                                 | No ideal      | 20  | 15  | 7   | 14  |
|                                 | Hand carrying | 100 | 100 | 100 | 100 |
| Transportation of medical waste | wheelbarrows  | 0   | 0   | 0   | 0   |

#### **4.1.2.1. Segregation and container issues**

Table 5 depicts that 26% of the total population of the three healthcare centres said that they segregate their waste, 47% of the population did not segregate their waste while 27% of the population had no idea of medical waste segregation. After the interviews with health care staff, results revealed that segregation applied only for sharp waste which is collected in special sharp boxes at the beginning after usage. Collection is done first by medical staff then transported along with other types of wastes by cleaners. This explains the differences between answers among respondents about presence of medical waste segregation. About 17% of the respondent agreed on the use of different bins, 68% of them did not while 15% of the respondents had no idea on the use of different bins for waste collection. The findings for health care waste segregation practices in this study was similar to some other developing countries, such as in Iran (Askarian et al., 2004); Jordan (Abdulla et al., 2008);Egypt (Soliman and Ahmed, 2007); Nigeria (Longo and Williams , 2006); and in Karachi (Rasheed et al., 2005), as well as to the local research results as two studies were applied in Palestinian governorates of Nablus (AL-khatib and Sato, 2009) and Gaza (Massrouji, 2001) which

revealed that segregation of all waste materials was not conducted according to definite rules and standards.

#### **4.1.2.2. *Treatment, reuse and Storage of medical waste issues***

From the table 5, 27% of the respondents agreed that there was a temporal storage site, 40% disagreed while 33% had no idea on any storage site for medical waste. About 46% of the respondents said that their wastes were treated, 27% deny any treatment while 27% had no idea of waste treatment. Moreover, 42% of the population agreed on waste reused, 32% disagreed while 26% of the population have no idea on the reuse of medical waste. In Nablus–Palestine there was no special storage room for medical waste in the hospitals that, hazardous waste was sometimes stored in the same containers as the domestic waste, and there is no control measures existed for the management of these waste materials (AL-khatib and Sato, 2009). According to Soliman and Ahmed (2007), in Egypt, some department store their biomedical waste inside the utility rooms such as surgical, medical, laboratory and intensive care units, while Labour, operating rooms and dialysis units do not store biomedical waste in the department, but the waste is immediately transported to the general storage area of the hospital which is located on the basement floor near to the exit door or near the incinerator.

#### **4.1.2.3. *Transportation of medical waste issues***

All the waste (100 %) is transported by hand carrying. In northern part of Palestine mainly in Nablus Governorate, hospital waste was collected by cleaning personnel who picked up the medical waste from different departments and transported it manually to a temporary storage area where the hospital waste was kept before being taken to the final disposal site as most of time general waste mixed with medical waste, and this area was poorly sanitized and not secured (AL-khatib and Sato, 2009). In a pilot study in Egypt by Soliman and Ahmed (2007), the department aid workers are usually responsible for biomedical waste collection and transportation; but those workers are not specially assigned for handling of waste, as they move wastes to the storage area of the hospital on a trolley or cart, which is not especially designed for this purpose. In Jordan collection and internal transportation in were carried out primarily by private contractors with little experience.

Results of the study (fig 11) show that training courses and awareness programs about medical waste management for health care providers and workers at hospitals were limited, as 10% only of all study subjects received training while 76% of them at three healthcare

centres did not receive any training about medical waste management (MWM) with some difference between governmental and private hospitals. In the public hospital, more workers (20%) are not aware about training compare to the other two private healthcare centres (15% and 7%).

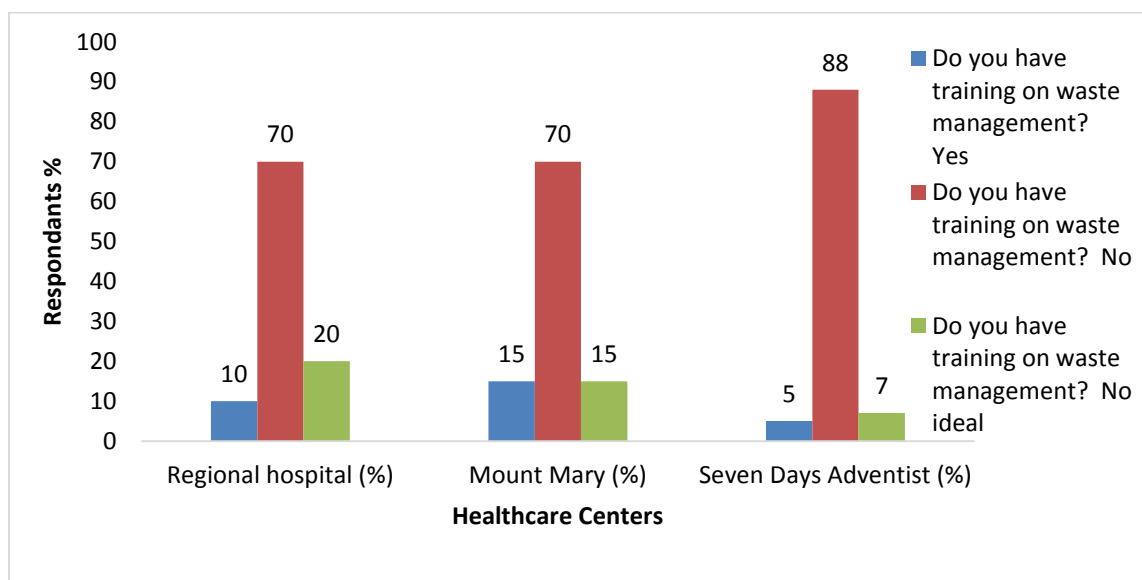


Figure 9: Training about health care management

In the study of Abdulla et al. (2008) in Jordan about 29% of the hospitals had not provided training to doctors and other personnel about medical waste management and their potential hazards. More so, the Mount Mary healthcare centre provides training more (15%) that the Regional hospital (10%) and the Seventh Days Adventist (5%).

#### 4.1.3. Perceptions about policies guiding the ongoing practice in the three healthcare centers

There is no clear policy and plan put in place for managing medical waste in these healthcare centres. In addition, there is no definite policy or plan for purchasing the necessary equipment and for providing the facilities for the correct management of medical waste in these health care centres. However, all the three healthcare centres have a medical waste management guideline prepared by a supervisor but it is usually not strictly followed. There are areas where medical waste management at the healthcare centres are not properly done. For instance, there is no proper segregation of medical waste, particular sharps at the source. This result is in line with the findings of Gabriel and Peter (2013) who stated that clinical waste management in Cameroon is ineffective, part due to the absence of an elaborate clinical waste management policy and also due to the knowledge, attitude and practice of the

people involved in the sector. They added that waste is seldom segregated in the hospitals and it is common to see potentially infectious items such as needles, syringes, scalpel blades and intravenous sets among other waste materials piled-up around hospital complexes.

Moreover, all the centres do not have a regular report about their medical waste management practices and processes. Figure 12 presents the staff awareness status about existing waste management policies and guidelines in the three healthcare centres.

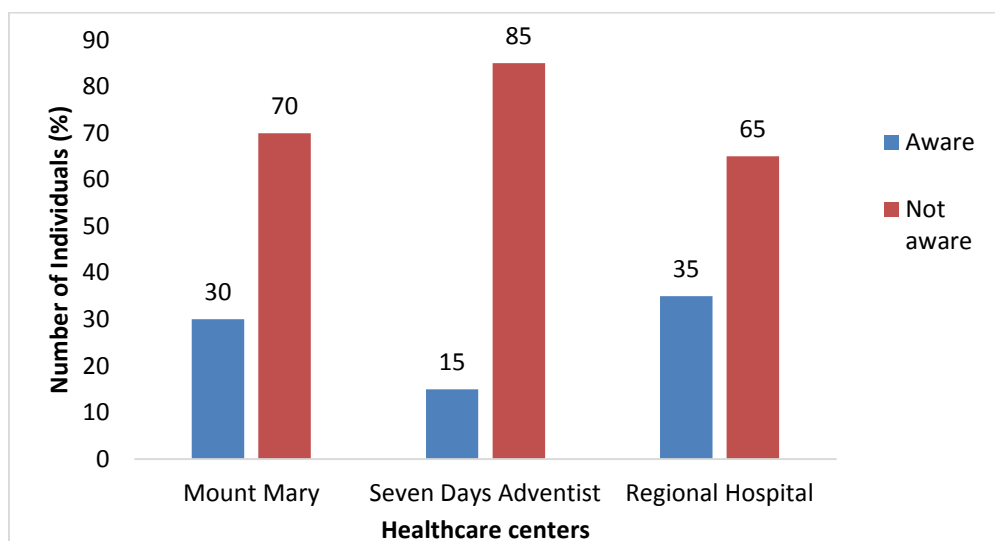


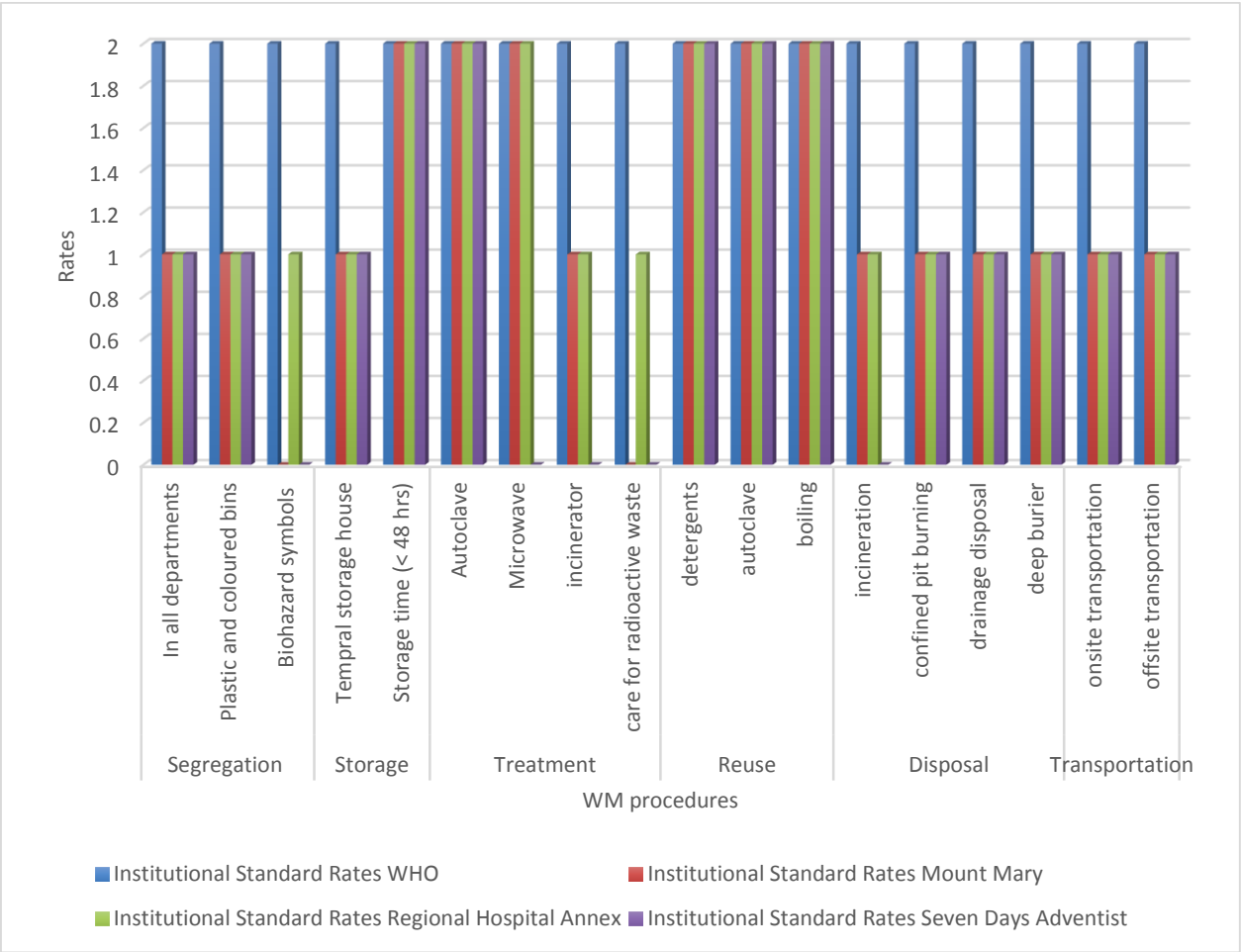
Figure 10: Staff awareness status about existing waste management policies and guidelines in the three healthcare centres.

The results show that from each healthcare centre (Mount Mary, Seven Days Adventist and Regional hospital annex), 70%, 85% and 65% respectively of people in the hospital are not aware of the existing waste management policies and guidelines. In fact, a greater proportion of them had never heard of a policy or guideline linked to efficient management of clinical waste, at either the national or international level. In this light, they lack sound background knowledge about the main issues of poor clinical waste management that needs to be dealt with. This result supports the findings of Gabriel and Peter (2013) who carried out a health impact assessment and evaluation of a clinical waste management policy for Cameroon and identified the need for sharpening staff background knowledge of clinical waste and its management to increase their awareness of the main issues of poor clinical waste management. In fact, it is expected that a sustainable system of improved clinical waste

management that guarantees reduction or complete elimination of unintended risks to hospital workers and the community be put in place.

#### 4.2. Medical waste management systems (in the three healthcare centers in Buea) Vs the WHO standard.

The results reveal that there exist some differences and similarities in the procedures used for medical waste management in these hospitals, and how these procedures either conform or deviate from the international standard for medical waste management prescribed by WHO (figure 13).



Description of Standard Rates:            2            =            Comply with WHO,

                                                                 1            =            Partially Comply with WHO,

0 = Does not comply with WHO

Figure 11 Compares between the medical waste management systems in the three healthcare centers in Buea and the WHO standard

Figure 13 shows that segregation was done in some of the departments of the three hospitals such as in the laboratory and the theatre. This depicts that waste in other departments such as the wards (emergency, accident, maternity, male, female and children) are not segregated. This separation is not done following the WHO standards which require storage in prescribed colour bins in the regional hospital of Buea have the biohazard label while those of the other two hospitals do not have the biohazard label. The use of metal bins at the regional hospital is not accepted by the WHO standards. Although there is segregation taking place in the laboratory and theatre of these three hospitals it was not properly done as required by the WHO. Polythene bags are placed in some bins before waste collection while this is not the case with other bins. These three hospitals do not have a temporary storage site as required by the WHO. The Seven Day Adventist hospital uses their pit as a storage site. The regional hospital has a site close to the incinerator where the waste was stored as well as Mount Mary hospital but these sites do not meet the specifications required by WHO (they have a waste pit instead of a storage house). The waste storage time (24hrs) in all the three healthcare centres falls well below the WHO limit (<48hr) before it is taken for disposal or treatment. The wastes treated in these three hospitals are sharps and some blood containing substances. Autoclave treatment was commonly used in these three hospitals and it was normally set to the required temperature for treatment. Microwave was used just in mount Mary and the regional hospital and it was also set to the required standard temperature range prescribed by WHO for the treatment of medical waste. Incinerators were found in Mount Mary and the regional hospital but they were not set to the required temperature for treatment because they were locally constructed and hence of low quality performance. The Seven Day Adventist did not have an incinerator but their waste was sometimes taken to the Mount Mary for incineration. Radioactive waste is one of the most dangerous wastes produced only in the Regional hospital Annex and this waste was not properly management. The waste easily got in to the atmosphere through the open windows of the radiological centre and the solid and liquid radioactive wastes were treated like any other waste produced in the hospital. Not all the waste produced in all three healthcare centres was disposed of. Some of them (plastic bottles used for stool and urine collection) were sterilized and reused. The process

of sterilization was done using autoclave, boiling and the use of detergents. All these three healthcare centres did practice pit burning but the standard of the pits vary amongst them. The pits were not confined and therefore caused air pollution. Deep burial was practiced in the Regional Hospital and Mount Mary. However, the depth of the pit could not be accounted for. Some of the waste produced in all three centres were quickly flushed down the drains. These wastes include blood samples, stool and any other liquid chemicals produced in these hospitals. Incineration for disposal was done only in the Mount Mary and the regional hospital. These incinerators were not up to the standard recommended by the WHO. Transportation of wastes in and out of these three healthcare centres were done by hand carrying. The WHO standard denies hand carrying of medical wastes because workers can trip and fall while carrying some dangerous waste and these can cause injuries thereby infecting those carrying the waste and those around them. Medical waste is supposed to be carried using trolleys or wheelbarrows.

#### **4.3. Discussions**

Generally this implies that the medical wastes are not judiciously planned and managed and hence are not treated and disposed of in accordance with Schedule I, and not in compliance with the standards prescribed in Schedule V. However, the health care centres have set up in accordance with the time-schedule, some requisite bio-medical waste treatment facilities like incinerator, autoclave, microwave system for the treatment of waste, or, ensure requisite treatment of waste at a common waste treatment facility or any other waste treatment facility. Bio-medical waste is not segregated into containers/bags at the point of generation in accordance with Schedule II prior to its storage, transportation, treatment and disposal. The containers are not labelled according to Schedule III. Interestingly, untreated bio-medical wastes are not kept/stored beyond a period of 48 hrs.

The results typify the short-comings associated with segregation, collection, transportation, temporal storage and treatment and disposal. Similar situations have been reported in Nigeria (Oke, 2008), where infectious and non-infectious waste were collected in the same dust bin; Botswana (Ketlogetswe et al, 2004), where disposal techniques vary from one centre to another and Iran (Taghipour and Mosaferi, 2009), where segregation is weak and ineffective. These studies suggest that a holistic approach needs to be adopted to successfully manage clinical waste in developing countries. Patil and Shekdar (2001) identified short-comings in the existing clinical waste management system in India. According to the authors, only few establishments contain separate systems for disposal of clinical waste while mixing and co-

disposal is common in the others. This was also observed in three healthcare centres as co-disposal at the rear of hospital premises rendered void ad hoc segregation efforts taking place in the wards and other generation points such as consultation offices of doctors.

A fundamental and very important step in any waste management process is the availability of sufficient and accurate information, including understanding the generation rates and quantities of the materials that needs treatment and disposal (Pruss et al, 1999; Qdais et al, 2007; Diaz et al, 2008). This is because it can be all too easy to ignore a problem about which there are few data (Sagoe-Moses et al, 2001). The existing systems in the three healthcare centres is plagued with unreliable and inaccurate data on the quantities and composition of the generated waste, poor planning and lack of adequate budget allocation, including the absence of color-coded storage containers for different categories of waste. None of the hospitals visited during the study kept data on the type and amount of waste they generate. In fact, some directors and employees were surprised at the interest in the quantity of waste they generate. Taghipour and Mosaferi (2009) reported that most cities in Iran dispose domestic and clinical waste together in municipal dumpsites or in poorly designed landfills, or they use on-site waste incinerators that pose operational and maintenance problems. This bears a clear resemblance to what was observed in the three healthcare centres as medical waste was dumped in municipal waste bins. Despite the difference in current clinical waste management practices in the three healthcare centres, the problem areas remain approximately the same at all stages of management and this is in line with the findings of Tsakona, (2007). These medical waste management processes, according to Girolletti and Lodola (1993) are important and serve as integral components for any successful waste management action.

The biggest problem in effective clinical waste management in developing countries lies with insufficient resource allocation, lack of training and appropriate skills, risk awareness, public apprehensions and misguided information on exposure, incinerator capacity and the increasing need for a solid and sustainable national health care strategy (HCWS, 2008). These problems arise due to the absence of qualified staff and insufficient training of those available on issues related to efficient clinical waste management and the hazards that might emerge from their inappropriate handling (Tsakona, 2007). Very little political and financial power is usually allocated for training and awareness programs as well as selection and construction of suitable treatment and disposal facilities.

A national strategy for clinical waste management is a major recommendation of the WHO (WHO, 1999) and such a strategy should be part of a more comprehensive legislation which

ensures legal control and orderliness in the clinical waste management process. The government of Cameroon has taken some steps to improve the current situation of clinical waste management. For example; a national strategy on solid waste management elaborated in 2007 by the Ministry of Environment and the Protection of Nature specifies techniques for prevention, collection and storage, transportation, treatment, and elimination. Another national strategy on the security and management of injection materials developed in 2002, elaborates guidelines for the disposal of such materials, stating that “used syringes and needles should be immediately dropped together in the appropriate receptacles which in this case are the security boxes” and that “In no situation should an injection material be dropped in a public waste bin.” The document also states that “the method to destroy injection materials is by incineration at high temperature and the burial of the combustion residue. “Despite the above mentioned efforts, the situation on the ground remains deplorable thus giving reason to believe that the strategic documents serve more as voluntary guidelines rather than thorough requirements.

## **CHAPTER FIVE**

### **SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS**

#### **5.1. Summary of Findings**

Generally medical and non-medical wastes were produced from three health care centres. The amount of waste generated depended upon factors such as number of beds, types of health services provided, economic, social and cultural status of the patients and the

population the area where the hospital is situated. Medical wastes produced from the different department in the three healthcare centres and hospitals were improperly segregated. Segregation was applied only for sharp waste which is collected in special sharp boxes at the beginning after usage. In addition, although the waste storage time was less than 48 hrs, the wastes were stored in both plastic and metal container with and with plastic lining ant biohazard symbols. Collection was done first by medical staff then transported with other types of waste by cleaners. A transport of medical waste was made in plastic sacks as well as domestic waste disposed in the same kind of bags which is generally subject to tear in spite of being fastened properly. Most of respondents don't know where medical storage place is, and don't know if there is mark to show place of storage. Besides, training courses and awareness programs about medical waste management for health care providers and workers at hospitals were limited.

The medical wastes are not judiciously planned and managed and hence are not treated and disposed of in accordance with Schedule I, and not in compliance with the standards prescribed in Schedule V. However, the health care centres have set up in accordance with the time-schedule in Schedule VI, some requisite bio-medical waste treatment facilities like incinerator, autoclave, microwave system for the treatment of waste, or, ensure requisite treatment of waste at a common waste treatment facility or any other waste treatment facility. Bio-medical waste is not segregated into containers/bags at the point of generation in accordance with Schedule II prior to its storage, transportation, treatment and disposal. The containers are not labelled according to Schedule III. Interestingly, untreated bio-medical waste are not kept/stored beyond a period of 48 hrs.

## **Résumé des résultats**

Les déchets médicaux et non médicaux étaient généralement produits par trois centres de santé. La quantité de déchets générée dépendait des facteurs tels que le nombre de lits, les types de services de santé rendus, le statut économique, social et culturel des patients et la population du milieu où se trouve l'hôpital. Les déchets médicaux produits par les différents services des trois centres de santé et hôpitaux étaient séparés de manière incorrecte. Seuls

les déchets tranchants étaient séparés et collectés dans des boîtes spéciales au début après usage. En plus, malgré le fait que le temps de stockage de déchets était de moins de 48 heures, les déchets étaient conservés dans des contenants en plastique et en métal avec et sans revêtement plastique, ni symboles de danger de contamination. La collecte était d'abord effectuée par le personnel médical, puis transportée avec les autres types de déchets par les agents d'entretien. Les déchets médicaux étaient transportés dans des sacs plastiques avec les ordures ménagères contenus dans le même genre de sacs qui se déchirent généralement facilement même s'ils sont bien fermés. La plupart des répondants ne savent où se trouve le lieu de stockage médical, et ne savent pas s'il y a une marque pour indiquer le lieu de stockage. En outre, les cours de formation et les programmes de sensibilisation sur la gestion de déchets médicaux du personnel de centre de santé et des employés d'hôpitaux étaient limités.

Les déchets médicaux ne sont pas planifiés et gérés de manière judicieuse et par conséquent, ne sont pas traités et jetés selon Annexe I, et pas en accord avec les normes prescrites dans Annexe V. Toutefois, les centres de santé se sont équipés de quelques matériels pour le traitement de déchets biomédicaux comme l'incinérateur, l'autoclave, le système micro-onde pour le traitement de déchets, ou, s'assurent du traitement de déchets requis à l'installation du traitement de déchets ordinaire ou toute autre installation de traitement de déchets. Les déchets biomédicaux ne sont pas séparés dans des contenants/sacs au point de génération selon Annexe II avant le stockage, transport, traitement et ramassage. Il est intéressant de noter que les déchets biomédicaux non traités ne sont pas gardés/stockés plus de 48 heures.

## **5.2. Conclusions**

Generally medical and non-medical wastes were produced from three health care centres. The amount of waste generated depended upon factors such as number of beds, types of health services provided, economic, social and cultural status of the patients and the population the area where the hospital is situated. Medical wastes produced from the different department in the three healthcare centres hospital were improperly segregated. Segregation was applied only for sharp waste which is collected in special sharp boxes at the beginning after usage. In addition, although the waste storage time was less than 48 hrs, the wastes were stored in both plastic and metal container with and with plastic lining and biohazard symbols. Collection was done first by medical staff then transported with other types of waste by cleaners. A transport of medical waste was made in plastic sacks as well

as domestic waste disposed in the same kind of bags which is generally subject to tear in spite of being fastened properly. Most of respondents don't know where medical storage place is, and don't know if there is mark to show place of storage. Besides, training courses and awareness programs about medical waste management for health care providers and workers at hospitals were limited. However, the medical wastes were not judiciously planned and managed and hence are not treated and disposed of in accordance with Schedule I, and not in compliance with the standards prescribed in Schedule V, but the health care centres have set up in accordance with the time-schedule in Schedule VI, some requisite bio-medical waste treatment facilities like incinerator, autoclave, microwave system for the treatment of waste, or, ensure requisite treatment of waste at a common waste treatment facility or any other waste treatment facility. Bio-medical waste is not segregated into containers/bags at the point of generation in accordance with Schedule II prior to its storage, transportation, treatment and disposal. The containers are not labelled according to Schedule III. Interestingly, untreated bio-medical waste are not kept/stored beyond a period of 48 hours. Accordingly, the Ministry of Health, institutions should pay more attention towards policies for the proper management and disposal of wastes to ensure enhancement and adequacy in the medical waste management practices. Additionally, there is need to be incorporated into regular worker training, continuing education, and management evaluation processes for systems and personnel.

## **Conclusions**

Les déchets médicaux et non médicaux étaient généralement produits par trois centres de santé. La quantité de déchets générée dépendait des facteurs tels que le nombre de lits, les types de services de santé rendus, le statut économique, social et culturel des patients et la population du milieu où se trouve l'hôpital. Les déchets médicaux produits par les différents services des trois centres de santé et hôpitaux étaient séparés de manière incorrecte. Seuls les déchets tranchants étaient séparés et collectés dans des boîtes spéciales au début après usage. En plus, malgré le fait que le temps de stockage de déchets était de moins de 48 heures, les déchets étaient conservés dans des contenants en plastique et en métal avec et sans revêtement plastique, ni symboles de danger de contamination. La collecte était d'abord effectuée par le personnel médical, puis transportée avec les autres types de déchets par les agents d'entretien. Les déchets médicaux étaient transportés dans des sacs plastiques avec les ordures ménagères contenus dans le même genre de sacs qui se déchirent généralement facilement même s'ils sont bien fermés. La plupart des répondants ne savent où se trouve le

lieu de stockage médical, et ne savent pas s'il y a une marque pour indiquer le lieu de stockage. En outre, les cours de formation et les programmes de sensibilisation sur la gestion de déchets médicaux du personnel de centre de santé et des employés d'hôpitaux étaient limités. Toutefois, les déchets médicaux ne sont pas planifiés et gérés de manière judicieuse et par conséquent, ne sont pas traités et jetés selon Annexe I, et pas en accord avec les normes prescrites dans Annexe V, mais les centres de santé se sont équipés de quelques matériels pour le traitement de déchets biomédicaux comme l'incinérateur, l'autoclave, le système micro-onde pour le traitement de déchets, ou, s'assurent du traitement de déchets requis à l'installation du traitement de déchets ordinaire ou toute autre installation de traitement de déchets. Les déchets biomédicaux ne sont pas séparés dans des contenants/sacs au point de génération selon Annexe II avant le stockage, transport, traitement et ramassage. Il est intéressant de noter que les déchets biomédicaux non traités ne sont pas gardés/stockés plus de 48 heures. Le Ministère de la Santé et les institutions devraient prêter davantage attention aux politiques de gestion adéquates et traitement de déchets pour assurer l'amélioration et la conformité des pratiques de gestion de déchets médicaux. De plus, il est nécessaire d'intégrer chez le travailleur régulier, les procédés de formation, d'éducation continue et d'évaluation de gestion pour les systèmes et le personnel.

### **5.3 Recommendations**

The following recommendations need to be enacted for medical waste management in the health care centres in Buea to become more efficient in protecting the environment and population health, as well as meeting sustainable goals:

- Strategic plans and policies need to be put in place for medical waste management.
- Those directly involved in medical waste management should be given training on how to handle the waste.
- Proper disposal sites need to be created such as deep pits and modern incinerators. They need to be of standard and big enough to hold the waste.
- Radioactive waste needs to be handled with care.
- Further research on the medical waste management, quantity and impacts of medical waste from other health care centres in Buea is vital to cover a wider perspective and to ascertain the importance of innovations for a sustainable development.

### **Recommendations**

Les recommandations suivantes devraient mises en application pour que la gestion de déchets médicaux dans les centres de santé de Buéa devienne plus efficace dans la protection de l'environnement et la santé des populations, et atteigne des objectifs durables :

- Des plans et politiques stratégiques devraient établis pour la gestion de déchets médicaux.
- Ceux qui sont directement impliqués dans la gestion de déchets médicaux devraient être formés sur comment manipuler les déchets.
- Des sites de dépôt appropriés tels que des fosses profondes et des incinérateurs modernes devraient être créés. Ils devraient être faits selon la norme et assez grand pour contenir les déchets.
- Les déchets radioactifs devraient être manipulés avec précaution.
- Des recherches sur la gestion de déchets médicaux, la quantité et les impacts des déchets médicaux d'autres centres de santé de Buéa sont vitales pour couvrir une perspective plus large et pour déterminer l'importance les innovations pour un développement durable.

## REFERENCES

- Abah, S.O., and Ohimain, E.I. (2010). Assessment of Dumpsite Rehabilitation Potential using the Integrated Risk Based Approach: A case study of Eneka, Nigeria. *World of Applied Science Journal*. 8(4): 436-442
- Abah, S.O., Ohimain, E.I., and (2011). Healthcare waste management in Nigeria:A case study. *Journal of Public Health and Epidemiology*.3(3): 99-110.
- Abdulla F., Qdais H.A. and Rabi A. (2008). Site investigation on medical waste management practices in northern Jordan. *Waste Management*. 28:450–458.
- Adegbita, M.A., Nwafor, S.O., Afon, A., Abegunde, A.A. and Bamise, C.T. (2010).Assessment of dental waste management in a Nigerian tertiary hospitals. *Waste Management Research*. 28:769-777
- Alagoz, B.A.Z., and Kocasoy, G. (2007).Treatment and disposal alternatives for health-care wastes in developing countries: A case study in Istanbul, Turkey. *Waste Management Research*. 25:83-89.
- AL-khatib I. and Sato C. (2009).Solid health care waste management status at health care centres in the West Bank-Palestinian Territory.*Waste Management*. 29:2398-2403.
- AlvimFerraz, M.C.M., and Alfonso, S.A.V. (2003a). Dioxin emission factors for the incineration of different medical waste types. *Archives of Environmental Contamination and Toxicology*. 44:460-466.
- AlvimFerraz, M.C.M., and Alfonso, S.A.V. (2003a). Medical waste management in Ibadan, Nigeria: Obstacles and Prospects. *Waste Management*. 29(2):804-811.
- AlvimFerraz, M.C.M., and Alfonso, S.A.V. (2003b). Incineration of different types of medical wastes: emission factors for particulate matter and heavy metals. *Environmental Science andTechnology*., 37:3152-3157.
- AlvimFerraz, M.C.M., Barcelos Cardoso, J.I., and Ribeiro Pontes, S.L. (2000).Concentration of atmospheric pollutants in the gaseous emissions of medical waste incinerators.*Journal of Air and Waste Management Association*.50:131-136

- Askarian, M., Vakili, M., and Kabir, G. (2004).Results of a hospital waste survey in private hospitals in Fars province, Iran. *Waste Management*.24:347- 352.
- Azage, M. and Kumie, A. (2010).Healthcare waste generation and its management system: the case of health centres in West Gojjam Zone, Amhara Region, Ethiopia. *Ethiopian Journal of Health Development*, 24(2):119-126
- Baveja, G., Muralidhar, S. and Aggarwal, P.(2000).Hospital waste management– an overview.*HospitalToday*.5(9):485–486.
- Bdour, A., Altrabsheh, B., Hadadin N., and Al-Shareif M. (2004).Assessment of medical wastes management practice: a case study of the northern part of Jordan. *Waste Management*. 27(6):46–59.
- Chitnis, V., Chitnis, S., Patil, S., and Chitnis, D.S., (2002). Is Inefficient in Decontaminating Blood Containing Hypodermic Needles.*Indian Journal of Medical Microbiology*. 20:215-218.
- Code, A., and Christen, J., (1999). How are we managing our healthcare wastes? St. Gallen, Switzerland: SKAT.
- Coker Vakili, M.Ahmed, I. and Kabir (2009). Medical waste management in Ibadan, Nigeria: Obstacles and Prospects. *Waste Management*. 29(2):804-811.
- Diaz, L.F., Savage, G.M., and Eggerth, L.L. (2005).Alternatives for the treatment and disposal of healthcare wastes in developing countries. *Waste Management*, 25;626-637.
- Hazardous Chemicals and Wastes Conventions (HCWC).(2007). [http://www.healthcarewaste.org/fileadmin/user\\_upload/resources/UNEP-3Conventions-2007-EN.pdf](http://www.healthcarewaste.org/fileadmin/user_upload/resources/UNEP-3Conventions-2007-EN.pdf), Accessed August 15, 2011).
- Ikome, P. (2011).Environmental Exposure and Public Health Impacts of Poor Clinical Waste Treatment and Disposal in Cameroon.
- Kerdsuwan, S. (2000).Case study of using hospital waste incinerator in Thailand. In: 93<sup>rd</sup> Annual meeting and Exhibition, Air and Waste Manage. Assoc. paper No. 00-107, Salt lake City, UT, 18-22 June

- Ketlogetswe, C., Oladiran, M.T., and Foster, J. (2004). Improved combustion processes in medical wastes incinerators for rural applications. *African Journal of Science and Technology*. 5(1):67-72.
- Malviga, K. (1999). Existing Solid Waste Management from Hospitals.MSc Dissertation. Devi Alivya University, Indore, India
- Manyele, S. and Anicetus, H. (2006). Management of medical waste in Tanzanian hospitals. *Tanzania Health Research Bulletin*. 8:177-182.
- Manyele, S.V. and Lyasenga, T.J. (2010). Factors affecting medical waste management in low level health facilities in Tanzania. *African Journal of Environmental Science and Technology*. 4(5):304-318
- Massrouji, M. (2001). Medical waste and health workers in Gaza governorates. *East Mediterranean Health Journal*. 7:1017-24.
- Mehta, G. (1998) Hospital Waste Management, National Guidelines (Draft) prepared for GOI/WHO project IND EHH 001, Lady Hardinge Medical College and Associated Hospitals, New Delhi.
- National Environmental Engineering Research Institute, NEERI (1995). Comprehensive Characterization of Municipal Solid Waste at Calcuttain Nagpur
- Northwest Regional Delegation of Public Health, NWRDPH (2005). Annual Report. Office of Technology Assessment (OTA, 1988), U.S. Congress. Issues in medical waste management - background paper. Washington, DC; U.S. Government Printing Office, October 1988 (OTA-BP-O-49).
- Oke, I.A. (2008). Management of immunization solid wastes in Kana State, Nigeria. *Waste Management*. 12(25):12-21.
- PATH. (2009). Achieving effective sharps waste management in GAVI host countries. A proposed approach with estimates of cost 2006. Available at, [http://www.Path.org/files/TS\\_ach\\_eff\\_swm.pdf](http://www.Path.org/files/TS_ach_eff_swm.pdf)., Accessed 6th April, 2012.
- Patil, G. Pokhrel, K. (2005). Biomedical solid waste management in an Indian hospital: a case study. *Waste Management*. 25:592–599

- Prüss, A., and Townend, W.K. (1998). Teacher's Guide- Management of wastes from health-care activities,.
- Pruss-Ustun, A., Rapiti, E. andHutin, Y. (2005).Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers.American Journal of Industrial Medicine. 48:482-490.
- Pruthvish, S., Gopinath, D., Jayachandra, Rao M., Girish, N., Bineesha, P. andShivaram, C., (1998). Health-Care waste management
- Rutala, W.A. andMayhall, C.G. (1992).Medical waste.Position paper, The Society for Hospital Epidemiology of America.Infections, Control and Hospital Epidemiology.13:38-48.
- Sagoe-Moses, C., Pearson, R.D., Perry, J., Jagger, J. (2001).Risks to health care workers in developing countries.North England Journal of Medicine. 345(7):538 – 540.
- Sarkar, S.K.L., Haque, M.Z., Khan, T.A. (2006). Hospital waste management in Sylhet City, Bangladesh.Journal of Engineering and Applied Sciences. 1(2):1-9.
- Shah, S., Mehta, M., Mukherjee, M.D. (2001). Occupational Health Hazards Encountered at Health Care Facility and Medical College in India. American Industrial Hygiene Association.
- Silva, C.E., Hoppe, A.E., Ravanello, M.M. and Mello, N. (2005).Medical waste management in the south of Brazil.Waste Management. 25:600–605.
- Singh, I.B., and Sarma, R.K. (1996).Hospital Waste Disposal System and Technology.Journal of Academy of Hospital Administration. 8(2):44-48.
- Soliman, S. and Ahmed, I. (2007). Overview of biomedical waste management in selected Governorates in Egypt: A pilot study. Waste Management. 27:1920–1923.
- Taghipour, H. and Mosaferi, M. (2009).Characterization of medical waste from hospitals in Tabriz, Iran.Science of the Total Environment. 407:1527-1535.
- Tsakona, M., Anagnostopoulou, E. andGidarakos, E. (2007). Hospital waste management and toxicity evaluation: a case study. Waste Management, 27: 921-920

- U. S. Environmental Protection Agency, USEPA (1988). Hospital waste combustion study: data gathering phase. EPA-450/3-88-017, Research Triangle Park, North Carolina.
- U. S. Environmental Protection Agency, USEPA (1994). Estimating exposure to dioxin-like compounds, volume I: Executive Summary, Office of Research and Development, EPA/600/6-88/005Ca.
- U.S. Environmental Protection Agency, USEPA. (1986). Guide for infectious waste Management, EPA/530-SW-86-014. Washington, DC.
- U.S. Environmental Protection Agency, USEPA. (1994). Guide for infectious waste Management, EPA/530-SW-86-011.
- U.S. Environmental Protection Agency, USEPA. (2000). Exposure and health assessment for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds: PART III Integrated summary and risk characterization for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds. Available at: <http://www.epa.gov/ncea/pdfs/dioxin/dioxreass.htm>. [Accessed 23 November 2010].
- U.S. Environmental Protection Agency, USEPA. (2001). Database of sources of environmental releases of dioxin like compounds in the United States. EPA/600/C-01/012.
- U.S. Environmental Protection Agency, USEPA. (2011). Database of sources of environmental releases of dioxin like compounds in the United States. EPA/600/C-01/014
- U.S. Environmental Protection Agency, USEPA. (2003). Framework for cumulative risk assessment, External review draft, EPA/630/P-02/001A, Risk assessment forum, U.S. Environmental Protection Agency, Washington, DC 20460.
- U.S. Environmental Protection Agency, USEPA. (2007). Human and ecological risk assessment of coal combustion wastes. Research Triangle Park (RTI), Washington, DC.
- World Health Organization (WHO) and the World Bank. (2005). Better healthcare waste management: an integral component of health investment. WHO Library Cataloguing in Publication Data. ISBN 92-9021-389-2.

- World Health Organization, WHO.(2007). Wastes from healthcare activities. WHO fact sheetNo.354,reviewed Nov2010
- World Health Organization, WHO. (1992). Managing medical wastes in developingcountries: report of a Consultation on Medical Wastes Management in Developing Countries.WHO\_PEP\_RUD\_94.1.pdf.
- World Health Organization, WHO. (1992). Managing medical wastes in developing countries: report on Medical Wastes Management in Developing Countries.
- World Health Organization,WHO.(1999). Health Care wastes. Available at: [http://www.who.int/water\\_sanitation\\_health/Environmental sanit/MHCWHanbook.htm](http://www.who.int/water_sanitation_health/Environmental_sanit/MHCWHanbook.htm). Retrieve October 2014
- World Health Organization, WHO.(2005a). The global patient safety challenge 2005-2006:cleancareissafurtherthancare.Geneva,Switzerland. [www.who.int/gpsc/resources/en/](http://www.who.int/gpsc/resources/en/). Accessed 11/10/2010.
- World Health Organization, WHO.(2005b). Healthcare waste management (HCWM): [http://www.healthcarewaste.org/en/115\\_overview.html](http://www.healthcarewaste.org/en/115_overview.html). Accessed, 14/04/2011.
- World Health Organization, WHO.(2007). Wastes from healthcare activities. WHO fact sheetNo.253,reviewedNov2007.  
<http://www.who.int/mediacentre/factsheets/fs253/en/>. Accessed 14/04/2011.
- World Health Organization,WHO.(2012). Antimicrobial resistance.Available on, <http://www.who.int/mediacentre/factsheets/fs194/en/>, Accessed 24th August, 2012.

## APPENDICES

### 1, Questionnaires

I am a master student from the pan African institute for development West Africa. I am doing a research on medical waste management and I want to investigate if the hospital staffs are aware of the policies of medical waste management at their hospitals

#### Personal information

1. ☐Age: 20-30☐ 30-40☐ 40-50☐
2. Department:              Lab☐              Wards☐              Maternity ☐
3. Position:                      Nurse☐              Cleaner☐              Doctor☐

#### Information on medical waste management

4. Do you practice waste management? Yes☐              No☐
5. Is waste sorted before disposal?              Yes ☐              No ☐
6. Do you differentiate the bins in waste collection              Yes ☐              No ☐
7. Is waste treated?                      Yes ☐              No ☐
8. Is the waste stored in a temporal storage?              Yes ☐              No ☐
- If yes specify
9. How is waste transported?
10. Is waste reused?                      Yes ☐              No ☐
11. Do you have any training on waste management?              Yes ☐              No ☐
12. Are you aware of any policies or guidelines on medical waste management?