KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

INSTITUTE OF DISTANCE LEARNING

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Assessment of Solid Waste Management In Healthcare Facilities In The Offinso Municipality

BY

Philip Yawson

NOVEMBER 2014

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Assessment of Solid Waste Management In Healthcare Facilities In The Offinso Municipality

A thesis submitted to the Department of Environment Science, Kwame Nkrumah University of Science and Technology in partial fulfillment of the Requirements for the Degree of

Master of Science in Environmental Science

BY

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(B.Ed, Agric Science)

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DECLARATION

I declare that this thesis is my own work towards the MSc. degree and that, to the best of my knowledge, it contains no material previously published by another person or material which has been accepted for the award of any other degree of the University , except where due acknowledgement has been made in the text.

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(Head of Department)	Signature	Date

DEDICATION

I entirely dedicate this thesis to the Almighty God for helping me to go through this course successfully. It is also dedicated to the entire family and friends.

ABSTRACT

The management of hospital waste creates a number of environmental and health challenges in most countries especially, developing countries including Ghana. Despite the possible health implications associated with hospital waste, much attention has not been given to its management.

This study sought to assess the solid hospital waste management practices in the Offinso Municipality. Four hospitals were selected for the study. Waste quantification using a weighing scale, questionnaire administration, interviews and observational surveys were undertaken and data thereof analyzed. Differences in total waste generated over the period at the various hospitals was significant (P value < 0.0001).Means of total infectious (420 Kg) and total non-infectious (2626.5 Kg) waste for the period was 13.0% and 86.2% respectively. The study revealed that with the exception of few sharps (0.3%), segregation of solid hospital waste in terms of infectious and non-infectious materials was rarely done.

It was revealed that lack of records (data) on the quantity of waste generated, non - segregation of waste, improper waste disposal and treatment method, lack of waste management department/ officer, lack of effective supervision, lack of hospital waste policy/legislation/regulation, inadequate and non-use of personal protective equipment (PPE) among others; were the main factors hindering proper waste management at the various hospitals studied.

The study recommends effective and sustainable management of medical waste at the various hospitals to avoid its negative impact on the health of living organisms especially, humans and the environment.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA…….	Analysis of Variance
BMW……..	Biomedical waste
CAT……	Cost Analysis Tool
CEC …….....	Contaminants of Emerging Concern
ECAT…….. …..	Expanded Cost Analysis Tool
EPA……	Environmental Protection Agency
HW……. …..	Hospital waste
HCW……..	Healthcare waste
HCWM……..…	Health Care Waste Management
HBV…….	Hepatitis B virus
HBC……....	Hepatitis C virus
HIV……	Human Immunodeficiency Virus
HCRW……	Health Care General Waste
IARC…… …….	International Agency for Research on Cancer
IWMI……..	Integrated Waste Management Incorporated
MWI……..	Medical Waste Institutions
MSW…….	Municipal Solid waste
OPD……	Out Patients Department
OT……	Operation Theatre
OSHA……	Occupational Safety and Health Association
PPE……	Personal Protective Equipment
PPCP……..	Pharmaceuticals and Personal Care Products
PVC……	Polyvinyl Chloride
RMW……...	Regulated Medical Waste
USEPA ……	United States Environmental Protection Agency
WHO……	World Health Organization

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CHAPTER ONE

INTRODUCTION

The management of wastes all over the world especially, in developing countries like Ghana, is a major challenge due to its associated environmental and health implications. Even though there are problems associated with the management of residential, commercial, municipal, agricultural as well as construction and demolition of solid and liquid wastes; institutional wastes like healthcare waste is not an exception and needs to be considered more seriously.

Improper management of healthcare waste can pollute the air, land and water sources- leading to serious health implications on humans, animals and other living things. The infectious and hazardous nature of healthcare waste makes it necessary to manage or handle such wastes with care and tact (Riyaz *et al*., 2010).Mismanaging healthcare waste can have serious health implications to waste handlers (workers), healthcare professionals like; nurses, doctors, paramedical staff, laboratory technicians, pharmacists or dispensary technicians as well as patients, waste scavengers and the general populace as a whole. Studies have shown that a high percentage of workers who handle wastes and individuals who live near disposal sites are infected with gastrointestinal parasites, and other diseases like; cholera, yellow fever and salmonellosis (Fei-Baffoe, 2010).

The nature of pollutants caused by medical waste can be classified as biological, chemical and radioactive (Manyele, 2004).

Population growth, changes in eating habits and lifestyles, rising disposable income as well as increasing awareness of the general populace on quality health issues; have all contributed to an increase in the number of hospitals and other healthcare institutions all over the world (Fei-Baffoe, 2010).

The increase in the number of hospitals and other healthcare related institutions has, undoubtedly and unavoidably, resulted in an increase in the quantum of healthcare waste generation.

According to the World Health Organization (WHO,2008), hazardous wastes deal with infectious, radioactive or toxic materials coming out of bodily structures of animals, object with sharp edges, pharmaceuticals, genotoxic waste as well as heavy metals.

Non-hazardous waste is related to waste generated from administration, compounds and the cafeteria/ kitchen.

Most wastes generated in the various healthcare facilities are non-infectious but few are infectious and hazardous. A research conducted in the kingdom of Bhutan shows that, out of approximately 365 tons of healthcare waste generated annually, only 20% were infectious and hazardous whiles 80% were non-infectious and non-hazardous (WHO, 2005b).A report from the World Bank (2008) shows that only 10%-25% of hospital wastes are infectious and hazardous. It is estimated that, of all the solid wastes generated in Bangladesh only 1% are hospital wastes (WHO, 2008).Even though hospital wastes are only 10%-25% infectious and 75%-90% non-infectious and non-hazardous; their non-segregation makes the whole waste (100%) infectious. Disposal of medical waste has emerged as a major problem in the United States. The public is increasingly concerned over the improper disposal of medical wastes, particularly, the wastes contaminated with communicable disease agents such as; AIDS, hepatitis B virus and hepatitis C virus (Kau- Fui and Ramarathnam, 1994).

1.1 Justification

Improper handling or management of healthcare waste in terms of: lack of records (data) on the quantity of waste generated, non -segregation of infectious from non-

infectious wastes, improper waste disposal and treatment methods, lack of waste management department/officer, lack of effective supervision, lack of hospital waste policy/legislation/regulation, inadequate and non-use of personal protective equipment (PPE) as well as lack of education and training for waste generators and handlers are the major problems in healthcare facilities in the Offinso Municipality which has necessitated the need for this research.

1.2 Aim/Goal

The study sought to assess the solid waste management in healthcare facilities in the Offinso Municipality.

1.3 Specific Objectives

Specific objectives were to determine;

(i) The quantity of solid wastes generated at each hospital.

(ii) Segregation practices available.

(iii) The current healthcare wastes disposal and treatment practices available.

(iv) The factors responsible for improper hospital waste management.

CHAPTER TWO

LITERATURE REVIEW

2.0 Waste Management

Waste management is a discipline associated with the; control of generation, storage, collection, transfer and transport, processing, reusing, recovery and disposal of solid waste in a manner that is in accordance with the best principles of public health, economics, engineering, conservation of nature, aesthetics, and environmental considerations in general and that is also responsive to public attitude(Fei-Baffoe,2010).Waste is mobile, movable materials arising from human activities discarded as useless or unwanted, without positive value, sometimes solid that the owner is no longer interested in the ownership. Waste is something solid that is just being disposed of, something solid that somebody wants to get rid of (Fei-Baffoe 2010).

PARN (2007), defines Hospital waste as "any waste which is generated in the diagnosis, treatment or immunization of human beings or animals or in research" in a hospital.

Hem (1999), refers to Hospital waste as all waste generated, discarded and not intended for further use in the hospital.

Vorapong (2009), quoting from Klangsin and Harding (1998), referred to Medical waste as all waste materials generated at health care facilities, such as hospitals, clinics, physician's offices, dental practices, blood banks, and veterinary hospitals or clinics, as well as medical research facilities and laboratories.

Bio-medical waste is any waste, which is generated during the diagnosis, treatment or immunization of human beings or animal or in research activities pertaining thereto or in the production or testing of biological waste (Anil and Anupem, 2005).

Work conducted by Kau-Fui and Ramarathnam (1994), indicated that the disposal of medical waste (biohazardous as well as non-biohazardous) is the responsibility of the Environmental Services Department of the hospital.

2.1 Type of Waste

Different types of waste exists which include ; nuclear wastes, agricultural wastes, construction and demolition wastes, industrial wastes, radioactive wastes, sewage sludge, electronic wastes ,municipal wastes as well as hospital/medical/clinical wastes (Wikipedia, 2012) ; EPA , 2012) . Municipal solid wastes predominantly includes food wastes, yard wastes, containers and product packaging, other miscellaneous wastes from residential, commercial and institutional sources ((Wikipedia, 2012 ; EPA , 2012).

Waste can be classified in several ways but the following list represents a typical classification:

- Biodegradable waste: food and kitchen waste, green waste, paper (can also be recycled).
- Recyclable material: paper, glass, bottles, cans, metals, certain plastics, fabrics, clothes, batteries etc.
- Inert waste: construction and demolition waste, dirt, rocks, debris.
- Electrical and electronic waste (WEEE) - electrical appliances, TVs, computers, screens, etc.
- Composite wastes: waste clothing, Tetra Packs, waste plastics such as toys.
- Hazardous waste including most paints, chemicals, light bulbs, fluorescent tubes, spray cans, fertilizer and containers
- Toxic waste including pesticide, herbicides, fungicides
- Medical waste

Hospital/healthcare/clinical solid wastes are managed separately from other wastes because a portion of it is considered a hazardous material that may be infectious, toxic or radioactive (Fact Sheet, 2011). The type of healthcare wastes that may be considered as infectious include: wastes contaminated with blood and its by- products, cultures and stocks of infectious agents, sharps and pathological wastes (Fact Sheet, 2011).

2.2 Types of Hospital/ Healthcare Waste

World Health Organization (WHO, 2008) states that "Healthcare waste includes all waste that is generated by healthcare waste establishments, research facilities, and laboratories. In addition, it includes the waste originating from "minor" and "scattered" sources, such as that produced in the course of health care undertaken in the home (dialysis, insulin injections, etc.)".

Visvanathan and Radha (2006) explain Healthcare Waste as total waste generated by hospitals, healthcare establishments and research facilities in the diagnosis, treatment, Immunization and associated research.

WHO (2005c), defines Healthcare waste (HCW) as by-product of healthcare that includes sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive materials.

The Government of India Environmental Protection Act (1986), Rule 29 issued a notification on Bio-medical Waste (Management and Handling), Rules 1998. It defines "Bio-medical waste" as any waste, which is generated during the diagnosis, treatment or immunization of human beings or animal or in research activities pertaining thereto or in the production or testing of biological waste (Anil and Anupem, 2005).

Healthcare Waste(HCW) is defined as the total waste originating from all healthcare establishments; laboratories and research facilities(both human and animal);blood banks

and collection centres; funeral and ambulance services, and, also the waste arising from the treatment in the home (Habibur and Mansoor,2000).

According to Pruss *et al*. (1999), the World Health Organization (WHO) defines all waste generated by healthcare establishments, research facilities, and health laboratories as healthcare waste.

2.3 Management of Hospital Waste

Hem (1999), has given the need or rationale for spending so many resources in terms of money, man power, material and machine for the management of hospital waste as follows:

- Those injuries from sharps could lead to infection to all categories of hospital personnel and waste handlers.
- Nosocomial infections in patients from poor infection control practices and poor waste management.
- Risk of infection outside hospital for waste handlers and scavengers and at times general public living in the vicinity of hospitals.
- Risk associated with hazardous chemicals, drugs to persons handling wastes at all levels.
- "Disposable" being repacked and sold by unscrupulous elements without even being washed.
- Drugs which have been disposed of, being repacked and sold off to unsuspecting buyers.
- Risk of air, water and soil pollution directly due to waste, or due to defective incineration emissions and ash.

Riyaz *et al*. (2010, stated that the management or handling of bio-medical waste is proving to be an overwhelming challenge for the government and the health sector. Hospital effluent not only has aberrant physico-chemical characteristics but also has high loads of multiple drug resistant bacteria and discharging of the effluent in a municipal sewage system could be a grave public health hazard.

Arvind and Girish (2010), have it that the proper management of biomedical waste is still in its infancy all over the world. There is a lot of confusion among generators, operators, decision makers and the general community about the safe management of bio-medical waste. Hospital waste management in India has become an intractable problem. Since the late 1980's increased attention has been focused on medical waste, its handling and safe disposal.

Hanumantha (2009), quoting from an article published by The Times of India (2008), reported that only the Goa Medical College Hospital treated its own waste and that which comes from the two district hospitals. One hundred and fifty other hospitals in Goa either dump their biomedical waste within their premises or dispose of it with the other garbage that goes to municipality dumps.

Proper management ensures that infectious waste is handled in accordance with established and acceptable procedures from the time of generation through treatment of the waste and its ultimate disposal (Sawalem et al., 2009).

The safe management of healthcare waste may be achieved by ensuring care in dealing with the healthcare waste. Hence it is the ethical responsibility of management of hospitals and health care establishments to have concern for public health. Safe handling, segregation, storage, subsequent destruction and disposal of healthcare waste ensure mitigation and minimization of the concerned health risks involved through contact with

the potentially hazardous material, and also in the prevention of environmental contamination (Vijaya *et al*., 2007).

Rolando *et al*. (1997), hold the view that, there appears to be no safe way of managing all the hazardous medical wastes that are currently produced in Metro Manila.

2.4 Segregation/Importance of Segregation

Segregation is a very important step in waste management, as segregation errors present a threat to those managing wastes. Effective segregation at the source is a key factor in the waste management strategy and it will enable hospital authorities to save money on waste disposal Vorapong (2009).

2.5 Segregation of Hospital Waste

Present study conducted at Pravara Rural Hospital, Loni and Maharashtra with an aim to characterize and quantify the waste generated at the hospital, found that there was no segregation of the waste starting from generation to disposal (Arvind and Girish, 2010).

Studies in Uttar Pradesh revealed that segregation of biomedical waste was not properly done and disposal was unscientific; Waste is segregated at source and stored in plastic bins of the same colour, with plastic covers of different colours inside (Hanumantha, 2009).

Greeta (2005), has suggested that infectious waste should be segregated into sharp waste and non-sharp infectious waste streams. The colour coding for infectious waste will be red and colour coding for sharps waste will be yellow. Waste will be further segregated into biodegradable and non-biodegradable waste.

For characterization and segregation of hospital waste the most important criteria for waste management facility to work effectively in hospitals are proper identification of

each type of waste at the point of waste generation. All hospital wastes were characterized into various streams depending upon its severity on human health viz: safety consideration of hospital workers, general public health and patients. The most common technique to identify the waste in a later stage of disposal is by means of different colored bags used for storing specific types of waste (Anant and Dwinedi, 2002).

Medical wastes need to be segregated separately, according to its characteristics, at the point of generation (Prüss *et al.*, 1999).

Hem (1999), noted that Segregation is the essence of waste management and should be done at the source of generation of Bio-medical waste. Example, all patient care activity areas, diagnostic services areas, operation theatres, labour rooms, treatment rooms etc.

2. 6 Storage of Hospital Waste

Vijaya *et al*. (2007), indicated that storage of segregated healthcare waste was away from the patients and nursing stations. However, the storage area did not have secured bins to eliminate the possibility of access to the waste by flies, rodents and dogs. On the other side there was no appropriate designated place for the storage and they were observed to be dumped haphazardly. The healthcare waste was not stored for more than 24 hours on-site.

In order to avoid both the accumulation and decomposition of the waste, it must be collected on a regular daily basis. This area, where the larger containers are kept before removal to the central storage area, should both be close to the wards and not accessible to unauthorized people such as patients and visitors. Storage time should not exceed 24-48 hours especially in countries that have a warm and humid climate (WHO, 2005f).

Waste Storage, refers to the holding of Bio-Medical Waste for a certain period of time, after which it is sent for treatment and disposal. In other words it means the duration of time for which waste is kept at the site of generation and transit treatment and final disposal is done Yashpal and Poonam (2000).

According to Bio-Medical Waste Management and Handling Rules (1998), storage of waste is necessary at two points:

(i) at the point of generation and

(ii) common storage for the total waste inside a health care organization.

Untreated waste should not be stored beyond a period of 48 hours. Collection room(s)/intermediate storage area where the waste packets/bags are collected before they are finally taken (transported) to the treatment or disposal site are necessary for large hospitals having a number of departments, laboratories, operating theaters (OTs), wards etc.

2.7 Transportation of Hospital Waste

Verma's investigation (2010), showed that transportation of infected waste was by wheelbarrows. Verma also indicated that for transporting infected waste, air-conditioned vans with appropriate compartment would be required. Despite the provision in the Municipal Solid Waste (MSW) Rules, covered vans are not provided for transporting municipal waste, and it remains un-enforced.

Hem (1999), has suggested that within hospital, waste routes must be designated to avoid the passage of waste through patient care areas. Separate time should be earmarked for transportation of bio-medical waste to reduce chances of its mixing with general waste. Desiccated wheeled containers, trolleys or carts should be used to transport the waste or plastic bags to the site of storage or treatment.

According to Bio-medical Waste Management and Handling Rules (1998), wastes have to be transported according to the Motor Vehicle Act which prescribes standards for the transport of hazardous wastes. This specifies that the vehicle should be a covered one with proper markings to indicate that infectious bio-medical wastes are being transported in it.

Rolando *et al*. (1997), have it that most transportation of hospital waste is carried out by use of traditional dump trucks often together with municipal solid waste. However, during 1992 an increasing number of private hospitals have contracted a private hazardous waste management company, the Integrated Waste Management Incorporated (IWMI). This company supplies the plastic containers to their clients and hauls them to their incinerators.

2. 8 Disposal of Hospital Waste

The practice of use and disposal of waste from pharmaceuticals compromises the safety of the environment as well as representing a serious health risk, as they may accumulate and stay active for a long time in the aquatic environment. A survey was also carried out among the general public, involving the questioning of randomly selected participants in order to investigate the household disposal of unused and expired pharmaceuticals.(Institute For Environmental Chemistry-Germany,2011).

For developing countries, the unsanitary disposal of waste has put millions of lives at risk because dumping sites are often visited by people scavenging for goods. One of the biggest risks for African healthcare facilities is the disposal of sharps (needles, scalpel blades, blood vials, glassware, etc) that are in contact with infectious germs. The high cost of safety boxes for proper disposal of sharps limits the use of these boxes (News Analysis, 2010).

A lot of people dispose of wastes anyhow by either throwing such wastes on the bear ground, discarded into water bodies or thrown anywhere. In Pakistan for instance, hospital wastes are simply thrown out on the ground or mixed with the ordinary waste or buried without any appropriate measure (Mustapha Anjum, 2009).

Ak-Dwividi *et al.* (2009), are of the opinion that in India, except a few large hospitals; most of the smaller hospitals and nursing homes lack any effective system to safely dispose of their waste. Even the Government and municipal hospitals are no better than the private nursing homes, regarding disposal of their waste.

Agenda (2009), reported on waste disposal issues from various countries surveyed in Africa as indicated below:

In Ghana, disposal at dumping site through the municipal authority is the most method employed in the disposal of solid waste, that is, infectious, general, and pharmaceutical and in some cases sharps. The dumping grounds are not engineered to serve as sanitary landfill sites. They therefore constitute high potential for the spread of infections through run offs during rains and contamination of underground water.

According to the national plan, 90% of waste, which are generally collected from various Health Care Facilities in Kenya, is disposed through crude dumpsites. Many institutions do not have dumpsites.

Rolando *et al.* (1997), was of the view that a large volume of infectious wastes is disposed in burial pits located at hospital sites, and in Municipal landfills, both practices of which pose significant risks to humans, including direct contact and contamination of surface water or groundwater.

2.9 Technologies for Treating Hospital Waste

Dinesh (2010), is of the opinion that common methods to be adopted for biomedical waste disposal are incineration and land filling. However, these methods are considered more expensive and less eco-friendly due to their negative impact on the environment.

Bagamoyo Hospital in Tanzania has been using an autoclave and shredder to render their waste harmless before disposal. A year of monitoring after the project initiation demonstrated that this technology can work well in the African context (Healthcare without Harm & Partners, 2010).

Verma (2010), is of the view that no single technology can scientifically take care of all the ingredients of hospital waste. Autoclaves increase the weight and volume of the waste and therefore require a compactor along with it.

According to Greeta (2005), in the Kingdom of Bhutan the following hospital waste management technologies are available as indicated below:

Primitive incineration in drums/containers/locally built incinerators:

This has serious problems similar to that of incinerators. It is again extremely unlikely that temperatures achieved/ emission standards will comply with environmental norms. The possible release of dioxins and furans is a major concern.

Open Pit Burning: Disposal of waste health care waste is often done through burning in open pits on the ground or in concrete pits.

The pits are filled with waste over a period of time (few days to a week) and then burnt. There is no fencing around these pits.

Landfills: Hazardous waste from hospitals is currently being deposited in landfills meant for general waste. There is no appropriate fencing and poor supervision of landfills, allowing easy access to scavengers and animals.

Hydroclave: Alternatively can be installed for the treatment of waste instead of autoclave and Shredder. Shredded parts are to be recycled.

Deep Burial: For the disposal of human organs, placenta, body parts, animal parts, carcasses.

Sharps pits: For the disposal of needles, scalpels, lancets, broken ampoules, glass slides. These pits may be clay lined or concrete lined or in the form of concrete lined septic vault design depending upon amount of waste and resources.

Sanitary Landfill: for disposal of general waste and treated health care waste should have a secure section for disposal of hazardous waste such as chemical and toxic waste.

Waste Water Treatment: Hospitals not connected to municipal sewage treatment plant, should construct their own waste water treatment plant.

Shredder (for sterilized waste generated by autoclave): Shedder is required for shredding of sterilized/ autoclaved waste before disposal to landfill. Its aim is to reduce the volume of the sterilized waste and as far as possible make the waste unrecognizable.

Type of Waste to be shredded: Waste sharps, needles, broken ampoules, small pieces of metal blood bags, laboratory waste, cultures, biotechnology waste, discarded glassware, latex rubber gloves, bandages, dressings, disposable PVC/plastic/ cardboard/catheters, thermocol.

Greeta (2005), has given suggestions concerning the Equipment or Facilities for waste treatment and disposal on infection control and health care waste management in the kingdom of Bhutan as shown below:

1. Needle and syringe destroyers: For destruction of needles at point of use in every ward.

2. Autoclave: For the sterilization of infectious waste including; waste sharps, syringes, needles, scalpels, ampoules, broken glass, infected plastic, disposable catheters, soiled

waste including swabs, dressings, gloves, infected glassware, cultures, specimens, blood bags.

Ravi (1998), has explained that Superheated Steam Sterilization, Wet Oxidation Technology, Microwave Disinfection, Electron Beam Gun Technology, and pulse power technology are some of the technologies used in treating hospital waste as indicated below:

Superheated Steam Sterilization: This technology comprises a heated shredder and sterilization unit. In the shredder, organic liquids are vaporized and solids reduced to gas by 'super-heated' steam at temperatures between 500 and 700 ^{0}C.

Wet Oxidation Technology: This technology resembles that of a washing machine. Weighed plastic drums filled with medical waste are placed on top of a shredder. Shredded waste drops into a spinning basket in an oxidation chamber. Once full, the chamber is closed and a water based solution containing 10% sulphuric acid, an iron ion catalyst and a co-catalyst is introduced. Sulphuric acid maintains a very acidic pH value of the mixture while mechanical agitation ensures that the entire waste mass is saturated with the solution.

Microwave Disinfection: The equipment can be installed on or off site in stationary or mobile units. Microwave disinfection relies on treating medical waste with moist heat and conventional microwaves. Waste loaded from an automatic hoisting bucket into a hopper is treated with high-temperature steam from where it goes through a heap filter. The filtered residues are then shredded, high temperature steam treated and disinfected with microwave heat at 940^{0}C.

Electron Beam Gun Technology: Medical Waste is exposed to an ionized electron beam inducing chemical and biological changes in the waste material. Decontamination

occurs when nucleic acids in living cells are irradiated. The equipment emits sufficient radiation to destroy

Micro-organisms and change the molecular structure of materials.

Pulse Power Technology: The process involves the use of pulsed plasma of electrical discharges in water, using ultraviolet radiation, hydrogen, hydroxyl, ozone and shock waves to act as disinfectants.

Incineration: Incineration is controlled combustion process where waste is completely oxidized and harmful microorganisms present in it are destroyed/ denatured under high temperature (Bio-medical waste management & handling rules 1998).

2.9.1 Types/Categories/Sources of Hospital Waste

Hospital generated biomedical waste, according to Dinesh (2010), are of two kinds - non-hazardous and bio-hazardous. Examples of nonhazardous waste include non-infected plastic, packaging material, paper etc. Bio hazardous waste consists of;

(a) Infectious wastes like sharps, non-sharps, plastic disposables, liquid waste, etc.

(b) Noninfectious wastes like radioactive waste, discarded glass, chemical waste, cytotoxic waste and incinerated waste.

Health-care units: mostly general waste with a small percentage of infectious waste.

Laboratories: mainly pathological (including some anatomical), highly infectious waste (small pieces of tissue, microbiological cultures, stocks of infectious agents, infected animal carcasses, blood and other body fluids), and sharps, plus some radioactive and chemical waste.

Pharmaceutical and chemical stores: small quantities of pharmaceutical and chemical wastes, mainly packaging (containing only residues if stores are well managed), and general waste (WHO, 2008).

A presentation on Hospital waste management by Jawed (2006), grouped hospital waste broadly into 2 categories as shown below:

- Risk waste-consisting of infectious wastes, pathological wastes, sharps, pharmaceutical wastes, chemical wastes and radioactive waste.
- Non-Risk waste;is that which is comparable to normal domestic garbage and presents no greater risks therefore,than waste from a normal home.That is,paper,packaging,food waste.

Diana (2002), is of the view that there six major waste streams generated within hospitals that is; liquid wastes, solid wastes, hazardous wastes, radioactive wastes, air emissions and Medical wastes.

2.9.2 Hospital Waste Management Policy/Legislation/Regulation

Hospital waste streams are regulated at the state and local level while others may be governed by federal regulations. For example, states develop regulations for office and municipal type waste, whereas the federal government develops regulations for hazardous waste such as mercury or radioactive wastes. State regulations generally cover potentially infectious medical waste, sometimes referred to as regulated medical waste U.S Environmental Protection Agency (US EPA, 2011).

Medical waste problems in the developing world are associated poor funding and the lack of national regulations for the sanitary disposal of waste and lack of oversight (News Analysis, 2010).

Policy is a course of action or program of actions adopted by a person, group, or government, or the set of principles on which they are based. Regulation, on the other hand, is a rule or order- that is, an official rule, law, or order stating what may or may not be done or how something must be done (Microsoft Encarta Dictionaries, 2009).

Many of the countries surveyed by Agenda (2009), lack elaborated legal policy specifically for Health Care Waste; institutional framework for healthcare waste management in healthcare facilities and proper sanitary landfills.

National legislation is the basis for improving health-care waste practices in any country. It establishes legal controls and permits the national agency responsible for the disposal of health-care waste, usually the Ministry of Health, to apply pressure for their implementation. In some countries the Ministry of Environment or National Environmental Protection Agency is the principal authority or may also be involved and usually designation of responsibilities before the law is enacted is considered.

According to the draft HCRW management regulations (South Africa) in terms of the national environmental management (Waste management Act, 2008); final disposal of treated healthcare risk waste may not occur in a manner which causes harm to the public health or the environment. The regulations require that all healthcare risk waste must be treated by a licensed treatment facility prior to disposal.

Treated healthcare risk waste that is liquid must be discharged to a public sewage system in a manner that complies with all applicable wastewater discharge by-laws of the relevant Municipality and any other legislative requirements (Ak-Dwividi *et al*., 2009).

Policy statement aims to provide for a system for management of all potentially infectious and hazardous wastes in accordance with the Bio-Medical Waste (Bio-medical waste management & handling rules, 1998).

Ravi (1998), reported that first draft rules of the Indian Ministry of Environment and Forests which were issued in June 1995, ignored all international trends and recommended that all 50 bedded hospital and above must install on-site incinerators. On the legislation front, the Government has been slow to move. To ensure continuity and

clarity in these management practices, health care institutions should develop clear plans and policies for the proper management and disposal of wastes.

Hospital Waste Management in the Philippines, is primarily regulated by three (3) laws, namely, the Metropolitan Manila Authority (MMA) Ordinance No. 16, Hospital Licensure Law (Republic Act No. 4226) and The toxic Substances and Hazardous and Nuclear Waste Control Act of 1990 (Rolando *et al*.,1997).

Given the general lack of federal standards and regulations and the large amount of biohazard us waste generated, it becomes extremely important to device efficient methods of waste handling and its disposal (Kau-Fui and Ramarathnam, 1994).

2.9.3 Environmental impact of Hospital Waste-Pollution

Ak- Dwividi *et al*. (2009), has it that Biomedical waste, because of its infectious nature and serious health hazards need care for its proper collection, segregation and disposal to minimize the pollution of air, water and soil.

Vorapong (2009), in his research, has it that most of the hospitals used waste incinerators that were improperly operated and managed, and which emit toxic air pollutants, because medical waste typically contains a variety of plastic materials such as polyvinyl chloride (PVC).

Air may be a source of infection in high risk areas such as operation theatres. Airborne contamination is best controlled by proper design and ventilation. The ventilation standard for operation theatres is that the theatre should have mechanical ventilation of the plenum type which should provide approximately 20 air changes per hour. When these standards are being met; routine air sampling is not recommended (Greeta, 2005).

Healthcare generates thousands of tons of waste each day, including toxic materials and chemical waste, and still relies heavily on the incineration of large portions of waste including pathological and chemothe -rapy waste, but also tons of regular waste that continues to be burned – implicating healthcare as a large source of toxic air emissions and other serious concerns related to incineration (Laura, 2005).

In the view of Manyele (2004), the presence of plastics and hazardous materials in the waste will generate harmful gases – such as oxides of sulphur, oxides of nitrogen, carbon dioxide, etc. and suspended particulate matter which may contain heavy metals. These when inhaled can cause respiratory diseases. Certain organic gases, such as dioxins and furans, are carcinogenic whose effects have longer latency periods. Open burning of medical waste is practiced in many Tanzanian hospitals. This should be strictly avoided. Air pollution control devices should be used for waste combustion technologies which produce toxic emissions. Such units exist now in Tanzania, designed at the University of Dar es Salaam.

Hem (1999), is of the opinion that air pollution due to emission of hazardous gases by incinerator such as Furan, Dioxin, Hydrochloric acid etc. have compelled the authorities to think seriously about hospital waste and the diseases transmitted through improper disposal of hospital waste.

2.9.4 Quantity of Hospital Waste generated

According to an estimate, India produces about 3000 million tons of wastes annually and nearly 60% of this constitutes decomposable organic waste. Although 75-90% of the Biomedical Waste (BMW) is non-hazardous and harmless as any of the other municipal waste, the remaining 10-25% is hazardous to humans or animals and deleterious to

environment. Inappropriate handling of BMW may have serious public health consequences and a significant impact on the environment (Dinesh *et al*., 2010).

In South Indian City, daily generation of biomedical waste in the Outdoor Department of Baripada district hospital, ranged from 9.9 to 14.0 kg day–1 with an average of 11.6 kg day–1, and 22.4% of the waste was infectious (Hanumantha, 2009).

Sawalem *et al*. (2008), reported in Libya that the average waste generation rate obtained in this study lies within the range of values estimated by WHO that 1.3–3 kg of wastes are generated by each patients per day for countries in North Africa and the Middle East.

According to(Anil and Anupem, 2005) at present, the total amount of non-infectious and infectious waste generation in Taj City, India is approximately 9.4 metric ton per day respectively.

Studies carried out have indicated that about 2 Kg of wastes are generated per bed per day which gives an idea about the tremendous volume of waste generated on a day to day basis.

Ravi (1998), has it that in India, normally 1 to 2 kg of waste per bed have been measured. For example, in a city like Delhi, with about 40,000 beds, this translates to 60 tons per day. According to a study carried out in Karachi, Pakistan, the hospital studied produced 427 kg of waste per bed annually or less than 1.5 kg per day. The EPA estimates that there are approximately 2400 MWIs operating in the U.S, burning approximately 846 thousand tons of medical waste annually.

2.9.5 Training and education for workers on Hospital Waste

Training of Hospital Waste Management Team was held at Taluka Kotri Hospital which was conducted by Mashriq Team. The training of Hospital Waste Management Team was held at Hafiz Mubarak Shah Hospital (Naseer, 2011).

Verma (2010), was of that there should be education for all classes of health care workers-that is, doctors, nurses, paramedical staff and the waste handlers. There was recommendation to ensure protective clothing for all the health care workers.

Mustapha and Anjum (2009), reported that the staff of the hospital was neither vaccinated against contagious or infectious disease of zoonotic importance nor had training for Health Care Waste Management (HCWM). The staff had lack of attitude and ignorance towards waste and had low priority in handling waste management.

A survey conducted by Sawalem *et al*. (2009), in Libya showed that 85% of the personnel including managers, cleaning staff, and environmental workers, were not trained in hospital waste management and did not have a detailed description of their duties in respect of waste handling; 55% of doctors and nurses were unaware of hospital waste management protocols and showed insufficient knowledge of the potential hazards.

World Health Organization (WHO, 2005h), has observed that insufficient training is conducted at the healthcare facilities in the area of waste management. That is, healthcare does not get the necessary training required to enable them to manage hospital waste efficiently.

According to Diana (2002), training should include proper handling and storage of hazardous materials so that spills can be prevented or immediately responded to, so as to minimize their impact.

Hem (1999), has it that each and every hospital must have well planned awareness and training programme for all category of personnel including administrators (medical, paramedical and administrative).Again, all the medical professionals must be made aware of Bio-medical Waste (Management and Handling Rules, 1998).Also, training

should be conducted to all categories of staff in appropriate language/medium and in an acceptable manner.

2.9.6 Health risk/occupational hazard associated with Healthcare Waste

Developing countries face a myriad of health problems arising from the burning of the waste. Incinerators are still the main vehicle used to dispose of medical waste in much of the developing world, especially in sub-Saharan Africa (News Analysis, 2010).

From Verma (2010), WHO estimates that India is on the verge of having an HIV epidemic. Tuberculosis and HIV combined, is taking great toll on the human health and life. Hepatitis B and C infections are on the rise. Mortality due to Hepatitis C has gone up significantly. The vulnerable group includes the health care workers, the waste handlers, and the most affected- the rag pickers. There is no doubt in the mind of any educated or enlightened person that improper hospital waste management is the source of many communicable and infectious diseases.

World Health Organization (WHO,2005a),estimates that over 23 million infections of hepatitis B, hepatitis C and HIV occur yearly due to unsafe injection practices (reuse of syringes and needles in the absence of sterilization.

In the view of Greeta (2005), the common types of hospital associated infections are; blood stream infection, urinary tract infection, nosocomial pneumonia, post-operative wound infection and gastrointestinal infection.

Health-care waste can cause serious harm if not managed properly. For example, (WHO,2000),estimated that injections with contaminated syringes caused 21 million hepatitis B virus (HBV) infections (32% of all new infections), two million hepatitis C virus (HCV) infections (40% of all new infections) and 260 000 HIV infections (5% of all new infections). In addition, health-care activities generate significant amounts of

hazardous waste such as mercury and expired pharmaceuticals, as well as large amounts of general waste. Poor management of HCW exposes healthcare workers, waste handlers and the community to infections, toxic effects and injuries. The International Agency for Research on Cancer (IARC) classifies dioxins as a "known human carcinogen (WHO, 2005e).

Inadequate and inappropriate handling of healthcare waste may have serious public health consequences and a significant impact on the environment (Pruss *et al*., 1999).

2. 9.7 Healthcare Waste financing/ cost implication

Vorapong (2009), wrote that practical segregation at the source is the main factor in waste management strategies and will enable medical facilities or healthcare authorities to save money on the cost of waste disposal. As a result, an effective waste management plan can rapidly reduce the amount of infectious medical waste by segregating it from general waste at its point of generation. It also leads to a 50% reduction in total financial costs, and minimizes health risks and costs of environmental hazards.

Segregation at Source (ward, Operation Theater, laboratory, labour room, and other places**)** reduces costs. "There must be a greater emphasis on ensuring that wastes are correctly segregated at the source, rather than relying on steps further along in the waste treatment process" Pakistan Antimicrobial Resistance Network (PARN, 2007).

Allocating insufficient financial resources to manage Healthcare waste properly has an even greater financial cost in the medium and long term in terms of morbidity and mortality as well as environmental damage, which will, in the end, impact negatively on peoples' health. The expanded costing analysis tool (ECAT) is a modified version of the cost analysis tool (CAT) and provides more options and approaches than the CAT (WHO, 2007).

According to Laura (2005), the estimated cost for managing Municipal Solid Waste in USA is US$70–120, average cost for all recyclables/reuse waste materials is US$(100)–US$50 , cost for Regulated medical waste (RMW) is US$450–1,000 and cost for Hazardous waste is US$1,000 or greater.

The treatment technologies and disposal costs vary from one waste stream to another, making it fiscally prudent to handle the waste in the cheapest waste category legally allowed. If employees are unable to recognize the various waste streams they not only increase the cost of disposal but also increase the likelihood of personal or public injury. Added to this situation is the unknown cost created by bad publicity and possible enforcement actions for failing to properly handle the waste stream. This may increase the cost of disposal by at least 20 times over the cost if the waste streams had not been commingled (Diana, 2002).

CHAPTER THREE

MATERIALS AND METHODS

3.0Study Area

Offinso South Municipality is located in the extreme north-western part of the Ashanti Region. It lies between longitude 1^0 65W and 1^0 45E and latitude 6^0 45N and 7^0 25S. The Municipality has a total population of about 138 190, representing about 0.62% of the total population of Ghana. Covering an area of 1255Km^2, the Municipality has its capital as Offinso Ashanti. Offinso Municipality forms about half of its boundary in the north and the west is shared with Brong Ahafo Region. It is also bordered in the east by Ejura-Sekyeredumase District and in the South by Kwabre, Sekyere South, Ahafo-Ano South and Atwima-Nwabiagya Districts.

Figure 1 below shows a plan (layout) of health facilities (study sites) in the Offinso Municipality.

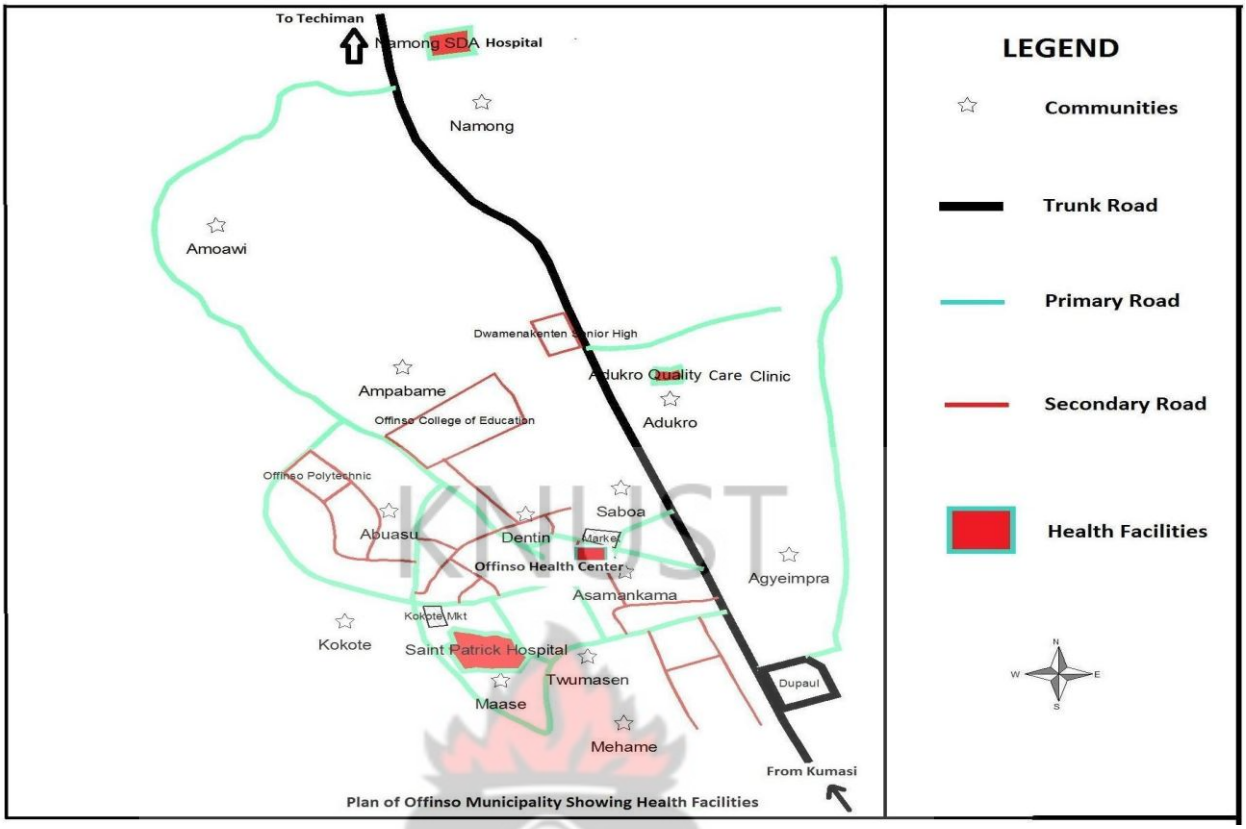

Figure 1: Plan (layout) showing the health facilities (study sites) in the Offinso Municipality

3.1 Selection of Sites

Out of the twelve health facilities within the Offinso Municipality, four were selected using random sampling technique.

3.2 Study Sites

Altogether there are twelve (12) health facilities within the Offinso Municipality.

Of these health facilities, four (4) were randomly selected for the purpose of this research.

The selected healthcare centers were; St Patrick's Hospital, S. D. A. Hospital, Offinso Health Center and Quality Care Clinic.

St Patrick's Hospital is situated at Maase-Offinso and is a government-assisted Mission hospital. It is the biggest in terms of facilities, patient attendance and therefore serves as a referral hospital for the Municipality and other surrounding communities as well.

S. D. A Hospital is a government-assisted Mission hospital located at Namong-Offinso. It is the second largest hospital in the Offinso Municipality. It serves the people of Namong, Ofinso and the people in the catchment area.

Offinso Health Center is situated at Dentin-Offinso which is the centre of Offinso township. It is owned by the government and serves as a health centre without a hospital status. It serves the people of Offinso and its catchment areas.

Quality Care Clinic is located at Adukro-Offinso and is purely a Private health facility. It serves the citizens of Adukro, Offinso, Namong and others within the catchment area.

St Patrick's Hospital, S.D.A Hospital, Offinso Health Centre and Quality Care Clinic have on the average daily patient's attendance records of two hundred (200), one hundred (100), eighty (80) and twenty (20) respectively. All the four selected healthcare's render in-patient and out- patient services.

St Patrick's and S.D.A are both mission hospitals. Offinso Health Centre is owned by the government with clinic status and that of Quality Care Clinic is privately owned.

All the health facilities provide general healthcare services.

The following units/departments were used for the research: theater, laboratory, dressing room, injection room, pharmacy, X-ray, male ward, female ward, children's ward, maternity ward, side ward and Out-patients department (OPD).

3.3Waste Measurement (Quantification)

Measurement of waste generated per day was undertaken at the various units/departments of each hospital for a period of three months from January to March,

2012. The quantity of hospital waste generated per day/week/month was measured in Kilograms using weighing scale for effective and efficient management of such wastes.

The initial weight of the empty waste container was taken after which the wastes were measured. After taken the measurement of the waste, the weight of the empty container was deducted from the measured wastes to get the actual weight.

Measured wastes were classified as infectious and non-infectious (general/municipal).

Infectious wastes measured include; soiled dressings, cotton wool, surgical gloves, swabs as tubing, disposable towels, gloves, laboratory coats and sharps (e.g. hypodermic needles and syringes, intravenous needles, scalpels, lancets blades).

Some non-infectious wastes measured are; used papers, waste food, plastic/polythene bags and empty cans.

Wastes measured were taken from the theater, laboratory, injection room, dressing room, Out Patients wards and Department (OPD).

This was carried out without prior education on segregation.

3. 4 Segregation of Waste

After educating the workers on the need for segregation, waste containers were provided to the various units (departments) to segregate (separate) waste at source. Each unit (department) was given two Colour-coded waste containers (580.0 cm^3).One of the waste containers was red in colour whiles the other was black. The red container was labeled 'infectious' and the black container labeled 'non-infectious'.

In order to segregate (separate) infectious wastes from non-infectious wastes, health workers involved directly or indirectly in the management of waste were educated and sensitized to dump all the waste that are likely to cause infection(infectious waste) into the red containers and that of non-infectious(general) waste dumped into the black containers**.**

3.5 Observational Survey

To determine the current hospital waste management practices pertaining to the four selected healthcare facilities, each site was visited twice per week for observation to obtain first-hand information on practices pertaining at the facilities.

This was done within a period of eight (8) weeks (November 2011 to December 2011).

Checklist was used for this purpose.

All the site visits were uninformed (unannounced) and were helpful in obtaining information about common practices in the management of hospital wastes.

Final disposal sites were also visited to observe how wastes were treated and disposed off.

The observations were carried out to support and supplement the information gathered through the use of interviews and questionnaires.

3.6 Interviews

Using the Purposive sampling approach, some workers on duty who agreed to be interviewed were used.

Interviews were conducted with those involved directly or indirectly with hospital waste management. Healthcare management staffs like administrators, health professionals (such as nurses), waste handlers and orderlies were interviewed.

The interview centered on issues such as; measurement of waste, waste segregation, occupational health hazards or risks associated with waste handling, awareness of the existence of hospital waste management policies/legislations, training of healthcare providers on waste management and proper disposal as well as treatment of hospital waste.

3.7 Questionnaire Administration

The questionnaire was drawn on the basis of the objectives of the project such as; segregation, collection, treatment of and disposal of waste, existence of regulations/legislations/policies concerning waste management, awareness of colour code for waste containers, incidence of needle-stick injuries as well as data(records) on the quantity of waste generated per day/week/month/year.

Eighty questionnaires were administered to various categories of health workers from the different departments (units) in all the four selected healthcare facilities.

Respondents who needed assistance or some clarification(s) on certain aspects of the questionnaire were assisted.

3.8 Data Analysis

The data was organized using the excel software. Analyses of Variance (ANOVA) as well as T-test were used to determine the differences between means of daily measurement of wastes using the software called Graph Pad Prism 5.01 version, 2007.

CHAPTER FOUR

RESULTS

4.0 Measurement of Waste

4.1 Total Waste Generation

Waste generated at the various hospitals ranged from 302.6Kg to 1559.2 Kg [Figure 2; Appendix D]. St Patrick's hospital generated the highest quantity of waste (1559.2 Kg) within the study period followed by S.D.A hospital (429.6 Kg), Offinso Health Centre (335.1 Kg) whilst Quality Healthcare generated the least amount of waste (302.6 Kg)- [Figure 2; Appendix D].

Difference in means of total waste generated over the period at the various hospitals was significant (P value < 0.0001)[Appendix A (i)].

Figure 2 below shows the total waste generated at the various healthcare facilities.

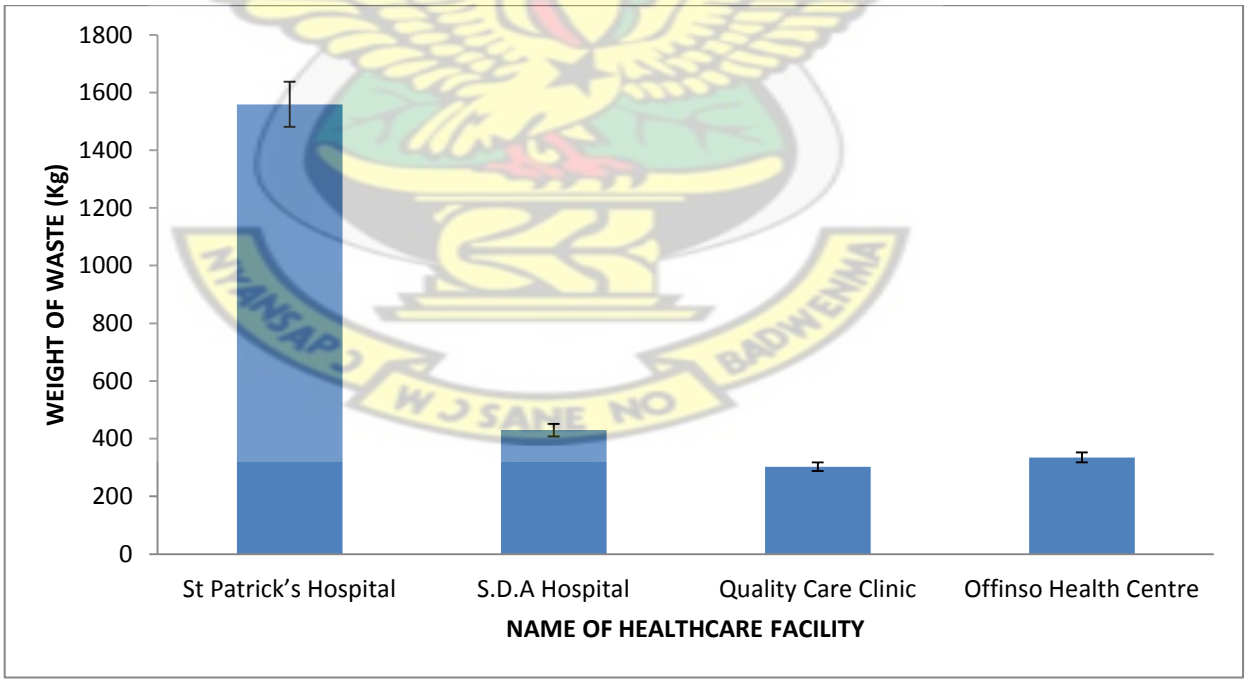

Figure 2: Total waste generation at the various healthcare facilities

4.1.2 Monthly Generation of Infectious Waste (Kg/Month)

Infectious waste generated at the various hospitals ranged from13.8 Kg to 81.6 Kg [Figure 3; Appendix B].

St Patrick's hospital generated the highest quantity of infectious waste (81.6Kg), followed by Quality Care Clinic (21.9 Kg), S.D.A Hospital(21.3Kg) and the least from Offinso Health Centre (13.8 Kg) in January[Figure 3; Appendix B].

St Patrick's Hospital produced the highest quantity of infectious waste in February (73.7 Kg) and March (81.6 Kg) whilst Quality Care Clinic produced the least quantity of infectious waste in February (19.8 Kg) and March (21.2 Kg) [Figure 3; Appendix B].

Analysis of means of infectious waste generated in February between S.D.A Hospital and Quality Care Clinic compared was not significant (P value = 0.5744) [Figure 3; Appendix A (ii)].

Analysis of result showed that the mean differences between St Patrick's Hospital and Quality Care Clinic in the month of March was significant (P value = 0.0021) [Appendix A(iii)]. Figure 3 Monthly infectious wastes generated at the various healthcare facilities.

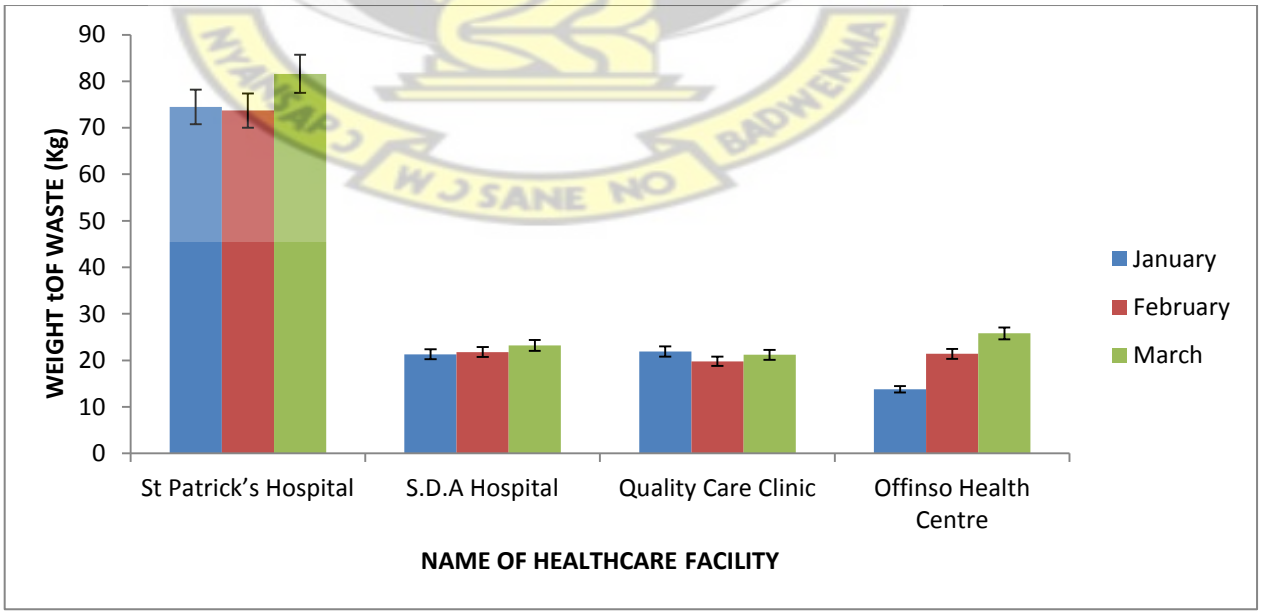

Figure 3: Monthly infectious waste generation at the various healthcare facilities

4.1.3 Total Infectious Waste

Total infectious waste generated at the various hospitals ranged from 61.0 Kg to 229.8 Kg [Figure 4; Appendix D].

St Patrick's hospital generated the highest quantity of infectious waste (229.8 Kg), followed by S.D.A Hospital (66.3 Kg), Quality Care Clinic (62.9 Kg) whilst the least came from Offinso Health Centre (61.0 Kg) [Figure 4].

Total infectious waste generated at SDA hospital (66.3 Kg) was slightly higher than that of Quality Care Clinic (62.9 Kg) and Offinso Health Centre (61.0 Kg) [Figure 4; Appendix D].

T-test analysis of means of total waste generated between St Patrick's hospital and SDA hospital was significant (P value = 0.0205) [Appendix A (iv)].

However, t-test analysis of total infectious waste generated between SDA hospital and Quality Care Clinic was not significant (P value = 0.8781) [Appendix A (v)].

Also analysis of total infectious waste generated between SDA hospital and Offinso Health Centre was not significant (P value = 0.8118) [Appendix A (vi)].

Figure 4 illustrates total infectious waste generation at the various healthcare facilities.

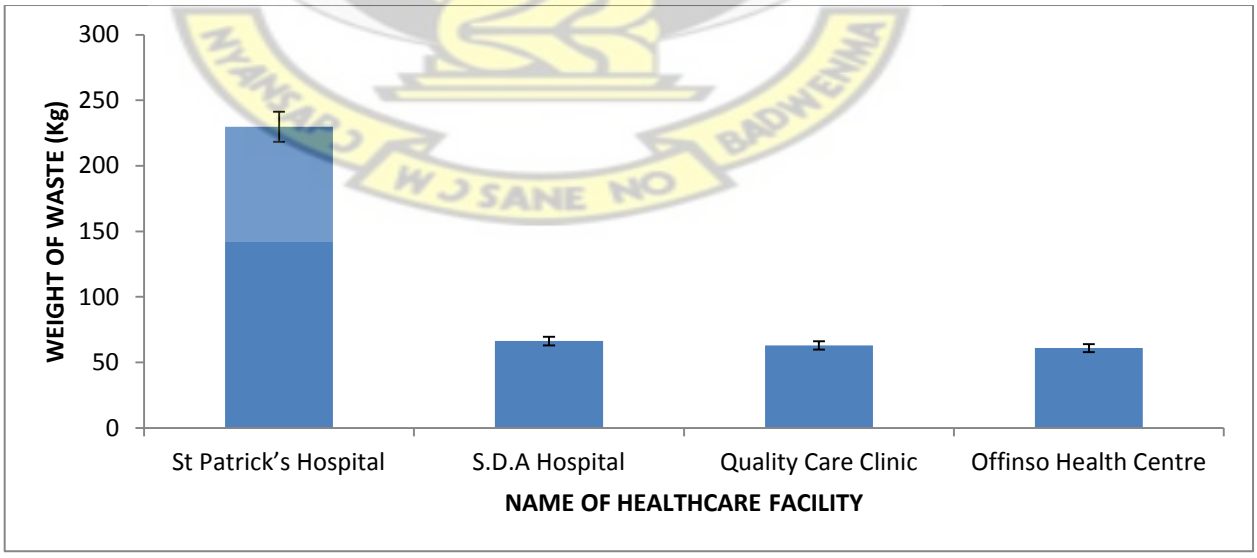

Figure 4: Total infectious waste generation at the various healthcare facilities

4.1.4 Non-Infectious Waste Generation (Kg/Month)

Non-infectious waste generated from January to March ranged from Kg 63.6 Kg to 488.8 Kg [Figure 5; Appendix C].

In the month of January, St Patrick's hospital (395.6 Kg) generated the highest quantity of non-infectious waste with the least from Quality Care Clinic (63.6 Kg) [Figure 5; Appendix C].

St Patrick's hospital again, generated the highest quantity of non-infectious waste in February (445.0Kg),followed by S.D.A Hospital (115.1Kg), Offinso Health Centre (82.9 Kg) and the least from Quality Care Clinic (69.3 Kg) [Figure 5; Appendix C].

Non-infectious waste generated in the month of March, was however lowest at Offinso Health Centre (67.6 Kg) and the highest at St Patrick's Hospital (488.8 Kg) [Figure 5; Appendix C].

The highest quantity of non-infectious waste generated at St Patrick's hospital was in the month of March (488.8 Kg) whilst January recorded the lowest (395.6 Kg) [Figure 5; Appendix C].

T -test analysis of mean non-infectious waste generated between S.D.A hospital and Quality Care Clinic in the month of January was not significant. (P value = 0.4436) [Appendix A (vii)].

Mean analysis of non-infectious waste generated in March between St Patrick's hospital and Offinso Health Centre was significant (P value < 0.0001) [Appendix A (xiii)].

Figure 5 shows non-infectious waste generation at the various healthcare facilities.

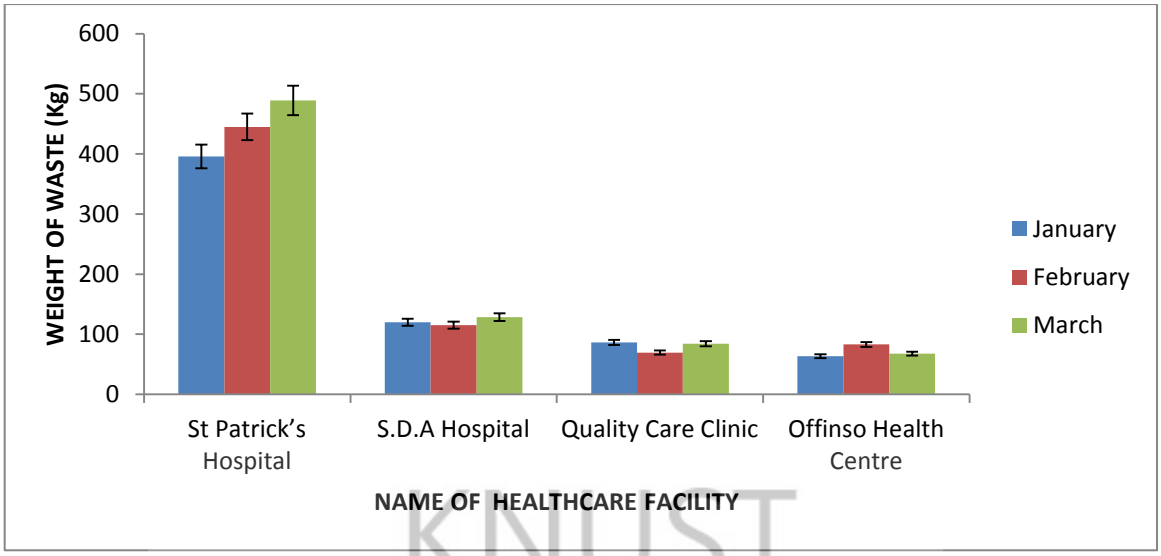

Figure 5: Non-infectious waste generation (Kg/Month) at the healthcare facilities

4.1.5 Total Non-Infectious Waste Generation

Total Non-infectious waste generated at the various hospitals from January to March ranged from 239.7 Kg to1329.4 Kg [Figure 6; Appendix D].

The highest quantity of total non-infectious waste was generated at St Patrick's hospital (1329.4 Kg) followed by S.D.A hospital (363.3 Kg), Offinso Health Centre (274. 1 Kg) and the least at Quality Care Clinic (239.7 Kg) [Figure 6; Appendix D].

Analysis of total non-infectious waste generated between St Patrick's hospital and S.D.A Hospital was significant (P >0.0220) over the study period [Appendix A (ix);]

However, analyzed data of non-infectious waste between Quality Care Clinic and Offinso Health Centre was not significant (P<0.6299) [Appendix A (x)].

Similarly, on-infectious waste between S.D.A Hospital and Offinso Health Centre was not significant (P >0.2575) [Appendix A (xi)].

Figure 6 below illustrates total non-infectious waste generation at the various healthcare facilities

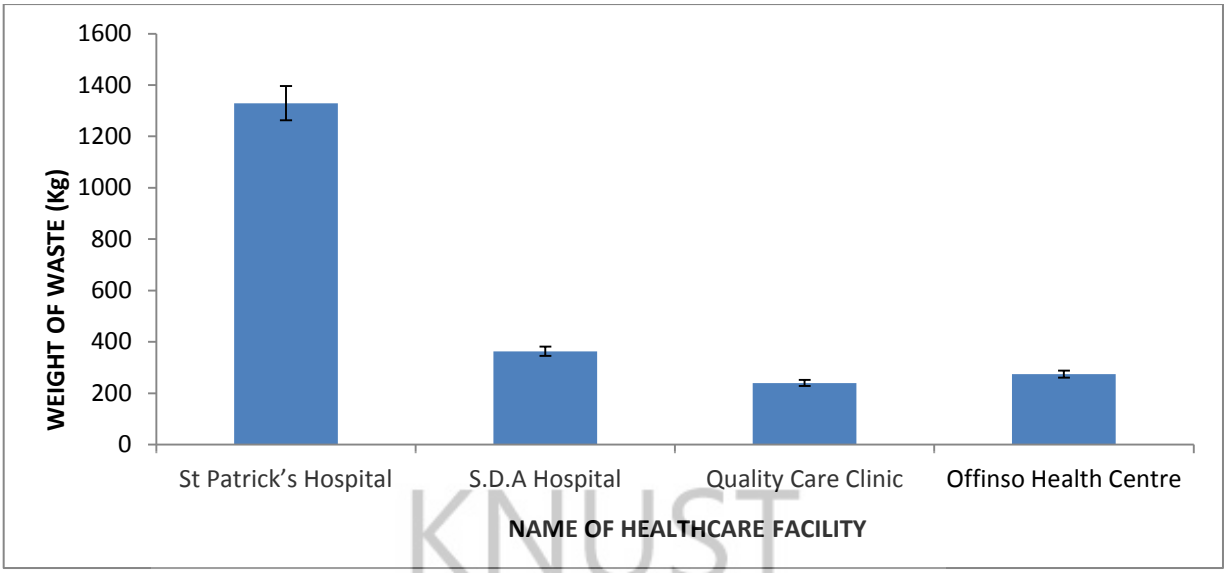

Figure 6: Total non-infectious waste generation at the various healthcare facilities

4.2 Segregation of Waste

Following education, sensitization and provision of colour-coded bins, the level of segregation was generally low (0.3%). That is, only a negligible portion of the total waste was segregated (sharps) at source. At St Patrick's Hospital, only 2.2 Kg (0.14%) of the entire waste was segregated at source, S.D.A Hospital 1.7Kg (0.40%), Quality Care Clinic 1.3 Kg (0.43%) and Offinso Health Centre 1.1Kg (0.33%); [Table 1].

The bulk of wastes at the various hospitals were not segregated representing 99.7% of the entire waste [Table 1].

Table 1: Mean Segregation/Non-segregation of Waste at the Various Hospitals

Name Of Healthcare Facility	Total Waste (Segregated & Unsegregated)	Unsegregated Waste (Kg)	Segregated Waste (Kg)	Percentage Segregation (%)	Percentage Waste Not Segregated (%)
St Patrick's Hospital	1559.2	1557.0	2.2	0.14	99.86
S.D.A Hospital	429.6	427.9	1.7	0.40	99.60
Quality Care Clinic	302.6	301.3	1.3	0.43	99.57
Offinso Health Centre	335.1	334.0	1.1	0.33	99.67

4.3 Disposal Methods and Sites

In all four (4) healthcare facilities studied, solid wastes are dumped openly/Land disposal (open dump method) on the ground.

Pit is used at Offinso Health Centre to dispose of sharps.

The dumped sites are not fenced.

Dumped wastes are treated by subjecting it to burning (incineration) occasionally openly on the ground.

Plate 1: Final Disposal Site: Land Disposal/Open Dump Method Of Waste At Healthcare Facility

4.4 Handling of Waste Containers

Most respondents (56.3%) were of the opinion that waste containers are uncovered [Table 2].

Personal observation confirmed that, most waste containers at the selected healthcare facilities studied are mostly uncovered (83.0%) [Plate 2].

Table 2: Respondents View on Handling of Waste Containers (Covered/Uncovered)

NAME OF HEALTHCARE FACILITY	COVERED	UNCOVERED
St Patrick's Hospital	17 (42.5%)	23 (57.5%)
S.D.A Hospital	7 (46.7%)	8 (57.3 %)
Offinso Health Centre	4 (26.7%)	11 (73.3%)
Quality Care Clinic	7 (70.0%)	3 (30.0%)

Plate 2: Showing Non-Covering Of Waste Container

4.5 Waste Handlers/ Collectors

On the average, each waste worker at St Patrick's Hospital, S.D.A Hospital, Quality Care Clinic and Offinso Health Centre relatively handles 17.30 kg, 5.0Kg, 4.0Kg and 3.5Kg of waste per day which is not too a burden [Table 3].

Table 3: Waste Handlers At Various Healthcare Facilities

Name Of Healthcare Facility	Number Of Waste Handlers	Mean Waste(Kg)/Day/Handler
St Patrick's Hospital	2	17.3 ± 0.3
S.D.A Hospital	3	5.0 ± 0.3
Offinso Health Centre	1	3.5 ± 0.3
Quality Care Clinic	1	4.0 ± 0.3

4.6 Use of Personal Protective Equipment (PPE)

Only few waste handlers wear only gloves. That is , twenty seven percent(27%) at Offinso Health Centre ,twenty five percent (25.0%) at St Patrick's Hospital, twenty percent(20%) at S.D.A Hospital and Centre and ten percent (10%) at Quality Care Clinic (Table 4).

It means ninety percent(90%), eighty percent(80%), seventy five percent(75%) and seventy three percent(73.0%) of waste handlers do not use gloves at Quality Care Clinic, S.D.A Hospital, St Patrick's Hospital and Offinso Health Centre respectively (Table 4).

Table 4: Type of Personal Protective Equipment (PPE) used at the Healthcare facility

NAME OF HEALTHCARE FACILITY	USE OF GLOVES	NON-USE OF GLOVES
St Patrick's Hospital	10 (25.0%)	30 (75.0%)
S.D.A Hospital	3 (20.0 %)	12 (80.0 %)
Offinso Health Centre	4 (27.0%)	11 (73.0 %)
Quality Care Clinic	1 (10.0%)	9 (90.0 %)

4.7 Needle-Stick Injury/Injury Associated With Hospital Waste

There have been instances where waste handlers and other health workers have been exposed to needle-stick injuries as well as other forms of injuries in the cause of handling hospital waste.

Interviews conducted revealed that some health workers and waste handlers are occasionally exposed to needle-stick or other forms of injuries associated with hospital waste.

The incidence of needle-stick injuries/injuries associated with hospital waste was highest at St Patrick's Hospital (35.0%), followed by S.D.A Hospital (33.3%),Offinso Health Centre (30.0 %) and Quality Care Clinic (26.7%)[Table 5].

Table 5: Incidence of Needle-Stick Injury/Injury Relating To Waste Management

NAME OF HEALTHCARE FACILITY	INCIDENCE OF INJURY	NO INCIDENCE OF INJURY
St Patrick's Hospital	14 (35.0%)	26 (65.0%)
S.D.A Hospital	5 (33.3%)	10 (66.7%)
Offinso Health Centre	3 (30.0 %)	7 (70.0%)
Quality Care Clinic	4 (26.7%)	11 (73.3%)

4.8 Existing Waste Management Practices

Table 6: Existing Waste Management Practices Available At The Study Sites

Name Of Healthcare Facility	Segregation Of Waste	Record On Quantity Of Waste	Existence Of Waste Management Team/Head Of Dept(officer)	Knowledge Of Hospital Waste Management Policy/Legislation	Labeling On Containers/ Colour-Code	Training On Waste Handling	Incidence/Reported Case Of Injury/Needle-stick	Handlers Of Waste	Type Of Containers Used
1.St Patrick's Hospital	2.2 (0.14%)	NO	NO	NO	NO	NO	YES	Waste handlers and Orderlies	Paper boxes/Polythene bags
2.S.D.A Hospital	1.7 (0.40%)	NO	NO	NO	NO	NO	YES	Orderlies	Paper boxes/Polythene bags
3.Offinso Health Centre	1.1 (0.33%)	NO	NO	NO	NO	NO	YES	Any health worker on duty	Paper boxes/Polythene bags
4.Quality Care Clinic	1.3(1.3%)	NO	NO	NO	NO	NO	YES	Orderly and any health workers on duty	Paper boxes/Polythene bags

CHAPTER FIVE

DISCUSSION

5.0 Measurement of Waste

The quantity of hospital waste produced per day/week/month/year, no matter how small, is very important due to its sensitive nature and negative impact on the environment.

About 250,000 tons of medical wastes are produced annually from all sorts of health care facilities in Pakistan which has adversely affected the environment by contaminating the air, water and land resources (Hospital Waste Factsheet Environmental Pollution Unit-Pakistan).

It is therefore important (imperative) to measure(quantify) such wastes to identify the categories/nature/types of waste generated in order to map out effective strategies (proper planning) to combat the likely negative effect that such wastes could have on the environment. This view is supported by Kelly (2012), who was of the opinion that waste management plan guides employees performing the disposal process.

5.1.1 Total Waste Generation for the Periodic

Total waste generated in all the hospitals studied in the district was 2626.5.8 Kg, which consisted of 420.0 Kg of infectious waste and 2206.5 Kg of non-infectious waste

St Patrick's hospital generated the highest quantity of total waste and the least was from Offinso Health Center [Figure 2]. The overall waste generated at St Patrick's hospital was significant (P value < 0.0001), and could probably be due to the high patients' attendance [Appendix H]. The high patronage could be attributed probably, to the presence of good facilities compared to the other facilities.

Total hospital waste consisted of infectious and non-infectious waste. Once both the infectious and non-infectious wastes are put together, the whole (total) waste becomes infectious.

This has been confirmed by the WHO (2005d), that if these two basic categories of waste (infectious and non-infectious) are not segregated (separated) properly- the entire volume of health care waste, must be considered as being infectious according to the precautionary principle, hence the importance of setting up a safe and integrated waste management system. It is therefore necessary to keep infectious waste from non-infectious waste to manage the total waste effectively. This supports the assertion made by Yashpal and Poonam (2000), that there is an urgent need to keep the infectious waste separate from non-infectious waste. This is because if the infectious waste, which constitutes only 10-15%, is mixed with the non-infectious waste (80-85%); it can render the entire waste infectious. Once the quantity of hospital waste has gone up (increased), its impact on the environment could be serious.

5.1.2 Infectious Waste Generation

The high amount of infectious portion of hospital waste generated at St Patrick's hospital (54.7%) was followed by S.D.A hospital (15.8%), Quality Care Clinic and Offinso Health Center could be attributed to number of patients who patronize these facilities [Appendix H]. Infectious hospital waste, no matter how small, poses health threat. The infectious hospital waste constituted a small fraction of the entire hospital waste.

This conforms to the findings made by Dinesh et al. (2010), that India produces about 3000 million tons of wastes annually of which 10-25% is infectious or hazardous to humans or animals and deleterious to the environment.

Infectious hospital wastes have the potential to spread deadly diseases or cause personal injuries. In order to protect people from being exposed to these infectious wastes, the contaminants must be properly handled, packaged, marked and disposed of.

In the view of Kelly (2012), infectious waste should be managed effectively by practicing good hygiene and proper handling to avoid cross contamination. One of the biggest risks for African healthcare facilities is the disposal of sharps that are in contact with infectious germs (News Analysis, 2010).

5.1.3 Non-Infectious Hospital Waste Production

In all the hospitals studied, the percentage (quantity) of non-infectious hospital waste generated were higher (83.60%) than the infectious portion (16.40%) with St Patrick's hospital generating the highest quantity of non-infectious waste, followed by S.D.A hospital, Quality Care Clinic and Offinso Health Center-[Appendix D].

This confirms the survey conducted in Bangladesh which revealed that out of 6.4 tons of hospital waste generated/day, 5.2 tons/day were found to be non-infectious representing 80.77% of the total waste (Prism, 2002).

The non-infectious portions of hospital wastes constitute what is termed general (municipal) waste which also poses its own environmental challenges.

Studies have shown that Non-infectious (general/municipal) waste could cause foul odours, unsightliness as well as the attraction of rodents and insects. A high percentage of workers who handle wastes and individuals who leave near disposal sites are infected with gastrointestinal parasites, worms, and other diseases like; cholera, yellow fever and salmonellosis (Fei-Baffoe, 2010).

5.2 Segregation of Waste

All the four hospitals studied do not segregate (separates) the waste they generate at source. Even, the sharps that are put in improvised boxes are not treated separately from the rest of the entire medical waste generated. Instead, the sharps, together with the rest of the hospital wastes are lumped up for final disposal and treatment.

Despite the sensitization and education to all healthcare personnel involved directly or indirectly in the management of hospital waste to segregate (separate) infectious waste from non-infectious waste, it did not materialized.

The waste generators and handlers continued to put or dump all the wastes in one container instead of separating (segregating) them.

Only a negligible portion of the entire waste (sharps) was segregated (0.3 %) where improvised sharps boxes were provided by each hospital selected; leaving the chunk of the waste unsegregated (99.7%) - [Table 1].

The improvised sharps containers were not strong and also not puncture proof.

Since sharps could be a potential source of infection, it should be put (kept) in strong and puncture-proof containers. WHO (2005e), has recommended that sharps must be put in strong, puncture-proof yellow containers and marked "Sharps-"[Appendix F].

Segregation must be done at the point of generation (source) of the waste. To encourage segregation at source, containers or baskets with liners of the correct size and thickness are placed in the containers (WHO, 2005f).

Yashpal and Poonam (2000), were of the opinion that segregating or separating different types (categories) of waste by sorting out at the point of generation, should be considered as the "key" for the entire process –as it allows special attention to even the relatively small quantities of infections and hazardous waste, thus reducing the risks and cost of waste management.

According to WHO (2005g), a simple three bin segregation system (sharps, infectious waste and general waste) is an efficient first step that should be quite easy to implement and that enables to reduce the most important risks drastically before going into more detailed solutions taking into account all the different categories of healthcare waste.

It is now universally accepted that segregation is the responsibility of the generator of wastes that is, the doctor, nurse or Para-medical personnel.

In order to ensure the safety of staff, patients, attendants, general public and the environment, the waste generated in the hospital(healthcare institutions) should be properly segregated at the source of production, transported in covered trolleys or wheel barrows and then scientifically disposed of as per the available treatment technology (Yashpal and Poonam ,2000).

5.3 Disposal, Treatment and Impact of Hospital Waste On The Environment

In all the hospitals studied, waste treatment was done by simply dumping and burning openly on the bear ground which was a common practice-[Plate 7].

In the case of St Patrick's and S. D.A hospitals, water bodies (streams) are few meters away which could be polluted (water pollution) thereby affecting the aquatic fauna and flora negatively.

According to United States Environmental Protection Agency (USEPA, 2011), contaminants of emerging concern (CEC), including pharmaceuticals and personal care products (PPCPs), are increasingly being detected at low levels in surface water, and there is concern that these compounds may have an impact on aquatic life.

A large volume of infectious waste is disposed in buried pits located at hospital sites and in Municipal landfills. Both practice pose significant risks to humans, including direct contact and contamination of surface water and groundwater (Roland *et al.*, 1997).

Smoke emanating as a result of the burning the hospital waste could pollute the air.

Hydrogen chloride and heavy metals are emitted from medical waste incinerators causing air pollution (Kai-Fui, 1994).

In New Delhi, improper hospital management results in air, water and soil pollution, especially due to imperfect treatment and faulty disposal methods (Yashpal and Poonam, 2000).

When harmful gases like; oxides of sulphur, oxides of nitrogen, carbon dioxide and suspended particulate matter present in air which may contain heavy metals are inhaled, they can cause respiratory diseases. Also, certain organic gases like dioxins and furans are carcinogenic whose effects have longer latency periods (Manyele, 2004).

For developing countries, the unsanitary disposal of waste has put millions of lives at risk because dumping sites are often visited by people scavenging for goods (News Analysis, 2010).

A percentage of workers handling wastes and individuals who leave near disposal sites are infected with gastrointestinal parasites, worms, and other diseases like; cholera, yellow fever and salmonellosis (Fei-Baffoe, 2010).

A lot of people dispose of wastes anyhow by either throwing such wastes on the bear ground, discarded into water bodies or thrown anywhere (Mustapha and Anjum, 2009).

5.4. Handling/Types of Waste Containers

Most waste containers used in all the hospitals studied were uncovered representing 73.3% at Offinso Health Centre, 57.5% at St Patrick's Hospital, 57.3% at S.D.A Hospital and 30.0% at Quality Care Clinic-[Table 2; Plate 8].

Uncovered waste containers always expose the waste to flies and foul odour which could lead to the transmission of diseases.

Vorapong (2009), suggested that waste containers should be covered always with lids during transport and storage.

Puncture –proof, leak-proof and colour-coded containers are not used. The most prevailing waste containers available in all the hospitals selected are paper boxes and polythene bags.

WHO safe management of wastes for healthcare activities has given recommendations for different categories of waste and the type of containers, colour-code and the marks (symbols) to be used for such waste, [Appendix F]- (Pruss *et al*., 1999).

5.5. Hospital Waste Handlers (Collectors)

Each waste collector at St Patrick's hospital, S.D.A Hospital, Quality Care Clinic and Offinso Health Centre handles at least 17.3Kg, 5.0 Kg, 4.0Kg and 3.5Kg of waste per day respectively [Table 3].

Analyzing critically the quantum of waste that each waste worker handles each day, in respect of the hospitals studied, the workload per each worker is not too much. Yet, workers are unable to manage the waste properly especially at St Patrick's hospital.

There is no coordination between the generators of waste (example, nurses, doctors, and paramedical staff) and the cleaning staff in terms of waste management.

Yashpal and Poonam (2000), are of the opinion that hospital waste management is a shared responsibility of all viz; doctors, nurses, paramedical staff, cleaning staff, all employees and administrators.

However, where only one person manages the entire waste (Quality Care Clinic and S.D.A Hospital)[Table 3], if that worker is indisposed, then, waste handling would become a problem for that particular day/period.

5.6.0 Healthcare Facility Waste and Occupational Health Issues

5.6.1. Use of personal protective equipment (PPE)

Majority of workers managing waste directly or indirectly do not use personal protective equipment-[Table 4].

Considering the infectious nature and bad odour emanating from the waste, it is imperative that waste workers wear personal protective equipment such as nose mask, safety boots and puncture-proof gloves to prevent them from being infected.

Greeta (2005), has recommended that gloves should be heat resistant and its length must be up to the elbow.

A study conducted in Bangladesh showed that cleaners employed for handling waste in healthcare establishments do not use complete personal protective equipment. Lack of suitable and sufficient protective equipment and knowledge could expose them to serious health problems (Prism, 2002).

5.6.2. Injuries/ Needle-stick injuries

All the hospitals studied have had experiences relating to needle-stick injuries so far as hospital waste handling and management are concerned [Table 5].

Waste generators and handlers alike, are exposed to needle-stick injuries or injuries associated with hospital waste handling.

World Health Organization (WHO, 2005a), reported that, sharps waste disposal expose people who scavenge domestic waste to accidental needle stick injury. Sharps waste, although produced in small quantities, is highly infectious. Poorly managed, they could expose healthcare workers, waste handlers and the community to infections. Epidemiological studies indicate that a person who experiences one needle-stick injury from a needle used on an infected source patient has risks of 30 %, 1.8% and 0.3% respectively to become infected with Hepatitis B Virus (HBV), Hepatitis C Virus (HCV) and Human Immunodeficiency Virus (HIV)-(Verma, 2010).

India is on the verge of having an HIV epidemic, Tuberculosis and HIV combined. Hepatitis B and C infections are on the rise. The vulnerable group includes health care workers, waste handlers and the most affected is the rag-pickers (Verma, 2010).

5.7.0 Existing Waste Management Practices

5.7.1 Waste Management Department/ Officer

All the hospitals studied do not have waste management department and an officer. It means there would not be effective supervision and planning, resulting in improper waste management [Table 6].

Where hospital waste management department as well as officer exists, such an outfit would ensure effective planning, strategies and modalities in terms of supervision and training of waste workers and generators aimed at ensuring efficient hospital management.

5.7.2 Hospital Waste Management Policy/ Legislation/ Regulation

Hospital administrators from all the healthcare facilities studied indicated that no policy or legislation or regulation exists to serve as a guide for effective waste management [Table 6].

Policy is necessary to assist in the effective management of hospital waste.

World Health Organization (WHO, 2005h), has it that policies and plans should be implemented to ensure comprehensive waste management from production to disposal.

It is a requirement that hospitals and other areas that generate clinical waste comply with good practice and legislation regarding its disposal.

Many developed countries have legal provisions with regard to proper management of hazardous waste (Phillips, 1999).

According to Ak –Dwividi *et al.* (2009), there is no specific legislation, regulations or by-laws for the management of healthcare waste.

5.7.3. Hospital Waste Management Training (In-service Training)

No waste management training (in-service) programmes are organized for any of the workers involved directly or indirectly with the management of hospital waste in all the hospitals studied (Table 6).

A survey conducted by Sawalem et al. (2008), in Libya showed that 85% of the personnel including managers, cleaning staff and environmental workers were not trained in hospital waste management.

Training is therefore essential for all categories of health personnel so as to manage hospital waste effectively and efficiently.

Verma (2010), has it that there should be education for all classes of health care workers such as; doctors, nurses, Para-medical staff and waste handlers.

Medical waste handlers are trained on how to protect themselves from hazardous environments and situations such as needle sticks. It is imperative that medical waste handlers receive extensive training on how to handle infectious and hazardous waste as well as receive preventive medical treatment, proper supervision and ongoing training (Roe Gillis, 2012).

5.8.0 Factors Responsible for Improper Hospital Waste Management

Unavailable records (data) on the quantity of waste produced was due to the absence waste management department or officer.

Non-segregation of waste as well as improper disposal and treatment methods were partly due to lack of proper in-service training, delay in the final disposal of waste due to lateness by waste handlers due to lack of supervision as a result of an absence management department or officer coupled with lack of hospital waste management.

Absence of policy or legislation or regulation, inadequate or non-use of personal protective equipment (PPE) as well as non-existence of waste management guide book (manual) also contribute to improper handling of waste [Table 6].

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The main types of solid waste generated regarding the four hospitals studied were infectious, non-infectious and pharmaceutical wastes. The study shown that no records (documents) are kept on the quantity of waste generated. With the exception of few sharps, no segregation of waste is done. Waste containers are not covered and non-labelled according to WHO recommendations.

There are no waste management training (in-service) programmes for hospital workers. It was also observed that workers managing waste do not use personal protective equipment (PPE).

Through the survey, it came to light that no waste management department (officer) exists resulting in ineffective supervision. Non-existence of waste management policy (legislation/regulation), lack of manual(guide) document as well as delay in the final disposal of waste were revealed as some factors militating against improper management of hospital wastes.

Generally, hospital wastes were not managed effectively and efficiently which could have a lot of health implications on both humans and other living organisms as a whole.

6.2 Recommendations

- There should be proper documentation on the quantity of medical waste generated per day/week/month/year to serve as a guide for effective and efficient planning.
- Waste should be segregated using management tools like colour-coding and proper labeling of waste containers.
- There should be proper and modernized methods of disposing of and treating medical waste.
- Infectious waste should be treated and disposed of separately from non-infectious waste.
- Waste management department headed by waste management Officer should be in place to ensure effective supervision of the waste workers.
- There should be regular training programmes for all categories of health workers concerning waste management.
- Waste management policy/legislation should be in place to regulate how waste would be managed.
- Waste management manual or guide document should be provided to guide waste handlers on how best to handle medical waste such as infectious and non-infectious.
- I would recommend for further research (work) on liquid waste management at the various healthcare facilities studied.

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APPENDICES

Appendix A: Analytical Results

(i)Total waste generation for the period

Table Analyzed	Data 2		
One-way analysis of variance			
P value	**< 0.0001**		
P value summary	***		
Are means signif. different? (P < 0.05)	Yes		
Number of groups	4		
F	233.7		
R squared	0.9723		
Bartlett's test for equal variances			
Bartlett's statistic (corrected)	11.78		
P value	0.0082		
	**		
Do the variances differ signif. (P < 0.05)	Yes		
ANOVA Table	SS	df	MS
Treatment (between columns)	758600	3	252900
Residual (within columns)	21640	20	1082
Total	780200	23	

(ii) T-test analysis of infectious waste between S.D.A hospital and Quality Care Clinic

Parameter	
Table Analyzed	Data 1
Column B	S.D.A Hospital
vs	vs
Column C	Quality Care Clinic
Unpaired t test	
P value	**0.5744**
P value summary	ns
Are means signif. different? (P < 0.05)	No
One- or two-tailed P value?	Two-tailed
t, df	t=0.6652 df=2
How big is the difference?	
Mean ± SEM of column B	21.80 ± 3.000 N=2
Mean ± SEM of column C	19.80 ± 0.2000 N=2
Difference between means	2.000 ± 3.007
95% confidence interval	-10.94 to 14.94
R squared	0.1812
F test to compare variances	
F,DFn, Dfd	225.0, 1, 1
P value	0.0848
P value summary	Ns
Are variances significantly different?	No

(iii)T-test analysis of infectious waste between St Patrick's Hospital and Quality Care Clinic

Parameter	
Table Analyzed	Data 1
Column A	St Patrick's Hospital
vs	Vs
Column C	Quality Care Clinic
Unpaired t test	
P value	**0.0021**
P value summary	**
Are means signif. Different ? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
t, df	t=21.78 df=2
How big is the difference?	
Mean ± SEM of column A	81.60 ± 2.500 N=2
Mean ± SEM of column C	21.20 ± 1.200 N=2
Difference between means	60.40 ± 2.773
95% confidence interval	48.47 to 72.33
R squared	0.9958
F test to compare variances	
F,DFn, Dfd	4.340, 1, 1

(iv)T-test analysis of total infectious waste between St Patrick's Hospital and S.D.A Hospital

Parameter	
Table Analyzed	Data 1
Column A	St Patrick's Hospital
vs	vs
Column B	S.D.A Hospital
Unpaired t test	
P value	**0.0205**
P value summary	*
Are means signif. different? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
t, df	t=6.870 df=2
How big is the difference?	
Mean ± SEM of column A	114.9 ± 7.100 N=2
Mean ± SEM of column B	33.15 ± 9.550 N=2
Difference between means	81.75 ± 11.90
95% confidence interval	30.54 to 133.0
R squared	0.9593
F test to compare variances	
F,DFn, Dfd	1.809, 1, 1
P value	0.8140
P value summary	ns
Are variances significantly different?	No

(v) T-test total infectious waste between S.D.A Hospital and quality care clinic

Parameter	
Table Analyzed	Data 1
Column B	S.D.A Hospital
vs	vs
Column C	Quality Care Clinic
Unpaired t test	
P value	**0.8781**
P value summary	ns
Are means signif. different? (P < 0.05)	No
One- or two-tailed P value?	Two-tailed
t, df	t=0.1737 df=2
How big is the difference?	
Mean ± SEM of column B	33.15 ± 9.550 N=2
Mean ± SEM of column C	31.45 ± 2.150 N=2
Difference between means	1.700 ± 9.789
95% confidence interval	-40.42 to 43.82
R squared	0.01486
F test to compare variances	
F,DFn, Dfd	19.73, 1, 1
P value	0.2819
P value summary	ns
Are variances significantly different?	No

(vi)T-test total infectious waste between SDA hospital and Offinso Heath Centre

Parameter	
Table Analyzed	Data 1
Column B	S.D.A Hospital
vs	vs
Column D	Offinso Health Centre
Unpaired t test	
P value	**0.8118**
P value summary	ns
Are means signif. different? (P < 0.05)	No
One- or two-tailed P value?	Two-tailed
t, df	t=0.2710 df=2
How big is the difference?	
Mean ± SEM of column B	33.15 ± 9.550 N=2
Mean ± SEM of column D	30.50 ± 2.100 N=2
Difference between means	2.650 ± 9.778
95% confidence interval	-39.43 to 44.73
R squared	0.03542
F test to compare variances	
F,DFn, Dfd	20.68, 1, 1
P value	0.2756
P value summary	ns
Are variances significantly different?	No

(vii) Non -infectious waste between S.D.A hospital and Quality Care Clinic

Parameter	
Table Analyzed	Data 1
Column B	S.D.A Hospital
vs	vs
Column C	Quality Care Clinic
Unpaired t test	
P value	**0.4436**
P value summary	ns
Are means signif. different? (P < 0.05)	No
One- or two-tailed P value?	Two-tailed
t, df	t=0.9469 df=2
How big is the difference?	
Mean ± SEM of column B	119.9 ± 29.70 N=2
Mean ± SEM of column C	86.10 ± 19.80 N=2
Difference between means	33.80 ± 35.69
95% confidence interval	-119.8 to 187.4
R squared	0.3095
F test to compare variances	
F,DFn, Dfd	2.250, 1, 1
P value	0.7487
P value summary	ns
Are variances significantly different?	No

(viii) Non -infectious waste between St Patrick's hospital and Offinso health centre

Parameter	
Table Analyzed	Data 1
Column A	St Patrick's Hospital
vs	vs
Column D	Offinso Health Centre
Unpaired t test	
P value	< **0.0001**
P value summary	***
Are means signif. different? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
t, df	t=113.2 df=2
How big is the difference?	
Mean ± SEM of column A	488.7 ± 2.800 N=2
Mean ± SEM of column D	67.55 ± 2.450 N=2
Difference between means	421.2 ± 3.721
95% confidence interval	405.1 to 437.2
R squared	0.9998
F test to compare variances	
F,DFn, Dfd	1.306, 1, 1
P value	0.9152
P value summary	ns
Are variances significantly different?	No

(ix)Total non-infectious waste between St Patrick's hospital and S.D.A hospital

Parameter	
Table Analyzed	Data 1
Column A	St Patrick's Hospital
vs	vs
Column B	S.D.A Hospital
Unpaired t test	
P value	**0.0220**
P value summary	*
Are means signif. different? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
t, df	t=6.626 df=2
How big is the difference?	
Mean ± SEM of column A	664.7 ± 70.90 N=2
Mean ± SEM of column B	181.7 ± 16.95 N=2
Difference between means	483.1 ± 72.90
95% confidence interval	169.4 to 796.7
R squared	0.9564
F test to compare variances	
F,DFn, Dfd	17.50, 1, 1
P value	0.2988
P value summary	ns
Are variances significantly different?	No

(x)Total non-infectious waste between Quality Care and Offinso Health Centre

Parameter	
Table Analyzed	Data 1
Column C	Quality Care Clinic
vs	vs
Column D	Offinso Health Centre

Unpaired t test	
P value	**0.6299**
P value summary	ns
Are means signif. different? (P < 0.05)	No
One- or two-tailed P value?	Two-tailed
t, df	t=0.5633 df=2

How big is the difference?	
Mean ± SEM of column C	119.9 ± 20.25 N=2
Mean ± SEM of column D	137.1 ± 22.85 N=2
Difference between means	-17.20 ± 30.53
95% confidence interval	-148.6 to 114.2
R squared	0.1369

F test to compare variances	
F,DFn, Dfd	1.273, 1, 1
P value	0.9233
P value summary	ns
Are variances significantly different?	No

(xi)Total non-infectious waste between S.D.A Hospital and Offinso Health Centre

Parameter	
Table Analyzed	Data 1
Column B	S.D.A Hospital
vs	vs
Column D	Offinso Health Centre
Unpaired t test	
P value	0.2575
P value summary	ns
Are means signif. different? (P < 0.05)	No
One- or two-tailed P value?	Two-tailed
t, df	t=1.568 df=2
How big is the difference?	
Mean ± SEM of column B	181.7 ± 16.95 N=2
Mean ± SEM of column D	137.1 ± 22.85 N=2
Difference between means	44.60 ± 28.45
95% confidence interval	-77.82 to 167.0
R squared	0.5513
F test to compare variances	
F,DFn, Dfd	1.817, 1, 1
P value	0.8126
P value summary	ns
Are variances significantly different?	No

APPENDIX B

Mean monthly infectious waste (Kg)

	MONTH		
NAME OF HOSPITAL	January	February	March
St Patrick's Hospital	74.5 ± 0.3	73.7 ± 0.3	81.6 ± 0.3
S.D.A Hospital	21.3 ± 0.3	21.8 ± 0.3	23.2 ± 0.3
Quality Care Clinic	21.9 ± 0.3	19.8 ± 0.3	21.2 ± 0.3
Offinso Health Centre	13.8 ± 0.3	21.4 ± 0.3	25.8 ± 0.3

APPENDIX C

Mean monthly non -infectious waste (Kg)

	MONTH		
NAME OF HOSPITAL	January	February	March
St Patrick's Hospital	395.6 ± 0.3	445.0 ± 0.3	488.8 ± 0.3
S.D.A Hospital	119.9 ± 0.3	115.1 ± 0.3	128.3 ± 0.3
Quality Care Clinic	86.1 ± 0.3	69.3 ± 0.3	84.3 ± 0.3
Offinso Health Centre	63.6 ± 0.3	82.9 ± 0.3	67.6 ± 0.3

APPENDIX D

Total mean waste generation for the period

Name Of Hospital	Infectious Waste(Kg)	Non-Infectious Waste(Kg)	Total
St Patrick's Hospital	229.8	1329.4	1559.2
S.D.A Hospital	66.3	363.3	429.6
Quality Care Clinic	62.9	239.7	302.6
Offinso Health Centre	61.0	274.1	335.1

APPENDIX E

Overview of disposal and treatment methods suitable for different categories of health-care waste

TECHNOLOGY OR METHOD	CATEGORIES OF WASTES						
	Infectious waste	**Anatomical waste**	**Sharps**	**Pharmaceutical waste**	**Cytotoxic waste**	**Chemical waste**	**Radioactive waste**
Rotary Kiln	Yes	Yes	Yes	Yes	Yes	Yes	Low-level infectious waste
Pyrolytic incinerator	Yes	Yes	Yes	Small quantities	No	Small quantities	Low-level infectious waste
Single-chamber	Yes	Yes	Yes	No	No	No	Low-level infectious waste
Drum or brick incinerator	Yes	Yes	Yes	No	No	No	No
Chemical Disinfection	Yes	No	Yes	No	No	No	No
Wet thermal Treatment	Yes	No	Yes	No	No	No	No
Microwave irradiation	Yes	No	Yes	No	No	No	No
Encapsulation	No	No	Yes	Yes	Small quantities	Small quantities	No
Safe burial on hospital premises	Yes	Yes	Yes	Small quantities	No	Small quantities	No
Sanitary landfill	Yes	No	No	Small quantities	No	No	No
Discharge to sewer	No	No	No	Small quantities	No	No	Low-level liquid waste
Inertization	No	No	No	Yes	Yes	No	No
Other methods				Return expired drugs to supplier	Return expired drugs to supplier	Return expired drugs to supplier	Decay by storage

Source: WHO Safe management of wastes from healthcare activities, 1999 (Pruss et al., 1999).

APPENDIX F

Recommended colour-code and type of container for health-care waste

Type of waste	Colour of container and markings	Type of container
Highly infectious waste	Yellow/Red, marked "HIGHLY INFECTIOUS"	Strong, leak-proof plastic bag, or container capable of being autoclaved
Other infectious waste, pathological and anatomical waste	Yellow/Red	Leak-proof plastic bag or container
Sharps	"Yellow, marked "SHARPS	Puncture-proof container
Chemical and pharmaceutical waste	Brown	Plastic bag or container
Radioactive waste	N/A	Lead box, labelled with the radioactive Symbol
General health-care waste	Black	Plastic bag

Source: WHO Safe management of wastes from healthcare activities, 1999 (Pruss et al., 1999).

APPENDIX G

Sample Questionnaire

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI MSC ENVIRONMENTAL SCIENCE QUESTIONNAIRE ON HOSPITAL WASTE MANAGEMENT IN THE OFFINSO MUNICIPALITY

Dear Respondent,

This questionnaire is designed to collect some information from hospital workers on hospital waste management in some selected hospital(s)/ healthcare facilities in the Offinso Municipality. It is purely for research purposes. Your information will be treated as confidential. You have been selected at random to answer the questions provided below. You are kindly entreated to give honest answers, as the research is vital to national development.

SESCTION A

GENERAL INFORMATION (Name, Status, Service Provision, Patients Attendance Records and Available Units)

1. Name of Hospital…….....

2. Status of Hospital **[Tick one]**

Private Hospital [ ] Private Clinic [ ] Local Hospital/Clinic [ ]

Government Hospital [ ] Government Health Center [ ]

Mission Hospital [ ] Mission Health Center [ ]

3. Service Provision/Services being provided

[Tick one]

Specialist Hospital [ ] General Hospital/Clinic Health Center [ ] Teaching Hospital [ ]

4. Location of Health Facility

Sub-District [ ] District [ ] Municipality [ ] Metropolitan [ ] **[Tick one]**

5. Sex of respondent/Worker Male [ ] Female [ ] **[Tick one]**

6. Job Description: Doctor [ ] Administrator [ ] Nurse [ ]

Health/Ward Asst [ ] Orderly [ ] Lab Tech/Asst [ ] Waste Handlers [ ] Other [ ]

If 'Other', specify……

7. Patients Attendance Record: - (Provide the N^{o} of Patients/beds in the spaces indicated below):

(FOR HOSPITAL ADMINISTRATORS/ADMINISTRATION/OFFICIAL ONLY)

(i) N^{o} of Patients at OPD/day…… (ii) N^{o} of Beds at Male Ward……

(iii) N^{o} of Beds at Female Ward…… (iv) N^{o} of Beds at Children's Ward……...

(v) N^{o} of Beds at Maternity Ward…….

8. **Tick** the **Unit** of the Hospital you are working at/on duty **(Tick one based on where on duty)**. OPD [ ] Injection/Dressing Room [ ] Theater [ ]

Laboratory [ ] Wards [ ] Pharmacy/Dispensary [ ] X-ray [ ]

Emergency [ ] Renal [ ] Pathology unit [ ] Eye unit [ ]

SECTION B : WASTE CATEGORY/NATURE OF WASTE GENERATION

9. List the type of wastes that are generated at the unit you are working at/on duty **(List for only the unit you Ticked in N^{O}8 above)**

OPD ……

Injection/Dressing Room ……

Theater ……

Laboratory ……

Wards……

Pharmacy/Dispensary …….

X-ray ……..

Emergency …….....

10. What is/are the nature of the waste**? [Tick as many as available/appropriate/applicable]**

Infectious [ ] Hazardous/Toxic [ ] Non-hazardous/non-toxic [ ]

General waste [ ] Highly infectious [ ]

SECTION C: HOSPITAL WASTE MANAGEMENT PLAN/ISSUES (Waste Segregation, Collection, Storage, Handling and Disposal/Treatment)

11. Is/Are there waste container(s) at each unit of the health facility? **[Tick one]**

YES [ ] NO [ ] NOT AWARE [ ]

[Tick **one** or as **many** as appropriate/applicable/available from the information provided below]

12. Are the waste generated at each unit kept/put in the same container? **[Tick one]**

YES [ ] NO [ ] NOT AWARE [ ]

13. What type of waste container(s) is/are used? **[Tick the appropriate one(s)]**

Cardboard [ ] Paper boxes [ ] polythene bags [ ] NONE [ ]

Plastic bins [ ] Paper bags [ ] Metal bins [ ]

14. Are the waste container(s) if any, labeled? **[Tick one]** YES [ ] NO [ ] NOT AWARE [ ]

15. How are these waste containers if any, labeled? …….....

16. Are you aware of WHO recommended colour-code for different categories of hospital waste containers? **[Tick one]**

YES [ ] NO [ ] NOT AWARE [ ]

17. If YES write the colour-code for each of the following categories of hospital waste:

(i) Infectious waste…… (ii)Non-infectious waste……

(iii)Hazardous/Toxic waste…… (iv)Non-hazardous/toxic waste……

(v) General/Municipal waste……

18. How are these waste containers (if any), managed?

Uncovered/Not covered [ ] Not always covered [ ] Uncovered properly [ ]

Covered [ ] partially covered [ ]

19. How often are these hospital wastes collected? **[Tick one]**

Daily [ ] Twice/week [ ] Thrice/week [ ] irregularly [ ] Not often [ ] Not reliable [ ]

20. Where are these waste kept/put/stored after collection from the various units of the hospital before final disposal? **[Tick one]**

On the ground /floor [ ] In metal waste bins [ ] In plastic bins [ ]

In polythene bags [ ] On hospital premises [ ] In paper boxes [ ]

21. How are these wastes disposed of from the hospital finally? **[Tick one]**

To Municipal dump site [ ] To landfill site [ ] Buried on hospital premises [ ]

Dump behind hospital premises [ ] To community dump site [ ] Dump in plastic waste bins [ ] Dump on hospital premises [ ] Dump in open shallow pit [ ]

22. How are these waste treated after final disposal? **[Tick one]**

Burnt on the floor [ ] Recycle [ ] Buried in open shallow pit [ ]

Autoclaved [ ] Deep burial [ ] Incinerated [ ]

Open pit burning [ ] Reuse [ ] Sterilized/disinfected before disposal [ ]

23. How are sharps (e.g. needles) disposed of? **[Tick one]**

Burnt on the ground/ floor [ ] Deep burial [ ] Buried in pits [ ]

Dump on shallow open pit [ ] Dump on Municipal/Community dump site [ ]

Not aware [ ]

SECTION D

Personnel, Policy, Regulatory And Safety Issues On Waste Management

[Tick **one** or as **many** as appropriate/applicable/available from the information provided]

24. (i) Who is/are responsible for the collection of waste from the various units of the health facility? Waste workers/handlers [ ] Nurses [ ] Patients [ ]

Orderlies [ ] Any health worker on duty [ ] All healthcare personnel [ ]

(ii) Have you ever experience any injury/needle-stick or any reported case of injury/needle-stick caused by used equipment like sharps before? **[Tick one]**

YES [ ] NO [ ]

N^{OS}25, 26, 27, 28, 29, 30 AND 32 ARE FOR HOSPITAL ADMINISTRATORS OR ADMINISTRATION OR OFFICIALS ONLY

25. Is there/are you aware of any waste management team?

[Tick one]

YES [ ] NO [ ] NOT AWARE [ ]

26. Please, kindly list the membership of this waste management team as indicated below:

(i)Head of Waste Department/Officer:……

(ii) Team members: ……..

(iii) Waste handlers/workers:……

27. Are you aware/know of any document containing waste management policy?

[Tick one]

YES [ ] NO [ ] NOT AWARE [ ]

28. Write the title of the document and if possible, attach a copy…….……

……

29. (i) Is/Are there any manual/guide document on hospital waste?

[Tick one]

YES [ ] NO [ ] NOT AWARE [ ]

(ii) Do you document/is there any record(s) on the quantity of wastes generated daily/weekly/monthly/yearly? **[Tick one]**

YES [ ] NO [ ] NOT AWARE [ ]

30. Write the title of this manual ……

31. Are you aware/know of any hospital waste management policy? **[Tick one]**

YES [ ] NO [ ] NOT AWARE [ ]

32. Please, kindly write the title of this policy and if possible attach a copy ……

……

33. Are you aware/know of any legislation(s) applicable to hospital waste management?

[Tick one] YES [ ] NO [ ] NOT AWARE [ ]

34. Have you had/ever attended any waste management training/in-service course before?

[Tick one] YES [ ] NO [ ] NOT AWARE [ ]

35. Give evidence by writing the title/certificate of that course/training

……...

36. Is it necessary for healthcare staff/workers to have hospital waste management training? **[Tick one]** YES [ ] NO [ ]

37. Give reason(s) … ……

38. Do the waste handlers/workers wear Personal Protective Equipment (PPE)?

[Tick one] YES [ ] NO [ ] NOT AWARE [ ]

39. What is/are this/these PPEs? **[Tick as many as applicable/ available/appropriate]**

Gloves [ ] Apron [ ] Nose mask [ ] Goggles [ ] Safety boots [ ]

40. Are you happy with the way wastes are generally managed in your healthcare facility?

[Tick one] YES [ ] NO [ ] NOT AWARE [ ]

APPENDIX H

Patients Attendance Record

Name Of Hospital	**Number Of Patients/Day**
St Patrick's Hospital	200
S.D.A Hospital	100
Offinso Health Centre	80
Quality Care Clinic	20