

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

185,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Health Care Waste Management – Public Health Benefits, and the Need for Effective Environmental Regulatory Surveillance in Federal Republic of Nigeria

Nkechi Chuks Nwachukwu, Frank Anayo Orji and
Ositadinma Chinyere Ugbogu

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/53196>

1. Introduction

Waste generated by health care activities includes a broad range of materials, from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials (WHO, 2011).

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

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

Classification of Health Care wastes shows that

1. Of the total amount of waste generated by health-care activities, about 80% is general waste.

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

Health-care activities protect and restore health and save lives. But what about the wastes and by-products they generate

Types of waste

Waste and by-products cover a diverse range of materials, as the following list illustrates (percentages are approximate values):

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

Pathological waste: recognizable body parts and contaminated animal carcasses; Pathological waste consists of organs, tissues, body parts or fluids such as blood. Even if pathological waste may contain healthy body parts, it has to be considered as infectious waste for precautionary reasons.

Anatomical waste is a sub-group of pathological waste and consists in recognisable human body parts, whether they may be infected or not. Following the precautionary principles, anatomical waste is always considered as potential infectious waste.

Pharmaceutical wastes: expired, unused, and contaminated drugs; vaccines and sera; Pharmaceutical waste includes expired, unused, spilt and contaminated pharmaceutical products, drugs and vaccines. In this category are also included discarded items used in the handling of pharmaceuticals like bottles, vials, connecting tubing. Since various ministries of health or their equivalents usually put in place specific measures that will reduce the the wastage of drugs, Health care facilities should deal only with small quantities of pharmaceutical wastes. This category also includes all the drugs and equipment used for the mixing and administration of cytotoxic drugs. Cytotoxic drugs or genotoxic drugs are drugs that have the ability to reduce/stop the growth of certain living cells and are used in chemotherapy for cancer. Cytotoxic waste is dealt with under a separate heading.

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

Radioactive waste: such as glassware contaminated with radioactive diagnostic material or radiotherapeutic materials; Radioactive waste includes liquids, gas and solids contaminated with radionuclides whose ionizing radiations have genotoxic effects. The ionizing radiations of interest in medicine include X- and g-rays as well as α - and β - particles. An important difference between these types of radiations is that X-rays are emitted from X-ray tubes only when generating equipment is switched on whereas g-rays, α - and β - particles emit radiations continuously.

The type of radioactive material used in HCF results in low level radioactive waste. It concerns mainly therapeutic and imaging investigation activities where Cobalt 60Co, Technetium 99mTc, Iodine 131I and Iridium 192Ir are most commonly used.

With the noticeable exception of Cobalt 60Co, their half-life is reasonably short (6 hours for 99mTc, 8 days for 131I and 74 days for 192Ir) and the concentrations used remain low. A proper storage with an appropriate retention time is sufficient to prevent radioactivity spillage in the environment.

Infectious and anatomic wastes together represent the majority of the hazardous waste, up to 15% of the total waste from health-care activities. Sharps represent about 1% of the total waste but they are a major source of disease transmission if not properly managed. Chemicals and pharmaceuticals account for about 3% of waste from health-care activities while genotoxic waste, radioactive matter and heavy metal content account for around 1% of the total health-care waste.

The major sources of health-care waste are:

1. hospitals and other health-care establishments
2. laboratories and research centres
3. mortuary and autopsy centres
4. animal research and testing laboratories
5. blood banks and collection services
6. Nursing homes for the elderly.

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

Laboratory waste: This is also high risk category waste. This includes chemicals used in the pathological laboratory, microbial cultures and clinical specimens, slide, culture dish, needle, syringes, as well as radioactive waste such as Iodine-125, iodine -131.

Health impact

Health-care waste contains potentially harmful micro-organisms which can infect hospital patients, health-care workers and the general public. Other potential infectious risks may include the spread of drug-resistant micro-organisms from health-care establishments into the environment.

Waste and by-products can also cause injuries, for example:

1. radiation burns;
2. sharps-inflicted injuries;
3. poisoning and pollution through the release of pharmaceutical products, in particular, antibiotics and cytotoxic drugs;
4. poisoning and pollution through waste water; and
5. Poisoning and pollution by toxic elements or compounds, such as mercury or dioxins that are released during incineration.

Sharps

WHO estimates that, in 2000, injections with contaminated syringes caused 21 million hepatitis B virus (HBV) infections, two million hepatitis C virus infections and 260 000 HIV infections worldwide. Many of these infections were avoidable if the syringes had been disposed of safely. The re-use of disposable syringes and needles for injections is particularly common in certain African, Asian and Central and Eastern European countries.

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

Vaccine waste

In June 2000 six children were diagnosed with a mild form of smallpox (vaccinia virus) after having played with glass ampoules containing expired smallpox vaccine at a garbage dump in Vladivostok (Russia). Although the infections were not life-threatening, the vaccine ampoules should have been treated before being discarded.

Radioactive waste

The use of radiation sources in medical and other applications is widespread throughout the world. Occasionally, the public is exposed to radioactive waste, which originates from radiotherapy treatment, which has not been disposed of properly. Serious accidents have been documented in Brazil in 1988 (where four people died and 28 had serious radiation burns), Mexico and Morocco in 1983, Algeria in 1978 and Mexico in 1962.



Figure 1. Boxes for sharps disposal (AIHPPRP, 2007)

Risks associated with other types of health-care waste, in particular blood waste and chemicals, may be significant but have not been fully assessed. In the meantime, precautionary measures should be taken.

Risks associated with waste disposal

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

1. Landfills can contaminate drinking-water if they are not properly constructed. Occupational risks exist at disposal facilities that are not well designed, run, or maintained.
2. Incineration of waste has been widely practised but inadequate incineration or the incineration of unsuitable materials results in the release of pollutants into the air and of ash residue. Incinerated materials containing chlorine can generate dioxins and furans, which are human carcinogens and have been associated with a range of adverse health effects. Incineration of heavy metals or materials with high metal content (in particular lead, mercury and cadmium) can lead to the spread of toxic metals in the environment. Dioxins, furans and metals are persistent and bio-accumulate in the environment. Materials containing chlorine or metal should therefore not be incinerated.

3. Only modern incinerators operating at 850-1100 °C and fitted with special gas-cleaning equipment are able to comply with the international emission standards for dioxins and furans.

Alternatives to incineration are now available, such as autoclaving, microwaving, steam treatment integrated with internal mixing, and chemical treatment.

Waste management: reasons for failure

Lack of awareness about the health hazards related to health-care waste, inadequate training in proper waste management, absence of waste management and disposal systems, insufficient financial and human resources and the low priority given to the topic are the most common problems connected with health-care waste. Many countries either do not have appropriate regulations, or do not enforce them. An essential issue is the clear attribution of responsibility for the handling and disposal of waste. According to the 'polluter pays' principle, the responsibility lies with the waste producer, usually the health-care provider, or the establishment involved in related activities. To achieve the safe and sustainable management of health-care waste, financial analyses should include all the costs of disposal.

Steps towards improvement

Improvements in health-care waste management rely on the following key elements:

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

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

World Health Organisation response

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

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

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

1. a monitoring tool

2. a cost assessment tool
3. a rapid assessment tool
4. a policy paper
5. guidance to develop national plans
6. management of waste from injection activities
7. management of waste at primary health care centres
8. management of waste from mass immunization activities
9. Management of waste in emergencies.

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

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

2. Medical and pharmaceutical waste in Europe and America

In Europe, wastes are defined by their European Waste Catalogue (EWC) Codes. EWC Codes are 6 digits long, with the first two digits defining the overarching category of waste, the next two defining the sub-category, and the last two defining the precise waste stream. Clinical waste comes under the "18" codes, for example: "18 01 01" corresponds to healthcare waste (18), from humans (01), that is sharp and not infectious [01].

United Kingdom

In the UK, clinical waste and the way it is to be handled is closely regulated. Applicable legislation includes the Environmental Protection Act 1990 (Part II), Waste Management Licensing Regulations 1994, and the Hazardous Waste Regulations (England & Wales) 2005, as well as the Special Waste Regulations in Scotland.

United States

In 1988 the Federal government passed The Medical Waste Tracking Act which set the standards for governmental regulation of medical waste. After the Act was repealed in 1991, States were given the responsibility to regulate and pass laws concerning the disposal of medical waste. All fifty states vary in their regulations from no regulations to very strict. Disposal of this waste is an environmental concern, as many medical wastes are classified as *infectious* or *biohazardous* and could potentially lead to the spread of infectious disease. Examples of infectious waste include blood, potentially contaminated "sharps" such as needles and scalpels, and identifiable body parts. Sharps include used needles, lancets, and other de-

vices capable of penetrating skin. Infectious waste is often incinerated. The most common method of sterilization is an autoclave. The autoclave uses steam and pressure to sterilize the waste. Additionally, medical facilities produce a variety of hazardous chemicals, including radioactive materials. While such wastes are normally not infectious, they may be classified as hazardous wastes, and require proper disposal.

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

3. Health care waste in Nigeria

In developing countries like Nigeria, where many health concerns are competing for limited resources, it is not surprising that the management of healthcare wastes has received less attention and the priority it deserves (Abah and Ohimain, 2010). Unfortunately, practical information on this important aspect of healthcare management is inadequate and research on the public health implications of inadequate management of healthcare wastes are few and limited in scope (Abah and Ohimain, 2010). Although reliable records of the quantity and nature of healthcare wastes and the management techniques to adequately dispose of these wastes has remained a challenge in many developing countries of the world, it is believed that several hundreds of tones of healthcare waste are deposited openly in waste dumps and surrounding environments, often alongside with non hazardous solid waste (Alagoz and Kocasay, 2007; Abah and Ohimain, 2010).

A near total absence of institutional arrangements for HCW in Nigeria has been reported by others (Coker et al., 1998). Various methodologies have been used all over the world to assess and quantify HCW. They include the use of physical observation, questionnaire administration and quantification (Adegbita et al., 2010; Olubukola, 2009; Phengxay et al., 2005), as well as checklists (Townend and Cheeseman, 2005) and private and public records (Coker et al., 2009). Recent studies in Nigeria has estimated waste generation of between 0.562 to 0.670 kg/bed/day (Abah and Ohimain, 2011) and as high as 1.68 kg/bed/day (Abah and Ohimain, 2011). As reported in the literature, there may not be much of a difference in the way and manner wastes generated in various health care institutions are managed in Nigeria. A good example is given by the findings of the study in Lagos by Olubukola which reported the

similarity in waste data and HCW management practices in two General hospitals, characterized by a lack of waste minimization or waste reduction strategies, poor waste segregation practices, lack of instructive posters on waste segregation and disposal of HCW with general waste (Olubukola, 2009). The mismanagement of healthcare waste poses health risks to people and the environment by contaminating the air, soil and water resources. Hospitals and healthcare units are supposed to safeguard the health of the community. However, healthcare wastes if not properly managed can pose an even greater threat than the original diseases themselves (PATH, 2009).

A study of Health Care Waste management in Jos Metropolis, Nigeria has demonstrated that the waste management options in the hospitals did not meet the standard practices (Ngwuluka *et al.*, 2009). Waste management with safe and environmentally sound methods cannot be over-emphasized. The hospital management board and the hospitals should make a conscious and deliberate effort to ensure they do not contribute to the present and future threats to human health and the environment by poor waste management practices. In order to execute standard waste management, an understudy of a healthcare establishment with standard waste management practices in or outside the country may be the first practical step to undertake (Ngwuluka *et al.*, 2009). A waste management team should be constituted which will prepare waste management plan, policy documents and technical guidelines and in addition supervise waste management activities (Ngwuluka *et al.*, 2009).

In another study in Port-Harcourt metropolis, Nigeria carried out to assess hospitals waste management practice (Ogbonna, 2011). The study enquired into waste generation rates and various waste disposal options by different categories of hospital. It was further evident in this study that hospital waste management issues and problems are not peculiar to Port Harcourt metropolis alone. Solid waste disposal methods indicated that open dump sites is most preferred while incineration was non existent in the hospitals, clinics. Most other hospitals do not segregate wastes into marked or colour coded containers for the different waste streams neither do they keep records of waste generation and disposal (Ogbonna, 2011). In addition, the survey revealed that both hospital waste generators and handlers treat hospital wastes as a usual domestic waste (Ogbonna, 2011).

Therefore disposal of ashes containing toxic metals from Hospital waste incineration can be done through solidification-stabilization of fly and bottom ash with cement because it appears to be the best method to render ash less toxic. Similarly, the concentration of toxic heavy metals in the ash of hospital waste incinerator can be avoided to some extent through segregation of the waste prior to incineration. Lack of relevant training and protective equipment for waste handlers was a common feature in the survey. Generally, Port Harcourt, as a fast growing city in Nigeria, like most developing countries, lacked the infrastructure, as well as institutional capacity necessary to effectively manage medical wastes as part of the effort to enhance protection of human life and the environment from health hazards arising from improper management of hazardous waste (Ogbonna, 2011).

It was further observed that open dump sites are not even engineered or treated, thus expose the entire public to risks of infection. Ogbonna (2011) reported that except for the oil company clinics such as the SPDC, all the other hospitals sampled do not have any unit or

department responsible for waste management. Knowledge, attitude and practices towards environmental issues are relatively low among the various actors in the tasks of hospital waste management.



Figure 3. Temporary storage area at NOH, Igbobi (AIHPPRP, 2007)

4. Microorganisms associated with health care waste

The following groups of persons are at the risk of health care waste: Medical staff: doctors, nurses, sanitary staff and hospital maintenance personnel; In and out-patients receiving treatment in healthcare facilities as well as their visitors. Workers in support services linked to healthcare facilities such as laundries, waste handling and transportation services; Workers in waste disposal facilities and the general public. Presence of various microorganisms such as pathogenic viruses and bacteria have been investigated by both cultivation and by (RT)-PCR assays. A number of (opportunistic) pathogenic bacteria, including *Pseudomonas* spp., *Lactobacillus* spp., *Staphylococcus* spp., *Micrococcus* spp., *Kocuria* spp., *Brevibacillus* spp., *Microbacterium oxydans*, and *Propionibacterium acnes*, were identified and reported from the various medical wastes. In addition, pathogenic viruses such as noroviruses and hepatitis B virus have been also detected in human tissue wastes. Commonly identified bacterial and viral pathogens such as *Pseudomonas* spp., *Corynebacterium diphtheriae*, *Escherichia coli*, *Staphylococcus* spp., and respiratory syncytial virus (RSV) have been reported to be part of the medi-

cal wastes. Medical waste should be carefully controlled and monitored to prevent nosocomial infection associated with the exposure to these wastes (Nascimento *et al.*, 2009)

Health service waste gives rise to controversy regarding its importance for human, animal and environmental health (Nascimento *et al.*, 2009). Occurrences of clinically relevant bacteria in piles of health service waste in a sanitary landfill and their antimicrobial susceptibility profile have been previously studied by Nascimento *et al.*, 2009. Nascimento *et al.*, 2009 reported that aliquots of leachate from health care waste in Brazil contained pathogenic strains of *Staphylococcus* sp, Gram-negative rods of the *Enterobacteriaceae* family and non-fermenters. Bacterial resistance to all the antimicrobials tested was observed in all microbial groups, including resistance to more than one drug. This makes it possible to suggest that viable bacteria in health service waste represent risks to human and animal health. Furthermore, occurrences of multi-resistant strains support the hypothesis that health service waste acts as a reservoir for resistance markers, with an environmental impact. The lack of regional legislation concerning segregation, treatment and final disposal of waste may expose different populations to risks of transmission of infectious diseases associated with multi-resistant microorganisms.

S/N	Microbial Group	Type of Disease caused
1	Bacterial	Tetanus, gas gangrene and other wound infection, anthrax, cholera, other diarrhoeal diseases, enteric fever, shigellosis, plague etc
2	Viral	Various hepatitis, poliomyelitis, HIV-infections, HBV, TB, STD rabies etc.
3	Parasitic	Amoebiasis, Giardiasis, Ascariasis, Ancylostomiasis, Taeniasis, Echinococcosis, Malaria, Leishmaniasis, Filariasis etc.
4	Fungal infections	Various fungal infections like Candidiasis, cryptococcoses, coccidioidomycosis etc.

Table 1. Microbial diseases associated with health care waste (Akter, 2010)

5. Dangers of improper disposal of health care waste

Transmission of disease through infectious waste is the greatest and most immediate threat from healthcare waste.

If waste is not treated in a way that destroys the pathogenic organisms, dangerous quantities of microscopic disease-causing agents—viruses, bacteria, parasites or fungi—will be present in the waste. These agents can enter the body through punctures and other breaks in the skin, mucous membranes in the mouth, by being inhaled into the lungs, being swallowed, or being transmitted by a vector organism (World Health Organization,

1992). People who come in direct contact with the waste are at greatest risk. Examples include healthcare workers, cleaning staff, patients, visitors, waste collectors, disposal site staff, waste pickers, drug addicts and those who knowingly or unknowingly use “recycled” contaminated syringes and needles. Although sharps pose an inherent physical hazard of cuts and punctures, the much greater threat comes from sharps that are also infectious waste. Again, healthcare workers, waste handlers, waste pickers, drug addicts and others who handle sharps can, and have, become infected with HIV/AIDS and hepatitis B and C viruses through pricks or reuse of syringes/needles. These infections may be fatal (Johannessen, 2000). Contamination of water supply from untreated healthcare waste can also have devastating effects. If infectious stools or bodily fluids are not treated before being disposed of, they can create and extend epidemics, since sewage treatment in Africa is almost nonexistent.

For example, the absence of proper sterilization procedures is believed to have increased the severity and size of cholera epidemics in most parts of Africa during the last decade.

Chemical and toxic threats

Chemical and pharmaceutical wastes, especially large quantities, can be health and environmental threats. Since hazardous chemical wastes may be toxic, corrosive, flammable, reactive, and/or explosive, they can poison, burn or damage the skin and flesh of people who touch, inhale or are in close proximity to them. If burned, they may explode or produce toxic fumes. Some pharmaceuticals are toxic as well (Johannessen, 2000).

When chemical and pharmaceutical waste is disposed of in unlined landfills, especially unlined pits, these wastes may contaminate ground and surface water—particularly when large quantities are disposed of. This can threaten people who use the water for drinking, bathing and cooking, and damaging plants and animals in the local ecosystem. Burning or incinerating healthcare waste, while often a better option than disposal in an unlined pit, may create additional problems. Burning or incineration of healthcare waste may produce toxic air pollutants such as Nitrogen Oxides (NO_x), particulates, dioxins and heavy metals and distribute them over a wide area. Dioxins and heavy metals are of particular concern (Prüss and Townend, 1998). Dioxins believed to be potent cancer-causing agents, do not biodegrade, and accumulate in progressively higher concentrations as they move up the food chain (WHO, 1999).

Heavy metals such as mercury and cadmium are toxic and/or cause birth defects in small quantities and can also concentrate in the food chain.

Disposable pressurized containers pose another hazard for incineration, as they can explode if burned.

In fact, disposal of large quantities of hazardous chemicals and pharmaceuticals is a serious problem. In most of Africa, no methods are available to small-scale facilities that are safe and affordable (Prüss and Townend, 1998).



Figure 4. Improvised incinerator at UCH, Ibadan



Figure 5. Medical waste storage area at LUTH, Lagos, Nigeria without proper symbols to differentiate wastes into categories (AIHPPRP, 2007)

Antibiotic resistance spread in the Environment through improperly disposed Health Care Wastes

Antimicrobial resistance (AMR) is resistance of a microorganism to an antimicrobial medicine to which it was previously sensitive. Resistant organisms (they include bacteria, viruses and some parasites) are able to withstand attack by antimicrobial medicines, such as antibiotics, antivirals, and anti-malarials, so that standard treatments become ineffective and infections persist and may spread to others. AMR is a consequence of the use, particularly the misuse, of antimicrobial medicines and develops when a microorganism mutates or acquires a resistance gene (WHO, 2012). In places like Nigeria most families become financially distressed after hospitalization of members of their families. Many infectious diseases risk becoming uncontrollable and could derail the progress made towards reaching the targets of the health-related United Nations Millennium Development Goals set for 2015. When infections become resistant to first-line medicines, more expensive therapies must be used. The longer duration of illness and treatment, often in hospitals, increases health-care costs and the financial burden to families and societies (WHO, 2012). Multidrug resistance is described as a phenomenon where a microbial pathogen resists at least three groups of antibiotics (CDC, 2005). Healthcare liquid wastes are the reservoirs of harmful infectious agents such as the pathogens and multiple drug resistant microorganisms (Sharma *et al.*, 2010). Potential infectious risks include the spread of infectious diseases and microbial resistance from health-care establishments into the environment and thereby posing risks of getting infections and antibiotic resistance in the communities (Sharma *et al.*, 2010).

Therefore, even if the hospitals are discharging their healthcare liquid waste into Sewage system, it is mixed with the sewage and gets in surface water without proper treatment. If the hospital effluents are not treated, concentrated forms of infectious agents and antibiotic resistant microbes are shed into communities resulting in water borne diseases such as cholera, typhoid fever, dysentery and gastroenteritis. Antibiotics, disinfectants and bacteria resistant to them have been detected in the environmental compartments such as waste water, surface water, ground water, sediments and soils (Kummerer, 2004). Studies have discovered trace level concentrations of antibiotics in waste water treatment plant effluents and surface waters (Kolpin et al, 2002). Long term exposure of microorganisms to low concentrations of antibiotics in wastewater and surface water has the potential for the development of antibiotic resistance in these organisms (Smith *et al.*, 1999).

The concerns about antimicrobial resistance are increasing. In a report by the United Kingdom, House of Lords, it is stated that the resistance to antibiotics and other anti-infective agents constitutes a major threat to public health and ought to be recognized (HLSCST, 1998). Input of resistant bacteria as well as of antibiotics can disturb the established well balanced and important interdependencies (Hiraishi, 1998). The input of resistant bacteria into the environment seems to be an important source of resistance in the environment.

Therefore, the development of antibiotic resistance in bacteria and their dissemination in the environment is of serious public health concern because an individual patient can develop an antibiotic resistant infection by contacting a resistant organism and spread in the communities. Hospitals and public health care units must safeguard the health of the community. However, the waste produced by the health care centres if disposed of improperly, can pose an even greater threat than the original diseases themselves due to the presence of concentrated forms of numerous risks including pathogenic and antibiotic resistant microorganisms (Sharma *et al.*, 2010).

In Nepal, where several thousand die due to infectious diseases and several more, losing quality of lives, untreated hospital liquid waste discharge into surface water directly or indirectly must have been adding more problems. It is our common observation that majority of the healthcare facilities do not practice safe healthcare liquid waste treatment and disposal.

6. International agreements and principles on health care management

Basel convention

This convention is a global agreement, ratified by some 178 member countries to address the problems and challenges posed by hazardous waste. Nigeria is a signatory to this convention.

The Secretariat, based in Geneva (Switzerland) is administered by UNEP. It facilitates the implementation of the Convention and related agreements. It also provides assistance and guidelines on legal and technical issues and conducts training on the proper management of hazardous waste.

The key objectives of the Basel Convention are:

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

A central goal of the Basel Convention is “environmentally sound management” (ESM), the aim of which is to protect human health and the environment by minimizing hazardous waste production whenever possible. ESM means addressing the issue through an “integrated life-cycle approach”, which involves strong controls from the generation of a hazardous waste to its storage, transport, treatment, reuse, recycling, recovery and final disposal. Health Care Related Wastes (HCRW) is one of the **categories of hazardous wastes covered by the Convention**. It was adopted in 1989. During its first decade, the Convention’s principal focus was the elaboration of controls on the “transboundary” movement of hazardous wastes that is the movement of such wastes across international frontiers and the development of criteria for environmentally sound management of the wastes. More recently the work of the Convention has emphasized full implementation of treaty commitments, promotion of the environmentally sound management of hazardous wastes, a lifecycle approach, and minimization of hazardous waste, generation. The Convention entered into force 5 May 1992. (HCWC, 2007).

The **Basel Convention** (Article 4) requires each Party to minimize waste generation and to ensure, to the extent possible, the availability of disposal facilities within its own territory. The Conference of the

Parties at its sixth meeting in December 2002 adopted a Strategic Plan for the implementation of the Basel Declaration to 2010 building on and using the framework of the 1999 Ministerial Basel Declaration on Environmentally Sound Management. The **Basel Convention** covers wastes that are listed in Annex I, if they display the hazardous characteristics listed in Annex III. Hazardous wastes are those wastes that are: explosive, flammable, poisonous, infectious, corrosive, toxic, or ecotoxic.

The Stockholm convention on persistent organic pollutants

This Convention is a global treaty to protect human health and the environment from persistent organic pollutants (POPs). POPs are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms and are toxic to humans and wildlife. Persistent Organic Pollutants (POPs) circulate globally and can cause damage wherever they travel. In implementing the Convention, Governments will take measures to eliminate or reduce the release of POPs into the environment. The countries that have signed these conventions are Afghanistan, Albania, Algeria, Andorra, Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia, and Herzegovina, Botswana, Brazil, Brunei, Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Rep, Chad,

Chile, China, Colombia, Comoros, Congo, Costa Rica, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Dem. Rep. of Korea, Dem. Rep. of the Congo, Denmark, Niger, Nigeria and many more other countries.

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

The Rotterdam convention

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

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

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

World conventions and Principles of Health Care Waste management

1. Duty of care principle

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

2. Polluter pays principle

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

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

3. Precautionary principle

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

4. Proximity principle

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

Five fundamental principles for handling health care wastes

These principles include Minimization and Recycling, Sorting receptacles and handling, Collection and Storage, Transportation, and Treatment and Disposal (ICRC, 2011).

Minimization and recycling

The reduction of waste generation must be encouraged by the following practices: Reducing the amount of waste at source, Choosing products that generate less waste: less wrapping material, for example, Choosing suppliers who take back empty containers for refilling (cleaning products); returning gas cylinders to the supplier for refilling, Preventing wastage: in the course of care, for example, or of cleaning activities, Choosing equipment that can be reused such as tableware that can be washed rather than disposable tableware (Bassey *et al.*, 2006; ICRC, 2011).

Sorting receptacles and handling

Sorting consists of clearly identifying the various types of waste and how they can be collected separately. There are two important principles that must be followed. The simplest way to identify the different types of waste and to encourage people to sort them is to collect the various types of waste in separate containers or plastic bags that are colour-coded and/or marked with a symbol (ICRC, 2011).

Waste sorting must always be the responsibility of the entity that produces them. It must be done as close as possible to the site where the wastes are produced. There is no point in sorting wastes that undergo the same treatment process, with the exception of sharps, which must at all times be separated at source from other wastes (Longe and Williams, 2006).

Collection and storage

Waste must be collected regularly - at least once a day. It must never be allowed to accumulate where it is produced. A daily collection programme and collection round must be planned. Each type of waste must be collected and stored separately with different known signs on the containers (Longe and Williams, 2006).

Infectious wastes must never be stored in places that are open to the public.

The personnel in charge of collecting and transporting wastes must be informed to collect only those yellow bags and sharps containers which the care staff have closed. They must wear gloves. The bags that have been collected must be replaced immediately with new bags (Longe and Williams, 2006).

Transportation

This means of conveyance must meet the following requirements: they must be easy to load and unload; they must not have any sharp corners or edges that might tear the bags or damage the containers; they must be easy to clean; (with a 5% active chlorine solution); they must be clearly marked.

Furthermore, off-site means of transport must meet the following requirements: they must be closed in order to avoid any spilling on the road; they must be equipped with a safe loading system (to prevent any spilling inside or outside the vehicle); they must be marked according to the legislation in force if the load exceeds 333 kg (for some countries). The entity producing the waste is responsible for packaging and labelling the waste to be transported outside the hospital. Packaging and labelling must be in conformity with national legislation on the transport of dangerous substances and with the Basel Convention in the case of cross-border transport. If there is no national legislation on the subject, the [United Nations] Recommendations on the Transport of Dangerous Goods¹³¹² or the European Agreement on the International Carriage of Dangerous Goods by Road (ADR) 1413 should be referred to. If a vehicle is carrying less than 333 kg of medical waste entailing the risk of contamination (UN 3291), it is not required to be marked. Otherwise it must bear sign plates

Treatment and disposal

Choices of treatment and disposal technique depend on a number of parameters (Bassey *et al.*, 2006). These include the quantity and type of waste produced, availability of waste treatment site near the waste generating facility, availability of reliable means of transport, availability of National legislation on health care waste management, climate conditions, groundwater level, regular supply of electricity in the area etc. The handling and treatment of waste entails health risks for staff throughout the chain. The purpose of protective measures is seriously recommended. The purpose of protective measures is to reduce the risks of accident/exposure or the consequences (Sharma *et al.*, 2006; Longe and Williams, 2006).

7. Environmental regulatory agencies in Nigeria with health care wastes related mandates

Federal Ministry of Environment (FMENV)

The need to protect the environment in Nigeria started with the pronouncement prohibiting water pollution through the colonial hygiene of public health inspectors. In 1975, a Division was created in the Federal Ministry of Economic Development to deal with pollution and other industrial matters. Lack of effective implementation of its mandate led to the relocation of the Division from one Ministry to another (Rain Forest, 2012; FMenv, 2012)

The discovery of six ship loads of toxic waste of Italian origin in Koko, Delta State in 1988, exposed the need for stringent environmental laws and its effective enforcement with monitoring mechanism put in place. The Federal Government promulgated the Harmful Wastes Criminal Provision Decree 42 of 1988, which made it a criminal offence to import or trade in toxic waste. The Federal Environmental Protection Agency (FEPA) was created by Decree 58 of 1988 as a parastatal of the Ministry of Works and Housing. The agency authority was strengthened through Decree 59 of 1992 and October 12th, 1999 saw the creation of the Federal Ministry of Environment (FMEnv) (FMenv, 2012). The Federal Ministry of Environment is charged with the overall responsibility of protecting the Nigerian environment including biodiversity, conservation and sustainable development of natural resources (Rain Forest, 2012).

The National Environmental Protection (Pollution Abatement in Industries & Facilities Generating Waste) Regulation S. 19 of 1991,

- Prohibits the release of hazardous or toxic substances into the environment beyond the limits approved by the Agency,
- Solid, liquid and gaseous discharge should be analyzed and reported to their nearest office,
- The factory is required to submit yearly environmental audit report within 90 days of demand by the Agency(FMenv, 2012).

Waste Management and hazardous Waste Regulations of 1991,

- Regulates the collection, treatment and disposal of solid and hazardous wastes from municipal and industrial sources (FMenv, 2012).

Guidelines and Standards for Environmental Pollution Control in Nigeria 1991,

- Directs industries to improve the quality of the environment.
- Serves more or less as recommended standards of environmentally good behaviour for industries.

The Federal Government of Nigeria also passed into law the Environmental Impact Assessment (EIA) Act No 86 of 1992, which is summarized below,

- Requires the government, its agency and private enterprises to carry out EIA study of a proposed project,
- The study also covers for proposed expansion of existing project or facility/ industry(FMenv, 2012).

In November 1989, the present Nigeria Environmental Policy was launched to guide environmental activities in Nigeria. The main objective of the policy is to achieve sustainable development which can be achieved by;

1. Securing for all Nigerians a quality of Environment adequate for their health and well being;
2. Conserving and using the natural resources for the benefit of the present and future generations;
3. Restoring, maintaining and enhancing the ecosystem and ecological process essential for the preservation of biological diversity;
4. Raising public awareness and promoting understanding of the essential linkages between environment and development;
5. Co-operation with other countries and international organizations and agencies to achieve the above specific goals, and prevent transboundary environmental pollution(FMenv, 2012)..

National Environmental Standards and Regulation Enforcement Agency (NESREA)

The basis of environmental policy in Nigeria is contained in the 1999 Constitution of the Federal Republic of Nigeria. Section 20 of the Constitution empowers the state to protect and improve the environment; and safeguard the water, air and land, forest and wildlife of Nigeria. Hitherto, various laws and regulations have been enacted to safeguard the Nigerian environment. These include:

- National Environmental Protection (Effluent Limitation) Regulations;
 - National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations; and
 - National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations.
- National Environmental Health Practice Regulations 2007; and
- Nigerian Radioactive Waste Management Regulations 2006.
- Environmental Impact Assessment Act of 1992 (EIA Act).
 - The Petroleum (Drilling and Production) Regulations 1969, made pursuant to The Petroleum Act.
 - Harmful Wastes (Special Criminal Provisions etc.) Act of 1988 (Harmful Wastes Act).

- The National Oil Spill Detection and Response Agency (Establishment) Act 2006 (the NOSDRA Act).
- Nigerian Radioactive Waste Management Regulations 2006 issued pursuant to the Nuclear Safety and Radiation Protection Act 1995
- The National Environmental Standards and Regulations Agency 2007 (NESREA Act).

The NESREA Act was enacted on the 31st July, 2007 to provide for the establishment of the National Environmental Standards and Regulations Agency (NESREA). This Act repealed the Federal Environmental Protection Agency Act (the FEPA Act) pursuant to which the FEPA which was formerly charged with the protection and development of the environment in Nigeria was established. However all regulations, authorizations and directions made pursuant to the FEPA act and which were in force at the commencement of the NESREA Act shall continue to be in force and have effect as if made by the NESREA Act. The NESREA Act applies to the regulation and the protection and development of the environment in Nigeria with the exception of the oil and gas sector. The NESREA is responsible for the protection and development of environmental standards, regulations, rules, laws, policies and guidelines within Nigeria. The NESREA's functions do not however include enforcement of environmental standards, regulations, policies and guidelines in the oil and gas sector of Nigeria. The NESREA Act give authorized officers of the NESREA powers to:

1. enter and search any land, building, vehicle, tent, vessel, floating craft or any inland water; for the purpose of conducting inspection, searching and taking samples for analysis which are reasonably believed to be carrying out activities or storing goods which contravene environmental standards or legislation
2. seize or detain for such a period as may be necessary articles which are reasonably believed to contravene provisions of the legislation or any of its regulations; and
3. Obtain an order of a court to suspend activities, seal and close down premises including land, vehicle, tent, vessel, floating craft or any inland water and other structure.

Functions of NESREA Act

1. Under the NESREA Act, the Minister charged with the responsibility of the environment is empowered by regulations to prescribe any specific removal methods and reporting obligations on the owners or operators of vessels discharging harmful substances and waste into the environment.
2. Public authorities are statutorily required to inform the public of Environment-related issues. The NESREA Act requires NESREA to enforce compliance with environmental regulations, to create public awareness, provide environmental education on sustainable environmental management and to publish data resulting from the performance of its functions.
3. The NESREA Act provides that a person who breaches the provisions of the Act commits an offence and shall on conviction be liable to a fine, or imprisonment, or both.

4. The NESREA Act also provides that where there has been a discharge of any hazardous substance in violation of environmental laws/permits, the person responsible for the discharge will bear the liability of the costs of removal and clean up.
5. In executing its functions, the NESREA is required to conduct environmental audits and establish a data bank on regulatory and enforcement standards.

The following are environmental impacts associated with the improper disposal of medical wastes:

Pollutants from medical waste (e.g. heavy metals and PCBs) are persistent in the environment

Accumulation of toxic chemicals within soil (proximity to agricultural fields, humans, soil organisms, wildlife, cattle) ground water contamination, decrease in water quality bio-accumulation in organism's fat tissues, and biomagnify through the food chain

Repeated and indiscriminate application of chemicals over a long period of time has serious adverse effects on soil microbial population - reducing the rate of decomposition, and generally lowering the soil fertility.

Pathogens leads to long term accumulation of toxic substances in the soil specimens collected for analysis have the potential to cause disease and illness in man, either through direct contact or indirectly by contamination of soil, groundwater, surface water, and air wind blown dusts from indiscriminately dumping also have the potential to carry hazardous particulates with domestic animals being allowed to graze in open dumps, there is the added risk of reintroducing pathogenic micro-organisms into the food chain.

Public nuisance (e.g. odours, scenic view, block the walkway, aesthetics, etc.)

Improper sterilization of instruments used in labour room may cause infection to mother and child

Combination of both degradable and non-degradable waste increase the rate of habitat destruction due to the increasing number of sites necessary for disposal of wastes (degradation of habitat)

Plastic-bags, plastic containers, if not properly destroyed may contaminate the soil and also reduces the chance for water percolation into the soil during precipitation.

Open air burning does not guarantee proper incineration, and releases toxic fumes (dioxin) into the atmosphere from the burning of plastics i.e., PCB's (Atkin, 2010).

Medical waste management has received very little attention in waste management process in Nigeria. Neither the government nor hospital authorities pay proper attention to its management. Unwholesome waste disposal by many hospitals, clinics and health centers in Abuja pose serious health hazard to the city dwellers in general and people living within the vicinity of the health care institutions in particular (Bassey *et al.*, 2006).

Almost all the health care institutions surveyed dispose every kind of waste generated into municipal dumpsites without pre-treatment, leading to an unhealthy and hazardous environment around the health institutions, affecting patients and staff (Bassey *et al.*, 2006).

Scavengers who collect waste from dustbins are at risk of injury from sharp instruments and direct contact with infectious materials. Liquid medical wastes are disposed directly into the

municipal sewer system by all the institutions surveyed (Bassey *et al.*, 2006). Direct disposal of feces and urine of infectious patients in municipal sewer system may cause outbreak of epidemic diseases. The scavengers that engage in recycling operations are unaware of the harmful consequences of exposure to contaminate and hazardous waste (Bassey *et al.*, 2006).



Figure 6. Scavenging at Ojota dumpsite in Lagos, Nigeria



Figure 7. Infected carcasses gathered in a dump for burning (AIHPPRP, 2007)

Most at times, the absence of Environmental impact assessments before commencement of public health and pharmaceutical industry projects is responsible for the archive of challenges associated waste management in the developing worlds including Nigeria. Nigeria lacks both effective and adequate waste management facilities and an inadequate Government policy to guide health providers and punish offenders. There is great need to incorporate standard EIA processes into the Nigerian regulatory documents for Public health institutions and pharmaceutical industries. These regulatory bodies need to establish mitigatory measures especially on waste management during the EIA process of Health care facility in Nigeria.

Incidentally, lapses on these bodies have resulted in no or poor implementation of hazard/risk/ waste management processes in health care institutions.

NESREA and FMEnv are required to follow-up medical laboratories, hospitals, Pharmaceutical companies springing up all over Nigeria on laboratory waste, and Industrial effluent treatment and disposal.

Without this strict implementation of impact mitigation and management of health care waste, Sustainable development is far from being attained.

Health care waste should be treated with utmost attention, since the wastes could be virulent, pathogenic, carcinogenic, mutagenic, and teratogenic. This shows that its impact on environment and human and plant's health is greater than that of petroleum hydrocarbon spill.

8. Emerging issues of health care waste management

There is no proper waste management system in place in most developing countries. On-site incineration, autoclaving, and steam disinfection are a few processes currently in use for treating very small amounts of hazardous wastes.

Countries found to practice incineration are Brazil, Argentina, Peru, India, Pakistan and Bangladesh etc. Clinical waste incinerators, particularly in developing and poorer countries, often operate under sub-optimal conditions. Most of the cases the percentage of incinerators that were functioning poorly or not operational (HCWH, 1999). Most medical administrations usually focus on installing disposal technologies such as incinerators and do not implement a "practice" of waste management within the hospital. Over 6500 incinerators were installed in the US alone in the 1980s (Agarwal, 1998). Chronic problems both relating to very high toxic levels as well as difficulties in operating a sophisticated engineering technology in a medical setting have given rise to a debate which attempts to define a clean technology for medical waste disposal. There are some techniques practiced by different countries all over the world such as: Incineration, Autoclave Disinfection, Microwave Disinfection, and Mechanical/Chemical Disinfection. Each of this technique has limitations in terms of technological aspect, environmental condition and waste composition. Burning and incineration of medical and municipal waste have been linked to severe public health threat and pollution resulting in the release of toxic dioxin as well as mercury and other toxic substances. These substances produce a remarkable variety of adverse affects in humans at extreme-

ly low doses (Basset *et al.*, 2006). Putrefaction occurs in portions of refuse, which have not been fully burnt and add to air pollution through foul smells. Sanitary landfill can lead to pollution of ground water if not properly managed.

However, most of the developed countries have defined policy and regulations to handle and manage medical waste such as Germany, France, Canada, and USA. Unfortunately, health care waste management is not yet carried out with a satisfactory degree of safety in many parts of the globe especially in the underdeveloped world (Stanley *et al.*, 2011).

In Nigeria, the lack of will by policy makers and implementation groups to adopt current technology in Health Care Waste management is an emerging challenge towards HCW management. The Health Care system is not developed in Nigeria, and by extension Health Care Waste Management.

9. Environmental impact assessment for public health and pharmaceutical institutions

In Nigeria Health Care facilities are constructed and flagged off in terms of operations without due considerations to Environmental Impact Assessment (EIA). Its hazards are numerous to be counted. The regulatory agencies in Nigeria on the Environment such as NESREA, FMEnv etc must rise to the challenges of environmental pollution coming from health care facilities. Community engagement during the process of establishing Public health institutions and pharmaceutical companies is also advisable. This will ensure the development of robust Terms of Reference, EIA document, Environmental Management Plan (EMP). The EMP should address the issues or negative impacts of the health care facility on the bio-physical, social environment and health.

It is worthy to note that some health care facilities such as medical and Environmental Laboratories are small projects and may not require full blown EIA. However, the regulatory agencies should develop a module of monitoring their waste disposal to avoid pollution. The situation is bit different in developed countries, where there is integrated Health management system; medical laboratories are usually part of large health care facilities. It is good to state categorical that laboratory wastes are among the most infectious group of health care waste. They contain live virulent pathogens and mutagenic, teratogenic chemicals including dyes. Laboratories must be forced to have a standard waste tracking protocol, in line with the international convention called Polluters Pay Principles (PPP).

10. Conclusion

Federal Republic of Nigeria will gain a lot from the battery of Public health benefits of Health Care waste Management. It is still not well understood why Nigeria at its level of development, Health Care Waste management is not well legislated and thus proper atten-

tion has not been given to it by Environmental regulators and Health Care operators. The issues are to be treated as urgent and very critical by Government. Immediate interventions are also required. All hands including the National Orientation Agencies and communities must be on deck to get over this challenge.

11. Recommendation

There is great need for effective Environmental regulatory Surveillance in Nigeria. National laws on Health Care waste management should be established and be moved to an act.

This is the best time for Nigerian Government to establish a regulatory agency to effectively monitor medical wastes and its treatment in Nigeria. Otherwise, the FMEnv and NESREA are to be strengthened to establish a well funded unit (Finance and good Human Resources) for monitoring of Health Care Institutions over Health Care Wastes.

Author details

Nkechi Chuks Nwachukwu^{1*}, Frank Anayo Orji^{2*} and Ositadinma Chinyere Ugbogu^{1*}

*Address all correspondence to:

1 Department of Microbiology, Faculty of Biological and Physical Sciences, Abia State University, Uturu, Abia State, Nigeria

2 Enzymes and Genetics Division, Department of Biotechnology, Federal Institute of Industrial Research, Oshodi, Lagos State, Nigeria

References

- [1] Abah, S. O., & Ohimain, E. I. (2010). Assessment of Dumpsite Rehabilitation Potential using the Integrated Risk Based Approach: A case study of Eneka, Nigeria. *World Appl. Sci. J.*, 8(4), 436-442.
- [2] Avian Influenza Control and Human Pandemic Preparedness and Response Project. (2007). Final report on Medical Waste Management Plan, Environquest, Nigeria.
- [3] Adegbita, M. A., Nwafor, S. O., Afon, A., Abegunde, A. A., & Bamise, C. T. (2010). Assessment of dental waste management in a Nigerian tertiary hospital. *Waste. manag. Res.*, 28, 769-777.

- [4] Alagoz, B. A. Z., & Kocasoy, G. (2007). Treatment and disposal alternatives for health-care wastes in developing countries- A case study in Istanbul, Turkey. *Waste Manag. Res.*, 25, 83-89.
- [5] Coker et al. (2009). Medical waste management in Ibadan, Nigeria: Obstacles and Prospects. *Waste Manag.*, 29(2), 804-811.
- [6] Olubukola, B. O. (2009). Comparative Analysis of Health Care Waste Management Practice in Two General Hospitals in Nigeria. Available at, <http://www.eco-web.com/edi/index.htm>., Accessed August 10, 2012.
- [7] PATH. (2009). Achieving effective sharps waste management in GAVI host countries. A proposed approach with estimates of cost 2006. Available at, http://www.Path.org/files/TS_ach_eff_swm.pdf., Accessed 6th April, 2012.
- [8] Phengxay, S., Okumura, J., Miyoshi, M., Sakisaka, K., Kuroiwa, C., & Phengxay, M. (2005). Healthcare Waste Management in Lao PDR: A case study,. *Waste. Manage. Res.*, 23, 571-581.
- [9] The Hazardous Chemicals and Wastes Conventions (HCWC). (2007). http://www.healthcarewaste.org/fileadmin/user_upload/resources/UNEP-3Conventions-2007-EN.pdf, Accessed August 15, 2011).
- [10] Park, H., Lee, K., Kim, M., Lee, J., Seong, S. Y., & Ko, G. . (2009). Detection and hazard assessment of pathogenic microorganisms in medical wastes. *Environ Sci Health A Tox Hazard Subst Environ Eng.*, 44(10), 995-1003.
- [11] Nascimento, T. C., Januzzi, W. A., Leonel, M., Silva, V. L., & Diniz, C. G. (2009). Occurrence of clinically relevant bacteria in health service waste in a Brazilian sanitary landfill and antimicrobial susceptibility profile,. *Rev. Soc. Bras. Med.Trop.*, 42(4).
- [12] Rain Forest. (2012). Nigerian Regulatory bodies. Available at, <http://www.rainforestlimited.com/contactus.html>., Accessed on 20 August, 2012).
- [13] Federal Ministry of Environment (FMEnv). (2012). Vision Statement of the Ministry. available on, <http://directory-nigeria.org/federal-ministry-of-environment-housing-and-urban-dev.html>, Accessed on 20th August, 2012.
- [14] Akter, N. (2010). Medical Waste Management: A Review,. Asian Institute of Technology, Thailand,, 25.
- [15] Agarwal, R. (1998). Medical waste Disposal. *Issues, Practices and Policy.*, An Indian and International Perspective. Seminar on Health and the Environment. Centre for Science and Environment. New Delhi. India.
- [16] BAN & HCWH. (1999). Medical Waste in Developing Countries. *An analysis with a case study of India, and A critique of the Basel-TWG guidelines.*, Basel Action Network (BAN) secretariat, Asia_Pacific Environmental Exchange, 1827 39th Ave. E., Seattle, WA. 98112, USA.

- [17] WHO. (1999). Health Care wastes. Available at; http://www.who.int/water_sanitation_health/Environmental_sanit/MHCWHanbook.htm.
- [18] Prüss, A., & Townend, W. K. (1998). Teacher's Guide- Management of wastes from health-care activities,. World Health Organization, Geneva, 227 pages. Available at; http://www.who.int/environmental_information/Information_resources/worddocs/HCTeachguid/health_care_wastes_teacher.htm.
- [19] Johannessen, L. M. (2000). Healthcare Waste Management Guidance Note. Anchor Team, The World Bank,, 68, Available at; <http://wbln0018.worldbank.org/hdnet/hddocs.nsf/c0d65c5ea6fcb4688525670c004d14c2/0d87e869807f2f69852568d20054e66b>.
- [20] World Health Organization, Geneva. (1992). Managing medical wastes in developing countries: report of a Consultation on Medical Wastes Management in Developing Countries, Geneva,. Available at; http://whqlibdoc.who.int/hq/1994/WHO_PEP_RUD_94.1.pdf.
- [21] Ngwuluka, N., Ocheke, N., Odumosu, P., & John, S. A. (2009). Waste management in healthcare establishments within Jos Metropolis, Nigeria,. *African Journal of Environmental Science and Technology*,, 3(12), 459-465.
- [22] Ogbonna, D. N. (2011). Characteristics and waste management practices of Medical wastes in healthcare institutions in Port Harcourt, Nigeria,. *Journal of Soil Science and Environmental Management*,, 2(5), 132-141.
- [23] Abah, S. O., Ohimain, E. I., & (2011, . (2011). Healthcare waste management in Nigeria: A case study,. *Journal of Public Health and Epidemiology*,, 3(3), 99-110.
- [24] Stanley, H. O., Okpara, K. E., Chukwujekwu, D. C., Agbozu, I. E., & Nyenke, C. U. (2011). Health care waste management in Port Harcourt Metropolis. *American Journal of Scientific and Industrial Research*, 2(5), 769-773.
- [25] Basse, B. E., Benka-Coker, M. O., & Aluyi, H. S. A. (2006). Characterization and management of solid medical wastes in the Federal Capital Territory, Abuja Nigeria. *African Health Sciences*,, 6(1), 58-63.
- [26] WHO. (2012). Antimicrobial resistance. Available on, <http://www.who.int/mediacentre/factsheets/fs194/en/>, Accessed 24th August, 2012.
- [27] Sharma, D. R., Pradhan, B., & Mishra, S. K. (2010). Multiple drug resistance in bacterial isolates from liquid wastes generated in central hospitals of Nepal. *Kathmandu University Medical Journal*, 8(29), 40-44.
- [28] Kümmerer, K. (2004). Resistance in the environment. *Journal of Antimicrobial Chemotherapy*, 54, 311-20.
- [29] Kolpin, D. W., Furlong, E. T., Meyer, M. T., Turman, E. M., Zaugg, S. D., & Barber, L. B. (2002). Pharmaceuticals, Hormones, and Other Organic Waste water Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance. *Environmental Science and Technology*,, 36(6), 1202-11.

- [30] Smith K E, Besser J M, Hedberg C W, Leano F T, Bender J B, & Wicklund J H. (1999). Quinolone resistant *Campylobacter jejuni* infections in Minnesota, 1992-1998,. *The New England Journal of Medicine*., 340, 1525-32.
- [31] House of Lords Select Committee on Science and Technology (HLSCST). (1998). 7th Report of House of Lords (UK). London: The Stationery Office.
- [32] Hiraishi, A. (1998). Respiratory quinone profiles as tools for identifying different bacterial populations in activated sludge. *Journal of General and Applied Microbiology*., 34, 39-56.
- [33] International Committee of the Red Cross (ICRC). (2011). Medical Waste Management,. 19, avenue de la Paix 1202 Geneva, Switzerland., 164, Available at, <http://www.icrc.org>., (Accessed 26th August, 2012).
- [34] Longe, E. O., & Williams, A. (2006). A preliminary study on medical waste management in Lagos Metropolis, Nigeria. *Iranian Journal of Environmental Health Sciences and Engineering*., 3(3), 1333-139.