

THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Assessing the Health Risk from Medical Waste Management in Benin: The Case Study of the Centre Hospitalier Universitaire de la Mère et de l'Enfant Lagune (CHU-MEL)

Fandohan Béthel Missinmahu

Student, Département de Génie de l'Eau & Assainissement (GEA),
Institut National de l'Eau (INE), Université d'Abomey-Calavi (UAC), Benin Republic

Labité Elysée Hervé

Researcher, Laboratoire des Sciences et Techniques de l'Eau (LSTE),
Institut National de l'Eau (INE), Université d'Abomey-Calavi (UAC), Benin Republic
Lecturer, Département de Génie de l'Eau & Assainissement (GEA),
Institut National de l'Eau (INE), Université d'Abomey-Calavi (UAC), Benin Republic

Aina Martin Pepin

Director, Laboratoire des Sciences et Techniques de l'Eau (LSTE),
Institut National de l'Eau (INE), Université d'Abomey-Calavi (UAC), Benin Republic
Professor, Département de Génie de l'Eau & Assainissement (GEA),
Institut National de l'Eau (INE), Université d'Abomey-Calavi (UAC), Benin Republic

Elegbede Bernadin Manou

Researcher, Laboratoire des Sciences et Techniques de l'Eau (LSTE),
Institut National de l'Eau (INE), Université d'Abomey-Calavi (UAC), Benin Republic
Lecturer, Département de Génie de l'Eau & Assainissement (GEA),
Institut National de l'Eau (INE), Université d'Abomey-Calavi (UAC), Benin Republic

Pognon Elias

Chemical Engineer, Laboratoire de Contrôle Qualité des Eaux et des Aliments (LCQEA),
Direction Nationale de la Santé Publique (DNSP), Ministère de la santé, Benin Republic

Djaboutouboutou Lamouratou

Sanitary and Hygiene Technician, Centre Hospitalier Universitaire de la Mère et de l'Enfant-Lagune, Ministère de la santé, Benin Republic

Abstract :

Medical waste is becoming a serious threat to all hospital users due to their high potential risk. This study aims to evaluate the health risk associated with the management and practices at "the Centre Hospitalier Universitaire de la Mère et de l'Enfant Lagune (CHU-MEL)" located in Benin by using the preliminary risk assessment technique. This assessment uses a qualitative human health risk-based approach that includes the potential hazard that can be generated during medical waste and management, their severity and likelihood of occurrence. The evaluation of the waste flow at CHU-MEL showed that the health risk varied from medium to high and this highlighted the potential risk associated the medical waste management hence the need to put a rigorous management procedure in place. This will contribute to minimize the health risk of medical waste to the hospital users and especially to workers.

Keywords: Health-care waste, Hazards, Preliminary Risk Assessment, Benin

1. Introduction

Hospital and health care activities are means to protect and save lives. Unfortunately these are potentially the source of health-care waste (HCW) generation which can pose a significant risk to medical and paramedical staff, patients, community and the environment (Abd El-Salam 2010). In general at the hospital, the generated HCW are classified into two categories (WHO, 2014; Rushbrook and Zghondi, 2005):

- The General health-care waste (GHCW) which counts for 75 to 90% of total HCW and this includes general office waste, packaging, garden waste and left over food. This waste category is considered no hazardous and can follow the general domestic or municipal waste management flow (WHO, 2014; Rushbrook and Zghondi, 2005).

- The hazardous health-care waste HHCW (*i.e.*, Human anatomical waste, sharps, pharmaceutical waste, Blood and body fluid) which are considered as highly harmful.

Despite the small amount of HHCW which is generated in health care facilities, there is a serious concern as this category of wastes can potentially cause an infection or injury if it is not managed properly (Zarook and Shareefdeen, 2012). For example each year, around 16 billion injections are used over the world but not all of the generated needles or syringes are properly disposed (WHO, 2015). Unfortunately, 16 million new cases of Hepatitis B virus, 4,7 millions cases of hepatitis C virus and 160 000 cases of Human Immuni deficiency Virus (HIV) are recorded each year due to unsafe injections disposal (WHO, 1999). More efforts are required internationally to improve the sharp waste management (Harhay *et al.*, 2009). HCW at hospitals can be hazardous not only to medical and paramedic staff, patients and visitors but also to the surrounding environment; in order to allow hospitals to fulfill their missions which are means to save lives, it is important to put a clear HCW management practice in place with the view to avoid the environmental and health risks associated with HCW (Tabasi and Marthandan, 2013). While it is a common practice to monitor exposure and health impacts in developed countries to carry out a risk assessment of HCW with the view promote good health care waste practices, this is not the case in all over the world (Tabasi and Marthandan, 2013). Several studies have raised the issue of unsustainable medical waste management in developing countries and this include lack of awareness, handling of HHCW similarly to GHCW, inadequate HHCW treatment, waste scavenging, lack of financial and human resources (WHO, 2007; Manyele, 2004; Awodele *et al.*, 2016; Ali *et al.*, 2017). In Benin in which the situation is similar to the most sub Sahara African countries, little research work is done on HCW management hence the need to assess the health risk associated with medical waste management. To date there are several methods to assess the risk of HCW including preliminary risk assessment (PRA) which are used to promote a good HCW management. The PRA method has the merit to be applicable in an event when data are often limited or unavailable such as public health events (WHO, 2012).

The objective of this study was to assess the health risks from the medical waste management of the public hospital "Centre Hospitalier Universitaire de la Mere et de l'Enfant Lagune" (CHU-MEL) in the Benin Republic.

2. Materials and Methods

2.1. Description of the CHU-MEL

The CHU-MEL created in 1958 is located in Cotonou the economical capital of Benin. With 125 beds, it is a public institution and used as the national reference hospital in the field of gynecology, obstetrics and paediatrics. It comprises the following department: laboratory, maternity section, x-ray department, surgery, etc. Due to the intense health activities which take place, HCW is managed through the steps described in **Figure 1**. Unfortunately there are some issues associated to the HCW at the CHU-MEL (and this include poor waste segregation, lack of containers, personal protection equipments and inadequate HCW treatment) which can jeopardize the surrounding environmental and the human health. Unfortunately they are some issues associated with HCW management procedure is not strictly put in practice due to poor waste segregation, lack of containers, personal protection equipments

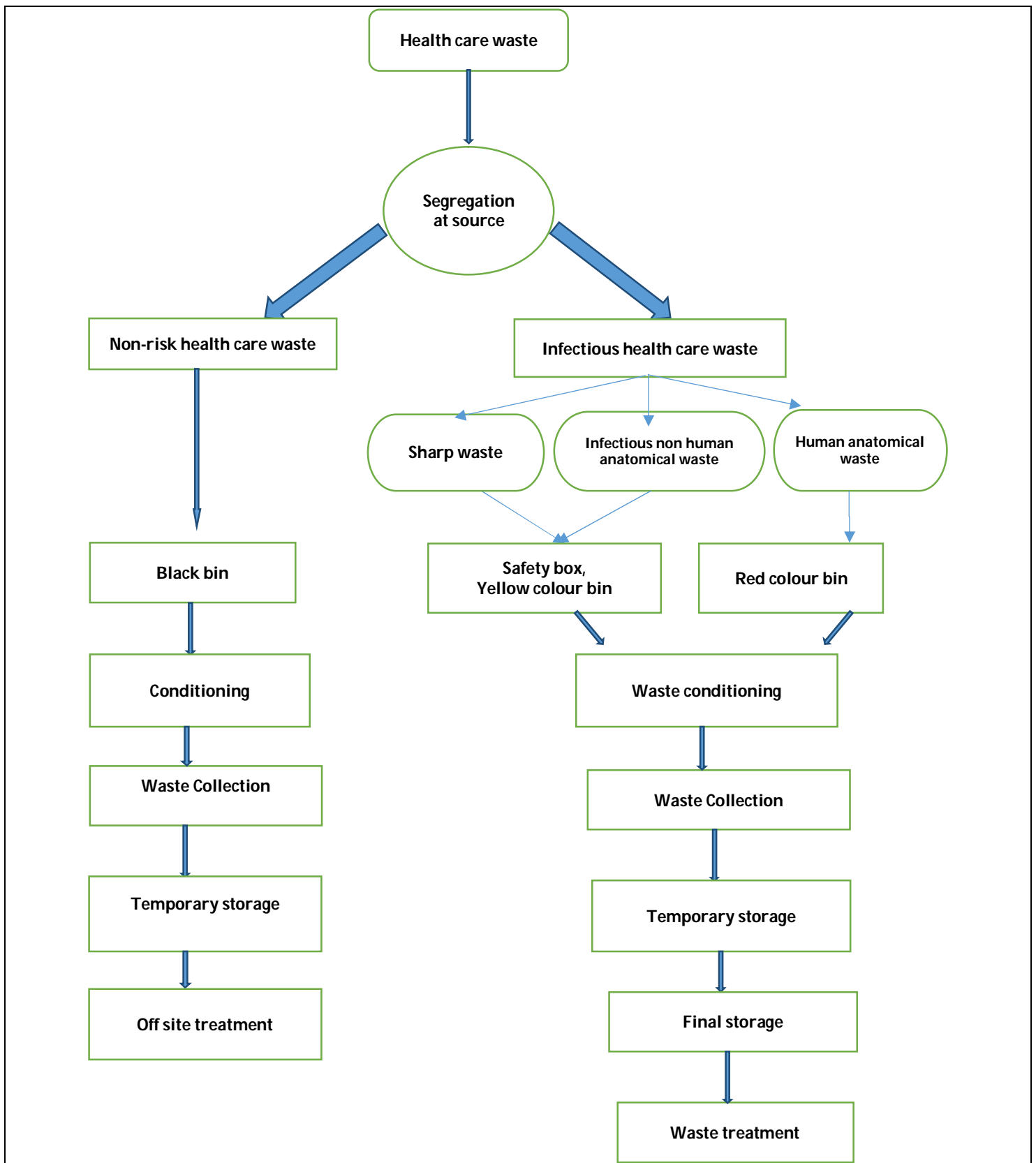


Figure 1: Health care waste flow at the CHU-MEL

2. Data Collection

In this study, all wastes generated in the different services of the hospital were weighed every day during a period of one month to estimate the amount of HHCW generated. Additional data were collected from a comprehensive sample of the CHU-MEL staff (Table 1) by using the following:

- A visual observation based on the authors experience in sanitary engineering in Benin
- A semi-structured open-ended questionnaire were administered to medical, paramedical staff to assess the working conditions and waste collectors with focus on the HCW management procedure waste (risks the equipments in place, frequency of waste removal, training received, personnel protection equipment and potential difficulties encountered)

Categories	Number of personnel	Number of interviewed people
Administrative	05	05
Physician	19	10
Nurses	77	53
Waste collectors and incinerator operators	9	9

Table 1: Number of participating staff assessed

3. Preliminary Risk Assessment

Likelihood \ Hazard		Hazard severity				
		No effect (1)	Minor (2)	Major (3)	Hazardous (4)	Catastrophic (5)
Likelihood of occurrence	Very unlikely (1)	1	2	3	5	5
	Unlikely (2)	2	4	6	8	10
	Possible (3)	3	6	9	12	15
	Likely (4)	4	8	12	16	20
	Very likely (5)	5	10	15	20	25

Low risk 1-4

Medium risk 5- 12

High risk 14 -20

Table 2: Risk assessment matrix

The Preliminary Risk Assessment (PRA) aims to identify and to evaluate all potential hazards and hazardous events that may lead to an accident (Rausand, 2011). Recently this technique has been used for assessing the health risk of medical wastes (Alwabr and Al-Mikhlaifi, 2017; Sefouhi *et al.*, 2013). In general, the technique of PRA follows these steps: hazard identification, risk analysis, risk, evaluation and risk control. It should be mentioned that all hazard with not follow the same preliminary risk assessment steps. If some hazards appear less harmful, the evaluation will stop at the risk evaluation step and further measure will not be required. At the risk analysis step, each hazard is evaluated based on its likelihood and severity. A likelihood occurrence is an event that is likely to occur to the specific period and circumstances and in this study the likelihood was divided into five categories (**Table 2**). Similarly, the hazard severity was divided into five categories based on an increasing level of severity at an individual's health, the property, and the environment. The risk assessment matrix was built based on of the intersection of severity and likelihood with the view to determine the level of acceptable risk.

4. Results and Discussion

4.1. HCW Wasted Generated

Health-care waste generation	Health-care facilities broad categories	Examples
Major sources of health-care waste	Hospitals	University, General and District hospital
	Other health-care facilities	Emergency medical care services Health-care centres and dispensaries Obstetric and maternity clinics Outpatient clinics Dialysis centres
	Long-term health-care establishments and hospices	Transfusion centres Military medical services Prison hospitals or clinics Medical biotechnology and biomedical laboratories or institutions
	Medical research centres	
	Mortuary and autopsy centres	
	Animal research and testing	
	Blood banks and blood collection services	
	Nursing homes for the elderly	
Minor sources of health-care waste	Small health-care establishments	First-aid posts and sick bays Physicians' offices Dental clinics Acupuncturists and Chiropractors
	Specialized health-care establishments and institutions with low waste generation	Convalescent nursing homes Psychiatric hospitals Disabled persons' institutions
	Activities involving intravenous or subcutaneous interventions	Cosmetic ear-piercing and tattoo parlours Illicit drug users and needle exchanges
	Funeral services	
	Ambulance services	
	Home treatment	

Table 3: Health-care facilities classification

Source: WHO, 2014

In this study, the wastes generated in the different services at CHU-MEL were weighed every day during a period of one month (1st to 30th August 2017). Containers and bags were weighed and recorded by the end of the working day. The quantity of medical wastes generated by this hospital was about 94 kg /day with the rate of 0,7 kg/bed/day while according to WHO (2015), high-income and low income countries generate on average around 0.5 to 0.2 kg of hazardous waste per bed per day, respectively. Although similar values were found in the literature (Taghipour and Mosaferi, 2009; Abd El-Salam, 2010), the amount of medical wastes generated per bed at CHU-MEL is higher than the WHO indication for low income and even high income countries. This may be due to the wastes included because two or more health care institutions may not have the same HCW composition. There is a wide range of health-care facilities and these can source of minor or major waste generation (WHO, 2014; **Table 3**). Moreover, there are several factors(including the number of occupied beds, number of patients per day, number of staff, temporal variations, location, etc) which can potentially affect the quantity and type of health-care waste generation (Taghipour and Mosaferi, 2009; WHO, 2014). The WHO value is just an indication and must be considered with cautious. Due to limited studies in Benin on the amount of health-care generated, further monitoring is needed. Based on the national health care waste procedure, the HHCW included in this were limited to the following: Human anatomical waste, sharps, infectious non human anatomical with the latter which accounted for 85% of waste produced at CHU-MEL (**Figure 2**).

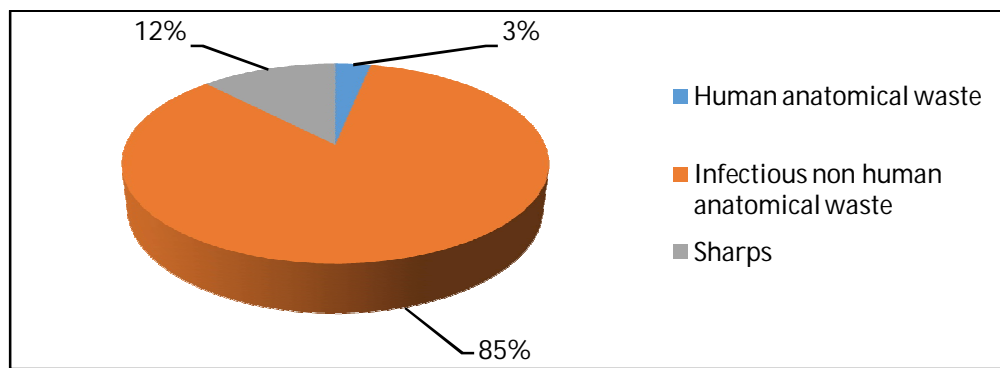


Figure 2: Characterization of HHCW at CHU-MEL

4.2. Workers conditions at CHU-MEL

Overview of the working conditions of the staff is shown in **Figure 3**. The results showed that the majority of the staff including the waste collectors of CHU-MEL is aware of the health risk associated with HCW although the lack of training on HCW at site. The difference in the risk perception between waste collectors and medic or paramedical staffs (physician and nurses) is probably due to the fact that the latter may have acquired knowledge on HCW risk during their education or the course of professional experience. The waste sorting is still an issue at the CHU-MEL as this practice is not strictly observed. The participants of this study, specially the nurses, have indicated a lack of containers in their units or services hence the need for the hospital managers and medical staff to work in synergy for a better resources allocation. Concerning the use of personnel protection equipment the situation is alarmous at the CHU-MEL due to the insufficiency of suitable personal protection equipments for the waste collectors and operator incinerators. During the visit of this hospital the authors have noticed that most the waste collectors in service were partly equipped (either with clothing, gloves, masks or boots) and agreed being injured during their duties (Figure 2). Unfortunately this category of workers at CHU-MEL is not vaccinated in contrast to nurses and physician. These situations may expose waste and incinerator operators at risks and appeal prompt actions from the CHU-MEL representatives. All the staff at CHU-MEL which can be potentially in contact with HCW should be offered an appropriate immunization (e.g, vaccinated against hepatitis B, tetanus, etc) as stipulated by the WHO (2005a). Irrespective to the category of workers, they indicated the non existence of the reporting procedure of incident or accident and the authors did not notice any evidence of documented past accident or incident report in relation to HCW. Concerning the management aspect, the group discussion with the hospital administration revealed no existence of budget for HCW while this is a key aspect of any HSW management plan (WHO 2005a). Moreover they have no idea of generated HCW in the hospital and this will hamper any customized HCW plan. These situations require to revise the HCW procedure at CHU-MEL according to the state of art with the view to minimize the health risk associate to HCW (WHO 2014; Rushbrook and Zhongi 2005).

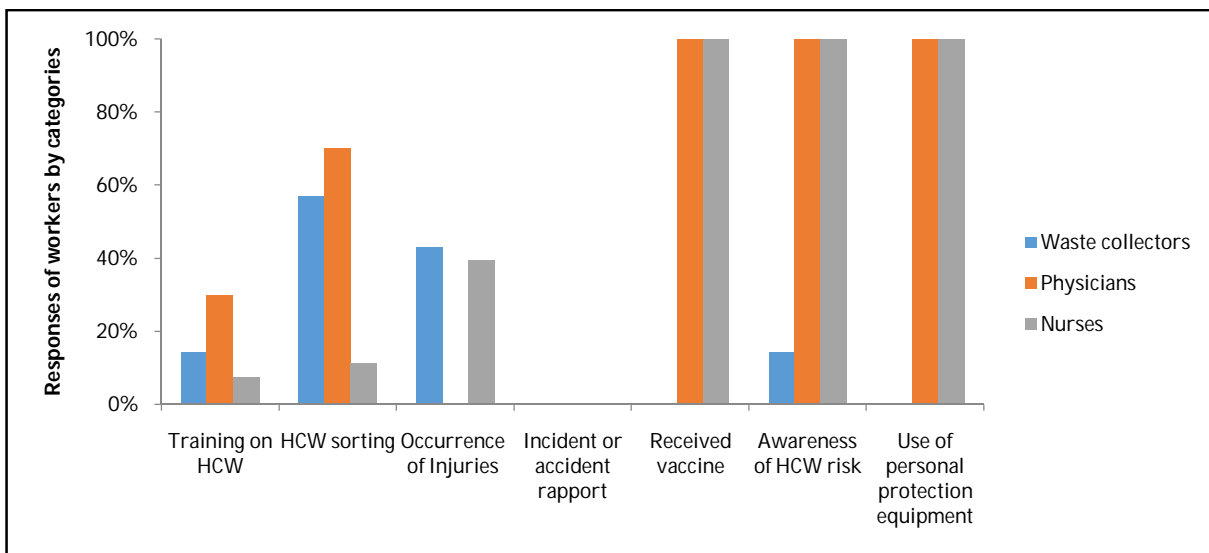


Figure 3: Working conditions

4.3. Risk Assessment of the Medical Waste Flow

After analyzing the waste flow at the CHU-MEL, seven critical steps were identified and evaluated in **Table 4** based on the preliminary risk assessment technique. The evaluation showed that the health risk varied from medium to high and this highlighted how risky is the medical waste management. The highest risk was noticed at the health care waste disposal stage.

This was followed by the segregation of sharp waste, waste sorting, internal HCW transportation, temporary storage, hospital waste conditioning and colour coding. The CHU-MEL has a low cost incinerator the model De Montfort and during the visit, the authors have noticed a malfunctioning of the plant. The “De Montfort” which, is recommended by the WHO is dual chambered with a temperature reaching over 800C in a short residence time and used internationally (Europe, Africa, Asia, etc.) for the medical waste treatment (WHO, 2005b). Based on the pitfalls, since the original design labeled of the plant “Mark1”, there is continuous improvement of “DeMontfort incinerator”, there is nowadays a wide range of models available (such as “Mark 7”, “Mark 8a” and “Mark 9”) based on the user requirements (Picken, 2004). Like any plant, the “DeMontfort” incinerator designer has recommended a fair operating procedures and maintenance to prolong the life span of the plant (Picken, 2004; Practical action, 2000). It is highly recommend to the CHU-MEL authorities to install a medical waste disposal in a safety and sustainable manner for to the environment and human health (Bokhoree *et al.*, 2014). The CHU-MEL has a waste segregation policy based on colour coding according to the Benin national plan of medical waste management. Black bin stand for general waste, yellow for infectious non human anatomical waste and red colour for human anatomical waste. The waste segregation is partly put in practice at the CHU-MEL. The situation is satisfactory especially for sharps wastes which are put in a safety yellow box with a distinctive symbol to characterize this as hazardous wastes and there is no reported case of sharp injuries to date. Unfortunately, this is not observed for the human anatomical and the other non human anatomical wastes as the human anatomical waste are sometimes in found in the non human anatomical container (*i.e.*, yellow) and vice versa. Those wastes are also mixed with the general wastes and this will potentially result in the increase of the HHCW with a subsequent of excess HHCW to be treated and this can contribute to the failure of the treatment plant. This can potentially increase the cost of HCW treatment as general waste is out of its normal treatment procedure (Hossainet *al.*,2011).Before the disposal stage, the medical wastes are transported manually inadequately to a temporary and final storage area. Unfortunately , this is a common practices in several developing countries (Kagonji *et al.*, 2016; Abd El-Salam, 2010; Bokhoree *et al.*, 2014; El-Salam MMA, 2010; Manyele, 2004).The visit of the storages areas at CHU-MEL showed that were not in a good conditions due to the lack of hygiene and there was a huge messy of medical wastes. To improve the HCW management at the CHU-MEL, although it is necessary to emphasize on training, sensitization and awareness due to their importance in the HCW management (Baaki et al. 2017), the entire procedure should be handled in a systemic approach as the different processes which involved (waste sorting, collection, storage, transportation and treatment) are inter-dependent and individual measures (specialized training, motivation, etc) as well as administrative decisions (availability of financial and human resources, timely resources allocation to supply equipments such as containers, personal protection equipment, etc) are needed towards appropriate targets.

4.4. Way Forward and Recommendations

The challenges faced by the CHU-MEL of this case study may generally be applied to the rest of hospital in developing countries and especially in Benin. The following recommendations were made:

- **Towards the Technical staff**
 - Wear adequate protective personnel equipment
 - Observe strictly the HCW procedure
 - Keep updated the occupational accident or incident records.
- **To hospital managers**
 - Elaborate hospital waste management plan with all stakeholders with emphasis on not only financial and human resources but also on roles and responsibilities
 - Organize frequent review of the adopted plan
 - Promote hospital best waste management practices within the hospital by deserving awards to unit or staff
 - Ensure effective management of workplace accident victims, including clinical and follow-up
 - Provide sufficiently plastic, bag and containers based on the adopted colour code (red, yellow, black) ;
 - Raise awareness to all hospital users (workers, patients and visitors)
 - Provide training on medical waste management to new workers and refresher courses to all staff
 - Organize frequent monitoring of the waste monitoring plan
 - Provide a financial resources for waste management
- **To the authorities in charge of medical waste management such as the Ministries of Health and environment:**
 - Include health-care wastes in the curricula of medical and paramedical staff (doctors, nurses, laboratory technician, etc)
 - Monitoring the HCW management nationally
 - Set the management of HCW a major health concern by adequate and regulation and legislative measures
 - Provide incentives to promote a good HCW management practices.

Activities	Current Status at	Hazards	Effects	Risk assessment		Risk analysis	Risk control
				Likelihood of hazard	Hazard severity		
Colour coding	Available	Difficulty of hazardous waste identification Waste mixing Increase of infectious waste	Waste handlers at risk Occupational hazards Spread of disease	2	4	8	<ul style="list-style-type: none"> Continue colour coding
Waste segregation	Partly available and Sharps are found in appropriate container	Waste mixing hazardous	Infection risk increase of HHCW	3	5	15	<ul style="list-style-type: none"> Infectious and hazardous waste should be segregated and collected properly with a distinctive international and dangerous symbol as follows: <ul style="list-style-type: none"> -Yellow colour bin (infectious non-human anatomical waste) -safety box (sharps) -Red color bin (human anatomical waste) -Black bin (general waste) -Use of appropriate personal protective equipment. <ul style="list-style-type: none"> The staff has to receive written information and training on waste segregation. Make waste collection facilities available Disseminate the CHU-MEL medical waste management plan
HCW collection	Available	Waste leakage Waste ventilation Poisonous	Risk of infection from bacteria, viruses, parasites or fungi spread of diseases	2	4	8	<ul style="list-style-type: none"> ensure timely waste collection protection equipment use of sealed container removed and replaced immediately when they are no more than three-quarters full
Internal HCW transportation	Available and is done manually	Waste leakage Waste ventilation Poisonous	Health risk Environmental risk	3	4	12	<ul style="list-style-type: none"> Make a trolleys available and marked with a distinctive symbol of hazardous waste Wash the trolley regularly
Temporary Storage	Available partly	Waste leakage Waste ventilation	Health risk Environmental risk	3	4	12	<ul style="list-style-type: none"> Avoid a long storage time not more than 24 hours

		Poisonous					<ul style="list-style-type: none"> No mixing wastes to avoid cross contamination
Final storage	Partly available	Waste leakage Waste ventilation Poisonous	Health risk Environmental risk	4	3	12	<ul style="list-style-type: none"> Storage facility should not be near food stores Facility available only to authorized persons
HCW treatment facility	Malfunctioning	volatile metals physical injury heavy metal airborne smoke Flue gases Waste leakage Waste ventilation	Health risk to workers and public Increase of cardiovascular and respiratory Diseases Environmental risk	4	4	16	<ul style="list-style-type: none"> Ensure that treatment / disposal option is compatible with the local operational and maintenance capacities; <ul style="list-style-type: none"> select the most environmental friendly options taking into consideration the operation and maintenance costs. Training of plant operator Supply appropriate protection equipment

Table 2: Risk assessment of the HCW process at the CHU-MEL

5. Conclusion

In this study, a preliminary risk assessment technique was used to assess the possible threat of medical waste management to human and environmental health. After identifying all potential hazards occurring during medical waste management process at the CHU-MEL, the risk assessment matrix was constructed on both the likelihood of each hazard and its likelihood of occurrence. The highest risk was noticed during the treatment of medical waste. The medical waste management is potentially hazardous hence the need to define a systemic approach to reduce the environmental and health risks.

6. Abbreviations

- CHU-MEL: Centre Hospitalier Universitaire de la Mère et de l'Enfant Lagune
- General health-care waste (GHCW)
- Hazardous health-care waste HHCW
- HCW: Health care waste
- Human Immunodeficiency Virus (HIV)
- PRA: Preliminary risk assessment technique
- WHO: world health organization

7. References

- i. Abd El-Salam, M.M. (2010). Hospital waste management in El-Beheira Government, Egypt. *Journal of Environmental Management* 91, 618-629.
- ii. Akter, N., Tränkler, J. (2003). An analysis of possible scenarios of medical waste management in Bangladesh. *Management of Environment Quality: An International Journal*, 14(2), 242-255.
- iii. Alwabr, G.M.A., Al-Mikhlaifi, A. S., Al-Hakimi, S. A., & Dughish, M. A. (2017). Risk assessment of the current handling medical waste in hospitals of SANA'A city, Yemen. *International Journal of Science and Technology*.ISSN 2454-5880. Regular Issue 3(1), 01-09.
- iv. Baaki, T. K., Baharum, M. R.&Akashah, F, W. (2017).Critical Success Factors of Medical Waste Management Implementation in Healthcare Facilities in Nigeria: A Case Study. *Journal of Design and Built Environment Vol. 17* (1).
- v. Bokhoree, C., Beeharry, C. Y., Makoondlall-Chadee, T., Doobah, T., &Soomary, N. (2014). Assessment of Environmental and Health Risks Associated withthe Management of Medical Waste in Mauritius. *Science Direct APCBEE Procedia*, 9, 36 – 41.

- vi. El-Salam, M. M. A. (2010). Hospital waste management in El-Beheira Governorate, *Egypt. J. Environ. Manag*, 91, 618-629.
- vii. Hossain, M.S., Santhanam, A., Nik Norulaini, N.A. & Omar, A.K. (2011) Clinical Solid Waste Management Practices and its Impact on Human Health and Environment—A Review. *Waste Management*, 31, 754-766.
- viii. Kagonji, I.S., Manyele, S. V. (2016). Analysis of Health Workers' Perceptions on Medical Waste Management in Tanzanian Hospitals. *Engineering*, 8, 445-459.
- ix. Komilis D, Fouki A, Papadopoulos D.(2012). Hazardous medical waste generation rates of different categories of health-care facilities. *Waste*. 32(7), 1434-1441.
- x. Manyele, S.V. (2004). Effects of improper hospital waste mgt. on occupational health and safety. *Africa Newsl Occup Health Saf*.14:30–5.
- xi. Mustafa Ali, Wenping Wang, Nawaz Chaudhry, Yong Geng (2017). Hospital waste management in developing countries: A mini review. *Waste Management and Research*. 35 (6), 581-592.
- xii. Practical Action (Editor) (2000): Low-Cost Medical Waste Incinerator. Rugby: Practical Action. Available at: http://sustain.pata.org/wp-content/uploads/2015/02/PRACTICAL-ACTION_medical_waste_incinerator.pdf
- xiii. Picken, D. J. (2004). the new "De Montfort" medical waste incinerators. Available at: https://mw-incinerator.info/en/101_welcome.html.
- xiv. Awodele, O., Adewoye, A, A., & Oparah, A.C. (2016). Assessment of medical waste management in seven hospitals in Lagos, Nigeria Awodele et al. *BMC Public Health*.16:269 DOI 10.1186/s12889-016-2916-1.
- xv. Rausand M., 2011. Risk Assessment Theory, Methods, and Applications. Wiley.
- xvi. Rushbrook, P, Zghondi, R. (2005). Better health care waste management: an integral component of health investment. ISBN 92-9021-389-58 pages.
- xvii. Sefouhi, L., Kalla, M., Bahmed, L., & Aouragh, L. (2013). The Risk Assessment for the Healthcare Waste in the Hospital of Batna City, Algeria. *International Journal of Environmental Science and Development*, Vol. 4, No. 4.
- xviii. Tabasi, R., Marthandan, G. (2013). Clinical Waste Management: A Review on Important Factors in Clinical Waste Generation Rate. *International Journal of Science and Technology*. Volume 3 No.3. ISSN 2224-3577.
- xix. Taghipour, H., Mosaferi, M. (2009). Characterization of medical waste from hospitals in Tabriz, Iran. *Sci. Total Environ*. 407, 1527-1535.
- xx. World Health Organization (WHO) 1999. Unsafe injection practices and transmission of blood borne pathogens. *Bull World Health Org.*;77: 787–819.
- xxi. WHO. 2005a WHO (2005). Management of solid health care waste at primary health care centres: a decision-making guide. Geneva, Immunization, Vaccines and Biologicals (IVB); Protection of the Human Environment Water, Sanitation and Health (WSH), World Health Organization.
- xxii. WHO (2005b). Managing Health Care Waste Disposal – Guidelines on how to construct, use and maintain a waste disposal unit. WHO, Washington, USA. Available at: <http://www.path.org/publications/detail.php?i=1352>
- xxiii. WHO 2007. WHO Core principles for achieving safe and sustainable management of healthcare waste. Available at: http://www.who.int/water_sanitation_health/publications/hcwprinciples/en/
- xxiv. WHO 2012. Rapid risk assessment of acute public health events. Available at: http://www.who.int/csr/resources/publications/HSE_GAR_ARO_2012_1/en/
- xxv. WHO 2015 Health-care waste. Fact sheet N°253. <http://www.who.int/mediacentre/factsheets/fs253/en/>
- xxvi. WHO 2014 Safe management of wastes from health-care activities / edited by Y. Chartier et al. – 2nd ed. ISBN 978 92 4 154856 4
- xxvii. Shareefdeen, Z, M. (2012). Medical Waste Management and Control. *Journal of Environmental Protection.*, 3, 1625-1628.