Potentiality of In-house Treatment for Khartoum State Medical Wastes Case study: Khartoum Breast Care Center (KBCC)

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Abstract- As a result of the growing number of hospitals in Khartoum state, huge quantities of medical waste have been produced. Proper handling and treatment are urgently needed in a way that ensures the safety of the individual and society. This study is a simple assessment for an already existing treatment unit by using HAZOP study. The treatment unit is located in Khartoum Breast Care Center (KBCC). A brief review is presented about the amount of waste generated in Khartoum State hospitals and briefing about HAZOP. The assessment and analysis proved that the autoclaving process is safe, uncomplicated, does not require a lot of labor, and most importantly, the treatment is easy to handle. Compared to the medical waste generated by each hospital, autoclaving process is suitable and convenient size wise and operational wise. Some environmental and operational adjustments have been recommended.

Keywords: *Safe Treatment, HAZOP, Medical Waste, Autoclaving*

المستخلص – نتيجة للعدد المتزايد للمستشفيات بولاية الخرطوم والانتاج العاليلكميات كبيرة من النفايات الطبية أصبح هناك حاجة ماسة إلى مناولتهاومعالجتها بطريقة تضمن سلامة الفرد والمجتمع. هذه الدراسة هي تقييم بسيط لوحدة معالجة موجودة بالفعل باستخدام دراسة HAZOP. تقع وحدة العلاج في مركز رعاية الثدي بالخرطوم. اشتملت الدراسة على عرض موجز عن كمية النفايات المتولدة بمستشفيات ولاية الخرطوم بالاضافة الى تعريف موجز عن HAZOP. أثب التقييم والتحليل أن عملية التعقيم والمعالجة الموجودة بالمركز آمنة وغير معقدة ، ولا تتطلب الكثير من العمالة ، والأهم من ذلك ، أن العلاج سهل المعالجة. مقارنة بالنفايات الطبية الناتجة عن كل مستشفى ، فإن عملية التعقيم مناسبة من حيث حجم النفايات النايجة داخل كل وحدة طبية وحجم وحدة المعالجة وايضا من حيث العملية التشغيلية الآمنة. تمت التوصية ببعض التعديلات البيئية والتشغيلية.

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. As it contains various type and state of degree of hazardous waste, it has a high importance in terms of its environmental impact and public health hazard.[1]

Persons at risk

All individuals exposed to hazardous health-care waste are potentially at risk, including those within health-care establishments that generate hazardous waste, and those outside these sources who either handle such waste or are exposed to it as a consequence of careless management. The main groups at risk are the following:

- Medical doctors, nurses, health-care auxiliaries, and hospital maintenance personnel;
- Patients in health-care establishments or receiving home care;
- Visitors to health-care establishments;
- Workers in support services allied to health-care establishments, such as laundries, waste handling, and transportation;
- Workers in waste disposal facilities (such as landfills or incinerators)

Environmental Impact

Treatment and disposal of healthcare waste may pose health risks indirectly through the release of pathogens and toxic pollutants into the environment.

- Landfills can contaminate drinking-water if they are not properly constructed. Occupational risks exist at disposal facilities that are not well designed, run, or maintained.
- Incineration of waste has been widely practiced, but inadequate incineration or the incineration of unsuitable materials results in the release of pollutants into the air and of ash

residue. 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 [2].

Relevant international bodies issued a lot of manual and handbooks, where standard procedures are set [3].

Hospitals in Khartoum generate a total of 6253.8 kg/day of wastes, of which about 5003 kg (80%) are non-hazardous and 1250.8 kg (20%) are hazardous. The production per hospital various according to the number of beds and the services it offers which varies between 0.096 up to 1.12 Kg/bed/day [4].

The current health care waste management practices observed in Khartoum state hospitals are not fully safe and have harmful environmental effects. These are due to the absence of disposal facilities and the poor financial resources. Medical waste management in Khartoum's hospitals is inefficient, due to:

- Almost all types of wastes being mixed together;
- The partial separation of wastes existing only in a few hospitals;
- Most of the workers being illiterate or having very low education levels, and there being a shortage of personal protective equipment (PPE) (e.g., boots, aprons, gloves);
- At the hospital level, no policies or rules being found except in a few centers;
- Limited training and that which is provided being inefficient;
- In the majority of the hospitals (75%), the transportation of HCW to temporary storage are as being done manually;'
- A color-coding system often not being implemented [5].

Only a small portion of waste in some hospitals (part of potentially infectious, body parts, and sharps) are collected separately and treated in a central incinerator. The estimated value of per bed generation rate in the studied hospitals was found to be 0.87 kg/day, which lies within the range for the low-income countries. In all studied hospitals, it was found that workers were working under very poor unsafe conditions with very low salaries ($35 to $45 per month on average).

About 90 % were completely illiterate or had very low education levels. At the national level, no laws considering hospital waste, or even hazardous waste, were found; only some federal general environmental regulations and some procedures from town and city localities for controlling general municipal waste exist. At the hospital level, no policies or rules were found, except in the radiotherapy center, where they manage radioactive wastes under the laws of the Sudanese Atomic Agency. Urgent actions are needed for the remediation and prevention of hazards associated with this type of waste [6].

Assessment of a medical waste treatment facility used to be carried using tradition methods like questionnaires, interviews and observations [7]. With the merge of new technologies and the uses of hazardous processes and chemical, a need to an advance technique is highly required to assess any process and to predict the risks so as to take safety measures [8].

HAZOP is one of these techniques. It is an abbreviation to Hazard and Operability Study. It is a structured and systematic examination of a complex planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment or environment.

The intention of performing a HAZOP is to review the design to pick up design and engineering crisis issues that may otherwise not have been found. The technique is based on breaking the overall complex design of the process into a number of simpler sections called 'nodes' which are then individually reviewed.

The HAZOP technique is qualitative, for each node in turn a list of standardized guide-words and process parameters is used to identify potential deviations from the design intent. For each deviation, identifications to feasible causes and likely consequences then decides (with confirmation by subsequent risk analysis where necessary) whether the existing safeguards are sufficient, or whether an action to install an additional safeguard is necessary to reduce the risks to an acceptable level.

The HAZOP technique was initially developed in the 1960s[9] to analyze major chemical process systems but has since been extended to other areas, including mining operations and other types of process systems and other complex systems such as nuclear power plant operation and software development. It is also used as the basis for reviewing batch processes and operating procedures.

Advantages and disadvantages of HAZOP

An advantage of the systematic study of HAZOP methods for the practice:

1. Systematic and thorough examination of the assessed equipment with an aim to identify the dangerous statuses (scenarios),
2. Possibility to evaluate of the consequences of a failure of personnel, finding of such situations, where the mistake of personnel would have a significant consequence,
3. Finding of new dangerous situations, a systematic procedure allowing to find new dangerous situations, that may occur,
4. Increase of the efficiency of the operation equipment, finding of situations, that may lead towards disturbing of the operation, unplanned breaks, damage of the equipment, loss of the in-processed raw material, but also towards improvement of the operational regulations,
5. Better understanding of the process, even experienced members of the meeting may acknowledge anew information regarding the operation of the assessed equipment.

A disadvantage of the systematic study of HAZOP methods for the practice:
1. Long time needed (depends on the size of technology),
2. The need to clear definition of objectives / focus and set of HAZOP studies considered the effects – at the beginning of the study, without a clear definition of objectives (e.g., identification of emergency situations) gives boundless studies which do not give clear outputs,
3. High demands on the knowledge and skills of HAZOP study participants, without good HAZOP team and HAZOP leader good HAZOP study can't be done.[10]

Objectives of the Study

The aim study is to find a suitable method for the medical waste treatment in Khartoum State by:
1. Studying and assessing an existing method of medical waste treatment in Khartoum state, by carrying HAZOP analysis.
2. Find its potentiality to be used for another situ.
3. Suggesting any required modifications.

Methodology:

Case Study *(Khartoum Breast Care Center)*

The Khartoum Breast Care Centre (**KBCC**) is a non-profit, privately funded organization opened in October 2010. It is the only specialized and multidisciplinary Breast Cancer Centre in Sudan. With advanced diagnostic & surgical equipment utilized by our highly dedicated and qualified physicians & support staff we have managed to establish an elite standard for specialized medical services in Sudan. (KBCC) covers not just Sudan but also neighboring countries (Chad, South Sudan, Eritrea and Ethiopia). It incorporates all the relevant specialties, Imaging, Pathology, Surgery and Oncology in one building. It generates round 50 kg of medical waste per day. The center adopts the technology of autoclaving (Shown in Figure 1) for the treatment of the waste by use "ECODAS, Hydroclave T_{150}" as shown in Figure 2 [11].

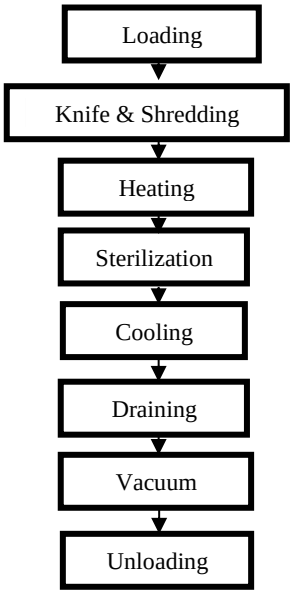

Figure 1: Autoclaving Process flowchart

Figure 2: Operation Procedure Scheme of ECODAS, Hydroclave T_{150}.

Method

To evaluate and assess the autoclaving process to treat medical waste applied in Khartoum Breast Care Center, a simple HAZOP study was carried, in addition to evaluation of the working environment by observation.

A. *Description of the Operation Procedure* of ECODAS, Hydroclave T_{150}**:** The whole unit consists of 8 steps:

Loading: The contaminated waste is manually loaded into the upper chamber at the top of the unit. It's takes approximately 5 minutes.

Knife and Shredding: After the loading cover is sealed, the heavy-duty shredder cuts the material into small pieces and features a unique reversing system to avoid jamming but knife before shredding cut it by uniform way. It's takes approximately 30 minutes.

Heating: Saturated pressurized steam raises the temperature to138°C(280F), and the pressures to 3.8 bar(55psi). And it's takes approximately 30 minutes.

Sterilization: The pressurized heated steam comes into direct contact with the shredded material; reduction of the infectious load is achieved by maintaining138°C/3.8bars. And it's takes approximately 12 minutes.

Cooling: Temperature is lowered to80°C by spraying cool water on to the double Jacket of the treatment vessel. Simultaneously, the unit returns to ambient pressure. And it's takes approximately 12 minutes.

Draining: The steam is condensed to water and discharged with the cooling water to the sanitary sewer system. And it's takes approximately 5 minutes.

Vacuum: The remaining residual steam is vented out through a vacuum pump. And it's takes approximately 5 minutes.

Unloading: A digital signal informs the operator that all safe operating conditions have been met.

Control Unit: The unit has a digital control system which gives alarm and has an automatic shutdown system. The unit is operated by one operator; the process is done during normal working hours (7.30 am to 15.30 pm).

B. Assessment

The assessment was carried on both the operation parameters and the working environment.

- Operation Parameters: a simple HAZOP study is carried out. The three main parameters examined are temperature, pressure and the flow of the cooling water.
- The documents were also examined for previous accidents.
- The environment is assessed by observation.

Results and Discussion

1.Sterilization Cycle:

The sterilization cycle for the 8 steps of the autoclaving unit shown by Figure **3** reveals that:

- the raise of temperature is well distributed,
- The raise of temperature in step (3); is accompanied by raise in pressure and done in short time,
- Residence time in step is adequate to reduce the infectious pollutants,
- The remaining steps are carried with low gradient in suitable time to avoid sudden cooling.

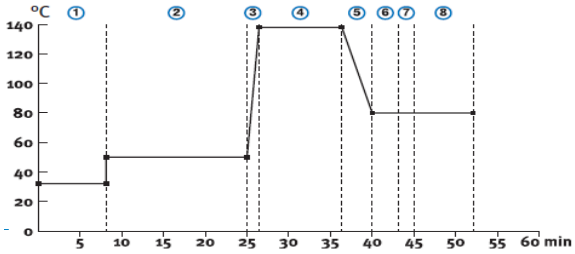

Figure 3: Sterilization Cycle

2. Crosschecking the data of the HAZOP with records for previous accidents:
   - The inspection for the unit is carried out on regular base,
   - No serious accident happened as a results of operation failure,
   - The relief valve is connected automatically with control unit.
   - Temperature hazard is very minimized by giving extra time for the solid effluent to cool.
   - Cooling water flow rate is kept constant as possible as there are a standby tank and pump.
3. *Environment Observations*:
   - The geographic location is perfect (east of the main building)
   - The ventilation is perfect.
   - Sub offices and stores are enough and well housekeep.
   - The space where the unit is erected is small.
   - The lightening is week.
   - There only one operator.
   - Not enough PPE.

Conclusion

The paper reveals that the amount of medical waste in Khartoum State is increasing and there is no proper complete management system for that. The technology adopted by the Khartoum Breast Care Center is a good practice. As the amount medical waste generated by each hospital is with the range that can be handled easily by autoclaving technology, it will be suitable and safe to use the autoclaving technology as the size range of the autoclaves matches the size range of waste production per medical units in Khartoum State.

4.HAZOP study:

TABLE 2: HAZOP FOR TEMPERATURE, PRESSURE AND COOLING WATER FLOWRATE

Code NO	Element	Deviation	Possible Causes	Consequence	Safe Guards	Action Required	Action Assigned to
T1	Temperature inside incinerator	More than 138 C.	1.Failure in valve. 2.Amount of steam so much.	1.Explosion. 2.Harm to build and persons. 3.Damage in incinerator	Make temperature control valve (TCV).	1.Put alarm to check temperature 2.Decrease temperature 3.Decrease amounts of steam.	Operator.
T2	Temperature inside incinerator	Less than 138 C.	1.Decrease of temperature. 2.Loss of temperature.	1.Most of waste is not sterilizing. 2.Increase amount of output waste. 3.Decrease the efficiency of incinerator	Make temperature control valve (TCV).	1.Put alarm to check temperature 2. Increase temperature 3. Increase amounts of steam.	Operator.
P3	Pressure inside incinerator	More than 3.8	1-Increase of pressure 2-Increase of amount of steam 3- Increase of temperature 4- Failure valve pressure	1.Explosion. 2.Harm to build and persons. 3.Damage in incinerator tubes.	Put pressure control valve. (PCV).	1.Decrease of pressure. 2.Control of the steam amount	Operator.
P4	Pressure inside incinerator	Less than 3.8	Decrease of pressure.	1.Pressure drop inside tubes. 2.Amount of steam will decrease.	Put pressure control valve. (PCV).	1.Increase of pressure.	Operator
L5	cooling water flowrate	Less	1.The levels of water in cooling tank not enough. 2.The input valve is close. 3.Error in control unit. 4.Plug in main water supply	1.The waste is not cooled. 2.Harm to persons. 3.Damage inside equipments.	Check level control valve (LCV)	Increase the flowrate.	Operator.

The operation process is efficient (sterilization is adequate); operation procedure is very controllable with minimum number of labors; no previous serious accidents; effluent is manageable and of no infectious effects. In spite of that more safety measures should be considered as using of proper PPE; training [12].

The paper reveals that there is an urgent need to tack the medical waste with a very technical and safe processes. First, it is very crucial to enact laws and regulations in the field of dealing with medical waste. A body has to be established to work on awareness, assistance and control. Continuous assessment and audit system for

existing treatment plant should be set. A map of the sites of the production of medical waste has to be created. Internal treatment (onsite) has to be adopted to reduce the risk of waste transport as well as adopting and supporting centers of excellence in the field to elaborate researches.

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