

Modification of the incinerator to prevent the emission of toxic air pollutant in biomedical waste incineration process at Base Hospital Udugama

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Abstract

Background: Medical waste incinerators emit toxic air pollutants and toxic ash residues that are the major sources of dioxins and furan. However, Incineration is the best available option for treating clinical waste. The harm can be minimized by designing an incinerator according to the composition of components of the clinical waste generated at the hospital. The incinerator at Base Hospital Udugama has been emitting polluted air causing environmental pollution.

Objective: To identify the cause of emitting polluted air and modify the incinerator to prevent environmental pollution.

Methods: A survey was conducted on similar incinerators in other institutions to see the efficiency and working conditions and followed an audit to identify the composition of the clinical waste generated in the hospital setting. The incinerator was modified according to the composition of waste to tolerate high calorific value.

Results: Survey proved that all other similar incinerators emit polluted air during the incinerating process. The audit showed the rubber and plastic composition of waste is around 50% against the recommended value of 10%. The existing machine was modified to tolerate high volumes of rubber and plastic by increasing the calorific value.

Conclusion: Existing incinerator at BH. Udugama emits polluted air due to the incompatible composition of clinical waste with the machine specification. This can be prevented by modifying the incinerator by increasing the Calorific value.

Recommendations: It is recommended to re-evaluate the existing incinerators and modify them up to the standard to prevent environmental harm considering 50% of rubber and plastics in clinical waste.

Keywords: Incinerator, emission, biomedical waste, hospital

Introduction

Biomedical waste (BMW), medical waste or clinical waste means any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities ^[1]. The burning of solid and regulated medical waste generated by health care creates many problems. Therefore, the management of medical waste produced in hospitals or healthcare facilities has raised concerns relating to public health, occupational safety, and the environment ^[2].

Medical waste incinerators emit toxic air pollutants and toxic ash residues that are the major source of dioxins and furan, carbon monoxide, /hydrogen Chloride, and metals including mercury, lead, arsenic and cadmium ^[3,4]. Clinical waste has been identified by United Nations

Environmental Agency as the 3rd largest source of dioxin air emission ^[5,6] and a contributor of about 10% of mercury emissions to the environment ^[7]. Dioxin is one of the most toxic chemicals links to cancer, immune system disorders, diabetes, birth defects and disrupted sexual development ^[8]. It says that the formation of organic compounds even at a very low concentration is found to be toxic ^[9]. However, incineration is known to be the best available option for treating clinical waste ^[9]. A proper operation of the incinerator is essential to ensure complete destruction of the waste ^[10]. Generation of hazardous materials in the incineration process is dependent on the waste type, waste feed rate, incinerator operation, and air pollution control (APC) equipment type and operation ^[11].

Once the engine starts, clinical waste is loaded into the primary chamber. Burners have been fixed to supply high-temperature heat to burn the clinical waste. This is known as combustion. In this chamber, clinical waste is oxidized and undergoes pyrolysis process to convert long-term carbon to short-term volatile carbon under low concentrations of oxygen. The temperature of the primary chamber is maintained at around 800°C for slow combustion to happen pyrolysis process. Slow combustion process produces high-temperature flue gas that enters the secondary combustion chamber. The smoke stays in the combustion chamber for a few seconds, undergoes high-temperature combustion, fully decomposes harmful bacteria, and removes gases through relevant equipment to environment. Fully combustion process is dependent on the three 'T' (Temperature, Time and Turbulent flow). Once the flue in the secondary chamber receives maximum

temperature, adequate time period and enough turbulent flow, all the harmful substance is destroyed and prevent expelling toxic substance. Separate burners and oxygen supply have been provided to the secondary chamber to maintain optimum conditions.

The Incinerator installed at Base Hospital Udugama

This inclinator was installed in 2021 December. It has a capacity of incinerating 25 kg per 30 minutes by maintaining a calorific value of around 116250 Kcal. To achieve this calorific value, the hospital was instructed to add less than 10% rubber and plastic with non-rubber and polythene to prevent releasing polluted air. The calorific value of the rubber is around 6500 to 18500 kcal ^[14] and non-rubber and non-plastic is around 3500 Kcal ^[15]. According to the specification of the machine, it can burn 20 kg of non-plastic and non-rubber with 5 kg of rubber and plastic to maintain the machine's capacity of burning 116250 Kcal (calorific value) to prevent the emission of harmful flue. The machine was operated according to the specification. However, it emits polluted air from the incinerator with a foul smell. The company was instructed on several occasions to correct the failure. They have made several adjustments but were unable to correct the defect.

This issue was becoming very serious and the public and hospital staff complained to the hospital administration. Therefore, this project was implemented to find the reasons for the issue to correct the defect of the machine.

Methodology

1. A survey was conducted in other hospitals using a similar type of machine to find the working conditions of them.

This survey was conducted through telephone interviews with the participation of infection control nursing officers of each hospital having similar types of incinerators. Data was collected using a checklist from BH Elpitiya, BH Kahawatta, BH Pimbura, BH Balangoda, BH Warakapola and DH Arachchikanda. Information was collected on the capacity of the machine, fuel type and colour and smell of the smoke emitting from the incinerator.

2. An audit was conducted to determine the composition of different types of waste in a medical waste bag (Yellow bag).

It was observed that the concentration of emitting black air is very high when adding more rubber content. Therefore, an audit was conducted using medical waste collected bags to identify the composition of the different types of waste. All waste bags were collected from BH Udugama and BH Balapitiya brought to the store in a day was taken as the sample frame. Four bags from each hospital were selected randomly. Each bag was opened carefully wearing protective equipment by two health care assistants in front of the infection control

nursing officer. Rubber, plastic non-rubber and non-plastic materials were separated and measure the weight separately.

3. The incinerator was modified according to the audit result to prevent the emission of harmful material

The audit confirmed the machine failure is due to the high calorific value of the clinical waste generated by the hospitals. According to the audit results the machine was modified to burn clinical waste by increasing the calorific value to prevent emitting polluted air.

Results

According to the survey, all similar machines installed by the relevant company produced black air in the incineration process. That indicates all the machines emit polluted air causing environmental pollution.

The total weight of waste bags collected from Base hospital Udugama was 20.45 kg. It included 10.05 kg (49%) of rubber and plastics and the rest of 10.40 kg (51%) included non-rubber and non-plastics components. The weight of the waste bags collected from Base Hospital Balapitiya was 12.81 kg. It consisted of 7.65 kg (60%) of rubber and plastics and 5.15 kg (40%) of non-rubbers and non-plastics.

Table 1: Survey result on assessment of efficiency of incinerator

Hospital	Capacity of the incinerator (kg/hour)	Fuel type	Polluted air (Yes or no)
BH Elpitiya	50	Diesel	Yes
BH Kahawatta	50	Gas	Yes
BH Pimbura	50	Diesel	Yes
BH Balangoda	50	Gas	Yes
BH Warakapola	50	Gas	Yes
BH Arachchikanda	50	Diesel	Yes

Table 2: Audit result -Composition of waste material in Yellow bag

Bag number	BH Udugama		BH Balapitiya	
	Weight of Rubber and plastic (Gloves, Drip sets, cannulas) (g)	Weight of Non-rubber and non-plastic (Diaper/paper/Gauze/Cotton/cardboard) (g)	Weight of Rubber and plastic (Gloves, Drip sets, cannulas) (g)	Weight of Non-rubber and non-plastic (Diaper/paper/Gauze/Cotton/cardboard) (g)
Bag 1	4430 (72.6%)	1697 (27.4%)	1587 (66.1%)	813 (33.9%)
Bag 2	2233 (34.4%)	4647 (65.6%)	1735 (44.5%)	2160 (55.5%)
Bag 3	1580 (33.7%)	3113 (66.34%)	2606 (65.8%)	1356 (34.2%)
Bag 4	1610 (62.5%)	965 (37.5%)	1730 (67.8%)	824 (32.3%)
Total	10053 (49%)	10406 (51%)	7658 (60%)	5153 (40%)

Modification of incinerator to prevent harmful air expulsion to the environment

According to the audit, rubber and plastic contents in each bag was much higher (>50%) than the recommended values (<10%) of the machine. Therefore, calorific value is much higher (243900 kcal) than the recommended capacity of the machine. This tends to release polluted air by incomplete incineration due to incomplete combustion process. It is recommended to modify the machine to burn clinical waste generated in the hospital having 50% of (243900 kcal) rubber and plastics to increase the calorific value of the machine.

This machine was designed to incinerate 25 kg of clinical waste per 30 minutes with less than 10% of rubber and plastics to maintain a low calorific value, which is expected to generate hospital-generated medical waste with 10% of rubber and plastic. However, the audits proved that the hospital medical waste comprised more than 50% of rubber and plastic (High calorific value). Therefore, the company decided to modify the incinerator to increase the calorific value of the machine. This was achieved by

increasing the volume of the primary chamber to control to primary combustion process while adjusting 3Ts (time, temperature and turbulent flow) at the secondary chamber. The outlets of the secondary chamber were reduced to keep the flue at the secondary chamber adequate time while two burners were positioned in secondary chamber to increase the temperature. Efficient turbulence was ensured through modifying the flow of the flue at the incinerator. This modification increased the calorific value of the incinerator. Post modification test was done, and no black air emitted from the incinerator.

Discussion

Public concerns about incinerator emissions, as well as the creation of environmental regulations for medical waste incinerators, are causing many healthcare facilities to rethink their choices in medical waste treatment ^[1]. Healthcare activities generate waste with varying degrees of risk for the patient, staff, and the environment ^[16, 17]. However, many research findings indicate that incineration

is the best waste disposal technique among the available alternatives ^[18]. Therefore BH. Udugama selected the best option and installed an incinerator in 2021 from a local manufacturer following competitive bidding. Since BH Udugama has been adhering to a proper waste management system, the hospital generates around 0.2 kg of clinical waste per patient a day ^[19] Hence, small capacity incinerator which can incinerate around 500 kg of medical waste per day was selected. BH. Udugama generates around 25 kg of clinical waste per day. Therefore, the hospital incinerated the clinical waste generated at BH. Balapitiya and other surrounding hospitals in Galle district. It was observed that the incinerator emits black air. The company was given many solutions and options for the issue but none of them corrected the issue. Therefore, hospital administration decided to conduct a small survey to find out the function of similar machine installed in the country. The survey proved that all incinerators had similar issue. We observed that black air emission is increased with the rubber and plastic (Table 1). Therefore, it was decided to conduct an audit on the clinical waste bags received at the incinerator. According to the audit (Table 2) rubber and plastic contents of each bag were more than 50%. Since the calorific value of the rubber and plastic is very high (17500 kcal) the machine only tolerates 10% of rubber and plastic. Since the specification of the machine also mentions on the percentage as 10% of rubber and plastic, the administration would not be able to complain against the company. The machine can tolerate only 116250 kcal of waste to prevent emitting harmful air. This has happened due to poor knowledge of the composition of clinical waste generated in hospital settings. This was communicated to the company which agreed to modify the

incinerator without additional cost to the government. The technology must be adjusted to increase the calorific value of the machine accepting unsegregated clinical waste having 50% rubber and plastic. This was achieved by increasing the volume of the primary chamber to allow slow combustion of clinical waste while adjusting time, temperature and turbulent flow at the secondary chamber. The incinerator was modified according to the requirement and increased the calorific value capacity up to 243900 kcal to incinerate 50% of rubber and plastic content. Now the incinerator is functioning very efficiently, and no black air is emitted to the environment. The company started to modify the other similar incinerators distributed in the country.

Conclusion

Incineration is the best option for clinical waste disposal. However, environmental pollution is a dangerous effect of this process. This can be prevented by adhering to the standards when manufacturing incinerators according to the components of the waste. Calorific value is the most valuable parameter to be considered when purchasing an incinerator to the health care organization.

Recommendations

It is recommended to re-evaluate the existing incinerators in the country and modify up to the standards to prevent environmental harm. Specification of an incinerator must be included to have a capacity of incinerating clinical waste having 50% of rubber and plastics when purchasing new incinerators.

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