Air Pollution VIII, C.A. Brebbia, H. Power & J.W.S Longhurst (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-822-8

Management of pollution from an hospital incinerator in Nigeria

A.O.Coker[1], A.M. Akanmu[1], M.K.C. Sridhar[2] & I. O. Aladenola[1]
[1]*Department of Civil Engineering, University of Ibadan, Nigeria.*
[2] *Department of Preventive and Social Medicine, College of Medicine, University of Ibadan, Nigeria.*

Abstract

In Nigeria, there has been in recent times, a growing need to effectively manage the pollution stemming from biomedical waste disposal by hospital incinerators. This is not unconnected with the enormous quantities of the biomedical wastes being churned out haphazardly to the environment coupled with the increasing awareness of the Nigerian populace to health-care delivery. The case-study is the incinerator being currently used in Nigeria's oldest Teaching Hospital – University College Hospital (UCH) located at Ibadan, Oyo State. The UCH's incinerator handles close to 300kg of biomedical wastes daily. Plastics mainly Polyvinylchloride (PVC) products and absorbants which are major sources of air pollution constitute about 70% of the wastes being generated in this hospital. The incinerator, a locally - made earth – brick furnace type with a kaolin – brick refractory is at present grossly unable to handle the vast quantities of biomedical wastes being generated in the hospital. Furthermore, investigations show that overcharging with wastes coupled with incomplete combustion of the waste constituents in the incinerator are the two major problems of the UCH's incinerator. Data collected between 1998 and 1999 indicate that the newly – installed incinerator at UCH cannot on her own, handle the wastes being generated in the entire hospital complex. Hence the need to still improve the old, locally - made incinerator which has a greater relative capacity. Some recommendations were thus proferred to make the incinerator more functional and less polluting.

Introduction

The rapid rate of urbanization in major cities in Nigeria and Ibadan in particular, has brought about several environmental problems, amongst which

Air Pollution VIII, C.A. Brebbia, H. Power & J.W.S Longhurst (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-822-8

biomedical waste management stands out prominently. Biomedical waste refers to the largely infectious waste generated from health-care establishments, medical institutions, diagnostic laboratories, veterinary clinics, hospitals and research facilities. It includes absorbants, sharps and needles, glass, gauze, paper, plastics and human anatomical remains and animal carcasses. It is a waste capable of producing an infectious disease (United States Environmental Protection Agency [1]). Thus, it contains pathogens with sufficient virulence and quantity so that exposure to them by a susceptible host could result in an infectious disease. According to World Health Organisation [2], World Population reached 5.8 billions in mid-1996. In that year, 52 million people died, out of which over 17 million deaths were attributed to infectious or parasitic diseases. Moreover, of the over 52 million deaths in 1996, 40 million reportedly occurred in developing countries of which Nigeria is one.

Considering the potency of contamination and eventual death which may arise from biomedical waste, waste managers in major urban cities have intensified research to finding a lasting solution to this nagging problem. Based on research studies, incineration still stands out as one of the viable options of hospital waste disposal in Nigeria (Coker *et al* [3]). This is because it sterilizes pathogenic wastes, reduces waste volumes by over 90 percent, and, in some cases, may provide economic benefits through waste heat recovery. On-site incineration is very attractive because it reduces cost of handling and transportation of the wastes and because waste heat recovery can have economic advantages for the facility. Moreover, it has been found out from this study that the ash residue is rich in fertilizer components.

However, hospital waste incinerators may emit a number of pollutants depending on the waste being incinerated. These pollutants include: particulate matter, acid gases, toxic metals, toxic organic compounds, sulphur oxide, nitrogen oxide, pathogens and viruses. Moreover many privately - owned hospitals in Nigeria can hardly afford incinerators and study has shown that 60% of hospitals in Ibadan city for example are privately – owned (Coker *et al* [3]). Table 1 presents possible health threats of some major air pollutants [1]. Nevertheless, proper operation of the incinerator will reduce the emissions of these pollutants. Air pollution control devices are also available to control them.

Table 1. Health threats posed by some major air pollutants

Pollutants	Health concerns
Ozone	Respiratory tract
Airborne particulates	Eye and throat irritation
Carbon monoxide	Cardiovascular, nervous and pulmonary systems
Hydrocarbons	Various compound specific health hazards
Sulphur oxide	Respiratory tract
Nitrogen dioxide	Respiratory illness and lung damage
Lead	Retardation and brain damage in children

Air Pollution VIII, C.A. Brebbia, H. Power & J.W.S Longhurst (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-822-8

Study Area

The University College Hospital, Ibadan, Oyo State of Nigeria emerged as a purpose – built premier Teaching Hospital conceived to serve the need for internationally comparable medical education in West Africa. It spans an area of approximately 60 hectares in the North-eastern part of Ibadan – Nigeria's largest city. It is located between latitude $7^o23'$ north and longitude $3^o35'$ east of the Greenwich Meridian. In more than four decades, the hospital has more than justified the vision of its founders as the stimulus to medical education in West Africa, a centre of clinical excellence and the bastion of scientific research in medical sciences. These attributes verify its choice as a case-study for this research.

Methodology

The monitoring work was started by undertaking a preliminary survey of the hospital complex. Investigations revealed that the biomedical waste generation varies from ward to ward based on the nature and function of the wards. The approach is to follow the waste generation pattern from the source to the point of final disposal. This entails the following procedures:
(i) Knowing the wards from which each particular waste bin is carried from and the contents of such bin.
(ii) Estimating the number of patients in any particular ward.
(iii) Sorting out of the wastes into different components.
(iv) Determining the weights of each component and the ash residue resulting from the wastes that were incinerated.

Waste Generation Pattern and Characterization

The hospital has 633 beds spread across various wards and departments. The Environmental Health Department is the unit saddled with the responsibility of waste management in the premises. However, it was discovered that waste generation data was practically non-existent, a bane of effective hospital waste management in Nigeria (Coker *et al* [4]). Nevertheless records show that about 300,000 patients are admitted annually, with over 12 million patients till date since the hospitals' inception in November 1957.
Wastes generated in the various wards are stored in plastic or metal waste bins from where they are collected for disposal. The amount of wastes generated at any ward or section is primarily a function of the number of patients and the nature of the ward. Such wards or sections include Labour, Paediatrics, Laboratories, Mortuary, Theatres, Blood banks, Casualty, Pharmacy, Radiology, Instrument etc. Although wastes emanating from these wards are fairly consistent in composition, but its volume at any point in time depends on the number of patients. This has been similarly found out by Waseem *et al* [5] in a study on hospital waste management in Karachi, Pakistan. Table 2 shows the different wards in the hospital complex, their activities and the number of beds.

Air Pollution VIII, C.A. Brebbia, H. Power & J.W.S Longhurst (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-822-8

Table 2. UCH wards and beds capacity.

	Name of ward	Activity of the ward	No. of beds
1	Labour	Giving birth to babies	11
2	Casualty	Treatment of accidents victims and emergencies	13
3	West 1, 2, 3, & 4	General medical practice	112
4	Southwest 1,2,3 & 4	General medical practice including obstetrics and gyneacology	240
5	Radiology	X-ray	16
6	Special Baby Care	Intensive baby care and post-natal activities	128
7	Paediatrics	General children care	32
8	Instrument	Manufacture of body parts	49
9	Others	Blood banks, laboratories, pharmacy, mortuary etc.	32

The quantity and type of waste to be incinerated are the primary criteria for selecting the incinerating devices to be employed. The contents of the wastes depend on the wards they are coming from (i.e. the sources). These wastes are categorized according to their characteristics and include:

(i) Absorbants (swabs, pads, garments, bandages) constituting about 32.5%
(ii) Pathological wastes (surgical biopsies, post-mortem samples) constituting about 18%
(iii) Glass (slides, pipettes, injection bottles) constituting about 8.5%
(iv) Plastic (PVC products, syringes) constituting about 37%
(v) Sharps and needles constituting about 4%

Waste disposal option

The waste disposal option in the case study - incineration, allows for on-site disposal. Incineration is a pre-treatment process available to improve the standard of landfill. The success of incineration as a technique for treating hospital waste depends on the proper operation of the incinerator and its pollution control devices. Proper incineration may provide economic benefits through waste heat recovery. The objectives of the incinerator for hospital waste as documented [1] include the following:

(i) The pathogens in the waste must be destroyed
(ii) Waste volume substantial reduction
(iii) Good ash quality should be ensured
(iv) Emission of particulate matter, organic compounds, carbon monoxide and acid gas must be minimized.

The incineration process consists of the following steps:

(a) Waste preparation,
(b) Waste charging,
(c) Waste combustion,
(d) Pollution control and waste heat recovery, and
(e) Residual ash handling

For the University College Hospital case study, the incinerating facilities currently in use are the local metal – cased, earth – brick furnace incinerator and the modern diesel - fuel continuous - duty incinerator. The locally made incinerator is made from burnt earth brick binded with sulphate cement. It is cased with mild steel plates. It can handle up to 1.76m^3 of waste per cycle which is about 7 times the volume of wastes that can be handled by the newly – installed incinerator. It is ignited by using coal or charcoal. The exhaust is linked to the waste heat boiler and later the damper which facilitates air pollution control. From the damper, it links the central chimney thus releasing the exhaust into the atmosphere at a great height which is a vital requirement for effective pollution control.

Findings and discussion

It was found out that biomedical wastes from various wards are kept in plastic or metal waste bins placed strategically at various locations within the hospital premises. Wastes are bagged in disposable paper sacks which are sealed. This discourages scavenging and at the same time prevents absorption of moisture from the environment. It was also discovered that high moisture content affects combustion and hence aids emission of pollutants from the incinerator. Thus, it is important that moisture should be checked as much as possible. Additionally, incomplete combustion, overcharging and predomination of waste feed with plastic products are major sources of air pollution. However, a simple pollution control device - the cyclone separator is used to manage the pollution that may arise from the incinerating operations. It is locally manufactured using metal plates and the construction is quite easy. It mainly collects particles resulting from the operation of the incinerator. The exhaust gases are made up of particulate (0.01 to 50microns) and non-particulate (greater than 0.05mm) gases. The cyclone has a gas entrance to cause the gas to swirl inside the cylindrical body. Though, the particles and the gas in the cyclone have the same tangential velocity, the particles however have a greater normal velocity. This forces the particles (e.g. heavy metal oxides) to move toward the cyclone wall, where they are separated from the gas stream and fall to the bottom of the cyclone. Then, the cleaner air passes through the stack at the centre of the separator. This device has been tested and found very effective, having been designed with local materials at a relatively cheap cost.

The determinant of a successful incineration operation is the quality of the ash residue, which is initially assessed by visual inspection. A good ash quality tells of how effective the combustion reaction has been. Thus, potentially - polluting emittants such as plastics and absorbants which form the bulk of the wastes, should be restricted to the old incinerator with the cyclone separator device while the others can be incinerated in the new, diesel – fuel continuous duty incinerator. Furthermore, the ash residue was subjected to laboratory analysis. It was found to be rich in fertilizer components, which makes it a potential resource. The breakdown of the chemical laboratory analysis of the ash residue of the different components are presented in table 3. From table 3, it is obvious that the highly infectious wastes such as pathological wastes and sharps and needles are very rich in nitrogen which fixes some nitrogen into the soil for plant growth.

Air Pollution VIII, C.A. Brebbia, H. Power & J.W.S Longhurst (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-822-8

Table 3. Breakdown of chemical analysis of the ash residue

Components	pH	% Nitrogen	% Potassium	% Phosphorous	% Organic Carbon
Plastics (PVC)	6.7	0.018	1.453	0.422	1.86
Pathological wastes	5.1	0.502	3.038	0.411	1.45
Sharps and needles	5.0	0.417	0.642	0.552	5.19
Papers and paper products	2.0	0.033	0.436	0.408	1.89
Absorbants	6.6	0.036	4.752	0.342	0.28

The breakdown of the daily generation of biomedical wastes monitored over a period of one month is presented in table 4. The values quoted represent weekly averages over the one month monitoring period. Sharps and pathological wastes were not always available for collection by the research team everyday. Food wastes which were separated from biomedical wastes were not incinerated. The incinerated process spanned between 5 and 25 minutes.

Conclusions and Recommendations

A successful hospital waste management practice that is thorough and pollution – free, via incineration at University College Hospital, Ibadan is not a difficult feat to achieve. The demands are not impossible to meet and following the findings highlighted in this research, the disposal of biomedical wastes is feasible. Given the fact that the hospital is a model in Nigeria, it serves as a reference point for other health facilities in the country. However, the following guidelines should be should be given due attention:

(1) Wastes should be properly bagged and sealed from the source of their generation.
(2) The moisture content of these wastes should be regulated to the barest minimum.
(3) Highly polluting wastes such as plastics and absorbants should be evenly distributed across waste feed cycles instead of concentrating them in a particular cycle.
(4) Overcharging the incinerator with wastes should be avoided as much as possible
(5) All necessary routine checks should be done, so as to ensure total combustion.
(6) Adequate records of the waste management practice should be kept.
(7) All personal safety equipments must be used during operation.
(8) Only trained personnel should handle the incinerator.
(9) Containers of flammable liquids or explosives should never be fed into the incinerator.
(10) The Federal Government of Nigeria should formulate policies that would regulate air emission.

Air Pollution VIII, C.A. Brebbia, H. Power & J.W.S Longhurst (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-822-8

Table 4. Quantification of the daily generation of biomedical wastes at UCH, Ibadan.

Days	Categories of wastes	Aggregate weight (kg)	Aggregate volume (litre)	Percentage (%)	Ash weight (kg)
Monday	Absorbants	80.0	640.0	30.0	4.00
	Glass	6.0	48.0	2.10	0.60
	Plastics	80.0	640.0	30.0	8.50
	Paper	64.0	512.0	22.38	6.20
	Sharps	8.0	64.0	2.80	0.40
	Food	48.0	384.0	16.78	__
	Daily total weight (kg)	286	__	__	__
Tuesday	Absorbants	72.0	576.0	28.13	3.60
	Glass	8.0	64.0	3.13	0.40
	Plastics	96.0	768.0	37.50	9.00
	Paper	24.0	192.0	9.38	2.00
	Sharps	none	__	__	__
	Food	56.0	448.0	21.88	__
	Daily total weight (kg)	256	__	__	__
Wednesday	Absorbants	96.0	768.0	32.82	3.60
	Glass	4.0	32.0	1.37	0.50
	Plastics	64.0	512.0	21.88	6.00
	Paper	60.0	480.0	20.51	5.80
	Sharps	none	__	__	__
	Food	68.50	548.0	23.42	__
	Daily total weight (kg)	292.50	__	__	__
Thursday	Absorbants	64.0	512.0	25.60	3.20
	Glass	8.0	64.0	3.20	0.80
	Plastics	72.0	576.0	28.80	7.20
	Paper	32.0	256.0	12.80	3.00
	Sharps	9.60	76.80	3.84	0.50
	Food	64.0	512.0	25.60	__
	Daily total weight (kg)	249.60	__	__	__
Friday	Absorbants	60.0	480.0	24.39	3.00
	Glass	8.0	64.0	3.25	0.80
	Plastics	68.0	544.0	27.64	6.50
	Paper	40.0	320.0	16.26	4.00
	Sharps	none	__	__	__
	Food	70.0	560.0	28.46	__
	Daily total weight (kg)	246.0	__	__	__
Saturday	Absorbants	70.0	560.0	24.18	3.50
	Glass	4.50	36.0	1.56	0.60
	Plastics	75.0	600.0	25.91	7.50
	Paper	60.0	480.0	20.73	6.00
	Sharps	none	__	__	__
	Food	80.0	640.0	27.73	__
	Daily total weight (kg)	289.50	__	__	__
Sunday	Absorbants	100.0	800.0	32.78	5.00
	Glass	5.00	40.00	1.64	0.65
	Plastics	60.00	480.0	19.67	6.00
	Paper	70.00	560.0	22.95	7.00
	Sharps	none	__	__	__
	Food	70.00	560.0	22.95	__
	Daily total weight (kg)	305.0	__	__	__

References

[1] United State Environmental Protection Agency. *Guide for Infectious Wastes Management,* EPA Publication, pp. 1-91, 1986.

[2] World Health Organization. WHO to provide potable water to Nigerian communities. *Bi-annual bulletin of the World Health Organisation,* **2(1),** pp. 17-18, 1997.

[3] Coker A. O., Sangodoyin, A. Y. & Ogunlowo O. O. Managing Hospital Wastes in Nigeria. *Proceedings of the 24th Annual Conference of Water, Engineering and Development Centre, UK*, pp. 70-72, 1998.

[4] Coker A. O., Sikiru K. A., Sridhar, M. K. C. & Sangodoyin A. Y. Characterization and Management of Solid Hospital Wastes, *Proceedings of the 25th Annual Conference of Water, Engineering and Development Centre, UK*, pp. 331-334, 1999.

[5] Waseem, A., Iqbal, A. & Hassan, Z. Field Investigation on Characterization and Management of Karachi Hospital Waste, *Environmental News*, **3(1)**, pp. 2 – 6, 1995.