Study of Bio-Medical Waste Management of Gwalior & Bhind hospitals

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Abstract: Bio medical waste a significant impact on health and environment. In this paper the study involve various hospitals of Gwalior and Bhind city, the assessment of biomedical waste generated by them and to the design an incinerator according to the date obtained by hospitals for its disposal .

The study involves the analysis of assessment of biomedical waste generated per bed day and also designing a suitable incinerator for the disposal of waste being generated according to the data obtained by hospitals of Gwalior and Bhind respectively in Gwalior 88.kg/day and Bhind 79.1kg/day.

Waste generated incineration is one of the best method among various disposal facilities to detoxify medical waste, Basically incineration can be defined as the thermal decomposition of waste at elevated temperature say 1100°C and 1500°C under controlled operational condition which leave co_2 and Water and ash as it bi-product.

I. INTRODUCTION

According to bio-medical waste means waste generated during the diagnosis, treatment or immunization of human being. Management of healthcare is an integral part of infection control and hygiene program in healthcare setting. These setting are a major contributor to community-acquired infection, as they produce large amounts of biomedical waste.

Biomedical waste can be categorized based on the risk of causing injury and/or infection during handling and disposal .waste targeted for precautions during handling and disposal includes sharps (needles or scalpel blades), pathological waste (anatomical body parts, microbiology cultures and blood samples) and infectious waste (items contaminated with body fluids and discharges such as dressing, catheters and I.V lines).other waste generated in healthcare setting includes radioactive wastes, mercury containing instruments and polyvinyl chloride (PVC) plastics.

II. OBJCTIVE OF STUDY

A. To dispose the bio medical waste and to prevent transmission of disease from patient to patient, from patient to health worker and vice versa.

B. To prevent general exposure to the harmful effect of the cytotoxic, genotoxic and chemicals biomedical waste and to prevent injury to the health care worker and workers and workers in support services, while handling biomedical waste.

C. To design the incinerator as per the data obtained by the assessment of bio medical waste for its disposal.

III. METHODOLOGY

1) *Study Area:* In Gwalior hospitals like BIMR ,clinics, laboratories some other hospitals data collection .there are various type of waste ,and denotes all different waste in different colours like;

a) Yellow bag-(non chlorinate plastics bags) separates collection system lading to effluent treatment system .human and animals anatomical waste, solid waste, expired or discarded medicines, chemical waste, lab waste, chemical liquid waste.

b) Red bag-(Non chlorinated plastic bags or container) contaminated waste(recyclable)tubing ,bottles, intravenous tubes an sets, catheters, urine bag, syringes(without needles) and gloves.

c) White waste-(translucent), puncture, leak, tamper, proof containers, waste sharps including metals.

d) Blue bag –(cardboard boxes with blue colored marking) glass

IV. INCINERATOR TECHNOLOGY

Incineration may be defined as the thermal destruction of the waste at elevated temperature say 1100°C to 1500°C under controlled operational condition. The product combustion are carbon-di-oxide, water, and ash as a residue. The unit in which the process takes place is termed as incinerator.

A. Incinerators To Treat Bio-Medical Waste

There are basically three types of incinerators that are available for the incineration of bio-medical waste, namely;

1) Multiple-chamber (retort and in-line)
2) Controller-air
3) Rotary kiln

B. Quantification of Waste

From the study it can be concluded that average waste quantification in Gwalior   hospitals covering one of the big hospital and 20 clinics and laboratories.

Total waste generated per day of Gwalior   = 88.3kg/day.

Total waste generated per day of Bhind   = 87.5kg/day.

V. DESIGN OF INCINERATOR

A. Design of Primary Chamber

For designing the primary chamber, initially volume of the chamber is to be found out. For finding out the volume 100kg of a waste is dumped as a heap and the volume of the volume of the heap is considered.

Volume of the heap = $6m^3$

Assuming a suitable depth of 2.5m, we can find out the area of the chamber

Area = v/depth = 6/2.5

$2.4m^2$

Assume length and breadth as 1.5:1

Therefore L/B = 1.5/1

L = 1.5B

Dimension of the primary chamber = L*B*H

Therefore A = L*B

2.4 = 1.5B*B

$2.4 = 1.5B^2$

B = 1.26m

L = 1.89m

H = 2.5m

B. Heat And Material Based Sample Calculation

A heat and material balance is an important part of designing and/or evaluating incineration. The procedure entails a mathematical evaluation of the input and output condition of the incineration. It can be used to determine the combustion air and auxiliary fuel requirement for incinerating a given waste and/or to determine the limitations of an existing incinerator when charged with a known waste.

1) *Assumption:* an incinerator is to be designed to incinerate a mixture of 30% red bag and 70% yellow bag (with a PVC contented 4%) biomedical waste.

Throughout is to be 100kg/h of waste. The auxiliary fuel is natural gas; the waste has been ignited; and the secondary burner is modulated design requirements are summarized as follow:

Secondary chamber temperature: 1100°c

Flue gas residence time at 1000°C: 1 second

Residual oxygen in flue gas: 6% minimum.

Chemical characteristics

Components	Empirical Formula	Molecular Weight	Higher Heating Value (kj/kg)
Tissue	$C_5H_{10}O_3$	118.1	20,471
Cellulose ,swabs, Bedding	$C_6H_{10}O_5$	162.1	18,568
PVC4 %	$(C_2H_3Cl)_x$	62.5	22,630
Sharps	Fe	55.8	0
Moisture	H_2O	18.0	0
Disinfectants, Alcohol	C_2H_5OH	16.1	30,547
Glass	SiO_2	60.1	0
Plastics-poly-ethylene 96%	$(C_2H_4)_x$	28.1	46,304

1) *Step 1:* Assumptions

Calculations involving incineration of biomedical waste are usually based on a number of assumptions. In our design, the chemical empirical formula, the molecular weight and the higher value of each of the main components of biomedical waste have been taken as above.

i) Input temperature of waste fuel and air is 15.5°C.
ii) Air contains 23% by weight 0_2 and 77% by weight N_2.
iii) Air contain 0.0132kg H_2O/kg dry air at 60% relative humidity and 26.7°C dry bulb temperature.
iv) For any ideal gas 1kg mole is equal to 22.4 m^3 at 0°C and 101.3kpa.
v) Latent heat of vaporization of water at 15.5C is 2460.3kj/kg.

Components	HIV kj/kg	Input kg/h	Total heat in kj/h
$C_5H_{10}O_3$	20,471	4.5	92,119.5
H_2O	0	24.0	0.0
$(C_2H_4)_x$	46,304	24.5	1,134,448.0
$(C_2H_3Cl)_x$	22,630	2.8	63,364.0
$C_6H_{10}O_5$	18,568	35.7	662,877.6
Ash	0	8.5	0.0
		100.0	1,952,809.1kj/h

2) *Step 2:* Calculation of Material Input

The above table provides a range of characteristics for various type of biomedical waste. Sound judgment should be exercised when making use of this table to assign the components weight percent required performing heat and material balance calculations.

The red bag waste is typically composed of mainly human tissue as indicated in table 3A. based on an input of 30% of 100kg/h (i.e. 30kg/h) the red bag was assumed to have the following composition.

Tissue (dry) $C_6H_{10}O_3$ 0.15 * 30 = 4.5 kg/h
 Water H_2O 0.8 * 30 = 24.0kg/h
Ash   0.05 * 30 = 1.5kg/h
Total red bag   = 30.0kg/h

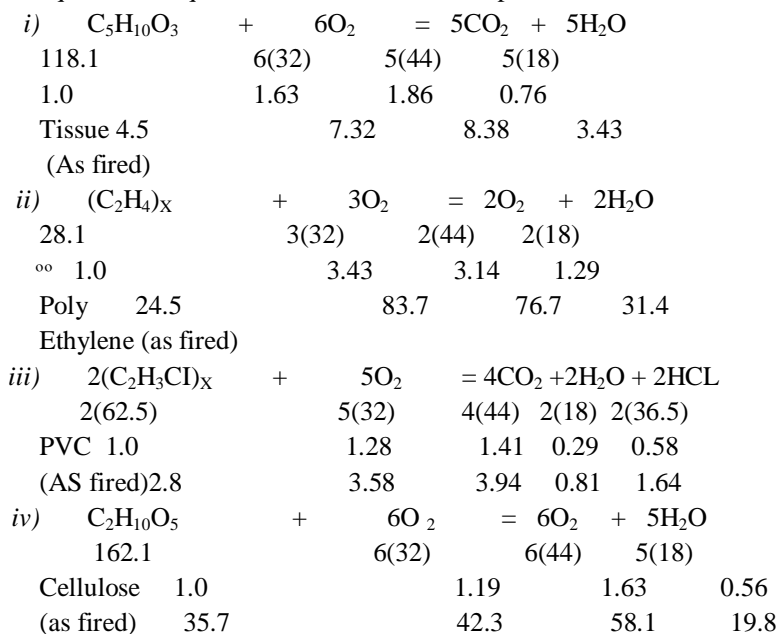The yellow bag waste input is 70% of 100kg/h (i.e. 70kg/h) And was assumed to have the following composition.
Polyethylene $(C_2H_4)_x$ 0.35 * 70 = 24.50kg/h
Polyvinylchloride $(C_2H_3Cl)_x$ 0.04 * 70 = 2.80kg/h
Cellulose $C_6H_{10}O_S$ 0.51* 70 = 35.70kg/h
Ash   0.1 * 70 = 7.0 kg/h
Total yellow bag   = 70.00kg/h

3) *Step 3:* Calculation of heat input of waste (k j/h)
The HIV and heat input of each components are tabulated above.

4) *Step 4:* Determination of stoichiometric oxygen for waste
The total stoichiometric (theoretical) amount of oxygen required to burn (oxidize) the waste is determine by the chemical equilibrium equation of the individual components of the biomedical waste and are provided in the following.

i) $C_5H_{10}O_3$ + $6O_2$ = $5CO_2$ + $5H_2O$

118.1		6(32)	5(44)	5(18)
1.0		1.63	1.86	0.76
Tissue 4.5		7.32	8.38	3.43
(As fired)				

ii) $(C_2H_4)_X$ + $3O_2$ = $2O_2$ + $2H_2O$

28.1		3(32)	2(44)	2(18)
∞ 1.0		3.43	3.14	1.29
Poly 24.5		83.7	76.7	31.4
Ethylene (as fired)				

iii) $2(C_2H_3CI)_X$ + $5O_2$ = $4CO_2$ +$2H_2O$ + $2HCL$

2(62.5)		5(32)	4(44)	2(18)	2(36.5)
PVC 1.0		1.28	1.41	0.29	0.58
(AS fired)2.8		3.58	3.94	0.81	1.64

iv) $C_2H_{10}O_5$ + $6O_2$ = $6O_2$ + $5H_2O$

162.1		6(32)	6(44)	5(18)
Cellulose 1.0		1.19	1.63	0.56
(as fired) 35.7		42.3	58.1	19.8

The stoichiometric oxygen required to burn the combustible components of the biomedical waste (67.5kg/h oxygen (sum of 7.32, 83.7, 3.58, 42.3).

5) *Step 5:* Determination of air for water based on 150% excess
From step 4, stoichiometric oxygen is 136.9 kg/h.
Therefore, stoichiometric air = 136.98*100/23 = 595.2kg/h air
Total air required for waste (at 150% excess) = (1.5*595.2)+ 595.2 =1488kg/h

6) *Step 6: Material Balance*
Total mass in waste = 100.0kg/h
Dry air = 1488.0kg/h
Moisture in air = 19.6 kg/h (1488* 0.0132)
Total mass in = 1607.6 kg/h
Total mass output (assuming complete combustion)

i) *Dry Product From Waste*
Air supplied for waste
= 1488.0 kg/h
Less stoichiometric = 595.2 kg/h
Air for waste
Total excess air = 892.8 kg/h or 150%
Add nitrogen from
Stoichiometric air
0.77 * 595.2 = 458.3kg/h
Subtotal = 1351.1kg/h
Add total CO2 from combustion.
CO_2 formed from $C_5H_{10}O_3$ = 8.38Kg/h

CO_2 formed from $(C_2H_4)_X$ = 76.70kg/h
CO_2 formed from $(C_2H_3CI)_X$ = 3.94kg/h
CO_2 formed from $C_6H_{10}O_5$ = 58.10kg/h
Total waste from dry product = 1498.22kg/h

ii) *Moisture*

H_2O in the waste = 24.0 kg/h
H_2O in the combustion reaction = 55.44kg/h
H_2O in combustion air = 19.6 kg/h[step 6]
Total moisture = 99.04 kg/h

iii) *Ash Output* = 8.5 kg/h

iv) *HCL Formed From Waste*

HCL formed from ($C_2H_3CI)_X$ = 1.64 kg/h
Total mass out = sum of (A, B, C, D)
= 1607.4 kg/h

7) *Step 7:* Heat balance

i) Total heat in from waste (Q I)

Q i = 1,952,809.1 KJ/h [see step 3]

ii) Total heat out based on equilibrium temperature of 1100°c (Q o)

a. Radiation loss = 5% of total heat available
= 0.05 * 1,952,809.1
= 97,640.0 KJ/h

b. Heat to ash = mCpdt
= (8.5) (0.831) (1084.5)
= 7660.4 KJ/h
Where m = weight of ash
= 8.5 kg/h
Cp = mean heat capacity of ash
= 0.831 KJ/h C (assumed average value)
dT = temperature difference
= (1100 – 15.5) °C =1084.5°C

c. Heat to dry combustion
Products = mCpdT
= (1498.22) (1.086) (1084.5)
= 1,764,554.1 KJ/h
Where m = weight of combustible products
= 1498.22kg/h
Cp = mean heat capacity of dry product
= 1.086 KJ/kg°C (assumed average value)
dT =(1100-15.5)C = 1084.5C

d. Heat of moisture = (mCpdT) + (mHv)
(mCpdT) + (mHv) = (99.04 * 2.347 *1084.5) + (99.04 * 2460.3)
= 252,088.6 + 243,668.1
= 495,756.7KJ/h
Where m = weight of water = 99.04 kg/h
Cp = mean heat capacity of water
= 2.347 KJ/h C
dT = (1100- 15.5) C = 1084.5C
Hv = latent heat of vaporization of water
= 2460.3KJ/h
Total heat out (Qo) = sum of (i, ii, iii, iv) = 2,365,611.2Kj/h

Net balance = Qi - Qo

= 1,952,809.1 – 2,365,611.2

= -412,802.1 KJ/h (deficiency)

Auxiliary fuel must be supplied to achieve

Design temperature of 1100°C

8) *Step 8:* Required auxiliary fuel to achieve 1100°C

i) Total heat required from fuel = 412,802.1 + 5% radiation loss = 433,442.2 KJ/h

ii) Available heat (net) from natural gas at 1100°C and 2.0%

Excess air = 15,805.2 KJ/m^3 (assumption)

Natural gas required = 433,442.2 / 15,805.2 m^3/h = 27.42m^3/h

9) *Step 9:* Product of combustion from auxiliary fuel

i) Dry product from fuel At 20% excess air = 16.0 kg [8] * 27.42m^3 /hm^3 fuel = 438.7 kg/h

ii) Moisture from fuel = (1.59 kg (8) /m^3fuel) * 27.42m^3/h = 43.59 kg/h

10) *Step 10:* Secondary chamber volume required to achieve one second

Residence time at 1100°C

i) *Total Dry Product*

From waste + fuel = 1498.22 kg/h + 438.7 kg/h

= 1936.9 kg/h

Assuming dry product have the properties of air and using the ideal gas law, the

Volumetric flow rate of dry product (dp) at 1000°C (Vp) can be calculated as

Follow

Vp = 1936.9kg dp/h * (22.4m^3)/29kg dp) *(1273k/273)* * (1h /3600s)

= 1.94m^3/s

ii) *Total Moisture*

From waste + fuel = 99.04 kg/h + 43.6kg/h = 142.6kg/h

Using the ideal gas law, the volumetric flow rate of moisture at 1000C (Vm) can

Be calculated as follow:

Vm = (142.6kg H_2O /h) * (22.4 m^3/18kg H_2O) * (1273K/273K) * (Ih/3600s)

= 0.23m^3/s

Total volumetric flow rate = sum of (I,ii)

= 1.94+ 0.23

= 2.17m^3/s

Therefore, the active chamber volume required to achieve one second retention is

2.17 m^3 (dead area with little or no flow should not be included in the retention

Volume).it should be noted that in sizing the secondary chamber to meet the

One second retention time required, the length of chamber should be calculated

From the flame front to the location of the temperature sensing device.

K = ° C + 273

11) *Step 11:* Residual Oxygen in the flue gas

Residual oxygen (%02) can be determined using the following equation:

EA (excess air)   = % O_2/(21%-%O_2)

Therefore, (150/100)   = %O_2/(21%-%O_2)

%02   = 12.6%

VI. CONCLUSION

A. Waste generation rate in BIMR hospital varies from 75-85 kg/day and in case of   private hospital the waste generation varies from 15-20kg/day.

B. An incineration has been designed to treat the biomedical waste which is being generated in Gwalior city with a capacity of 100kg/hr.

C. From material balance analysis by assuming by assuming complete combustion total mass input (1607.6kg/h)

D. From the heat balance analysis , total heat input is found to be 1952809.1kj/h and total heat output is found to be 2365611.2kj/h and therefore a deficiency of 412802.1kj/h incurred and hence this deficiency should nullified by supplying an auxiliary fuel to achieve the design temperature of 1100°C

E. From the analysis its is found out that an additional amount of 27.42m^3/hr natural, gas is required to nullify the deficit and to achieve a design temperature of 1100°C

F. From the design the volume of secondary chamber is found to be 2.17 m^3 with a detention time of 1sec.

G. The design dimension of primary chamber obtained is 1.8*1.2*2.2 (L*B*H)

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