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An Analysis of Bio-Medical Waste for Bijnor City: "Design of Incineration Plant"

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Abstract: ***Biomedical waste contains potential health and safety hazards. The purpose of the study is to get background information about bio medical waste handling procedures followed by hospitals in Bijnor district. This study also asses the disposal of generated biomedical wastes and their health risks on our society. The management of hospital waste requires its removal and disposal from the health care establishment s as hygienically and economically as possible by methods that a l l s t ages minimizes the risk to public health and t o Environment . To analyze the present situation analysis of medical waste management systems was performed to understand the various handling and disposal procedures, the knowledge and awareness of individuals involved in medical waste generation, handling and Disposal , and the potential impacts of the waste stream on both human health and the natural environment. The method adapted for present study was literature review and survey method. The data collection was done through questionnaire (data collect ion form) , informal interviews and site visits . It was found that a variety of methods were used by the medical facilities to dispose their wastes including burning burial , entombing, selling, dumping, and removal by municipal bins . The waste disposal practice was found to be quite unsafe, and both clinical and non-clinical wastes were found to be thrown together. There was insufficient awareness of the magnitude of the medical wastes issue by concerned individuals at different levels from director or divisional head to waste pickers. There was no safety measure observed in dealing with waste disposal or laboratory analysis of infectious diseases. Medical waste incineration is identified as the most preferred disposal method. It is important to point out that there is a great potential to emit air toxic pollutants from such incinerators if improperly operated and managed.. The results of the study demonstrate that there is a need of strict enforcement of legal provisions and a better environmental management system for the disposal of biomedical waste.***

Keywords: bio medical waste, bio medical waste management system, hospital waste, Design of Incineration unit

1. Introduction

With growing world population today, there is a great need to manage the civic amenities including solid waste collection and disposal. Waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in a research activities pertaining there to, or in the production or testing of biological , and including human anatomical waste, animal waste, microbiology and biotechnology waste, sharps, discarded medicines and drugs, soiled waste, solid waste, liquid waste, incineration ash, chemicals used in production of biological, chemicals used in disinfection, as insecticides, etc is called Bio medical waste. 85% of hospital waste is actually non-hazardous and around 10% is infectious while the remaining 5% is non-infectious. In addition to their infectious and toxic characteristics, the highly variable and inconsistent nature of biomedical waste streams has increased public concern about storage, treatment, transportation and ultimate disposal. Inadequate management of biomedical waste can be associated with risks to health care workers, patients, communities and their environment.

2. Study Area

Bio-medical waste management is one of the major fields of infrastructure Development, which has lacked due attention of policy makers and health managers, especially in Bijnor city. The present study area is Bijnor city, district of Utter Pradesh, where there is found to be little awareness about the importance and criticality of proper bio-medical waste disposal. There are 24 government and 120 private hospitals and small clinics.

In the Bijnor city around 40 lakhs people lives. There are no treatment plants in the city for treatment of Bio-medical waste. All the wastes which are generated in the hospitals, clinics or laboratories are collected and send the bio-medical waste for the treatment to **Synergy Waste Management Pvt. Ltd.**, **MEERUT.** Bijnor city is located at latitude of 29.37^{o}N and longitude of 78.13^{o}E at an elevation of 225m (738ft.) from mean sea level situated at the bank of river Ganga. Bijnor city nagar palika parishad has total 25 wards.

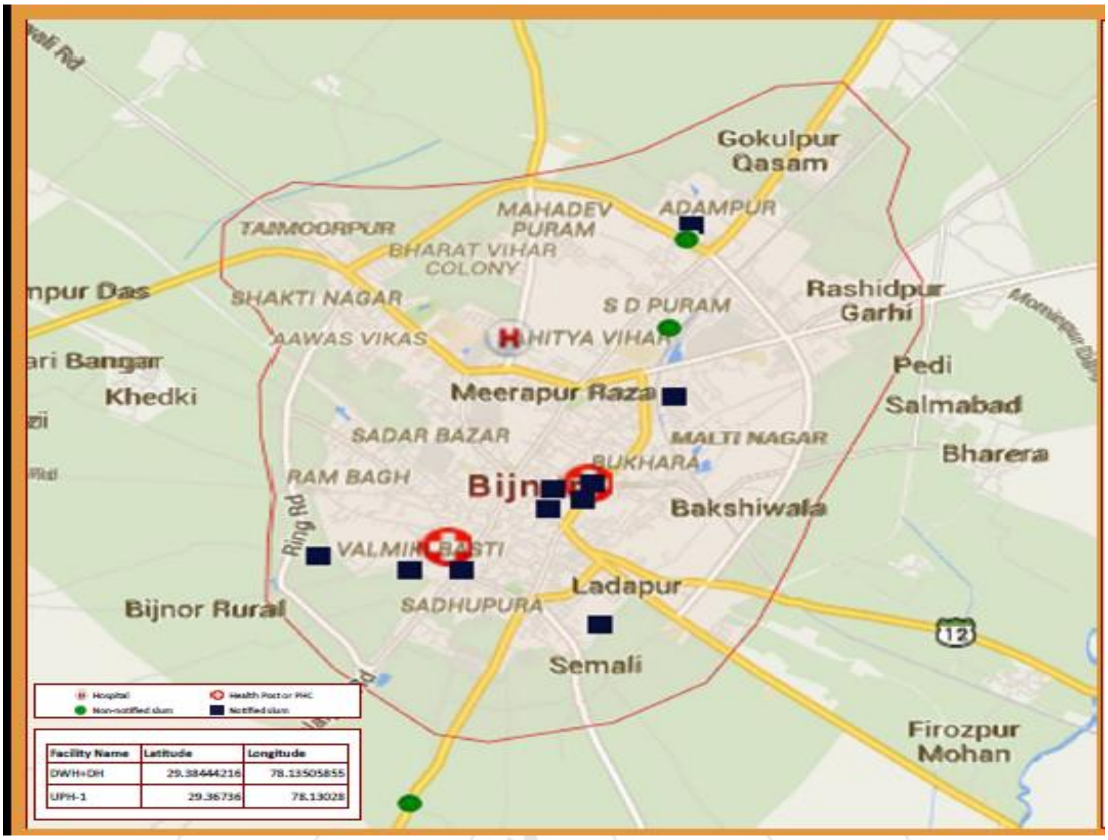

Figure 1: Bijnor district map

Figure 1 shows the thematic map of bijnor city in which important location has been depicted various main route of hospitals**.**

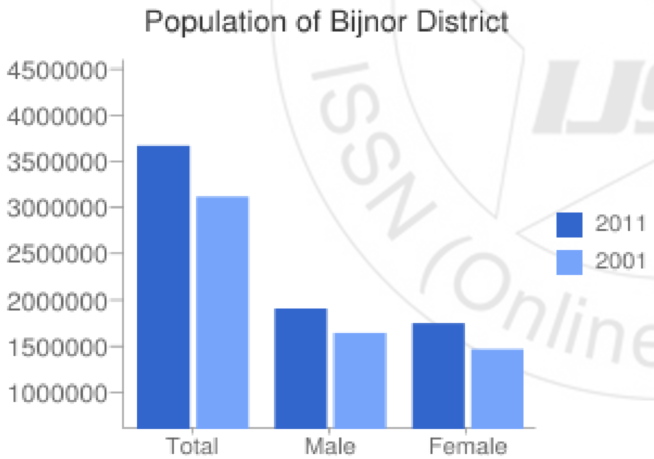

Figure 2: Population of Bijnor district

In the Bijnor city around 40 lakhs people lives. . If talking about whole district, major part is comprises of rural area and only 25% people lives in urban part of district.

3. Materials & Methods

There are various method are available for Bio-medical waste management such as incineration ,shredding , deep burial pit , autoclaving and microwaving. For the collection of data and requisite information we have visited Pollution Control Board, Bijnor and field survey of all the hospital present in the Bijnor city is done through questionnaire ,discussion with hospital staff and waste collection authority. After analysis of collected data and questionnaire we have concluded that a incineration plant is best suited for Bijnor city. So we have proposed a design of incineration plant for Bijnor city.

The type of question that were asked in questionnaire

A: Condition of waste receptacles

1) Is black coloured waste bin available in ward?
2) Is yellow colored waste bin available in ward?
3) Is red coloured waste bin available in ward?
4) Is blue coloured waste bin available in ward?
5) Has black bag been placed lining the inner side of black bin?
6) Has yellow bag been placed lining the inner side of yellow bin?
7) Has red bag been placed lining the inner side of red bin?
8) Has blue bag been placed lining the inner side of blue bin?
9) Is black bag securely fitted with the bin?
10) Is yellow bag securely fitted with the bin?
11) Is red bag securely fitted with the bin?
12) Is blue bag securely fitted with the bin?
13) Are waste bins covered?
14) If covered, is cover foot-operated?
15) Is the biohazard symbol imprinted over waste bags? 16 Are posters to guide users displayed near waste bins?

B. Segregation of waste

16) Does black bag contain only general waste?
17) Does yellow bag contain only soiled infected waste?
18) Does red bag contain only plastic waste?
19) Does blue bag contain only sharps waste?

C. Mutilation of recyclable waste
20) Are used hypodermic needles destroyed?
21) Is nozzle of used syringes destroyed?
22) Are used hypodermic needles found re-capped?
23) Are used hypodermic needles found bent?
24) Are used plastic bottles cut? 26 Are used plastic tubings cut?

D. Disinfection of plastics and sharps
25) Is disinfectant solution put into red containers?
26) Is disinfectant solution put into blue containers?
27) Is barrel and plunger of syringe separate before immersion into disinfectant solution?

Information was obtained through literature review and online search. After extensive literature search, a questionnaire was developed to collect information regarding disposal of biomedical waste generated in the hospitals. The hospitals were visited and the administration of the institutions were interviewed to get in-depth knowledge regarding waste management policy and training of staff. The study was explained to them and verbal consent was obtained. The statistical technique used for the analysis of collected data was estimation of simple percentage. From the analysis of data various graph are plotted in the result section .

4. Design of Incineration Plant

There are basically three types of incinerators that are available for the incineration of Bio-medical waste, namely:
- Multiple-chamber (retort and in-line)
- Controlled-air
- Rotary kiln

According to type of waste and their collection procedure we have designed multiple chamber incinerator.

Quantification of Waste
From the study it can be concluded that average wastes quantification in Bijnor city covering 23 Government hospital, 101 private hospitals and Nursing homes and 27 clinics and laboratories . they are generating 475 kg/day.

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 waste is dumped as a heap and the volume of the heap is considered.

Volume of the heap = 5m^3

Assuming a suitable depth of 2.2m, we can find out the area of the chamber
Area = v/depth = 5/2.2 = 2.3m^2
Assume length and breadth as 1.5:1
Therefore L/B =1.5/1
L =1.5B
Dimensions of the primary chamber = L*B*H
Therefore A = L*B
2.3 = 1.5B*B
2.3 = 1.5B^2
B = 1.238m
L = 1.857m
H = 2.2m
Where L = Length, B = Breadth , H = Height of incineration plant

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

Assumptions:
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.

Table 1: Quantity of waste generation in Bijnor city

S. No	Type of health care establishment	Quantity of waste generation /month(Kg)	Quantity of waste generation/day(Kg)
1	Government general hospital	3900	130
2	101Hospitals and Nursing home	7050	235
3	24 clinics and laboratories	3300	110

Total waste generation per month =14250 Kg
Total waste generation per day =475 Kg

Table 2: Chemical Characteristics of Bio-medical waste

Component	Empirical formula	Molecular weight	Higher heating value(kj/Kg)
Tissue	$C_5H_{10}O_3$	118.1	20471
Cellulose, swabs, bedding	$C_5C_6H_{10}O_5$	162.1	18568
Plastics- poly-ethylene 96%	$(C_2H_4)_x$	28.1	46304
Sharps	Fe	55.8	0
Moisture	H_2O	18.0	0
Disinfectants, Alcohol	C_2H_5OH	46.1	30547
Glass	SiO_2	60.1	0
PVC	$(C_2H_3Cl)_X$	62.5	22630

Throughput is to be 100 kg/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 follows:

Secondary chamber temperature: 1100°C Flue gas residence time at 1000°C: 1 second Residual oxygen in flue gas: 6% minimum

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 heating values of each of the main components of biomedical waste have been taken as above.
2. Input Temperature of waste, fuel and air is 15.50C.
3. Air contains 23% by weight O_2 and 77% by weight N_2.

4. Air contains 0.0132kg H_2O/kg dry air at 60% relative humidity and 26.7^oC dry bulb temperature.
5. For any ideal gas 1kg mole is equal to 22.4m^3 at 0^0C and 101.3kpa.
6. Latent heat of vaporization of water at 15.5^0C is 2460.3kj/kg.

Step 2: Calculation of Material Input

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

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

Tissue (dry) $C_6 H_{10}O_3$ 0.15 x 30 = 4.5 kg/h
Water H_2O 0.8 x 30 = 24.0 kg/h
Ash - 0.05 x 30 = 1.5 kg/h
Total Red Bag = 30.0 kg/h
The yellow bag waste input is 70% of 100 kg/h (i.e. 70 kg/h) and was assumed to have the following composition:
Polyethylene ($C_2 H_4$) x 0.35 x 70 = 24.50 kg/h
Polyvinylchloride (C 2 H 3 Cl) x0.04 x 70 = 2.80 kg/h
Cellulose C 6H 10OS 0.51 x 70 = 35.70 kg/h
Ash _ 0.1 x 70 = 7.0 kg/h
Total Yellow Bag = 70.00 kg/h

Table 3: Bag Component

Component	HHV kJ/Kg	Input Kg/h	Total heat in kJ/h
C5H10O3	204714	4.5	92119.5
H20	0	24.0	0.0
(C2H4)X	46304	24.5	1134448.0
(C2H3Cl)x	22630	2.8	63364.0
C6H10O5	18568	35.7	662877.6
ASH	0	8.5	0
TOTAL	292216	100	1952809.1

Step 3: Calculation of Heat Input of Wastes (Kj/H)

The HHV and heat input of each component are tabulated below.

Step 4: Determination of Stoichiometric Oxygen for Wastes

The total stoichiometric (theoretical) amount of oxygen required to burn (oxidize) the waste is determined by the chemical equilibrium equations 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
4.5 7.32 8.38 3.43
Tissue
(As fired)

ii. $(C_2H_4)_x + 3O_2 = 2CO_2 + 2H_2O$
28.1 3(32) 2(44) 2(18)
1.0 3.43 3.14 1.29
Polyethylene (as fired)

iii. $2(C_2H_3Cl)_x + 5O_2 = 4CO_2 + 2H_2O + 2HCl$
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. $C_6H_{10}O_5 + 6O_2 = 6CO_2 + 5H_2O$
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 component of the biomedical waste (67.5kg/h) is 136.9kg/h oxygen (sum of 7.32, 83.7, 3.58 and 42.3).

Step 5: Determination of Air for Waste 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

Step 6: Material Balance

Total Mass in Waste = 100.0 kg/h Dry air = 1488.0 kg/h Moisture in air = 19.6 kg/h (1488 x 0.0132) [step1] Total Mass In = 1607.6 kg/h Total Mass output (assuming complete combustion)

A. Dry Products from waste

Air supplied for waste = 1488.0 kg/h
Less stoichiometric
Air for waste = 595.2 kg/h
Total excess air = 892.8 kg/h or 150%
Add nitrogen from
Stoichiometric air
.77 X 595.2 = 458.3 kg/h
Subtotal = 1351.1kg/h
Add total CO_2 from combustion:
CO_2 formed from $C_5H_{10}O_3$ = 8.38 kg/h
CO_2 formed from $(C_2H_4)_x$ = 76.70 kg/h
CO_2 formed from $(C_2H_3Cl)_x$ = 3.94 kg/h
CO_2 formed from $C_6H_{10}O_5$ = 58.10 kg/h
Total Waste Dry products = 1498.22 kg/h

B. Moisture

H_2O in the waste = 24.0 kg/h
H_2O from combustion reactions = 55.44 kg/h
H_2O in combustion air = 19.6 kg/h [step 6]
Total Moisture = 99.04 kg/h

C. Ash Output = 8.5 kg/h

D. HCl formed from wastes

HCl formed from $(C_2H_3Cl)_x$ = 1.64 kg/h
Total Mass out = Sum of (A, B, C, D)
= 1607.4 kg/h

Step 7: Heat Balance

A. Total Heat in From Waste (Qi)

Qi = 1,952,809.1 kj/h [see step 3]

B. Total Heat out Based on Equilibrium Temperature of 1100OC (Qo)

a) Radiation loss = 5% of total heat available
= 0.05 x 1,952,809.1
= 97640 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/kg. ^{o}C (assumed average value)
dT = Temperature difference
= (1100- 15.5) ^{o}C
= 1084.5^{o}C

c) Heat to dry combustion

Products = mCpdT
= (1498.22) (1.086) (1084.5)
= 1,764,554.1 kj/h
Where m = weight of combustion products
= 1498.22 kg/h
Cp = mean heat capacity of dry products
= 1.086 kj/kg^{o}C (assumed average value)
dT = (1100-15.5)^{o}C = 1084.5^{o}C

d) Heat to moisture = (mCpdT) + (mHv)

(mCpdT) + (mHv) = (99.04 x 2.347 x 1084.5) + (99.04 x 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/kg ^{o}C
dT = (1100- 15.5)^{o}C = 1084.5^{o}C
Hv = latent heat of vaporization of water
= 2460.3 kj/kg
Total heat out (Qo) = sum of (a, b, c, d) = 2,365,611.2 kj/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 1100oC

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 20% excess air = 15,805.2 kJ/m3 (assumption)
Natural gas required = 433,442 .2/15,805.2 m3/h = 27.42 m3/h

Step 9: Products of Combustion from Auxiliary Fuel

i) Dry Products from Fuel at 20% Excess Air = 16.0 kg [8] x 27.42 m^3 /h m^3 fuel = 438.7 kg/h
ii) Moisture From Fuel = (1.59 kg (8)/m^{3}fuel) x 27.42 m ^{3}/h = 43.59kg/h

Step10: Secondary Chamber Volume Required Achieving One Second Residence Time at 1000 °C

i) Total Dry Products From waste + fuel = 1498.22 kg/h + 438.7 kg/h = 1936.9 kg/h

Assuming dry products have the properties of air and using the ideal gas law, the volumetric flow rate of dry products (dip) at 1000°C (Vp) can be calculated as follows:
Vp = 1936.9 kg dp/h x (22.4 m3)/29kg dp) x (1273K / 273k)* x (1 h/3600s) = 1.94 m^3 /s

ii) Total Moisture From waste + fuel = 99.04 kg/h +43.6 kg/h = 142.6 kg/h
Using the ideal gas law, the volumetric flow rate of Moisture at 1000°C (Vm) can be calculated as follows:
Vm = (142. 6 kg H_2O/h) * (22.4 m^3/18kg H_2O) * (1273K/ 273k) * (lh/3600s) = 0.23 m^3/s
Total Volumetric Flow Rate = sum of (i , ii) = 1.94 + 0.23 = 2.17 m^3/s
Therefore, the active chamber volume required to achieve one second retention is 2.17 m^3 ('dead' areas – 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

Step 11: Residual Oxygen in the Flue Gas

The residual oxygen (%O_2) can be determined using the following equation:
EA (excess air) = % O_2/ (21%-%O_2)
Therefore, (150 /100) = % O2/ (21%-%O_2)
%O_2 = 12.6%

Step 12: Conclusion of design

1) An incinerator has been designed to treat the biomedical waste which is being generated in Bijnor city with a capacity of 100kg/hr.
2) From material balance analysis by assuming complete combustion total mass input (1607.6kg/hr) is found to be equal to total mass output (1607.4kg/ hr).
3) From the heat balance analysis, total heat input is found to be 1952809.1kj/hr and total heat output is found to be 2365611.2kj/hr and therefore a deficiency of 412802.1kj/hr incurred and hence this deficiency should nullified by supplying an auxiliary fuel to achieve the design temperature of 11000C.
4) From the analysis it is found out that an additional amount of 27.42m3/hr natural, gas is required to nullify the deficit and to achieve a design temperature of 1100oC.
5) From the design the volume of secondary chamber is found to be 2.17m3with a detention time of 1sec.
6) The design dimension of primary chamber obtained is 1.8*1.2*2.2 (L*B*H)

5. Result and Discussion

A field survey was conducted in 39 hospitals of Bijnor through convenience sampling. Hospitals of both government and private sector were included. The hospitals were visited and the presence or absence of waste management technique was noted. The administrators of the institutions were interviewed to get in-depth knowledge regarding waste management policy and training of staff. Data collected from questionnaire was analyzed using percentages.

1) During the field survey of hospitals various types of questions were asked an discussed with the medical staff. Following table is prepared of the questions.

Table 3: Questionnaire

Questionnaire	H_{17}	H_{18}	H_{19}	H_{20}	H_{21}	H_{22}	H_{23}	H_{24}	H_{25}	H_{26}	H_{27}	H_{28}	H_{29}	H_{30}	H_{31}	H_{32}
Type of hospitals	Govt.	Govt.	Govt.	Govt.	Govt.	Govt.	Pvt.	Pvt.	Pvt.	Pvt.	Pvt.	Pvt.	Pvt.	Pvt.	Pvt.	Pvt.
No. Of beds	25	30	25	23	22	12	10	5	12	15	16	13	10	12	8	6
BMW department	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
Sharp pit availability	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
Awareness about Bmw rules 1998	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Segregation of waste	No	No	No	No	No	Yes	Yes	No	No	No	No	Yes	No	No	No	No
Regular monitoring and record keeping	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Any training imparted	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
Any Standby mechanism for sharp at each point	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Use of sharp pit for final disposal	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
Frequency of collection of waste	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days	2-3 days
Bags are securely fitted with bin	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is disinfectant solution put into blue containers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

H_1 - DD upaddhayay district hospital Bijnor H_2 - Govt. women hospital,Bijnor H_3- Aaysha hospital nazibabad Bijnor H_4- Govt. hospital Chandpur siau H_5- Govt. hospital Nagina H_6- Govt. hospital(Women) Najibabad H_7- Govt. hospital Dhampur H_8- PHC noorpur H_9- Women hospital Chandpur H_{10}- Paras health centre Chandpur H_{11}- Govt. hospital Afzalgarh dhampur H_{12}- PHC najibabad H_{13}- PHC Dhampur H_{14}- PHC Jalilpur H_{15}- Govt. hospital Syohara, dhampur,bijnor H_{16}- PHC Haldaur,Bijnor H_{17}- PHC Kasimpur garhi H_{18}- PHC Kiratpur,Bijnor H_{19}- PHC Nahtaur Bijnor H_{20}- PHC Kadrabad,Bijnore H_{21}- PHC Sherkot, Bijnor H_{22}- Gov women hospital Najibabad ,Bijnor H_{23}- Ayushman health care, kiratpur road, Bijnor H_{24}- Agrawal clinic civil lines, Bijnor H_{25}- Buddha hospital ,judgi road H_{26}- Bhagirathi nursing home Bijnor H_{27}- Chaudhary child hospital, Bijnor H_{28}- Dayawati hospital , Dhampur , Bijnor H_{29}-J .K. eye hospital ,najibabad,Bijnor H_{30}- Kundan hospital , Bijnor H_{31}- Akanksha nursing home, Bijnor H_{32}- Bachpan nursing home, judgi road, Bijnor

2) Segregation of waste is an important step in waste management plan. Segregation is separation of risk waste from non-risk waste at source, that is at the ward bedside, operation theatre, laboratory, or any other room in the hospital where the waste is generated, by the doctor, nurse, or other person generating the waste. Segregation is done in all hospitals as shown in figure 3.

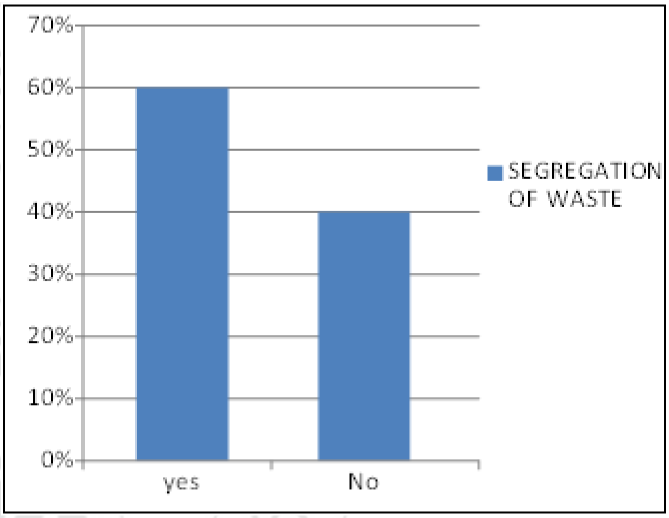

Figure 3: Is there segregation of waste?

3) All disposal medical equipment and supplies including syringes, needles, plastic bottles, drips and infusion bags shall be cut or broken and rendered non-reusable at the point of use by the person in-charge. Needle cutter used in 80% of hospitals in Bijnor district.

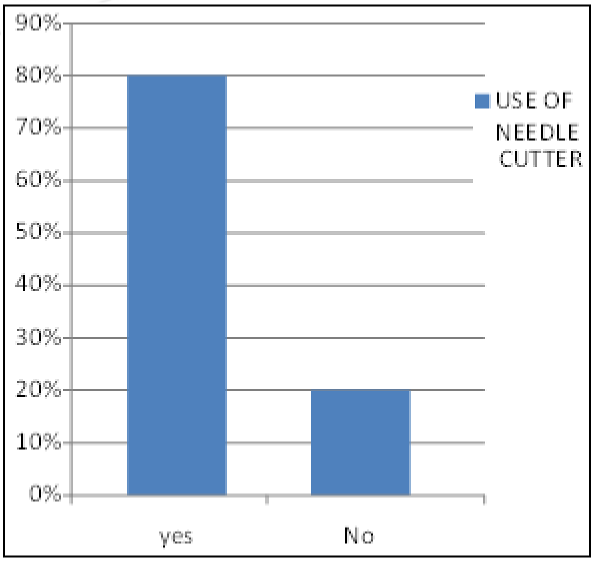

Figure 4: Needle cutter for used syringes

4) Hospital waste generation plan shows the disposal points of waste of every ward and department, details and numbers of every container and trolleys used for the disposal, time tables showing frequency of waste collection, duties and responsibilities for each of the different categories of hospital staff member. Figure 5 shows that 60% of hospitals have waste generation plan.

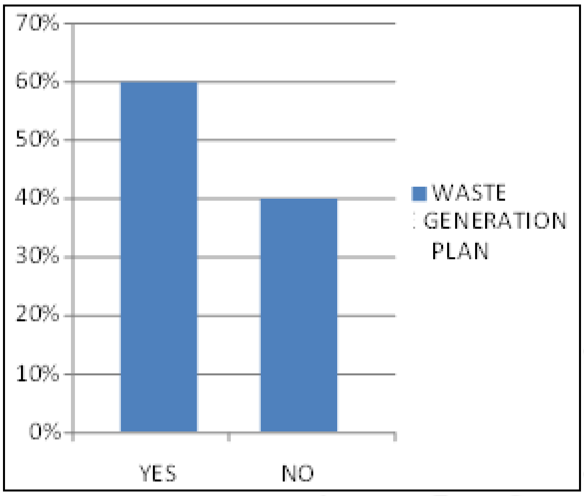

Figure 5: Hospital has waste generation plan?

5) Waste management team is responsible for better administration, preparation, careful planning, monitoring, periodic review and control disposal operations figure 6 shows that 60% of hospital have waste management team.

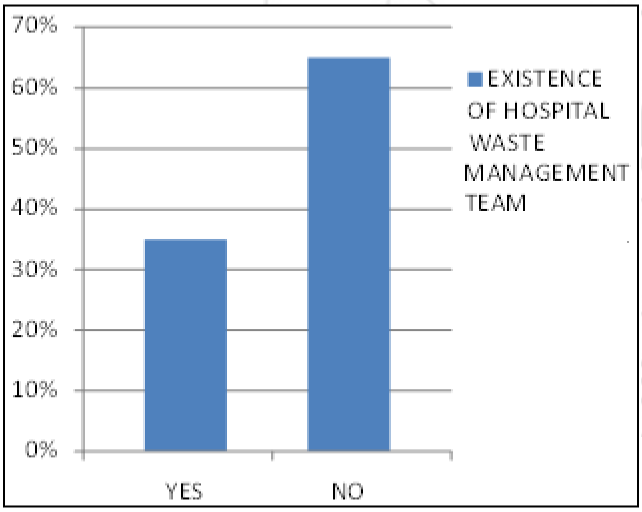

Figure 6: Existence of hospital waste management Team.

6) Segregation of waste in different coloured bags like yellow, red and black coloured containers was practiced in 80% of hospitals as shown in figure 7.

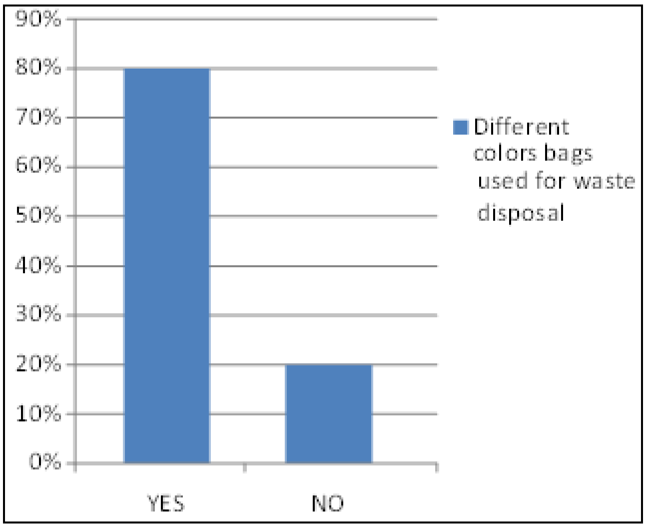

Figure 7: Different colors bags used for waste disposal

7) Infectious liquid waste from laboratories, different departments is produced in all hospitals but 40% hospitals have liquid waste management plan. That is shown in figure 8.

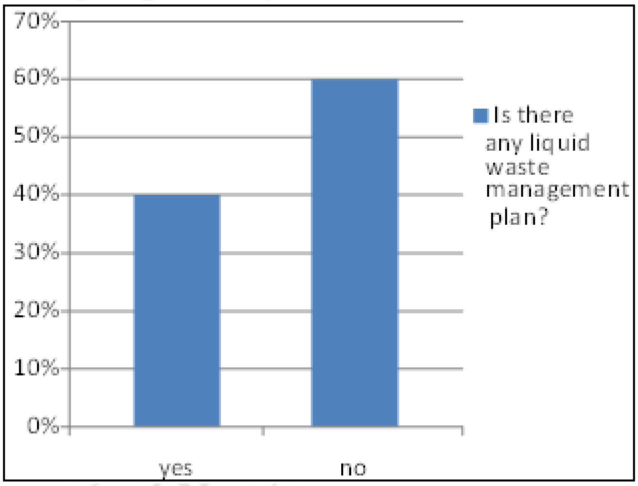

Figure 8: Is there any liquid waste management plan?

8) Record keeping of waste generated is very important as it provides information about categories and quantities of waste handled every day. Record of waste generated kept in 65% of hospitals as shown in figure 9.

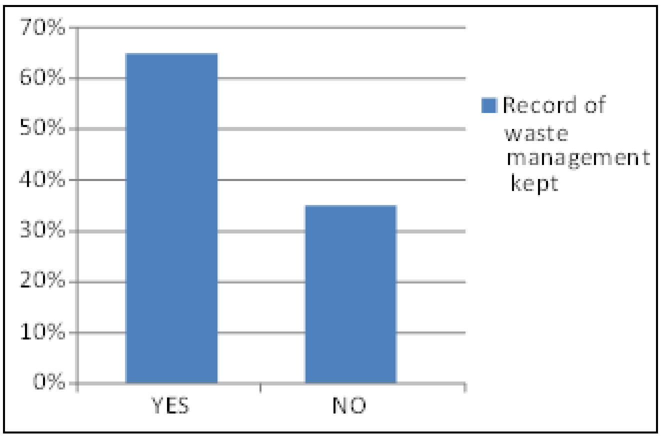

Figure 9: Record of waste generated kept

9) Pharmacist is member of waste management team in 80% of hospitals a shown in figure 10.

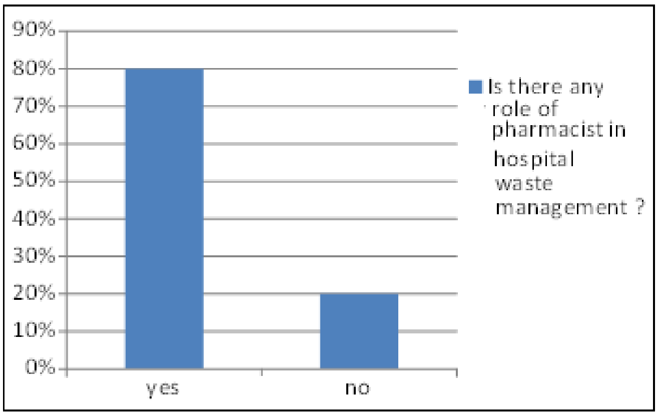

Figure 10: Is there any role of pharmacist in hospital waste management?

10) Depending upon the type and nature of the waste material and the organisms in the waste, risk waste should be inactivated or rendered safe before final disposal by a suitable thermal, chemical, irradiation incineration, filtration or other treatment method, or by a combination of such methods, involving proper validation and monitoring procedures. Figure 11. shows that incineration was considered the final treatment method in 80% of hospitals.

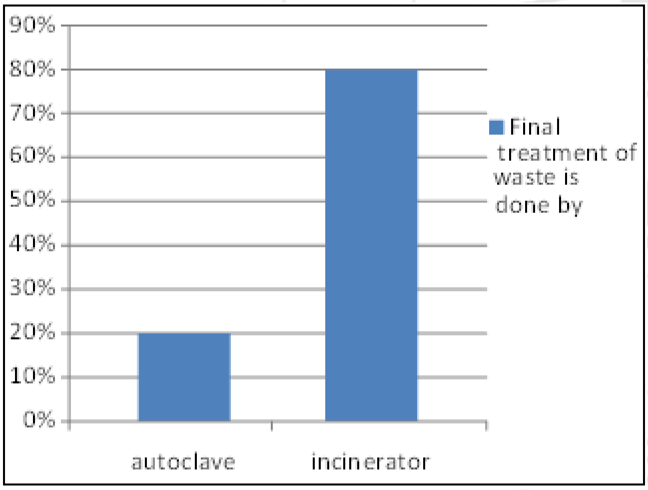

Figure 11: Final treatment of waste is done by

11) Vaccination of hospital employees is essential. It protects the employees against many infectious diseases like HBV and employees of all hospitals visited were vaccinated as shown in figure 12.

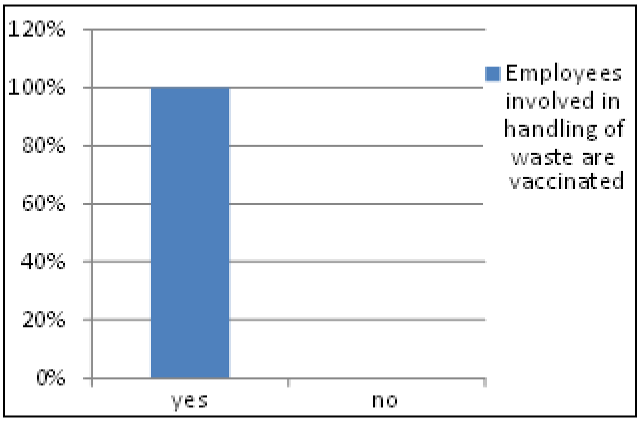

Figure 12: Employees involved in handling of waste are vaccinated

12) Hospital employees, private company and other co-operative hospitals could be involved in waste management as shown in figure 13.

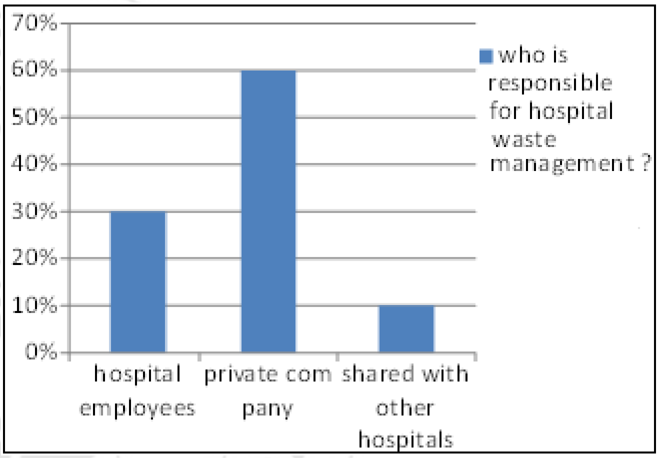

Figure 13: Who is responsible for hospital waste management?

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