

Biomedical Waste Management in Hospitals – A Case Study of Madurai, India

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ABSTRACT: Wastes are creating a major problem worldwide. Proper management of wastes has become as an essential need for the proper well being of the society. Bio-medical wastes are very important in the waste category that needs to be managed properly due to their hazardous nature. This report describes the scenario of how the bio-medical wastes are managed in the hospitals that were surveyed in the Madurai city. The survey in the hospitals revealed that some of the essential preventive measures in bio-medical waste management were not followed, that will end up in the risk of life of the workers associated with the waste management. The survey report concluded that there is a lack of implementation of strict rules and regulations on both solid and liquid waste management in the hospitals and there is also a lack of awareness among the workers about vaccination and they need to be corrected for proper waste management that would otherwise put our priceless lives and our beautiful environment to a major risk by their hazardous nature.

KEYWORDS: Bio-medical waste, hospital, hazardous, environment, Madurai.

I. INTRODUCTION

The biomedical waste management has emerged as a great concern in the present world due to enormous increase of the medical care units and hospitals. These wastes have to be managed properly from their source of secretion. They must be properly collected, segregated, transported and treated before final disposal with great care as they are hazardous due to presence of harmful substances such as infective microbes, radioactive substances from treatment units, expired medicines and antibiotics, etc., These wastes may be solid or liquid. Examples of biomedical wastes are blood and other body fluids, discarded medicines, used bandages and syringes, infected sharps, discarded medicine bottles, etc., According to Bio-Medical Waste Management Rules, 2016, "Bio-medical waste" means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps, including the categories mentioned in Schedule I appended to the rules.

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1.1 Categories of Biomedical Wastes According to BMW Rules 2016

Table 1.1 represents categories according to schedule I of biomedical waste management and handling rules, 2016.

Table 1.1 Categories of Biomedical Wastes According to BMW Rules 2016

| Category | Type of waste | Type of bag or container to be used | Treatment and disposal options |
|----------|--|--|--|
| (1) | (2) | (3) | (4) |
| Yellow | (a) Human Anatomical Waste: Human tissues, organs, body parts and fetus below the viability period (as per the Medical Termination of Pregnancy Act 1971, amended from time to time) | Yellow coloured non-chlorinated plastic bags | Incineration or Plasma Pyrolysis or deep burial |
| | (b) Animal Anatomical Waste : Experimental animal carcasses, body parts, organs, tissues, including the waste generated from animals used in experiments or testing in veterinary hospitals or colleges or animal houses. | | |
| | (c) Soiled Waste: Items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs handbags containing residual or discarded blood and blood components. | | Incineration or Plasma Pyrolysis or deep burial. In absence of above facilities, autoclaving or micro-waving/hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery. |
| | (d) Expired or Discarded Medicines: Pharmaceutical waste like antibiotics, cytotoxic drugs including all items contaminated with cytotoxic drugs along with glass or plastic ampoules, vials etc. | Yellow coloured non-chlorinated plastic bags or containers | Expired cytotoxic drugs and items contaminated with cytotoxic drugs to be returned back to the manufacturer or supplier for incineration at temperature >1200 0C or to common bio-medical waste treatment facility or hazardous waste treatment, storage and disposal facility for incineration at >12000C Or Encapsulation or Plasma Pyrolysis at >12000C. All other discarded medicines shall be either sent back to manufacturer or disposed by incineration |
| | (e) Chemical Waste: Chemicals used in production of biological and used or discarded disinfectants. | Yellow coloured containers or non-chlorinated | Disposed of by incineration or Plasma Pyrolysis or Encapsulation in hazardous waste treatment, storage and disposal facility |

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| | | | |
|---------------------|---|--|---|
| | | plastic bags | |
| | (f) Chemical Liquid Waste : Liquid waste generated due to use of chemicals in production of biological and used or discarded disinfectants, Silver X-ray film developing liquid, discarded Formalin, infected secretions, aspirated body fluids, liquid from laboratories and floor washings, cleaning, house-keeping and disinfecting activities etc. | Separate collection system leading to effluent treatment system | After resource recovery, the chemical liquid waste shall be pre-treated before mixing with other wastewater. The combined discharge shall conform to the discharge norms given in Schedule-III. |
| | (g) Discarded linen, mattresses, beddings contaminated with blood or body fluid. | Non-chlorinated yellow plastic bags or suitable packing material | Non-chlorinated chemical disinfection followed by incineration or Plazma Pyrolysis or for energy recovery. In absence of above facilities, shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery or incineration or Plazma Pyrolysis. |
| | (h) Microbiology, Biotechnology and other clinical laboratory waste: Blood bags, Laboratory cultures, stocks or specimens of microorganisms, live or attenuated vaccines, human and animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices used for cultures. | Autoclave safe plastic bags or containers | Pre-treat to sterilize with nonchlorinated chemicals on-site as per National AIDS Control Organisation or World Health Organisation guidelines there after for Incineration. |
| Red | Contaminated Waste (Recyclable): Wastes generated from disposable items such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and <i>fixed needle syringes</i>) and vaccutainers with their needles cut) and gloves. | Red coloured non-chlorinated plastic bags or containers | Autoclaving or micro-waving /hydroclaving followed by shredding or mutilation or combination of Sterilization and shredding. Treated waste to be sent to registered or authorized recyclers or for energy recovery or plastics to diesel or fuel oil or for road making, whichever is possible. Plastic waste should not be sent to landfill sites. |
| White (translucent) | Waste sharps including Metals: Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts. This includes both used, discarded and contaminated metal sharps | Puncture proof, Leak proof, tamper proof containers | Autoclaving or Dry Heat Sterilization followed by shredding or mutilation or encapsulation in metal container or cement concrete; combination of shredding cum autoclaving; and sent for final disposal to iron foundries (having |

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| | | | |
|------|---|---|---|
| | | | consent to operate from the State Pollution Control Boards or Pollution Control Committees) or sanitary landfill or designated concrete waste sharp pit. |
| Blue | <p>(a) Glassware: Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic wastes.</p> <p>(b) Metallic Body Implants</p> | Cardboard boxes with blue colored marking | Disinfection (by soaking the washed glass waste after cleaning with detergent and Sodium Hypochlorite treatment) or through autoclaving or microwaving or hydroclaving and then sent for recycling. |

1.2 List of Authorities Responsible for the BMW

- Ministry of Environment & forests
- Central/state Ministry of Health Family Welfare, Veterinary and Animal Husbandry
- Ministry of Defense
- Central Pollution Control Board
- State government/union Territory government/Administration
- State pollution control Boards/Committees
- Local bodies such as Gram panchayat Municipalities

1.3 Liquid Waste Disposal

1.3.1 Nature of Liquid Wastes from Hospitals

The liquid wastes are generated in hospitals from different wards such as clinical laboratories, operation theatres, radiology, etc. These liquid wastes possess hazardous substances in them due to presence of infectious agents and other antibiotics given in the treatment. Hence they are very harmful if discharged to normal sewerage system and septic systems. These waste liquids should be separately collected and store until they meet the standard parameters for discharging into municipal sewers or other systems. Amongst all the category of BMW, liquid wastes pose a serious threat to human health and the environment because of their ability to enter watersheds, pollute ground water, and drinking water when improperly handled and disposed.

1.3.2 Problems in Liquid Waste Disposal

Most existing systems and technologies being used in handling liquid biomedical waste are failing to address the problem of effective management of liquid waste. Untreated liquid biomedical waste contains a wide variety of contaminants that poses health hazards to the community. The wastewater treatment plants can be an additional source of release of methane gas into the atmosphere, which requires capture, destruction, or utilization to reduce the possibility for reducing greenhouse gas emissions. Besides there is increase in the use of this untreated wastewater for irrigation due to the scarce water resources.

1.3.3 Liquid Wastes Classification

- Based on source:
 - Major Hospitals: medical college & hospital, general hospitals, district hospitals.
 - Minor Hospitals: Dispensaries, medical care services etc.
- Based on their nature:
 - Hazardous liquid wastes: It comprises infectious, pathological, chemically hazardous, pharmaceuticals, etc. E.g.: Blood, body fluid, laboratory liquid waste, discarded vaccines etc.
 - Non-hazardous liquid waste: It is from hospital kitchen, canteen, and food centre and laundry facilities. They are grey water and given to normal sewage system

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- Infectious liquid wastes:
 - Laboratory liquid wastes
 - Blood
 - Body fluids
- Chemical liquid wastes:
 - Formaldehyde (from labs, discarded vaccines, etc.)
 - Mercury (from thermometers and similar equipments)
 - Solvents
 - Radio actives

1.3.4 Standards for Liquid Waste

The liquid wastes, before final disposal into common waste water treatment system must satisfy the parameters given below according to BMWM Rules, 2016.

- The effluent generated or treated from the premises of occupier or operator of a common biomedical waste treatment and disposal facility, before discharge into the sewer should conform to the following limits.

Table: 1.2 Permissible limits

| Parameters | Permissible Limits |
|------------------|--|
| pH | 6.5-9.0 |
| Suspended solids | 100 mg/l |
| Oil and grease | 10 mg/l |
| BOD | 30 mg/l |
| COD | 250 mg/l |
| Bio-assay test | 90% survival of fish after 96 hours in 100% effluent |

- Sludge from Effluent Treatment Plant shall be given to common bio-medical waste treatment facility for incineration or to hazardous waste treatment, storage and disposal facility for disposal.

II. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Hospitals A, B, C located in three different regions of Madurai city. The bio-medical waste management in all those three hospitals were analyzed based on the direct visit after prior permissions have been granted. The hospitals were located within the city limit in the populated area of the city. The amount of waste collected, type of waste, how they are segregated, the colour coding, their transportation, disposal and treatment methods were all studied by direct visit to the hospitals. The waste quantities for 20 days were collected and data were analyzed. The data were analyzed by direct visit every day to three hospitals simultaneously.

2.2 Study of Existing Waste Management System

The waste management in the hospital is the responsibility of the housekeeping staffs who work under the housekeeping manager. Under the housekeeping manager, supervisors work to organize the waste collection from each ward by the housekeeping workers responsible for a separate individual ward. They collect the waste based on a specific routine followed in the hospital according to their flexibility in timings. The waste are collected separately and packed based on their colour codes as white, blue, red and yellow that is prescribed in the BMWM Rules, 2016.

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2.3 Data Collection

The 20 days data for three hospitals were simultaneously collected. The type of waste and their quantities based on the colour code of waste as Red, blue, yellow, and white are analyzed. The type of waste such as infectious anatomical, microbiology, biotechnology, sharps, radioactive, etc. They were separately collected and packed based on the colour code. The information's were collected from each department with structured questionnaires administered on the appropriate category of staff in the hospitals. The waste collected on each day were weighed and measured. The questionnaire was prepared and it was invested in all three hospitals. The hospital housekeeping manager and his staffs were responsible for the waste management in the hospital. The waste was collected 7 times a day in hospital A and B and 3times a day in hospital C according to the amount of waste secreted. The waste was collected on a daily basis to the ultimate disposal facility. There are four colour codes basically used. They are yellow, red, blue, and white. Yellow code mainly consists of non chlorinated plastic bags which include human anatomical waste, animal anatomical waste, soiled waste, expired or discarded medicines, chemical waste, micro, bio-t and other clinical waste and certain chemical liquid waste. The treatment / disposal option of this waste are incineration or plasma pyrolysis or deep burial. Red code mainly consists of non chlorinated plastic bags or containers which includes contaminated waste which are recyclables such as tubing, bottles, intravenous tubes and sets, urine bags, syringes(without needle) and gloves. The treatment / disposal option of this waste are auto/micro/ hydro and then sent for recycling not for landfill. White code mainly consists of puncture, leak, and tamper proof containers which include waste sharps including metal. The treatment / disposal option of this waste are auto or dry heat serializations followed by shredding or mutilation or encapsulation. Blue code mainly consists of cardboard boxes with blue3coloured marking which includes glassware. The treatment / disposal option of this waste are disinfection or auto/micro/hydro and then sent for recycling.

2.4 Questionnaire Session

A questionnaire was prepared for the purpose of obtaining information about the bio-medical waste management and the methods followed in the hospital for the efficient management. The questionnaire was asked to the appropriate staff responsible for the hospital waste management in all the three hospitals. It revealed about the systems followed for the collection, segregation and disposal of waste along with the frequency of collection of waste. The questionnaire was asked to the persons in charge of the waste management. They were interviewed with the questions below and the waste management plan was thoroughly studied. This revealed the true strategies followed by the hospital administration on waste management practices such as waste collection, segregation into the color codes, use of needle cutter, waste management plan and timetables followed for the frequency of collection, transportation of waste to the central storage area inside the hospital premises, and making their way to final disposal site.

2.4.1 Questionnaire for Study of Hospital Waste Management

Questionnaire

1. What is the type of hospital?
2. How much number of departments is there? (Name them)
3. How much number of beds is there?
4. Do color bag systems are followed for the waste segregation? (Yes/No)
5. Say about the Average inpatients & average outpatients?
6. How many times waste was collected every day?
7. At what time waste was collected every day? (Mention timings)
8. What is the Frequency of removal of waste from the hospital site?
9. Whether incineration plant is located or not? (Yes/No)
10. If yes, where is the incineration plant? (Mention place)
11. Which site is meant for Final disposal? (Mention place)
12. What type of container is used for collection?
13. Is there any hospital waste management team? (Yes/No)
14. How many number of team members are there in the waste management plan?
15. Is there any waste management plan?

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16. Is there any manual (or) guideline followed in waste management of hospital?
17. Is there a timetable for waste collection frequency?
18. What is the means of transportation to the final disposal site?
19. Whether the Segregation of waste is done in the hospital or not?
20. Is needle cutter is used to cut the needles/syringes?
21. Transportation to final disposal site is by own employees or by municipality/corporation members?
22. Is there any record keeping for the waste generation and its management?
23. What is the type of container used for collection (for internal transport of waste)?

About Personnel:

24. Who is the head of the waste management in the hospital?
25. How many staffs are working under him?
26. Do employees in the waste management system are vaccinated?

Liquid Waste:

27. What about liquid waste?
28. Is there any separate plan for liquid waste collection?
29. Do any record keeping is there for the liquid waste?
30. What is the type of container used for the liquid waste collection?

2.5 Estimation of Quantities

Totally how much quantity of waste is collected for each day and what are the types of waste collected were examined. The waste collected in each colour code such as Red, white, blue, yellow were weighted and an average of total waste collected on each day were estimated. Totally, the survey was done for 20 days in all three hospitals and estimated. The quantities for each colour-coded bag were identified separately by investing three hospitals for 20 days. The various processes of waste collection, segregation, transportation, and disposal in the hospitals have been analyzed.

2.6 Data Analysis

The waste quantity collected on each day was separated into different bags based on their nature. The colour codes indicated by BMWM rules are red, yellow, white & blue. The waste quantity amount in red coloured bag indicates the amount of contaminated waste that can be recycled such as tubing, tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes and vacationers with their needles cut) and gloves. the yellow bag indicates human and animal anatomical waste, soiled waste, expired or discarded medicines, chemical waste and liquids, discarded linen and mattresses, microbiology and biotechnology waste, etc., The waste in white coloured bag indicates waste Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts.

III. RESULTS

3.1 Overview of the BMWM in the Hospitals

3.1.1 Assessment of Operating Procedures

During this study it was observed that majority of the hospitals investigated had waste management department properly maintained. There is also no special training program for the sanitary workers about the waste segregation. Hospital C did backyard combustion which was dangerous to the society. Hospital A and B did not use needle cutter for sharps. Liquid waste was disposed into the sewage system. Municipal authorities should provide adequate infrastructure and services for safe transport, treatment and final disposal of hospital waste. This case study ensures that the hospitals have a waste management officer who properly maintains and monitors the bio medical waste Management system at regular intervals. Regular visits were held by the administration members to the hospital waste storage site within the premises to know the status of biomedical waste Management.

3.1.2 Segregation of Waste

Segregation and identification of waste is the best way for the reduction as well as the effective management of biomedical waste. Study of three hospitals in Madurai city for the case study of hospital waste management reveals that

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there was well established system for maintenance and segregation of hazardous waste from non-hazardous waste. The general waste was also frequently disposed into Municipal waste system for the treatment. The Hospitals follow the colour code system for proper maintenance of waste. The hazardous solid waste was properly handled by the hospitals. The waste was segregated at the point of generation in the wards using polythene bags for easy disposal.

3.1.3 Final Disposal

This study showed that the present waste management practice employed by the sampled hospital in Madurai is moderate. There is an open pit in the backyard for combustion of some waste which is considered as harmful by the hospital authorities. This open burning practice and the leachate produced at these dumpsites poses a serious environment problem to the atmosphere, underground water, surrounding Rivers and the general well- being of the people . The final disposal of waste is properly handled by the private organization.

3.2 Observation

From the questionnaire interviewed to the corresponding person in charge of the waste management in the hospital, some observations were made that were written as remarks below each of the that was asked. The questionnaire provided detailed information about the scenario that was followed in the hospitals when surveyed.

3.2.1 Data Sheet for the Type and Quantity of Wastes Collected

Table 3.1 represents the 20 days data collected from hospital A, B and C

Table: 3.1 20 days data collection for hospital A, B and C

| Day | Yellow Kg/Day | | | Red Kg/Day | | | White Kg/Day | | | Blue Kg/Day | | | Total Kg/Day | | |
|-----|---------------|-------|-----|------------|-------|-----|--------------|------|-----|-------------|------|-----|--------------|-------|------|
| | A | B | C | A | B | C | A | B | C | A | B | C | A | B | C |
| 1 | 240.5 | 80.4 | 5.4 | 352.7 | 98.9 | 7.9 | 30.6 | 11.4 | 0.6 | 86.5 | 39.7 | 2.5 | 710.3 | 230.4 | 16.4 |
| 2 | 282.8 | 43.9 | 3.8 | 358.2 | 106.5 | 8.7 | 32.0 | 7.5 | 1.1 | 57.0 | 45.8 | 2.5 | 730.0 | 203.7 | 16.0 |
| 3 | 257.7 | 83.2 | 3.7 | 370.5 | 134.5 | 7.8 | 33.5 | 35.7 | 0.9 | 72.6 | 22.5 | 1.5 | 734.1 | 275.9 | 14.0 |
| 4 | 280.3 | 98.7 | 4.6 | 411.9 | 123.2 | 6.5 | 35.3 | 21.0 | 0.8 | 76.0 | 49.7 | 2.8 | 803.5 | 292.6 | 14.8 |
| 5 | 272.7 | 115.9 | 5.9 | 343.6 | 143.4 | 6.4 | 36.2 | 18.0 | 0.8 | 137.4 | 71.0 | 2.2 | 789.8 | 348.3 | 15.2 |
| 6 | 210.0 | 80.2 | 4.6 | 362.5 | 121.7 | 7.9 | 42.9 | 37.5 | 0.8 | 78.7 | 17.9 | 2.6 | 694.1 | 257.3 | 15.8 |
| 7 | 220.0 | 95.7 | 4.8 | 314.2 | 111.9 | 7.7 | 17.8 | 11.5 | 0.9 | 83.0 | 32.7 | 3.8 | 635.0 | 251.8 | 17.3 |
| 8 | 241.5 | 18.5 | 4.3 | 453.8 | 78.8 | 6.1 | 61.7 | 36.0 | 0.4 | 100.4 | 38.0 | 1.5 | 857.4 | 171.3 | 12.3 |
| 9 | 264.8 | 112.1 | 4.5 | 397.5 | 123.4 | 7.4 | 25.5 | 23.0 | 1.8 | 82.0 | 55.6 | 2.7 | 769.7 | 314.1 | 16.4 |
| 10 | 246.9 | 86.4 | 3.2 | 388.2 | 107.9 | 6.6 | 32.7 | 10.2 | 0.7 | 63.9 | 10.9 | 3.1 | 731.6 | 215.4 | 13.6 |
| 11 | 298.1 | 78.9 | 5.6 | 371.0 | 94.7 | 7.9 | 38.0 | 29.0 | 1.2 | 103.6 | 49.9 | 3.5 | 810.6 | 252.5 | 18.2 |
| 12 | 259.6 | 92.1 | 3.5 | 388.5 | 85.3 | 5.9 | 36.6 | 42.0 | 0.5 | 59.4 | 43.0 | 2.8 | 744.1 | 262.4 | 12.4 |

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|----|-------|-------|-----|-------|-------|-----|------|------|-----|------|-------|-----|-------|-------|------|
| 13 | 216.2 | 68.4 | 3.9 | 346.6 | 90.8 | 4.7 | 31.4 | 19.8 | 0.3 | 55.2 | 79.8 | 1.3 | 649.3 | 258.8 | 10.2 |
| 14 | 227.9 | 183.7 | 3.6 | 211.5 | 205.3 | 7.3 | 31.8 | 13.0 | 0.7 | 79.8 | 11.4 | 3.6 | 551.0 | 413.4 | 15.2 |
| 15 | 197.2 | 69.7 | 4.9 | 293.8 | 84.6 | 8.7 | 45.7 | 27.0 | 1.9 | 17.1 | 42.0 | 3.2 | 553.8 | 223.3 | 18.7 |
| 16 | 160.9 | 14.8 | 5.4 | 239.8 | 19.5 | 7.8 | 28.4 | 8.2 | 0.7 | 83.6 | 102.0 | 2.5 | 512.7 | 144.5 | 16.5 |
| 17 | 245.3 | 81.0 | 5.5 | 344.7 | 121.2 | 6.8 | 33.3 | 44.0 | 0.7 | 63.5 | 119.0 | 2.4 | 686.8 | 365.2 | 15.4 |
| 18 | 233.2 | 80.1 | 3.7 | 341.3 | 95.8 | 7.5 | 26.1 | 17.9 | 1.0 | 74.5 | 56.0 | 2.9 | 675.0 | 249.8 | 15.1 |
| 19 | 271.7 | 79.6 | 4.3 | 372.8 | 108.5 | 6.8 | 33.6 | 9.0 | 0.7 | 64.1 | 108.5 | 3.4 | 742.2 | 305.6 | 15.2 |
| 20 | 210.3 | 88.7 | 3.8 | 319.0 | 128.5 | 7.7 | 42.9 | 11.0 | 1.0 | 37.4 | 116.0 | 2.6 | 609.5 | 344.2 | 15.1 |

3.2.2 Data Sheet for the Different Types of Wastes Collected in the Three Hospitals A, B and C

Table 3.2 represents Different Types of Wastes Collected in the Three Hospitals A, B and C

Table: 3.2 Different Types of Wastes Collected in the Three Hospitals A, B and C

| Nature Of Waste | Total Generation Of Waste (Kg/Day) | | |
|---|------------------------------------|------------|------------|
| | Hospital A | Hospital B | Hospital C |
| Contaminated Waste | 349.09 | 109.255 | 7.189 |
| Needles And Other Sharps | 20.3 | 21.635 | 0.818 |
| Broken Glassware & Metallic Body Implants | 122.93 | 55.569 | 2.671 |
| Soiled & Infectious Waste | 241.87 | 82.6 | 4.453 |
| Total Generation | 734.19 | 269.06 | 151.131 |

IV. DISCUSSION

4.1 Comparison of the Hospitals A, B and C

The following figures (Fig.: 4.1 – 4.6) shows the response of the following questions, ‘is there any segregation of waste within the hospital premises?’, ‘Comparison of the percentage of wastes produced in three hospitals A, B & C based on the colour codes’, ‘use of needle cutters’, ‘is there any waste management plan?’, ‘are employees vaccinated?’ and ‘is there any liquid waste management plan?’ respectively.

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Fig. 4.1 – 4.6 Responses of the hospitals for the Questionnaire

Fig 4.1 Response of the hospitals to the question, ‘is there any segregation of waste within the hospital premises?’

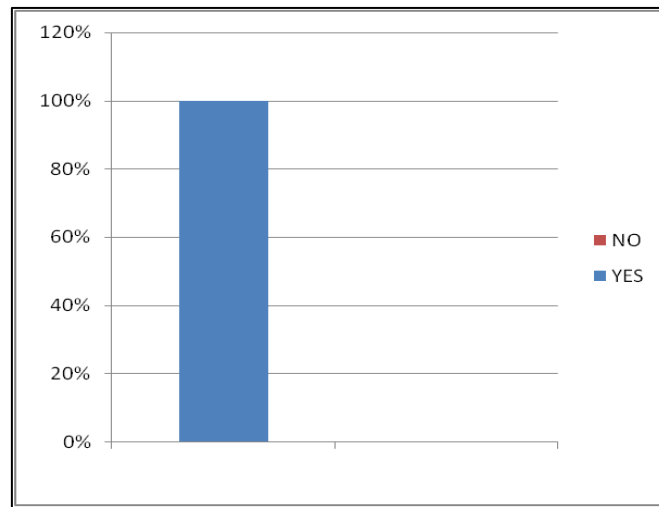


Fig 4.2 Comparison of the percentage of wastes produced in three hospitals A, B & C based on the colour codes.

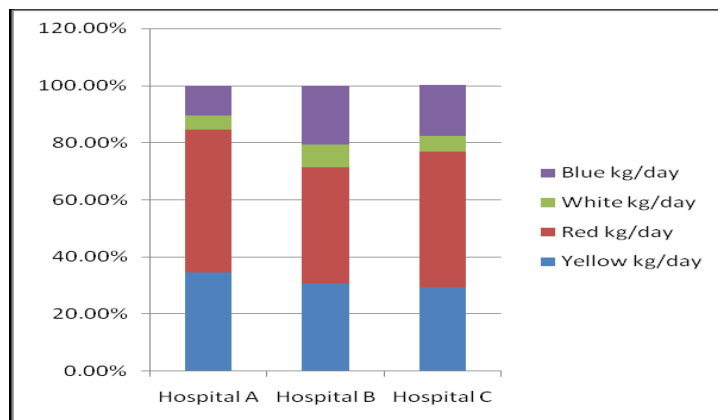


Fig 4.3 Response of the hospitals for the use of needle cutters

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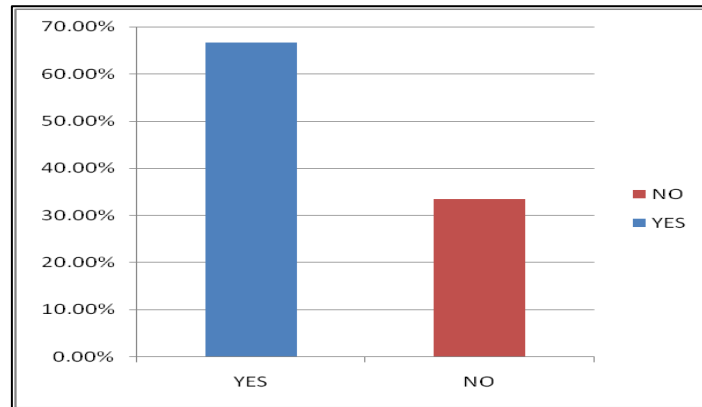


Fig 4.4 Response for the question, 'is there any waste management plan?'

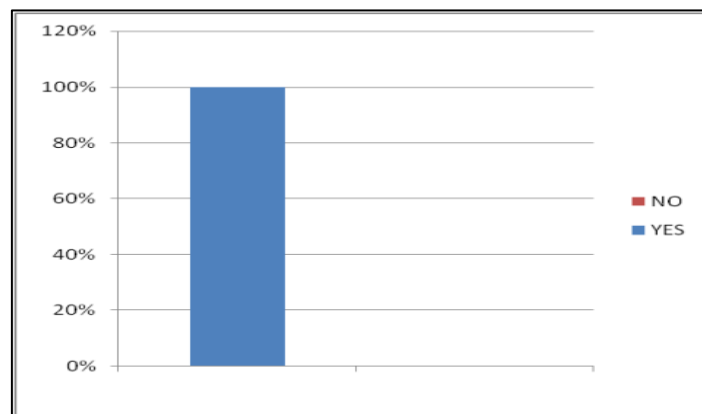


Fig 4.5 Response for the question, 'are employees vaccinated?'

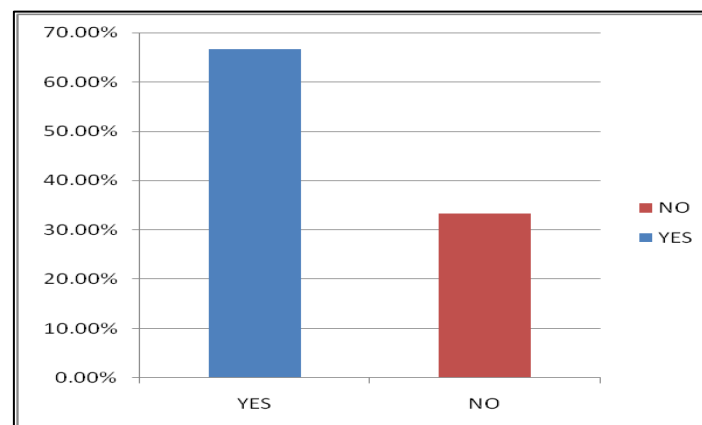


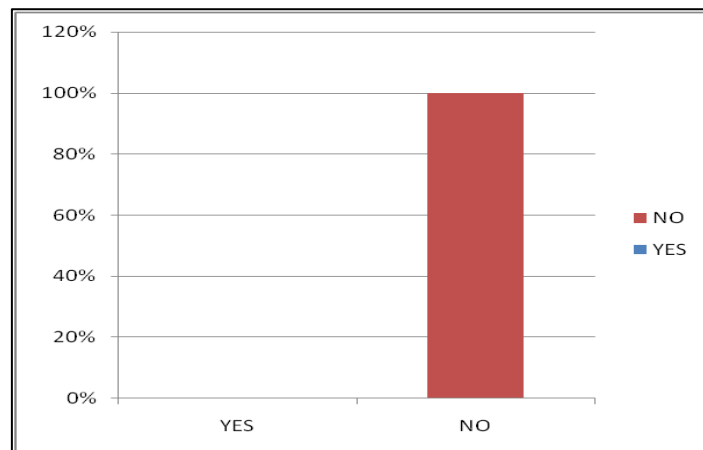
Fig 4.6 Response for the question, 'is there any liquid waste management plan?'

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4.2 Short Comings of the Existing System:

- There is not much awareness among the workers on the degree of hazard of the bio-medical wastes arising from the hospitals.
- The persons and the staffs dealing with the biomedical wastes are not properly vaccinated.
- Use of needle cutters to the needles and sharps is not properly monitored.
- The central waste storage system is not disinfected periodically with in the hospital premises.
- Some hospitals incinerate the biomedical hazards with in the hospital premises.
- Only few hospitals have proper planning for the waste management system.
- Liquid wastes in the hospitals are not treated properly.
- The liquid wastes which are potentially hazard are disposed off into septic and sewerage systems.

4.3 Recommendations for Safer Bio-Medical Solid Waste Management

- All hospitals should strictly follow the segregation of wastes according to the Bio-Medical Waste Management Rules, 2016.
- The hospitals should ensure the use of needle cutters to cut the needles before they are disposed into the disposal site for further treatment.
- All hospitals must strictly join and follow the schedules of the common treatment facilities.
- The labeling of the biomedical wastes as biohazards mentioned in the BMW Rules 2016 must be done.
- All health workers must be properly vaccinated before they are allowed to handle the wastes.
- Proper training should be given for the persons handling the biomedical wastes.
- Record keeping of both solid and liquid biomedical wastes should be followed by the hospitals.
- The hospitals, Municipal Corporation and common bio-medical waste treatment and disposal facility (CBMWTF) should work together for the proper management of bio-medical wastes in the city.

4.4 Recommendations for Safer Bio-Medical Liquid Waste Management

- The liquid wastes in the hospitals must not be discharged into the septic and sewerage systems without prior treatment.
- The liquid wastes must be stored in leak proof containers and should be disposed to final treatment facility units.
- Liquid pathological and chemical waste should be appropriately treated before being discharged into the public sewer systems.
- Liquid waste should not be discharged in to the drainage system or to water bodies.
- The wastes must be segregated and contained in leak proof, rigid containers.

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- These containers are labeled with the biohazard symbol and the word "Biohazard" is to be clearly mentioned in the label.
- Liquid waste should be collected separately in a twin bin container labeled as biohazard as per the BMW Rules, 2016.
- Placing directly in the Biohazardous Waste Bin: This option involves in placing the infectious liquid waste into the red or yellow biohazard waste container depending upon the type of further treatment options as followed by the health care facility (HCF). It can be placed in the yellow biohazard bin if the HCF has an incinerator facility, if there are no incinerators then it can be placed in the red bin for autoclaving.
- Solidification of the Liquid Waste: when solidifying agents are added to liquid wastes, it changes them into gelatinous substance within few minutes and then it can be safely transported in solid form in red waste bags.
- Closed disposal system: it is a system that is mounted to the floor or wall with a vacuum system that uses canisters that empties directly to the sanitary sewer, thereby can help a facility cut its infectious waste volume, reduce exposure risk, after prior treatment to reduce its hazardous nature to the recommended level by BMW rules, 2016.

V. CONCLUSION

Though all three hospitals that were visited had awareness about medical waste management, they did not take any care regarding the proper disposal of liquid waste; they are severely lacking in actions to dispose the liquid waste properly. Regular visit to the hospital and analysis of questionnaire data revealed that the hospitals dispose the solid medical waste by proper segregation. After the interaction with the staffs, it was known that proper schedule was followed for the collection of waste. The hospital staffs and workers are not aware of the level of the hazard when infectious liquid waste disposed to the septic systems reach ground water. This is due to the lack of education, training and awareness among the hospital administrative staffs and the persons in charge of the waste management system. The result of the study demonstrate the need for a strict enforcement of legal provisions and laws. A better environmental management system is needed to manage the waste properly. The hospital staffs should go beyond data compilation, enforcement of regulations and acquisition of better equipments. The hospital staffs should strictly follow the vaccination of the health care workers. The liquid waste should also be given a proper disposal method according to the norms.

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