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Bio-Medical waste management of Ujjain city by on-site treatment of bio-degradable infectious waste by low cost technology

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Abstract

Biomedical waste management is emerging as a serious topic not only for health care organizations but for the whole world too recently. According to the societies (who form the standards, rules & regulation for BMW Management) each and every health care facility should have a proper management method for their generated waste. The MoEF notified Bio-medical waste and handling rules 1998 in July 1998 and then modify them in 2016. According to these rules every hospital generating Bio-medical waste needs to set a requisite treatment facility nearby to ensure degradation of Bio-medical waste as the untreated Bio-medical waste should not be kept beyond 48 hours. In this research we try to elaborate the effects of Bio-medical waste and will also propose its on-site treatment techniques in various main hospitals of Ujjain city.

Keywords: Infectious, Biomedical waste management, MoEF, Ujjain city

1. Introduction

Since from beginning health care facilities were very well known for the treatment of unhealthy persons but people were not aware by the side effects of the garbage produced by them. Generally the waste was dumped in open areas near the health care facilities, which creates threat to hospital staff as well as the person around that area. In March 2009, around 240 people in Gujarat, India contagious by hepatitis B because of use of previously used syringes, which later have been acquired by illegal black market trade. Generation of waste is depends upon number of factors like source of generation, quantity of generation, segregation for reuse and recyclable items, management methods used by HCFs etc. This waste includes syringes, cottons, vaccines, sharps, needles, lancets, body amputee parts, and plastic and glass materials etc.

Definition: Biomedical waste is a waste of biological origin which mainly generated by organizations engaged in medical field

Destruction of waste: There are generally two type of method for destruction of biomedical waste. One is sterilization and other is incineration.

Incineration: It involves the complete breakdown of waste by combustion and results in conversion of most of the waste into CO₂. It can be used for both anatomical and non-anatomical waste.

Sterilization: It simply kills the microorganisms by injected them in high temperature. It is used only for non-anatomical waste.

Waste minimization, recycling and reuse

Significant reduction of waste generation in health care facilities may be implement by following

- Reduction at source:
- Products which can recycle
- Segregation of waste
- Reuse and Recycle

Some materials (Medical equipment, containers etc.) can be reuse and recycle which helps in waste minimizations too. Like some medical equipment can be further reused after sterilization treatment. Reusable item may include sharps, syringes, glass bottle and containers, needles and scalpels etc. After treatment with these items, they can be collected separately, carefully washed and then can be sterilizing by thermal or chemical treatment. Some containers can be washed and disinfected then reuse.

Problems faced by HCFs

- Unawareness
- Inadequate funds
- Indiscipline in following of Management programme
- Unavailability of equipment
- Inadequate space
- No proper monitoring facility
- Most of the people are not taking their responsibility seriously

Recommendation for HCFs

- **Waste storage:** Storage of waste storage beyond 48 hours is prohibited but if it is necessary, an authorized person must have taken the responsibility.
- **Location of disposal containers:** All color coded disposal bags should be kept at point of waste generation. As provided by bio-medical waste rules, the whole of the waste should be fragmented into colors due to their hazardous nature.
- **Bags:** It should be fix that disposal bags are filled upto their 3 / 4 Capacity, properly tied, and removed from site by time to time.

Transportation

For inside transportation – Clean wheeled trolleys in good condition should be used and waste route should be designated.

For outside transportation - BMW should be transported via authorized vehicles only.

- **Treatment and disposal of waste:** Generally 80% - 90% generated waste is comes under general waste category. This waste is kept into black colored bag and dumped with municipal waste. Rest over waste is comes under biomedical waste which should be handle with more care. Anatomical waste should be deep burial. Waste of glass and plastic material should be autoclaved or chemically disinfected, shredded, recycle and sent for final disposal to municipal waste. Syringes should be cut, chemically disinfected and then sent for final disposal to sharp pits. Bio-medical wastes should not be mixed with other waste of Municipal Corporation.
- **Training & Awareness:** For dealing with waste, proper Training & awareness should be given to staff members. Housekeeping staff must wear personal protective devices i.e. gloves, masks, gowned, during the handling of the waste. There should be biomedical waste label on waste carry trolley & bags and also poster can fix on the wall adjacent to the bins (waste) providing details about the type of waste that needs to dispose in the baggage as

per biomedical waste management rule. Carry bags needs to have the bio hazardous symbol on them also.

- **Establishing of Management board:** Bio-medical waste Management Board can be established in each District. Specific fund should be allocated for the management programme. Judicial powers should be given either to the management board or special court, which should be established for the matters of environment pollution for imposing fines/penalty and awarding damages etc.
- Private hospitals should also allow using incinerator, which is installed, in govt. hospital. For this purpose they can charge a specific fee from private hospitals too.
- Only 20% of BMW is hazardous and rest 80% is non-hazardous and only 15% is infectious or dangerous. If biomedical waste is mix with municipal waste then the entire waste become infectious and possess risks.

Description of concerned area

Ujjain, one of the holy city of India is a rapidly growing city day by day with a population of about 1,986,597 lakhs. City generates tons of waste each and every day, in which quantity of clinical waste is also high. Out of which twenty to twenty five percent waste is considered as hazardous which poses health issue too. There are total 4 government and 53 main private hospitals approximately we not includes small nursing homes and clinics of beds less than 10. Government hospitals generate an average of 0.592 kg/bed/day of the waste and private hospitals generates 0.435 kg/bed/day of waste approx.

Collection of Waste

For collection of general as well as biomedical waste plastic bins are used of different colors. i.e. infectious waste - Red bags, Domestic waste - Green Bags, Sharps - Needle cutters / Puncture proof containers, incinerated ash & chemical waste – black bag, anatomical waste – yellow bag, solid waste – blue bag.

Different color coded plastic containers with waste category

- **Category 1:** (Anatomical Waste (Human Tissues, organs, body parts)), 2(Animal waste (tissue, body parts, carcasses, fluid, blood and experimental animals used in research, veterinary hospitals waste, discharge from animal houses.), 3(Microbiology and Biotechnology waste) 5(Discarded medicines and cytotoxic drugs, 6 (Solid waste (item contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, lines, bedding, other material contaminated with blood) will collected in yellow color plastic container.
- **Category 4:** {sharps (needle, glass, syringes, scalpels, blades, etc.) This includes both used and unused}, 7 (Solid plastic waste) will collected in red color coded plastic container.
- **Category 8:** waste (Liquid waste (waste generated from laboratory and washing cleaning and housekeeping and disinfecting activities) will collected in Blue color coded plastic container
- Municipal waste will collected in Black color coded plastic container.



Materials and methods

Method for sample collection

The various type of biomedical waste generated in the hospital is collected by the all the members of the hospital. First we done a survey on the type of waste generation in each ward, quantity of waste generated, type as well as time of disposal etc.

Analysis on waste

Almost each and every ward is having two types of waste containers, one for general waste collection and other is for BMW. Color coded bags are used for waste collection and

whole waste is stored in a separate room. The quantity of waste generation is measured at the end of the day or before final hospital disposal transportation.

Amount of waste generated

Health care facilities are divided into 3 types according to the number of beds.

- Small HCFs (less than 100 beds)
- Medium HCFs (100-500 beds)
- Large HCFs (more than 500 beds)

We have collected the data of 15 days quantity of waste collected on the basis of color coded containers.

Table 1: Quantity of waste generated in Ujjain

Day	Shift1				Shift2				Shift3				Shift4				TDC
	Y	R	B	T	Y	R	B	T	Y	R	B	T	Y	R	B	T	
1	220	18	8	246	124	5	6	135	409	78	85	572	603	87	43	733	1686
2	150	10	12	172	160	9	19	188	611	88	96	795	603	96	70	769	1924
3	132	15	40	187	141	7	21	169	345	142	120	607	493	73	79	645	1608
4	186	11	13	210	150	9	28	187	410	89	98	597	492	75	71	638	1632
5	141	12	45	198	156	13	25	194	472	118	114	704	439	71	66	576	1672
6	182	10	50	242	162	12	35	209	411	142	112	665	498	82	72	652	1768
7	211	15	50	276	355	9	56	420	380	130	140	650	480	70	80	630	1976
8	230	16	47	293	147	8	14	169	402	147	198	747	762	112	110	984	2193
9	150	10	42	202	134	5	12	151	412	150	90	652	712	82	40	834	1839
10	246	14	47	307	115	6	32	153	240	145	95	480	510	132	62	704	1644
11	180	10	60	250	122	7	30	159	460	114	118	692	680	40	90	810	1911
12	230	12	65	307	104	3	21	128	482	80	156	718	661	55	85	801	1963
13	214	11	60	285	203	10	39	252	421	85	161	667	582	73	72	727	1931
14	286	12	62	360	175	12	58	245	401	190	110	701	605	80	104	789	2095
15	261	11	70	347	138	6	28	172	320	90	131	541	515	62	80	657	1717

$$\text{Average 15 days collection is} = \frac{(1686+1924+1608+1632+1672+1768+1976+2193+1839+1644+1911+1963+1931+1963+2095+1717)}{15} = \frac{29522}{15} \approx 1970 \text{ kg/day}$$

Y= yellow, R= red, B= blue, T= total, TDC = total day collection

On site transportation

Medical waste is transported in hospitals via containers, bags, trolleys, and carts by staff members. They have also given the health care personals, but we found they are less in quantity and generally most of the members are not using them properly. Means of transportation or collection should be cleaned on daily basis but they are not doing it in a disciplined way.

Off-site collection

Generally waste is pre segregated as general and medical waste via the HCFs, hence general waste is collected by the Ujjain municipal corporation collection vehicle, and rest is collected by the licensed company vehicles of Indore. Since govt. hospital of Ujjain have their own incinerator so treat their waste by themselves only and private hospitals are

linked with authorized companies for handling their waste. Companies sent their vans to the hospitals of Ujjain on daily purpose. Each van is equipped with some drums for waste collection of measured quantity. They also carrying waste measuring scale for measuring waste collected on Kilogram basis. Since companies taking charge on Kg basis so most of the HCFs handed over the hazardous waste to them and rest they mix with municipal waste. They charging money between 4 Rs/bed/day to 7 Rs/bed/day.

Coordination between hospitals and authorized agencies in Ujjain

- **With Ujjain Municipal corporation (UMC):** Since the large quantity of waste generated in hospitals is comes under general waste category. Hospitals of Ujjain have constant connectivity with the municipal authorities so

that this type of waste will be disposed by them. Hence extra work for disposal is reduced.

- **With Ujjain pollution control board (UPCB):** for better treatment methods, technology and approval of any proposed model, hospitals are linked with UPCB.

- **With waste handling companies:** BMW of hospitals is handed over to some companies of Indore, who sent their vehicles to HCFs and collected the waste and rest further treatment is done by them. All hospitals of Ujjain have interacted with these companies expect the govt. hospitals because they have their own incinerator.

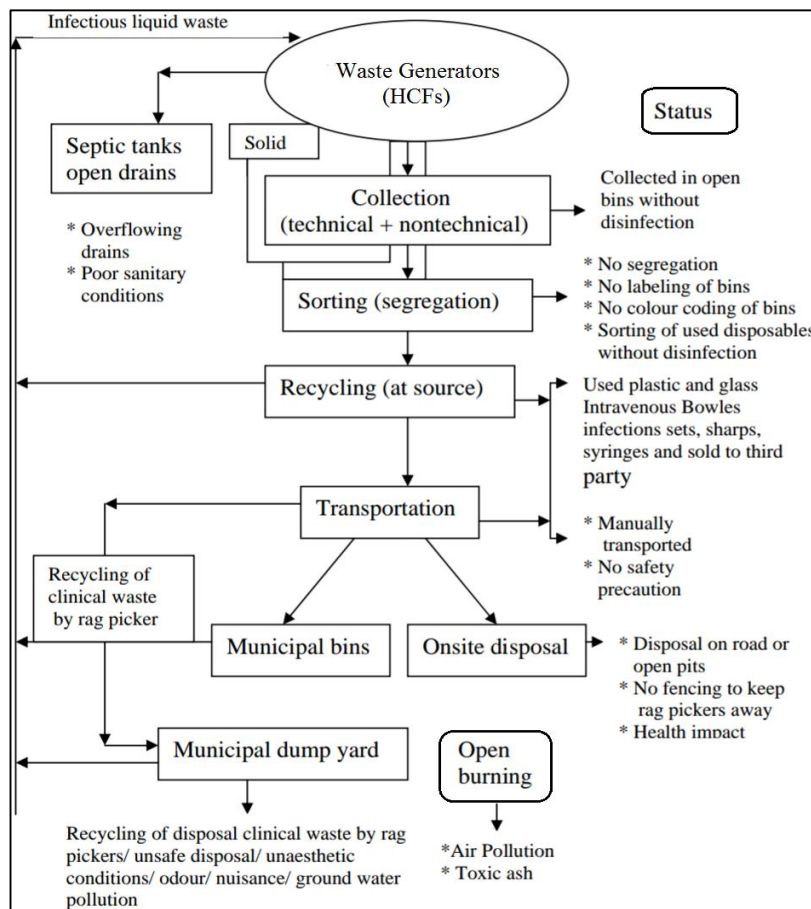


Fig 1: Current Status of medical waste disposal in Ujjain

Treatment technology: Treatment methods are selected on the basis of local and national situation.

- Mechanical process–Cutting, shredding, grinding, mixing etc. means almost all type of compaction technologies are come under this process. Waste is reshaped into smaller pieces for volume reduction.
- Biological process–Composting and vermiculture are the best example of this process.
- Chemical process–Waste is subjected to a chemical agent. Disinfection like bleach, ozone gas, lime solution, sodium carbonate etc. are used in this process.
- Thermal treatments (Autoclaving, pyrolysis, microwaving)–At the early stage of treatment, infectious microorganism are destroyed by application of heat, if there is a possibility.
- Irradiation–by electron beam, ultraviolet rays etc. is done.
- Land disposal – Final treatment

We have selected four type of observations with the sample of Bio medical waste generated in Ujjain city with the following results:

Constant temperature

In first step, we have arranged a sample of health care waste about 10 kg in quantity in a reactor R₁ Where we maintained a constant temperature around 30 °C and recorded the change for about 35–36 days.

Vermicomposting

Table 2: Constant temperature reactor and vermin composting reactors readings.

S. No.	R ₁	R ₂	
Days	30°C temperature	MSW (liters)	Manure (liters)
0	20.0	20.0	0.0
4	18.0	11	1.5
8	15.0	9.0	2.0
12	13.5	7.0	1.7
16	12.2	6.7	2.2
20	11.6	6.8	2.6
24	11.1	5.5	3.9
28	10	5.4	3.8
32	10	2.2	6.7
36	9.9	0.0	8.1

One of the method for treating organic solid waste released from health care facilities. The reactor R₂ is filled with segregated waste (10 kg) and then load with earth worms (500gm) and the water is sprinkled from the top of reactor to maintain the moisture about 50%. During the process pH should maintained at 7.0-7.3, temperature 20 °C – 35 °C and moisture content is 45-55%. As in this environment the worms can degrade about 90 gm. worms/Kg organic solid waste. These worms breaks the complex structure of waste into noncomplex water soluble substances. The organic solid

waste has been treated for a period of 35-36 days through Vermicomposting and the volume is reduced to 35% of total volume means 65% of the volume is reduced. From onwards 4th day, we have observed that the color of waste starts to change into green to brown/black and after 36th day volume of manure is 8 Liters which is about 60% of the degradation. Result: This manure can be used in farms and gardens for plantation and agriculture purpose.

Incineration

A type of combustion process. The intense heat generated during the incineration process is able to dispose of almost all types of waste. Mainly categories 1, 2, 3, 5 and 6 of waste are treated with this technology. Mainly we use this treatment for the waste which cannot be of further use or reuse or recycle. Incinerators are specially designed for treatment of waste that should operate at temperatures range between 900 °C – 1200 °C (Pruss et al.1999). It reduces almost 80-85% mass of the waste. During this process waste is completely oxidized and microorganisms are destroyed under the influence of high temperature. All kinds of incinerator, if properly operated reduce waste to ashes and eliminate pathogens from waste.

Advantages

- On site incinerator helps to reduce the transportation cost.
- High temperature of incinerator is almost sufficient to kill infectious compounds.
- Cost and area for landfilling is reduced.

Disadvantage

- Incinerators emission contains release of toxic metals.

Microwaving

It is one of the methods we can apply for remediation of hazardous waste. The waste comes under category 3,4,6,7 can be treated by these methods. Most of the microorganisms are killed by the action of microwave at a frequency of 2450 MHz and a wavelength of 12.2 cm. Disinfection by Microwaving is a steam-based process since the disinfection takes place by the action of moist heat and steam is produced by microwave energy. First we load the waste in reactor then by the special arrangement of microwaves in the chamber, the waste will be heated to a temperature of about 97 °C to 100 °C. The water present in waste is heated by microwaves and infectious substances are removed by heat conduction process. Almost 30% of total volume of mass is reduced under this treatment.

Advantages

- Since this technique is not hectic and many health care units have microwave systems it is easy for HCFs members to understand and accept the technology.
- If HCFs take proper precautions for excluding hazardous material, the emissions from microwave units are minimum.
- Maintenance cost is low.

Disadvantages

- If hazardous chemicals are present in the waste, then toxic contaminants are released into the air or might remain in the waste to contaminate the landfill.
- There will be a possibility of some offensive odors around the microwave unit.
- Investment cost is high.

Shredding

It is one of the processes for waste minimization. It helps to reduce the size and quantity of waste by cutting or reshaping them into small pieces. The plastics (bottles, IV sets, syringes, catheters etc.), sharps (needles, blades, glass, scissors etc.) must be shredded but only after chemical treatment, microwaving or autoclaving.

Advantage

- It makes the waste unrecognizable.
- Helps in minimizing the amount of waste generated.
- Encourage the recycling
- It enhances the chemical and thermal treatment effectiveness

Disadvantage

- Electricity requirement
- Trained person are needed means person should have the knowledge of process.
- Sometimes expensive and can be damaged.

Result and discussion

The ideal scenario is to minimize waste produced as much as possible and try to produce useful products from the leftover of the treatment technologies too. Recycling and waste reduction should be the first concern and instead of disposing them into landfills.

Proposed plan for future scope

- Production of manure by composting or vermicomposting is a better option instead of throwing away the organic waste.
- With the waste to energy concept we can generate electricity and heat that can be used as a source of power for the buildings and industries.
- A new concept of production of Air ink is also emerging nowadays, we can use it in incinerator too. By this process we can remove the heavy metals and carcinogens from the ash removed after the incineration process and the final result is a purified carbon rich pigment, and then we can use this to make paints & ink.
- Installation of separate shredders/sterilizers for treatment of non-anatomical biomedical waste: Since it is both a sterilizer and a shredder, it has the ability to sterilize the waste in the least amount of time, enabling it to process the volumes generated by the HCFs.
- Govt. should encourage stem cell banking

Conclusion

There was an acute shortage of facilities in waste management methods of HCFs but the coordination between health care facilities and the waste handling authorities is quite good in Ujjain. It was however noticed that all organizations were keen to adopt a safe, practical, economic and sustainable system. The system we proposed above is suitable and effective so should be adopted as soon as possible.

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