Bio – Medical Waste Management in Pondicherry Region: A Case Study

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Abstract— Health Care Establishments (HCEs) generate biomedical waste (BMW), 15 – 35% of which are 'hazardous and toxic'. In spite of existence of regulatory mechanisms for handling etc., the ground reality is far from satisfactory, in India. There is a need to assess the actual practices that are followed in HCEs in all major cities and towns. In this study BMW handling and management in HCEs located in Pondicherry, India has been investigated. It was found that the importance of 'segregation' of waste has been realized by hospital staff. Further, HCEs in the region has been practicing one of the three methods (i.e. autoclaving, incineration and microwave irradiation) of treatment of BMW. A novel and low cost treatment of BMW has been proposed and implemented in private hospitals, Pondicherry as a case study. The results are very encouraging and cost effective.

Key words—BMW, low cost treatment method, assessment of quantity, neem and tobacco extract, management of BMW.

I. INTRODUCTION

Environmental – related problems have gained importance, since the last few decades, and they have reached a stage that they cannot be ignored any longer and at any cost. Realization of the need to 'provide health care as a basic social obligation' in a large socialist and democratic country like India, coupled with the overall development in the field of medicine, has led to proliferation of large number of 'health care establishments' (HCEs) like: hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories and blood banks, both in private and public sectors in India. This has resulted in the generation of huge wastes from the HCEs called as 'bio – medical waste (BMW)'. BMW means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto, or in the production or testing of biological, including categories mentioned in the schedule I of BMW (Management & Handling) rules, 1998, with amendments up to 2003. If such wastes are not properly collected, stored and disposed – off, then, there is a likelihood of the stakeholders getting infected and can also become a source of infectious diseases to others in the society. World health organization (WHO) has stated that 85% of hospital wastes are actually non – hazardous, 10% are infectious but non-hazardous, and 5% are hazardous. Generally, 15% to 35% of hospital waste generated can be regarded as 'infectious waste', and categorized as 'hazardous and toxic'.

In order to properly regulate the handling and management activities of the various HCEs, Govt. of India (GoI), has notified the Bio – medical (handling and management) rules, 2003, under the Environmental Protection Act (EPA) of 1986, and National guidelines on 'Hospital Waste Managements' Based upon the Bio-Medical waste (Management & Handling) Rules. In spite of the existence of the above rules, the ground reality is far from satisfactory, to say the least. Investigations have been carried out to assess the extent of implementation of BMW handling and management rules in various HCEs located in several towns and cities of India, like: Chennai, Coimbatore, Agra, Anand, Srinagar, Visakhapatnam, Bijapur, Belagam. Further comparative studies that exist in India and elsewhere have also been carried out. All these lead to unambiguous conclusion that BMW management in HCEs is far from satisfactory. The recommendations/observations of the study can be summarized as: (i) there must be strict enforcement of rules; (ii) there must be proper training given to all levels of staff in HCEs; (iii) there must be proper segregation and systematic collection and treatment of BMWs; (iv) infrastructural facilities for treating BMW to be strengthened; (v) there must a 'hospital infection control committee' to supervise all aspects of BMW; (vi) there must be a common BMW treatment facility; (vii) one of the reasons cited is lack of funds. [Shah and Ganguli (2010); Sharma and Chauhan (2008); Pandit et al (2007); Sreegiri and Krishna Babu (2009); Rao et al (2004); Sheth and Desai (2006); Yadavannavar et al (2010) and Goddu et al (2007)]. This shows that there is scope to extend such studies to HCEs located in all major and important towns and cities in India.

It has been reported that various methods like: incineration, autoclaving, plasma pyrolysis, use of ozone, use of fungus, have been adopted for treating BMW in India and elsewhere in the world. [Mohanasundaram (2003); Patil and Pokhrel (2005); PPCC (2006); Katoch (2007); Pandey and Gundevia (2008); Rasmussen and Charowsky (2009) and Gawtam et al (2010)]. Of them, the most popular method adopted in India, is 'incineration', and the ash generated there from is then disposed - off in landfills. However, it has been proven that 'dioxin' emitted during incineration is responsible for causing serious health hazards through environmental (air) pollution and the landfill becoming a source of groundwater pollution. Thus, safe and efficient methods of treatment and disposal of BMWs are important. The most important aspect in the treatment of BMW is the 'destruction of pathogens' for which certain traditional materials/ approaches can also be used. Pandey and Gundevia (2008) developed a cheap, easily available and effective method by using fungus – *Perconiella Sp.* isolated from cow dung for degrading.

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BMW materials. It has been reported that the above method was very efficient and quick without leaving any harmful effect on the population. However, the above method require controlled method of culturing, isolation and testing facilities.

In the absence of the above, the adoption of the above method becomes difficult. Jayanthi and Sanojini (2010) have used 'neem' extract for destruction of pathogens in infections BMW collected from a hospital at Coimbatore, India, and have reported that lime solution has effectively destroyed the pathogens with respect to time, where as, reduction in percentage is better only in fresh neem leaves extract. However, the feasibility and performance of such treatment methods have to be established, by explaining the use of similar types of materials either alone and in combination and based on extensive studies carried out on BMWs generated from HCEs of India.

Hence, the focus of the present study is on: (i) to assess the quality of BMW generated in the Pondicherry region; (ii) to identify the existing treatment / disposal systems and management practices being followed in the various HCEs and critically evaluate them and (iii) to evaluate the performance of using 'neem and tobacco extract' for the treatment of BMW, obtained from a large private hospital located in Pondicherry.

II. METHODOLOGY

A. Details of study area

The union territory (UT) of Pondicherry comprises of four regions, and Pondicherry region located in the east coast of India is the largest one and also the capital of U.T. It lies between latitudes 11^0 56' and longitude 79^0 53'. The general slope of the region is towards east. The total geographical area of Pondicherry is 492 sq km. Recently, it has witnessed tremendous growth in education, healthcare and tourism. It is also home to several reputed hospitals under central, state and private sectors, which is a unique feature of the above region. In order to evaluate the performance of the chosen methods of treatment of BMW, a large private hospital, which has been in existence for nearly 15 years and having 310 beds with good infrastructure facilities was chosen. The above chosen hospital is referred as to 'the hospital', henceforth in this paper.

B. Field survey

A survey was conducted to indentify the various HCEs located in Pondicherry region and the amount of waste generated including the number of beds available, in both the Govt. and private sectors. Further, the management practices like segregation, treatment and disposal methods that are being currently followed in all the indentified HCEs, were also collected. The data thus collected was then analysed, to draw critical inferences there from.

C. Experimental

In order to experimentally investigate the usefulness and performance of the chosen methods on the treatment of 'infectious' wastes, samples (i.e. cotton wastes) were collected from 'the hospital' and stored in airtight containers. Tobacco obtained from local sources and neem (*Azadirachta indica*) leaves extract solutions were used for treating the above waste. The above two materials were used to prepare 'neem' extract solution and a combination of 'neem' and 'tobacco' extract solution. For brevity, 'tobacco' extract solution is used in this paper to refer to the above

combination. After treatment, various physico-chemical (COD, total solids, volatile solids, electrical conductivity, alkalinity) and biological parameters (microbial colony count) were determined as per standard methods, (APHA, 2005) at different stages of destruction of pathogens. The results obtained were critically analysed to evaluate the relative performance of the chosen treatment methods for the 'infections sample'.

III. RESULTS AND DISCUSSION

Table 1: Generated BMW in the various HCEs of Pondicherry Region

Sl. No.	Name of the hospitals.	No. of beds	Quantity (kg/day)
I. Government hospitals			
1	General Hospital	698	1081.9
2	JIPEMER	1112	1723.6
3	Chest clinic	80	124
4	Mahatma Gandhi Govt. Leprosy Hospital	138	213.9
5	ESI hospital	75	116.25
6	Primary Health Centre (PHCs) (27Nos)	108	103.68
7	Govt. Maternity Hospital	330	511.5
	Total (A)		**3875**
II. Government and private medical colleges			
1	Govt. Medical College	300	408
2	Sri manakula vinayagar medical college	320	425.2
3	AarupadaiVeedu Medical College & Hospital	400	544
4	Pondicherry Institute of Medical Sciences (PIMS)	310	421.6
5	Mahatma Gandhi Medical College and Research Institute	300	408
6	Mahatma Gandhi Dental College & Hospital	30	40.8
7	Sri Lashminarayanan Medical College	220	299.2
8	Venkatewara Medical College	280	380.8
	Total (B)		**2928**
III. Private health care centres			
1	St. Joseph of Cluny Nursing Home	200	272
2	Nallam Clinic	75	102
3	Sedhu Nursing Home	65	88.4
4	New Medical Centre	42	57.12
5	Sri Mahalakshmi Nursing Home	20	27.5
6	Sri Krishna Nursing Home	20	27.5
7	Aswin Maternity Hospital	08	10.88
8	Rani Hospital	24	32.64
9	A.G. Padmavati Hospital	120	163.2
10	Sri Devi Nursing Home	10	13.6
11	Jagadesh Eye Clinic	02	2.72
12	Aurobindo Ashram Nursing	30	40.8
13	Jothi Eye Care Centre	10	13.6
14	VKN Hospital	17	23.12
15	Kamala Nursing Home	08	10.88
16	Madhava hospital	25	34
17	Aravind eye hospital	265	360.4
	Total (C)		**1280**

A. Field survey

(i) Total BMW Generation

The total amount of BMW generated (in kg/day) from each of the HCEs are given in Table 1. HCEs of the region have been categorized into: (i) Government hospitals, (ii) Government and private medical colleges and (iii) private healthcare centers. Incidentally, the quantity of BMW generated also ranks in that order, the highest by Govt. hospitals and the lowest by private health care centers.

The total BMW generated has been assessed as 8.1 tons/day. Of the above, 70 - 80% can generally be considered to fall under 'non - infectious' wastes.

(ii) Segregation

It has been observed that there is a positive change in the attitude of hospital staff, where by, the importance of segregation has been felt and hence, more and more HCEs in this region have presently implemented segregation in substantial terms, which is expected to result in 'complete segregation', in future. Further, it was observed that the basic system followed is the usual 4 – bins combination (3 – bins for infectious wastes and the fourth one for sharps). The segregation practices actually followed in all the HCEs can be classified into any one of the four types, namely; (i) well segregated; (ii) substantial segregation (with poor monitoring); (iii) poor segregation and (iv) no segregation. It is found most of the Government hospitals in the Pondicherry region fall in the second category, whereas, the private hospitals and nursing homes fall under the third category.

(iii) Pre-treatment

Most institutions that adopt segregating of BMWs at source, also pre – treat (i.e. disinfect) the BMWs with 1% of sodium hypochlorite solution, before sending the samples for further treatment and disposal. Apart from the above form of disinfection, use of calcium hypochlorite, bleaching agent / Dettol were also used.

(iv) Treatment and disposal

The HCEs surveyed have been practicing autoclaving, incineration, and microwave irradiation.

B. Case study

(i) Segregation

The amount of BMW generated by 'the hospital' is about 397 kg/day, which works to about 1.3kg/day/bed. This is slightly lower than the average quantity reported at national level (i.e. in India). [Shah and Ganguli, 2010]. It is found that the BMWs were carefully segregated at source itself and that the hospital staff were very much aware of the handling and safety procedures. The solid waste from the hospital consisting of bandages, linen and other infection materials constituted 30 – 40 % of the total waste. In terms of quantity, infectious waste generated is about 159 kg/day.

(ii) Present treatment methods

The hospital has two incinerators, one operating on furnace oil and the other using diesel. The capacity of the incinerator is about 500 kg, with an operating temperature of about 900°C. The incinerators were found to be operating between 6 to 9 pm and the 'infectious waste' generated is generally gets incinerated in about two hours. Control devices have been installed to prevent air pollution by particulate matters and flue gases, as a result of incineration.

(iii) Treatment of Neem and Tobacco extracts

Within 3 hours of treatment by both the methods (i.e. using neem and tobacco extract), the bacterial colony count (BCC) has decreased by one order of magnitude and it continuous to decrease. At the end of 9 hours of treatment the BCC is only 1% of the raw BCC. In other words there is a reduction of

three orders of magnitude in the reduction of BCC, within 9 hours of treatment by both the methods. At the end of 24 hours of treatment BCC has reduced by three orders of magnitude, by both the methods and the trend continuous till 120 hours of treatment, by which time the BCC has decreased by atleast 6 orders of magnitude, with respective to its original BCC value of raw waste. Of the two methods, the performance of 'tobacco extract' has always and consistently been better than with 'neem extract'.

COD continue to decrease from the instant of treatment, by both the methods COD has reduced by atleast 50% at the end of 9 hours and 6 hours of treatment by 'neem extract' and 'tobacco' extract, respectively. Rate of reduction in COD is slightly higher with 'tobacco' extract than with 'neem extract' and that about 99% of the raw BMW COD has been reduced at the end of 120 hours. The same trend in the results were observed with respect to variation in total solids, alkalinity, when the sample was treated with the combination of neem and tobacco. Reduction in total solids represent the ready / easy biodegradable nature of huge amount of complex cellulose materials and the effectiveness of the method on them. Reduction in alkalinity indicates the reduction of salts of carbonates and bicarbonates. Reduction in electrical conductivity (EC) was found to vary from 191.2μs to 30.8μs (neem) and to 28.4μs (tobacco). In the case of reduction in EC, the influences of both the methods are quite comparable. The concentration of EC is found to be within desirable limits and shows the presence of various dissolved ionic salts.

(iv) Cost comparison

The costs of treatment of 'infectious waste' by incineration (presently followed in the hospital) and by neem and tobacco methods (the methods used in this study) were compared. For the above, it was assumed that: i) time of duration is 4 hours; ii) amount of diesel required is 20 liters, for the 'incineration' method. However, local market rate for tobacco was adopted. Based on the above, the cost is about Rs. 5.03 and Rs. 1.67 for per kg of waste treated by 'incineration' and 'neem' methods. In other words, treatment by 'neem' methods is three time cost – effective, which is very encouraging and promising.

IV. SALIENT CONCLUSIONS

Based on the field survey and the experimental investigations carried out, following are the salient conclusions:

i. The total BMW generated in the various healthcare establishments of Pondicherry region is about 8.1 tons day, out of which 30 – 40% can be considered as 'infectious'.

ii. Importance of 'segregation' at source is seen to have been realized with the hope that 'complete segregation' can become a reality, in future.

iii. There is very high reduction in the chosen physico-chemical and biological parameters using 'neem' and 'neem' & 'tobacco' methods. After 120 hours of treatment by the two methods, 99% of COD of raw BMW has been reduced and the BCC (bacterial colony count) has reduced by atleast 6 orders of magnitude with respect to raw BMW, which is very very high.

iv. In general, marginally better results are obtained when the waste is treated with a combination of neem and tobacco extract.

v. Treatment with a combination of neem and tobacco extract is three times cost – effective than the incineration method currently used for treating infectious wastes sampled from the HCE chosen for the case study.

vi. On overall assessment, the new method adopted is very efficient and promising. However, its efficiency for treating large quantities of BMWs, has to be assessed.

Table 2: Materials used for disinfection of the sample

Sl. No.	Details of materials used	Quantity
1	Sampled BMW	3 Kg
2	Neem leaves extract	100 ml
3	Tobacco leaves extract	50 ml
4	Water added during disinfection process	6 l

Table 3: Chemical characteristics of raw waste (BMW):

Sl. No	PARAMETERS	VALUE
1	Moisture content (%)	20 – 30
2	Total Solids (mg/l)	89000
3	Volatile solids (mg/l)	76800
4	Electrical Conductivity (µs/cm)	191.2
5	COD (mg/l)	9200
6	Alkalinity (mg/l)	8220
7	Bacterial colony count (CFU/ml)	28×10^9

Table 4: Variation of monitoring parameters of the sample with detention time using 'neem' extract

Sl. No.	Detention time (hrs)	COD (mg/l)	TS (mg/l)	VS (mg/l)	Bacterial Colony Count (CFU/ml)	EC (µs/cm)	Alkalinity (mg/l)
1	3	8950	74800	68510	28×10^8	175.8	6501
2	6	7502	60100	51987	82×10^7	140.9	5742
3	9	6020	49240	46025	8×10^7	143.2	3504
4	24	3280	44670	43190	42×10^6	123.3	3124
5	27	3000	39104	35235	8×10^6	93.2	2842
6	30	2730	36300	32193	65×10^5	87.4	1812
7	48	1080	32382	27954	18×10^5	80.2	1915
8	51	914	28198	24520	5×10^5	71.7	1241
9	54	768	25005	22647	86×10^4	64.9	954
10	72	315	20524	19985	42×10^4	52.6	648
11	96	202	17880	15720	5×10^4	42.1	420
12	120	160	14200	11340	5×10^3	30.8	327

Table 5: Variation of monitoring parameters of the sample with detention time using 'tobacco' extract solution

Sl. No.	Detention time (hrs)	COD (mg/l)	TS (mg/l)	VS (mg/l)	Bacterial colony count (CFU/ml)	EC (µs/cm)	Alkalinity (mg/l)
1	3	8250	74500	69200	12×10^8	175.8	6040
2	6	7300	66000	66300	2×10^7	140.9	5120
3	9	5520	49250	55250	56×10^6	131.2	3850

4	24	3050	36300	42355	36×10^5	110.3	3000
5	27	1080	33205	33030	12×10^5	91.2	2115
6	30	824	30310	30000	48×10^4	82.4	1718.5
7	48	529	28020	26245	6×10^4	65.2	1080
8	51	202	25900	21325	58×10^3	60.7	700.33
9	54	198	22100	20112	21×10^3	55.9	600.21
10	72	154	18300	19315	6×10^3	46.8	480
11	96	123	16210	16872	41×10^2	37.6	356.8
12	120	87	12164	14534	22×10^2	28.4	228.4

REFERENCES

[1] Gautam V, Thapar R, Sharma M (2010) Biomedical waste management: Incineration Vs environmental safety, *Indian Jl of Medical Microbiology,* 28: 191-192.

[2] Goddu V K, Duvvuri K and Bakki V K (2007) A critical analysis of healthcare waste management in developing countries: Case studies from India and England. *Proc. of the Intl. Conference on Sustainable Solid Waste Management,* Chennai, India, Sep. 5-7, pp. 134-141.

[3] Government of India (GoI), Ministry of Environment and Forests (MoEF), Bio-Medical Waste (Management and Handling) Rules, 1998 and Bio-Medical waste (Management and Handling) (Amendment) Rules, 2003.

[4] Government of India (GoI), National Guidelines on Hospital Waste Management Based upon the Bio-Medical Waste (Management & Handling) Rules.

[5] Jayanthi S and Sarojini E (2010) Destruction of pathogens in infectious BMW using lime and neem (*Azadirchta indica*).

[6] Katoch S S (2007) Biomedical waste classification and prevailing management strategies, *Intl Conference on Sustainable Solid Waste Management*, Chennai, India, Sep. 5-7, pp 169-175.

[7] Mohanasundram V (2003) The environmental implications and economic issues in biomedical waste management in urban Coimbatore Tamil Nadu, India, *Proc. of the Third Intl. Conference on Environment and Health,* Chennai, India, Dec.15-17, pp 270-275.

[8] Pandey A and Gundevia H S (2008) Role of the fungus-*Periconiella sp*. in destruction of biomedical waste. *Journal of Environ,Science & Engg*., 50(3): 239-240.

[9] Patil G V and Pokhrel K (2005) Biomedical solid waste management in Indian hospital: A case study, *Waste Management* (25): 592-599.

[10] Pandit N A, Tabish S A, Qadri G J and Ajaz Mustafa (2007) Biomedical waste management in local teaching hospital, JK-Practitioner, 14(1): 57-59 (Jan-Mar.).

[11] Pondicherry Pollution Control Committee (PPCC) 2006, *ENVINS,* Project Report, 2(3): 1-13 (July - Sep).

[12] Rao S K M, Ranyal, R K Bhatia S S and Sharma V R (2004) Biomedical waste management: An infrastructural survey of hospitals, *Medical Journal of Armed Forces of India (MJAFI)*, 60(4): 379-382.

[13] Radha K V, Kalaivani K, Lavanaya R (2009) A case study of biomedical waste management in hospitals, *Global Journal of Health Science*, 1(1): 82-88 (April)

[14] Rasmussen C D and Charowsky (2009) Treatment of biomedical waste with Ozone.

[15] Sarojini E, Jayanthi S, Jothi Venkatraman S and Prashanthini K (2007) Performance study on common biomedical waste treatment facility, Chettipalayam, Coimbatore. *Proceedings of the International Conference on Sustainable Solid Waste Management*, Chennai, India. pp 182-188.

[16] Shah H K and Ganguli S K (2010) Hospital waste management – A Review, *Indian Jl of Community Medicine,* 25(3): 136-137 (July – Sep.).

[17] Sharma S and Chauhan SVS (2008) Assessment of bio-medical waste management in three apex Government hospital of Agra, *Jl. of Environmental Biology,* 29(2): 159-162 (Mar.).

[18] Sheth K N and Desai P H (2006) Characterization and management of bio – medical waste in SAE hospital, Anand – A Case study, *Electronic Jl. of Environmental Agricultural and Food Chemistry (ISSN: 1579-4377).* 5(6): 1583-1589.

[19] Sreegiri S and Kirshnababu G (2009) Biomedical waste management in a tertiary level hospital in Visakhapatnam. *Jl. of Community Medicine,* 5(2): 1-6 (Jul-Dec.).

[20] Yadavannavar M C, Berad A S and Jagirdar P B (2010) Biomedical waste management: A study of knowledge, attitude and practices in a Tertiary Health care institution in Bijapur, *Indian Jl. of Community Medicine*, 35(1): 170-171 (Jan.).