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Assessment of Biomedical Waste Disposal and Management in Three Hospitals of Rishikesh, India

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Abstract- Biomedical wastes generated in hospitals and clinics and its management is becoming an area of great concern and importance in view of potential public health risks associated with such wastes. Biomedical waste management is complex issue as it has several dimension associated with it like proper and safe disposal of waste, waste treatment technologies and development of environmental friendly treatment and management technologies. In many developing countries like India, the insufficiency of data regarding the composition and quantity of biomedical waste is one of the considerable reasons for inappropriate biomedical waste management. This study explores the present scenario of biomedical waste management, handling, practices, generation, and treatment of biomedical waste management within Rishikesh region (part of Uttarakhand, India). The biomedical waste related practices have been studied at three major hospitals of Rishikesh which includes AIIMS (All India Institute of Medical Sciences), Government hospital and NAH (Nirmal ashram hospital) (private) starting from month of October 2017 to February 2018 by analyzing the procurement lists. The data is analyzed to find variation in biomedical waste generation over the study period. The average waste generated per day (kg/day) in AIIMS, Government hospital, NAH was 286.64, 123.263, and 63.653.Whereas average number of patients/day were 1314.88, 360.42, and 120.1 along with the total bed capacity of 439,165, and 130 respectively in each hospitals. The cross-sectional study involves various issues like sources, container and color coding types, qualitative and quantitative composition of infectious wastes along with different methods of waste handling, collection, segregation, treatment and disposal methods. After investigating all aspects, it was founded that there is lack of proper disposal methods in the government hospital and NAH as compared with the AIIMS, although waste is transported from all the three hospitals to the same combined biomedical waste treatment plant (CBMWTP) for disposal. This study will help in tackling these emerging issues related to biomedical waste management.

Keywords- Biomedical waste, Infectious waste, CBMWTP and Biomedical waste management rule.

1. INTRODUCTION

Biomedical waste can be defined as the waste (solid or liquid) produced by hospitals, clinics, nursing homes and other health care units, that are potential source of health hazards and hence these are needed to be treated, managed specially and disposed of. Biomedical waste management has recently turn out as an issue of major concern not only to hospitals, nursing home authorities but also to the environmental and law enforcement agencies, media and the general public in India [1]. Biomedical waste forms approximately 1-2% of the total municipal solid waste (MSW) stream, although not all of hospital wastes are vulnerable to transmit diseases. Out of 1-2% hospital waste approx. 80-85 % are non-infectious and 10% are infectious and 5% are hazardous [2]. Although the solid waste management has become one of the major topic of importance but still local bodies have failed to develop proper focus towards some special sources of wastes out of which biomedical waste is one.

Biomedical wastes are categorized as infectious and non-infectious [3]. Infectious waste includes human tissue, body fluids, excreta, articles such as urine containers, sharp-edged and glass pieces, many of which can be adulterated [4].Non-infectious wastes are generated from laboratory work, wastes from surgery and patients suffering with infectious diseases. A second category of clinical waste includes drugs that have become outdated or contaminated. Other types of biomedical waste includes recyclables items, radioactive waste, mercury carrying instrument, PVC plastics etc., further these items require special precaution while handling [5]. Needles, metal sharps, blades etc. possess potent threat to biohazard even after sterilisation, so requires greater attention while handling and disposing [6].

Huge amount of hospital waste generation is a condemnatory issue in not only in developing countries but also in the developed countries. Hospital waste generation differs not only among the countries but within countries based on the type of

infrastructure, type of management system followed, proportion of reusable items and proportion of waste generated on an outpatient basis. The total Biomedical waste generated in India is approx.519 tonnes/day from over 187485 nos. of Health Care Facilities (HCFs) having 1701986 beds. An estimated 489 tonnes/day of biomedical waste gets treated in India, detailed information is given in the Table 1 [7]. The health care sector of India is growing rapidly and according to sources, it will grow more approx. 2.9 million hospital beds by 2025. Biomedical market will grow at compound annual growth rate of 8.41 % higher than the projected growth rate for waste generation.

Table 1.Information about total waste generated and treated.

Year	BMW(Tonnes/Day)	
	Total Generated	**Treated**
2008	409	295
2009	406	291
2010	407	308
2011	408	370
2012	416	380
2013	484	447
2014	495	462
2015	501	486
2016	519	483

The hospital refuse also become harmful, when reusable items find their way back to the hospital and ultimately to the patient. The amount and type of waste is increasing because of development in hospital healthcare technology, advances in scientific knowledge and utilization of more disposal products [9-11]. The vulnerability to infectious and hazardous hospital waste can cause consequential health problems to those who handle it, particularly to waste collectors or rag pickers and the environmentalists [12].This also becomes a source of many contagious diseases. There are very few research report which deals with proper disposal of biomedical waste have been reported up till now [13-20].Safe and effective disposal management techniques of biomedical waste are not only legally important but also have social importance [21].

Rishikesh is located in the state of Uttarakhand, in the North West of India. It is surrounded by the Himalaya Mountains on three sides and has the holy River Ganga flowing through it and had a population of 102,138 according to census 2011. It has many private hospitals and one AIIMS and a government hospital which generate huge amount of waste every day. In Rishikesh unlike other cities of India, not many people are aware that medical waste contributes substantially to environmental pollution and hazards. This is reflected by lack of awareness and specific policy to address the menace of healthcare facility (HCF) waste, some of which is deemed hazardous. In Rishikesh BMW is segregated at the hospitals and further gets collected, transported and treated at the MPCC site i.e. the combined biomedical waste treatment plant (CBMWTP).Management of handling the bio medical in hospitals are not perfect due to which the segregation and disposal technique are not implemented properly in hospitals. Newer technologies are not adopted. The disposal methods which may be conditioned by proportions will be either recyclable, non-degradable or degradable materials [22-24]. Hence, the present study was undertaken to know the disposal practices of bio-medical wastes, to suggest proper disposal methods and management of bio-medical wastes in three major hospitals of Rishikesh AIIMS, Government hospital, Nirmal ashram hospital (NAH).

2. MATERIALS AND METHODS

The methodology involves starting from the point of generation of medical waste (MW) to the disposal of the waste from the hospitals in the town. The study involves different technique adopted in Rishikesh town to choose the ways and means for the data collection. The study was conducted over a period of five months from 1 October 2017 to February 30, 2018, for data collection from the primary and secondary source related to medical waste (MW) generation, segregation, collection, disposal and its hazardous health impact to the waste collectors (rag pickers). Methods adopted for data collection are shown in Table-2**.** The information related to the generation, segregation, collection, storage, disposal, transportation and its management were carefully studied and collected. The problems faced by the management of the waste staff were also interviewed regarding the loophole in the system.

Table 2.Methods adopted for data collection.

	Regarding	**Methods**
Primary Source	Generation, segregation, collection, transportation and disposal of the medical waste.	Personal observation and investigation at the site, questioner, interview
Secondary Source	Topic related research paper collection	E-journal, internet

2.1. *Study Area*

All health care facilities are located in Rishikesh, one of the famous town of Uttarakhand state of India. Rishikesh is located at 30.103368^{o} N 78.294754^{o}E in the Himalayan foothills besides the holy Ganges river in India's northern state of Uttarakhand. It is also known as the 'Gateway to the Garhwal Himalayas and 'Yoga capital of the world [25]. Rishikesh is small town of Uttarakhand size wise with an area of 11.5 km^2 but it is the seventh most populous city in the state and due to its location. People are shifting towards Rishikesh from mountains this lead to increase in population of the town which directly affects the waste generation rate of the town. The present study was conducted over a period of five months from 1 October 2017 to 28 February, 2018 to check out the status of biomedical waste management in the some of the selected major hospitals of the city in order to understand the problems associated with biomedical waste management system in the city.

The present study was limited to three major hospitals of Rishikesh (AIIMS, Govt. Hospital, and NAH). The waste management practices of each facilities provided by these hospitals were carefully observed, studied and information regarding the management, generation, segregation, collection, storage and disposal of wastes were obtained. Average number of total waste bags generate was studied over a period of five months i.e. October, November, December, January and February of the year 2017 and 2018.Average weight of individual waste bag (color coding) from three major hospitals of city were also recorded. The segregation of the waste, collection of recyclable plastics and glass wares by the waste management staff during collection from the individual wards were personally observed to know workers responsibility and awareness towards the biomedical waste handling. Average solid waste generated per day at each source (S) at each hospital was calculated using the standard formula given by the S=A*C, where average number of patients per day was denoted as (A) and average waste per capita per day as (C) [18].In order to have proper waste disposal system of hospitals, various management approaches and guidelines are given by the government [26]. The data obtained were analyzed by one way analysis of variance (ANOVA) method on SPSS (Statistical package of social science).

2.2. *Basic information related to hospitals*

The availability of the data and size of the health care centers was based on the available infrastructure such as the number of beds and the patient visited per day. The bed capacity and number of patients visited per day is given in Table 3.

Table 3.Basic information related to the hospitals.

Name of the hospitals	Bed capacity	Waste generation during one month	Avg. number of patient per day
AIIMS	439	8318.1	1314.88
Government	165	3700.8	360.42
NAH	130	1935	120.1

2.3. *Sampling and Methodology*

The sampling and methodology divided in three phase. First phase includes post period i.e. the time before the actual study which includes the permission from the authority, questionnaire designing, fixing of day and time of performing the study, consulting with the guide regarding the methodology adopted and also consulting with relevant persons involved in the waste management staff in the hospitals under observation. The purpose of the study was informed to the hospitals management staff and the participants involved in the study and they were assured about their confidentiality. Second phase includes the implementation of the methodology adopted on the field. Name of the hospitals, bed capacity, classification of waste generation during one month, color coding, waste class, average number of individual bags collection from the hospitals during six months (Avg. no. bags per day per months), waste generation in three hospitals (generation rate kg/bed/day). The calculation of average quantity of waste generated per bed were carried out manually or with help software simply dividing quantity of waste by number of bed capacity in the hospital [27].The third phase includes the collected data were tabulated, analyzed and presented by proper statistical method with the Microsoft excel 2013 and SPSS statistics base software package [28].

3. RESULTS AND DISCUSSION

The bed capacity and patients per day data of each hospital were obtained from the records of hospitals i.e. AIIMS, Govt. hospital and NAH, which is further shown in Table 3. Beside this, waste generated during per month was also recorded for each hospitals and is shown in Table3.Data based on the type of waste coding container and color of waste bags used in hospitals for disposal was collected. Average weight biomedical waste generated from three major hospital of Rishikesh during October2017 to February 2018 (kg/day) is shown in Table 4 and the individual bag

collections (yellow, red and blue) are presented in the Table 3to 9.

The average waste generated per month was observed to be 8318.1kg/month at AIIMS hospital as mentioned in Table 3. From the recorded data in Table 3to 9, the individual bags collection for different months of waste in different color codes as yellow, red and blue bag was founded to be (in Kg/day) as 41.94, 77.23, and 13.85 for October, 50.8767, 95.04, and 14.156 in November, 47.4064, 92.035, and 15.332 in December, 55.1870, 98.33, and 15.183 in January, and 63.928, 131.171, and 18.73 in February respectively. The number of patients admitted in AIIMS hospital per day is about 1314.88 and the average waste generation per capita per day was observed to be0.218 kg as shown in Table 10. The waste generated per day at AIIMS was founded to be 286.64 kg (Table 10). Whereas in government hospital, the average waste generated per month was observed to be 3700.8 kg/month as mentioned in Table 3. From the recorded data in Table 4to 9, the individual bags collection for different months of waste in different color codes as yellow, red and blue bag was founded to be (in Kg/day) as16.129, 51.61, and 5.32 in October23.33, 50, and 7.69 in November, 19.35, 39.67, and 6.385 in December, 20.926, 42.87, and 6.91 in January, and 24.537, 45.62, and 8.097 in February respectively. The number of patients admitted in government hospital per day is about 360.42 and the average waste generation per capita per day was observed to be 0.342 kg (Table 10). The waste generated per day at Government hospital was founded to be 123.263 kg (Table 10). Likewise in Nirmal ashram hospital the average waste generated per month was observed to be 1935 kg/month. From the recorded data in Table 4to 9, individual bags for waste collection in different months in different color codes as yellow, red and blue bag was recorded as (kg/day) 25.08, 3.25, and 8.27 in October, 20.06, 3.66, and 6.60 in November, 26.5, 2.838, and 8.745 in December, 28.80, 5.161, and 9.504 in January, 28.96, 4.82, and 9.55 in February respectively. The number of patients admitted in NAH hospital per day is about 120.1 and the average waste generation per capita per day was observed to be 0.53 kg (Table 10). The waste generated per day at NAH was found to be 63.653kg (Table 10).

Table 4.Average weight of biomedical waste generated from three major hospitals during October 2017- February 2018 (kg/day).

	AIIMS	**Government**	**NAH**
Oct.	44.83	24.35	12.2
Nov.	53.35	27.01	10.68
Dec.	51.59	21.6	12.69
Jan.	56.23	23.58	14.49
Feb.	71.27	26.8	14.44

Table 5.Average weight of individual waste bags generated from three major hospitals of Rishikesh city of October (kg/day).

	Yellow	**Red**	**Blue**
AIIMS	41.935	77.23	13.85
Government	16.129	51.61	5.32
NAH	25.08	3.25	8.27

Table 6.Average weight of individual waste bags generated from three major hospitals of Rishikesh city of November (kg/day).

	Yellow	**Red**	**Blue**
AIIMS	50.87	95.04	14.156
Government	23.33	50	7.69
NAH	20.06	3.6	6.6

Table 7.Average weight of individual waste bags generated from three major hospitals of Rishikesh city of December (kg/day).

	Yellow	**Red**	**Blue**
AIIMS	47.4	92.04	15.33
Government	19.35	39.67	6.38
NAH	26.5	2.83	8.75

Table 8.Average weight of individual waste bags generated from three major hospitals of Rishikesh city of January (kg/day).

	Yellow	**Red**	**Blue**
AIIMS	55.18	98.33	15.18
Government	20.96	42.87	6.91
NAH	28.8	5.161	9.5

Table 9.Average weight of individual waste bags generated from three major hospitals of Rishikesh city of February (kg/day).

	Yellow	**Red**	**Blue**
AIIMS	63.928	131.17	18.73
Government	24.5371	45.62	8.09
NAH	28.96	4.82	9.55

Table 10.Solid waste generation in three major hospitals of Rishikesh

	Avg. number of Patients per day(A)	**Avg. Waste Capacity (C)**	**Avg. Waste Generated /day S=A*C**
AIIMS	1314.88	0.218	286.64
Government	360.42	0.342	123.26
NAH	120.1	0.53	63.65

Waste generation rate was high in AIIMS Rishikesh followed by the government hospital and least in the Nirmal Ashram Hospital. Waste generation is high in AIIMS Rishikesh due to more number of bed capacities and high number of patient per day as compared with the other two. The generation rates depend upon several factors such as the type of healthcare establishment, level of instrumentation, and its location.

Fig. 1. Shows, the average number of patient per day from the three hospital in percentage, whereas Fig. 2, depicts the waste generation rate (kg/day) for three different hospitals. The individual waste bag generated from the three hospitals in kg from October 2017 to February 2018 is shown (kg/day) in Table 5 to 9. The generation rate of yellow bag waste was maximum in AIIMS in month of February (63.928 kg/day or 1790 kg/month) which is followed by January (55.1870 kg/day or 1710.79 kg/month) similar observation and generation rate noticed for the red and blue bag.

The main cause of increase in the waste was due to increase in number of beds and the number of patients admitted in the hospital. In government hospital and Nirmal ashram hospital generation rate of waste in different colour bag, month wise is depicted in Table 5 to 9.

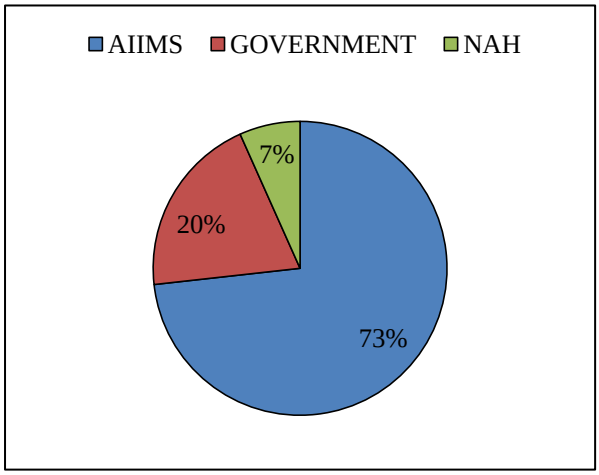

Fig. 1.Average number of patients per day in three major hospitals of Rishikesh

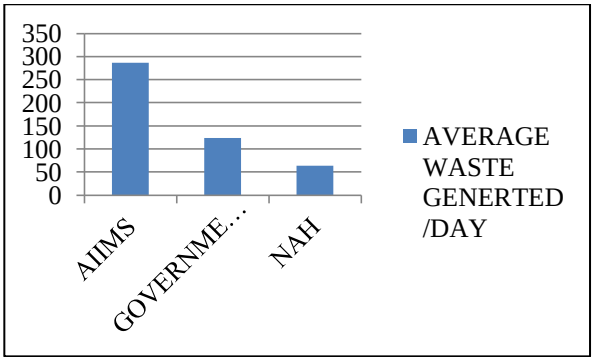

Fig. 2.Average waste generated per day in three hospitals of Rishikesh city (kg/day)

waste from October to February in all three hospitals, it clearly shows that the generation of waste in AIIMS is highest throughout the study duration whereas, NAH was founded to be lowest in terms of waste generation.

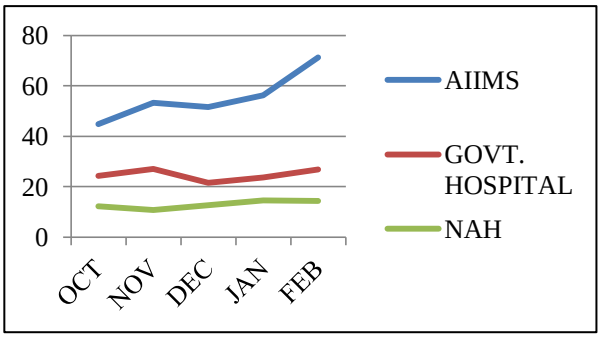

Fig. 3.Average weight of biomedical waste generated from three major hospitals during October 2017-February 2018 (kg/day)

The government of India guidelines related to biomedical waste management rule 2016, specifies that the management of hospital waste is part of hospital cleanliness i.e. hygiene and maintenance activities which basically includes the engineering process such as segregation, collection its transportation operation, treatment methodology and finally includes the disposal method of the waste. Although initial collection, its segregation and storage is responsibility of the hospital waste handler management team within the hospital, clinics or nursing homes itself. Hospital waste management, is desired to be aware about the different colour coding bags used for segregation, which is one of the most important guideline for the biomedical waste management system. Waste handlers are needed to be cautious while handling the hospital waste, they should wear proper protective cloths such as mask,

gloves, apron, so that they could protect themselves from infectious diseases which gets transmitted by them. The infectious waste should be segregated initially, so that it does not get mixed with the other non-infectious waste. As if they get mixed with the other wastes, the entire mass waste becomes potentially hazardous [29][30]. After investigating, it was observed that there is gap of knowledge among the hospital workers regarding the different colour coding of bins and segregation which may be due to lack of awareness among them about these biomedical wastes and their ill effects.

At the time of study, it was observed that less attention was given while segregating the hospital wastes, in the government hospital. Further, there was no proper mechanism of segregation of hospital waste existed, also color coding container were founded to be less in number and were pathetic in condition. The workers who were handling the hospital waste were not wearing proper protective clothing such as gloves, apron and mask, which are essential for protecting them from infectious diseases. Waste handlers collect the waste from various departments in same container without segregating and unload in the large container placed outside the biomedical waste storage room. No proper records were maintained as per the guideline given by the government in biomedical waste management rule 2016. The waste generated in hospital is transported to the combined biomedical waste treatment plant (CBMWTP) site regularly but due to poor rules implementation related to BMW i.e. lack of proper segregation at initial stages, it becomes highly difficult for CBMWTP to carryout proper disposal of these wastes.

Similar observations was seen in the Nirmal Ashram Hospital. There was no proper implementation of rules given for the biomedical waste management. There was no proper availability of color coding bin, segregation, bar code system for bag or container containing biomedical waste, which is to be sent out of the premises. Even, waste handlers were not wearing proper protective cloth. There is also lack in system in maintaining the records related to biomedical waste as they are totally dependent on private vendor company for their waste management.

While observing the waste management system of AIIMS Rishikesh, it was observed that the guidelines specified by the government of India on biomedical waste management rule 2016 are followed strictly. Proper color coding bins were found in each and every department with waste bag with in bins and specification board on the wall about the segregation of waste in different color coding bin. The waste handlers were wearing proper protective cloth as per specification. Waste bags were removed as it get full on time after that all bags were transported through systematic manner to the storage room within hospital, from where these wastes were taken to the Combined biomedical waste treatment plant (CBMWTP) i.e. MPCC, situated in Roorkee. The waste carrying transport vehicle were marked with biohazard symbol, name and address of the CBMWTP.

The present study investigates a combination of factors such as collection, segregation, transportation, and disposal of hospital waste, which are existing in the current waste management system in the city of Rishikesh. This study can be used more aptly in designing the effective plan, by the concerned agencies in order to improve the status of BMW in Rishikesh city. Integrated approaches must be followed by the corporation for successful implementation of BMW. It can be easily observed, monitored and checked regularly. Corporation should also adopt some alternative mode of collection, transportation and disposal of hospital waste and it should be strengthened covering each and every hospital of the city. Hospitals of Rishikesh might need to look for alternate and better solution for managing the waste disposal site at more frequent intervals.

Due to increase in population growth rate of the Rishikesh city, number of hospitals having more than thousand plus beds got increased abruptly. Therefore by keeping in view to these foresaid problems, there is need for implementation of effective and strict master plan by corporations of Rishikesh city for proper management of medical wastes. Statistics and survey results show that in the future (2020 and 2021), there will be increase in enormous amount of biomedical waste in hospitals. All three hospitals were surveyed for five months and but the result obtained is different for different hospitals. It was observed that NAH had lower waste generation during November and October while government hospital had highest during November and February. It is obvious that the AIIMS and government hospital have highest amount of waste generation as these general hospitals are well known centers for the accident victims. AIIMS having almost all facilities for efficient and effective treatment of various diseases, therefore it have high number of daily patients, hence generations of waste bags is higher in it. Although generation of waste in AIIMS is not a major problem because of its waste management system.

4. CONCLUSIONS

Management of the bio medical waste is core responsibility of the hospital waste management team. Its management totally depends on the input from hospital administration along with the active

participation of the trained waste handling staff for collection, segregation, transportation and disposal of biomedical waste. Hence, there is serious requirement of developing a hierarchal structure for the biomedical waste management by the hospital associations, which includes all the head of departments, hospital superintendent, nursing superintendent, and engineers. Waste management officer should be appointed by the management team who will be advised by the environmental control advisor and infectious waste control advisor. There should be strict implementation of biomedical waste management rules as it is need of hour. Management of biomedical waste could not be successfully implemented without active participation, willingness and cooperation among the hospital management team.

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