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Quantification and Characterization of the Bio-Medical Waste in Arunachal State Hospital, Naharlagun

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Abstract— Hospitals produce waste, which is increasing over the years in its amount and type. The bio-medical waste is the waste that is generated during the diagnosis, treatment or immunization of human beings, animals or in research activities and production or testing of biological components. The bio-medical waste, in addition to the risk for patients and personnel who handle them also poses a threat to public health and environment. Most countries of the world, especially the developing nations, are facing the grim situation arising out of environmental pollution due to pathological waste arising from increasing populations and the consequent rapid growth in the number of healthcare centres. The main objective of the study was to analyse the amount of biomedical waste generated in the Arunachal State Hospital, Naharlagun, feasibility of the currently available waste management system and also to recommend suitable methods for the disposal and management of biomedical waste of the State Hospital, Naharlagun. The present waste management system was analysed by comparing the properties of the waste water at the intersection where the waste water of the hospital meets the sewer. The biomedical waste generated at the hospital and the energy associated with it was determined.

Keywords—Arunachal State Hospital, BMW, environmental pollution, energy

I. INTRODUCTION

Hospitals have been in existence in one form or the other since time immemorial but there never has been so much concern about the waste generated by them. Hospitals and other health care facilities generate lots of waste which can transmit infections, particularly HIV, Hepatitis B & C and Tetanus, to the people who handle it or come in contact with it. The environmentalists have been up in arms against the casual manner in which hospital waste is being treated in our country. The last few decades have seen a rapid mushrooming of hospitals to cater the needs and demands of the increased population. Correspondingly there has been an increase in the wastes generated by them. It is ironical that the very hospital that brings relief to the sick can at the same time create health hazards due to improper management of the waste generated by it. Unlike in the developed countries, the concept of Hospital Waste Management (HWM) has not really caught up in India. It is time we realize the importance of HWM and the need of sensitizing the top level managers orienting them with various types of waste, their generation, segregation, collection and transportation and final disposal. Though 75-80% of wastes generated from hospitals are non-infectious, 20-25% is hazardous [8]. Except a few large private hospitals in metros, most of the hospitals and nursing homes have no effective system to safely dispose of their wastes. With no care or caution, these health establishments have been dumping waste in local municipal bins or even worse, out in the open. Such

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irresponsible dumping has been promoting unauthorized reuse of medical waste by the rag pickers for some years now.

Disposal of Bio-medical wastes (BMWs) has become a major problem in India. The public has become aware over improper disposal of hazardous wastes but bio-medical wastes are still handled and disposed together with domestic wastes, thus creating a great health risks to both the public and the environment. After the notification of the Bio-medical Waste (Handling and Management) Rules, 1998, some hospitals are slowly streamlining the process of waste segregation, collection, treatment, and disposal. Many of the larger hospitals have either installed the treatment facilities or are in the process of doing so.

In Arunachal Pradesh, it is observed that the BMW and the municipal waste of the capital are dumped at a common disposal site at Chimpu which is very harmful to both the human beings and the environment. It is to be understood that management of biomedical waste is an integral part of health care. Although other parts of the country have taken initiatives to prevent the harmful effect of unmanaged biomedical waste caused mainly due to infectivity and toxicity, Arunachal lags behind such initiatives not only in case of BMW management but also in municipal solid waste management. The Arunachal State Hospital, Naharlagun established as a dispensary in 1974 later became the General Hospital in 1976 and got its name on 18th November 2009 to become the 1st State level Hospital. With the development of the State, the population of the state has also increased thereby increasing BMW generation. Viewing the harmful effects of the BMW, a question arises as to what extent the hospital serves the state and its people. Does the hospital have a proper BMW management system to treat or handle the BMW produced by it?

II. Potential Implications of BMW

A. Health impacts of BMW

Exposure to infectious BMW can result in disease or injury. It may contain infectious agents, toxic or hazardous chemicals or pharmaceuticals, radioactive wastes and waste sharps. The infectious wastes may contain any of the great variety of pathogenic microorganisms which may enter the human body through a number of routes like a puncture or cut in the skin, mucous membranes, by inhalation or ingestion. Sharps may not only cause cuts and punctures but also infect the wounds if they are contaminated with pathogens. Because of this dual risk – of injury and disease transmission – sharps are considered as a very hazardous waste class. Poor hospital waste management may cause hepatitis B & C, HIV infection, gastro-enteric infection, respiratory infection, blood stream infection, skin infection, radioactive toxicity and other health problems associated with air and water pollution. Epidemiological studies indicate that a person who experiences one needle-stick injury from a needle used on an infected source patient has risks of 30%, 1.8%, and 0.3% respectively to become infected with hepatitis B virus, hepatitis C virus and HIV. It is estimated that approximately 3million healthcare wastes (HCWs) experience per cutaneous exposure to blood borne viruses (BBVs) each year. This results in an estimated 16,000 hepatitis C, 66,000 hepatitis B and 200-5000 HIV infections annually [14].

B. Environment impacts of BMW

The environmental problems associated with the disposal of untreated BMW generated from the healthcare units (HCUs) are air pollution due to uncontrolled and open burning of wastes, generation of foul odour inside the hospital premises and surrounding area, clogging of drains with waste materials creating an unhygienic environment in the surrounding hospital premises which may lead to breeding of mosquitoes/flies that might contribute to the spread of infectious diseases. Waste dump may attract stray animals and birds that might spread waste materials leading to an unaesthetic and unhygienic environment. Indiscriminate disposal of pharmaceutical products (antibiotics and cytotoxic drugs) and discharge of untreated wastewater generated from the HCUs could have disastrous ecological effects. Open dump of waste may decompose to produce leachate that might contaminate ground water.

III. Field Work and Methodology Adopted for Study

The Arunachal State Hospital (ASH), Naharlagun was selected as the study site. Every waste generating unit in the hospital was identified. The major activities included

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survey of the site, identifying every waste generating unit, performing field investigations to assess the quantity of bio-medical waste generation per day and determining waste composition and characteristics. In addition, requisite secondary data were collected from the municipal authorities using a predesigned questionnaire

A. The survey report on Bio-medical Waste in Arunachal State Hospital, Naharlagun

A survey was conducted on the BMW management of ASH, Naharlagun and the survey report is completely based on responses to the questionnaires [2] by the hospital staff and personal observations. It was observed that the hospital wastes generated at the site were filled in coloured polybags (Fig.1) and gathered at a site within the hospital premise which were then collected by a private party. Thus the responsibility of treatment and disposal of the BMW generated at the site was left on the private party. Although the hospital has a centralized collection area (Fig.2) for dangerous waste but the area was not properly or clearly identified and labelled.

Fig. 1: Collection of waste outside the Male Ward

Fig. 2: Centralized collection area of the hospital waste

The waste containers were not properly labelled but all the wastes were packed and disposed of daily. It was observed that the hospital did not keep record of the amounts of dangerous waste generated although the staffs, who handle the wastes, received regular bio-medical waste management training. The transportation and proper disposal of solid waste facilities were not up to mark and needed improvement.An incinerator and an autoclave had been used to dispose the hazardous waste in order to reduce, eliminate and recycle toxic chemical, equipment and materials or use pharmaceuticals return programs whenever possible although they are out of order now and needs to be repaired.

The state does not have a waste to energy (WTE) plant or a common biomedical treatment facility (CBWTF) yet, therefore, the question of availing their services by the does not arise. All the wastes were dumped together in the unlabellled dustbins/containers provided at the wards without proper segregation of dangerous different types of wastes. None of the waste produced in the hospital were recycled but the hospital did reuse some equipments like patient's dishware, employee dishware, glass ware, baking pans, metal trays, bath basins, bed pans, urinals, pillows, instrument pans, splash basins, medicine cups, gowns, towels, drapes etc. For solid wastes, they had the facility of accumulation through some coloured containers (although not provided according to the BMW management rule, 1998) and of central storage. Transport and proper disposal of bio-medical waste facilities were not up to mark. The wastes were collected by a private party and disposed off along

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with the municipal solid waste of the city at Chimpu which is a threat to both the environment and the people living nearby. The Chimpu waste disposal site (Fig.3) is adjacent to the road and is at a steep valley thereby creating nuisance to the passerby and also polluting the downstream side of the area (Fig.4). For liquid wastes the hospital had a discharge authorization to discharge the liquid into the sewer by the State Pollution Control Board (SPCB) but there was neither a proper record about quantity of waste generated nor for their discharging measures. The liquid wastes was not sampled and directly discharged in sewer system. No attempt to minimize the quantity of waste generation was observed.

Fig. 3: Waste Disposal site, Chimpu

Fig. 4: Burning of the biomedical waste, Chimpu

Thus, it is clear that no efficient management of hospital waste is in existence.

IV. Quantification of the BMW Generated in ASH Naharlagun

All the waste generating units in the hospital were identified and divided into 13 different sites according to the position of the units and also the availability of the dustbins. The units include emergency ward, TB centres, medicine stores, OPD, Dept. of eyes, microbiology, orthopaedics, head office, cancer registry, male medicine and surgery wards, kitchen, mental dept., Gyanae, OT, dialysis room, female medicine and surgery, padriatic ward, labour room etc. During the course of the project safety clothing and equipment for the waste handlers were identified and selected. The wastes generated were collected in each site and weighed weekly from 1st Feb. 2012 to 10th May 2012.

The following conclusions were drawn from the quantification of the biomedical waste at ASH, Naharlagun:

- General waste containing food wastes, paper, plastics, floor sweeping, discarded glassware, earthen pot etc. constitute bulk percentage of the hospital waste.
- Average waste generated in the Arunachal State Hospital, Naharlagun was observed to be 380.805 kg /day.
- Average waste generated per head per day in the Hospital is 0.74kg per head per day.

TABLE I

Average BMW Generated in ASH, Naharlagun

Site No.	Name of Units	No. of daily Patients	BMW generated (kg/day)
1.	Medicine Stores, Emergency Ward, TB Centre	25	50.67
2.	OPD		9.71
3.	Dept. of Eyes, Microbiology, Urine, Blood, Ultrasound, X ray Test	224	5.08
4.	Head Office	27	4.375
5.	Cancer Registry and Blood Bank	46	5.92
6.	Dept. of Orthopaedics	40	6.33
7.	Male Medicine , Male Surgical	44	60.67
8.	Kitchen	--	17.16
9.	Dept. of Mental Disorder, VIP Cabin	8	8.73

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10.	Gynae Ward	17	35.75
11.	Operation Theatre, Dialysis Room	30	40.83
12.	Female Medicine, Surgery, Padriatic, Doctor's, Sister's Cabin, Waiting Room, Labour Room	52	112.83
13.	General Compound Waste	--	22.75
	TOTAL	513	380.805

V. Determination of the Parameters of the Waste Water Sample of the ASH, Naharlagun

As per Bio-Medical Waste (Management and Handling) Rules,1998 the effluent generated from the hospital should conform to the permissible limits (Table 2).These limits are applicable to those, hospitals, which are either connected with sewers without terminal sewage treatment plant or not connected to public sewers. For discharge into public sewers with terminal facilities, the general standards as notified under the Environment (Protection) Act, 1986 shall be applicable. It was observed that the hospital effluent was simply discharged to the sewer. To comply with the permissible limits given by the bio-medical rule, 1998 the waste water sample of the hospital was collected and analysed. The waste water sample was collected thrice on 06/04/12, 22/04/12 and 07/05/12 and tested according to standard method [1].The observed values of the samples are tabulated in Table 2.

The pH showed a safe value according to the bio-medical rule. The suspended solids on the 3 dates were determined to be 0.08mg/l, 0.12mg/l and 0.24mg/l respectively which lies in the safe limit according to the BMW rule. The BOD of the waste water samples were observed to be 8.9mg/l, 11.85mg/l and 16.3mg/l respectively. The COD was observed to be 17.14mg/l, 34.29mg/l and 28.57mg/l respectively which falls below the safe limits of the bio-medical rule.The Bioassay Test was done to check the survival of the fishes in the 100% effluent. The result showed 100% and 90% survival of the fish thus proving the sample to be under safe limits.

TABLE 2: Permissible Limits of Hospital Effluents and the Observed value of Samples

Parameters	Permissible Limits	Observed Value of Sample taken on		
		06/04/12	22/04/12	07/05/12
pH	6.3-9.0	8.1	8.2	8.6
Suspended solids (mg/l)	100	0.8	1.2	2.4
BOD(mg/l)	30	8.9	11.85	16.3
COD(mg/l)	250	17.14	34.29	28.57
Bioassay Test* (%)	90	100	90	90

*(% survival of fish after 96 hours in 100% effluent)

A. Characterization of the Bio-Medical Waste of the ASH, Naharlagun

The constituents of each fraction present in the BMW of ASHN were determined separately after segregation. The amount determination of weight was done with a spring type weighing machin from February to April The first segregation was done on 08/02/12, the second on 15/03/12 and the third on 25/04/12. The different types of waste observed were paper, plastics, cotton, cloth, syringes, metals, glasses etc. All the types of wastes were separately weighed and the average amounts of the different waste generated were tabulated. Table3 shows the amount of the different type of segregated waste generated at the Hospital.

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Sites	Paper kg/d	Plastic kg/d	Cloth kg/d	Cotton kg/d	Metals kg/d	Glasses kg/d	Food kg/d	Others* kg/d
1.	11.00	42.697	0.145	0.145	0.0040	6.50	-	-
2.	2.60	5.220	-	-	0.0040	1.50	-	-
3.	2.00	1.250	-	-	-	-	-	-
4.	3.50	0.375	-	-	-	-	-	-
5.	0.75	3.738	-	-	0.0030	0.75	-	-
6.	3.75	1.514	0.135	0.135	0.0002	0.27	-	1.50
7.	17.50	52.490	0.850	0.850	0.0027	2.00	6.500	-
8.	-	0.750	-	-	-	-	18.500	-
9.	1.00	2.500	-	-	-	-	0.1875	-
10.	2.00	4.580	1.000	1.000	0.0031	1.50	0.500	25.75
11.	5.00	30.620	0.250	0.250	0.0008	1.50	1.000	27.00
12.	31.50	76.198	0.250	0.250	0.0012	2.00	5.000	3.50
13.	21.00	5.000	0.250	0.250	-	-	0.250	0.75
Total	101.60	226.23	2.880	6.015	0.0190	16.02	31.938	58.50

TABLE 3: Approximate Average Weight of segregated Wastes Generated at the ASHN

*The other wastes include the plaster (1.5kg), human anatomy (43.75 kg), blood (4 L), water (3.5 L), wood and leaves (0.75kg) etc.

B. Energy Content of the Biomedical Waste of the ASHNaharlagun

The total BMW generated per day from theASHNaharlagun and the energy content associated with it is tabulated in the Table 4.

TABLE 4: Energy Content in the Constituents of BMW of ASH, Naharlagun

Sl No.	Constituents	Total Weight (kg)	dry Weight (Kg)	Energy Content* (kJ/kg)	Total Energy (kJ)
1.	Paper	101.600	96.723	16747.20	1619839.426
2.	Plastic	226.232	223.970	32564.00	7293359.080
3.	Cloth	2.880	2.592	17445.00	45217.440
4.	Cotton	6.015	5.714	17445.00	99680.730
5.	Metal	0.019	0.019	697.80	13.258
6.	Glass	16.020	15.699	139.56	2191.036
7.	Food	31.938	21.079	4652.00	98059.508
8.	Wood	0.750	0.713	18608.00	13267.504
Total wt. (kg)		388.454	366.51		7713627.98

*[G Tchobanoglous, 1993]

The approximate total energy of the BMW generated at the hospital was observed to be7713627.982kJ and the total weight of the segregated waste is 388.454 kg per day thereby giving a value of 19857.249kJ of energy per kg of the BMW.

VI. Results and Analysis

The survey at the ASHNaharlagun based on responses to questionnaires and personal observations showed that for the solid waste, they have the facility of treatment and disposal although not provided according to the bio-medical waste management rule, 1998. The treatment equipments and the disposal system at the hospital need more attention and improvement. For the liquid waste there is no proper record about the quantity of waste generated and they are directly discharged in the sewer system. No attempt to minimize the quantity of waste generation was observed. Thus it is clear that rules in form of Acts are also inadequate if there is lack of commitment to implement these acts. In the quantification process it was observed that general waste containing food wastes, paper, plastics, floor sweeping, discarded glassware, earthen pot etc. constitute bulk percentage of the hospital waste thereby indicating that the hospital needs a proper understanding on the need and importance of segregation. Average waste generated in the ASHNaharlagun was observed to be 380.805 kg/day. Average waste generated per head per day in the Hospital is 0.74kg per head per day.

The various tests done on waste water sample of the ASHN to comply with the permissible limits as per the Bio-medical Waste Management Rules1998 showed that

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the waste water of the hospital was well within safe limits and hence safe for disposal into the sewer system but at the same time it needs attention as it was being diluted with thedrain water. The characterization of the waste was done by segregation of the waste and then separately determining the weight of the components of the BMW of the hospital. The approximate total energy of the BMW generated at the hospital was observed to be 7713627.982kJ and the total weight of the segregated waste is 388.454 kg thereby giving a value of 19857.249kJof energy per kg of the BMW. Thus it can be concluded that the BMW if undergone waste to energy (WTE) system would generate enough energy for electricity generation for the hospital or to develop enough steam for the waste treatment processes like the autoclave, hydroclave, microwave etc. The WTE can save some tonnes of coal used in the production of electricity and also can offer much more effective environment friendly waste management system than landfilling as it would reduce the methane emission whose potential is 23 times more than CO_2. Lead and SO_2 emission is also reduced as compared to that of incinerators.

VII. Discussion and Future Scope

It is obvious that waste is a planetary problem, which effects climate and the environment in every country, and touches the lives of all human beings through the air, water, and/or food they consume. To solve (or even just remediate) this problem, national and international cooperative action must be undertaken [5].Effective management of medical waste requires the hospital to meet all legal obligations, achieve public and environmental protection, and accomplish this in a cost-efficient manner. Overlaying the proper management of medical waste is the increasing attention on reducing the medical waste stream through pollution prevention activities. Balancing these issues is a challenge that requires a commitment from the highest levels of management and from staff entrusted to carry out the medical waste handling activities throughout the hospital [7]. The contribution analysis on global warming indicates that the direct landfill gases releasing from landfill stage is the key issue in current hospital waste management system. The contribution analysis on human toxicity indicates that landfill stage is the main contributor in all scenarios. Dioxins contribute 16% to the human toxicity impact from incineration processes [17].The methane collected by landfill gases collection system has an energy potential, which can be used to generate electricity and heat. [18].Viewing the effects of landfilling, it leaves a scope for further study in the treatment and recycling process of the BMW. Healthcare waste management should be supported through appropriate education, training and the commitment of the healthcare staff, management and healthcare managers [15]. There is hope that the initial successful experience with privately built, owned, and operated CWTFs in Andhra Pradesh and other states in India will form the foundation for common practice for urban areas of India. Changes in culture regarding hygiene and HCW management practices have occurred at many healthcare facilities, and many facilities now accept the need to pay for off-site treatment and disposal of BMWs (BekirOnursal). CBWTF being a highly specialized and specific job, involvement of specialized agencies would be necessary. Private entrepreneurs with adequate background and capability may be encouraged to take up and organize such ventures. The health care establishments may find it much more workable to hand over the day to day O&M to a private concern rather than doing it on their own. In this case, proper contract agreement must be made with the party with necessary terms and conditions and safeguards [4]. In a sponsored project from DRDO (Delhi), FCIPT explored the possibility of energy recovery during pyrolysis of plastic and cotton waste and understood its effect on the economics of the pyrolysis technology in the study and observed that the results from the initial set of experiments are highly promising and an intensive study is underway to understand and optimize the process and to increase the energy recovery close to the theoretical value.The CBWTF and WTE could work as a life saver in developing areas like Arunachal Pradesh, therefore, intensive study on these systems of treatment and energy recovery can be carried out to understand and optimize the CBWTF and WTE in the State.

VIII. Conclusion

After the assessment made regarding planning of bio-medical waste management at the ASH, Naharlagun and the survey on the basis of responses of the hospital staffs

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to the questionnaire verified by means of personal observations for the evaluation of the know-how, outlook and practices of employees towards waste management, it has come out very clearly that segregation and understanding the need and importance of segregation needs to be imbibed in the minds of the health functionaries from CMO level to the sanitary assistant. Certain salvageable items like saline bottles, surgical gloves, fluid bottles syringes etc. are disposed after use in the wards without distorting or damaging. As a result, there remains a possibility of reuse of the said items which should be allowed only under strict supervision of an executive member in Bio-medical waste manangement of the hospital. The hospital needs to check its discharge perimeter prior to its discharge into the sewer which could vary during peak periods. The energy content of the waste determined is a huge amount and can be used to generate electricity or treatment of BMW of the hospital. It was observed that no attempts were made to minimize the quantity of waste generation; neither there is any attempt to switch over from more toxic to less toxic substances in respect of their use. Thus, it is clear that Rules in the form of Acts are inadequate if there is lack of commitment to implement these Acts. The committee members of BMW Management should guide the staff in assessing the waste generation in hospital in frequent intervals of time, details of assessment should include minimum weight of bio-medical waste in each unit of hospital and composition of which to be determined by segregating the waste at the point of generation itself. It should be understood that initiating HCW management legislation and practice without adequate background work results in delay and costly readjustments. The private sector's role in on-site HCW management is becoming increasingly important. Effective state strategies for CWTFs, with private sector involvement can play a vital role in treatment of the state bio-medical waste.

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