



Hospitals waste management practices in Punjab, India – A case study approach

Vinit Prakash^{1*}, Satnam Singh², G.S.Batra³, Ritu Bala⁴

¹ Department of Applied Sciences, Global Group of Institutions, Amritsar, 143501, Punjab, India.

² School of Chemistry and Biochemistry, Thapar University, Patiala, 147004, India.

³ School of Management Studies, Punjabi University, Patiala, 147002, India.

⁴ Department of Chemistry, Guru Nanak Dev University, Amritsar, 143005, India

Corresponding Author: vinitprakash@gmail.com

Date of Submission: 06-06-2024

Date of Acceptance: 18-06-2024

ABSTRACT: Waste management is the collection, transport, processing, recycling or disposal of waste materials. The practices of waste management followed by local hospitals in accordance with Biomedical Waste (Management & Handling) Rules have been described. A case study approach has been followed for an in depth analysis of hospital waste management practices being followed by the hospitals under study during 2007. This is as per the standard management research practices adopted in conducting the research on different functional areas.

KEYWORDS: Waste management; Hospital waste; Biomedical waste; Health organization

I. INTRODUCTION

Hospitals are one of the complex institutions which are frequented by people from every walk of life in the society without any distinction between age, sex, race and religion. Patients and staff are over and above the normal inhabitants of hospitals. All of them produce waste which is increasing in its amount and type due to advances in scientific knowledge, and is creating its impact [1]. Hospital waste generally refers to all wastes, biological or non biological that is discarded and not intended for further use. The waste generated in hospitals can be classified into two types based upon health effects; general waste and infectious or potentially infectious waste. The general waste is similar to the domestic waste and can be directly disposed off through municipal waste disposal methods. It is the infectious or potentially infectious waste which is of special concern and in India, it is known as Bio-Medical Waste (BMW). The BMW, in addition to the risk for patients and personnel who handle these wastes poses a threat to public health and environment [2]. It is a subset of hospital waste; in turn

infectious waste is subset of BMW. BMW originates from human or animal health care, medical research, medical teaching facilities, funeral establishments, laboratories and other facilities. A portion of this waste stream is infectious or potentially infectious and presents a potential hazard to the public health and the environment.

For many years, healthcare workers, hospital administrators, sanitarians, and other health-related professionals have understood the necessity to protect themselves and the public from exposure to wastes that might be reservoirs of disease-transmitting organisms. However, efforts to manage such wastes have differed between developed and developing countries [3]. BMW is the second most hazardous waste after radioactive waste.

The term “hazardous waste” means a solid waste or a combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may:

- i) Cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness or
- ii) Pose a potential hazard to human health or the environment

when improperly treated, stored, transported, disposed of, or otherwise managed [4].

Applying more comprehensive waste management approach will help to ensure environmentally sound and economically feasible waste practices. At a minimum, it should be noted that (as with most waste problems), there is no single management scenario that can “solve” all BMW problems; rather, each BMW management problem must be assessed independently to develop a viable and sound solution.



II. CLASSIFICATION

Each country has its own set of regulations defining and setting standards for handling, treatment and disposal of regulated medical wastes. Handling, segregation, mutilation, disinfection, storage, transportation and final disposal are vital steps for safe and scientific management of BMW in any establishment [5]. World Health Organization released the first global and comprehensive guidance document on safe management of wastes from health-care activities in 1999 [6]. It addresses aspects such as regulatory framework, planning issues, waste minimization and recycling, handling, storage and transportation, treatment and disposal options, and training. The wastes from health-care activities include immunizations, diagnostic tests, medical treatments and laboratory examinations.

Almost 80% of total wastes generated by health-care activities are comparable to domestic waste and can be disposed through regular municipal waste methods. The remaining 20% of wastes are considered hazardous [7]. BMW have been classified into nine categories: infectious waste, pathological waste, sharps, pharmaceutical waste, genotoxic waste, chemical waste, waste with high contents of heavy metals, pressurized containers and radioactive waste [8]. Generally, BMWs represents HW (including low level radioactive wastes), all infectious waste that are generated from all types of healthcare institutions, including hospitals, clinics, doctor (dental and veterinary) offices, and medical laboratories. Infectious waste is the one capable of producing an infectious disease.

US Environmental Protection Agency [9] defines BMW as any solid waste that is generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals, including but not limited to: blood-soaked bandages, culture dishes and other glasswares, discarded surgical gloves, discarded surgical instruments, needles, cultures, stocks, swabs used to inoculate cultures, removed body organs and lancets.

In 1989, the Government of India, in exercise of powers conferred under Section 6, 8 and 25 of the Environment Protection Act, 1986 formulated the Hazardous Waste (Management and Handling) Rules, 1989 which did not cover hospital wastes, despite of the fact that India was a party to Basel Convention of medical wastes management and therefore is bound to implement the same [10]. In consonance with the same draft watch

notification on biomedical wastes (management and handling) [BMW(M&H)] rules, 1995 was issued in April 1995 and objections were invited from public. After duly considering necessary amendments in the Draft Rules, the BMW (M&H) Rules, 1996 finally came into operation with effect from 20th July, 1998. The amendments of principal rules have further been notified on March 06, 2000; June 02, 2000; September 17, 2003 to ensure effective BMW management and are applicable to all persons who generate, collect, receive, store, transport, treat, dispose, or handle BMW in any form.

In India, BMW refers to as any waste, 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 biologicals, and is classified into 10 categories: 1. human anatomical waste, 2. animal waste, 3. microbiology and biotechnology waste, 4. waste sharps, 5. discarded medicines and cytotoxic drugs, 6. soiled waste, 7. solid waste, 8. liquid waste, 9. incineration ash and 10. chemical waste [11]. Although not included in the standard definition, the BMW is also generated at the domestic level in the form of sanitary pads, diapers, cotton swabs and gauzes, disposable razors, diabetic patient syringes and needles etc. In many cases, the patient is given treatment in his or her own house when the hospitalization is not possible due to some reason. Such “domestic BMW” has not been given any consideration so far.

Generation and Segregation

Hospital is a place, where an individual is examined by the doctors, diagnosis is made and an appropriate treatment plan is worked out. Depending upon the extent or the intensity of illness, the patients are either treated in/ out patient department or are admitted in the hospital for treatment and follow up. In both the cases, greater amount of waste is generated during this procedure. The quantum of waste thus generated varies according to the site and the nature of treatment. According to BMW (M&H) rules, it will be the duty of every occupier of an institution generating BMW which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank by whatever name called, to take all steps to ensure that such waste is handled without any adverse effect to human health and the environment. BMW should not be mixed with other wastes. It should be segregated into colored containers/bags at the point of generation in accordance with BMW (M&H)



rules - Schedule II prior to its storage, transportation, treatment and disposal. It is not possible to segregate it thereafter without any undue risk.

Segregation means “separation of different types of BMW by sorting or the systematic separation of BMW into designated 10 categories. It is the most important step in the entire process of BMW management as it needs special attention to be given to the relatively small quantities of infectious and HW, there by reducing not only the risks but the cost of handling, treatment and disposal. For example if general waste gets mixed with infectious waste, the whole waste has to be incinerated which may prove to be costly. It is universally accepted fact that segregation of BMW is and should be the responsibility of the generator of the waste. During segregation special emphasis should be given to infectious, hazardous and sharp wastes. From amongst all categories of waste, the “sharps” which include syringes, needles, trocar, canula, guide wires, broken glasswares, scalpel, blades etc. have the highest disease transmission potential. Almost 85% of sharp injuries are caused between their usage and subsequent disposal and more than 20% of those handle them encounter “stick” injuries [12].

III. METHODOLOGY

The primary data was collected on the basis of a questionnaire distributed to ten hospitals (nine of Punjab and one of Union Territory), a common biomedical waste treatment facility (CBMWTF) of Punjab situated in Ludhiana. The questions were designed to access compliance with Biomedical Waste (Management and Handling) Rules, 1998 as amended in 2003. The primary data is compared with the secondary data collected from State Pollution Control Boards.

Questionnaires

The questionnaires were designed so as to collect general and technical information related to:

- (i) General information about hospitals
- (ii) Practices being followed by them in handling biomedical waste
- (iii) Disposal options being undertaken

The technical information was designed on the basis of Biomedical Waste (Management and Handling) Rules so as to access the overall waste stream, waste generation by categories and the practices being followed during segregation, collection, treatment and final disposal. Other issues like ash management, mercury pollution,

training level of employees and training need assessment were also included.

The questionnaire were also extended to have the information on the availability of any BMW management guidelines developed either by hospitals themselves or some other concerned government authorities such as State Governments or State pollution Control Boards. The question related to awareness about the impact of incineration, pollution release from burning of waste, knowledge about international conventions/treaties related to BMW/ HW or persistent organic pollutants were also included. The collected data was compared with secondary data.

Samples of study

Ten hospitals (small/ medium/ large scale) and a CBMWTF have been investigated during this study. Nine hospitals of Patiala city of Punjab state and another hospital situated in Union Territory of North India viz., Post Graduate Institute of medial education and research, Chandigarh were analyzed for investigation of waste management practices followed by them.

Characteristics/profile of Hospitals

Patiala city of Punjab state is one of the famous princely states of erstwhile Punjab, forming the south-eastern part of the state, it lies between 29°49' and 30°47' north latitude, 75°58' and 76°54' east longitude. It is surrounded by the districts of Fatehgarh Sahib and Rupnagar and the Union Territory of Chandigarh in the north, Sangrur district in the west, Ambala and Kurukshetra districts of neighboring state of Haryana in the east and Kaithal district of Haryana in the south.

Nine major hospitals of Patiala city and PGI, Chandigarh (largest hospital of North after AIIMS, New Delhi) were undertaken for investigation in order to study BMW management practices and problems faced by them in complying with environmental regulations along a common biomedical waste treatment facility (CBMWTF) of Ludhiana district of Punjab. The data was collected through questionnaires which include questions related to Biomedical Waste (Management and Handling) Rules. The characteristics of these hospitals are:

- i. Postgraduate Institute of Medical Education and Research, (PGIMER), Chandigarh: The Institute is an autonomous body under the Act of Parliament in 1967 functioning under the Ministry of Health and Family Welfare,



Government of India. PGIMER is an institute of excellence providing state of the art tertiary care and has highest bed capacity (from the selected hospitals) of 1412 beds.

ii. Govt. Rajendra Hospital (GRH), Patiala: This is the biggest hospital in terms of bed capacity (~907 beds) and the number of staff in Patiala district of Punjab state. It starts functioning in 1954 and offers specialized services in surgery, obstetrics, plastic surgery, ultrasonography and radiotherapy. The hospital consists of eleven different diagnosis and treatment units along with operating rooms and surgical intensive care units, laboratories and other general units (kitchen, laundry, coffee shop, etc.).

iii. Mata Kaushalya Hospital (MKH), Patiala: It is a unique hospital of North India which caters to the gynae and obstetrics needs of female patients only. The hospital is having bed capacity of 154 and with about fifty staff members. Mata Kaushalya Devi Hospital was originally founded in 1890 as the Lady Dufferin Hospital.

iv. Amar Hospital (AH), Patiala: AH was founded by Dr. J. S. Bahia in March, 1997 with all the latest technology and modern facilities. It is multispeciality hospital with 55 bedded complete diagnostic centres, I.C.U/C.C.U/Cardiac lab. The C.C.U department of the hospital is specially equipped with world class cardiac facilities. It is a private hospital and offers the services to employer, employee and their families of State sector undertakings.

v. Diesel Component Works Hospital (DCW), Patiala: This hospital is located in the campus of Diesel Components Workshop of Indian Railways. In addition to diagnosis and treatment units, it also provides services to outdoor patient. The total bed capacity of this hospital is 50.

vi. Kamal hospital (KH), Patiala: The bed capacity of this hospital is 30 and it does not treat outdoor patient. In addition to diagnosis and treatment units, there is dialysis facility to serve the patients with kidney problems.

vii. Garg Hospital and Maternity Home (GHMH), Patiala: This hospital has total 20 numbers of beds. There is an operating room, surgical and intensive care unit apart from laboratory. This private hospital serves patients for various diseases apart from female patients as well as new born babies.

viii. Giani Lal Singh Memorial Hospital (GLSMH), Patiala: This is a small hospital with seven diagnosis and treatment units. The number of the beds is 19 and caters to the needs of Arthritic patients.

ix. Singla Hospital (SH), Patiala: This hospital is the smallest and has total bed capacity of 15 beds. This hospital has six patient treatment wards.

x. Community Health Centre (CHC), Patiala: Community Health Centre delivers free primary health care, health education, counseling, and chronic-disease prevention, education and management services. This health center has capacity of 10 beds.

xi. SembRamky Environmental Management Pvt. Ltd. (SEMP), Ludhiana: SEMPL is a largest biomedical waste treating common BMW treatment facility (CBMWTF) which collects BMW from most of hospitals (1374) of Punjab and treat almost 2000 - 2300 kg of BMW per day (24461 beds covered) as record of 2006.

So these ten hospitals have different characteristics in terms of number of beds and the type of patients. It is possible that their waste composition differs. However, all wastes of nine hospitals of the Patiala city are currently collected together and transported to CBMWTF viz., SEMPL, Ludhiana. The primary data from above said health care facilities/ CBMWTF is collected and compared with the secondary data from Punjab Pollution Control Board, Patiala; and Punjab State Council of Science and Technology, Chandigarh.

Categorization of Hospitals

The hospitals undertaken for study are divided into three categorized depending upon their bed capacity in accordance to the Schedule VI of Biomedical Waste (Management and Handling) Rules. Category A includes hospitals having bed capacity more than or equal to 500, Category B includes hospitals having bed capacity in between 50 to 200 and Category C includes hospitals having bed capacity less than or equal to 50.

Scenario of Biomedical waste management in Punjab

Scenario of biomedical management is studied from the collected data. In Punjab, BMW is treated and disposed off according to Biomedical Waste (Management and Handling) Rules, 1998 as amended in 2003. The responsibility to ensure the proper treatment and disposal of BMW by health care facilities (HCFs) rests with Punjab Pollution Control Board (PPCB), Patiala. During 2003 [13], there were 220 hospitals, 1,482 dispensaries and 441 primary health centers in the state. Apart from these, there were 1,362 Veterinary Hospitals, and 25,362 medical institutions in the state. Total numbers of HCFs were 2,760. HCFs with bed



capacity ≥ 500 , 200-500, 50 - 200 and ≤ 50 were 6, 12, 88, and 2403 respectively. There were 251 other institutions generating BMW. Almost 62 % of HCFs were violating the BMW (M&H) rules. Only 0.01% HCFs had possessed BMW treatment facilities while 38% HCFs had employed CBMWTF.

With the ever growing population and the number of hospitals and other medical facilities, the problems of pollution from BMW are supposed to be increasing simultaneously but according to the data collected from PPCB, It has been observed that the total number of hospitals situated in Punjab decrease from 2,760 to 2,398 within five years [14]. This may due to problems faced by them in complying with Biomedical Waste (Management and Handling) Rules/ violation of Biomedical Waste (Management and Handling) Rules, resulting in the closer of some of the HCFs.

There are total 181 hospital/HCFs in Patiala district as on March, 2007 [14]. There being only one hospital having bed capacity of more than 500 beds viz., Govt. Rajendra Hospital (907 beds). There are 12 hospitals having bed capacity of 558 beds in category of HCFs having beds more than 50 but less than 200 beds. The hospital with less than 50 bed capacity are 155 having total bed capacity of 1810 beds. The 98 % hospitals of Patiala district supply their waste to CBMWTFs. Only 2 % hospitals have BMW treatment and disposal facilities. The rate of BMW generation in Patiala is 129 g bed-1 day-1 while rate of total BMW generation is 424.2 Kg day-1.

In Punjab [14], HCFs with bed capacity ≥ 500 , 200-500, 50-200 and ≤ 50 are 5, 11, 98, and 1947 respectively. There are 321 other institutions generating BMW. 16% of HCFs numbering 372 violate the Biomedical Waste (Management and Handling) Rules. 70 % of hospitals in Punjab utilize CBMWTF for BMW treatment. There being 9 hospitals having BMW treatment and disposal facilities. Only 0.004% hospitals numbering 9 have BMW treatment and disposal facilities. Only 98% of the total BMW is treated daily. The secondary data is collected from Central Pollution Control Board (CPCB), New Delhi, Punjab Pollution Control Board (PPCB), Patiala and Punjab State Council of Science and Technology (PSCST), Chandigarh.

The analysis of secondary data showed that hospitals having less bed capacity produce more BMW bed-1 day-1 as compared to larger bed capacity hospitals. 14% BMW bed-1 day-1 is produced by the hospitals having bed capacity

more than 500 while hospitals having bed capacity less than 50 produce 37% BMW bed-1 day-1. After the amendments of 2003 in Biomedical Waste (Management and Handling) Rules, there is a continuous reduction in the percentage of violators of these rules in subsequent years. In 2003, 62.32 % HCFs violated these rules where as by march 2008, the percentage was greatly reduced to 3.67 % as a result of monitoring by PPCB as per rules.

PGI MER - Chandigarh is the second largest hospital of North region having bed capacity of ~1400 and produces BMW 1400-1600 Kg day-1. It generates the largest amount of BMW (1.06 kg bed-1day-1). The PGI MER has its own incinerator for treatment of incinerable waste of PGI Chandigarh which also caters to 319 other medical establishments in Chandigarh. Non-incinerable waste is treated in a CBMWTF of U.T., viz., M/s Alliance Envirocare Company Pvt. Ltd., Chandigarh.

Common BMW Treatment Facilities. In Punjab, many hospitals (78%) hand over the BMW to CBMWTF (PPCB, 2007) [14]. Presently there are four CBMWTF in Punjab and one in Chandigarh. All these facilities have installed double chambered incinerator with air pollution control devices (APCDs), autoclave, shredders and effluent treatment plant. Out of four facilities three have adopted conveyer waste feeding system while one situated at Mohali district of Punjab is using mechanical batch lifting process for waste feeding. These four CBMWTF of Punjab are:

- A. SembRamky Environmental Management Pvt. Ltd., Ludhiana.
- B. Rainbow Environments (A Unit of Raical Builders India Pvt. Ltd. Mohali.
- C. Bio-Medical Waste Treatment Plant Pvt. Ltd. Village- Pangoli, Pathankot.
- D. Amritsar Health Care Systems, Village- Ibban kalan, Chabhal Road, Amritsar.

SembRamky Environmental management Pvt. Ltd. Ludhiana collects BMW from 55% hospital situated in Punjab. Nearly 2000 - 2300 kg BMW is collected and treated by the facility daily [15]. In 2006, Central Pollution Control Board Zonal Office, Lucknow has monitored the CBMWTFs of Punjab and Chandigarh, and suggested that segregation of BMW needed to be done in different hospitals and maintenance of records of BMW areas needed improvement [16].



IV. FINDINGS BASED UPON PRIMARY DATA

The primary data information is based upon the questionnaire designed for eliciting information about biomedical waste management practices. The secondary data is obtained on the basis of published annual reports/ Pollution Control Boards. The collected data through questionnaires is compared with secondary data collected from pollution control boards to know the emerging scenario of waste management and problems faced by them in complying with environmental regulations. The higher authorities of Army Hospital, Patiala were also requested to provide the primary data but request application to provide data was not entertained. However, the army hospitals do not come under State Pollution Control Boards but under CPCB.

Waste Generation, Segregation and Transportation

The generation rate of hospital waste is the fundamental information for evaluating and designing the disposal system of hospital waste. The survey conducted on nine hospitals situated in Patiala city and another PGI MER – Chandigarh, to determine the BMW management and handling practices followed by them. The primary data is collected from ten hospitals along with one CBMTF (SembRamky Environmental management Pvt. Ltd., Ludhiana) through questionnaire. The occupancy rate of PGI, GRH and MKH is always 90 - 120 %. The numbers of patient in summer season are more than winter season. The data was collected from the PGI-MER, GRH, MKH, AH, DCW, KH, GHMH, GLSMH, SH and CHC hospitals, having the bed capacity of ~ 1412, ~907, 154, 55, 50, 30, 25, 19, 15 and 10 respectively. These hospitals generate the BMW approximately 1500, 800, 20, 6, 6, 0.75, 0.5, 0.5, 0.5 and 0.5 kg day⁻¹. PGI MER, GRH and GH have more than eleven patient treatment wards. Only KH does not entertain the outdoor patient.

The results of data collected are compared with the data available from CPCB, PPCB and PSCST. It has been observed that the rate of BMW generation per bed per day is more in larger hospitals as compared to smaller ones. The rate of BMW generation for these hospitals was 1062.32, 1066.67, 129.87, 109.09, 120.00, 25.00, 20.00, 26.32, 33.33 and 50.00 g day⁻¹ bed⁻¹ respectively.

Govt. Rajendra hospital, Patiala is the largest generator of BMW and generates 23 % of total BMW produced in district. On an average about 45% of the total waste produced in hospitals

is BMW. Segregation process of BMW with color bags is followed by all hospitals. The number of employees engaged with segregation process vary from 1-12. Only in GRH, the segregation process is done on spot under the supervision of Doctors and Nurses, and eight persons are kept for transportation of BMW up to central collecting vehicle. All hospitals of Patiala district supply their waste to CBMWTF (SEMP, Ludhiana) except PGI Chandigarh (which have own incinerator). There is one vehicle available to collect the BMW from Patiala city. SEMPL, Ludhiana is having 25 vehicles for collecting the waste from different regions of Punjab.

Treatment, Disposal and Expenditure

For treatment and disposal of BMW (except liquid and chemical waste) all hospitals of Patiala city under study supply their waste to CBMWTF. PGI-MER has its own treatment facility. Chemical waste and liquid waste are treated by hospitals themselves. Fewer posters were displayed for public awareness by all hospitals while BMW dealing containers were labeled with bio-hazardous and cytotoxic symbols.

Final disposal provided by CBMWTF/ PGI MER to the yellow bag waste is incineration followed by deep burial of ash inside the municipal landfill. GRH and PGI MER too have incinerators but the incinerator of Rajendra hospital, Patiala was not in working condition due to lack of funds and trained staff since 2002. Both the incinerators (of CBMWTF and PGI MER) are starved air incinerators. The incineration capacity of incinerator of PGI is > 100-150 kg h⁻¹ and trained operators were kept to operate incinerators. The analysis for emission gases CO_x, NO_x and SO_x is being done routinely. PAHs/ PCDD/Fs and Hg in emission gases of incinerators are not analyzed by PGI and CBMWTFs as segregated waste (Hg contamination free) is being treated. Heavy metals in ash are monitored monthly by both waste treatment facilities. APCDs are used in the incinerators of PGI (VS) as well as of CBMWTF (VS and WS). These facilities also provide treatments to the waste water produced after cleaning the APCDs. No facility is recovering the energy from waste incineration. Combustion efficiency of all incinerators reported by them is 99%. Stack heights are of 30 meters as per requirements.

For Government hospitals funds are provided by State Governments to treat and dispose off the biomedical waste. The per annum expenditure over biomedical waste management for



PGI-MER, GRH, MKH, AH, DCW, KH, GHMH, GLSMH, SH, CHC and CBMWTF is approximately Rs. 6,00,00,000/-, 2,00,000/-, 72,000/-, 3,600/-, 1,900/-, 5,0000/-, 7,200/-, 10,000/-, 4000/-, 12,000/- and 2,40,00,000/- respectively. All the BMW from Patiala city is collected by SembRamky Environmental management Pvt. Ltd. Ludhiana except Army Hospital, Patiala (as they have their own incinerator). Average expenditure is Rs. 56.61 bed-1 day-1 for all hospitals under study. The daily expenditure over BMW in PGI MER was found to be Rs. 106.72 bed-1 day-1. The per annum expenditure for hospitals of Patiala city was found to be Rs. 118.

Since, PGI MER is functioning under the Ministry of Health and Family Welfare, Government of India, so there is no scarcity of funds while in case of GRH even after having incinerator in the premises, they used to supply their waste to CBMWTF due to supply of less funds by Punjab State Government on BMW management. Since the rate of BMW generation in smaller hospitals is quite less, so they prefer to supply their waste to CBMWTFs instead of having their own incinerators.

V. CONCLUSIONS

In past decades, efforts have been made to better manage the waste produced from hospital. Based on the observations made during the study of ten hospitals, common biomedical waste treatment facility, the biomedical waste management practices adopted by hospitals are effective and efficient. Health care staff is involved in the identification and segregation of waste and is adhering to the guidelines imposed by Ministry of Environment and Forests. In Punjab, about 15% of the total waste produced in hospitals is biomedical waste and its average rate of generation was found to be 88, 161, 414 g bed⁻¹ day⁻¹ for the hospitals of Punjab having bed capacity ≥ 500 , 50-200 and ≤ 50 beds. SembRamky Environmental management Pvt. Ltd., Ludhiana is a common biomedical waste treatment facility which collects biomedical waste from almost 55% hospitals of Punjab and treat about 2000-2300 Kg of biomedical waste per day. Biomedical waste from all health care facilities of Patiala is also collected by same CBWTF for treatment.

Acknowledgment

Authors are thankful to Council of Scientific and Industrial Research, New Delhi for providing financial support to carry out this work and to all hospital/ waste treatment facilities for providing data.

REFERENCES

- [1]. Rao S. K. & Garg R. K. (1994). Hospital waste disposal by Incineration. *The Journal of Allergy and Clinical Immunology* 6, 43-47.
- [2]. Singh, I. B. & Sharma R. K. (1996). Hospital waste disposal system and technology. *Journal of Academy of Hospital Administration* 8, 44-48.
- [3]. Askarian, M.; Vakili, M. & Kabir, G. (2004). Hospital waste management status in university hospitals of the Fars province, Iran. *International Journal of Environmental Health Research* 14, 295 – 305.
- [4]. US EPA (1986). EPA Guide for Infectious Waste Management. Office of Solid Waste and Emergency Response, Washington, D.C. EPA 530-SW-86-014.
- [5]. Rao, S. K. M.; Ranyal, R. K.; Bhatia, S. S. & Sharma, V. R. (2004). Biomedical Waste Management: An Infrastructural Survey of Hospitals. *Medical Journal Armed Forces India* 60, 379-382.
- [6]. WHO, 1999. World Health Organization. Waste from health-care activities. <http://www.who.int/mediacentre/factsheets/fs253/en/>
- [7]. CPCB, (2000). Manual on Hospital Waste Management. Central Pollution Control Board, Delhi. <http://whqlibdoc.who.int/publications/9241545259.pdf>
- [8]. WHO 2003. Safe management of wastes from health-care activities, edited by Pruss, A.; Giroult, E. & Rushbrook, P.
- [9]. US EPA (2004). Medical waste. <http://www.epa.gov/epaoswer/other/medical/> accessed on 15 June, 2008.
- [10]. Patnaik, R. (2001). Bio-Medical Waste Management and the Process of Environmental Governance. *Central India Law Quarterly* 14, 321-332.
- [11]. MoEF (1998). The Gazette of India: Extraordinary, Notification on the Bio-medical Waste (Management and Handling) Rules, [Part II . Sec.3(ii)], No.460, Ministry



- of Environment and Forests, New Delhi, 01-20.
- [12]. Yadav M, 2001. HOSPITAL WASTE - A MAJOR PROBLEM. JK-Practitioner 8, 276 – 202.
- [13]. PSCST (2003). Biomedical Waste. www.punervis.nic.in/swmngmt_BMW.htm
- [14]. PPCB, 2003-2007. Data collected from Punjab Pollution Control Board
- [15]. CPCB, (2007). Annual report 2006-2007. www.cpcb.nic.in/upload/AnnualReports/AnnualReport_34_final-report-06-07-A.
[http://wbln0018.worldbank.org/HDNet/hddocs.nsf/0/b45c5d33764a3f4185256df600562e30/\\$FILE/AAG%20HCWM.pdf](http://wbln0018.worldbank.org/HDNet/hddocs.nsf/0/b45c5d33764a3f4185256df600562e30/$FILE/AAG%20HCWM.pdf).
- [16]. CPCB, (2006). Bio-medical waste management: Performance of Bio-medical Waste Treatment Facilities in Central Zone. www.cpcb.nic.in/Highlights/2006/BIOMEDICALWASTEMANAGEMENT%5B1%5D.pdf