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Biomedical solid waste management in an Indian hospital: a case study

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Abstract

The objectives of this study were: (i) to assess the waste handling and treatment system of hospital bio-medical solid waste and its mandatory compliance with Regulatory Notifications for Bio-medical Waste (Management and Handling) Rules, 1998, under the Environment (Protection Act 1986), Ministry of Environment and Forestry, Govt. of India, at the chosen KLE Society's J. N. Hospital and Medical Research Center, Belgaum, India and (ii) to quantitatively estimate the amount of non-infectious and infectious waste generated in different wards/sections. During the study, it was observed that: (i) the personnel working under the occupier (who has control over the institution to take all steps to ensure biomedical waste is handled without any adverse effects to human health and the environment) were trained to take adequate precautionary measures in handling these bio-hazardous waste materials, (ii) the process of segregation, collection, transport, storage and final disposal of infectious waste was done in compliance with the Standard Procedures, (iii) the final disposal was by incineration in accordance to EPA Rules 1998, (iv) the non-infectious waste was collected separately in different containers and treated as general waste, and (v) on an average about 520 kg of non-infectious and 101 kg of infectious waste is generated per day (about 2.31 kg per day per bed, gross weight comprising both infectious and non-infectious waste). This hospital also extends its facility to the neighboring clinics and hospitals by treating their produced waste for incineration.

1. Introduction

Hospitals are health institutions providing patient care services. It is the duty of hospitals and health care establishments to look after the public health. This may directly be through patient care or indirectly by ensuring a clean, healthy environment for their employees and the community. In the process of health care, waste is generated which usually includes sharps, human tissues or body parts and other infectious materials (Baveja et al., 2000), also referred to as "Hospital Solid Waste" and "Bio-medical Solid Waste" (Manohar et al., 1998).

The Government of India (Notification, 1998) specifies that Hospital Waste Management is part of hospital hygiene and maintenance activities. This involves management of a range of activities, which are mainly engineering functions, such as collection, transportation, operation/treatment of processing systems, and disposal of waste. However, initial segregation and storage activities are the direct responsibility of nursing personnel who are engaged in the hospital. If the infectious component gets mixed with the general non-infectious waste, the entire mass becomes potentially infectious (Info Nugget, 2003). Before the notification of Bio-Medical Solid Waste (Management and Handling) Rules 1998, waste from houses, streets, shops, offices, industries

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and hospitals was the responsibility of municipal or governmental authorities, but now it has become mandatory for hospitals, clinics, other medical institutions and veterinary institutions to dispose of bio-medical solid waste as per the Law. The onus lies on hospitals and other health care institutions to ensure that there are no adverse health and environmental consequences as a result of their waste handling, treatment and disposal activities.

The actual biomedical waste management situation in the democratic developing country like India is grim. Lakshmi (2003), in the leading national newspaper of the country, reports that even though there are Rules stipulating the method of safe disposal of Bio-medical Waste (BMW), hospital waste generated by Government Hospitals is still largely being dumped in the open, waiting to be collected along with general waste. According to World Health Organization (Biomedical Wastes, 2004) the human element is more important than the technology alone. Almost any system require treatment and disposal that is operated by well-trained and well-motivated staff provides more protection for staff, patients and the community, than an expensive or sophisticated system that is managed by staff who do not understand the risks and the importance of their contribution (Biomedical Wastes, 2004). The study conducted by the Central Pollution Control Board (CPCB), an apex pollution monitoring body on incinerators in Delhi Hospitals, concludes that the incinerators were found to spew a high level of deadly residues and toxic emissions such as cancer-causing dioxins and furans besides chemicals which cause neonatal abnormalities, reproductive and skin disorders, endocrine disruption and suppression of the immune system, reports Krishna of The Independent Media Center India (2004). He also notes that there is also even prevalence of reuse/recycling of biomedical waste being practiced due to: (i) lucrative monetary returns, and (ii) lack of awareness about the problems associated with biomedical wastes. The crux to all of this may be due to a lack of awareness and appreciation amongst medical staff and residents, as well as the public; inadequate existing facilities, and lack of strict enforcement of the Rules in light of the enormous population of the country. Biomedical waste management is a special case wherein the hazards and risks exist not just for the generators and operators but also for the general community (Sandhu and Singh, 2003). There are about 1.6 million health care workers at approximately 27,500 health care facilities in India (Shah et al., 2001).

Waste management has become a critical issue as it poses potential health risks and damage to the environment, which has taken a central place in the national health policy and is attracting a considerable international interest. India participated in the United Nations Conference on the Human Environment held at Stockholm in June, 1972, where decisions were taken to take appropriate steps for the protection and improvement of human environment. Therefore, the Environment (Protection) Act 1986 (EPA) was formed under the Ministry of Environment and Forests, which is the most comprehensive Act on the Indian Statute Book relating to Environment Protection (Jaswal and Jaswal, 2000). It is general legislation for the Protection of Environment, enacted under article 253 of the Constitution, which came in force on 19th November 1986. In July 1998, the Government of India Environment (Protection) Act 1986 (Rule 29 of 1986) issued a Notification on Biomedical Waste (Management and Handling), Rules 1998, indicating the Rules for the Management and Handling of bio-medical solid waste. It defines ''Biomedical waste'' as 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 biologicals, and including categories mentioned in Schedule I (1998).

Looking into the existing scenario of biomedical waste management in the country it was thought to undertake a study to: (i) assess the human factor in handling and treatment of clinical waste, i.e., to study the existing modus operandi and its compliance with the Standard Procedures of the Biomedical Waste Management Rules as per EPA 1986 and (ii) quantitatively determine the amount of non-infectious and infectious waste in various blocks of a recently built, multi-speciality, high-technology hospital known for its most advanced diagnostic and surgical specialities. The study lasted a period of 3 months.

2. Hospital study center profile

The KLE Society's 1000-bed Hospital and Medical Research Center, Belgaum, sprawled over 16 acres of land situated on the Pune–Bangalore highway, is the only hospital in this region of Karnataka State that has all basic specialities including General Medicine, General Surgery, Orthopedics, ENT, Obstetrics & Gynecology, Ophthalmology, Pediatrics and Psychiatry. In addition, this hospital offers super-speciality services in Cardiology, Cardiovascular and Thoracic Surgery, Urology, Nephrology, Neurology, Neuro-Surgery, Laparoscopic Surgery, Pediatric Surgery, Neonatology and Gastroenterology. These clinical services are comprehensively supported by diagnostic and support facilities like CT Scan, 'C' Arm with Image Intensifier 800 MA X-ray machine with Image Intensifier, 500 MA mobile X-ray, various endoscopes, Ultra-sonography, Gamma Camera for thyroid, brain, bone and others. The multi-speciality teaching hospital is claimed to be meticulously build, planned, painstakingly designed using modern scientific knowledge-based technology and equipped by its young and dynamic Chairman, Shri.

Prabhakar Kore at a cost of nearly 100 crores (~220 million USD), and is attached to Jawaharlal Nehru Medical College. It has recently collaborated with Illinois University Chicago and Sunderland University UK as part of an exchange programme in the fields of Medical and Pharmaceutical Education (KLES Hospital & Medical Research Center, 2004).

Belgaum town is located in the northwestern part of Karnataka state, in the southern region of India, on the borders of Maharastra and Goa states, Fig. 1 (Karnataka, 2004), in the foothills of Sayadhri range (Western Ghats) at an altitude of 2500 feet above sea level (Belgaum, 2004), latitude of 15.86°N and longitude of 74.50°E, and ranks 88 in population of 423,400 (Census of India, 2001). It is well connected by rail, road and air to Delhi, Bombay, Bangalore, Goa and most of the major cities in India (KLES Hospital & Medical Research Center, 2004). The hospital attracts people over a radius of 300 km.

3. Method

3.1. Assessment of operating procedures

A general survey of the operating procedures practiced in handling and treatment of solid waste was performed to assess its compliance with Standard Legal Norms and Procedures as per the Bio-Medical Waste Management Rules 1998.

3.2. Quantitative determination of waste

The following steps were involved in the determination of the bio-medical waste generated from different places in the study center:

(i) The supporting staff of each ward/laboratory/department was briefed over the nature of assistance and support that was needed in determining the quantity of wastes during the study period.
(ii) The staff was given coded stickers to paste on all of the color-coded, high-density, polyethylene bags used for collection of the waste to facilitate in tracing the source of waste generation for the data collection. The details are given in Table 1.
(iii) The quantities of infectious and non-infectious solid waste were recorded in two places: inside the incinerator room and outside the incinerator room for infectious and non-infectious wastes, respectively.
(iv) Solid waste of both types (infectious and non-infectious) was weighed individually on a suspension spring scale (±100 g) with the assistance of the staff and the weight was recorded by department.

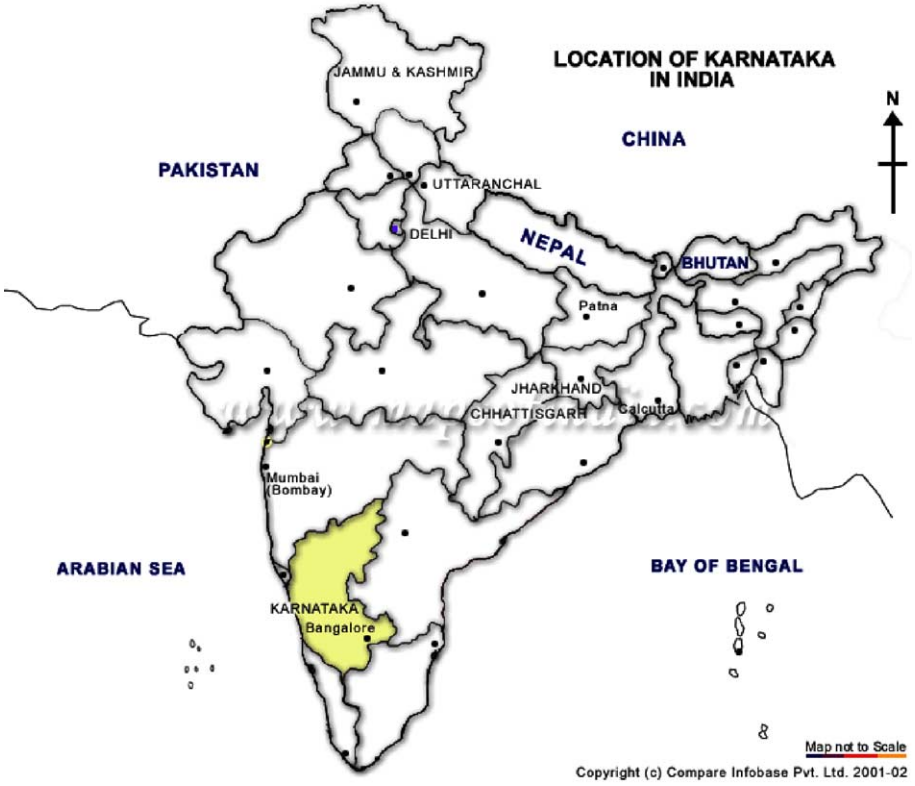

Fig. 1. Location of the study area.

Table 1
Segregation of bio-medical solid waste at KLES's Hospital and Medical Research Center, Belgaum

Color coding of polyethylene bag	Type of waste material collected
Black	Non-infectious and non-hazardous waste
Red	Microbiological waste from pathological laboratory, items contaminated with blood and body fluids, and waste generated from disposable items other than sharps, etc
Yellow	Human anatomical waste, microbiological waste from pathological laboratory, items contaminated with blood and body fluids, and waste generated
Blue	Waste sharps, solid waste generated from disposable items other than the waste sharps such as tubing, catheter, i.v. sets, etc

The amount of non-infectious and infectious waste generated in kg/day in each ward and various blocks was determined and recorded for each day over a 3-month period, Table 2. The values in parentheses are the sample standard statistical deviations σ_{n-1} (Gupta, 1998) calculated

$$\sigma_{n-1} = \sqrt{\frac{\sum x^2 - \frac{\left(\sum x\right)^2}{n}}{n-1}}. \quad (1)$$

The arithmetic mean x was determined as $(\sum x)/n$, where n is the number of days. Projections for the average quantity of various types of waste generated for one month and for one year were computed from the data. The percentage of non-infectious and infectious types of waste generated from various blocks is shown in Fig. 2 and the total quantity of waste generated in percentage in the study center is shown in Fig. 3.

The wet waste generated in the hospital kitchen and restaurant, and the soiled cloths sent to the laundry were not included in the study.

3.3. Final disposal of waste

3.3.1. Non-infectious waste

The separately collected and transported non-infectious waste is put in the large municipal bins to be removed by the city municipal authorities.

3.3.2. Treatment of infectious biomedical solid waste

The final disposal of infectious bio-medical waste is carried out by incineration. Destromat Pyrolytic Incinerator Model PY-300 equipped with a 30-m high chimney with a load capacity of 1000 kg and 150-kg/h incineration rates, operates using an oil-blast technique. The minimum operating temperature maintained in the incinerator is 800 °C over an 12-h incinerating cycle (from 8 AM to 8 PM), having a break period of 12 h for cooling and emptying the accumulated ash, before a fresh load of bio-medical waste is inserted. During incineration, the door of the incinerator is periodically opened and the waste material is turned upside down for complete incineration of the waste matter. The last load of bio-medical waste that is charged in the incinerator in a particular day is fed at least 2 h prior to start of the cooling cycle so that no part of the bio-medical waste is left unburned. The ash generated in the incinerator is removed from the incinerator every day and stored outside the incinerator room. Periodically, after accumulation of a sufficient quantity of ash, the material is transported to be dumped in pits, away from the populated area.

4. Results

4.1. Assessment of operating procedures

Observations were made during the waste handling process and questions were asked to the staff in charge regarding the care taken in handling wastes. The explanation given by staff was that they were handling biohazardous materials and that if they were careless it could be injurious to them and to others, and also could cause the spread of infection or disease. Staff further added that there could be serious ramifications on the human health in the community, which might spread to a larger area.

At the study center, the management of waste was conducted as follows:

4.1.1. Segregation

The waste was segregated separately, according to its characteristics, at the point of generation, mainly from the patient care areas. The hospital used color-coded, high-density polyethylene bags for easy identification and segregation of bio-medical solid waste. Non-infectious and domestic type of waste was collected in black polyethylene bags, placed in bins while the infectious wastes was collected in red, yellow and blue color-coded polyethylene bags placed within blue high-density polyethylene bags labeled with a bio-hazardous infectious materials symbol in specific bins. The details of the segregation of the waste in the containers are shown in Table 1.

Table 2
Generation of waste (infectious & non-infectious) in different wings of respective wards in kg/day for 3 months and the calculated percentage values along with number of beds

Ward	Number of beds	Average waste generated (in kg)		%
		For one day	For 3 months	
1. Sharavati wing				
(a) Semi Private	26	14.45 (±5.16)	1300.50	5.01
(b) ICCU[a]	17	14.36 (±4.01)	1292.40	4.97
(c) Cardiology	33	16.27 (±6.90)	1464.30	5.64
(d) Private	13	9.82 (±3.25)	883.80	3.21
(e) Hemodylysis	6	12.00 (±5.70)	1080.00	4.16
Total	95	66.9 (±5.00)	5971.00	~22.98
2. Sagar wing				
(a) Female Surgical	39	15.18 (±4.40)	1366.20	5.26
(b) Labour Room	15	14.18 (±2.23)	1276.20	4.91
(c) NICU[b]	20	13.55 (±2.77)	1219.50	4.69
(d) L G Private[c]	39	12.18 (±5.21)	1096.20	4.22
(e) Casualty	18	7.45 (±1.92)	670.50	2.58
Total	131	62.54 (±3.31)	5628.60	~21.66
3. Krishna wing				
(a) Male Surgical	39	16.73 (±7.56)	1505.70	5.80
(b) ICU[d]	14	16.37 (±7.62)	1473.30	5.67
(c) Semi Private	26	13.18 (±2.52)	1186.20	4.57
(d) Private	13	8.81 (±1.78)	792.90	3.05
Total	92	55.09 (±4.87)	4958.10	~19.08
4. Ghataprabha wing				
(a) MICU[e]	24	18.27 (±6.74)	1644.30	6.33
(b) SICU[f]	24	15.45 (±4.89)	1390.50	5.35
(c) Smile Train	39	10.64 (±3.11)	957.60	3.69
(d) Private	13	6.73 (±2.49)	605.70	2.33
Total	100	51.09 (±4.31)	4598.10	~17.70
5. Cauvery wing				
(a) Male Medical	39	15.09 (±4.01)	1358.10	5.23
(b) Semi Private	26	12.09 (±4.59)	1088.10	4.19
(c) Private	13	9.18 (±4.09)	826.20	3.18
Total	78	36.36 (±4.23)	3272.40	~12.60
6. Malaprabha wing				
(a) Urology	39	10.45 (±2.98)	940.50	3.62
(b) Neurology	39	6.81 (±2.82)	612.90	2.36
Total	78	17.26 (±2.9)	1553.40	~5.98
Grand total	574	289.24 (±4.10)	25981.60	~100.00

ICCU[a], Intensive Coronary Care Unit; NICU[b], Neonatal Intensive Care Unit; LG Private[c], Labour Gynecology Private; ICU[d], Intensive Care Unit; MICU[e], Medical Intensive Care Unit and SICU[f], Surgical Intensive Care Unit.

Both types of waste were collected twice a day, once in the morning before 8 am and once in the evening before 6 pm. However, the waste from the Operation Theater (OT) and Intensive Care Units (ICU) was collected more often, depending on the number of operations and cases attended in any particular day. All containers kept for collection of hazardous wastes were labeled with biohazard/cytotoxic symbols while other containers for non-hazardous wastes were not labeled.

4.1.2. Packaging

Infectious waste was packaged to: (i) protect waste handlers and the public from possible injury and disease that could result from exposure to the waste and (ii) avoid attraction to rodents and vermin. The integrity of packaging was preserved during handling, storage, transportation and treatment. Objects that are capable of puncturing or cutting including syringes with needles, scalpels, blades, pipettes and broken glass, were put in puncture-proof containers. The needle tips were first destroyed by shredding. Later, these materials were disinfected prior to incineration by soaking them for a period of at least 30 min in a freshly prepared 1% hypochlorite solution before discarding them in the bins.

4.1.3. Storage

The bio-medical solid wastes were not stored for more than 18 h off-site. The bins in the wards were

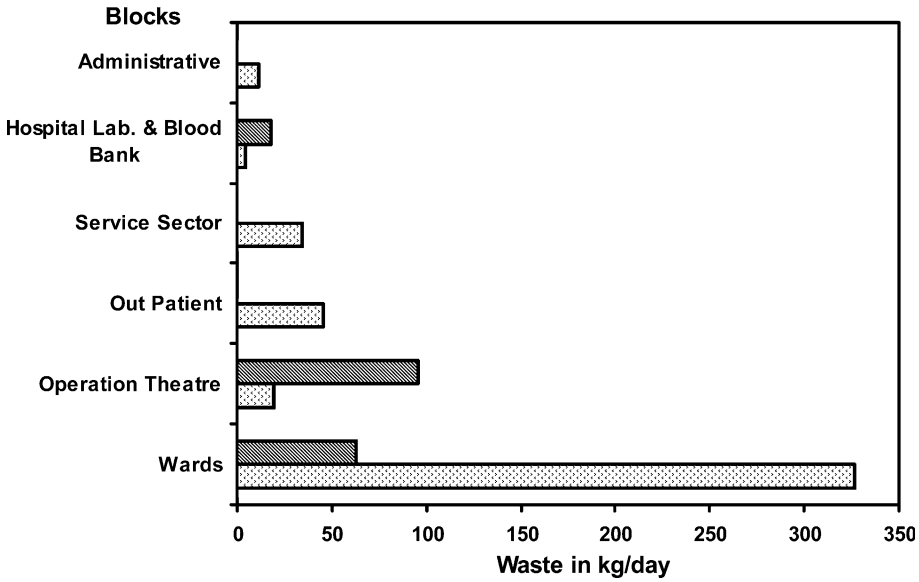

Fig. 2. Relative quantity of both non-infectious and infectious hospital solid waste generated in kg/day different sections in the selected study center.

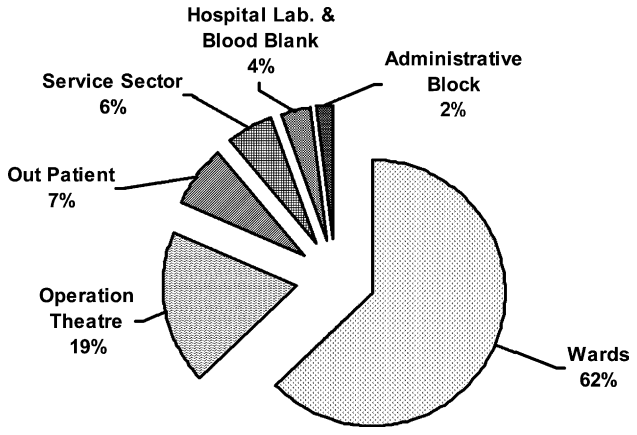

Fig. 3. Percentage gross total quantity of bio-medical solid waste generated in the selected study center.

strictly placed away from patients and from the nursing station.

4.1.4. Collection, replacement of empty color-coded bags and transportation

The collection of infectious and non-infectious wastes was undertaken by two teams of two members each, one for pulling the cart and distributing empty polyethylene bags and the other member for sealing the bags, putting the bags into the cart and replacing the bins with polyethylene bags. The staff was aware of the potential hazards of the material they were handling and were found to take requisite protective measures. They wore impervious gloves and masks during collection of infectious waste, segregation of various color-coded containers and transporting waste in the designated cart, taking adequate precaution to prevent any spillage from the plastic bags. Upon questioning, it was found that the staff had been instructed to report any injury during material handling to the medical authorities in charge.

4.1.5. Final disposal

A simple dictum was followed in the final disposal of hospital waste: "infectious waste is subjected to treatment with either heat or chemicals and non-infectious waste need not be treated." Bio-medical solid waste comprising: (i) human anatomical waste, (ii) microbial and biotechnology waste, (iii) sharps, (iv) soiled waste, (v) solid waste and (vi) discarded medicines and cytotoxic drugs were collected in red, yellow and blue color-coded high-density polyethylene bags and disposed of in an incinerator. The local municipal authorities transported the segregated non-hazardous general waste collected in black bags every other day for suitable disposal.

4.1.6. Annual report

Based on the available records, it was determined that the Hospital and Medical Research Center, Belgaum regularly submitted an Annual Report through prescribed Form No. II (Rule 10), on or before January 31 of every year.

4.1.7. Appeal procedure

The hospital did not have any records of any accidents.

4.2. Quantitative estimation of medical solid waste

Records were maintained over a period of three months of the number of beds in different wards and in various wings, as well as the amount of waste generated each day. Based on this information, the total

quantity of wastes generated and its contribution to the gross quantity of waste (both infectious and non-infectious) was computed and is presented in Table 2. The Sagar wing, which is mainly concerned with Gynecology, is the biggest wing with 131 beds, generates approximately 62.54 (±3.31) kg/day. Sagar wing and Sharavati wing (95 beds) jointly contribute about 45% of the total waste. Details of other wards in different wings are given in Table 2.

The ratio of non-infectious to infectious wastes in various sections in the study center was estimated. The data in Fig. 2 indicates that wards generate about 327 kg/day of non-infectious waste. This is about five times the quantity of infectious waste (63 kg/day) generated by the wards. The data also show the amount of non-infectious waste generated by the wards is about 74% of the total non-infectious waste generated by the entire hospital. The remaining 26% is generated in the OT/delivery room, OPD, Service Sector, Hospital Laboratory & Blood Bank and administrative block. The least amount of non-infectious waste is generated in the Hospital Laboratory & Blood Bank (BB) with approximately 1%, which is about 10 times less than the total infectious waste generated in the same block. Infectious wastes are not generated in OPD, Service Sector and the Administrative Block, because there is only paper movement and any instruments used for diagnosis are reused after sterilizing. However, approximately 54% of the total quantity of infectious waste is generated in the OT/Delivery Room. The gross total quantity of both infectious and non-infectious waste generated in the study center is presented in Fig. 3. It was found that about two-thirds of the total quantity of the waste is generated in the Wards, about 18% in OT, 7% OPD, 6% from the Service Sector and 6% from the Hospital Laboratory, Blood Bank and the Administrative Block combined. Approximately 521 kg/day of non-infectious and 102 kg/day of infectious waste with an approximate ratio of 5:1 is generated, compared to 4:1 reported by Baveja et al. (2000). About 622 kg/day of both non-infectious and infectious wastes are generated. From the records of in-patient register monitored over the study period, it was found that about 375 (±23) beds are occupied at any one time, with an average admission, discharge and death rate of about 47.04% (±6.13), 48.16% (±7.15) and 1.45% (±1.45) respectively. Hence, the amount of waste generated per bed would be 2.31 kg/day.

5. Discussion

5.1. Waste management procedures

The personnel engaged in the process of segregation, handling and transport of waste were found to be skilled for the type of job they were doing and took adequate safety measures to protect them and prevent spillage, as they were aware of the potential hazards involved in this process. Paramedic and medical staff working in the hospital disposed of the infectious waste in designated containers which conformed to the guidelines given by EPA Rules 1998 (Notification, 1998). It was a general observation that the bin size was sufficient and the bins were always emptied before it was filled to the brim.

5.2. Incineration room and its operating procedures

The incinerator room was located at the rear of the hospital, separated from the main building with sufficient space for easy movement of the trolleys and vans carrying the waste directly into the room where the segregated solid biomedical waste could be unloaded for incineration. It was observed that the hospital was extending its incineration facility at a very nominal price to the clinics and nursing homes in the city and in nearby areas with a dedicated team of staff for transport and collection of biomedical wastes for incineration at its site, once a day, everyday.

The operating conditions were found to be well monitored with periodic checks of the temperature of incineration as per the EPA Rules 1998. This institution has been rendering its services since June 1996 and until the date of the study period, no complaints had been made. However, a method has not been adopted to determine if the incineration process is complete except that the last load is fed two hours prior to the end of the burning cycle of the day and that the temperature is automatically and constantly maintained at 800 °C during incineration. This observation was very positive compared to a study undertaken in Delhi, India which reported that the low quality incinerators that have been installed in many hospitals are causing more harm than good (Biomedical Wastes, 2004) because they operate at temperatures below 300 °C and discharge toxic emissions polluting the environment and causing a major public health hazard, and do not meet the standards set forth by the Bio-medical Waste Rules which states that the combustion efficiency must be at least 99% with zero emission standards of dioxins, furans, heavy metal vapors, harmful particles, by Bio-medical Rules (Management and Handling), 1998.

6. Conclusions

In general, the management and treatment of biomedical solid waste in the study center conformed to the Bio-medical Solid Waste Rules (Management and Handling), 1998. At present, the hospital has a capacity

of 574 beds, but is commissioned for 1000 beds. The total amount of non-infectious and infectious waste generated is approximately 2310 and 385 kg/day, respectively, which is well within the capacity of the installed incinerator. About 16.4%, the waste generated in this center is infectious. The hospital administration extends its incineration facilities to the clinics and nursing homes operating in the area by charging them very nominal fees. The facility's records indicated that an average of 200 kg (±65) of waste is being handled from outside facilities.

Some suggestions were made to the hospital staff, which were well taken and appreciated. It was told to the authors that the suggestions would be taken to the hospital administration for discussion. The suggestions were as follows:

(i) In order to achieve aesthetic appeal for the entire process of waste management, the collection of the non-infectious and infectious waste should start at the patient/visitor area so that a less full trolley moves along these areas. It was advised that the infectious wastes should be collected separately from the Laboratory and OT and should go directly to the incinerator and should not be transported through the patient area.
(ii) Rather replacing the polyethylene bags in the respective bins (with periodic disinfections of the bins), the bins should be collected each time and replaced with clean bins with the polyethylene bags already in them. The collected bins should be carried in separate trolleys to minimize the possibility of spillage.
(iii) Periodic meetings should be conducted involving administrative and maintenance staff who are directly or indirectly involved with waste management in order to share and discuss the technical or practical difficulties and provide suggestions that may be specific to a particular hospital and region.
(iv) A compulsory inducting training programme should be conducted for all new staff in the hospital to familiarize them with the operating procedures practiced in the hospital.
(v) A Diploma Course in Hospital Waste Management should be initiated, keeping the needs of developing nations in mind.

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