Advances in Recycling & Waste Management: Open Access

Manasi, Adv Recycling Waste Manag 2017, 2:1

Research Article Open Access

Challenges in Biomedical Waste Management in Cities: A Ward Level Study of Bangalore

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Abstract

Bio-medical waste (BMW) although comprises a small segment of total municipal waste generated, needs special handling and treatment due to its highly toxic contents, besides being infectious. Cities face serious problems in managing waste in general and it is more important to address issues concerning specific streams of waste. If not managed properly, toxic wastes like biomedical waste, electronic waste can contaminate the municipal waste causing serious implications on public health and environment. The Ministry of Environment and Forests (MoEF) in 2011 indicated that 13,037 healthcare facilities in the country have been found to be in violation of BMW generation and disposal rules 1998. Lately, Bangalore city has been emerging as the centre for medical tourism with its professional experts, technological sophistication in health care services. Although the Central Pollution Control Board has come up with the 'Bio-medical Waste-Handling and Management Rules-1998' again amended in 2000 by the MoEF, problems concerning proper management remains. This paper aims at identifying issues related to BMW in ward 128 of Bangalore city, Southern India. Questionnaires and Checklists were developed and survey of all the prevailing 27 medical institutions was carried out in the ward. Besides, the role of formal recyclers and their challenges was also considered. Issues like lack of comprehensive data, dumping of medical waste with municipal garbage, poor awareness among the hospital staff were identified indicating the need for a comprehensive research study to be undertaken at a city level.

Keywords: Waste; Biomedical waste; Waste management; Toxic waste; Recycling

Introduction

Serious questions are being raised about economic and environmental effects of Bio-medical waste (BMW) in developing countries in recent times. BMW although constitutes a small portion of the total municipal waste generated, needs special handling and treatment as it is highly infectious and can pose a serious threat to human health if not managed in a scientific manner. In fact, the problem of BMW is more a question of its hazardous nature rather than the quantity. With this backdrop, the present study considers the existing trends of BMW management in Bangalore City, Southern India. With the expansion of tourism in tandem with IT/BT boom, the Bangalore city administration is struggling to provide improved infrastructure while trying to cope with its massive unplanned development. One such supportive infrastructure that needs a thorough streamlining is the management of BMW, an offshoot of a boom, in the number of medical clinics. Although several initiatives have been undertaken for managing hospital waste in the city, there are still exist several missing links that have serious implications on human health and ecology of Bangalore.

Almost all the countries around the world are directing their efforts towards a proper disposal of BMW. The management of BMW, due to the use of disposable items, is one of the major problems faced by the developed countries. In the United States, the hospitals discard more than two million tons of waste annually and are the third largest source of medical waste. In the developing countries, the waste gets dumped in open areas where rag pickers and beggars involve in search of goods; risk their lives by contacting hazardous diseases. Many hospitals in the developed countries are recycling or donating the scraps to the developing countries, for instance, at least 50% of the US hospitals send their single-use items to the re-processors who in turn resell them at relatively low prices after sterilizing them.

In the developing world, the problems associated with medical waste are linked to the lack of funding and national regulations for the sanitary disposal of waste. A UNDP survey says that most of the African countries lack proper sanitary landfills and legal policies for medical waste management. The lack of sanitary landfills has led to the use of incinerators to large extent and it is reported that more than 1000 incinerators are found in Africa most of which are not operating or under operating. The disposal of infectious sharps is one of the challenging risks faced by African healthcare facilities. As the safety boxes used for the disposal of sharps are very expensive, there is a limit to the use of these boxes. A study by the UNDP shows that all the countries have never disposed of the sharp waste at the dump sites and that a very few hospitals have separate pits for the disposal of sharp waste.

Biomedical Waste Management–Indian Scenario

Surveys carried out by various agencies show that health care establishments in India are not giving due attention to their waste management. The need for treating BMW was not taken up as a serious issue till the late 90's. However, the initiatives taken up led to the formulation of the 'Bio-medical Waste – Handling and Management Rules – 1998' which was amended in 2000 by the MoEF and taken forward by the Central Pollution Control Board. After the notification of the Bio-medical Waste (Handling and Management) Rules, 1998, these establishments are gradually streamlining the process of waste segregation, collection, treatment, and disposal. Many of the larger

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Received January 16, 2017; **Accepted** February 04, 2017; **Published** February 06, 2017

Citation: Manasi S (2017) Challenges in Biomedical Waste Management in Cities: A Ward Level Study of Bangalore. Adv Recycling Waste Manag 2: 119.

hospitals have either installed the treatment facilities or in the process of doing so while entrepreneurs have set up centralized waste treatment facilities.

The MOEF in 2011 indicated that 13,037 healthcare facilities in the country have been found to be in violation of BMW generation and disposal rules (Table 1). The figures show that Maharashtra ranks first (4,667) followed by Bihar (1,221) and Kerala (1,547).

In Delhi, per National Green Tribunal's [1] findings, nine government hospitals are violating the BMW disposal rules which can cause health and environmental hazards. Per official figures around 70 tons of BMW is generated in the city, and an unofficial source put it even higher at about 100 tons daily. However, nearly 50% of this goes untreated or left to be lifted along with normal garbage. Most incinerators in the government hospitals are not working to its full capacity. Major government hospitals which do not have incinerators outsource this task and the BMW is dumped in the landfills of the city along with the other solid waste. Keeping in view the difficulties faced by private hospitals/ nursing homes in treatment of BMW the Government of NCT of Delhi (GNCTD), has allowed centralized treatment facility to avail the facility through India Waste Energy Development Limited (IWEDL) at four hospitals. Currently IWEDL is operating at only one hospital and is an interim arrangement and the government is planning for centralized facility. For smaller nursing homes, clinics, Blood banks and Diagnostic laboratories that cannot make their own arrangements due to high cost Government is taking initiatives to establish centralized waste treatment facilities. The GNCTD has purchased land from Delhi Development Authority for establishment of Centralized Biomedical waste treatment facilities. There are 26 hospitals under government of Delhi. Six hospitals have incinerators and nine hospitals have autoclaves and shredders for BMW management. Delhi generates approximately 60 tons of BMW daily. Some of the initiatives of GNCTD for effective management of BMW are

- Conducting inspections twice in a year in 100 bedded or more hospitals.
- Analysis of air and effluent quality.
- Training of health care professionals.
- Efforts to ensure proper storage, treatment and disposal of BMW.

In spite of these efforts, there exist some of the issues in management of BMW like the segregation of waste in hospitals are not satisfactory, colour coding is not followed properly. The storage of BMW is not in isolated are and non-maintenance of proper hygiene, personal protective equipment and accessories are not provided, absence of proper waste treatment and disposal facilities, non-compliance of emission norms, poor performance of incinerators and lack of general awareness regarding BMW management among the hospital staff.

States	Number of facilities violating BMW rules
Maharashtra	4,667
Kerala	1,547
Bihar	1,221
West Bengal	632
Uttar Pradesh	532
Tamil Nadu	507
All India	13,037

Source:http://indiatoday.intoday.in/story/disposed-medical-waste-karnataka-deadly-virus/1/158691.html

Table 1: States with highest number of violators

The Indian Express, dated August 22, 2013 [2], reported that the Auditor General (AG) of Maharashtra has found the Maharashtra Pollution Control Board (MPCB) [2,3] inadequate in disposing the BMW generated at pet clinics in Pune region - Pimpri Chinchwad and Solapur region. In Satara sub-region, none of the 162 institutes has obtained membership of the common BMW treatment facility and 87 of them have not even furnished the required undertaking. This issue poses threat to the environment and people living there, the audit observed.

An article published by The Times News Network, dated Aug 22, 2013 [3], highlights the Goa state pollution control board finds Aldona PHC 'polluting' and directed to dispose medical waste in a scientific manner. Inspections by the Board officials revealed that needles were being openly disposed within the premises, while wastes falling under categories 6 and 7 of the BMW Management Rules were being directly disposed in a deep burial pit without treatment.

Report on BMW Management for the year 2011, indicated that some of the Health Care facilities (HCFs) are violating the provisions of the Bio-Medical Waste (Management and Handling) Rules 1998. In response to this, the Environment Ministry has issued show cause notices to 3,585 defaulting HCFs and common bio-medical waste treatment facilities (CBMWTFs) across the country. Maharashtra state topped the list with 640 show cause notices, Rajasthan, the second place with 556 HCFs, while in Uttar Pradesh, Delhi and Karnataka 382, 380 and 374 HCFs were served show cause notices respectively.

Article by The Times Network, dated 7, August 2013 [4], emphasizes the issue of noncompliance of the norms of Orissa State Pollution Control Boards (OSPCB) by the hospitals in Bhubaneswar. The private hospitals are dumping their BMW at the common BMW treatment disposal centre at Tangiapada, Khurdha and the government hospitals are not so regular. Per OSPCB, government hospitals are not following the BMW treatment disposal rules. As per the OSPCB record till December 2011, wastes of hospitals in the twin cities of Cuttack and Bhubaneswar, Choudwar, Khurdha and Jatni were disposed at the rate of 1,282 kg/day while in the entire state, it was 5,514 kg/day. Dumping the hospital waste near the municipal garbage dumping yard by the workers was observed.

DNA (2013) [5], states that the State Legislature's Public Accounts Committee (PAC) of Mumbai has pointed out the unscientific disposal of BMW rampant in Mumbai and is posing a serious threat to citizens' health. The PAC also sounded an alarm over rising urban pollution levels and the other worrying points it raised was that the many hospitals and clinics do not segregate BMW and the hazardous way it is dumped has caused a spurt in diseases. "Citizens in the big cities like Mumbai and Pune are exposed to the rising hazard of the epidemics and critical illnesses due to rising pollution and bad environmental conditions.

With respect to Karnataka state, MOEF figures for 2011 [6], puts Karnataka as the highest BMW generators as 62,241 kg/day, followed by Uttar Pradesh (44,392 kg), Maharashtra (40,197 kg) and Kerala (32,884 kg). Karnataka is the worst offender as it fails to dispose of 18,270 kg of medical waste a day. The MOEF indicate a total of 4,05,702 kg of BMW is generated every day in the country, of which only 2,91,983 kg is disposed. The figure shows that 1,13,719 kg/day of waste is left unattended which more often re-enters the system (Table 2).

Bio-medical Waste Definition

Hospital waste includes both infectious (biological) and non-

States	BMW generated (kg/ day)	BMW Disposal (kg/day)
Karnataka	62,241	43,971
Uttar Pradesh	44,392	42,237
Maharashtra	40,197	40,197
Kerala	32,884	29,438
West Bengal	23,571	12,472
Total	4,05,702	2,91,983

Source: http://indiatoday.intoday.in/story/disposed-medical-waste-karnataka-deadly-virus/1/158691.html

Table 2: Top Five Bio-Medical Waste Generating States.

infectious (non-biological) waste generated by hospitals, clinics, research institutes, health care and teaching institutes, laboratories, blood banks, animal houses and veterinary institutes. BMW (infectious waste) is defined as a solid waste, which is generated during the diagnosis, testing, treatment, research, production of biological products for humans and animals. It includes needles, syringes, laboratory samples, cultures, live vaccines, bodily fluids and so on. Biomedical waste constitutes 15% of the total hospital waste. BMW is generated primarily from health care establishments including hospitals, nursing homes, veterinary hospitals, clinics and general practitioners, dispensaries, blood banks, laboratories, waste from households, industries, animal houses and institutes like educational and research [7]. All these sectors are included in the Bio-medical Waste – Handling and solid waste may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc. in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc.

It has been roughly estimated that of the 4 kg of waste generated in a hospital at least 1 kg would be infected. Global figures based on statistical data of Environmental Protection Agency of America and Japan, Ministry of Health suggested a volume of 1 to 1.5 kg/day/bed for hospitals. However, waste produced has been quoted up to 5.24 kg in developed countries. The average quantity of hospital solid waste produced in India ranges from 1.5 to 2.2 kg/day/bed.

Hospital Waste Classification

Municipal solid wastes

General waste like the domestic waste includes paper, diapers, plastic cups, food etc. This waste remains non-infectious if managed properly and not brought in contact with the infectious wastes.

Hazardous solid wastes

Includes laboratories and pharmaceutical chemicals and containers including discarded medicines, disinfectants, alcohols, anti-neoplastic agents, heavy metals etc.

Biomedical solid wastes

These are hazardous in nature and commonly referred as clinical and pathological wastes. The cultures, stocks of infectious agents, associated biologicals, human blood and blood products, contaminated sharps, ampullated body parts, isolation waste.

Further, the BMW is grouped into 10 categories (Table 3) for the proper handling, thereby making it non-hazardous to people and environment [8].

Health Hazards of BMW

Several health hazards are associated with poor management of BMW like injury from sharps to staff and waste handlers associated with the health care establishments, Hospital Acquired Infection (HAI) of patients due to spread of infection. Occupational risk associated with hazardous chemicals, drugs, unauthorized repackaging and sale of disposable items and unused/date expired drugs [9]. Bacterial contamination represents the highest and most immediate health risk and water is the main carrier medium. Infection due to unsafe injection practice infects 8-16 million with Hepatitis B, 2-45 million with Hepatitis C, 75000 to 150000 from HIV/AIDS [10].

The comprehensive rule covers various aspects of dealing with waste specifying the duty of the occupier of an institution generating BMW as to ensure safe handling, on segregation, packing, transportation and storage specifics, submission of annual report to Pollution Control Board of categories and waste generated, maintenance of records on generation, collection, reception, storage, transportation, treatment and disposal, type of waste to be incinerated and colour coding for segregation. The occupier of an institution generating BMW is required to take all steps to ensure that such waste is handled without any adverse effect on human health and the environment.

The environmental considerations must form an integral part of all development and be supplemented by mechanisms to see that environmental safeguards proposed are implemented together with systematic monitoring to assess the effectiveness of such precautions in protecting the environment. It is proposed to appoint an advisory committee constituting members from medical, healthcare, veterinary, environment management, municipality and other related departments to provide suitable advice.

The step-wise integrated waste management plan has been devised by the Centre for Environmental Education for infectious and non-infectious wastes [11]. While cytotoxic wastes remain a pending issue, BARC has laid-down regulations for radioactive wastes which must be stored until the half-life period of the wastes expires before disposal. General wastes can be dealt with by composting and recycling. Resource material produced by Shrishti, guides authorities towards implementation of a safe waste management system and culture in a health care establishment through a stage-wise scheme, making it a feasible task. A nodal person identified would serve as a key to implement the plan and act as a central point for dissemination of information. Evaluation of the existing system would aid in location to determine suitable positions for the placement of waste disinfection and disposal equipment. The guidelines also suggest a waste survey should be conducted in all the wards, operation theatre, outpatient departments, emergency, intensive care units, laboratories, administrative sections, kitchen and the main bin of the hospital for two weeks. Later, the waste should be weighed at the end of each shift or at the time of disposal. The information obtained would aid selecting specific receptacles for different wastes and different levels of output and determine the type of disinfection needed and the point at which it should be carried out in the waste stream. A pharmacy inventory is also considered necessary to determine the type of products being used and the number of disposables. To make it more stringent, it is suggested that each hospital must ensure that there exists a list of items and material that will always be considered infectious. Shrishti emphasizes that a time specific programme, which is more focused and need based as familiarity increases, is essential to sensitize the staff. In addition, finally a sound follow-up and accounting method enables regular appraisal of the plan.

Management of BMW

Different methods followed in the BMW management are

Option	Treatment & Disposal	Waste Category
Category 1	Incineration $/deep* burial	Human Anatomical Waste (human tissues, organs, body parts)
Category 2	Incineration $/deep*burial	Animal Waste, tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals / colleges, animal houses)
Category 3	Local autoclaving/ micro waving/ incineration $	Microbiology & Biotechnology waste (laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents)
Category 4	Disinfections (chemical treatment @/autoclaving/micro waving and mutilation shredding #	Waste Sharps (needles, syringes, scalpels blades etc.)
Category 5	Incineration $/ destruction and drugs disposal in secured landfills	Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)
Category 6	Incineration$, autoclaving/micro waving	Solid Waste (Items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, line beddings)
Category 7	Disinfections by chemical treatment @ autoclaving/micro waving& mutilation shredding. #	Solid Waste (waste from disposable items other than the waste sharps such as tubing, catheters, intravenous sets etc.)
Category 8	Disinfections by chemical treatment @ and discharge into drain	Liquid Waste (waste from laboratory and washing, cleaning, house-keeping and disinfecting activities)
Category 9	Disposal in municipal landfill	Incineration Ash (ash from incineration of any bio-medical waste)
Category 10	Chemical treatment @ and discharge into drain for liquid and secured landfill for solids	Chemical Waste (chemicals used in production of biological, chemicals, used in disinfection, as insecticides, etc.)

Source: http://www.mppcb.nic.in/Bio_Categories.htm#Top

@ Chemicals treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfections.
# Mutilation/shredding must be such to prevent unauthorized reuse.
$ There will be no chemical pretreatment before incineration. Chlorinated plastics shall not be incinerated.
*Deep burial shall be an option available only in towns with population less than five lakhs and in rural areas

Table 3: Categories of Waste.

Segregation

Initial segregation at source reduces the waste management problem to 15%. Segregation is done accordingly to colour coded bags (Table 4) which ensures handling and proper management of wastes and minimizes further handling of the wastes till the time of treatment. Segregation reduces risk of infecting workers, costs of treatment, risk of infecting community at large, recycle, and reuse of non-infectious waste. Though, the hospital waste generated is about 2 kg/bed/day, only 0.25 to 0.3 kg/bed/day of it is infectious. Therefore, about 10 to 15% of the total waste generated at the health care establishment is infectious in nature.

As per MOEF rules, the wastes cannot be stored for more than 48 hours. Hence, the authorized recyclers' collect the waste on daily basis. The collected wastes are placed in closed containers enclosed in a specially designed containerized vehicle and transported.

Disinfection and destruction

Infectious wastes are to be disinfected before final disposal as it contains pathological microorganisms causing diseases. Wastes are unloaded at the place of treatment and separated per colour codes, properly treated and then disposed. In accordance with the MOEF rules, categories 1, 2, 3 and 6 shall be loaded directly into the incinerators, whereas categories 4 and 7 shall be loaded into autoclave for disinfection. The residue obtained from these units is disposed into a landfill.

Disposal: Hospitals generate wide range of chemical hazardous waste. Ashes, residue from high temperature incineration and other materials from these units are to be collected in containers and disposed into a secured landfill facility.

Treatment Technologies

There are several treatment technologies used (Table 5) to process BMW. Bioremediation is the simple and the affordable technology used in India. The technique does not require high capital, maintenance cost and trained personnel. Though the technology is patented in India through National Research Development Council of India, is not in the Government notification 1998 regarding hospital waste disposal, a writ petition is pending before the Uttar Pradesh high court. In India, incinerators are used in combination with Autoclave that is more compatible.

Similarly, for liquid waste, BMW Rules advocate disinfection of infectious waste and neutralizing of liquid chemical waste to below pH7 before draining it into the sewer. Effluent Treatment Plants (ETP) are used to disinfect water from toxic substances and chemicals and remove high number of organics, dirt, debris, polymers. ETP uses evaporation, drying methods and other techniques like centrifuging, filtration, incineration for chemical processing.

Bangalore Scenario

Bangalore is situated in Southern India, capital of Karnataka. It is India's sixth most populous city and fifth most populous urban agglomeration. Bangalore with its strategic location and congenial climate attracts people from all over the country. Bangalore's urbanization process has been alarmingly unprecedented making it a challenge for the State government to provide the much-needed infrastructure. Of the many challenges that urban Bangalore face, hospital waste management is one of the critical issues. In this backdrop, the paper provides an overview of trends and practices in BMW management in ward 128 of Bangalore.

Bangalore's escalating hospital waste

Bangalore is one of the top medical tourism destinations in India [12], with professional experts, technological sophistication and health care services that easily match the best in the world. Its reputation as the global technology hub and cosmopolitan city has made it a prominent health care destination for foreigners from developed as well as developing countries. Medical tourism is slated to become a 2.3-billion-dollar industry next only to IT and BPO. The cost of surgeries is one-third the cost charged in developed countries like the US and UK. Flying

Color Coding	Type of Containers	Treatment Options
Red	Disinfected Container/ Plastic bag	Autoclaving/Micro waving/ Chemical Treatment
Blue/ White translucent	Plastic bag/puncture proof container	Autoclaving/Micro waving/ chemical treatment and destruction/shredding
Black	Plastic bag	Disposal in secured landfill
Yellow	Plastic bag	Disposal in secured landfill

Source: http://www.mppcb.nic.in/Bio_Categories.htm#Top

Table 4: Segregation of BMW.

Technology	Process
Incineration	Incineration is a dry oxidation process through high temperature, which reduces organic and combustible waste to incombustible matter and reduces the volume and weight of the waste significantly. This is usually applied to treat the wastes that cannot be recycled, reused or disposed of in a land fill site. (Park, 20th edition). The advantages of Incineration are it reduces landfill waste and saves costs, produces energy that can be reused, thus, reducing overall energy costs. Disadvantages are cause of pollution due to plastic waste releasing dioxins and furans into the atmosphere. Incinerators are banned in Western countries and Microwave technology is popularly used and considered safe. Lots of controversies exist regarding the use of Incinerators
Pyrolysis	It is like incineration in which it uses high heat to destroy medical waste and produces lower levels of pollution than incineration.
Autoclaves	Autoclave uses steam to sterilize medical waste. Some equipment has additional features to aid in disposal, such as drying and compacting. Microorganisms which because infection do not survive beyond 80^{0}c. However, as a precaution MOEF has stipulated a temperature of 121^{0}c with 15 psi pressure to ensure the distribution of temperature to ensure complete destruction of microorganisms.
Electron beams	Uses ionizing radiation to destroy microorganisms Microwave technology prepares medical waste to be taken to the landfill. It is a relatively clean technology, as microwave treatments do not result in air or liquid emissions.
Hydroclave	Tedious process and hence not very popular.
Bio-remediation	Bioremediation is the use of micro-organism metabolism to remove pollutants. *In situ*-Bioremediation involves treating the contaminated material at the site and *ex situ* Involves the removal of the contaminated material to be treated elsewhere.

Table 5: Technologies in HWM.

in from 30 different countries, 'medical tourists' account for 10 per cent of patients in the top hospitals. Apparently, the Karnataka Government is taking a slew of initiatives in promoting medical tourism in the state. With the expansion of medical tourism in continuation of IT boom, the city struggles to provide improved infrastructure and cope with its massive development. One such supportive infrastructure that needs thoroughness in management is hospital waste an offshoot of hospital boom. Although several initiatives are taken in managing hospital waste, missing links has its implications on the health directly and largely on the urban ecology of Bangalore.

Trying to understand status of BMW, studies have quoted varied figures on quantity of waste generated. Study by [13] indicate Bangalore generates 1,32,500 kg of health care waste per day while the health care facilities generate 5,100 kg daily [14]. Government hospitals generate far less BMW than corporate facilities. In Government hospitals, such as Victoria, it is around 0.5 to 0.8 kg per bed per day, whereas in corporate hospitals, it is 1 to 1.5 kg. Currently, Bangalore generates 40 tonnes of biomedical waste daily. The waste meant for the incinerator is a mere 2 percent, while the infectious waste meant for autoclaving is about 15 percent. General garbage makes up for over 75 percent of the waste. Study by TERI indicates generation of BMW in Bangalore to 0.5% of the total waste generated.

Study Area

The area selected for the study is in Bangalore, Nagarabhavi, Ward No. 128 covering an area of 1.6 sq. kms. There are 11 localities in the ward. The total population in the Ward is 20,269 (Male 10408 and Female 9861). There are 3 hospitals and 24 clinics in the ward.

Methodology

Both primary and secondary data were collected for the study. The primary data was collected from the Hospitals and Clinics, while the secondary data collected from – Bruhat Bangalore Mahanagara Palike (BBMP), Karnataka State Pollution Control Board (KSPCB), Health Care Waste Management Cell (HCWMC) and the formal recyclers - Ramky eco-industries and Maridi eco-industries. The study was conducted during the period from September 2011 to October 2011. Initially, the study was designed to take representation across wards. However, there was no data available on the total number of hospitals and clinics in Bangalore as we received different lists from the BBMP and the formal recyclers. Hence the study was limited to one ward covering all the medical institutions within the ward. Study was conducted in Nagarbhavi ward no 128 and covered all hospitals and clinics of this ward. A questionnaire was designed covering various aspects on segregation, collection, disposal and associated problems encountered with the waste management. Although the study did not cover all zones in Bangalore, we were still able to capture some important issues that could largely reflect the situation in other areas.

Formal recyclers

Initially few big hospitals treated their own waste by installing incinerators. In the process, many small hospitals also installed incinerators, which were not meeting the required standards. Lately, the KSPCB made it mandatory for all medical waste generators to outsource the waste to the formal recyclers. At present, Bangalore's BMW is processed by two entrepreneurs, Maridi Eco Industries and Ramky Industries. Both Maridi Eco-Industries and Ramky Industries were established in 2001. Maridi Eco-industries cover South Bangalore from Hoskote in the East to Kanakapura to Attibele on Hosur Road. They have extended their services to Ramanagar and Mandya as well. Maridi Eco-industries have established a plant at Tamilnadu and have plans to start at Chikkamangaluru. Ramky Industries covers the Northern part of Bangalore, Doddaballapur to Kengeri and Banaswadi to Tumkur. It's treatment plant is situated at Dabbaspet 45 kms from Bangalore in the north (Table 6). Besides these, Health Care Waste Management Cell (HCWMC) is working towards ensuring safe management of BMW besides increasing awareness among institutions. HCWMC perceives health care waste management as primarily an issue of occupational safety. The objective is to reach out to establish systems and sub-systems for safe management of health care waste. It persuades and motivates

Type	Ramky	Maridi
Hospitals*	338	402
Clinic and Day Clinic – A	343	446
Dental – B	221	213
Blood Bank – C	10	8
Laboratories – D	26	38
Diagnostic Centre's – E	90	92
Veterinary – F**	1	2
Veterinary – F**	1	2
Alternative Medicines and Health Clubs – G***	15	10
Research, Rehabilitation and Fertility Centers – I****	182	
Total	1225	1211

Source: BBMP
*Inclusive of Nursing Homes, Super Specialty Hospitals and Multispecialty Hospitals
**Animal Houses, Veterinary Clinics
***Ayurvedic dispensary, Homeopathy clinics, Health Clubs,
****Fertility Centers, Medical Centers, Health Care, Rehabilitation institutes, Society, Research Centers, Companies, Unnamed.

Table 6: Health Care Centers Covered by Ramky and Maridi.

the hospitals on personal and professional grounds. The Cell plans to set up independent monitoring systems and a comprehensive training programme for different levels of health personnel. The quantity of waste collected is around 5000 kgs/day by Ramky while 3500-4000 kg/day by Maridi. The charges are fixed based on the number of beds. For the hospitals, it is Rs 4.50/bed/day, for clinics, it is Rs.500/month and for diagnostic centres it is Rs.800/month. It follows guidelines of all State and Nations with affordable price with valuable management of medical and biohazardous waste management. The other features of Maridi are (i) 24/7 pickup, online sale service (ii) Customer care facility (iii) Solution for the serious problems within 24 hours (iv) Fast quote service (v) Flat rate service (vi) Service motto (vii) Good coordination and compliance affordability and reliability.

Ramky's work force has 50 employees and have 9 specially designed vehicles for the waste collection. The transportation begins at 4.30 am and ends at 10.00 am. While Maridi has 45 employees and 10 vehicles for waste collection and the transportation begins at 6 am. The waste is collected daily from the hospitals, weekly twice from the clinics and once in a week from the clinics, which have autoclaves with them. About 15 medical stores together form the drug dealer's association and the expired medicines are collected once in a month. Besides, there are some distributors who give such medicines to Ramky. The waste is weighed before collecting it and the number of covers, colour of the covers and the type of waste is noted.

Both Ramky and Maridi are also involved in conducting awareness and training programmes. Awareness is created through posters and power point presentation making it simple and effective. Swathi Mahila Sangha, EMPRI and Suraksha KHPT are supporting Maridi for conducting awareness and training camps.

The disposal operations are carried out using incineration and sterilization as the two main modes. The facilities provided are (i) Biomedical Incinerator (ii) Autoclave (iii) Scrubbers for Stack Emission Control (iv) Shredding (v) Secured landfill (vi) Effluent treatment plant. Ramky has 2 incinerators with 400 kg/hr. capacity and only 70% of its capacity is being utilized currently. Maridi also has 2 incinerators of 300 kgs/hr. capacity of which one is in regular use with 60% capacity, the other is used as a standby.

Both companies have Effluent Treatment Plants that treats water, which is used to clean the incinerators and floors. The incinerated ash is disposed of in specially set up landfills. All installations and operations are in line with regulatory requirements laid down by Biomedical Waste (Management and Handling) Rules 1998 and its amendments enunciated by the MoEF, Government of India.

Maridi has plans to extend its services to households and apartment complexes. KSPCB visits the plant once in two months for inspection and checks the pollutants in the atmosphere through Air Pollution Control System. Besides regular inspections, KSPCB also conducts surprise visits to the recycling plants.

Results and Discussion

Given the context, we were keen to understand the situation at a ward level to get preliminary understanding of the issues and concerns at a micro level. The aim was to further extend the study to the whole city and make it representative. We could identify certain issues that are of relevance, which we have discussed in this section.

We could identify the sources of bio medical waste generation at the first level. There are twenty-seven sources were identified as BMW generators in ward 128 (Table 7). Out of these, there were six Ayurvedic and Homeopathy clinics, which generally do not generate infectious waste.

Clinics

We observed that, at large, there was no consistency in following the guidelines. Among the 24 clinics in ward 128, six clinics were following colour coding, 12 clinics were not having coloured bins and the remaining 6 were not having coloured bins as they are Ayurvedic and Homoeopathic clinics. Even among the 6 who are following colour coding, all were having red bins, 3 were having blue and black bins, 4 clinics were having yellow and white bins. Doctors at the clinics complained that lack of space made it difficult to accommodate so many types of bins and follow the colour coding.

Only 11 clinics of the 18 were separating sharps and needles. The recyclers instructed the doctors not to break the syringes and needles and provided containers with solution for better storage. However, we also observed that used syringes and needles were piled up in a clinic and was informed that it was stored for three years. There was communication gap between the recyclers and the doctors in the clinics. Some of the doctors opined that their attempts to contact the recyclers were not fruitful.

The collected waste is disposed daily in only 3 clinics, twice in a week in 6 clinics, weekly once in 9 clinics. Among the 18 clinics, 11 clinics were disposing the waste to formal recyclers (8 to Ramky, 3 to Maridi), and remaining 7 clinics were disposing it to municipal bins after sterilization. Doctors in these 7 clinics opined that the formal recyclers had not approached them for the collection of waste. Earlier the waste was being dumped in the general garbage. Now it is being taken by the BBMP daily. The clinics who were not giving the waste to recyclers opined that the recyclers must be made accountable for their services in terms of regularity; however, they had also experienced

Category	Number
Clinics and day care	09
Dental	08
Blood banks	0
Laboratories	0
Diagnostic centers	0
Veterinary	0
Fitness center, unani dispensary, Ayurvedic dispensary, homeopathic clinic, health club, animal houses, veterinary clinics	07
Hospitals, Nursing homes, Super specialty and Multi-Specialty Hospital	03
Total	27

Source: BBMP

Table 7: BMW generation Sources.

difficulties in contacting them to register their clinics. They were comfortable treating the infectious waste through autoclave and then dispose it into the municipal bin. Of the 18 clinics, only 3 faced problems before disposing the waste due to delay in disposal causing foul smell while the rest did not encounter any problem.

11 clinics took precautions while managing waste by using gloves while the rest did not take any precaution. Masks were used only in 9 clinics and sterilization was carried out only in 2 clinics. The doctors and the staff were instructed to break the needles before putting into the bins. In some clinics, Maridi also provided a puncture proof container with liquid which contains water +1% hypochlorite solution. These needles were disinfected and autoclaved and finally disposed in the land fill along with the ash from incinerator at Mavallipura, Dabaspet.

Hospitals

Like clinics, we observed there was inconsistency in following all the prescribed guidelines in the hospitals. There are only 3 hospitals in Ward 128, which were covered during the survey. All these hospitals followed colour coding and placed all the 5 coloured bins with stickers of biohazard symbols. Only 1 hospital had an assigned a trained person to monitor the waste. It is important that all other staffs of the hospital are involved in taking responsibility of segregation of waste. In this regard, Doctors, Nurses, Ward boys and *Ayahs* were segregating the waste at source in one hospital and not in the other two. Gloves were used during segregation in all the three hospitals, but masks were used only in 2. Infection control injections were taken by staff only in one hospital. Syringes and needles were treated by breaking in 1 hospital and hypochlorite solution treatment before disposal in the other 2. The waste is being stored for only one day in all the three hospitals and 2 of them store it in a separate room while the other in the back yard. All the three hospitals were giving waste to both municipal bins (non-infectious waste) as well as recyclers (infectious waste). Ramky collects waste from two hospitals whereas Maridi from one hospital. 1 hospital is using chemical disinfectant to treat the liquid before discharging into sewage, one hospital has small treatment plant and there was no response in one hospital about the disposal of liquid waste.

Key Issues

Some of the concerns must be addressed in improving hospital waste management to ensure that health and quality of life of urbanites are not affected.

Lack of accurate data

It is a matter of serious concern that there is no data on comprehensive list of health care institutions with the BBMP or any other related organization. For instance, the data collected from BBMP Head office indicated the number of medical institutions as 2436, and the data collected from BBMP office of Malleshwaram indicated as 1599. Another newspaper article published in Vijaya Karnataka on 14 September 2011 indicated the number of hospitals, nursing homes and diagnostic centres obtained from the Revenue department of BBMP as 390. In controversy, the data collected from Ramky and Maridi indicate it is 2330 [13]. However, there is a positive sign that the introduction of the Health Care (Management and Handling) Rules 1998, had led to the increase in the institutions that are enrolled but a complete list is unavailable. As there was no data available on the number of clinics and hospitals at the ward level, the data during the study had to be collected personally.

Mixing of BMW with the municipal waste

Biomedical waste getting mixed with municipal waste is a matter of grave concern. It is alarming fact that only two-thirds of the waste i.e. 14 tons out of the total medical waste generated i.e. 40 tons generated in Bangalore every day is treated scientifically by the recycling units. The rest gets mixed up with municipal waste. Besides, these units are using only 60-70% of their capacity.

Non-registration with the recycling units

As per the rules, the unregistered clinics should get registered with formal recyclers and get a registration certificate from them and a registration number from the KSPCB. However, in practice, several clinics and small hospitals are not registered with the recycling units. In 2012 May, BBMP issued a final notice warning to unlicensed health units to obtain trade licenses. Notices were served earlier thrice – December 2010, February 2011 and June 2011. Despite this, 937 health units out of 2648 hospitals surveyed by BBMP were unregistered as of March 2012 [15].

This could be due to higher charges they must pay to the recyclers or lack awareness and access to the formal recyclers. Discussions with doctors revealed that charges were unaffordable as the numbers of patients treated were limited and accordingly the waste generated was negligible. They expected that HWM should be supported by the Health department, BBMP, and DHO and the cost should be shared by these departments. The doctors felt that they paid professional tax and was not fair to burden the doctors or the patients. The recyclers on the other hand opined that the cost of treatment was high and it would not be feasible to reduce the charges. As charges are fixed for 3 years in the agreement between hospitals, which is a constraint as expenditure keeps increasing. Renewal of agreement is done every year but convincing the increase in price is a difficult task.

However, all the Doctors believed HWM rules must be made mandatory and must be implemented strictly and that every waste generator should give the waste to the authorized recycler. Irrespective of the quantum of waste, BMW was considered infectious, safe waste disposal needed high priority. They were concerned about that all sources of waste generators were not covered and that the hospital waste was dumped in the general garbage.

Illegal dumping of bio-medical waste

Instances of illegal dumping in Bangalore, have drawn the attention in the media several times. Hospital waste was found dumped near Avalahalli, off Kanakapura road. The Environment Support Group brought this issue to the fore and the residents complained that

dumping of hospital waste in the vicinity is a common feature (Citizen Matters, 2008). Another instance of common illegal dumping was at Mavallipura and KSPCB had received several complaints in this regard. It is necessary to take immediate actions against such acts and the health care establishments should work towards proper disposal.

Irregularity in waste collection

Amongst the registered institutions, few clinics were disposing the waste twice in a week or once in a week, as per the collection trips made by the recyclers, which is against the rules. Regular collection daily was considered more relevant as medical waste was infectious in nature. Instances of irregularity in collection were observed at times, which add to the spreading of diseases. The waste is not collected regularly by the eco-industries, which leads to the spread of infection. Dental clinics are house of infection as the waste is related to the oral treatment. So, it is necessary to collect the waste daily form the clinics too.

Lack of awareness

Lack of awareness among various sections of the staff was a matter of concern. Unless all the hospital staff at all levels co-operate, the system will not be able to function effectively. Apart from awareness creation, it is imperative that waste management is systematized with proper monitoring. Study about awareness and practices among health care waste management among hospital staff in a medical college hospital, Bangalore indicated that doctors, nurses had better knowledge and attitude and practiced HWM better than other housekeeping and technical staff [16].

Interestingly, an initiative has been taken up to include hospital waste management as a subject in the post-graduate syllabus at Armed Forces Medical College (AFMC) and Medical Training Centre (MTC) Bangalore (for paramedics) [17]. The Medical Council of India, Nursing Council of India and the Dental Council of India have been approached to direct the teaching institutions to include the subject in the undergraduate and post graduate syllabi. Initiatives were taken to establish waste management cells to monitor and facilitate of biomedical waste at four hospitals coming under the Bangalore Medical College and Research Institute. Each hospital planned to have five to seven members team trained in safe management of hospital waste [17].

Lack of sufficient space

Another practical constraint for segregation of waste has been the space issue. As there are several clinics that are accommodated in small spaces, particularly in congested areas, doctors found it difficult to place the bins within the clinics per the colour codes and follow the prescribed guidelines. Doctors preferred two categories of infectious and non-infectious waste and were not keen on having more colour codes and segregate waste.

Mixing of infectious liquid waste with the common sewage

Disposal of infectious liquid waste is discharged to the common sewage without any treatment. Like the contamination of hospital solid waste getting mixed with municipal solid waste untreated liquid waste will contaminate the water significantly which is a matter of concern. Waste generated in the pet clinics and animal houses are infectious it is neither treated nor handed over to the recycling units. Currently, it is being dumped in the municipal dustbins or open spaces which can cause contamination and source of outbreak of diseases.

Conclusion

Crucial areas, which need to be addressed for effective handling of bio-medical waste are capacity building by training and retraining, concern and commitment on part of the healthcare providers, institutional and city level policies, occupational safety and personal protective devices, information dissemination and practical advocacy endeavours. There is a need for evolving policy and protocols by health care institutions and concerned institutions from the government to manage recyclables. To begin with, it would be useful to have a proper inventory of medical institutions. The government should hand over the responsibility to the health offices or BBMP ward offices to accept the registration of health care establishments and more specific details about the hospitals and waste generated could be collected at a second level. Arrangements should be made for the availability of the details of all health care establishments in the BBMP Head office. This results in compulsory registration and safe disposal of biomedical waste as well. The health inspector must be made responsible to monitor the documentation. Systematized training programmes should be conducted on a periodic basis for all the representatives of medical institutions. Representatives of BBMP should be involved in the training programmes. The awareness training camps must be conducted in all the wards with compulsory participation of the staff. Awareness creation regarding the biomedical waste disposal should be made part of the curriculum of all medical related schools. Awareness programmes should be extended to public through mass media communication. Besides systematization of hospital solid waste, installation of a treatment plant must be made compulsory to disinfect the liquid waste before discharging into the sewage**.** For HWM to be a successful initiative HWM should be a social responsibility and everybody should get involved.

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