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Biomedical Waste Management: Issues and Concerns - A Ward Level Study of Bangalore City

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BIOMEDICAL WASTE MANAGEMENT: ISSUES AND CONCERNS

- A WARD-LEVEL STUDY OF BANGALORE CITY

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Abstract

Bio-medical waste although constitutes a small portion of total municipal waste generated, needs special handling, treatment and disposal as it is highly toxic and infectious. This paper aims at identifying issues related to bio-medical waste in a BBMP. Ward No: 128 of Bangalore city, Southern India. In recent years, Bangalore city has emerged as an important centre for medical tourism due to the concentration of professional expertise, sophisticated medical/technological services and health care institutions. Twenty-seven medical institutions in the ward were surveyed and the role of formal recyclers of medical waste was also looked into. Also, issues like lack of comprehensive data, practice of dumping of medical waste with municipal garbage, poor awareness among the hospital staff, etc. in the ward were identified for analysis.

Introduction

Serious questions are being raised about economic and environmental consequences 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 treatment and disposal as it is highly toxic and 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 acute hazardous nature rather than the quantity generated. With this backdrop, the present study looks into the existing trends of BMW management in Bangalore City, Southern India.

With the expansion of tourism in tandem with IT/BT boom, 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 the unprecedented increase in the number of medical institutions. Although several initiatives have been undertaken to manage hospital waste in the city, there still exist missing links that have serious implications for human health and ecology of Bangalore. In this context, it is imperative to understand the current status of green initiatives in addition to finding ways and means for their further promotion. The goal of this new approach to ecological study is an interdisciplinary understanding of the relationships between cities and natural ecosystems.

Bio-medical waste management – Global Scenario

Almost all the countries around the world are directing their efforts towards proper disposal of BMW. The management of BMW, due to the increasing use of disposable items, has become one of the major problems faced by the developed countries. On the other hand developing countries are confronted with

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the problem of categorizing and disposing of medical waste in the sanitary arena. In the United States, hospitals discard more than two million tons of waste annually making it the third largest source of medical waste in the world. In the developing countries, BMW gets dumped in open spaces where rag pickers and beggars while searching for salvageable scrap come in contact with toxic waste and stand the risk contacting hazardous diseases. In sub-Saharan Africa, due of the presence of a large number of incinerators and burnt-out waste, people face innumerable health problems from air and water pollution. Many hospitals in the developed countries are shipping scraps and medical waste to the developing countries to get rid of the menace; for instance, at least 50% of the US hospitals send their single-use items to re-processors who in turn resell them at relatively low prices to third world customers 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 disposal of sanitary waste. A UNDP survey says that most of the African countries lack proper sanitary landfills and official policies for medical waste management. For example, Eritrea, Lesotho, and Ghana have no legislations for health care waste management, while Kenya, Nigeria, and Gambia have some significant laws passed in this respect. The lack of sanitary landfills in Gambia, Ghana, Lesotho, Nigeria, Senegal and Tanzania has led to the use of incinerators to a large extent, while, unscientific dumpsites are found in Kenya and Zambia. It is reported that more than 1000 incinerators are to be found in Africa most of which are not operating, or are under-operating.

The disposal of infectious sharps (needles, scalpel blades, blood vials, glassware, etc) is one of the challenging tasks faced by African healthcare facilities. The high cost of the safety boxes used for the disposal of sharps is a serious factor that discourages the use of these boxes. A study by the UNDP shows that most the countries have not disposed of the sharp waste at the dump sites and that a very few hospitals have separate pits for the disposal of sharp waste. Additional funding would definitely help the developing countries for better disposal of medical waste, and it is also necessary to have appropriate legislations for the proper disposal of hospital waste.

Efforts are made globally by many NGOs in association with the government and hospitals to address waste management issues by helping the hospitals to recycle the waste besides providing the needed equipment. For instance, Intervol, a New York-based NGO, collects used and unused (but functioning) medical equipment and also distributes them locally, nationally and internationally. This avoids the incineration of these equipments. Another NGO, Medshare, has been collecting medical goods and equipments and transporting to 80 countries for distribution. This in-turn saved more than 1 million cubic feet area of landfills *(Source: http://www.globalization101.org/news1/Medical_Waste*).

Bio-medical waste management – Indian Scenario

Surveys carried out by various agencies show that health care establishments in India are not giving due attention to waste management. The need for treating BMW was not taken up as a serious issue till the late 90's. However, certain initiatives in this direction led to the formulation of the 'Bio-medical Waste – Handling and Management Rules – 1998 which was again amended in 2000 by the Ministry of Environment and Forests and taken further forward by the Pollution Control Board. After the notification

of the Bio-medical Waste (Handling and Management) Rules, 1998, these establishments have been gradually streamlining the process of waste segregation, collection, treatment and disposal. Many of the larger hospitals have either installed waste treatment facilities or are in the process of doing so, while some entrepreneurs have also set up centralized waste treatment facilities.

The MOEF in 2011 found that 13,037 healthcare facilities in the country were violating BMW generation and disposal rules (refer Table 1). The number of errant healthcare units in 2007-08 was 19,090. The figures show that Maharashtra accounts for the highest number of errant facilities (4,667) followed by Bihar (1,221) and Kerala (1,547).

Table 1: States with highest number of violators

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

According to National Green Tribunal's findings, nine government hospitals in Delhi have violated the BMW disposal rules and caused possible health and environmental hazards. According to official figures, around 70 tonnes of BMW is generated per day in the city, and an unofficial source puts it even higher at around 100 tonnes per day. However, nearly 50% of this goes untreated or left to be lifted along with normal municipal 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 clandestinely 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 the treatment of BMW, the Government of NCT of Delhi (GNCTD), has allowed a centralized treatment facility to make available this facility through India Waste Energy Development Limited (IWEDL) at four hospitals. Currently IWEDL is operating at only one hospital as an interim arrangement and the government is planning to build a centralized facility. For smaller nursing homes, clinics, Blood banks and Diagnostic laboratories that cannot make their own arrangements due to high cost, the Government is taking initiatives to establish centralized waste treatment facilities. The GNCTD has already purchased land from Delhi Development Authority for establishment of Centralised Biomedical waste treatment facilities. There are 26 hospitals under Government of Delhi, of which six have incinerators and 9 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 a year in hospitals with 100 or more beds,
- Analysis of air and effluent quality,

- Training of health care professionals and
- Efforts to ensure proper storage, treatment and disposal of BMW

In spite of these efforts, there still exist some lacunae in management of BMW. These are unsatisfactory segregation of waste in hospitals., failure to follow color-code, failure to isolate BMW from other waste, non-maintenance of proper hygiene, failure to provide proper equipment and accessories to staff, 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.

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

An article published by The Times News Network, dated Aug 22, 2013, highlights the Goa state pollution control board finding about Aldona PHC's unscientific BMW disposal and the Board's direction 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) were 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. As per an order of the Principle Bench of National Green Tribunal (NGT), 33 hospitals in New Delhi were inspected and 17 hospitals were found to be violating the Bio-Medical Waste (Management and Handling) Rules 1998 which the hospitals attributed to financial crunch. Maharashtra state topped the list with 640 show cause notices, Rajasthan, is in second place with 556 HCFs, while in Uttar Pradesh, Delhi and Karnataka respectively 382, 380 and 374 HCFs were served show cause notices.

An article by The Times Network, dated 7, August 2013 highlights the issue of noncompliance of the norms of Orissa State Pollution Control Boards (OSPCB) by the hospitals in Bhubaneswar. The private hospitals dump their BMW at the common BMW treatment disposal centre at Tangiapada, Khurdha while the government hospitals seldom do so. According to OSPCB, government hospitals are callous and seldom follow the BMW treatment disposal rules. As per the OSPCB record, till December 2011, hospitals in the twin cities of Cuttack and Bhubaneswar, as also cities of Choudwar, Khurdha and Jatni were disposing waste at the rate of 1,282 kg/day while in the entire state (including all private and government hospitals), the quantity disposed was 5,514 kg/day. Clandestine dumping hospital waste near the municipal garbage dumping yard by the workers was also detected.

State legislature's public accounts committee (PAC) has pointed out the unscientific disposal of BMW rampant in Mumbai and how it could pose serious threats to citizens' health. The PAC also sounded an alarm over rising urban pollution levels; the other worrying points it raised was that several

hospitals and clinics in the city do not segregate BMW as also how the callous way of dumping waste has indeed caused a spurt in diseases such as malaria and even cancer. “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. The rise in critical illnesses like cancer is worrisome,” the report stated (Source: Hindustan Times, 10, August 2013)

With respect to Karnataka state, MOEF figures for 2011, puts Karnataka as the highest BMW generator at 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 a sizeable portion of this waste (18,270 kg/day) does not get disposed of scientifically, and probably gets mixed with other municipal waste. The MOEF indicate a total of 4,05,702 kg of BMW is generated every day in the country as a whole, 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 (refer Table 2)

Table 2: Top Five Bio-Medical Waste Generating States

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

A study by Madhu Narendra et al. on ‘Assessment of Biomedical waste of various hospitals in Mysore city Karnataka, India’ highlighted the issue of lack of knowledge and awareness regarding legislations on bio-medical waste management even among qualified hospital personnel.

Bio-medical waste – Definition

Hospital waste includes both infectious (biological) and non 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 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 (Source: http://www.ehow.com/about_5452204_biomedical-waste-definition.html). Another definition of BMW is “any solid and/or liquid waste including its container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research pertaining thereto, or in the production or testing thereof.”

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. All these sectors are included in the Bio-medical Waste – Handling and Management Rules, 2000, except households. Medical waste from households constitutes up to 0.5 per cent of the total waste generated. Hospital 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 as going 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. Table 3 below indicates the quantity of waste generated in different countries.

Table 3: Quantity of BMW generated in different countries

Country	Quantity of waste generated (kg/bed/day)
UK	2.5
USA	4.5
France	2.5
Spain	3.0
India	1.5

Source: http://www.jomfp.in/article.asp?issn=0973-029X;year=2007;volume=11;issue=1;spage=5;page=9;aulast=Hegde

Hospital Waste Classification

Hospital wastes can be classified primarily into 3 groups

(i) *Municipal Solid Wastes* - General waste similar to the domestic waste and includes paper, cans, diapers, plastic cups, food, and artificial linens etc. This waste remains non-infectious if managed properly and not brought in contact with the infectious wastes.

(ii) *Hazardous Solid Wastes* - includes laboratories and pharmaceutical chemicals and containers including discarded medicines, disinfectants, alcohols, anti-neoplastic agents, heavy metals like mercury etc.

(iii) *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, ampulated body parts, placenta, isolation waste i.e. the refuse associated with infectious patient's etc. fall under this category.

Further, the BMW is grouped into 10 categories for proper handling/treating and thereby making it non-hazardous to people and environment. BMW need to be managed by destruction, disinfection and ultimate disposal.

Table 4: Categories of waste

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 (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents, wastes from production of biological, toxins, dishes and devices used for transfer of cultures)
Category 4	Disinfectants (chemical treatment @/autoclaving/micro waving and mutilation shredding #	Waste Sharps (needles, syringes, scalpels blades, glass 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 generated 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 generated 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

@ Chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection.

Mutilation/shredding must be such so as 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

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. 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 millions with Hepatitis B, 2-45 millions with Hepatitis C, 75000 to 150000 from HIV/AIDS (WHO and Health Care Waste Management Cell, 2000). Armstrong E Sarah in his study highlights that the incidence of needle stick injuries is between 7.5 to 16 per 100 employees and 4.27 to 12.4 per 100 registered nurses, and also mentions that the figures quoted are underestimated as many incidents go unreported.

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 efforts and be supplemented by mechanisms to see that environmental safeguards proposed are actually 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. 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 in the implementation of a safe waste management system and culture in health care establishments through a stage-wise scheme, making it a feasible task. A nodal person identified would serve as a key to implement the overall plan and also 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 suggests that a waste survey 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. Also 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

i. Segregation - The segregation of waste at source initially reduces the waste management problem to 15% and is performed within the premises of the hospital/nursing home. Segregation is done accordingly to colour coded bags (refer Table 5) 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 the community at large, recycle and reuse of non-infectious waste. Though the hospital waste generated is about 2kg/bed/day, only 0.25 to 0.3kg/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.

Table 5: Segregation of BMW

Colour 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

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

ii. Disinfection and Destruction

Infectious wastes are to be disinfected before final disposal as it contains pathological micro organisms causing diseases. Wastes are unloaded at the place of treatment and separated according to colour codes, properly treated and then disposed. In accordance with the MOEF rules, categories1, 2, 3 and 6 shall be loaded directly into the incinerators, where as categories 4 and 7 shall be loaded into autoclave for disinfection. The residue obtained from these units is disposed of into a land fill.

iii. 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 of into a secured landfill facility.

Treatment Technologies

There are several treatment technologies used (refer Table 6) to process BMW. Bioremediation is a simple and the affordable technology used in India. The technique does not require huge capital, maintenance cost and trained personnel. Though the technology is patented in India through National

Research Development Council of India, was not found in the Government notification 1998 regarding hospital waste disposal, presumably due to a writ petition is pending before the Uttar Pradesh high court (Gupta RC, 2001). In India incinerators are used in combination with Autoclave for optimum results.

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 separate water from toxic substances and chemicals and remove high amount of organics, dirt, debris, polymers, etc. ETP uses evaporation, drying methods and other techniques like centrifuging, filtration, incineration etc for chemical processing.

Table 6: Technologies in HWM

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 sites. (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 include pollution due to plastic waste-burning 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 similar to 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 cause 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	It is a very 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.

Source: http://sourcing.indiamart.com/medical/pharmaceutical-machinery/pharmaceutical-processing-machines/etp-plant/.

Bangalore Scenario

Bangalore, also known variously as the Garden city or Silicon Valley of India, is situated on the Deccan Plateau in Southern India. Bangalore, the capital city of Karnataka, is India's sixth most populous city and fifth most populous urban agglomeration. Due to its elevation, the year round temperatures remain significantly lower than in the surrounding plains. Bangalore's strategic location as well as congenial climate attracts people from all over the country. Bangalore's urbanization process has been alarmingly fast 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 Bangalore.

Bangalore's Mounting Hospital Waste

Bangalore is one of the top medical tourism destinations in India, 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 people from developed as well as developing countries (http://www.chillibreeze.com/whitepapers/medicaltourism1.asp). Medical tourism is slated to become a 2.3 billion dollar industry soon, next only to IT and BPO (The Times of India, Medical tourism, 28 Feb 2007). The cost of surgeries is one-third the cost charged in developed countries like the US and UK. Flying in from 30 different countries, 'medical tourists' account for 10 per cent of patients in the top hospitals. Apparently, Government of Karnataka has been taking a slew of initiatives to promoting medical tourism in the state, particularly in Bangalore city. With the expansion of medical tourism in conjunction with the IT boom, the city has been struggling to provide improved infrastructure and cope with its massive development. One such supportive infrastructure that needs thoroughness in management is hospital waste management. Although several initiatives have been undertaken to manage hospital waste in the city, there still exist missing links that have serious implications for both human health and urban ecology of Bangalore.

Several studies have attempted to understand the volume of BMW generated in Bangalore, and their estimates vary widely. The Study by Pruthvish etal (1997) estimated the quantum of waste generated in Bangalore at 1,32,500 kg/day and put the quantum of health care waste in that at 5,100 kg/day (Gaur, 1995). 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 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 Ward No. 128, Nagarbhavi, Bangalore covering an area of 1.6 sq kms. There are 11 localities in the ward[4]. The total population in the Ward is 20,269 (Male 10408 and Female 9861).

[4] Chalukya Nagar, Hoysala Nagar, Nagarabhavi, Manasa Nagar, Madhura Nagar, Anand Jyothi Nagar, BDA Layout, Chandra Layout, Ahamad Nagar (P), Teachers colony, Gangodanahalli

Table 7: Details of Ward 128

Population	20269
Male	10408
Female	9861
Area (sq. kms)	1.6
Assembly Constituency	Govindrajnagar
Number of localities	11
No. of Hospitals	03
No. of Clinics	24

Source: http://bbmpelections.in/wards/128

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 was obtained 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 September 2011 - October 2011. Initially, the study was designed to make a comparison across wards. However, no data was available on the total number of hospitals and clinics in Bangalore as the lists we received from BBMP and the formal recyclers were at variance. Hence the study was limited to one ward covering all the medical institutions within it. The study was focused on ward No: 128, Nagarabhavi and covered all hospitals and clinics in this ward. A questionnaire was designed covering various aspects on segregation, collection and disposal, and associated problems encountered in waste management. Although the study did not cover all zones in Bangalore, it was still able to capture some important issues that largely reflected the situation in other zones as well.

Formal Recyclers

Initially there were few big hospitals that treated their own waste by installing incinerators. Many small hospitals also installed incinerators, but the incinerators could not come up to the required standards. Lately, the KSPCB made it mandatory for all medical waste generators to outsource waste disposal to formal recyclers. At present, Bangalore's BMW is processed by two entrepreneurs, MARIDI Eco Industries and RAMKY Industries. Both these Industries came to existence in 2001. Maridi Eco-industries covers areas in Southern Bangalore from Hoskote in the East to Kanakapura to Attibele on Hosur Road in the south. They have extended their services to Ramanagar and Mandya as well. Maridi Eco-industries have a plant operating in Tamilnadu, and is planning to start plant at Chikkamagaluru in Karnataka. Ramky Industries covers the Northern part of Bangalore, i.e. Doddaballapur to Kengeri and Banaswadi to Tumkur. Ramky Industries' treatment plant is situated at Dabbaspet, 45 kms north of Bangalore. Besides these, Health Care Waste Management Cell (HCWMC) is working towards ensuring safe management of BMW by increasing awareness on waste management 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 endeavors to persuade and motivate the hospitals on the need for safe waste management 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.

Table 8: Health Care Centers Covered by Ramky and Maridi[5]

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
Alternative Medicines and Health Clubs – G***	15	10
Research, Rehabilitation and Fertility Centres – 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 Centres, Medical Centres, Health Care, Rehabilitation institutes, Society, Research Centres, Companies, Unnamed

The quantity of wasted collected per day is around 5000 kgs/day by Ramky while 3500-4000 kg/day is collected 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 per month and for diagnostic centers it is Rs.800/month. It follows Federal and State guidelines in the management of medical and biohazardous waste and charges affordable prices. The other salient 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, affordability and reliability.

Ramky's work force consists of 50 employees and has 9 specially designed vehicles for the waste collection. Collection and transportation begin at 4.30 am and ends at 10.00 am. 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, twice a week from the clinics and once a week from the clinics that have own autoclaves. About 15 medical stores together form the drug dealers association of the ward. Date-expired medicines are collected once in a month from individual drug dealers. Besides, there are

[5] Ramky and Maridi's services outside Bangalore are 27

some distributors also who hand over 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 are noted.

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

The disposal operations are carried out using incineration and sterilization as the two main methods. The facilities provided are (i) Biomedical Incinerator (ii) Autoclave (iii) Scrubbers for Stack Emission Control (iv) Shredding facility (v) Secured landfill facility and (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 and the other is used as a standby.

Both the firms 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 amendments thereto as enunciated by the MoEF, Government of India.

Maridi has plans to extend its services to households and apartment complexes where they could dispose of medical waste generated by households. 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

Twenty seven sources were identified as BMW generators in ward 128 (refer Table 9). Out of these, there were six Ayurvedic and Homeopathy clinics which generally do not generate infectious waste.

Table 9: BMW generation Sources

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

Source: BBMP

(1) Clinics

Among the 24 clinics in ward 128, 6 are following colour coding, 12 clinics do not maintain coloured bins and the remaining 6 are Ayurvedic and Homoepathic clinics which do not generate hazardous waste. All the 6 clinics that are following colour coding have red bins, while 3 among them have blue and black bins, and the remaining 4 have yellow and white bins. In brief, there is no consistency in following the guidelines. Doctors at the clinics complained that lack of space made it difficult to for them to accommodate so many types of bins and follow the colour coding.

Only 11 clinics out of the 18 are found separating sharps and needles. The recyclers have instructed the doctors not to break the syringes and needles and have provided the container with solution to put them into it. Yet, used syringes and needles were found piled up in a certain clinic since 3 years. There is communication gap between the recycler and the clinics. The doctor manning the clinic stated that she had contacted Ramky, but had not heard from them.

The collected waste was being disposed daily in only three clinics, twice a week in 6 clinics, and once a week in 9 clinics. Among the 18 clinics, 11 clinics were giving waste to formal recyclers (8 clinics to Ramky, 3 to Maridi), and remaining 7 clinics were disposing it at municipal bins after sterilization. These 7 clinics stated 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 cleared by the BBMP people daily. The clinics that were not giving the waste to recyclers stated that the recyclers must be made accountable for their services in terms of regularity; notably, they had also experienced difficulties in contacting them to register their own clinics. They were comfortable with treating the infectious waste through autoclave and then dispose of it into the municipal bin. The needles are broken using needle breaker. Of the 18 clinics, only 3 reported as having faced problems before disposing of the waste due to foul smell caused by delayed disposal while the rest had not faced any such problems.

Eleven clinics reported as having taken precautions while managing waste by using gloves while the rest did not take any precaution. Masks were used only in 9 clinics. In regard to sterilization of waste before disposal, 2 clinics were following it and remaining 15 were not. The doctors and the staff are under instruction to break the needles before putting into the bins. As an alternative, Maridi has provided a puncture proof container with liquid which contains water +1% hypochlorite solution at the rate of 5 lts per clinic. Few hospitals are also using such cans and they give it Mardi as and when these cans gets filled. These needles are disinfected and autoclaved and finally disposed of in the land fill along with the ash from incinerator at Mavallipura, Dabaspet.

(2) Hospitals

All the 3 hospitals in Ward 128 were covered under the survey. These hospitals follow colour coding and have placed all the 5 coloured bins fixed with biohazard symbols. Only one hospital is found to have assigned a person to monitor the waste, and he has had training in waste segregation and management procedures. Also, all other staff were involved in taking responsibility in segregation of waste in the above hospital notably, Doctors, Nurses, Ward boys and Ayahs were segregating the waste at source in one of the hospitals and not in the other two. Gloves were being used by those who segregate the waste in all the three hospitals, but masks were used only in two hospitals Infection control injections

prescribed as a precautionary measure for the staff were taken by staff only in 1 hospital. Syringes and needles were being treated by breaking them in one hospital while hypochlorite solution treatment was done before disposal in the other two. The waste gets stored for only 1 day in all the three hospitals; while 2 of them store it in a separate room the others store it in the back yard. All the three hospitals give waste for disposal in municipal bins (for non-infectious waste) as well as to recyclers (for infectious waste). Ramky collects waste from 2 hospitals and Maridi from 1 hospital. One hospital uses chemical disinfectant to treat the liquid before discharging it into sewage, while another uses its own small treatment facility for the purpose. The third hospital did not respond to our query about the disposal of its liquid waste.

Key Issues

Lack of data

It is a matter of serious concern that BBMP or other concerned authorities have not compiled a comprehensive list of health care institutions in Bangalore. . For instance, the data collected from BBMP Head office indicated the number of medical institutions as 2436, while the data collected from BBMP office of Malleshwaram indicated it as 1599. According to a news paper article published in Vijaya Karnataka on 14th September 2011, the number of hospitals, nursing homes and diagnostic centres, as obtained from the Revenue department of BBMP, is 390. In contrast, the data collected from Ramky and Maridi indicate it is 2330. However, it is a positive sign that after the introduction of the Health Care (Management and Handling) Rules 1998, the number of institutions that are enrolled has gone up, but a complete list is yet unavailable. As there was no data forthcoming from concerned authorities on the number of clinics and hospitals in the ward, the data for the study had to be collected personally.

Mixing of BMW with the municipal garbage

Another alarming factor is that only one-third of the waste i.e. 14 tonnes out of the total medical waste of 40 tonnes generated in Bangalore city 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 installed capacity.

Non-registration with the recycling units

As per the rules, every unregistered clinic should get registered with formal recyclers and get a certificate from them and also obtain a registration number from the KSPCB. However, several clinics and small hospitals have yet to register themselves with the recycling units. In 2012 May, BBMP issued a final notice urging the unlicensed health units to obtain trade licenses. BBMP had issued notice thrice in the recent past – December 2010, February 2011 and June 2011. In spite of this, of the 2648 health units surveyed by BBMP only 937 were unregistered as of March 2012 (Citizen Matters, 2012).

This could be due to the charges they have to pay to the recyclers or lack awareness and access to the formal recyclers. Discussions with few doctors revealed that charges were unaffordable as the numbers of patients treated were limited per day 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 argue that they pay the prescribed professional tax and therefore it is not fair to burden either doctors or patients. The recyclers on the other hand stress that the cost of treatment was high and it would not be feasible to reduce the charges. As charges are fixed for 3 years as per the agreement between hospitals and the firm, reducing their fee is beyond question particularly when expenditure is increasing exponentially, the firms argue. Diesel being the prime requirement for waste management including transportation and treatment at the plant site, the periodic increase in its price makes the whole process uneconomical for the recycling firms. Renewal of agreement is done every year but convincing hospitals on the increase in price is a difficult task, they argue.

However, all the Doctors were unanimous that HWM rules must be made mandatory and must be implemented strictly, and that every waste generator should give the waste to the authorized recycler without fail. Biomedical waste being highly infectious, irrespective of the quantum of waste, its scientific disposal should get the highest priority, the doctors stressed. They were equally perturbed that presently all sources of waste generations were not utilizing the services of recycling firms and that the hospital waste was being dumped along with the general garbage.

Illegal dumping of bio-medical waste

Instances of illegal dumping in Bangalore have drawn the attention in the media several times. For instance a sizeable quantity of hospital waste was found dumped near Avalahalli, off Kanakapura road sometime back. The Environment Support Group brought this issue to the fore and the local residents complained that dumping of hospital waste in the vicinity was a common feature (Citizen Matters, 2008). Another spot where hospital waste gets dumped clandestinely is Mavallipura and KSPCB had received several complaints in this regard. It is necessary to take immediate action against such illegal acts by health care establishments and they should be made to follow healthy waste disposal practices through punitive methods if necessary.

Irregularity in waste collection

Amongst the institutions that had registered with the recycling units, few clinics were disposing the waste twice a week or once a week, as per the schedule of collection trips of the recyclers, which is an unacceptable practice. Regular collection on a daily basis is considered inescapable because of the infectious nature of medical waste. It is observed that irregular and scanty collection of medical waste had invariably led to the spread of infectious diseases in several parts of Bangalore. It is therefore clear that the failure of eco-industries to collect waste regularly from health care units is certain to result in spread of infectious diseases. Also, dental clinics need particular attention as the waste generated oral health care is particularly infectious. So it is necessary to collect the waste daily form these clinics too.

Lack of awareness

Lack of awareness among various sections of the staff is also a matter of concern. Unless 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. Our queries on awareness and practices about health care waste management among hospital staff in a medical college hospital in Bangalore revealed that doctors and nurses had better awareness and aptitude in this regard, and also practiced HWM better than other housekeeping and technical staff (Madhukumar and Ramesh, 2012).

It is heartening to note that the Armed Forces Medical College (AFMC) and Medical Training Centre (MTC) Bangalore has already taken steps to include hospital waste management as a subject in the post-graduate syllabus for paramedics. 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 are under way 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 plans to have five to seven members trained in safe management of hospital waste (The Hindu 2009, Nov 22).

Lack of sufficient space

Another practical problem has been the space constraint. As the clinics are usually accommodated in small spaces, doctors may find it difficult to place the bins according to the colour codes; they would rather have two bins, one each for infectious and non-infectious wastes.

Mixing of infectious liquid waste with the common sewage

Infectious liquid waste is often released into the common sewage pipes without any treatment. Much like the contamination possible from hospital waste getting mixed with municipal waste, mixing of untreated liquid waste with common sewage can cause contamination of ground water sources like wells, tanks and even bore-wells and adversely affect all life forms

Currently, the infectious waste generated in the pet clinics and animal houses is seldom treated or handed over to the recycling units but dumped in the municipal dustbins or open spaces. These obnoxious needs to be stopped in order to prevent water and air pollution and 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 the part of healthcare providers, institutional and city level policies, provision of occupational safety and personal protective devices, information dissemination and practical advocacy endeavors. There is a dire need for evolving policy and protocols by health care institutions and concerned government agencies to manage recyclables. To begin with, it would be useful to have a proper inventory of medical institutions. The government should delegate the responsibility to the health offices or BBMP ward offices to accept the registration of health care establishments, as also to collect details about the hospitals and waste generated therein as a secondary activity. Arrangements should be made to make available details of all health care establishments in the BBMP Head office. Compulsory registration of hospitals and other health care

institutions and keeping a tab on them will go a long way in ensuring safe disposal of biomedical waste. The area health inspector must be made responsible for monitoring the documentation. Systematized training programmes should be conducted on a periodic basis for all the representatives of medical institutions, and authorities of BBMP should be involved in the training programmes. Awareness training camps should be conducted in all the BBMP wards with compulsory participation of the staff. Awareness creation regarding disposal of biomedical waste should be made part of the curriculum of all medical related schools. A media campaign is also necessary to create awareness and urgency of safe disposal of biomedical waste. Besides systematization of hospital solid waste management, installation of treatment plant must be made a precondition for obtaining permission/operating license for health care institutions, and punitive laws should be used to make obstinate institutions to fall in line. For HWM to be a successful initiative it should be taken as social responsibility and everybody's participation/involvement ensured.

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Annex 1: List of Health Centers in Bangalore

Sl No.	Zone	Ward	H #	Clinic & day clinic- A	Dental - B	Blood bank -C	Laboratories - D	Diagnostic centre -E	Veternery - F	G*
1	MOH C.V.R. Nagar			50	15	2	1	6	1	4
2	Gandhinagar West zone			40		1	2	3		2
3	West	102	1	12						
4	West	74	3	15				1		
5	West	43	2	12	2					
6	West	67	6	21	5			3		1
7	West	44	3	6	1					
8	West	75	4	20	5					
9	West	68	3	18	14			1		
10	West	35		7	4		1	1		
11	West	36		2			2	1		
12	West	45		5	6		2	3		
13	West	64		18	1					
14	West	65		12	2		2	2		
15	West	66		1	2		1	1		
16	West	76		5	4					
17	White field	82	1	2						
18	White field	85	1	6	1					
19	Marathhalli	86	3	10	1					
20	Bairath kotanur road	54	2							
21	Kaggadasapura Main Rd	81	1	2	1		1			
22	A.S. Palya	87	1	1	1					
23	Udaya nagara	56					1			
24	East			24	2		1	4		1

Contd…

25	East	89	2							1
26	East	115	2	1						2
27	East	116	1	11	1			2		1
28	East	117	9	4	3		1	1		3
29	East Sarvagnanagar		10	18	3		2	13		2
30	MOH Hebbal (north)			51	6	3		7		3
31		99	9	9	2			2		4
32		100	2	8	2			2		1
33		101	2	34						
34		107	1	22	4	1		3		1
35		97	1	6				3		1
36		98	3	8	3			1		
37		108	5	8	2					2
38	MOH Shivajinagar range			73	19			9		28
39	Chamarajpet & JJR nagar	135	11	9						
40	Chamarajpet & JJR nagar	137	11	10						
41	Chamarajpet & JJR nagar	140	7				1			
42	Chamarajpet & JJR nagar	136	1		1					
43	Chamarajpet & JJR nagar	141	1	2	1			1		
44	Chamarajpet & JJR nagar	139		5						
45	South			322	60	1	13	43	72	25
46	RR Nagar Zone		33	50	22		3	11		
	Total		**142**	**940**	**196**	**8**	**34**	**124**	**73**	**82**
***** Fitness center, unani dispensary, ayurvedic dispensory, homeopathi clinic, health club, animal houses, veternery clinics										
# Hospitals, Nursing homes, Super speciality hospital, Multispeciality hospital										

Source: Compiled from data obtained from BBMP, JC West Office, Malleshwaram

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