CHAPTER 3

BIO-MEDICAL WASTE GENERATION AND MANAGEMENT IN VARIOUS HOSPITALS AND OTHER MUNICIPALITIES

3.1   INTRODUCTION

Bio-Medical Waste (BMW) is defined as discarded waste produced during the process of diagnosis, treatment, and immunization of humans and animals. The Government of India specifies that Bio-Medical Waste (BMW) management is part of hospital hygiene and maintenance activities. BMWs are normally regulated and managed according to various standards and protocols in different countries. In healthcare facilities, toxic wastes are generated because ofimproper management, which has a direct impact on the health of the healthcare workers, the society, and the environment. The implementation of biowaste regulations is insufficient in many hospitals and healthcare institutions, which is a major problem in BMW management. Most hospitals and healthcare institutions disposeof thebiowastes in an improper and indiscriminate manner.

The hospital wastes are mixed with general wastes, making the whole course of wastes ahazardous stream. Waste segregation in an improper manner results in an unscientific method of waste disposal. Unprofessional management of BMW causes unpleasant smell, environmental pollution, and growth and multiplication of vectors.It increases the transmission of diseases like hepatitis, typhoid, cholera and AIDS through injuries from syringes. Infected and contaminated areas brimming with hospital wastes like body parts, bandages, and plasters should be properly managed and the wastes

disposed of in a safe manner. The proper disposal of BMW prevents nosocomial (infections acquired through hospitals and healthcare facilities) or hospital-acquired infections.

The main objective of this work is to explore the available scientific data regarding BMWs in terms of their environmental impact. An important issue inenvironmental protection is the planning for the collection, transportation, processing, and disposal of hazardous and non-hazardous BMWs.

3.2 CATEGORIES OF BMW

The categories of BMW are listed as follows:

Table 3.1 Categories of BMW

Category	Type of Wastes	Treatment and Disposal
1	Human anatomical waste (human tissues, body parts, and organs)	Incineration/ Deep burial
2	Animal waste (tissues, body parts, organs, bleeding parts, fluid, blood, waste generated by veterinary hospitals and colleges, discharge from hospitals and experimental animals used in research)	Incineration/ Deep burial
3	Microbiology and biotechnology waste (stocks, specimens of micro-organisms live, human and animal cell culture used in research, infectious agents from research, waste from biological, toxins, dishes and devices used for transfer of cultures)	Local autoclaving/Micro-waving/Incineration
4	Waste sharps (needles, syringes, blades, glass and scalpels)	Disinfection/ Micro-waving and Mutilation/Shredding

Table 3.1 (Continued)

Category	Type of Wastes	Treatment and Disposal
5	Discarded medicines and Cytotoxic drugs (wastes comprising outdated, contaminated, and discarded medicines)	Incineration/Destruction
6	Solid waste (items contaminated with blood and body fluids and other materials contaminated with blood)	Incineration autoclaving/ Micro-waving
7	Solid waste (wastes generated from disposable items such as tubings, catheters and intravenous sets)	Autoclaving/Micro-waving and Mutilation
8	Liquid waste (waste generated from washing, laboratory, cleaning and house-keeping)	Chemical treatment
9	Incineration ash (ash from incineration of BMW)	Disposal in municipal landfills
10	Chemical waste (chemicals used in the production of biological)	Chemical treatment

Table 3.2 Color Coding for the Disposal of BMW

| Color coding	Types of Containers	Waste Category	Treatment Options Based on the Category
Yellow	Plastic bag	1, 2, 3 and 6	Incineration/Deep burial
Red	Disinfected container/plastic bag	3,6 and 7	Autoclaving/Mircro-waving/Chemical treatment
Blue/White translucent	Plastic bag/puncture-proof container	4 and 7	Autoclaving/Micro-waving/Chemical treatment and destruction/Shredding
Black	Plastic bag	5, 9 and 10 (solid)	Disposal in secured landfills

3.3   HOSPITAL WASTES

Hospitals are multifarious organizations providing healthcare to people from every walk of life without any discrimination based on age, gender, race and religion. They generate large amounts of wastes with increasing quantity and diversity due to advances in science and technology. The wastes are toxic, and are dangerous to both the patients and the personnel handling them. They pose a serious threat to public health and the environment. The following procedures are carried out in hospitals for collecting and examining the BMWs:

- Extensive discussions are conducted with the staff of each ward, laboratory, and department about the nature of assessment.

- The purpose of waste generation is determined for data collection.

- For waste management, infectious and non-infectious solid wastesboth inside and outside the incinerator room are monitored.

- Moreover, the infectious and non-infectious solid wastes are measured and recorded with the help of the staff. The recordings are doneevery day for both infectious and non-infectious wastes for a period of 12 months.
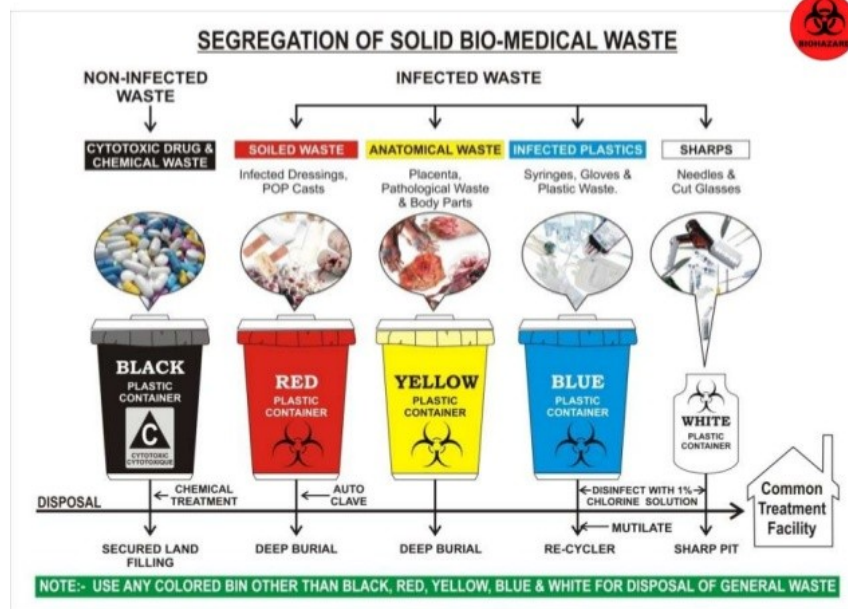
(Source: Ministry of Environment and Forests – Google Image)

Figure 3.1 Color Coding for BMW Categories

Role of Municipality

The municipal body of an area transports the segregated non-biomedical waste generated in hospitals, nursing homes, and medical institutes. Furthermore, it treats the BMW for disposal at municipal dumpsites.

3.4   BMW MANAGEMENT PROCESS

The BMW management process includes the following stages:

- Handling
- Segregation
- Mutilation
- Disinfection
- Storage
- Transportation
- Final disposal

3.4.1   Issues in BMW Management

A major issue exists in the BMW management practices followed in many Indian hospitals. In some hospitals, the disposal of wastes is carried out in a haphazard, improper and indiscriminate manner. Lack of segregation practices results in the mixing of hospital wastes with general wastes, turning the whole stream ofwastesintoa hazardousmess. Moreover, inappropriate segregation results in incorrect method of waste disposal. A bag that is not securely tied results in the scattering of BMW in and around the hospital and the spread of communicable diseases like plague and rabies. Most importantly, there is no mechanism to ensure that all the wastes collected and segregated reach their final destination without any mishaps. Moreover, there is no mechanism to ensure that the waste treatment is done within the prescribed time limits. If the BMWs are not handled properly within the stipulated time, it will result in infections which could sometimes prove fatal.
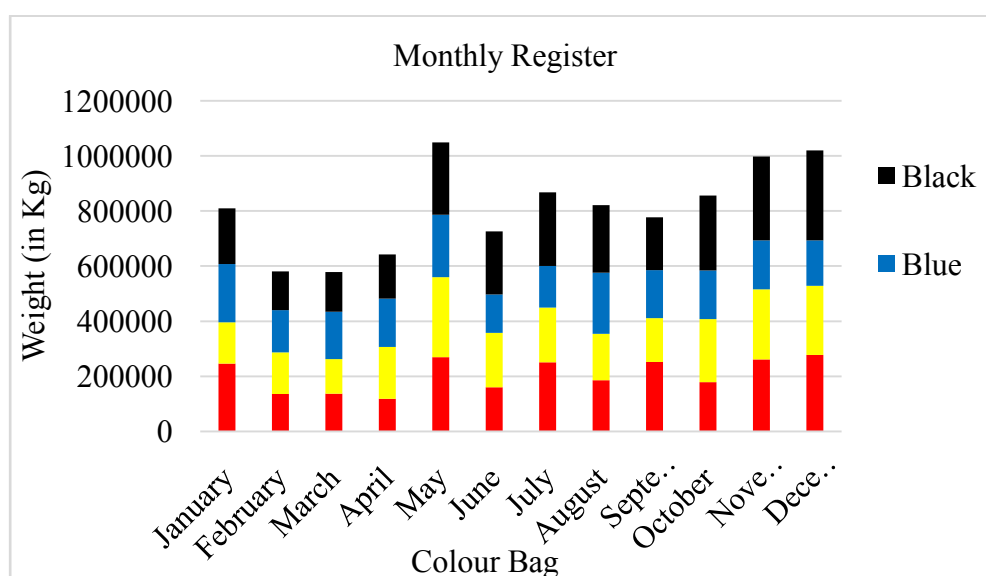
3.5   A MULTISPECIALTY HOSPITAL IN MADURAI

A hospital with a total of 3879 beds, under the Corporation ofMadurai, is considered here. Andrology,urology, cardiology, cardiothoracicsurgery, vascular surgery, dermatology, venereology, dental and maxillofacial surgery, neurology, diabetology, E.N.T, general medicine, opthamology, orthopedics, traumatology, medical oncology, nephrology, obstetrics and gynecology, paediatriconcology, paediatrics and neonatology, plastic surgery, radiation oncology, reproductive medicine, surgical gastroenterology, and surgical oncology are the specialties provided by the hospital. The BMW is collected from the following wards inthe hospital:Paediatrics, Gynacology, Casuality, ortho, ortho POW, IRCU, POW I & II. IMCU I & II, RICU, Nephrology, Dialysis, Medicine, Cath lab, SOT, MOT, urology, Surgery, 5th SPL, Neuro Surgery, Eye Ward, CTS, OT, ICU, RT Ward, Blood Bank, Cardiology, and so on.

Table 3.3 Study Report from a Multispecialty Hospital in Madurai Zone

3879-Bed Hospital In Madurai				
Monthly Register				
Month	**Red (Kg)**	**Yellow (Kg)**	**Blue (Kg)**	**Black (Kg)**
January	246510.45	149108.76	211758.489	202018.32
February	135765	151187.90	152956.72	141195.6
March	137083.86	125058.96	171956.07	144659.54
April	118697.4	188519.4	174555	160590.6
May	269357.76	291002.58	2260868.12	262142.82
June	160590.6	196665.3	139644	229248.9
July	250961.4	199163.55	150078.9	267985.85
August	186146.8	168182.58	222162.03	245348.47
September	252449.9	158258.1	174661.74	191525.17
October	179424.2	228224.72	176784.99	271720.27
November	261581.9	254609.85	177030.27	304969.95
December	278144.5	250415.55	164796.79	326846.48
Total	**2476713.77**	**2360397**	**2142453.119**	**2748251.97**

Figure 3.2 Study Report from aMultispeciality Hospital in Madurai Zone

Table 3.4 Analysis Report on Waste DisposalPer Bed Per Dayin Colored Bags from a Multispeciality Hospital in Madurai Zone

Month	Per Bed Per Day			Black (Kg)
	Red (Kg)	Yellow (Kg)	Blue (Kg)	Black (Kg)
January	2.05	1.24	1.761	1.68
February	1.25	1.392	1.272	1.30
March	1.14	1.04	1.43	1.203
April	1.02	1.62	1.50	1.38
May	2.24	2.42	1.88	2.18
June	1.38	1.33	1.20	1.97
July	2.08	1.69	1.24	2.22
August	1.54	1.42	1.84	2.04
September	2.16	1.38	1.5	1.64
October	1.49	1.93	1.47	2.25
November	2.24	2.23	1.52	2.62
December	2.31	2.08	1.37	2.71
Average total	**1.741**	**1.64**	**1.49**	**1.93**
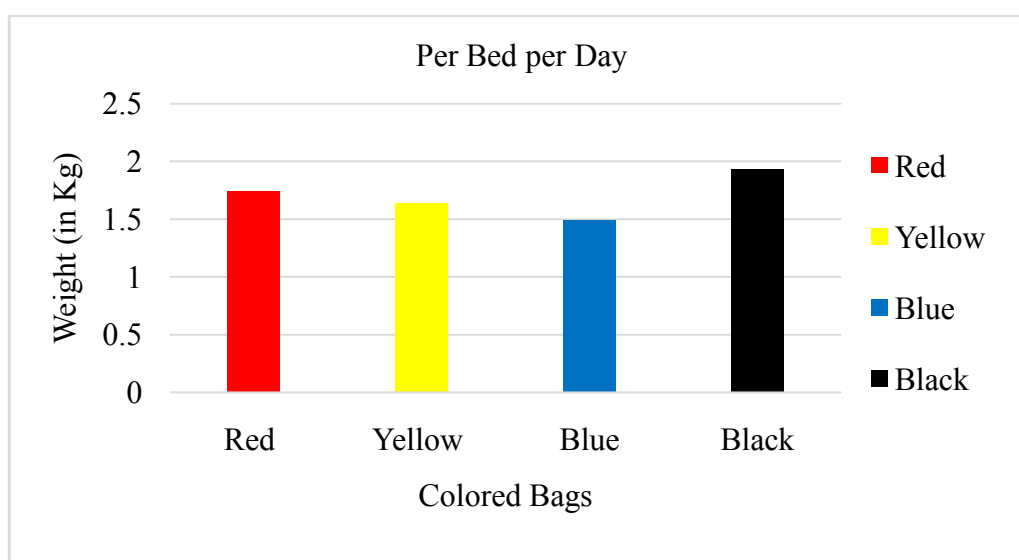
Figure 3.3   Analysis Report on Waste DisposalPer Bed Per Dayin Colored Bags from a Multispeciality Hospital in Madurai Zone

Table 3.4 Status of Bio-Medical Waste Management in the country for last three years

State	Bio-Medical Waste Generation and Disposal (Kg/day)						No. of Health Care Facilities Violated BMW Rules		
	2007-08		2008-09		2009-10		2007-08	2008-09	2009-10
	BMW Generation	BMW Disposal	BMW Generation	BMW Disposal	BMW Generation	BMW Disposal			
Andaman & Nicobar	518.41	518.41	963.67	963.67	404	407	-	Nil	-
Andhra Pradesh	13000	12100	14200	13000	14500	13018	567	343	173
Arunachal Pradesh	-	-	1368.54	1368.54	60	60	-	-	-
Assam	3673.9	1019.2	5130	1129	4595	2599	54	-	208
Bihar	3280	2336	3384	2403	3572	3095	1327	1247	1221
Chandigarh	1640	1640	1029	1029	1201	1201	-	384	32
Chhattisgarh	2608.87	2608.87	4386.87	4386.87	5852	5701	57	27	20
Daman,Diu, Dara and Nagar Haveli	-	90	9700	4000	65	65	Nil	Nil	0
Delhi	8879.5	8879.5	8522.93	8522.93	9859	9859	527	64	165
Goa	1074.11	1074.11	1179.55	1179.55	2438	2438	0	1	1
Gujarat	25747	10000	25765	15000	16565	16565	552	274	224
Haryana	6110.38	6041.38	6067	5994	7069	6868	88	201	143
Himachal Pradesh	922	922	1128	1128	1278	1278	20	38	15
Jharkhand	10733.5	6189.8	28975.26	11724.12	5451	4763	256	202	192
J & K	1281	436	6646.5	NA	4827	2634	229	778	332
Karnataka	40796	29163	60018	42464	62241	43971	1293	2292	344
Kerala	165444	52726	55425	47806	32884	29438	-	932	1547
Lakshadweep	-	-	-	-	40	40	-	-	-
Madhya Pradesh	4682.214	4449.034	4072.8	3654.9	65231	4713	738	409	510
Maharashtra	31996.1	30298	42860.8	42860.8	40197	40197	3171	4019	4667
Manipur	30558.7	30558.7	503.24	503.24	412	412	531	531	40
Meghalaya	372.76	359.86	1000.5	1000.5	578	578	2	-	0
Mizoram	315.8	180.1	821.47	798.27	631	560	6	Nil	0
Nagaland	-	-	NA	NA	0	0	-	Nil	0
Orissa	4382.42	3090.7	4240.56	3344.47	5089	3542	98	146	105
Puduchery	3923	3923	3755	3755	2394	2394	10	23	23
Punjab	5507.86	4865.76	5941.49	5547.57	6903	6903	94	147	170

Table 3.4 (Conitnued)

Rajasthan	31399	18620	32779.51	30448.21	19591	11816	1558	1106	946
Sikkim	620.86	620.86	821.47	798.27	-	-	-	Nil	-
Tamilnadu	44478	27279	16516	16041	21418	21418	1329	499	507
Tripura	483	NA	478	-	553	NA	NA	NA	NA
Uttarakhand	2211.85	1191.3	2200	1176	1872	740	85	72	288
Uttar Pradesh	35222	13500	35763	14000	44392	42237	2457	2710	532
West Bengal	24582.75	13523.25	23498.25	9256	23571	12472	4041	1695	632
Total	506745	288203.8	409114.4	295271.88	405702	291983	19090	18140	13037

During the study, it was observed that the hospital had been properly managing its BMW. Moreover, the hospital segregates the BMW according to specific categories and color coding. The hospital consistently follows the practice of decontamination before disposing of the BMW, or storing it for 48 hours. Regarding the capabilities and risks of biomedical treatment alternatives, it must be emphasized that only treatment technologies are usually used to treat the pathological waste. Depending on the type of incinerator and the nature of its control, incineration is one of the best treatment alternative to manage the BMW. An important issue in the incineration of BMW is the identification of combustion pollutants. It includes dioxins, furans, pathogens, metals, and acid gases that can cause acid rain besides enhancing the toxic effects of heavy metals. In healthcare centers around the world, a major issue ofconcernin BMW management is that, whatever treatment alternative is used, some form of additional solid waste disposal must ensue. In the BMW incineration, the ash becomes a waste product that requires landfill. For autoclaving, microwaving, and irradiation, too, landfilling processes are necessary.

3.6   SUMMARY

In India the BMW generation is estimated at 1-2 kg per bed per day in a hospital and 600 gms per day per bed in a general practitioner's clinic/ E.g. a 100 bedded hospital will generate hazardous/ infectious waste at the rate of 5 to 10 kgs/day. According to the Ministry of Environment and Forest (MoEF) gross generation of BMW in India is 4,05,702 kg/day, out of which only 2,91,983 kg/day is disposed, which means that almost 28% of the wastes is left untreated and not disposed finding its way in dumps or water bodies and reenters our system. According to another report of MoEF almost 53.25% of Health Care Establishments (HCEs) are in operation, without having the adequate authorization from State pollution Control Board (SPCB)/ Pollution Control Committee (PCC) for proper BMW handling methods adapted. The waste generated from such HCEs goes unaccounted and is dumped without any adequate treatment. India's plans to achieve a capacity of 2.9 million hospital beds by 2025 is expected to help bio medical waste management market to grow at a CAGR of 8.41%.

The concern of BMW treatment process implementation in hospitals is due to the generation of 4kg of waste per day per bed atleast 1 kg would be infectious reported by Environment department, Tamil Nadu (www.envromemet.tn.nic.in). There are 3875 bedded heath care destination located in Madurai Corporation Area, Tamil Nadu, and India.

With such rate of growth and challenges associated with the existing situation of the BMW, the market for BMW, the market for BMW management continues to have a promising future for its operators.

There are two important messages need to be conveyed to the stakeholders. One is due to human error; the manual segregation of BMW sometimes incorrectly disposed in the color coded waste collection containers.

So the collected waste will have mixing of waste which will not result in the correct treatment of BMW. So, it is important to categorize the waste for appropriate treatment. An automatic system based on evolutionary optimization will provide solution to such type of problem. It detects the waste from the garbage, so that the disposal of BMW is done appropriately. Hence it is strongly recommended in reducing the number of labours engaged for handling the infectious waste. Another aspect is the timeframe. Since the biomedical waste is infectious sometimes may spread diseases it has to be disposed timely. As most of the researchers are utilizing the evolutionary optimization technique for solving optimization problems, the current work utilized the evolutionary optimization technique for segregation and classification leads to sustainable environment. Hence the stake holders need to be given awareness about the usage of the automated system to sort the waste within the timeframe.

Hospitals, healthcare centers, emergency care centers, and private practitioners do not have much time and resources to properly dispose of the BMW. Self-contained on-site treatment methods may be desirable and feasible for large healthcare facilities. But they will not be practical and economical for smaller institutions. One of the most critical issues in BMW management is the selection of an appropriate treatment. Demographic factors and the availability of permitted landfills should be considered while selecting the most appropriate management strategy. The safety, reliability, and cost of alternative treatment methods also affect the selection of treatment alternatives. In order to overcome these issues and properly disposeofthe BMW, a new BMW waste management scheme is proposed in this work. The methodology of the system is explained in the next Section.