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Analytical Studies on the Impact of Bio-Medical Waste on Garden and Landfill Soil

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Abstract : The objective of the present study is to investigate the biomedical waste management system, including policies, practices (i.e., storage, collection, transportation and disposal), and its compliance with the standards prescribed by the Biomedical Waste (Management and Handling) Rules 1998. The analysis consisted of interviews with medical authorities, doctors, and paramedical staff involved in the management of the biomedical wastes in the healthcare facilities. A general survey of the healthcare facilities was undertaken to ascertain the efficacy of the implemented measures. The Bio-Medical Waste (BMW) assessment performed in the identified health care centres lead to a conclusion that problems associated with poor management of the Bio-Medical waste are immense and crucial. It was observed that hospitals have overall good management of Bio-Medical waste, whereas small clinics generating small quantum of Bio-Medical waste of category 3 and 6 lack in hygienic management of Bio-Medical waste. Attempts were taken to identify and study the phytoremediation methods of treating the Category 3 and 6 Bio-Medical wastes collected in small clinics which are most often mixed with Municipal Solid Wastes (MSWs). This observation led to study the variation of pH and conductivity of land fills soil and normal garden soil before and after category 3 and 6 BMW contamination. There is also a need to create awareness among the personnel associated in handling the waste.
Keywords : Bio-Medical waste, conductivity, EDAX, healthcare centers, pH, phytoremediation.

I. Introduction

Bio-Medical waste is the waste generated during diagnosis, treatment, or immunization of human beings or animals, from research activities or in the production or testing of biological equipments (1,2). Though 75-80% of waste generated from the hospital is non-infectious, 20-25% is hazardous. It poses a potential threat to public health, flora and fauna of the area(3). Hospitals, healthcare centre, veterinary hospitals, dental clinics, pathological & diagnostic laboratories, blood bank are considered to be the sources of Bio-Medical wastes(4).

Human anatomical / surgical waste, animal waste, pathological waste including tissues, organs, blood and body fluids, microbiological cultures, cotton, swabs etc are the major generated healthcare wastes. Used syringes, I.V. tubes, blood bags and other items stained with blood and body fluids are highly infectious wastes that are generated(16). Items such as plasters, casts and bandages, when infected by blood and pus, waste from isolation wards and radioactive waste in liquid form from chemical or biological research, from body organ imaging, from cleansing of radioactive spills, from patient urine and from scintillation liquids used in radioimmunoassay are also infectious(5). The amount of infectious waste is near about 25% of the total wastes generated from a health care firm (6).

The dumping of Bio-Medical waste on landfill/open land mass causes severe land pollution. However during the process of Bio-Medical waste transfer, stagnation/leaching there is high probability of air and water environment also getting affected (7).The Bio-Medical waste without pre-treatment if transported outside the healthcare centre can lead to air pollution, or if it is dumped in open areas can cause pathogens to enter into the atmosphere. Open burning of Bio-Medical waste is the most hazardous practice. Organic gases such as dioxins and furans released during incineration of Bio-Medical waste upon inhalation can cause respiratory diseases (8).Bio-Medical waste dumped on open land can also lead to contamination of ground water by the process of leaching. Heavy metals leaching from the Bio-Medical waste can alter underground water properties making it unsuitable for consumption. Soil pollution from Bio-Medical waste is caused due to contagious waste, discarded medicines, chemicals used in treatment and ash and other waste generated during treatment processes (9). Heavy metals such as cadmium, lead, mercury etc., which are present in the waste will get absorbed by plants and can then enter the food chain (10). Excessive amounts of elements including heavy metals in soil are harmful to crops, animals and human beings. Minimizing the waste and proper treatment before disposal on land are the only ways of reducing this kind of pollution.

Contact to infectious BMW can result in disease or injury. It may contain infectious agents, toxic or hazardous chemicals or pharmaceuticals, radioactive wastes and waste sharps. The infectious wastes may contain any of the great variety of pathogenic microorganisms. Pathogens in infectious wastes may enter the human body through a number of routes like a puncture or cut in the skin, mucous membranes, by inhalation or ingestion. Sharps may not only cause cuts and punctures but also infect the wounds if they are contaminated with pathogens. Because of this dual risk of injury and disease transmission sharps are considered to be very hazardous waste class. Poor hospital waste management may cause Hepatitis B & C, HIV infection, gastro-enteric infection, respiratory infection, blood stream infection, skin infection, radioactive toxicity and health problems associated with air and water pollution (11).Apart from the above, there are other environmental problems connected with the dumping of untreated Bio-Medical waste. Decaying waste may produce foul odour inside the hospital premises and neighbouring areas. Drains may be jammed with waste materials creating an unhealthy environment in the adjoining hospital premises. This phenomenon may improve the procreation of mosquitoes/flies that may contribute to the spread of infectious diseases. Waste dump may attract stray animals and birds that might spread waste materials leading to an unclean environment. Unsystematic disposal of pharmaceutical stuff and discharge of untreated wastewater generated from the health care units could have catastrophic ecological effects.

1.1 Legislation

The Ministry of Environment and Forests of the Government of India framed the Biomedical Waste (Management and Handling) Rules, which came into effect on 20th July, 1998. These rules have been framed as an application of the powers conferred by Sections 6, 8 and 25 of the Environment (Protection) Act 1986 having six schedules as shown in Table 1.

Table 1: Schedule of Biomedical waste rules

Schedule	Contents
Schedule I	Classification of biomedical waste in various categories.
Schedule II	Colour coding and type of containers to be used for each category of biomedical waste.
Schedule III	Performa of the label to be used on container/bag.
Schedule IV	Performa of label for transport of waste container/bag.
Schedule V	Standard for treatment and disposal of waste.
Schedule VI	Deadline for creation of waste treatment facilities.
Form I	Format of application for authorization.
Form II	Format of annual report.
Form III	Format of accident reporting.

Under schedule I of these rules, biomedical waste has been classified into ten categories, such as Human anatomical waste, Animal waste, Microbiology and Biotechnology waste, Waste sharps, Discarded medicines and cytotoxic drugs, Contaminated solid waste, Solid waste Liquid waste and Chemical waste, which are listed in Table 2, along with their corresponding treatment and disposal options (Incineration, Deep burial, Autoclave, Microwave and secured Landfill), as prescribed in schedule V. The colour-coding scheme and type of containers used for different categories of biomedical wastes are described under schedule 2, and are presented in Table 3. Performa of the label to be used on container/bag is given in Fig. 1.

Table 2: Categories of biomedical wastes and methods of their treatment and disposal

Category	Types of waste	Treatment and disposal
Category 1	Human anatomical waste: Human tissues, Organs, body parts.	Incineration/Deep burial.
Category 2	Animal waste: animal tissues. Organs, Body parts, carcasses, fluid, Blood.	Incineration/Deep burial.
Category 3	Microbiology and Biotechnology waste.	Incineration/ Autoclave/ Microwave.
Category 4	Waste sharps: Needles, syringes, scalpels, blades, glass, etc.	Disinfection (chemical treatment)/ autoclaving/ microwaving and shredding.
Category 5	Discarded medicines and cytotoxic drugs:	Incineration/ disposal in secured Landfill.
Category 6	Contaminated solid waste: Items Contaminated with blood fluids including cotton, dressings, Soiled	Incineration/Autoclave/ Microwave.
Category 7	Solid waste: Disposable items other than the waste sharps, such as tubing, catheters, IV sets etc.	Disinfection by Chemical treatment autoclaving and microwaving.
Category 8	Liquid waste: Waste generated from Laboratories, washing, cleaning.	Disinfection by Chemical treatment and discharge into drains.
Category 9	Incineration ash: Ash from incineration of medical wastes.	Disposal in municipal and fill.
Category 10	Chemical waste: Chemicals used in disinfection, insecticides, etc.	Chemical treatment and discharge into drain for liquids.

Table 3: Color coding and type of container for biomedical waste disposal

Colour coding	Type of container and waste category
Yellow	Plastic bag (Categories 1, 2, 3, 6)
Red	Disinfected container/plastic bag (Categories 3, 6, 7)
Blue/white	Plastic bag/puncture proof Container(Categories 4, 7)
Black	Plastic bag (Categories 5, 9, 10) (solid)

Figure 1: Performa of the label to be used on container/bag

1.2. Bio-Medical waste Management

The waste management structure consists of the whole set of activities related to handling, treating, disposing or recycling the waste materials. The idea of waste management system is to make sure that the waste materials are removed from the source or location where they are generated and treated, disposed of or recycled in a safe and proper manner. Modern waste management systems, which many developing country cities aspire to, are all characterized by high recycling rates of clean, source separated materials (12–14).

The waste management system consists of four main parts:

a. Bio-Medical waste generation
b. Collection (collection systems and transport of waste materials)
c. Treatment (Incineration, autoclaving, Shredding)
d. Final disposing

II. Materials and Methods

Assessment of the Health care centres and impact associated with BMW were studied for landfill and garden soil before and after BMW contamination and an economic and effective method for hygienic management of BMW generated in clinics has been proposed.

2.1. Assessment of healthcare centres

A general survey of the operating procedures practiced in handling and treatment of Bio- Medical waste was performed to assess its compliance with Standard Legal Norms and Procedures as per the Bio-Medical Waste Management Rules 1998 (15). Survey report was made based on the interviews held with the authorities and personnel involved in the management of the Bio-Medical wastes in the Common Bio- Medical waste treatment facility. Site visits to some of the hospitals in Chennai were conducted during the month of November 2014 to support and supplement the information gathered in the survey. A format of questionnaire used in the survey, interviews and site visits were helpful in obtaining information about the management of the Bio-Medical waste (i.e., collection, segregation, transportation, storage, treatment, and the disposal procedures) at the Health Care Centres. Data on the Bed Occupancy Rate, Average Surgery per Day, Average Deliveries per Day and Average Outpatient per Day were collected and are given in Table 4. The average daily values of the Bio- Medical waste generated for the 150 bedded hospital surveyed is given in Fig. 2.

2.2. Impact associated with Bio-Medical waste on landfill and garden soil

Study on the impact of Bio-Medical waste dumping was carried out for both garden and landfill soil, to understand the consequences of dumping Bio-Medical waste on open land areas and how it triggers the effect on landfill. To study the pH, organic matter and conductivity of garden and landfill soil confined in pot environment as shown in Fig. 3 were monitored. For the present study three pots named A, B and C were taken. Garden soil collected from Sathyabama University (Chennai, India) premises was kept in pot A while landfill soil collected from Perungudi municipal waste dump yard was kept in pot B and C for comparative study. 150 grams of category 3 and 6 BMW were taken and autoclaved was done by standard autoclaving equipment at 121^0 C, 15psi for 1 hour. The standard experimental procedure was followed to measure the parameter such as pH, and conductivity are shown in Fig. 4 and Fig. 5. The fresh garden and landfill soil sample were checked for elemental composition using FESEM (Carl Zeiss SUPRA-55) as shown in Table 5. The variation in elemental composition for garden and landfill soil after BMW contamination is given in Table 6.

2.3 Hygienic management of BMW generated in clinics.

For present study experiment were done using category 3 and 6 biomedical waste, which are predominantly generated in clinics. Disposal and treatment of BMW from clinics to BMW treatment facility is practically difficult owing to several economic constrains. Hence an onsite feasible phytoremedition technique was experimented using the *Similax zeylanica*. Healthy disease free, mature, fresh leaves (from southern part of Tamil Nadu is taken) of Smilax zeylanica were taken and washed under clean tap water. Leaves were then air dried for four hours at 45°C. The material was powdered to 2mm mesh size and 30 gram was weighed and fed into soxhlet apparatus for extraction of active metabolites. The phytochemicals were extracted by repeated washing with an organic solvent, usually like ethanol, under reflux. The concentrated solvent extracts were then allowed to settle in separating funnel. The bottom was collected and poured on a petri plate and allowed to dry for 24 hours at room temperature. The percentage of extract obtained is shown in Table 7. Then this extract was subjected to BMW waste and was checked for microbial activity. Using spread plate technique microbial activity of BMW was checked and is depicted in Table 8.

III. Results and Discussions

3.1 Assessment of health care centres

A general survey was made to obtain information on the management of the Bio-Medical waste (i.e., collection, segregation, transportation, storage, treatment, and the disposal procedures), bed occupancy rate, average surgery per day, average deliveries per day and average outpatient per day in surveyed Hospital as shown in Table 4 and it is clear that Hospital-3 has highest out-patient per day and so the Bed Occupancy Rate and Average Surgeries per day are higher for it. Hospital- 1 has lowest Bed Occupancy Rate and Average Surgeries per day. Questionnaire was used during the survey to collect information on the average daily values of the Bio- Medical waste generated for surveyed hospitals and is given in Fig. 2; shows the Waste Audit observations made in 150 bedded hospitals for 4 consecutive days and it is observed that the Bio-Medical waste collected in red and blue bags are higher than the yellow bag, leading to conclusion that generation of BMW of category 3, 6, 7 are more.

Table 4: Health care details

Health care name	Bed Occupancy Rate	Average deliveries Per Day	Average Out Patient Per Day	Average Surgeries Per Day
Hospital-1	42%	-	130	2
Hospital-2	60%	1	60	6
Hospital-3	62%	2	400	18

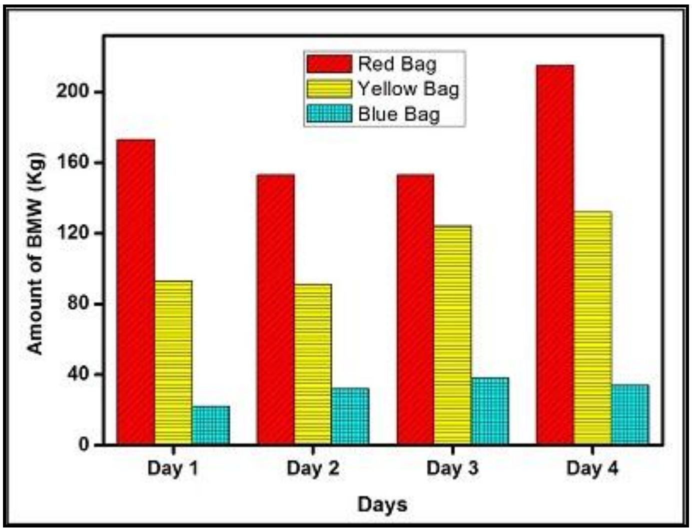

Fig. 2: Average quantum of waste generated in 150 bedded healthcare centers

Fig. 3: Pot system for impact study

3.2. Analytical studies on impact of Bio-Medical waste on soil

The soil samples were checked for elemental composition using FESEM analysis. The garden and landfill soil samples were checked for elemental composition before and after BMW contamination as shown in Table 5 and Table 6 and it is clear that Oxygen and Carbon by Weight % are lower in garden soil than garden soil non-autoclaved Bio-Medical waste is dumped. It is analyzed that in garden soil dumped with Non-Autoclaved Bio-Medical waste, there is increase in the composition of Oxygen, Aluminium and potassium. The presence of Titanium is negligible. From Table 6 and Table 7 it is evident that Oxygen and Silica by Weight % are higher in landfill soil than landfill soil where Non-Autoclaved BMW is dumped. It is analyzed that landfill soil when dumped with Non-Autoclaved Bio-Medical waste there is decrease in the presence of Aluminium and Silicon. The presence of Titanium and potassium is negligible. Landfill soil where Non- Autoclaved Bio-Medical waste is being dumped shows the presence of Sodium, Phosphorus and Sulphur. From Table 5 and Table 6 it can be inferred that Oxygen and Carbon by Weight % are lower in landfill soil than autoclaved Bio-Medical waste dumped landfill soil. Thus inferring Bio-Medical waste pollutes the soil environment.

Table 5: Elemental composition of soil before Bio-Medical waste contamination

Element	Garden Soil (Weight %)	Landfill Soil (Weight %)
C	5.71	8.17
O	44.19	52.57
Mg	4.01	0.38
Al	3.35	3.65
Si	22.27	31.68
K	0.29	0.28
Ca	6.06	0.51
Ti	0.38	0.15
Fe	13.75	2.62
Total	100.00	100.00

Table 6: Elemental composition of soil after Bio-Medical waste contamination

Element	Garden soil + Non-autoclaved BMW (Weight %)	Landfill soil + Non-autoclaved BMW (Weight %)	Landfill soil + Autoclaved BMW (Weight %)
C	5.87	31.54	19. 34
O	67.25	48.62	55.05
Mg	0.43	0.45	0.61
Al	7.76	2.79	5.24
Si	14.26	8.13	10.85
K	1.00	0.80	0.87
Ca	0.36	2.45	1.27
Ti	1.33	-	-
Fe	1.74	3.79	5.03
Na	-	0.45	0.73
P	-	0.48	0.51
S	-	0.47	0.28
TiK	-	-	0.22
Total	100.00	100.00	100.00

3.2.1. pH

The variation in soil pH before and after Bio-Medical waste contamination is given in Fig. 4. pH of soil is regulated by the presence of oxide of calcium and magnesium. These metal oxides make soil alkaline in nature. From EDAX report (Table 7 and Table 8) it is clear that garden soil has higher calcium and magnesium concentration than landfill soil and hence pH is more (alkaline) for garden soil. Whereas autoclaved Bio-Medical waste was added there was reduction in pH. This was because organism consumed the nutrients present in soil.

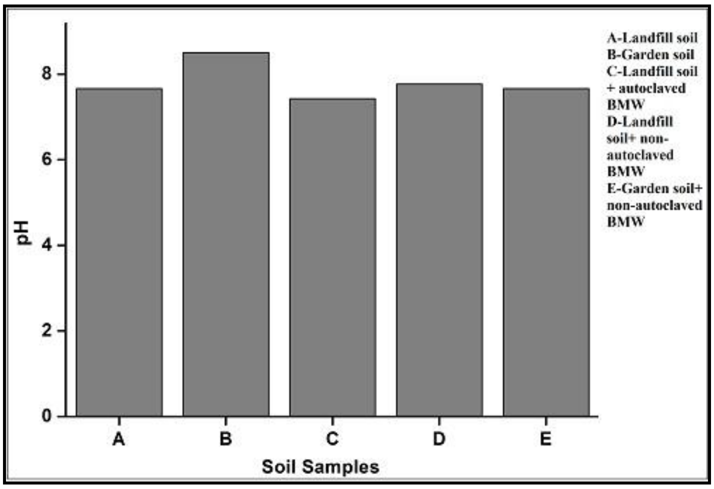

Fig. 4: Variation in pH for soil samples

3.2.2. Conductivity

Conductivity of soil is the function of oxide present in the soil. The variation in soil conductivity before and after Bio-Medical waste contamination is given in Fig. 5.Conductivity of soil is due to presence of metal salts. From Table 7 and 8 it is clear that garden soil has more concentration of metal oxide. Thus the garden soil has more conductivity than landfill soil.

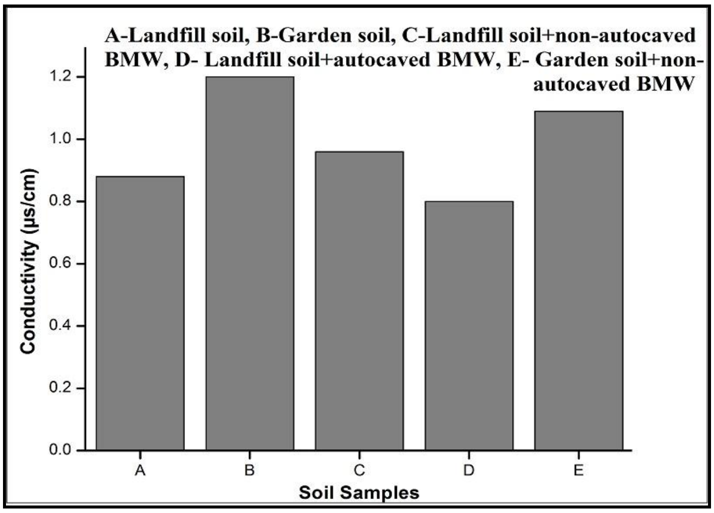

Fig. 5: Variation in conductivity for soil samples

2.3 Hygienic management of BMW generated in clinics.

The observed microbial count for BMW and BMW with plant extract is depicted in Table 8. It can be concluded that the extract plays a role in controlling the microbial growth in BMW. This method can effectively reduce the harmful and infectious effect of BMW generated in small clinics. The biomedical waste can be mixed up with extract and was subjected to autoclaving and the odour released was not stinky when compared to biomedical waste autoclave without extract.

Table 7: Percentage of phytochemical extraction

Dry Powder (gram) W_1	Solvent (Ethanol) ml	Weight of dried Residue (gram) W_2	Percentage of Extraction
30	350	26.3	12.33

Table 8: Variation in Microbial count

Dilution factor	Total number of CFU(colony forming unit per ml)	
	BMW	BMW with plant extract
10^{-3}	$298 * 10^4$	$227 * 10^4$
10^{-4}	$070*10^5$	$064*10^5$
10^{-5}	$007*10^6$	$009*10^6$

V. Conclusion

Bio-Medical waste audit was carried out to assess the management of the Bio-Medical waste in identified healthcare centres in Chennai. It was observed that Bio-Medical waste collected in red bag was higher, leading to a conclusion that generation of Bio-Medical waste of category 3, 6 and 7 is more. It was observed that the management of BMW in hospital was practice in hygienic manner, whereas small clinics generating small quantity of BMW of category 3 and 6 lacks in proper management of BMW. The present study investigates the hazardous nature of Bio-Medical waste by measuring parameters such as pH, conductivity, and of soil environment and suggests that dumping of BMW alters the soil parameters. If Bio-Medical waste autoclaving is practiced in clinics with limited occupancy, it produces an intense odour which effect will be immense. To curb the intensity during the autoclaving of Bio-Medical waste a bioremedial measure was experimented by blending a calculated quantity of Smilax zeylanica extract with Bio-Medical waste. It was observed that there was an effective reduction in infection inducing microbes.

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