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Biomedical Waste a Concerning Issue in National Contest

Ankit Chhabra*, Anju Agarwal and Krishna Gopal

K. S. Institute of Research and Training, Lucknow (U.P.), India – 226010

Abstract: *India is a developing country and health care sector is one of the fastest growing sectors in India as a result of which hospitals, clinics and nursing homes have sprung both in rural as well as in urban areas. Today biomedical waste management has become one of the major issues of concern taking into account the growth rate of population. The present study focuses on the biomedical waste management system in government and non-government hospitals in India with special reference to environmental education, in this paper an attempt is made to study the classification, legislation, management practices in India, it also includes detail of various methods adapted by different countries for disposal of biomedical waste generated in hospitals and other health care units. The data was collected from general literature, legislative aspects, hospital experience and online survey work for the review. The paper aims to create awareness among the individual and for better result we need to increase the level of training and education regarding the handling and disposal of biomedical waste.*

Keywords: Biomedical waste, Environmental education, Segregation, Handling, Disposal.

Introduction

As a result of increasing heath care facilities the rate of waste generated by them has also increased, though these are imperative for our health and well being but the waste generated from these medical activities are proving lethal because of their high potential for disease transmission, although biomedical waste constitutes a small fraction of total municipal waste generated but it proves to be highly dangerous for human beings if not treated in proper scientific manner, as improperly disposed biomedical waste may enter the food chain either by the air or by the soil and shows harmful effects in animals and humans, all the hospital and health care personnel's are at a risk of many infections like human immunodeficiency virus, hepatitis B virus, hepatitis C virus, HIV and many more. The Hepatitis outburst in Modassa, Gujarat (2009) pointed towards the improper biomedical waste management (Patel *et al*., 2012), thus the disposal of biomedical waste has emerged as a major concerning issue not only for the health care units and hospital but also for the environment, so in addition to the health risk associated with the poor, due consideration must be given to the impact on environment, with special emphasis on to the risk of pollution of water, air and soil. Rag pickers and the waste workers are often worst affected because unknowingly they poke around all kind of poisonous stuff while trying to collect items which they can sell for reuse and because of that they come in contact with untreated biomedical waste which leads to various infections and life threatening diseases. Worldwide, 8–16 million hepatitis B, 23-4.7 million hepatitis C, and 80,000 - 160000 HIV infection are estimated to occur yearly from reused unsterilized syringes and needles and is particularly common in certain developing countries (Onursal, 2003) The government of India (Notification 1998) state that hospital waste Management is a element of hospital hygiene and maintenance activities. Common bio-medical treatment facilities are required for ensuring environmentally sound management of bio-medical waste keeping in sight the techno-economic feasibility and

*Email: ankit90chhabra@gmail.com

viable operation of the facility with nominal impacts on human health and environment**.**

Biomedical waste

According to the Bio-medical Waste rules 1998 of India, Bio-medical Waste is defined as, 'Any solid, fluid or liquid waste, including its container and any intermediate product, which is generated during the diagnosis, treatment or immunisation of human beings or animals, research pertaining there to or in the production or testing of biological and animal waste from slaughter houses or any other like establishment.' (Agarwal *et al*., 2011; Nayak *et al.,* 2015). The first standard on the subject to be brought out in India was by the Bureau of Indian Standards (BIS), IS 12625: 1989, entitled 'Solid Waste – Hospitals – Guidelines for Management' (Annexure 7.1) but it did not work as expected and the situation did not change much, but the notification of 'Biomedical waste (Management and Handling) Rules, 1998' was quiet successful in comparison to that of previous one.

Table 1 Various schedules under biomedical waste management and handling rules.

Schedule	Contents
Schedule I	Classification of biomedical waste in various categories
Schedule II	Colour coding and types of containers to be used for each category of biomedical waste.
Schedule III	Performa of the labels to be used for the transport of biomedical waste.
Schedule IV	Performa of the labels to be used on the bags and container used for disposal of biomedical waste container /bags
Schedule V	Standards for treatment and disposal of waste
Schedule VI	Deadline for the creation of waste treatment facilities

Biomedical waste management – Global portrait

The entire World is directing its shot towards the proper disposal of biomedical waste management as it is of great concern in present day scenario, the issue of biomedical waste was brought in to focal point in at Bergen in 1983 when 19 countries (involving the experts of the field and administrators) come under the banner of WHO and discussed the issue and concluded that it requires a proper approach involving awareness, segregation and source reduction of various radioactive waste (Rudraswami *et al*., 2013), due to increase use of disposable items the developed countries are facing dilemma in its disposal and on the other hand the developing countries are facing problem of lack of funds and in some cases lack of regulations for the proper disposal of waste. The UNDP survey says that most of the African countries lack proper sanitary landfills and policies for proper disposal of biomedical waste, for example Eritrea, Lasotho, and Ghana have no legislation for health care waste management, the lack of sanitary landfills in Gambia, Ghana, Lesotho, Nigeria, Senegal, and Tanzania had lead to the use of incinerators to a large extent, where as in the case of Zambia and Kenya unscientific dumpsites are to a large extent. A Study of UNDP shows that most of the countries have not disposed off the sharp waste at the dumping site and only few hospitals have separate pit for the disposal of sharp waste as lack of funding being a major issue of concern (Manasi *et al.*, 2014). In UK environmental protection act 1990 (Part2), waste management licensing regulations 1994, Hazardous waste regulations (England and Wales) 2005 deals with the issues related to biomedical waste management and in USA medical waste tracking act was set up for regulating biomedical waste and after the act expired in 1991 states were given the responsibility for regulating biomedical waste disposal in US there exist a mail back biomedical waste disposal service under this service the waste is shipped through US postal service instead of transportation by private

organisation. In case of India Biomedical waste treatment facilities provided by the operators of the common biomedical waste treatment facility to a clinical establishment shall be exempted from service tax under entry 2B of notification number 25/2012 –ST as amended. This might prove very beneficial in broader prospect for future point of view. There are various methods adopted by different countries for biomedical waste disposal i.e. in Mongolia open dumping or open burning, incineration, autoclaving used (Shinee *et al*., 2008; Sawalem *et al*., 2008), in Greece recycling- reuse, Pyrolytic combustion, landfills are widely used, in Malaysia and India: Landfill, incineration, recycling is widely used and along with this autoclaving is also proving beneficial in India (Tsakona *et al*., 2007; Hossain *et al*., 2011), dumping and incineration are common biomedical waste treatment methods in Libya where as in Bangladesh dumping technique is mainly used for disposal of biomedical waste.

Table 2 Measures taken by different Countries for managing biomedical waste.

Name of Country	Measures Undertaken
India	The Bio-Medical Waste (Management and handling) rules, 2011, under Environment Protection Act 1986 by (MoEF), Government of India.
England and Wales	The Environment Permitting Waste (England and Wales) Regulations (Janagi *et al*., 2015).
North Island and Scotland	The Waste Management Licensing Regulation. The pollution Prevention and Control Regulation.
Canada	The Canadian Standards Association under the direction of Canadian council of ministers of environment (CCME) prepares a national guideline document for the management of biomedical waste in Canada.
Europe	European commission in 1990, under the environmental protection act imposed strict control and their ignorance leads to severe fine and custodial sanction.

Table 3 Health care waste generated according to national income level (Pruss *et al*., 1999)

National income level	Annual waste generation (Kg/ head of population)
High income countries All health-care waste Hazardous Health care waste	 1.1-12.0 0.4-5.5
Middle income countries All health-care waste Hazardous Health care waste	 0.8-6.0 0.3-0.4
Low income countries	0.5-3.0

Table 4 Total hospital waste and percentage of infective waste generated in various countries (Vetrivel *et al*., 2014).

Country	Total waste	I% of infective waste
USA	7-10 Kg	10-15
Western Europe	3-6 Kg	10-15
India	0.5-2 Kg	30-60

The NGO's in conjunction with the government and hospitals are making efforts globally for handling biomedical waste, there are several NGO's which collect used (but functioning) medical equipments and distribute them at local, national and international level this proves very beneficial in reducing its incineration.

Effects of biomedical waste

In India studies have estimated the average hospital waste generation rate ranges between 0.5 and 2.0kg/bed /day and annually about 0.33 million tons of waste (Mc Veigh *et al*., 1993). The common problems which are associated with

improper disposal of biomedical waste includes hepatitis B virus (HBV), Hepatitis C virus (HCV), immunodeficiency virus, leading to hepatitis B, hepatitis C and AIDS respectively, Staphylococcus ssp. leading to Septicemia, Steptococcus spp. causing skin infections and many more, along with this Pharmaceuticals waste which is generated due to unwanted and expired chemicals and pharmaceutical products, partially used vials causes poisoning by absorption through skin, mucous membrane, eyes and other respiratory tracts (Singh *et al*., 2014).

Along with this unauthorised repackaging and sale of disposable items and expired drugs proves very lethal for life and occupational risk are also associated with biomedical waste, injury from sharps in quite common among the waste handlers associated with the health care establishment.

According to UEAP (2005) dumping of health care waste in uncontrolled area can have direct environmental effect by contaminating soil and underground water and improper incineration can pollute nearby air.

The World Health Organization (WHO) has classified medical waste in to eight categories.

1. General waste: This type of waste makes up to the 85% of the total waste, it is parallel to the household or office waste which includes paper, glass or plastic waste.
2. Pathological waste**:** This section of waste includes human tissue, organ and body parts which are wished-for disposal but teeth hair and nails are not included in this category.
3. Radioactive: These include waste which is generated during nuclear medicine treatment, during the treatment of cancer, and in some cases pathological waste also contain radioactive waste.
4. Chemical waste: It includes chemical waste which is generated during chemical use in disinfections, use of chemicals as insecticides, during the production of biological etc. and falls under the category 10 of biomedical waste.
5. Infectious to potentially infectious waste: as the name suggest it includes those waste

Table 5 Hospital waste related infections.

ORGANISM	DISEASE CAUSED	RELATED WASTE ITEMS
VIRUSSES HIV Hepatitis B Hepatitis A, C Arboviruses Enteroviruses	• AIDS • Infectious Hepatitis • Infectious Hepatitis • Dengue, Japanese encephalitis, tick-borne fever, etc. • Dysentery	• Infected needles, body fluids • Infected needles, body fluids • Human excreta, soiled linen • Blood, body fluid • Human excreta, soiled linen.
BACTERIA Shigella ssp. *Salmonella typhi* *Vibrio cholerae* *Clostridium tetani* *Staphylococcus* *Borrellia* spp.	• Shigellosis • Typhoid • Cholera • Tetanus • Wound infections, septicemia, rheumatic fever, endocarditis, skin and soft tissue infections. • Louse and tick borne fevers	• Human excreta and body fluid in land fills and hospital wards • Sharps used as needles, surgical blades in hospital waste. • Rodent infestations of poorly managed landfills and dumping grounds
PARASITES *Giardia Lamblia* *Wucheraria bancrofti* *Plasmodium*	Giardiasis Cutaneous leishmaniasis, Kala Azar Malaria	Human excreta, blood and body fluids in poorly managed sewage system of hospital

which may cause infections to human beings, these waste includes human or animal tissue, used bandages, used surgical gloves, cultures and many more.

6. Sharps**:** This section of biomedical waste includes syringes, needles, broken glasses, microscopic slides, discarded blades, broken pipettes etc.
7. Pharmaceuticals: The pharmaceutical waste generated in the health care units includes partially used vials, syringes, expired drugs, patients personal, medication, etc.
8. Pressurized containers: It includes Gas cylinders, Aerosol cans, Gas Cartiges etc.

WHO has recommended that hospitals in developing countries use a simplified classification for practical purpose i.e. hazardous waste: It constitutes up to 5 % of the total waste, second is the non-hazardous waste: (This waste amount to 85% of the total most of the health care units), third one is the infectious waste: as the name suggest it includes those waste which may cause infections to human beings, these waste includes human or animal tissue, used bandages, used surgical gloves, cultures and many more (Constitutes around 10% of total biomedical waste), the fourth one is the non-infectious waste: It is also known as offensive waste and as the name suggest it is non-infectious or rather non harmful for human health. It includes Incontinence waste, non infectious clinical waste, nappy waste etc. Though it is not much harmful but it should be treated with proper care. Finally the chemical waste: It includes chemical waste which is generated during chemical use in disinfections, use of chemicals as insecticides, during the production of biological etc. and falls under the category 10 of biomedical waste.

According to World Health Organization reports, 85% hospital waste are actually non hazardous, whereas as 10% are infectious and 5% are non infectious. In USA, about 15% of hospital waste is regulated as infectious waste as, in India this could scope from 15%-35% depending on the total quantity of waste generated.

Some of the waste management processes that are applied till now is summarized as beneath. Handling, Segregation, multination, disinfection, storage transportation and final disposal are vital steps for safe and scientific management of biomedical waste in any establishment.

Segregation of biomedical waste

One of the most essential part of hospital waste management is the segregation of waste within the premises of the hospital or other health care units by using different colour coding container for different waste category suggested by the government of India, the options are listed below

Categories of Biomedical Waste

The waste is being classified in to 10 different categories as

1. Human anatomical waste (human tissue organ body parts), category
2. Animal waste (includes animal tissue body parts waste generated from veterinary hospitals etc) in category
3. Microbiology and biotechnology waste (waste generated from laboratories, waste generated during culture activities) in category
4. Waste sharps (includes blades, needle, syringes, glass etc), the
5. Unwanted medicine and cytotoxic drug, category
6. Soiled waste (items contaminated from body fluid it includes plasters, dressing, cotton contaminated by blood) in category
7. Solid waste (includes disposable waste other than sharps i.e. Tubes, catheters etc), in category
8. Liquid waste(waste generated during laboratory work, washing, cleaning, disinfecting process etc) are included whereas in category

Table 6 Biomedical waste categories and their treatment and disposal options (MoEF).

Category	Type of waste	Type of container bag to be used	Treatment and disposal options
1	2	3	4
Yellow	**a) Human Anatomical Waste** Human tissue organ and body parts. **b) Animal Anatomical Waste** Experimental animal carcasses, body parts organs**,** tissues including the waste generated from animals used in experiments or testing in veterinary hospitals or colleges or animal houses. **c) solid waste** Items contaminated with blood, body fluids like gloves, dressings, plaster casts, cotton swabs and bags containing residual or discarded blood and blood components. **d) Expired or discarded medicines** including all items contaminated with cytotoxic drugs **e) Chemical waste** chemicals used in the production of biologicals and used/discarded disinfectants. **f)** Discarded linen, beddings contaminated with blood or body fluid. **Microbiology, Biotechnology and other clinical laboratory waste** Laboratory culture, stocks or specimens of micro organisms, live or attenuated vaccines, human and animal cell cultures used in research industrial laboratories, production of biologicals, residual toxins, dishes and devices used for cultures.	Yellow coloured non chlorinated plastic bags Yellow coloured non chlorinated plastic bags or containers Yellow coloured containers or non- chlorinated plastic bags Non-chlorinted yellow plastic bags or suitable packing material Yellow coloured non chlorinated plastic bags or containers	Incineration After treatment liquid waste can shall be discharged in to drained complying to the discharge norms. Solid shall be disposed in secured landfills or by incineration. Incineration or chemical disinfection followed by disposal in municipal sanitary landfills. Incineration. Autoclaving/micro-waving hydroclaving/chemical disinfection followed by shredding an sterilization .After the treatment final disposal is secured / sanitary landfills or disposal through registered or authorized recyclers, which ever is applicable
Red	**Contaminated Waste (Recycable)** a) Waste generated from disposable items such as tubings, bottles intravenous tubes and sets, catheters, urine bags, syringes (without needles)	Red coloured non chlorinated plastic bags or containers	Autoclaving/micro-waving hydroclaving/ chemical disinfection followed by shredding an sterilization. After the treatment final disposal is secured / sanitary landfills or disposal through registered or +waste to energy plant or authorized recyclers, which ever is applicable. In case of occupier does not wish to opt for recycling the incineration may be opted.

(*Continued*)

Table 6 Continued

Category	Type of waste	Type of container bag to be used	Treatment and disposal options
White (Translucent)	**Waste sharps including metals** Needles, syringes with fixed needles scalpels, blades or any other contaminated sharp object that may cause puncture and cuts this includes both used discarded and contaminated sharps	Puncture proof containers	Chemicals disinfection/ Autoclaving followed by shredding/ mutilation/ sterilization by encapsulation `in metal container or cement concrete; combination of shredding cum autoclaving ; destruction by needle and tip cutters; which ever is applicable and final disposal through registered or authorised recyclers or secured/ sanitary landfills or designated concrete waste sharp pit.
Blue	**Glass** broken or discarded and contaminated glass	Puncture proof containers	

Table 7 Colour coding in biomedical waste management.

Colour Coding	Type of container	Waste Category
Yellow	Plastic bag	Cat 1,2,3,6
Red	Disinfected container/ Plastic bag	Cat. 3,6,7
Blue/White//, translucent	Plastic bag/ Puncture proof	Cat. 4,7
Black	Plastic bag	Cat 5,9,10

9. Incineration ash and the last category
10. Chemical waste i.e. Chemicals used in biological process (Rastogi *et al*., 2011)

Biomedical waste and present scenario

Like the two sides of the coin the present status of biomedical waste management policies have both the positive and the negative impact, as Environment Forest and Climate Change Minister Prakash Javadekar said in Lok Sabha that there has been a 16% increase in daily generation of biomedical waste in 2012-13 as against a marginal increase of 0.33 % the year ago. Karnataka was the highest producer of biomedical waste at 83,614 kg /day, followed by Maharastra, which produced 65,660 kg of bio waste every day. These two states also reported the highest number of violations of norms in 2013. Out of 4,430 incidents of norm violations by health care institutions and common biomedical waste treatment facilities in 2013, Karnataka alone reported 1233 cases and Maharastra 602. The overall waste generated throughout the Country was 4,84,271 kg/day in 2013, 4,16,823.6 kg/day in 2012 and 4,15,429 kg in 2011. along with this statement of Central Minister Prakash Javadekar an incidence of Bhopal where Six government and private hospitals, including AIIMS Bhopal have been pulled up by National Green Tribunal (NGT) for failing to comply with biomedical waste rule (Times of India- 31st May 2015, R. Ganguly) this shows that though there are several rules and regulation regarding the disposal of biomedical waste but their implementation is challenging task.

A report shows that PGI Chandigarh generates near about 1,400 Kg of biomedical waste every day out of which 850 Kg is incinerable

waste along with this PGI's incinerator plant also caters Government hospitals along with private sector hospitals and health care centres, PGI charges other hospitals 50.56 per Kg for the use of incinerators. Every day PGI receives around 250Kg of incinerable waste from GMCH-32 and around 150Kg from other envirocare and 4-5 Kg from Punjab University and some other sources. According to PGI officials in 1996 CPCC gave its consent to PGI to run the two incinerators, which have a shelf life of around 10-12 years, for 15 years and the consent period got over in 2011-12 but in the last three years PGI is getting annual approval from CPCC to run incinerator but ideally it should be replaced as now it has been 18 years and same incinerator is being used, resulting the problems in waste disposal and this may also lead to accident as the incinerators are worn out. This shows the careless behaviour towards the waste disposal program.

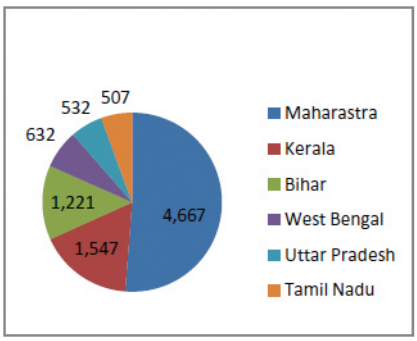


Fig. 1 States with highest violation of BMW management rules in 2011 report.

Table 8 Biomedical waste market to grow at a CAGR of 8.41% by 2025. Amount of biomedical waste generated in various places in India (Mandal *et al.,* 2009).

Place of Study	Type of Hospital	Biomedical waste generated in Kg/bed/day
Kolkata	Govt, private, Large Hospitals	1.044-1.368
New Delhi	Govt, and private	1.5-1.8
Mumbai	Large Tertiary care center	1.13
Manipal	Large Tertiary care	0.776
Punjab	Tertiary care	1.05-1.50

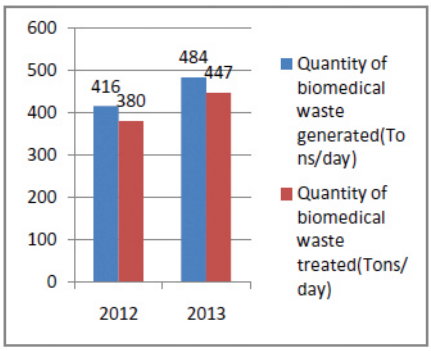


Fig. 3 Comparison of biomedical waste generated and its treatment in 2012 and 2013.

Along with these issues of concern there are some appreciable work done to handle the issue of biomedical waste disposal as report shows that the King George's Medical University received a special recognition award from the United Nations Development Programme (UNDP) and the World Health Organisation on 6th Mar 2013 for outstanding work of KGMU medical staff in transforming the hospital over two and a half years from an institution without any effective waste management program in to a regional model institution for sound bio-biomedical waste management practices.

The report of MoEF in 2011 shows that there have been huge number of violation of BMW management and handling rules according to the report Maharashtra (4,667) was the highest violator of the rules followed by Kerala (1,547), Bihar (1,221), West Bangal (632), Uttar Pradesh (532), Tamil Nadu (507) and overall there were 13,037 violations (Manasi *et al*., 2014) as shown in the chart below.

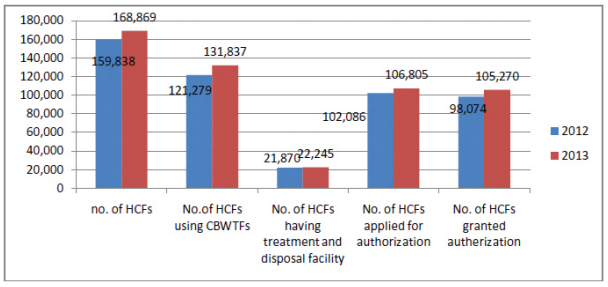


Fig. 4 Comparison of no. of HCFs; no. of HCFs using CBWTs; no. of HCFs having treatment and disposal facility; no. of HCFs applied for authorization and no. of HCFs granted authorization during 2012 and 2013.

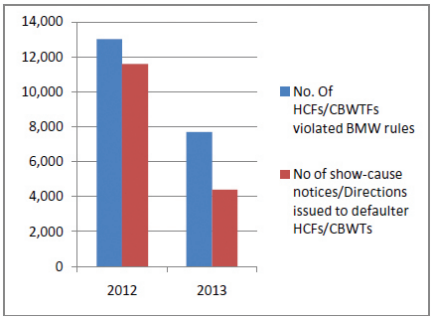
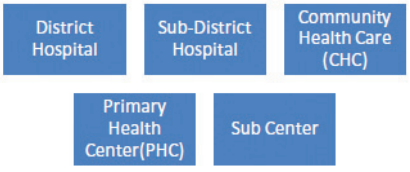


Fig. 5 Number of HCFs / CBWTFs violated BMW rules and Number of show cause notices issued to defaulters HCFs / CBWTFs during 2012 and 2013.

As per the (annual report 2013 on implementation of biomedical waste management and handling rules 1998 and as amended, by Central pollution control board) there is an increase of quantity of biomedical waste generated during 2013 in comparison to that of 2012 as shown in Fig. 3, and there is an decrease in the number of HCFs/CBWTFs violated BMW during 2013 when compared to year 2012 Fig. 5, there is an increase in the number of applications for authorization by HCFs from 1,02,086 to 1,06,805 from 2012 to 2013 and increase of authorization granted by government to HCFs from 98,074 to 1,05,270 from 1012 to 2013 Fig. 3.

Biomedical waste and rural India

Rural Health Structure



- CHC is 30 bedded hospital or referral unit for 4 PHC with specialized services and caters to a population of 1.2 lakh.
- PHC is a referral unit for 6 sub centres 4-6 bedded. caters population around 30,000
- Sub Centres are ring up points between PHC system and community and caters to a population of 5000.

The status of biomedical waste management in primary health care units of rural areas was nastiest in contrast to that of urban areas 742.7 million people live in rural areas and are served through 147,069 sub centres, 23,673 PHC's and 4535CHC's and there are no proper measures for managing biomedical waste. During 2002-2004 a widespread study was carried out by INCLEN (International climate Epidemiology Network)[25] Program evaluating network (IPEN) on biomedical waste management practices prevailing in the Country and the study indicated the subsistence of inappropriate BMWM practices across the country especially in rural areas and further an assessment was carried out by IPEN in 2009 study group in 25 project districts of 20 States aiming at documenting present biomedical waste management practices prevailing in the primary, secondary and tertiary health care centres across the study area and suggestions were given for the betterment of the same.

Treatment of biomedical waste: The Government of India has published a Gazette notification on 20th Jul 1998 according to which all persons who are associated with generation,

collection, receiving, storage, transportation, treatment, disposal, or handling medical waste in any form or are responsible for handling the medical waste without any unfavourable effect to human health and the environment. Along with this the publication of the above Gazette notification on biomedical waste management makes it mandatory for all the health care units to implement this rule., so in order to control the effect of biomedical waste proper methods are to be adapted to control the adverse effect some of which are as follows.

Incineration: under this process the wastes is completely oxidized and denatured.

Deep burial: According to biomedical waste rule 1998 the waste which falls under the category 1 and 2 may be treated by deep burial technique and some important points are to be kept in consideration while using this technique such as this method is only applicable in towns with population less than 5 lakhs and in rural areas and the site which is selected should be authorized by the concern authority along with this proper distance should be maintained from the residential area keeping in view that contamination of surface water or ground water may not occur and the area should not be prone to flood and erosions.

Autoclaving: It is a low heat thermal process where waste is brought in direct contact with the steam for such duration that the materials are disinfected. These are of three types

- Gravity type: Air is evacuated by the help of gravity alone; system operates at temperature of 121deg. C and steam pressure of 15 psi for 60-90 minutes.
- Pre-vacuum type: This process vacuum pump is used to evacuate air from the pre-vacuum autoclave system so that the time cycle is reduced 30-60 minutes and it operates at 132 deg. C.
- Retort type: It is used to operate for much larger volume at much high steam temperature and pressure.

Shredding: Under this processes biomedical waste such as syringes, bottles etc are broken down in to small pieces so that they may not be used again and can easily be disposed off.

Needle cutter: As in order to prevent the reuse of needles and their proper deposal needle cutters are used.

Microwaving: Under this technique the biomedical wastes are treated for sterilization and onsite disposal of biohazard. It requires an adequate power supply and does not produce any emissions.

Disinfection: For liquid 1-10 % bleach is used to disinfect biomedical waste, solution if sodium hydroxide is also used as disinfectant depending upon the nature of the waste (Thakur *et al*., 2012).

Chemical treatment: Under this method the waste including solid, sharps liquid etc are treated by chemicals using 1% hypochlorite solution with minimum contact time of 30 minutes. In USA this technique is quiet common and is also available in mobile vans, primarily the waste is shredded and is passed through 10% solution of pypochlorite followed by further fine shredding and drying of waste which is later on land filled.

Secured landfills: It is a dumping site where solid waste including paper glass and metal is concealed between the layers of different materials in such a way so as to trim down the contamination. Landfills are often lined with the layer of absorbent materials and sheet of plastics in order to prevent the leakage of waste in to the soil and water.

Along with all these basic techniques some work by Indian government agencies in collaboration with international organizations is bean done such as innovative biomedical waste management project was launched by Ministry of Environment and Forest (MoEF), United Nations Industrial Development Organisation (UNIDO), Global Environmental Facility (GEF) in association with State

Pollution Control Board, under this project five states i.e. Gujarat, Karnataka, Maharastra, Odisha, and Punjab were involved. The project was based on the non burning technique; microwaves will be established at the identified hospitals in the first phase. 28 leading hospitals (four large, eight medium and 16 small) will be covered in the in the pilot project. A hospital with more than 500 beds is categorised as a large hospital.

Solar thermal autoclave refiner: It is an important method for wet sterilization of biomedical instruments along with WES system and proves handy in rural areas of developing countries. It works on the absorption of Sun's energy by a semi parabolic black mirror which transmits energy to the aluminium plate which kills viruses', microbes and later on contaminated effluent water is treated with high speed water separation recycler for removal of contaminants without the use of any sought of chemical while executing the process primarily the electric impulse are applied to clump the contaminants and later on the low power pulses generate micro bubbles to lift the contaminates for harvest (Abitha and Dhanapal, 2014).

References

Abitha, S.B. and Dhanpal, R. (2014) Biomedical waste management in rural areas using solar powered thermal autoclave technique. National Conference on Green Engineering and Technologies for sustainable future. *J. Chem. Pharmaceut. Sci.*, Special issue 4, 144–145.

Agarwal, B., Kumar, M., Agarwal, S., Singh, A. and Shekhar, A. (2011) Biomedical waste and Dentistry. *J. Oral Hlth. Comm. Dent.*, **5**, 153–155.

Biomedical Waste (Management and Handling) Rules. (1998)

Biomedical Waste Management: Situational analysis and predictors of performances in 25 districts across 20 Indian States. *Indian J. Med. Res.,* **139**, 141–153.

Hossain, M.S., Anthanam, A., Narulaini, N.A.N. and Omar A.K.M. (2011) Clinical solid waste management practices and its impact on human health and environment – A review. *Waste Manage*, **31**, 754–766.

INCLEN Program Evaluation Network (IPEN) Study Group. (2012) Injection Practices in India. *WHO South-East Asia J. Public Hith.,* **1**, 189–200.

Janagi, R., Shah, J. and Maheshwari, D. (2015) Scenario of management of medical waste in US and UK: A Review. *J. Global Trends Pharm. Sci.*, **6,** 2328–2339.

Manasi, S., Umamani, K.S. and Latha, N. (2014) Biomedical waste management: issues and concerns, A ward level study of Banglore City. 1–22.

Mandal, S.N. and Dutta, J. (2004). Integrated Biomedical waste management plan for Patna city. *J. Inst. Town Plan India*, **6**, 1–25.

McVeigh, P. (1993) OR nursing and environmental ethics. Medical waste reduction, reuse and recycling. *Todays OR Nurse*, **15**, 13–18.

Ministry of Environment, Forest And Climate Change Notification (To be published in the Gazette of India, Extraordinary, Part II, Section 3, Sub section (i)) 2015, 1–39.

Nayak, A., Chopra, R. and Kaur, R. (2015) Biomedical waste management: A Review. *J. Adv. Med. Dent. Sci. Res*., **3,** 130–133.

Onursal, B. (2003) Health waste management in India. WHO Report.

Patel, D.A., Gupta, P.A., Kineriwala, D.M., Shah, H.S., Teivedi, G.R. and Vegad, M.M. (2012) An investigation of an outbreak of viral hepatitis B in Modassa town, Gujarat. India. *J. Global Infect. Dis*., **4,** 5–9.

Pruss, A., Giroult, E. and Rushbrook, D. (1999) Safe Management of Wastes from Health-Care Activities, World Health Organization, Geneva.

Rastogi, V., Rastogi, P. and Shalini, B. (2011) Bacteriological Profile of Biomedical Waste Management Guideline. *J. Indian Acad. Forens. Med.,* **33,** 145–149.

Rudraswamy, S., Sampath, N. and Doggalli, N. (2013) Global Scenario of Hospital Waste Management. *Int. J. Environ. Biol.,* **3,** 143–146.

Sawalem, M., Selic, E. and Herbell, J.D. (2009) Hospital waste management in Libya: A Case Study. *Waste Manage.,* **29**, 1370–1375.

Shinee, E., Gomoboja, E., Nishimura, A., Hamajima, N. and Ito, K. (2008) Health care waste management in the capital city Mongolia. *Waste Manage*., **28**, 435–441.

Singh, A., Singh. J., Singh, A.P. and Singh, R. (2014) Biomedical Waste Management and their Possible Health risks with Controlling Measures in Bareilly city, UP, India. Oct. *J. Res.,* **2**, 296–302.

Status and issues on the implementation on biomedical waste (Management and handling) rules, 1998

and as amended. Final annual report-2013 as on 26-3-15Central pollution control board (Hazardous waste management division).

Thakur, Y., Surjit, S. and Katoch. (2012) Emerging technologies in Biomedical Waste Treatment and disposal. *Chem. Eng. Transact.,* **29**, 787–792.

Tsakona, M., Anagonostopoulou, E. and Gidarakos, E. (2007) Hospital waste management and toxicity evaluation: a case study. *Waste Manage*., **27**, 912–920.

Sengodan, V.C. (2014) Segregation of biomedical waste in an South Indian tertiary care hospital. *J. Nat. Sci. Biol. Med.,* Jul-Dec; **5,** 378–382.