Biomedical Waste Management in Indian Context

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***Abstract*—This article is a detailed discussion of the biomedical waste characteristics, its effects, management and handling. Biomedical waste generated in hospitals, veterinary centers, biomedical research centers or laboratories are infectious, radioactive and chemically hazardous spreads contagious diseases, generates unhygienic conditions and end up with health hazards when the disposal or treatment is not proper. It is extremely important for each and every individual to be cognizant of all adverse effects induced by biomedical waste generation and their mishandling. This study gives an insight of all the ill effects generated by improper biomedical waste management, as human's proximity to the biomedical waste effects is very high in the present day scenario due to huge population growth and unawareness. This study also analyzes biomedical waste management and handling rules, 1998 notified under Environmental Protection Act, 1986 which is in existence to mitigate adverse effects of biomedical waste.**

***Index Terms*—Biomedical waste, biomedical waste management, proximity to biomedical waste effects, mitigation, biomedical waste management and handling.**

I. INTRODUCTION

Environmental science is a branch of science which deals with study of interaction of living species with its both living and non living components. All living species along with human beings interact with environment in a complex manner with balanced components. But all these components are strongly influenced by humans by their interference. World population is tremendously growing day by day and huge stress is imposed on all natural resources such as air, water, soil and biodiversity etc. Human is interfering, exploiting, and polluting all of them resulting dangerous consequences. Pollution can be generally referred under Air pollution, water pollution, soil pollution, marine pollution, noise pollution, radioactive pollution, thermal pollution. But, present day due to huge population growth, life styles, public unawareness, and improper technical management new problems are rising on global screen in the form of solid waste, hazardous waste and biomedical waste. There is a grave danger for the environment, human and animal health from these wastes especially in the developing countries which have relatively large populations. The reasons for this can be crowded habitat, illiteracy, low sanitation, least environmental awareness. There is an urgent necessity to the entire human community to get aware of the consequences generated by the negligence and mismanagement of dangerous and infectious waste. The civic responsibilities include (1)maintaining safe, clean and hygienic environment, (2)discussing the environmental issues, (3)establishing good rapport with local authorities related to the local environment, and (4)bringing in the notice of the government authorities in case of considerable disturbances. Various rules are notified under Environmental protection act, 1986, such as hazardous waste management and handling rules, 1999 and biomedical waste management and handling rules-1998 to handle the hazardous and biomedical waste. The purpose of this article is to educate the current generation on the negative health impacts generated by biomedical waste and also discuss the current biomedical disposal practices in India as there is clear evidence that human is very prone to various infections which may turn to health hazards when come intact with biomedical waste.

II.BIOMEDICAL WASTE

According to biomedical waste management and handling rules,1998 notified under Environmental Protection Act,1986 "Biomedical waste is defined as any solid or liquid waste that is generated in the diagnosis, treatment of immunization of human beings or animals in research pertaining Thereto, or in the production or testing of biological material." These wastes when come in contact will become infectious or may spread contagious diseases. Biomedical wastes include a wide variety of items that may carry disease-causing germs including those that cause hepatitis and the virus that causes AIDS. It also includes items such as: live vaccines; laboratory samples; cultures; sharp needles; lancets that have been used to puncture, cut, or scrape the body; and human or animal body fluids or Other wastes generated in healthcare settings include radioactive wastes, mercury containing instruments, PVC plastics etc.,. The status of poor waste

management currently practiced in the city poses a huge risk towards the health of the general people, patients, and professionals, directly and indirectly through environmental degradation. Communicable diseases like gastro-enteritis, hepatitis-A and B, respiratory infections and skin diseases are associated with hospital waste either directly as a result of waste sharp injuries or through other transmission channels.Table1,represents types of infectious, pathogens agents and transmission path due to Biomedical waste generations.

The Government of India in a recent Gazette notification has classified biomedical waste under Schedule I, into ten categories mentioned in Table2,include,(1) Human anatomical waste.),(2) Animal waste, (3) Microbiology and biotechnology waste,(4) Waste sharps, (5) Discarded medicines and cyto-toxic drugs,(6) Soiled waste,(7) Solid waste ,(8) Liquid waste generated from any of the infected areas,(9) Incineration ash and(10) Chemical waste etc. World Health Organization states (WHO) that 85% of hospital wastes are actually non-hazardous, whereas 10% are infectious and 5% are non-infectious but they are included in hazardous wastes like methyl chloride and formaldehyde. About 15% to 35% of Hospital waste is regulated as infectious waste. This range is dependent on the total amount of waste generated [1]. Among the 35 million healthcare workers worldwide, the estimations show that each year about 3 million receive hard exposures to blood borne pathogens[2], 2 million of those to HBV[2], 0.9 million to HCV and 1,70,000 to HIV[2].The hosts of micro organisms responsible for infection are enterococci, non-haemolytic streptococci, anaerobic cocci, clostridium tetani, klebsiella,cocci, non-haemolytic streptococci, anaerobic cocci, clostridium tetani, klebsiella, HIV and HBV [3].

TABLE I

TYPES OF INFECTIOUS, PATHOGENS AGENTS AND TRANSMISSION PATH DUE TO BIOMEDICAL WASTE GENERATIONS [4]

Sl.No.	INFECTION TYPE	PATHOGEN AGENTS	TRANSMISSION PATH
1	. Gastrointestinal Infections	Enterobacteria:salmonella, Shigella Spp, vibrio cholera Helminths.	Faeces or/and vomiting liquid
2	Respiratory Infection	Herpes virus Mycabocterium tuberculosis, Measles virus Sreptococcus preumonae	Respiratory secretions, saliva
3	Eye Infections	Herpes virus	Eye secretions
4	Genital Infections	Neisseria gonorrhoeae Herpes virus	Genital secretions
5	Skin Infections	Streptococcus spp	Purulent secretions
6	Anthrax Bacillus	anthracis	Secretions of skin lesions
7	Meningitis Neisseria	Neisseria meningitides	L.C.R.
8	AIDS HIV	HIV	Blood, Semen, Vaginal Secretions
9	Hemorrhagic fevers	Iunin viruses, Lassa, Ebola Marburg	Biological fluids and secretions
10	Septicemia	Staphylococcus ssp	Blood
11	Viral Hepatitis type A	VHA	Faeces
12	Viral Hepatitis type B and C	VHB, VHC	Blood, biological fluids.

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III.VARIOUS POTENTIAL SOURCES OF INFECTIONS

Hospitals, biomedical centers, Veterinary hospitals, laboratories and also improper disposal act as Potential sources of infection if biomedical waste is not handled or managed properly.

A. Viral Infection Transmission At Biomedical Centers:

Viral infections such as HIV shown in Fig.1 Hepatitis B, and Hepatitis A which cause AIDS, Infectious Hepatitis are spread by pathogen contaminated needles, body Fluids, Blood, soiled linen. Fig.2 represents Enterovirus causing Dysentery and Fig.3 represents Arbovirus which causes Dengue, Japanese encephalitis, tick-borne fevers and Fig.3 shows Arbovirus which causes Dengue, Japanese encephalitis, tick-borne fevers which can be spread through body fluids, Human excreta, soiled Linen.

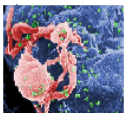

Figure 1. HIV Virus

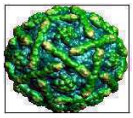

Figure 2. Enterovirus

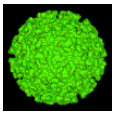

Figure 3. Arbovirus

B. Bacterial Infection Transmission At Biomedical Centers:

Shigellosis causing Shigella spp., Typhoid causing Salmonella typhi and Vibrio cholera which cause Cholera represented in Fig.4, Fig.5 and Fig.6, are transmitted by body fluid in landfills and hospital wards. Staphylococcus spp. shown in Fig.7 which cause wound infections, septicemia, rheumatic fever skin and soft tissue infections, endocarditis (inflammation of the inner layer of the heart) causing Bartonella henselae bacilli shown in Fig.8, Tetanus generating bacteria Clostridium Tetani are common bacterial transmissions by biomedical waste like Sharps such as needles, surgical blades in hospital waste.

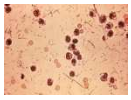

Figure 4. Shigella Spp A

Figure 5. Salmonella Typhi

Figure 6. Vibrio Cholera

Figure 7. Staphyloccocus Spp.

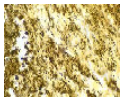

Figure 8. Bartonella Bacilli

C. Parasite Infection Transmission At Biomedical Centers:

Fig.9, Fig.10 and Fig.11 represents Giardia lamblia, Wucheraria bancrofti and Plasmodium parasites which cause - Giardia lamblia, Cutaneous leishmaniasis, Kala Azar and Malaria respectively, are transmitted by Human excreta, blood and body fluids in poorly managed sewage system of hospitals.

Figure 9. Giardia Lamblia

Figure 10. Wucheraria Bancrofti

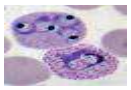

Figure 11. Plasmodium

D. Sources Of Infections At Veterinary Hospitals:

Veterinary practices without following infection control measures will end up causing zoonotic infections to the practitioners and staff members while diagnosis and treatment. A survey done veterinarians identified as practicing clinical medicine in King County proved One hundred five of 371 (28%) respondents indicated that they had been infected with a zoonotic disease in practice, with 22 respondents indicating that they had had > 1 zoonotic disease. A total of 133 cases of zoonotic disease, of which 70 (53%) were not medically confirmed, were listed by these 105 veterinarians [5].

E. Disease Transmission Due To Contamination In Laboratories :

Past history shows disease transmission is very common to the technicians, laboratorians or microbiologists working in laboratories by various reasons which can be proved by the following examples. A needle stick injury while passaging amastigotes (NIH strain 173) in mice infected a graduate student with L. tropica. [6].

While Inoculating a hamster with an infected macerate containing ~2,000 amastigotes/µl a laboratorian became infected with L. (V.)braziliensis (L1794 MHOM/VE/84[VE3]) by puncturing her thumb accidentally with a needle that “pierced its plastic hood” [7]. Four days after handling infected blood a

medical biology department student had skin excoriations and became ill. At the time of initial diagnosis his parasitemia was 5% and several days later, he developed oliguria and cerebral malaria, with altered mental status and hallucinations [8]. A solution of trypomastigotes (Tulahuen strain) was spilled by a microbiologist onto slightly abraded skin on his left hand developed Chagas' disease [9]. Ascitic fluid from infected mice was accidentally spilled onto small scratches on the left hand of a laboratorian and developed fever and left axillary lymphadenopathy 10 days later [10].

SARS coronavirus has also been propagated in reference and research laboratories, and distributed to other laboratories for research purposes after SARS outbreak in China. Research using live and inactivated SARS coronavirus – and other pathogens capable of causing serious illness -- is being conducted in many laboratories. "China's latest SARS outbreak has been contained, but biosafety concerns remain"(WHO) this statement clearly shows the risk of bio safety.

F. Effects Of Improper Disposal Of Biomedical Waste:

Biomedical waste disposal if not proper can generate high infectious, unhygienic conditions and pollutes environment. In the dumping site Bijauli as well as satellite areas of the Jhansi city the open dumping of the dangerous biomedical wastes, where found to be contaminated with disease carrying pathogens spreads infection . The disposal of incineration ash as well as fly ash having toxic because of heavy metals, dioxins and furan in it affecting ground water regime. Burning of biomedical waste at open dumping site, creating toxic elements and compounds and contaminating the environment with lethal chemical dioxin where materials containing chlorine burned [11].

Ministry of Environment & Forest, Govt. of India issued a notification on 20th July, 1998 for Biomedical Waste(Management & Handling) Rules 1998 in exercise of powers conferred by Section 6, 8 & 25 of the Environment (Protection) Act, 1986 that was published in The Gazette of India Extraordinary, Part-II, Section 3-Sub-Section (ii) New Delhi, July 27, 1998 . These rules may be called the Bio-Medical Waste (Management and Handling) Rules, 1998 by following these rules can reduce the ill effects of biomedical waste on human beings and environment.

IV.OBJECTIVES OF BIOMEDICAL MANAGEMENT

1) To prevent transmission of disease from patient to patient, from patient to health worker and vice versa
2) To prevent injury to the health care worker and workers and workers in support services, while handling biomedical waste.
3) To prevent general exposure to the harmful effects of the cytotoxic, genotoxic and chemical biomedical waste.

"Biomedical waste" according to biomedical waste rules includes categories mentioned in Schedule I; The Government of India in a recent Gazette notification has classified biomedical waste under Schedule I, into ten categories. According occupier of an institution generating biomedical waste shall be treated and disposed of in accordance with Schedule I, and in compliance with the standards prescribed in Schedule V shown in Table2.

TABLE II

TYPES OF BIOMEDICAL WASTE ,TREATMENT AND DISPOSAL UNDER SCHEDULE I AND IV OF BIOMEDICAL WASTE MANAGEMENT AND HANDLING RULES, 1998.

CATEGORIES (SCHEDULE I)	TYPES OF BIOMEDICAL WASTE	TREATMENT AND DISPOSAL(SCHEDULE V)
Category:1	Human anatomical waste (tissues, organs, body parts etc.).	Incineration/deep burial
Category:2	Animal waste (as above, generated during research/experimentation, from veterinary hospitals etc.).	Incineration/deep burial
Category:3	Microbiology and biotechnology waste, such as, laboratory cultures, micro- Organisms, human and animal cell cultures, toxins etc.	Localautoclaving/microwaving/incineration
Category:4	Waste sharps, such as, hypodermic needles, syringes, scalpels, broken glass etc.	Disinfection (chemical treatment/autoclaving /microwaving and mutilation/shredding
Category:5	Discarded medicines and cyto-toxic drugs.	Incineration/destruction and drugs disposal in secured landfills

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Category:6	Soiled waste, such as dressing, bandages, plaster casts, material contaminated with blood etc.	Incineration/autoclaving/microwaving
Category:7	Solid waste (disposable items like tubes, catheters etc. excluding sharps).	Disinfection by chemical treatment/autoclaving/ microwaving and Mutilation/shredding
Category:8	Liquid waste generated from any of the infected areas.	Disinfection by chemical treatment and discharge into drains
Category:9	Incineration ash.	Disposal at municipal landfills.
Category:10	Chemical waste.	Chemical treatment and discharge into drains for liquids and secured landfill for solids

While treating the biomedical waste certain things should be taken for consideration such as, Chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent and 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.

Segregation Of Biomedical Waste:

Biomedical waste shall not be mixed with other wastes. Biomedical waste shall be segregated into specific colored containers/bags at the point of generation in accordance with Schedule II prior to its storage, transportation, treatment and disposal is represented in Table 3, category wise treatment and disposal of biomedical waste is shown in Table 2 as per schedule I and II.

TABLE 3

SEGREGATION OF BIOMEDICAL WASTE IN ACCORDANCE WITH SCHEDULE II

CONTAINER COLOR CONDING	TYPE OF CONTAINER AND WASTE CATEGORY
Yellow	Plastic bag Cat. 1, Cat. 2, and Cat. 3, Cat. 6.
Red	Disinfected container/plastic bag Cat. 3, Cat. 6, Cat.7.
Blue/White translucent	Plastic bag/puncture proof Cat. 4, Cat. 7. Container
Black	Plastic bag Cat. 5 and Cat. 9 and Cat. 10. (solid waste)

Labeling The Containers:

Containers shall be labeled according to Schedule III with biohazard symbol shown in Fig.12, or Cytotoxic Hazard symbol shown in Fig.13, accordingly

Figure 12. Biohazard Symbol

Figure 13. Cytotoxic Hazard Symbol

If a container is transported from the premises where biomedical waste is generated to any waste treatment facility outside the premises, the container shall, apart from the label prescribed in Schedule III, also carry information prescribed in Schedule IV. If the waste treating site is outside the premises untreated biomedical waste shall be transported only in such vehicle as may be authorized for the purpose by the competent authority as specified by the government according to Motor Vehicles Act, 1988. Label on waste transporting shall be non-washable and prominently visible. It should have all the details like time of generation, waste category, waste class and description along with full address of sender and receiver.

Biomedical waste shall be treated and disposed of in accordance with Schedule I, and in compliance with the standards prescribed in Schedule V which gave clear guidance for standards of incineration operating and emission, autoclaving, microwaving, deep burial,

Liquid waste. No untreated bio-medical waste shall be kept stored beyond a period of 48 hours.

Prescribed authority of Government of every State and Union Territory will be granting authorization and implementing the rules. Operator of a bio-medical waste facility or occupier of an institution generating, collecting, receiving, storing, transporting, treating, disposing and/or handling bio-medical waste in any other manner, except such occupier of clinics, dispensaries, pathological laboratories, blood banks providing treatment/service to less than 1000 (one thousand) patients per month, shall make an application in Form I to the prescribed authority for grant of authorization shall be accompanied by a fee as may be prescribed by the Government of the State. Every occupier/operator shall submit an annual report to the prescribed authority in Form II by 31 January every year. They should maintain the records related to biomedical waste handling and report during inspection. Accidents should be reported in form III. By following these handling rules a clear solution is possible to minimize the burden on human health.

V.OBSERVATION AND REVIEW OF CURRENT PRACTICES OF DISPOSING BIOMEDICAL WASTE

The biomedical waste which is generated at all biomedical waste generation centers since recent past in India used to dump or incinerate without proper segregation and recycling is done by rag pickers or freelance workers scour these waste manually and separate recyclable material to pass on to relevant industries which acquire waste from them. Many of them contact diseases from syringes and needles and other biomedical waste and become carriers of great health risk to the general populace. Not only have that because of unawareness the people are still coming in risked zone.

All the reviews and observations clearly elevates the problems generated by biomedical waste at all the stages from its generation to improper disposal and human's proximity to ill effects of biomedical waste shows the immense necessity of Biomedical waste Management. Handling, segregation, mutilation, disinfection, storage, transportation and final disposal are vital steps for safe and scientific management of biomedical waste in any establishment [12]. In India at the present day biomedical waste management is given much priority in urbanized sectors can be shown by the following observations.

In KLE Society's J. N. Hospital and Medical Research Center, Belgaum, India [13], the process of segregation, collection, transport, storage and final disposal of infectious waste will be done in compliance with the Standard Procedures and the final disposal was by incineration in accordance to EPA Rules 1998**.** Sir Ganga Ram Hospital of New Delhi follows mutilation and disinfection of biomedical waste sharps and syringes while handling and disposes the sharps into sharp pit. Microwaving and shredding of syringes is opted in Ram Manohar lohia hospital, New Delhi, and plastic recycling in Ramaiah Medical College, Bangalore. Sundaram Medical Foundation, Chennai performs smelting of disinfected and mutilated metal sharps in an iron foundry. Tata Memorial Hospital, Mumbai prefers hyroclaving and shredding sharps Autoclave Effluent treatment plant has centralized facility for biomedical waste with Incinerators, WHO keenly studied Centralized Facilitly Medi, facility of Encapsulation of sharps in bunkers. at GJ Multiclave India Pvt. Ltd and Medicare Incin. Pvt-Hyderabad and expressed satisfactory management of sharps but still quotes sustainable final disposal is required [14].

VI. SOME PROPER METHODS OF HANDLING BIOMEDICAL WASTE

- The medical practitioners and veterinary practitioners need to follow bio safety measures using disinfectants, washing hands after diagnosis; prohibiting eating and drinking in testing areas can reduce their exposure to ill effects. They are suggested to give guidelines of safety to their supporting staff and made them aware of biomedical effects can improve hygienic attitude at the medical centers.
- Nasocomial infections to patients can be avoided with efficient infection control and Waste management.
- Safety measures should be taken by micro biologists and laboratory technicians while handling needles, medical sharps and biomedical liquid waste to avoid infections.
- Occupiers of any biomedical waste generation centers are to implant cost effective relevant technologies and also can opt for common biomedical waste treatment plants to manage the waste generated. Segregation should be done according to biomedical handling rules; safety is maintained by using masks and gloves. Medical and Para medical staff while handling or segregating biomedical waste suggested pertaining at most care.
- All the medical waste generating centers strictly need to follow biomedical waste management rules which are well monitored. In case of any negligence shown towards handling rules should get punished.
- Dumping Biomedical waste by following the handling rules which generates least scope of air, ground water or biological soil pollution.

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- Raising awareness, Information dissemination to be done through organizing seminars, workshops, practical demonstrations, group discussions and lectures etc to all the concerned persons. Above all from common man to professionals and rag pickers to municipality staffs are to be educated with biomedical waste characteristics and ill affects so that from basic level to high technology handling and treatment according to law can revert the hazardous health and environmental conditions in the way of safe living.
- Common and combined biomedical treatment plants can be worked out for 30 to 40 bed hospitals with cost efficient biomedical waste treatment.

SUMMARY AND CONCLUSION

With the reviews done and observation Human's proximity to the ill effects of biomedical waste clearly indicated at all levels from diagnosis, treatment, research laboratories and improper dumping if measures are not taken accordingly. The risk exists even from stored pathogens in research laboratories. Biomedical waste management and handling rules, 1998 notified under Environmental Protection Act, 1986 gave clear guidelines to handle the biomedical waste at all levels following which we can mitigate the effects of biomedical waste.

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