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Biomedical Waste Management Using Biological Methods: A Case Study

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ABSTRACT
Biomedical waste management has become one of the major issues in many developing countries including India. According to World Health Organization report, about 85% of hospital waste is non-hazardous but the remaining 15% is toxic, infectious or radioactive. Biomedical wastages generated in hospitals, clinics, research centers and laboratories differ from other wastes since it contains many microbes and toxic materials which may spread infection and cause health issues if it is not properly disposed. Incautious and random disposal of biomedical waste by hospitals and research laboratories can lead to the spread of contagious diseases including common flu, herpes, HIV and bacterial infection due to the interaction of people with used cotton, swab, needles, gauze and surgical blades. The most commonly practiced methods for treating infectious wastes includes incineration, steam treatment and land filling also doesn't decontaminate the waste completely. Biological waste management methods can be applied to ensure maximum decontamination of biomedical waste. This paper explores the application of natural components such as Neem, Turmeric and Garlic for ecofriendly biomedical waste management.

I. INTRODUCTION
A study conducted by industry body ASSOCHAM (The Associated Chambers of Commerce and Industry of India) and Velocity has stated that India will generate about 775.5 tons of medical waste per day by 2022 [1]. According to the definition of Biomedical Waste Management Rules, 2016 framed by the MoEFCC, Government of India, "biomedical waste" means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps [2]. Biomedical waste may be solid or liquid. The activities such as diagnosis, prevention, and treatment of diseases are the major sources that are responsible for the production of biomedical waste.

The fundamental idea of good BMW practice is based on the perception of 3R specifically, reduce, recycle and reuse. Biomedical waste treatment and disposal facility means any facility wherein treatment, dumping of BMW or procedure incidental to biomedical waste treatment and ejection are carried out. The high-risk part of the waste include physical, chemical, and/or microbiological risk to the general population and health-care workers associated with handling, treatment, and getting rid of this waste. Of the total waste generated from the hospital, approximately 85% is general (non risk) waste. 10% is precarious while a small percentage (5%) is identified as highly hazardous. Nowadays, all the hospital biomedical waste is being disposed along with municipal solid waste. The unprocessed liquid waste from the health institutions is disposed into drainage. On the whole the waste is collected in unwrap containers devoid of disinfection. As a consequence of all these, there will be a great impact on air and water quality changes which leads to cause of various diseases.

SOURCES OF BIOMEDICAL WASTE
Sources of biomedical wastes include unwanted microbiological cultures and stocks, identifiable body parts (surgical residuals), surgical gloves, sharp accessories, human tissue that includes infected/burnt skin, utilized bandages and dressings, scrap blood, other medical accessories that are used in contact with blood and bodily fluids (Urine, Saliva, Sputum) and clinical waste. Waste sharps may consist of potentially unsterilized needles, lancets, electrodes, strips, scalpels and other medical accessories that may penetrate through the skin [3]. Gauze, cotton, bandages, swab and other materials used to absorb bodily fluids were usually collected and stored in plastic containers. Biomedical waste from department wards, operation theatres, outpatient department, biochemistry and pathological laboratories that are thrown away

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without proper sterilization and decontamination also constitute for the biomedical waste. Anatomical wastes from surgeries, amputated body parts and other highly contagious wastes are incinerated wherever the incinerators are available; the remainder is burnt in some corner of the hospital grounds, mostly in open pits.

In the same manner, all expendable plastic items are isolated by the waste pickers, from where the waste is put aside either inside the hospital grounds or outside in the community bin for further transit and dumping along with municipal solid waste. Since the toxic waste gets mixed with municipal solid waste, it has potential to make the whole lot contagious in adverse environmental conditions. Most biomedical waste generated from hospitals are at present collected without segregation into toxic and non-toxic categories and are disposed in municipal bins located either inside or outside the hospital campus. All these wastes if not treated properly, leads to adverse effects on the environment. Hence a proper measure has to be taken to handle/ treat these wastes.

CLASSIFICATION OF BIOMEDICAL WASTE

Hirani et al. (2014) discussed the classification of biomedical waste. The rules organize biomedical waste into 10 categories [3] which is presented in the Table below.

Category No.	Waste Content	Components	Method of treatment and disposal
1	Human Anatomical waste	Injured Body parts and organs, waste human tissues	Deep burial / Incineration
2	Animal Waste	All types of Animal tissues and organs	Bleeding parts, body parts carcasses, etc
3	Microbiology & Biotechnology Waste	Specimens of micro- organisms used in research, Wastes from laboratory cultures, stocks etc	Micro waving / Local autoclaving / incineration
4	Waste sharps	Needles, blades, glass, syringes, scalpels etc	Disinfections chemical treatment
5	Discarded Medicines and Cytotoxic drugs	Expired, contaminated and discarded Medicines	Incineration/Destruction and disposal of drugs in landfills
6	Solid Waste	Blood contaminated cotton, dressings, Bandages, lines etc	Autoclaving, Incineration, micro waving
7	Solid Waste	Syringes, catheters, intravenous sets etc	Disinfections chemical treatment
8	Liquid Waste	Waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities	Disinfections by chemical treatment and discharge into drains
9	Incineration Ash	Ash from incineration of any bio-medical waste	Disposal in municipal landfill
10	Chemical Waste	Chemicals used in production of Biological	Chemical treatment and discharges into drains

Table 1: Categories of Biomedical waste

Waste is collected in varied forms. Some hospitals in the country have urbanized their own scheme of color coding. Depending on the category, different types of biomedical wastes are stored in different colored containers.

S.No	Colour	Category No.	Type of Waste
1	Yellow	1	Human Anatomical waste
		2	Animal Waste
		3	Microbiology & Biotechnology Waste
		5	Discarded Medicines and Cytotoxic drugs

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		6	Solid Waste
		8	Liquid Waste
		10	Chemical Waste
2	Red	7	Recyclable solid waste
3	White	4	Waste sharps
4	Blue	3	Glassware, Metallic body implants

Table 2: Color coding for collection of Biomedical waste

EFFECTS OF BIOMEDICAL WASTE

Biomedical waste has a great impact on human health and on the environment. The workers of hospitals like nurses, ward boys, sweepers, cleaners, waste pickers etc., will be working in contact with all these wastes and have a high chance of getting infected. Pathological and radioactive wastes cause adverse effects on the environment. These wastes cause air, water and soil pollution. A number of air and water borne diseases such as plague, jaundice, malaria, cholera and dysentery are reported due to biomedical waste [4,5].

RULES AND REGULATIONS FOR BIOMEDICAL WASTE MANAGEMENT

The Ministry of Environment and Forests (MOEF) notified Biomedical Waste (Management and Handling) Rules, 1998 and 2016 in order to control the unselective & unchecked disposal of hospital waste/ biomedical waste. As per these Rules, it is the duty of every 'occupier' i.e., a person who has power over the organization and or its place, has to take all steps to make sure that waste generated is handled without any undesirable effect to human health and environment. Hence it is necessary to set a place for the biological waste treatment in hospitals, nursing homes, clinic, dispensary, animal house and pathological lab etc., [6].

EXISTING BMW TREATMENT AND DISPOSAL METHODS

Some of the existing biomedical waste treatment methods are Incertization, Placenta Anaerobic Bioreactor (PAB), Incineration, Solar powered autoclave style sterilizer, Wet and dry thermal treatment, Plasma pyrolysis and land disposal. Biomedical waste shredding is another new technique in which the waste is condensed to as small as 20% of its original amount [7-14].

PROPOSED BIOLOGICAL TREATMENT AND DISPOSAL METHODS

Biomedical waste can not be decontaminated completely using existing methods since the volume of biomedical waste is increasing every year. Some of the potential alternatives must be applied to destroy or convert the biomedical waste into a less dangerous substance. Biological methods can be used as an alternative to treat biomedical waste in an eco friendly manner. These methods use biological solutions such as enzymes derived from natural extracts and convert the waste into a decontaminated sludge which can be disposed of in the landfill safely. The proposed work explores the possibilities of using natural fluids extracted from several herbal species including neem leaves (*Azadirachta indica*), Garlic (*Allium sativum*) and Turmeric (*Curcuma longa*) for biomedical waste management.

1. Neem (*Azadirachta indica):*

Neem leaves and its constituents (flowers, seeds, fruits, roots and bark) have been demonstrated to exhibit a wide range of medicinal properties including anti-fungal, antioxidant, anti-bacterial and anti-carcinogenic properties. Quercetin and Beta-sitosterol were the polyphenolic flavonoids purified earlier from fresh neem leaves and were known to possess antibacterial and antifungal properties. The present investigation explores the antifungal activity of ethanol and ethyl acetate extracts from neem leaves **(***Azadirachta indica also called as margosa, bead tree, indiar, holy tree, pride of China, lilac tree)* comprises a collection of triterpenoids, steroids, tetranortriterpenoids, esterterpenoids and sesquiterpenoids [15, 16]. These natural components may reduce the growth of some bacterial species including *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterococcus faecalis* and *Proteus mirabilis* which are commonly found hospital wastes.

2. Garlic (*Allium sativum*):

Garlic is a commonly used herb for many years throughout the world since it is considered to have many medicinal properties including antimicrobial, antiparasitic, antiseptic, expectorant, anthelmintic and diaphoretic properties. Garlic has putative active components such as a number of organo-sulfur compounds (*allicin* has potent anti bacterial agent) and a variety of non-sulfur compounds like steroid aponins and many organoselenium compounds. The intact bulb of

garlic has a mixture of γ-glutamylcysteines and cysteine sulfoxides. Disruption of garlic bulb causes the sulfoxidases to be cleaved to an active form of thiosulfinate allicin which exhibit potent anti-fungal properties [17-19]. A study conducted in hospital sites reported some commonly found fungi species in hospital waste including Penicillium rubrum, Penicillium viricadum, Rhizopus nigricans, Aspergillus flavus and Trichotheciumroseum. Another study done on isolated soil of hospital dumpsites showed presence of several other fungi species such as TrichotheciumroseumandPenicilliumviricadum. All these fungal species can be treated with garlic extract for hospital waste decontamination.

3. Turmeric (*Curcuma longa*):

Turmeric is a traditionally used herb in India for thousands of years which is proven to have antimicrobial, antifungal, antibacterial and antiviral properties. A potent phenolic component Curcumin present in turmeric exhibits a variety of antipathological properties against *Escherichia coli, Staphylococcus aureus, Bacillus cereus, Bacillus subtilis, Psuedomonas aeruginosa and Bacillus coagulans*. Some of the other major active components of turmeric include demethoxycurcumin and bisdemethoxycurcumin also have antimicrobial properties [20-22]. More than 100 potential medicinal components were isolated from turmeric used for the synthesis of pharmacological agents [23, 24]. A study conducted in Indian hospital sites reported that many types of bacteria isolated from hospital waste consisted of *Proteus vulgaris, Citrobacter sp., E. coli and Klebsiella sp.* can be converted into non-hazardous waste by processing the waste with biological enzymes derived from turmeric.

II. DISCUSSIONS

The above mentioned herbal species can be used for bioconversion of pathological waste into decontaminated waste which can be disposed of in an eco friendly manner. Herbal extracts can be used in the form of powders or fluids to process the hazardous waste. Herbal extracts as individuals or mixtures of two or more species can be used for treating the waste depending on the volume and type of medical waste. Treatment duration may be varied according to the effectiveness of different materials used. Different types of medical waste can be accumulated and processed collectively or separately in specific bio conversion reactors. Hospital waste can be collected and accumulated in an isolated space near the concerned departments. This stored waste can be treated routinely in the bioconversion plant established inside the hospital campus. After decontamination, non-hazardous waste can be transported carefully using dedicated vehicles marked with the "Biohazard" symbol. Decontaminated waste can be stored and transported within 48 hours after bio conversion.

III. CONCLUSIONS AND FUTURE ENHANCEMENT

Biomedical waste management in many developing countries requires more facilities to reduce the chances of disease spread among the general population as well as personnels in hospitals and research laboratories having close contact with these wastes. A case study showed that a marginal amount of biomedical waste has the capability to spread infectious and contagious diseases including skin infections, influenza, respiratory diseases, hepatitis and gastrointestinal maladies. Biomedical waste management becomes a major concern if it interferes with the environment. Proper decontamination of biomedical waste is necessary to ensure environmental safety since the volume of biomedical waste increases every day due to increasing population. Practising bioconversion techniques with biologically derived extracts will substantially manage biomedical waste decontamination and preserve the environment from infectious diseases and pollution.

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