REVIEW ARTICLE

A simplified model for biomedical waste management in dental practices - A pilot project at Thane, India

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ABSTRACT

A lot of biomedical waste (BMW) is generated in dental practices, which can be hazardous to the environment as well as to those who come in contact with the materials, if not dealt with appropriately. Most of the rules world-wide are not specific for dental BMW management and hinder easy understanding by dental practitioners. Because of lack of clear-cut guidelines either from Dental Council of India or Government of India or Indian Dental Association (IDA) on disposal of dental wastes, this article is designed to explore and review on these issues and formulate a simplified scheme. The guidelines by the Maharashtra Pollution Control Board from the directives of The Ministry of Environment and Forests, Government of India through BMW (Management and Handling) Rules, 1998, (BMW-MH-98), similar guidelines being followed elsewhere in the world, the local BMW disposal company's rules and the IDA's Clinic Standardization Program guidelines. We developed and implemented a simplified waste segregation protocol for practicing dentists and dental hospitals. A methodological dental waste segregation protocol was required considering its disposal and ill-effects on health and the environment. The simplified scheme provided a good model to be followed in developing countries like India. The scheme improved understanding among dentists because of its self-explanatory nature.

Key words
Biomedical waste, dental waste, new model, waste management

INTRODUCTION

According to the Notification by the Ministry of Environment and Forests, Government of India; "biomedical waste (BMW)" means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals, and including categories mentioned in Schedule I [Table 1]; and the "Occupier" in relation to any institution generating BMW, which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank by whatever name called, means a person who has control over that institution and/or its premises. It further mentions that it shall be the duty of every occupier of an institution generating BMW to take all steps to ensure that such waste is handled without any adverse effect to human health and the environment.[1] By these definitions, Dentist is the occupier of a clinic who generates BMW and should be responsible for its overall handling.

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Inadequate and inappropriate handling of dental health-care waste may have serious public health consequences and a significant impact on the environment, considering the increasing number of dentists in urban areas and increased awareness about the dental treatment amongst the public. The total dental care waste produced throughout metros, e.g. Mumbai - Navi Mumbai Thane (India) belt, may not be in any way insignificant. To our modest estimation, an average running dental clinic may produce around 0.5-1.0 Kg of waste per day. The waste generated by around 4500 dentists practicing in and in the vicinity of Mumbai might be substantial. Appropriate management of dental care waste is thus a crucial component of environmental health protection and it should become an integral feature of dental services. The handling of BMW is mentioned in Schedule II [Table 1] of the BMW-MH-98 Rules.

CLASSIFICATION OF HEALTH-CARE BMW

Several classifications of health-care waste have been put forward. One such classification divides hospital waste into hazardous and non-hazardous.[2] There are various categories of hospital waste, but some are important for dental care workers. Waste categories and description as suggested by World Health Organization,[3] is given in Table 2.

HEALTH HAZARDS OF DENTAL CARE WASTES

Because the BMW contains infectious agents, toxic or hazardous chemicals or pharmaceuticals, sharps and it may be genotoxic or radioactive; it is potentially risky for persons who are exposed to it. There are health risks to several different and overlapping populations, e.g. health-care employees, dentists, patients, waste handling and treatment workers, and the general population.

1. Hazards from infectious waste and sharps:[4] Pathogens in infectious waste may enter the human body through a puncture, abrasion or cut in the skin, through mucous membranes by inhalation or by ingestion. There is a particular concern about infection with Human immunodeficiency virus and hepatitis virus B and C, for which there is a strong evidence of transmission via health-care waste. Bacteria resistant to antibiotics and chemical disinfectants may also contribute to the hazards created by poorly managed waste
2. Hazards from chemical and pharmaceutical waste:[4] Many of the chemicals are toxic, genotoxic, corrosive, flammable, reactive, explosive or shock sensitive. Although present in small quantity they may cause intoxication, either by acute or chronic exposure and injuries, including burns. Disinfectants are particularly

Table 1: Categories of biomedical waste, their segregation and disposal

Schedule I: Categories of biomedical waste[1]

Option	Waste category	Treatment and disposal
Category no. 1	Human anatomical waste (human tissues, organs, body parts)	Incineration*/deep burial†
Category no. 2	Animal waste (animal tissues, organs, body parts, carcasses, fluids, blood, experimental animals, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses)	Incineration*/deep burial†
Category no. 3	Microbiology and bio-technology waste (wastes from laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell culture and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)	Local autoclaving/microwaving/incineration*
Category no. 4	Waste sharps (needles, syringes, scalpels, blades, glass, etc., that may cause puncture and cuts. This includes both used and unused sharps	Disinfection (chemical treatment ‡/autoclaving/microwaving and mutilation/shredding)
Category no. 5	Discarded medicines and cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)	Incineration*/destruction and drugs disposal in secured landfills
Category no. 6	Solid waste-Items contaminated with blood and body fluids including cotton, dressings, plaster casts, linen, beddings, etc	Incineration*/autoclaving/microwaving
Category no. 7	Solid waste (wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc)	Chemical treatment‡/autoclaving/microwaving and mutilation/shredding§
Category no. 8	Liquid waste (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)	Disinfection by chemical treatment‡ and discharge into drains
Category no. 9	Incineration ash (ash from incineration of any biomedical waste)	disposal in municipal landfill
Category no. 10	Chemical waste (chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.)	Chemical treatment‡ and discharge into drains for liquids and secured landfill for solids

*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 lakh (5,00,000) and in rural areas; ‡Chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent; It must be ensured that chemical treatment ensures disinfection; §Mutilation/shredding must be such so as to prevent unauthorized reuse

Schedule II: Color coding and type of container for disposal of biomedical wastes[1]

Color coding	Type of container	Waste category	Treatment options as per schedule I
Yellow	Plastic bag	Category 1, Category 2, Category 3, Category 6	Incineration/deep burial
Red	Disinfected container/plastic bag	Category 3, Category 6, Category 7	Autoclaving/microwaving/chemical treatment
Blue/white translucent	Plastic bag/puncture proof container	Category 4, Category 7	Autoclaving/microwaving/chemical treatment and destruction/shredding
Black	Plastic bag	Category 5, Category 9, Category 10. (solid)	Disposal in secured landfill

1. Color coding of waste categories with multiple treatment options as defined in schedule I; Shall be selected depending on treatment option chosen; which shall be as specified in schedule I; 2. Waste collection bags for waste types needing incineration shall not be made of chlorinated plastics; 3. Categories 8 and 10 (liquid) do not require containers/bags; 4. Category 3 if disinfected locally need not be put in containers/bags

Table 2: WHO classification of health care waste[3]

Waste category	Description with examples
Infectious waste	Waste suspected to contain pathogens; e.g., laboratory cultures, tissues, swabs, materials or equipment that have been in contact with infected patients, excreta, etc
Pathological waste	Human tissues or fluids; e.g., body parts, blood and other body fluids, fetuses, etc
Sharps	Sharp waste; e.g., needles, scalpels, blades, knives, infusion sets, broken glass
Pharmaceutical waste	Waste containing pharmaceuticals; e.g., pharmaceuticals that are expired or no longer needed, items contaminated by or containing pharmaceutics (bottles, boxes)
Genotoxic waste	Waste containing substances with genotoxic properties; e.g., cytotoxic drugs (cancer drugs), genotoxic chemicals
Chemical waste	Waste containing chemical substances; e.g., laboratory reagents, film developer, fixer, disinfectants that are expired or no longer needed, solvents
Wastes with high content of heavy metals	Batteries, broken thermometers, blood pressure gauges, etc
Pressurized containers	Gas cylinders, gas cartridges, aerosol cans
Radioactive waste	Waste containing radioactive substances; e.g., unused liquids from radiotherapy or laboratory research, contaminated glassware, packages or absorbent paper, urine and excreta from patients treated or tested with unsealed radionuclides, sealed sources

WHO – World Health Organization

important. They are used in large quantities and are often corrosive and reactive chemicals may form highly toxic secondary compounds

3. Hazards from genotoxic waste:[4] The main pathway of exposure is inhalation of dust or aerosols, absorption through the skin, ingestion of food accidentally contaminated with cytotoxic drugs, chemicals or other waste
4. Hazards from radioactive waste:[4] It is genotoxic and thus may affect genetic material. The effects of exposure can range from headache, dizziness, and vomiting to malignancies
5. Public sensitivity: Apart from health hazards, the general public is very sensitive to visual impact of health-care waste particularly anatomical waste.[4] There can be esthetic degradation of the surroundings from the careless disposal
6. Environmental issues: There can be several adverse environmental impacts from inappropriate handling of waste. It may lead to changes in microbial ecology and microbial resistance to several anti-microbial agents.

The waste, if allowed to accumulate, is a health hazard, because: It decomposes and favors fly breeding, it attracts rodents and vermin, the pathogens, which may be present in the waste may be conveyed back to man's food through flies and dust, there is a possibility of water and soil pollution and heaps of refuse present an unsightly appearance and nuisance from bad odors.[4]

Mercury in the environment

Mercury is a naturally occurring metal; however, about half of the mercury released to the environment comes from human activity. Of that amount, 53% is emitted from combustion of fuels for energy production and 34% is from the combustion of waste. Sources associated with manufacturers and consumers make up the remaining 13%, with dentistry contributing less than 1%. Dentists world-wide consume 3-4% of all the mercury produced. The mercury in dental amalgam can be released to the environment through various media (air, water, solid waste). Mercury is a persistent and deadly contaminant in the water environment. Metallic mercury such as that used in amalgam is relatively non-toxic. However, when mercury is released to the environment, some portion may be converted by bacteria to methyl mercury, a potent neurotoxin. Methyl mercury biomagnifies in the food chain such that levels of methyl mercury are created that are tens of thousands of times higher in some predatory fish than in the surrounding waters. The Federal Food and Drug Administration, USA has determined that any level of methyl mercury in fish above 1 mg/l is unsafe. Mercury is bio-accumulative, which means that it can build up in fish and cause health problems in humans and other animals that eat fish. Some mercury released into the air (when dental wastes that contain amalgam are incinerated, some of mercury in the fillings of removed teeth or scraps of amalgam in the waste) eventually collects in the waterways, where it enters the food chain. As a precautionary measure, one should assume that all or most of the mercury released into the air or surface water may accumulate in fish.[5]

In an interesting study in Finland,[6] the National Public Health Institute projected level of mercury in wastewater as related with levels of mercury in stimulated saliva and amalgam filled teeth. The mercury limit for sewage is 0.05 mg/l (=250 nmol/l) effluent, according to the European norms. The risk of exceeding the limit increased 2-fold for every 10 additional amalgam-filled surfaces. These results demonstrate that humans, especially in populated areas, can be a significant source of mercury pollutants. As a consequence of mercury release, bacteria may acquire mercury resistance as well as resistance to other antimicrobial agents; thus, resulting in failure of antibiotic treatment.

Mercury in the clinic environment

Mercury forms vapors at room temperature,[7] and also particles of amalgam fillings and mercury vapor from old

amalgams forms an aerosol that is projected into the clinic atmosphere.[8] The threshold limit value of mercury in air is 0.05 mg/m^3 of air. It is the vapor level to which the average worker can be safely exposed for 8 h a day and 5 days/week. The current standard for mercury is 0.1 mg/m^3 of air averaged over an 8 h work shift.[9] Mercury can produce a toxic effect if sufficient amounts are absorbed through the skin, lungs or gastro-intestinal tract. Most common route is through lungs by inhalation of the vapor.[7]

X-ray wastes

Silver, in the form of silver thiosulfate, is found in high concentrations in fixer solutions and rinses from X-rays. Light-sensitive silver-halide crystals present on the X-ray film are released as silver thiosulfate during the fixing process. Used X-ray fixer is regulated as a hazardous waste because of the high silver content. In the environment, free-ionic silver acts as an enzyme inhibitor by interfering with the metabolic processes of organisms.

Lead foil

Lead is used in the foil that shields X-ray film. Lead is a heavy metal that affects neurological development and functions and can potentially leach from landfills into the environment.

DISCUSSION AND MANAGEMENT OF DENTAL CARE WASTES

The management of health-care wastes involves active participation and co-ordination between governmental and non-governmental bodies, the bureaucracy and the health care personnel. In developing nations strong political will and requisite infrastructure may be lacking for appropriate management of BMW. The BMW disposal in India is dismal and that too about dental waste disposal is in nascent stages. Most standalone healthcare centers, including dental clinics, don't recognize the need for proper BMW disposal.

In a recent study,[10] on 432 private dentists in Bangalore city, 64.3% do not segregate waste before disposal and 47.6% hand over health-care waste to street garbage collectors; 42.1% felt that there was a lack of waste management agency services and 16.9% felt that a lack of knowledge were the main hurdles. They concluded that, a large proportion of the dentists are not practicing proper methods of health-care waste disposal and many require improvement in their knowledge. Similar reports and lack of seriousness has been reported throughout the world (Greece,[11] Palestine,[12] Italy,[13] Bangkok,[14] Sweden,[15] etc.). One more study by Kishore *et al.*[16] at New Delhi reiterated the need for dentists to be educated in BMW management.

We should take utmost care of BMW, even-though, the risk of transmitting infectious diseases through BMW is low because of the unlikelihood of survival of the infectious agent in refuse environments and the low probability of a portal of entry for infectious organisms in a susceptible host.[17] In multiple studies, household waste has been found to contain more microorganisms with pathogenic potential for humans on average than medical waste.[18,19] The only medical waste that has been associated with infectious disease transmission is contaminated sharps (needles, scalpels, or lancets).[19]

Dental offices generate a very small amount of silver waste relative to other photographic processing facilities. A batch-replenished processing of 450 size 2 dental films and eight 35 mm film strips, each 250 mm long, yields 830 ml of used fixer solution with a silver concentration of 10.90 g/l. Silver concentrations in used fixer solutions generally range from 8 g/l to 12 g/l. Silver in used fixer solutions is in the form of silver thiosulfate complexes, which are extremely stable and have very low dissociation constants. There is virtually no free silver ion (Ag+) in used fixer solutions. The effect of silver on aquatic life depends on the form of silver. In one aquatic life toxicity study using fathead minnows, silver thiosulfate was more than 17,500 times less toxic and silver sulfide was more than 15,000 times less toxic than free silver ion (Ag+). It is generally accepted that silver in used fixer solutions has little, if any, adverse environmental effect.[20] Use of an in-office silver recovery unit (e.g. Kodak Chemical Recovery Cartridge, Eastman Kodak, Rochester, N.Y.) to remove silver from used fixer solutions can be an effective method.

The dental waste of utmost importance is related to mercury and mercury-related products. Various precautions should be exercised while purchasing, storing, handling and disposal of these products. Mercury in various forms is found in clinic air, chair tubing, clinic plumbing, suction traps, and filters, etc. Appropriate guidelines on various aspects have been given by the American Dental Association.[5,9,21-25]

A scheme outlining various steps involved in managing BMW is modified from Rutala *et al*[26] and American Medical Association[19] for dental BMW and is presented in Table 3. Based on the above discussion we devised a simple, clear, cost-efficient, effective and implementable dental BMW disposal program considering local requirements in mind [Table 4]. The scheme was outlined to the dentists of Thane region, few workshops were held by the Indian Dental Association (IDA) and the waste segregation system's pamphlets [Table 4] were distributed. This scheme was then followed by around 200 dentists associated with the Thane Branch of IDA with good response and success since last 3.5 years.

CONCLUSION

As we, the dentists are an educated lot, aware of the biology and environments and respected citizens; we do have some responsibility toward our surroundings and

Table 3: Various components of a bio-medical dental waste management protocol (modified from Rutala *et al*.[26] and American Medical Association[19])

Steps to be followed for thorough dental BMW management
Identify the applicable regulations, accreditation standards, and guidelines in the dentist's country, state and municipality for the management of biomedical waste
Based on central, state and local regulations, dentists or health care facilities should develop protocols for biomedical waste management that address the following aspects, if applicable
Definition of dental waste
Identification of dental waste
Identification of materials that can be recycled
Segregation of dental waste from other waste
Segregation of materials that can be recycled
Containerization as per appropriate guidelines
Labeling when needed
Storage
Transportation
Recycling
Disposal
Education
Record keeping
Develop and conduct an educational program for dental staff
Educate patients involved in home health care/dental care about appropriate disposal of bio-hazardous waste
Verify appropriate implementation of the program
Regularly evaluate the program and update if required

Table 4: The proposed simplified biomedical waste segregation scheme for dental clinics

Red bag	Yellow bag	Blue bag	Black carboy
Disposable Injection syringes, IV set without needle	Anything contaminated by blood or body fluids	Glass bottles	Used or unused sharps
Saline bottles	Body parts	Broken glass	Needles without syringes
Plastic suction tips	Any item which have been in contact with the patient	Discarded medicines	Scalpel blades
Toothbrushes, denture brushes	Bandages, cotton	Antiseptics, disinfectants (not contaminated by body fluids)	Metal objects
Disposable plastic/fiber instruments	Teeth (with/without fillings but without amalgam fillings)	Used or unused drug vials	Metal matrix bands
Plastic/rubber tubes	Dressings and swabs	Cartridges and ampoules	Broken metal instrument tips
Rubber lids of any vial	Disposables such as gloves, aprons, masks, drapes, contaminated wipes, throat packs		Burs
Used plastic drapes	Discarded crowns, bridges and cast partial dentures		Endodontic files, broaches, reamers, spreaders, silver points
	Waxes, gutta purcha points, absorbent points		Orthodontic metal brackets, wires, bands
	Disposable impression trays with impression material		Suture needles
	Acrylic partial dentures, complete dentures, denture teeth		Broken/discarded ultrasonic tips
	Plaster/stone casts		Metallic bars, clasps from partial dentures
	Cheek retractors, tongue depressors, wedges		Metal lids of vials
	Rubber dam material		All metallic dental implants related material
	Plastic X-ray pouches (outer covering)		
	Catheters (after draining)		
	Unwanted laboratory specimens		
	Suture materials without needle		

X-ray developer and X-ray cleaner solution can be flushed into the drain; X-ray fixer can be flushed into the drain, till the availability of silver recovery units at individual or collective clinic level or till new regulations by Govt. of India; X-ray lead foils, used lead aprons and collars-suitable recycler or some scrap vendors buy them for recycling; Teeth with amalgam fillings should be disposed into the yellow bag after removing the filling; Waste amalgam, waste mercury, amalgam capsules should be stored in tightly sealed unbreakable containers away from heat; Don't dispose any type of amalgam or mercury in any of the above bags or black carboy. Once the container is full give it to a suitable recycler; Old and worn out metallic instruments to be discarded after autoclaving to any metal scrap vendor; It would be preferable to store all the X-ray films till any new guidelines from appropriate authorities; X-ray paper, waste acrylic powder, clinic stationary, any article which is not in contact with the patient should be disposed along with municipal waste. All non-infectious general waste to be collected in white colored or transparent plastic bags and handed over to municipal waste collectors; Appropriate bags and containers provided by the company for the respective purposes should only be used; The regulations would be revised on a timely basis; Developed by the authors in consultation with Indian Dental Association; Thane Branch (India) and Enviro-Vigil, the biomedical waste disposal agency

descendents. The way we dispose of waste affects the quality of the environment that we pass on to our children and their children. If we reap short term benefits from cheap disposal of wastes in the air, land, fresh water, seas or even outer space, we may pass on staggering costs on to future generations, which must either try to cleanse the disposal sites or abandon them altogether.

The authoritative bodies in India and other developing nations should strictly implement and monitor BMW management according to their requirements in a systematic and simplistic manner. The governmental bodies should take responsibility of making these services available to the practicing dentists as well as dental hospitals.

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Clinical relevance to general dentistry

- Dental practices/hospitals produce a lot of biomedical waste (BMW)
- There are no specific guidelines for management of BMW in dental settings
- The nature of BMW generated in dental practices is somewhat different as compared to that of medical settings
- There is a grave need for educating dentists as well as access to BMW services
- This paper proposes a simplified model for waste segregation for general dental practitioners as well as specialists
- This scheme is in the fourth successful year followed by 200 dentists at Thane (Mumbai), India, which can be replicated elsewhere.

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