Biomedical waste management - a public health hazard: an overview of literature

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ABSTRACT

Biomedical waste management in a health care setup is an alarming human and environmental health concern. Despite the implementation of biomedical waste management and handling rules by the Government of India, the biomedical waste management still remains a serious issue due to the lack of awareness, improper knowledge and practices among the health care personnel. Health care workers should have proper knowledge and training regarding collection, segregation, and disposal of biomedical waste. Best management practices should be followed, especially when disposing hazardous wastes. Biomedical waste management program should be made a part of the academic curriculum and continuing dental education. This article provides a detailed overview on biomedical waste management in medical and dental settings and emphasizes on the importance of public health stakeholders.

Keywords: Biomedical Waste, Color Coding, Silver Amalgam, Lead Foil, Fixer Solution.

1. INTRODUCTION

The term biomedical waste has been defined as “any waste that is generated during the diagnosis, treatment, or immunization of human beings or animals, or in the research activities pertaining to or in the production or testing of biological and includes categories mentioned in schedule 1 of the Biomedical Waste (Management and Handling) rules 1998”[1,2]. According to World Health Organization (WHO) statistics, nonhazardous waste forms 80-85% and hazardous waste forms 15-20% of the total hospital waste generated [3]. The biomedical waste management and handling rules, notified in 1998 and amended twice in 2000, makes it mandatory for the health care establishments to segregate, disinfect and dispose their waste in an ecofriendly manner [2]. American Dental Association (ADA) and the Center for Disease Control recommendations state that the medical waste should be disposed according to the regulations [4,5]. The indiscriminate health care waste disposal has lead to a global rise in infections such as AIDS and Hepatitis B [3]. Changes in microbial ecology and spread of antibiotic resistance may also occur as a result of improper waste management [6]. Dental practices produce large amounts of wastes such as plastic, latex, cotton, glass and other materials, most of them can be contaminated with infected body fluids, along with
small quantities of other types of waste, such as silver amalgam, mercury and varied chemical solvents. According to US medical waste tracking system, the dentist generates only 3% of the total medical waste [7].

**Classification of health care biomedical waste**

A number of classifications of health care waste have been put forward, and many of these classifications divides hospital waste into hazardous and non-hazardous waste. WHO classification of health care waste is the most commonly followed (Table 1).

**Biomedical waste management and handling rules 1998**

For a biomedical waste management program to be successful, segregation of different types of waste is an important criteria. For waste management to be effective, the waste should be managed at every step, from acquisition to disposal. [2, 9]

Schedule I and II of Biomedical waste management and handling rules can be summarized in Table 2 and Table 3.

**Categories of waste generated in dental practices** [10].

- Biomedical waste- Non anatomic waste & Anatomic waste, sharps.
- Silver containing waste-used fixer solution and unused x-ray films.
- Lead containing wastes-lead aprons and lead foils inside the x-ray films.
- Mercury containing wastes-element mercury, scrap amalgam.
- Chemicals, disinfectants and sterilizing agents.

**Mercury and mercury related products**

Mercury (Hg) as Amalgam has been used as a restorative material for over 150 years. Silver amalgam still remains the most widely used and economic dental material in restorative dentistry, although, new synthetic, non-metallic materials and novel, time-saving procedure have come into existence [11].

Mercury, a major constituent of dental amalgam, is a known neurotoxic and nephrotoxic substance. It is lethal as it “bioaccumulates” in the food chain, and collects and builds up within the tissues of small fish and other species and then accumulates in larger amounts as the food chain ascends.

Chin et al. [13] studied the environmental effects of dental amalgam and stated that contamination with dental mercury constitutes a small proportion of the terrestrial mercury (3-4%). In conclusion, he stated that the poor management of dental amalgam waste is a environmental hazard. In 2006, Jokstad and Fan [14] studied the management of amalgam waste, and concluded that dental mercury waste is approximately responsible for <1% of the total mercury waste discharged annually into the environment.

Elemental mercury and scrap amalgam are the two main forms of mercury containing waste. (Contact or noncontact amalgam scrap) [15]. Contact amalgam is amalgam that has been in contact with the patient, e.g., extracted teeth with amalgam fillings, carving scrap collected at chair-side, and amalgam captured by chair- side traps, filters, or screens. Non-contact amalgam is the one that is not in contact with the patient, e.g., excess unused set amalgam, amalgam capsules. Both these types of amalgam are stored separately in different containers and are labeled with a “biohazard” symbol. The American Dental Association, suggest that strict guidelines should be adhered to for proper disposal of amalgam waste [15,16,17].

Elemental mercury waste management includes-[12,18].

- Unused elemental mercury is stored in a tightly sealed container
- A certified biomedical waste carrier (CWC) should be used for recycling or disposal
- Spill mercury should be managed with “mercury spill kit”
- Scrap amalgam can be made by reacting unused elemental mercury with silver alloy
- Elemental mercury should not be placed in the garbage
- Elemental mercury should not be flushed down the drain.

Scrap amalgam waste management entails- [12,18].

- Disposable suction traps and amalgam separators on dental suction units should be used, the traps should be changed weekly to prevent amalgam accumulation
- Using only required amount of amalgam or using premeasured amalgam capsules
- Extracted teeth with amalgam fillings should not be discarded in the regular garbage
### Table 1. WHO Classification of Health care waste [8].

<table>
<thead>
<tr>
<th>Waste category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious waste</td>
<td>Waste suspected to contain pathogens; e.g., laboratory cultures, tissues, swabs, materials or equipment that has been in contact with infected patients, excreta, etc.</td>
</tr>
<tr>
<td>Pathological waste</td>
<td>Human tissues or fluids; e.g., body parts, blood and other body fluids, fetuses, etc.</td>
</tr>
<tr>
<td>Sharps</td>
<td>Sharp waste; e.g., needles, scalpels, blades, knives, infusion sets, broken glass</td>
</tr>
<tr>
<td>Pharmaceutical waste</td>
<td>Waste containing pharmaceuticals; e.g., pharmaceuticals that are expired or no longer needed, items contaminated by or containing pharmaceuticals (bottles, boxes)</td>
</tr>
<tr>
<td>Genotoxic waste</td>
<td>Waste containing substances with genotoxic properties; e.g., cytotoxic drugs (cancer drugs), genotoxic chemicals</td>
</tr>
<tr>
<td>Chemical waste</td>
<td>Waste containing chemical substances; e.g., laboratory reagents, film developer, fixer, disinfectants that are expired or no longer needed, solvents</td>
</tr>
<tr>
<td>Wastes with high content of heavy metals</td>
<td>Batteries, broken thermometers, blood pressure gauges, etc.</td>
</tr>
<tr>
<td>Pressurized containers</td>
<td>Gas cylinders, gas cartridges, aerosol cans</td>
</tr>
<tr>
<td>Radioactive waste</td>
<td>Wastes 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</td>
</tr>
</tbody>
</table>

### Table 2. Categories of Biomedical waste [1]

<table>
<thead>
<tr>
<th>Option</th>
<th>Waste category</th>
<th>Treatment and disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category no. 1</td>
<td>Human anatomical waste (human tissues, organs, body parts)</td>
<td>Incineration / deep burial</td>
</tr>
<tr>
<td>Category no. 2</td>
<td>Animal waste (animal tissues, organs, body parts, carcasses, fluids, blood, experimental animals, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses)</td>
<td>Incineration / deep burial</td>
</tr>
<tr>
<td>Category no. 3</td>
<td>Microbiology and bi-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)</td>
<td>Local autoclaving/microwaving/ incineration</td>
</tr>
<tr>
<td>Category no. 4</td>
<td>Waste sharps (needles, syringes, scalpels, blades, glass, etc., that may cause puncture and cuts. This includes both used and unused sharps)</td>
<td>Disinfection (chemical treatment /autoclaving/microwaving and Mutilation/shredding)</td>
</tr>
<tr>
<td>Category no. 5</td>
<td>Discarded medicines and cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)</td>
<td>Incineration /destruction and drugs disposal in secured landfills</td>
</tr>
<tr>
<td>Category no. 6</td>
<td>Solid waste- Items contaminated with blood and body fluids, including cotton, dressings, plaster casts, linen, beddings, etc</td>
<td>Incineration /autoclaving/microwaving</td>
</tr>
<tr>
<td>Category no. 7</td>
<td>Solid waste (wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc.)</td>
<td>Chemical treatment /autoclaving/ Microwaving and mutilation/shredding$</td>
</tr>
<tr>
<td>Category no. 8</td>
<td>Liquid waste (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)</td>
<td>Disinfection by chemical treatment</td>
</tr>
</tbody>
</table>
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Table 3. Color coding and type of container for disposal of biomedical wastes [1].

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

- A mercury container should be used to store all scrap/old amalgam, which is passed on to the CWC.

Silver

Silver, a heavy metal can enter our water system due to improper disposal of dental office waste. Silver thiosulfate present in radiographic fixer (a solution normally used in the processing of dental radiographs) poses a serious environmental challenge [19,20]. Developer solution can be diluted with water and put into sewer, as it doesn’t contain silver. Used radiographic fixer must not be washed down the drain. Recovery and recycling is the best way to manage silver waste. Establishment of in-house silver recovery units by dentists can retrieve the silver, and later silver can be sold, allowing for some monetary return on the equipment investment [19,20]. Registered certified agencies can also be contacted to manage the waste. [20,21].

Unused films contain unreacted silver and can be toxic to the environment, hence, they should not be considered as a general waste. The unused films should be returned to the manufacturer for proper recycling. Alternatively, a certified waste carrier can be contacted to dispose of the waste, ideally by recycling [19,20]. However, exposed X-ray films are harmless and can be considered as general waste. As there has been recent advancements in radiographic technology, digital imaging has become a popular means of obtaining dental radiographs. Reduced radiation exposure and the absence of chemical image processing are the advantages of digital radiography [19]. Therefore, the incorporation of digital imaging within the dental office can greatly reduce the amount of silver waste generated.

Lead

Lead shield in a film packet is an additional by product of traditional radiography. The collective lead shield waste produced can be significant, despite the small size of the lead shield [22]. Lead, like mercury and silver, is lethal and persists in the environment [19,22]. Complications associated with excessive lead intake include reproductive toxicity, neurotoxicity, carcinogenicity, hypertension, renal function, immunology, toxicokinetics etc. [23]. Environmental lead contamination by dental practitioners can be easily minimized and is
economic task [19,22]. The lead shields from film packets merely have to be collected and returned periodically to the manufacturer for recycling [19, 20, 22]. The only cost is for postage. However, due to lack of awareness, only 5% of products sold are returned to the manufacturing companies [22].

**Sharps and needles**

Sharps are regarded as highly hazardous health care waste as they can cause injuries and puncture wounds. Exposure of the contaminated sharps poses a high risk of HIV and Hepatitis (B, C) infections. According to US EPA, the annual exposure of dentists and dental assistants to hepatitis B infections is <1%, and 5-8% respectively [24]. The sharps (needles, scalpel blades) constitute the category of waste that requires utmost precaution and care. Needle destroyers or a syringe melting and disposal system should be used for disposal of sharps and they should be placed in a puncture proof sharp container containing 1% NaOCl for disinfection. A three-fourth filled container should be given to waste handlers and disposed in landfills [2, 25, 26]. Occupational Safety and Health Administration (OSHA) consider orthodontic wires as sharp wastes because skin penetration and contamination with blood may be seen with the ends of orthodontic wires. [27].

**Pharmaceutical waste**

Pharmaceutical wastes, including the expired drugs, are regarded as hazardous, non-infectious waste. They should either be returned to the manufacturer or collected in a separate black bag and given to the waste collection company, where they are either incinerated or buried in landfills [28,29].

**Chemicals, disinfectants, and sterilizing agents**

Workplace Hazardous Materials Information System (WHMIS) training should be made to the personnel handling these materials. Use of nonchlorinated plastic containers (not PVC) should be encouraged as they have negligible environmental hazards. Inflammable sterilants have a tendency to burst and should not be poured down the drain. Sterilants should never be poured into a septic system as this may significantly destroy the bacteria which normally break down wastes [30,31].

**Blood-soaked/dripping gauze**

Blood-soaked / dripping gauze, a biomedical hazardous waste, should be placed in a yellow biomedical waste bag and covered with a double bag. It should be labelled with a biohazard symbol and refrigerated. The certified biomedical waste carrier should be contacted for disposal. [30].

**Extracted teeth**

Extracted teeth are regarded as potential infectious material and should be disposed of in a medical waste container. Extracted teeth used for shade or size comparison should be cleaned and surface-disinfected with a disinfectant. Extracted teeth for preclinical exercises should be autoclaved, as external surface and interior pulp tissue may not be disinfected by a liquid chemical germicide [27].

**Nonhazardous wastes (Cardboard, paper, aluminum, plastics, etc.)**

The use of Poly Vinyl Chloride (PVC) plastic should be avoided, as it is difficult to recycle and can produce acid gases if incinerated. However, Paper waste, cardboard, and plastic containers (clean or rinsed) should be recycled [30].

2. **Conclusion**

Proper awareness and knowledge of biomedical waste management and handling rules among the people and health care workers is essential. Lack of awareness and knowledge about the health hazards from biomedical waste, improper practices of waste disposal and poor control of waste disposal are the most critical problems associated with health care waste disposal. Hospital waste should be separated and disposed of safely to prevent human and environmental health hazards.

**Conflict of Interest**

The authors declare that they have no conflicts of interest.

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