Review article

УПРАВУВАЊЕ СО БИОМЕДИЦИНСКИ ОТПАД

Short title: Medical waste

BIOMEDICAL WASTE MANAGEMENT

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Апстракт

Медицински отпад е целиот оној отпад кој се создава во здравствените институции како на пример болниците, клиниките, амбулантите, стационарите, ветеринарните амбуланти, како и местата за медицински испитувања и лабораториите.
Неорганизирано и слабо менаџирање на отпадните материјали потенцијално можат да го загрозат здравјето на здравствените работници, управувачите на отпадот, пациентите, како и околината преку инфекции, токсични ефекти и секако ризикот кој постои од загадување. Многу е важно целиот медицински отпад да биде поделен според видот, безбедно одвоен и со него соодветно да се постапува сè до неговото отстранување.

Клучни зборови: био-медицински, стоматолошки, медицински отпад, здравствен ризик, управување со отпад

Abstract

Medical waste is all waste material generated at health care facilities, such as hospitals, clinics, physician's offices, dental practices, blood banks, and veterinary hospitals/clinics, as well as medical research facilities and laboratories.
Poor management of health care waste potentially exposes health care workers, waste handlers, patients and the community at large to infection, toxic effects and injuries, and risks polluting the environment. It is essential that all medical waste materials have to be segregated at the point of generation, appropriately treated and disposed of safety.

Key words: biomedical, dental, medical waste, healthcare risk, waste management

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Introduction

In the process of health care, waste is generated which usually includes sharps, human tissue or body parts and other materials referred to as "Hospital Solid Waste" and "Bio-medical Solid Waste" [1].
According to the law of waste management in many countries in Europe, USA and India [2-6] and in Republic Macedonia regulated by Low of medical waste management (Official Gazette of Republic Macedonia Nº68/ 2004 and correction in Nº 71/2004) [7] medical and clinical waste is waste generated in medical and health institutions (dispensaries, hospitals, polyclinics and outpatient clinics, dental clinics, veterinary stations etc.), originated as a product of used items and materials during diagnosis, convalescence, treatment and prevention in humans and animals [8]. The major sources of health-care waste are:

- hospitals and other health facilities,
- laboratories and research centers,
- mortuary and autopsy centers,
- animal research and testing laboratories,
- blood banks and collection services,
- nursing homes for the elderly.

Medical waste that is a result of the provision of health care can be divided into two groups-municipal and hazardous medical waste. The municipal medical waste includes: paper, carton, glass, food and other common debris arising in the administration, kitchen and laundries [1].
On the other hand hazardous medical waste contains elements of chemical and biological threat, in solid, liquid or gaseous form. The properties of hazardous medical waste are virulence, ability for infection, toxicity, carcinogenicity, and so on. According to these properties hazardous medical waste differs from the municipal medical waste.

Definitions and type of medical waste

Medical (clinical) waste is defined as waste consisting of:

1. **Needle, syringe with needle, surgical instrument** of other article that is discarded in the course of medical, dental or veterinary practice or research and has a sharp edge or point capable of inflicting a penetrating injury on a person who comes into contact with it, or
2. **Human tissue, bone, organ, body part or fetus**, or

3. **A vessel, bag or tube containing a liquid body substance**, or
4. **An animal carcass** discarded in the course of veterinary research or medical practice or research, or
5. **A specimen or culture** discarded in the course of medical, dental or veterinary practice or research and any material that has come into contact with such a specimen or culture, or
6. **Any other article or matter** that is discarded in the course of *medical, dental or veterinary practice or research* and that poses a significant risk to the health of a person who comes into contact with it [9].

Although there is no universally accepted definition for medical waste, the definitions offered by most regulatory agencies are similar. Most federal and state agencies differentiate between common medical waste and those wastes with the potential for causing infection and for which special precautions are prudent. Depending on the state, these wastes are referred to as: regulated medical waste, infectious waste, biomedical waste. Some state regulations use a general definition, while others list specific wastes and categories of waste that are considered infectious. The following six medical wastes are commonly regulated [10]:

- **Pathological waste.** Tissues, organs, body parts, and body fluids removed during surgery and autopsy.
- **Human blood and blood products**. Waste blood, serum, plasma and blood products.
- **Cultures and stocks of infectious agents** (microbiological waste). Specimens from medical and pathology laboratories. Includes culture dishes and devices used to transfer, inoculate, and mix. Also includes discarded live and attenuated vaccines.
- **Contaminated sharps.** Contaminated hypodermic needles, syringes, scalpel blades, Pasteur pipettes, and broken glass.
- **Isolation waste.** Generated by hospitalized patients isolated to protect others from communicable disease.
- **Contaminated animal carcasses, body parts and bedding.** From animals intentionally exposed to pathogens in research, biologicals production, or in vivo pharmaceuticals testing.

Definition of biomedical waste "Any solid, fluid or liquid waste, including its container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals, in research pertaining there to, or in the production or testing of biological and the animal waste from slaughter houses or any other like establishments [11,12]

Namely, the term clinical waste is associated with waste originating from medical, dental and veterinary sources and has been defined as "*waste that is contaminated with blood, saliva or any other bodily hazardous fluids and which may prove hazardous to any person coming into contact with it*".

The World Health Organization (WHO) has defined healthcare waste as" all waste produced by healthcare establishment, research facilities and laboratories including the waste originating from "minor" or "scattered" sources such as the produced in the courses of healthcare undertaken in the home (such as dialysis and insulin injections) (WHO1999 p.6) [13]. 85% of the waste produced by health-care providers is non-risk or "general" health-care waste, comparable to domestic waste. This type of waste usually comes from the administrative and housekeeping functions of health-care establishments and may also include waste generated during maintenance of health-care premises. The remaining 10-15% of health-care waste as shown in Fig.1 is regarded as hazardous and may create a variety of health risks (WHO, 1999) [13].

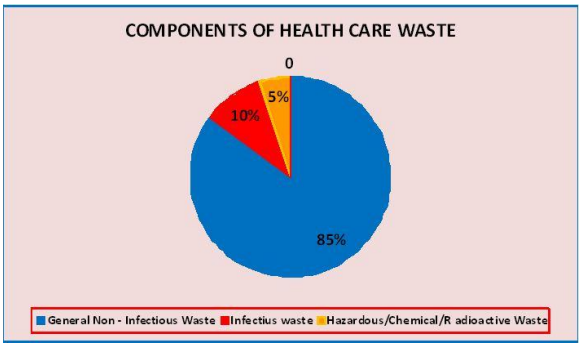

Fig. 1. Components of health care waste (WHO 1999) [13]

Waste and by-products cover a diverse range of materials, as the following list illustrates:

- **infectious waste:** waste contaminated with blood and other bodily fluids (e.g. from discarded diagnostic samples), cultures and stocks of infectious agents from laboratory work (e.g. waste from autopsies and infected animals from laboratories), or waste from patients in isolation wards and equipment (e.g. swabs, bandages and disposable medical devices);
- **pathological waste:** human tissues, organs or fluids, body parts and contaminated animal carcasses;
- **sharps:** syringes, needles, disposable scalpels and blades, etc.;
- **chemicals:** for example, solvents used for laboratory preparations, disinfectants, and heavy metals contained in medical devices (e.g. mercury in broken thermometers) and batteries;
- **pharmaceuticals:** expired, unused and contaminated drugs and vaccines;
- **genotoxic waste:** highly hazardous, mutagenic, teratogenic 1 or carcinogenic, such as cytotoxic drugs used in cancer treatment and their metabolites;
- **radioactive waste:** such as products contaminated by radionuclides including radioactive diagnostic material or radio therapeutics materials; and
- **non-hazardous or general waste:** waste that does not pose any particular biological, chemical, radioactive or physical hazard.

The following materials are not usually regarded as medical waste unless they fall into category of the medical waste definition: dressing and bandages; materials stained with or having had contact with body substances; containers no longer containing body substances; disposable nappies and incontinence pads; sanitary napkins [14].
Medical waste is a risk to those who produce, pack, store, transport, treat and perform disposition. The possibility of infection by some diseases and their spread in hospitals is possible due to negligence in handling of medical waste. The entire staff at the medical institutions should be trained/informed in medical waste management and disposition to be able to reduce the risk to minimum.
Dental practices produce large amounts of waste such as plastic, latex, cotton, glass and other materials, most of them can be contaminated with infected body fluids. Dental practices also produce tiny amount of other types of waste, such as silver amalgam, mercury and various chemical solvents [15-18]. The dental office generate only 3% of total medical waste estimated by US medical waste tracking system [19]. The quantity of waste generated is equally important. A lesser amount of biomedical waste means a lower burden on waste disposal work, a more effective waste disposal system and cost-saving [13].

Infectious waste

Potentially infectious wastes from patients care include: Dressings and swabs, contaminated with blood/body fluids; Laboratory waste including laboratory samples, cultures stocks of infectious agent, laboratory glassware; Instruments used in patient care: Those range from diagnostic equipment such as endoscopes, ultrasound probes, syringes and needles, sharps and other instruments, tubings and bags; Potentially infected materials: Placenta, tumors, organs or limbs, which are removed during surgery; Potentially infected animals used in diagnostic or research studies. In all these wastes the major concern is to prevent potential accidental transmission of infection [20].
Toxic wastes: Potentially toxic wastes include: Radioactive waste: These may be solids, liquids and gases used for analytical procedures, body organ imaging and tumor localization and treatment; Chemical waste: These may be hazardous, toxic, corrosive, flammable, reactive or genotoxic; Pharmaceutical agents: These may enter hospital because there was surplus stock, spillage or contamination was detected or the expiry date was over [21].

Categories of medical waste

Pathological & Anatomical Waste: All human anatomical wastes and all wastes that are human tissues, organs, or body parts removed by trauma, during surgery, autopsy, birth, research studies, or another hospital procedure, and which are intended for disposal. Pathological waste differs from anatomical waste in that these are typically samples of tissues that are examined in a laboratory setting to understand the nature of the disease or make a diagnosis. For the most part, pathological waste refers to very small tissues sections and body material derived from biopsies or surgical procedures that are then examined in the lab. Anatomical wastes are typically distinguished as recognizable human organs, tissue and body parts, and may require special treatment under some state regulations. Some states do not consider hair, teeth and nails to be pathological/anatomical waste [21-23].
Bulk human blood, blood products, bulk body fluids or other potentially infectious material (OPIM): This waste category typically includes bulk waste human blood, human blood components or products derived from blood including serum, plasma and other blood components, or bulk human body fluids as defined as other potentially infectious materials (OPIM), including the following human body fluids: semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, anybody fluid that is visually contaminated with blood, and all body fluids in situations where it is difficult or impossible to differentiate between body fluids. This category includes sample of these fluids taken in hematology labs, as well as drainage from surgery, and urine or feces when visibly contaminated by blood.
Microbiological Waste: Microbiological waste is made up of cultures and stocks of infectious agents, and associated microorganisms and biologicals. This waste stream is primarily generated by the healthcare organization's labs. Discarded cultures, culture dishes and devices used to transfer, inoculate and mix cultures, stocks, specimens, live and attenuated vaccines and associated items are considered microbiological waste, IF they contain organisms likely to have been contaminated by organisms likely to be pathogenic to healthy humans. Also typically included in this category are discarded etiologic agents and wastes from the production of biologicals and antibiotics likely to have been contaminated by organisms likely to be pathogenic to healthy humans, as well as waste that originates from clinical or research laboratory procedures involving communicable infectious agents [21-23].
Sharps: "Sharps" is a term applied to objects such as needles and scalpel blades-anything that can cut or puncture the skin. Their special hazard lies in the fact that, having been designed to pierce the skin, they are very efficient delivery mechanisms for putting infectious agents directly into the bloodstream. Wastes containing both infectious material and sharp objects create particular hazards for anyone handling them, or coming into contact with them.
Isolation Wastes (Wastes from Highly Communicable Diseases): This waste category includes biological waste and discarded materials contaminated with blood, excretion, exudates or secretion from humans or animals who

are isolated to protect others from highly communicable diseases (Lassa fever virus, Marburg virus, monkey pox virus, Ebola virus and others.

Animal Waste: Many facilities have affiliated animal research laboratories as part of their organizational footprint. This waste category includes animal carcasses, body parts, bedding and related wastes that may have been exposed to infectious agents during research, production of biologicals, or testing of pharmaceuticals.

As a **special heterogeneous mixture** of municipal, infectious, pathological, pharmaceutical, laboratory waste, disinfection agents and packaging, as well as radioactive and chemical waste, hazardous medical waste can be divided into *several subgroups* for easier and more accurate identification [24-26] and, therefore, is divided on:

- Infectious (laboratory cultures, fluids, materials and equipment that have been in contact with infected patients);
- Pathological (blood, other body fluids, body parts, fetuses);
- Sharp (objects of needles, scalpels, knives, broken glass);
- Pharmaceutical (drugs, residues of drugs);
- Genotoxic (cytostatic, genotoxic chemicals);
- Chemical (solvents, laboratory reagents, disinfectants);
- Heavy metal (batteries, sphygmomanometers, thermometers);
- Pressure vessels (gas cylinders, metal vessels) and
- Radioactive waste (scrap used in radiation therapy, urine and fluids of patients treated with radio-nuclides).

Management of medical waste

The Hospital Waste Management is part of hospital hygiene and maintenance activities and it involves range of activities, which are mainly engineering functions, such as collection, transport, treatment/ processing and disposal waste. Initial segregation and storage activities are directly responsibility of nursing personal who are engaged in the hospital.

The actual management of medical waste [24,25] is an organized process that consists of five elements*: separation, identification, handling, treatment and disposal*.

Collection of Medical Waste

Medical waste must be collected and stored prior to treatment in a way that reduces the possibility of interaction with humans, animals, or the environment. Medical waste containers are generally red, contain the word "biohazard" and are imprinted with the universal three-sided biohazard symbol (Table 1,2 Figure 2,3). This standardization immediately identifies these containers as medical waste. General storage guidelines include the following:

- Contaminated reusable sharps must be placed in containers that are puncture resistant, closeable, puncture resistant, leak-proof on sides and bottoms, and labeled or color coded,
- Reusable sharps that are contaminated with blood or other potentially infectious materials must not be stored or processed in a manner that requires employees to reach by hand into the containers,
- Specimens of blood or other potentially infectious material are required to be placed in a container that is labeled and color coded and closed prior to being stored, transported or shipped,
- Regulated wastes (liquid or semi-liquid) must be placed in containers that are constructed to contain all contents and prevent leakage of fluids, labeled or color coded, and closed prior to removal,
- All bins, pails, cans, and similar receptacles intended for reuse are required to be inspected and decontaminated on a regularly scheduled basis,
- Labels must include the biohazard symbol, be fluorescent orange or orange-red or predominantly so, with lettering and symbols in contrasting color, and affixed as closely as possible to the container by adhesive or wire to prevent loss or removal.

The most visible form of medical waste collection is the sharps container. Sharps containers are found in every medical office, and often in public places, for medical personnel and the general public to safely dispose of hypodermic needles. These containers are designed so the user is never exposed to any of the sharps already in the container, eliminating the possibility of contact or puncture by any of the used needles. Sharps containers are generally made of thick plastic, and have a door that opens and the user can insert the sharp into the container. When the door is closed, the sharp is dropped down into the main chamber of the container. The container functions much like a standard post office mailbox, in that the user cannot reach the sharps inside the container via the door. Sharps containers are also used for other categories of sharps, including scalpels and lancets.

Community Hazardous Waste Collection

Many municipalities have occasional household hazardous waste collection days when authorities designate a place where residents bring waste from their homes. These are intended to be strictly for residential/household waste, not from commercial facilities. Different authorities have different rules, but usually these collection days explicitly prohibit infectious waste.

Table 1. Category of medical and biomedical waste and disposal [25]

	Consist of	Disposal
Human Anatomical Waste	Human tissue, organs, body parts	**Incinerations / deep burial**
Animal Waste	Animal tissue, animals used in research, waste from veterinary hospitals, colleges, and animal houses	Incinerations / deep burial
Microbiology&Biotechnology Waste	Wastes from laboratory cultures, stocks or specimens of microorganisms live or attenuated vaccines, toxins, dishes and devices used for transfer of cultures	Incinerations
Waste sharps	Needles, syringes, scalpels, blades, glasses, etc.	Autoclaving / shredding
Discarded Medicines and Cytotoxic Drags	Outdated, contaminated and discarded medicines	Incinerations and secured landfills
Solid Wasted	Items contaminated with blood and body fluids, including cotton, dressing, soiled plaster casts, beddings	Autoclaving, microwaving
Solid Wasted III	Waste generated from disposable items like tubings, catheters, intravenous sets etc.	Autoclaving, microwaving and shredding
Liquid Wasted	Laboratory and washing, cleaning, housekeeping in hospitals	Treatment and discharge into drains
Incineration Wasted	Ash from incineration of any biomedical waste	Disposal in municipal landfill
Chemical Wasted	Chemical used in production of biologicals, chemicals used in chemical treatment and disinfections, as insecticides	Discharge into drains for liquids and secured landfill

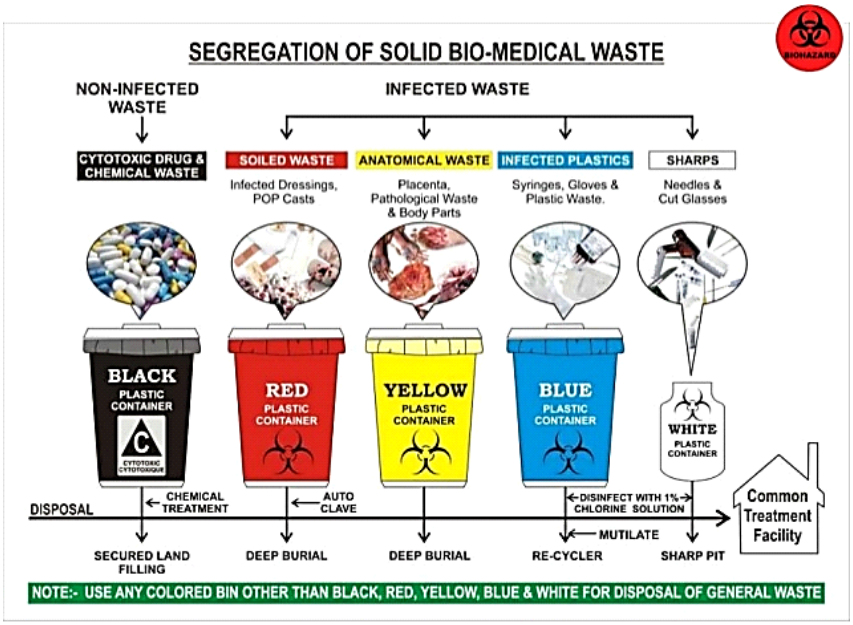

Fig. 2. Segregation of medical and biomedical waste [26]

SEGREGATION OF WASTE IN COLOR CODED BAGS			
BLACK CARBOY	**BLUE BAGS**	**RED BAGS**	**YELLOW BAGS**
Needles without syringes, blades, sharps and metal articles	All types of glass bottles and broken glass articles outdated & discarded medicines	Plastic waste such as catheters, injections, syringes, tubingsi.v.bottles	Infectious waste, bandage, gauzes, cotton, or any other things in contact with body fluids, human body parts, placenta

Table. 2. Segregation of Waste in color Coded Bags [25]

Fig. 3. Medical Waste Containers [27]

Treatment of Medical Waste

The primary methods of treatment and disposal of medical waste are:

- Incineration
- Autoclaves
- Mechanical/Chemical Disinfection
- Microwave
- Irradiation

The treated waste (if sufficiently sterile) can generally be disposed with general waste in a sanitary landfill, or in some cases discharged into the sewer system. In the past, treatment of medical waste was primarily performed on-site at hospitals in dedicated medical waste facilities. Over time, the expense and regulation of these facilities have prompted organizations to hire contractors to collect, treat, and dispose of medical waste, and the percentage of medical organizations that perform their own treatment and disposal is expected to drop [24,25,28].

To ensure that each treatment method provides the proper environment for the destruction of biologicals, test indicators for microbiological spores measure the treatment effectiveness. Microbiological spores are the most difficult of biologicals to destroy, so when the test package cannot be cultured after treatment, the waste is considered properly treated. In treatment methods where shredding or maceration is employed, the test package is inserted into the system after the shredding process to avoid physical destruction of the test package. The test package is then retrieved from the waste after treatment.

Incineration

According to the EPA, 90% of medical waste is incinerated. Incineration is the controlled burning of the medical waste in a dedicated medical waste incinerator. Among industry folks, these units are often referred to as hospital/ medical/infectious waste incinerators (HMIWIs) [24,2,28-30].

Autoclaves

Autoclaves are closed chambers that apply both heat and pressure, and sometimes steam, over a period of time to sterilize medical equipment. Autoclaves have been used for nearly a century to sterilize medical instruments for re-use. Autoclaves are used to destroy microorganisms that may be present in medical waste before disposal in a traditional landfill [25, 28-30].

Disposal

Mechanical/Chemical Disinfection

Chemical disinfection, primarily through the use of chlorine compounds, is another method to treat medical waste. The use of chlorine bleach for cleaning and disinfecting is well known and this method has been in use for many years. The mechanical/chemical disinfection process provides control and consistency to the disinfection process. The EPA identifies chemical disinfection as the most

appropriate method to treat liquid medical waste. Chemical disinfection processes are often combined with a mechanical process, such as shredding or maceration, to ensure sufficient exposure of the chemicals to all portions of the waste [15].

Microwave

The use of microwaves to disinfect medical waste has only recently been introduced in the United States. Microwave treatment units can be either on-site installations or mobile treatment vehicles. In this type of disinfection process, the waste is first shredded. The shredded waste is then mixed with water and subjected to microwaves. The microwaves internally heat the waste, rather than applying heat externally, as in an autoclave [11].

Irradiation

Another method used to sterilize medical equipment or waste is irradiation, generally through exposure of the waste to a cobalt source. The gamma radiation generated by the cobalt inactivates microbes. Dedicated sites are required for this form of treatment, while mobile versions are available for other non-incineration methods [29].
The World Health Organization recommends as protective gear for anyone who comes into contact with medical waste to wear: helmet; protective face mask; goggles; special jumpsuits; industrial aprons; feet guards; boots etc. [29].

Conclusion and Recommendations

It is important to underline that the management of medical waste takes over the strict control and record the waste from the spot of occurrence and up to final storage.
This process requires the preparation of strict procedures to be applied to the site of occurrence (eg in a hospital room, clinic, laboratory, etc.). In this way, the problem with the management of medical waste in health care could be reduced to the level of no risk or less risky waste.
In each health institution, actions should be organized and controlled with regards to the occurrence of the medical waste stream and reduce the amount of hazardous materials medical waste, as well as on-site waste collection.
It's important to clearly define the responsibility for proper waste management, to the process of its final processing. It is necessary to develop a comprehensive and planned management system that beside responsibility, should provide funds for safe implementation of waste. This is a long process that despite organizational structure requires individual and professional commitment.
Bio-Medical Waste management program cannot successfully be implemented without the devotion, self-motivation, willingness, cooperation and participation of all sections of employees of any health care establishment.

Conflict of interest statement. None declared.

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