SHEng
SMART HEALTHCARE ENGINEERING
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Definitions, classification and regulations regarding hazardous waste

Class content material

This document is part of a training materials collection developed within the Erasmus+ project “Smart healthcare engineering”, SHEng, project No. 2023-1-RO01-KA220-HED-000159985.

The collection is intended for engineering students and professionals working in the healthcare sector. It covers technical subjects relevant to hospital infrastructure, equipment, materials and support services, helping readers understand how engineering contributes to safe patient care and the reliable operation of healthcare facilities.

These materials support classroom teaching and independent study. They should be used alongside the project handbook and the presentations, courses and other learning resources available on the project website. Each document addresses a specific subject, while the collection provides a broader understanding of the responsibilities and practical challenges of healthcare engineering.

The content is educational. Its application in practice requires consideration of the conditions of each healthcare facility, the applicable standards and the instructions provided by equipment manufacturers.

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Definitions, classification and regulations regarding hazardous waste

1. Hazardous waste definition and regulations

As in any activity in which many people are involved, the functioning of hospitals results in a lot of garbage, but in addition to the waste we are daily used, there is also waste that can have dangerous effects. The term "**healthcare waste**" is used by European Union (EU) and World Health Organization (WHO) while "**medical waste**" is used in many countries (US, China and South Korea). In Japan is used the term "**infectious waste**" [1]. Administrative, kitchen, housekeeping and maintenance functions of healthcare facilities produce between 75% and 90% of the total waste generated by healthcare providers [2], which is comparable to household waste and is usually referred to as "non-hazardous" or "general medical waste."

According to World Health Organization (WHO) [2] "The term **healthcare waste** includes all the waste generated within healthcare facilities, research centres and laboratories related to medical procedures. In addition, it includes the same types of waste originating from minor and scattered sources, including waste produced in the course of healthcare undertaken in the home (e.g. home dialysis, self-administration of insulin, recuperative care)".

"Medical waste is a subset of waste generated at health care facilities, such as hospitals, physicians' offices, dental practices, blood banks, and veterinary hospitals/clinics, as well as medical research facilities and laboratories. Generally, medical waste is healthcare waste that may be contaminated by blood, body fluids or other potentially infectious materials and is often referred to as regulated medical waste" [3].

According to the Waste Management and Public Cleansing Act [4], "the **infectious wastes** are defined as waste materials generated in medical institutions as a result of medical care or research which contain pathogens that have the potential to transmit infectious diseases".

2. Hazardous waste regulations

International regulations on hazardous waste:

- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (UNEP, 1992) [T1].
- Bamako Convention (1991) [T2].
- Stockholm Convention on Persistent Organic Pollutants (UNEP, 2004) [T3].
- Agenda 21 (plan of action for the 21st century adopted by 173 heads of State at the Earth Summit held in Rio in 1992) [T4].
- United Nations Recommendations on the transport of dangerous goods, ST-SG-AC10/1/Rev.21, 2019 [T5]
- Safe health-care waste management, WHO, 2004 [T6].
- WHO core principles for achieving safe and sustainable management of health-care waste, 2007 [T7].

European regulations on hazardous waste:

- Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives [T8].
- Commission Regulation (EU) No 1357/2014 of 18 December 2014 replacing Annex III to Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directive [T9].
- Commission Implementing Decision (EU) 2016/2325 of 19 December 2016 on the format of the certificate on the inventory of hazardous materials issued in accordance with Regulation (EU) No 1257/2013 of the European Parliament and of the Council on ship recycling [T10].
- Regulation (EU) 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants [T11].

- Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). [T12]
- 2014/955/EU: Commission Decision of 18 December 2014 amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament and of the Council [T13].

USA regulations on hazardous waste:

- Guidelines for Environmental Infection Control in Health-Care Facilities, U.S. Department of Health and Human Services, 2003 [T14].

Japanese regulations on hazardous waste:

- Waste management and public cleansing law [T15].

3. Hazardous waste classification

Hospital waste can be categorized based on the type of waste, the location of the waste, and the type of infectious disease [4]. Classification according to the **waste type** is presented in Table 1.

Table 1. Classification of hospital waste according to form of waste [1, 5, 6]

Category	**EU/code***	**WHO**	**USA**
Terminology	Healthcare waste	Healthcare waste	Medical Waste
Sharps	Sharps Code 18 01 01	Sharps	Contaminated sharps/Unused sharps
Body parts and organic including blood bags and blood preserves	Body parts and organs including blood bags and blood preserves Code 18 01 02	Pathological	Bulk human blood/Pathological wastes
Waste whose collection and disposal is subject to special requirements to prevent infections	Human and Animal Infectious Code 18 01 03	Infectious	Isolation/Cultures and stocks of infectious agents and associated biologicals/animal wastes

Waste whose collection and disposal are not subject to special requirements to prevent infection (e.g., dressings, plaster casts, linen, disposable clothing, diapers contaminated with blood, etc.)	Infectious Code 18 01 04	Infectious	-
Chemicals consisting of or containing dangerous substances	Chemical Code 18 01 06	Chemical	-
Chemicals other than those mentioned in 18 01 06	Chemical/ Unused hazardous medicines Code 18 01 07	Chemical	Small volumes of chemical hazardous waste
Cytotoxic and cytostatic medicines	Unused hazardous medicines Code 18 01 08	Cytotoxic	Antineoplastic drug
Chemicals other than those mentioned in 18 01 08	Unused non-hazardous medicines Code 18 01 09	Pharmaceutical	Small volumes of chemical hazardous waste
Amalgam waste from dental care	Amalgam waste from dental care Code 18 01 10	Amalgam waste from dental care	-
Radioactive waste		Waste containing radioactive substances (from radiotherapy or laboratory research, sealed sources)	
Non-hazardous or general healthcare waste		Waste that does not pose any particular biological, chemical, radioactive or physical hazard	

Sharps waste

Scalpels and other blades, knives, needles, hypodermic needles, infusion sets, saws, glass fragments, and pipettes are examples of sharp objects that can cut or puncture wounds. These items are considered highly hazardous medical waste and should be treated as if they are potentially infected, regardless of whether they are infected or not.

Pathological waste

Although pathological waste could be considered a subcategory of infectious waste, it is classified separately – especially when special methods of handling, treatment and disposal are used. Tissues, organs, body parts, blood, body fluids and other waste from surgical interventions and autopsies on patients with infectious diseases are considered pathological waste. This also includes human foetuses and the carcasses of infected animals.

Anatomical waste can refer to identifiable human or animal bodily parts. Healthy body components removed after a medical operation or created during medical study may be considered pathological waste.

Infectious waste

Infectious waste is defined as material that is suspected of containing pathogens (bacteria, viruses, parasites, or fungus) in high enough concentrations or quantities to infect susceptible hosts. This category includes:

- waste contaminated with blood or other body fluids,
- cultures and stocks of infectious agents from laboratory work,
- waste from infected patients in isolation wards.

Pharmaceutical waste

Expired, unused, spilled, and contaminated pharmaceutical items, prescription and proprietary medications, vaccinations, and sera that are no longer needed are all considered pharmaceutical waste and must be disposed of properly because of their chemical or biological makeup.

Gloves, masks, connecting tubing, bottles, vials, and boxes containing pharmaceutical residues, and other discarded things that were highly contaminated during the handling of medicines fall under this category.

Genotoxic waste

Genotoxic waste is extremely dangerous and may be mutagenic (causes genetic mutations), teratogenic (causes problems in embryos or foetuses), or carcinogenic. Particular care should be paid to the disposal of genotoxic waste since it poses significant safety risks both within and outside of hospitals.

Certain cytostatic medications (see below), chemicals, radioactive substances, vomit, urine, or faeces from individuals receiving cytostatic medication are examples of genotoxic waste. Toxic to deoxyribonucleic acid (DNA) is referred to as genotoxic.

Cytotoxic and cytostatic waste

Cytotoxic means harmful to the cell; cytostatic means restricting cell growth and multiplication; antineoplastic means stopping the formation of aberrant tissue growth; and chemotherapeutic implies the use of chemicals for treatment, particularly cancer therapy. The primary compounds in this category are cytotoxic (chemotherapeutic or antineoplastic) medications, which have the power to kill or inhibit the growth of specific living cells and are employed in cancer chemotherapy. They have a key function in the treatment of numerous neoplastic illnesses, but they are also becoming more widely used as immunosuppressive agents in organ transplantation and the treatment of various immunological diseases.

Cytotoxic medicines are typically used in specialized departments such as oncology and radiotherapy units, where their primary function is cancer treatment. They are also being used more frequently in clinics and other settings outside of hospitals as well as in other hospital departments. Cytostatic drugs can be categorized as follows:

- alkylating agents: cause alkylation of DNA nucleotides, which leads to cross-linking and miscoding of the genetic stock;
- antimetabolites: inhibit the biosynthesis of nucleic acids in the cell;
- mitotic inhibitors: prevent cell replication.

Cytotoxic waste can come from a variety of sources, including:

- contaminated materials from drug preparation and administration, such as syringes, needles, gauzes, vials, packaging;
- outdated drugs, excess (leftover) solutions, drugs returned from the wards;
- urine, faeces and vomit from patients, which may contain potentially hazardous amounts of the administered cytostatic drugs or of their metabolites, and which should be considered genotoxic for at least 48 hours and sometimes up to 1 week after drug administration.

Chemical waste

Discarded solid, liquid, and gaseous chemicals, such as those from cleaning and disinfection processes as well as diagnostic and experimental activities, make up chemical waste. If medical waste contains at least one of the following characteristics, it is deemed dangerous:

- toxic (harmful),
- corrosive (e.g. acids of pH <2 and bases of pH >12),
- flammable,
- reactive (explosive, water reactive, shock sensitive),
- oxidizing.

Radioactive waste

Materials tainted with radionuclides are known as radioactive wastes. They are produced as a result of processes such as in vitro tissue and fluid analysis, in vivo organ imaging and tumour localization, as well as a variety of investigative and therapeutic methods. Radionuclides used in healthcare come from either unsealed (or open) or sealed sources.

Unsealed sources are often liquids administered directly, whereas sealed sources are radioactive materials stored in equipment components or enclosed in impervious or unbreakable items like needles, pins, or "seeds." The following categories apply to the waste generated by radionuclide-related medical and scientific operations as well as the upkeep and storage of associated equipment:

- sealed sources;

- spent radionuclide generators;
- low-level solid waste (e.g. absorbent paper, swabs, glassware, syringes, vials);
- residues from shipments of radioactive material and unwanted solutions of radionuclides intended for diagnostic or therapeutic use;
- liquid immiscible with water, such as liquid scintillation counting;
- residues used in radioimmunoassay, and contaminated pump oil;
- waste from spills and from decontamination of radioactive spills;
- excreta from patients treated or tested with unsealed radionuclides;
- low-level liquid waste (e.g. from washing apparatus);
- gases and exhausts from stores and fume cupboards.

Non-hazardous general waste

Garbage that has not come into contact with radioactive materials, dangerous chemicals, or infectious agents and does not present a sharps hazard is referred to as non-hazardous or general garbage. Non-hazardous trash makes up a sizable amount (about 85%) of all waste from healthcare facilities and typically has characteristics with municipal solid garbage. Paper, cardboard, and plastics account for more than half of all non-hazardous waste generated by hospitals, with the remainder made up of discarded food, metal, glass, textiles, plastics, and wood.

Recycling of materials is encouraged in many locations by community or legal standards. In the past, municipal and non-hazardous waste was either burned in municipal incinerators or dumped in landfills. The methods for handling general garbage have altered because of increased awareness of the effects of waste on the environment and the realization that most non-hazardous waste from healthcare facilities may be recyclable or compostable. Typical recyclables from medical institutions include:

- corrugated cardboard boxes,
- newspapers and magazines,
- polyethylene terephthalate (PET or PETE) (e.g. plastic water bottles, soft-drink bottles)

- polystyrene packaging,
- wood (e.g. shipping pallets),
- paper (e.g. white office paper, computer printer paper, coloured ledger paper),
- metals (e.g. aluminium beverage cans and containers, food tin cans, other metal containers),
- high-density polyethylene (HDPE) (e.g. plastic milk containers, containers for food, plastic bottles for saline solutions or sterile irrigation fluids),
- clear, coloured or mixed glass,
- construction and demolition debris.

The **source and quantity** of waste generated is influenced by several factors:

- activity level (number of occupied beds, number of patients per day and/or staff number);
- the type or specificity of the health facility (medical clinic, county hospital, etc.);
- medical specialties (e.g. department, operating rooms, office);
- location (rural or urban);
- legislative or political regulations regarding waste classification;
- internal waste management procedures;
- temporal variations (for example during the week versus weekend, seasonal);
- availability of material resources;
- the level of infrastructure development in the country.

4. Sources of hazardous waste

The major sources of healthcare waste are:

- Hospitals:
  - University hospital,
  - General hospital,

- District hospital,

➢ Other healthcare facilities:

- Emergency medical care services,
- Healthcare centres and dispensaries,
- Obstetric and maternity clinics,
- Outpatient clinics,
- Dialysis centres,
- Long-term healthcare establishments and hospices,
- Transfusion centres,
- Military medical services,
- Prison hospitals or clinics.

➢ Related laboratories and research centres:

- Medical and biomedical laboratories,
- Biotechnology laboratories and institutions,
- Medical research centres,

➢ Mortuary and autopsy centres,

➢ Animal research and testing,

➢ Blood banks and blood collection services,

➢ Nursing homes for the elderly.

The minor sources of healthcare waste are:

➢ Small healthcare establishments:

- First-aid posts and sick bays,
- Physicians' offices,

- Dental clinics,
- Acupuncturists,
- Chiropractors,

➢ Specialized healthcare establishments and institutions with low waste generation:

- Convalescent nursing homes,
- Psychiatric hospitals,
- Disabled persons' institutions.

➢ Activities involving intravenous or subcutaneous interventions:

- Cosmetic ear-piercing and tattoo parlours,
- Illicit drug users and needle exchanges,

➢ Funeral services,

➢ Ambulance services,

➢ Home treatment.

The treatment of each infectious disease generates various hazardous wastes, which determines the classification according to **kind of infectious disease**. Infectious waste represents all materials used for the treatment and examination of patients with infectious diseases [4, 7].

The **health risks** associated with hazardous medical waste can be divided into five categories [7]:

➢ trauma risk;

➢ infection risk;

➢ chemical risk;

➢ fire or explosion risk;

➢ radioactivity risk.

4. Review questions and suggested answers

Questions for independent study

1. Waste resulting from the self-administration of insulin is classified as medical waste?

2. Glass fragments from hospitals are hazardous medical waste?

3. Expired medicines are hazardous medical waste?

4. How is considered garbage that are not in contact with radioactive materials, dangerous chemicals, or infectious agents and does not present a sharps hazard?

5. The animal research and testing centres are sources of medical waste?

6. List three health risks associated with hazardous medical waste.

Answers

1. Yes, according to the World Health Organization, waste resulting from the self-administration of insulin is classified as medical waste.

2. Yes, glass fragments are sharp objects that can cause cuts or punctures, and they are considered highly dangerous medical waste.

3. All expired pharmaceutical items are considered pharmaceutical waste and must be disposed of properly because of their chemical or biological makeup.

4. Waste that has not come into contact with radioactive materials, hazardous chemical substances, or infectious agents, and which does not pose a risk of causing cuts or punctures, is referred to as non-hazardous waste or general waste.

5. The animal research and testing centres are considered as major sources of medical waste.

6. Trauma risk, infection risk, chemical risk, fire or explosion risk, radioactivity risk.

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