

DISPOSAL AND DISPOSAL OF MEDICAL WASTE

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Abstract: Modern management approaches are based on risk-based planning, compliance with international sanitary and hygienic standards and the application of continuous monitoring mechanisms. Autoclaving, incineration, chemical disinfection and alternative technologies occupy a special place among the methods of neutralization. In order to establish an effective system, it is necessary to improve the regulatory and legal framework, educate medical personnel, modernize technical infrastructure and apply digital control systems. Medical waste management is a system of complex organizational, technical and legal measures implemented to minimize the negative impact of hazardous and non-hazardous waste generated in healthcare facilities on human health and the environment. Medical waste consists of infectious, sharp-penetrating, pathological, pharmaceutical and chemical components and poses a high epidemiological and ecological risk. Therefore, their correct sorting at source, safe packaging, transportation by special vehicles and effective neutralization are of great importance.

Keywords: waste sorting; sanitary and hygienic standards; waste management system; monitoring and control

1. Introduction

The development of the modern healthcare system, along with improving the quality of medical services, has also led to an increase in the volume of medical waste. Waste generated in hospitals, clinics, laboratories, dental centers, veterinary institutions and other healthcare facilities acts as a source of epidemiological, chemical and physical risk. In this regard, proper and systematic management of medical waste is of strategic importance both in terms of public health and environmental protection.

Medical waste is divided into various categories according to its composition and degree of danger: infectious waste, sharps (needles, scalpels, etc.), pharmaceutical and chemical substances, pathological materials and household medical waste. Uncontrolled collection, transportation and disposal of this waste can lead to serious environmental and social problems such as the spread of infectious diseases, pollution of soil and water resources, and the release of harmful substances into the atmosphere.

In world practice, medical waste management is carried out on the basis of an integrated approach. This process includes sorting waste at source, safe packaging, temporary storage,

transportation by special vehicles and disposal using appropriate neutralization methods (incineration, autoclaving, chemical disinfection, etc.). The World Health Organization and other international organizations have developed normative and methodological recommendations to reduce risks in this area [4].

2. Experimental Section

Medical waste management is a multi-stage process that involves the safe, systematic and regulatory collection, transportation, neutralization and disposal of waste generated in healthcare facilities. The effective organization of this process is of great importance in terms of protecting public health and preventing environmental pollution. Medical waste is divided into the following main categories according to the degree of hazard and composition [3]:

Infectious waste - blood, biological fluids, materials contaminated with microorganisms;

Sharp-piercing waste - needles, scalpels, syringes and other instruments;

Pathological waste - tissue and organ residues;

Pharmaceutical and chemical waste – expired medicines, reagents;

Household waste – safe, but common waste generated in healthcare facilities.

Improper separation of this waste can lead to the spread of infections, pollution of soil and water bodies, as well as traumatic risks for staff.

Medical waste management is a complex process that requires a multi-stage and systematic approach. This process is not only the physical removal of waste, but also a management mechanism aimed at reducing epidemiological risks, protecting the environment and ensuring sanitary safety. As the volume and degree of danger of waste generated in modern healthcare facilities increase, each stage of their management acquires strategic importance. The management stages are closely interconnected and must be carried out in a consistent and coordinated manner. A defect at any of these stages can reduce the effectiveness of the entire system and create an epidemiological threat. Therefore, medical waste management is organized on the principle of “from source to final disposal”.

Transportation of medical waste is carried out by specially equipped and disinfected vehicles. During transportation, leakage, spillage or contact with third parties of waste should be prevented. The following principles are followed in the transportation process [1]:

- Planning routes in advance;
- Checking the integrity of the packaging;
- Regular disinfection of vehicles;
- Providing drivers and staff with personal protective equipment.

Since the transportation stage carries a high risk in terms of epidemiological safety, this process must be accompanied by strict control and documentation. Modern approaches use GPS tracking and digital accounting systems.



Figure 1. Decontamination and disposal

The final stage of medical waste management is its neutralization and disposal. This stage includes technological processes aimed at eliminating or minimizing the hazard of waste. The main methods are [2]:

Incineration – complete destruction of pathogenic microorganisms and organic matter at temperatures of 800–1200°C. Although this method is effective, it requires control of harmful gas emissions into the atmosphere.

Autoclaving – a process of sterilization with high pressure steam. This method is widely used for infectious waste and is considered safer from an ecological point of view.

Chemical disinfection – destruction of microorganisms using special disinfectants.

Alternative technologies – microwave processing, plasma technology and other innovative methods.

3. Result and discussion

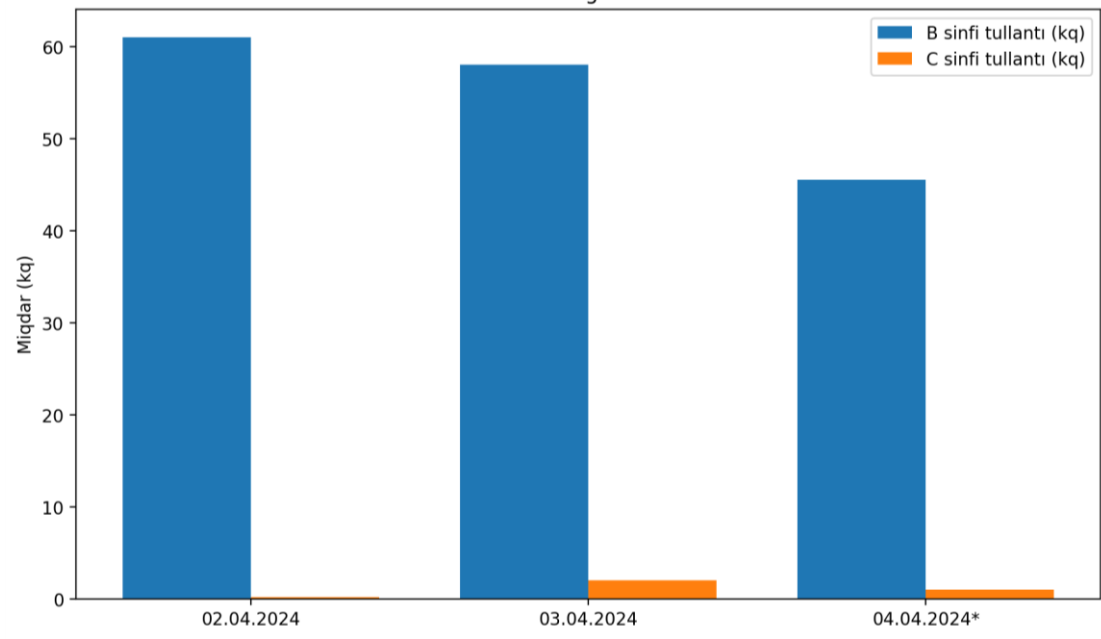
The choice of method is determined based on the type, amount of waste, economic efficiency and environmental impact. In modern approaches, the application of complex and integrated systems is considered a priority.

Table 2. Economic cost structure for medical waste management

Expenditure category	Components	Nature of costs	Economic impact assessment
Infrastructure costs	Storage space, containers, refrigeration systems	Capital (one-time)	Long-term investment, ensuring safety
Equipment and technology	Autoclave, incinerator, disinfection devices	Capital + depreciation	Process efficiency and risk reduction
Logistics and transportation	Special vehicles, fuel, disinfection	Current costs	Reducing epidemiological risks
Wages and training	Staff salaries, continuous training programs	Current costs	Reducing human factor risk
Monitoring and digitalization	Electronic accounting system, GPS tracking	Capital + current	Enhancing transparency and control
Environmental safety measures	Filtration systems, emission control	Capital + maintenance	Protecting the atmosphere and water resources
Accident and emergency fund	Contingency fund for leaks or contamination	Reserve cost	Reducing the financial impact of risk

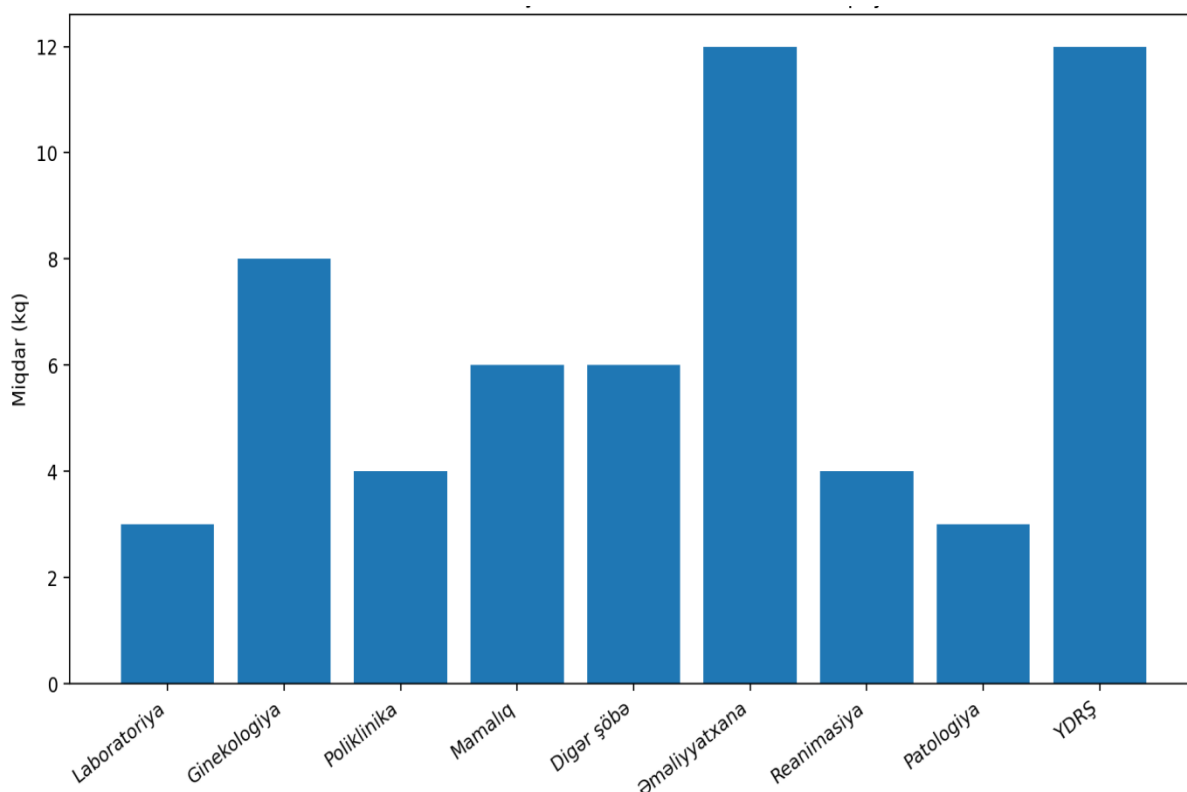
This table shows that the costs of medical waste management are not limited to direct disposal. Rather, the system has a complex structure of capital and current costs. In the long term, proper management leads to a reduction in healthcare costs and epidemiological harm.

Chart 3. Volume of medical waste by day



It is clear from the graph that the main part of medical waste during the observed period was class B waste. On 02.04.2024, this indicator was 61 kg, on 03.04.2024 it was 58 kg, and on 04.04.2024 it was 45.5 kg. The amount of class C waste was recorded at the level of 0.2 kg, 2 kg, and 1 kg, respectively. These results show that the main attention in waste management at the enterprise should be focused on the safe collection, transportation, and disposal of class B waste. At the same time, although the volume of class C waste is small, special control over them is important due to their high risk.

Chart 4. Distribution of Class B medical waste



Analysis of class B medical waste by departments on 03.04.2024 shows that the highest indicator was recorded in the Operating Room and ICU departments, each of which generated 12 kg of waste. In the Gynecology Department, this indicator was 8 kg, in Obstetrics and other departments - 6 kg. In the Polyclinic and Intensive Care Departments, 4 kg, and in the Laboratory and Pathology Departments - 3 kg of class B waste were recorded. These results indicate that the intensity of medical waste generation directly depends on the nature of the departments' activities.

4. Conclusion

Medical waste management is an integral and strategically important component of the modern healthcare system. The theoretical and practical analysis conducted shows that

improper management of medical waste is not only a sanitary problem, but also a source of serious epidemiological, environmental and economic risks. Therefore, the application of a systematic, integrated and regulatory management model in this area is necessary.

The research results show that effective management of medical waste should be based on the following basic principles:

- Correct and accurate sorting of waste at source;
- Organization of a safe packaging and temporary storage system;
- Controlled transportation by special vehicles;
- Application of environmentally safe and efficient neutralization technologies;
- Integration of digital monitoring and accounting systems;
- Continuous training and education of healthcare personnel.

Economic analysis shows that although initial capital investments and current costs create a certain financial burden, in the long term this system has high socio-economic efficiency in terms of preventing the spread of infections, protecting the environment and reducing healthcare costs. The assessment based on the risk matrix confirms that epidemiological and environmental threats require priority management measures. From an organizational perspective, medical waste management is closely related to institutional coordination, public-private sector cooperation and the principles of corporate social responsibility. Transparency, accountability and compliance with international standards are the main conditions for sustainable management in this area.

Thus, safe and efficient management of medical waste is of great importance in terms of protecting public health, ensuring environmental safety and implementing a sustainable development strategy. The application of modern technologies and risk-based management mechanisms not only increases the effectiveness of this system, but also serves to form a healthy and safe environment for future generations.

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