

## **PROBLEMS OF ENVIRONMENTAL PROTECTION AND BALANCED NATURE MANAGEMENT. MODERN TECHNOLOGIES OF ENVIRONMENTAL PROTECTION.**

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### **PROBLEMS OF DISINFECTION AND PROCESSING OF MEDICAL WASTE**

*The article provides an analysis of medical waste management in Ukraine. As medical waste is hazardous, it partially reflects the handling of dangerous waste components, such as chemicals used in medicine, heavy metals wastes, and other separately collected waste components.*

*Particular attention should be paid to medical waste because it can be not only a source of infectious but also toxic pollution. It can also contain very high concentrations of toxic compounds (cytostatics, antibiotics, and other drugs) and radioactive substances, which have a negative impact on human health and the environment. The amount of drugs and products of their metabolism that pollute the planet's water resources is increasing all over the world. That is why the problem of hazardous medical waste management in Ukraine needs to be solved.*

*We have carried out monitoring of medical waste, effective methods of disposal, and storage of waste within the dental medical center. The classification of pharmaceutical and medical wastes and ways of reducing the environmental impact of medical wastes are researched.*

*Biological waste, dressing material, polymer waste, metal, glass, chemical waste, mercury, X-ray film, paper, rubber, plaster casts, household waste were found among the medical waste of the dental clinic. The largest group of waste by weight in morphological composition are polymers (syringes, gloves, saliva ejector, etc.).*

*Hygienic and ecological assessment of waste disinfection methods is presented and relevant recommendations are provided. The higher efficiency of autoclaving in comparison with chemical disinfection of medical waste according to certain regulatory parameters is proved. Because the chemical disinfection does not guarantee the complete destruction of the infectious agent, it is recommended only as a temporary method of waste disinfecting with the following packaging and labeling for special disinfection.*

***Key words:*** medical waste, dangerous waste, utilization, disinfection.

**Introduction.** The accumulation of waste in authorized and unorganized landfills is one of the key environmental problems in Ukraine and the world. Many dangerous wastes are taken to landfills for solid household waste that seriously worsens the ecological situation. The category of hazardous waste includes medical, bioorganic, oil sludge, pharmaceutical, and others that can harm human health and the environment through improper storage, transportation, and processing. Particular attention should be paid to medical waste, which can be a source of infectious and toxic pollution.

As medical waste is hazardous, it partially reflects the handling of dangerous waste components, such as chemicals used in medicine, heavy metals wastes, and other separately collected waste components.

Most of the waste from medical institutions in Ukraine and the world is not hazardous and can be classified as solid waste. However, a large amount of this waste (about 10-16%) is a severe danger to patients, medical staff, as well as to the environment.

Medical waste cannot be classified as household waste, as its infectious risk can exceed 1000 and more times from harmless municipal solid household waste. They can also contain very high concentrations of toxic compounds (cytostatics, antibiotics, and other drugs) and radioactive substances, which have a negative impact on human health and the environment. Medical waste is for only 3-5% of total waste, but it is considered more hazardous.

The appearance of new scientific discoveries in the pharmaceutical field contributes to the creation of new technological processes that should increase productivity and improve the quality of finished products. However, hazardous medical waste management is an open question in Ukraine [1]. Only a small number of companies deal with the utilization of medical waste. Such waste should be disinfected and, as a possible option for utilization, incinerated, but not simply disposed of at all available landfills, which are intended for household waste. But it takes place that a very large part of medical waste is concentrated in these landfills.

Today, the pharmaceutical and medical industries are the important sectors of the world economy. The amount of drugs and products of their metabolism that pollute the planet's water resources is increasing all over the world. That is why the problem of hazardous medical waste management in Ukraine needs to be solved. Therefore, the issue of efficient, and safe collection, sorting, processing and utilization of medical waste remains actual for Ukraine and for the world community.

**Purpose of the research:** to track the dynamics of medical waste accumulation and identify perspective methods for their utilization.

**The objectives of the research** presented in the article are the analysis of medical waste management in Ukraine; dynamics of waste accumulation within one medical institution; hygienic and ecological assessment of waste disinfection methods.

**Theoretical basis of the research.** Currently, there are no common approaches to determining the qualitative and quantitative composition of medical organizations waste of different profiles at the present stage. Unfortunately, still there are no identical, scientifically defined hygienic and epidemiological approaches to the assessment and selection of the optimal method of hazardous waste disinfection. This may depend on the profile of the treatment and prevention measures, which determines the physicochemical, fractional properties of waste, and the organization of medical and geographical features. Moreover, there are differences in the classification of medical waste, both under Ukrainian law and by the classification adopted in the EU [1]. That is why the subject and purpose of the research are relevant.

Monitoring of hospital waste, determining effective methods of control and storage within each medical institution is important in effectively solving the problem of processing and disposal of medical waste. So, in experimental research, we tried to solve the following questions:

- determination of the number of unusable drugs and waste within the dental clinic;
- hygienic characteristics of waste management methods;
- effective logistics methods for waste disposal and removal [2].

Medical waste management in Ukraine is regulated by the «State sanitary and anti-epidemic rules and regulations on medical waste management» approved by the order of the Ministry of Health of June 8, 2015, № 325 (hereinafter – the Order) [3].

Unfortunately, health care facilities still use the Instruction on the collection, disinfection, storage, and delivery of used disposable plastic medical devices, approved by the order of the Ministry of Health of October 22, 1993, № 223. This instruction creates dangerous conditions both for medical workers and for an ecological situation. In particular, it contradicts the current Order in the part on disassembly of syringes and systems for intravenous infusion.

According to the current Order, medical waste is divided into the following categories:

- category A – epidemically safe medical waste;
- category B – epidemically hazardous medical waste;
- category C – toxicologically hazardous medical waste;
- category D – radiologically hazardous medical waste.

**Category B is the largest group of hazardous medical wastes, which includes any wastes that have been in contact with biological fluids. For example, this category includes wastes that remain during and after the care of patients with COVID-19.**

Chemical disinfection of category B wastes at the place of their generation is used as a mandatory temporary measure in the absence of a centralized disinfection system. Liquid waste of category B is poured into the centralized sewage system only after preliminary decontamination by chemical or physical methods. Thermal

disposal of category B waste is carried out by a centralized method, in the absence of special equipment in the institution. All wastes of categories B and C are collected in labeled containers with tight-fitting lids and stored in specially designated areas.

Collection, temporary storage of waste cytostatics and genotoxic drugs (class B), as well as all types of waste generated by the preparation of their solutions (vials, ampules, etc.), without decontamination is not allowed. Medical waste must be immediately decontaminated at the site of their generation using appropriate methods. It is also necessary to carry out complete decontamination of the workplace. All processes with such waste must be carried out with the use of appropriate personal protective equipment and always in a fume hood.

Category B medical waste must be transferred to specialized companies which are licensed to carry out operations of hazardous waste management.

**Experimental part.** Methods and equipment permitted for use in Ukraine in accordance with the procedure established by law should be applied for waste disinfection [3]. If disinfection is carried out on the objects of their formation, then both chemical and thermal disinfection is used. The most common are the following types:

- «Classical» chemical disinfection includes the treatment of waste with registered disinfectants, in the way prescribed by the Ministry of Health, and recommended for use as chemicals of disinfecting for medical waste class B in concentrations and exposure times specified for viral infections and/or mycobacteria of tuberculosis (for example, ammonium salts and organochlorine preparations).

- Sorption chemical disinfection involves the collection and disinfection of liquid (organic) waste of classes B and C. For this purpose, special packages of the complete isolation system and absorption of polymeric material (SAP-polymer) are used for this type of waste. Such systems convert liquid into a gel with simultaneous complete disinfection. Packages «Oops-bag» contain an external moisture-proof shell and an internal bag with the adsorbent (SAP-polymer).

- Ozone-oxygen disinfection is carried out in special apparatus. The disinfector is intended for low-temperature disinfection with ozone contained in the ozone-oxygen mixture of objects with the medical waste of class B, including directly in the places of their primary formation. Disinfection is carried out in the ozone-oxygen environment that fills the sterilization camera, due to the influence of ozone, which has an extremely high oxidizing ability.

- Chemical disinfection with simultaneous grinding. Technologically, this method includes the operation of a mechanized apparatus that uses chemicals as a disinfectant, followed by mechanical grinding in a closed camera. It should be noted that the equipment of «Sterimed-1» allows more complete penetration of the disinfectant into the thickness of disinfected medical waste. Thus, there is an increase in the efficiency of chemical disinfection, and as a result, the amount of disinfectant consumed significantly reduces, as well as recycled hospital waste.

- The action on the waste by steam under pressure is carried out in special autoclaves. Autoclaving is one of the methods that has long been used as a decontamination technology, and all over the world. This method is approved for use in many European countries and is regulated by the WHO Directive as a method of thermal disinfection of medical waste of classes B and C.

- Temperature disinfection with simultaneous grinding (Newster method). The principle of action of the installation is based on the previous fine shredding of waste by frictional heating supplemented by resistance heaters of waste up to about 155°C. The increased temperature occurs due to the force of friction in the process of fine grinding. Dry powder waste is generated as a result of the disposal, it reduces in volume by more than 7 times, completely safe in ecological, hygienic terms.

- Microwave disinfection. The disinfection system is represented by an instrument of passive way of action, which does not require direct contact with the patient, does not have any effect on him. The disinfection system complies with the requirements for the treatment of class C waste in terms of resistance to mechanical factors. This system is equipped with a personal operating device, such as a computer, which can print a check with the parameters specified in the cycle of medical waste disinfection. This equipment also includes a press.

**The chemical method is not recommended for use, including the Order of the Ministry of Health.**

It is dangerous for medical workers, expensive, has low disinfection efficiency. However, it is used by most health care facilities in Ukraine. Steam treatment at high temperatures under pressure (autoclaving) is the second method most used by health care facilities.

**Results and discussion.** The object of the experimental study was a private dental clinic located in Vinnytsia. The average annual number of patient visits is 4,000, the number of staff is 16 people. The number of employees serving 1 shift (daily) is as follows:

- doctors (including surgeons, pediatric dentists) – 5;
- technicians – 2;
- nurses, medical assistants – 6;

- administrator – 1;
- junior medical staff – 2.

The waste storage and disinfection room has an area of 14 m<sup>2</sup>, has a window, and is equipped with ventilation of household capacity. In accordance with the requirements of the Ministry of Health [3], the cabinets are provided with a cold and hot water supply, drainage, autonomous ventilation system.

Planning and design solutions of cabinets and offices provide the flow of the technological process and the ability to comply with the principle of division into «clean» and «dirty» zones. The room has shelves for storage and packaging of each type of hazardous waste. During the movement of materials and waste, the principle of «one-way road» is observed, which provides the logic of material flows, while «clean» and «dirty» material flows do not intersect. Movement of the infected and hazardous waste is planned through the incubation corridor.

Types and morphological composition of waste were studied by analysis of waste structural units of a multidisciplinary dental clinic. This analysis is shown in table 1.

**Table 1 – Sources of formation and morphological composition of waste**

Structural unit	Type of waste and their morphological composition
Dental therapeutic department	Dressing material, polymer waste (syringes, gloves, saliva ejector, etc.), metal, glass, chemical waste, mercury, X-ray film, paper, rubber, plaster casts, household waste
Pediatric dental therapeutic department	Dressing material, polymer waste (syringes, gloves, saliva ejector, etc.), metal, glass, chemical waste, mercury, X-ray film, paper, rubber, plaster casts, household waste
Dental surgical department	Biological waste (teeth), dressing material, polymer waste (syringes, gloves, saliva ejector, etc.), metal, glass, chemical waste, mercury, X-ray film, paper, rubber, plaster casts, household waste
Dental orthodontic department	Dressing material, polymer waste (syringes, gloves, saliva ejector, etc.), metal, glass, chemical waste, mercury, X-ray film, paper, rubber, plaster casts, household waste
X-ray room	Metals, glass, X-ray film, paper, rubber, household waste, polymer waste

The general structure of all types of waste generated daily in the studied dental clinic is presented in Fig.1.



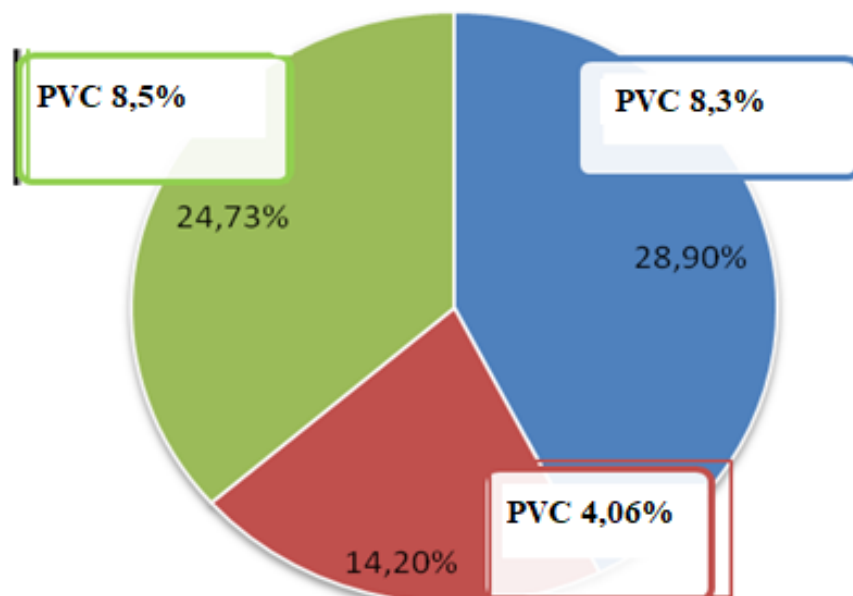
**Figure 1 - The average composition solid waste of the clinic:**

1 – safe waste (A); 2 – potentially infected waste (B);  
3 – toxicologically hazardous medical waste (C); 4 – other wastes.

Other wastes include wastes that are transferred in batches for special disposal without damaging the packaging. falsification and overdue drugs belong to this group first of all.

The largest group of waste by weight in morphological composition are polymers. Figure 2 shows the fractional composition of polymer waste in a dental clinic.

Thus, in the studied dental institution, the amount of PVC (polyvinyl chloride) in the composition of polymeric medical waste is from 4,06% to 8,50%. The largest amount of polymer waste is generated during therapeutic appointments.



**Figure 2 – Fractional composition of polymer waste:**  
■ - treatment cabinets 1-3; ■ - surgical cabinet; ■ - X-ray cabinet.

Disinfection of waste in this institution is carried out by the method of classical chemical disinfection and by treatment of waste with hot steam (autoclaving method). Chemical disinfection is carried out with drugs based on chloramines. In this way, not only wastes are disinfected but also medical cabinets, premises for procedures, and workplaces of staff. Comparative characteristics of the two methods of disinfection are shown in table 2.

**Table 2 – Evaluation of disinfection methods**

Evaluation criteria	Classical chemical disinfection	Steam treatment under pressure
Complete destruction of infections	No (-)	Yes (+)
Decrease of waste volume	No (-)	Yes (+)
Use of chemical reagents	Yes (-)	No (-)
Grinding	No (-)	No (-)
Presence of harmful emissions	Yes (-)	No (+)
Changing the appearance of waste	No (-)	Yes (+)
Need for additional sorting	No (+)	No (+)
Presence of filters	No (-)	No (-)
Productivity (kg / h)	1-5 (-)	8÷12 (+)
The sum of positive points	1	6

Thus, the higher efficiency of autoclaving in comparison with chemical disinfection of medical waste according to certain regulatory parameters is proved.

Because the chemical disinfection does not guarantee the complete destruction of the infectious agent, it is recommended only as a temporary method of waste disinfecting with the following packaging and labeling for special disinfection.

Timekeeping of disinfecting waste procedures has been performed for medical employees. Comparative characteristics for the two methods of waste decontamination are shown in table 3.

Therefore, the method of waste treatment by steam under pressure is recommended as a full-fledged disinfection method

**Table 3 - Timekeeping of procedures for medical employees for different methods of waste disinfection, min.**

Type of processing	Therapeutic and diagnostic processes	Preparation of chemical solutions	Preparatory activities	Waste processing	Tool processing	Working with documents	Total time
Chemical disinfection	16	32	25	125	40	25	263
Autoclaving	20	-	20	45	20	25	130

Thus, the staff spends twice as much time treating solid waste by chemical disinfection than when treating waste with steam under pressure. Summary of the advantages and disadvantages of each method, based on observations, are presented in table 4.

**Table 4 - Advantages and disadvantages of waste decontamination methods used in the dental medical center**

Type of disinfection	Advantages	Disadvantages
Chemical disinfection	High efficiency of disinfection at professional and long treatment. Low cost of disinfectants and equipment. The method is easy to realize.	Highly qualified service is required. Toxic substances are used that require special safety principles. Not used for toxic waste, drugs, and some infected waste.
Recommendations: Only as a temporary method of disinfection, private practice clinics.		
Autoclaving	Ecologically safe method. Significant reduction of waste. Relatively low capital and maintenance costs.	Highly qualified service is required. Not used for biological, pharmaceutical, and toxic wastes, for wastes impermeable to vapor.
Recommendations: ambulatory clinics, dental institutions, medical assistant and obstetric units.		

### Conclusions

Monitoring of medical waste, effective methods of disposal and storage of waste within the dental medical center were carried out. The analysis of quantitative characteristics and fractional composition of wastes of classes B and C testifies to their polymorphism and depends on the type, the volume of medical care, and logistical support of medical institutions. The monitoring of hazardous waste on the structural departments of the dental clinic indicates that 48% of all waste of classes B and C is generated in the surgical department.

The staff spends twice as much time treating solid waste by chemical disinfection than when treating waste with steam under pressure. The chemical disinfection does not guarantee the complete destruction of the infectious agent, that's why it may be recommended only as a temporary method of waste disinfecting with the following packaging and labeling for special disinfection.

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