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PROBLEMS OF MEDICAL WASTE MANAGEMENT DURING THE COVID-19 PANDEMIC

ПРОБЛЕМИ ПОВОДЖЕННЯ З МЕДИЧНИМИ ВІДХОДАМИ ПІД ЧАС ПАНДЕМІЇ COVID-19

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Abstract. The COVID-19 pandemic has become a serious threat not only due to the spread of coronavirus infection, but with the emergence of a new global problem that is growing not only in Ukraine but also around the world – the generation of potentially hazardous medical waste, namely used medical personal protective equipment (PPE), so it is important to determine their place in the system of medical waste management, their composition and possible ways of disposal. The article analyzes the problems of medical waste generation, especially used personal protective equipment, which appeared in connection with the spread of coronavirus infection COVID-19. The mechanism of receipt of such medical waste into the environment and their impact on the human body is analyzed. Problems with medical waste in Ukraine have been studied. It is analyzed that the solution of the problem of medical waste management in Ukraine is at the initial level. A priority direction for Ukraine in terms of medical waste management is proposed. Adjusting the classification of medical waste will create a developed system of potentially hazardous waste, which will include: separate collection, safe storage and transportation, environmentally friendly disposal using the useful properties of polymeric materials, it is possible to obtain additional energy resources. Today the main tasks of the pandemic medical waste management are to collect contaminated and potentially contaminated COVID-19 polymer waste to prevent them from entering landfills, to develop a national recycling network to effectively control all infectious and other hazardous medical wastes, which will further prevent use of landfills for waste disposal, creation of bases for introduction of proven methods and technologies of medical waste management, in particular ecologically safe circulating pyrolysis, which will allow to improve waste management standards in order to reduce pollution of NPS.

Key words: pandemic; personal protective equipment; hazardous waste; natural environment; human health; handling methods.

Анотація. Пандемія COVID-19 стала серйозною загрозою не лише через розповсюдження коронавірусної інфекції, але і через появу нової глобальної проблеми, яка зростає не лише в Україні, а й у всьому світі – утворення потенційно небезпечних медичних відходів, а саме використаних медичних засобів індивідуального захисту, тому зараз важливо визначити їх місце в системі поводження з медичними відходами, склад і можливі шляхи утилізації. У статті проаналізовано проблеми утворення медичних відходів, а саме використаних засобів індивідуального захисту, які виникли у зв'язку з поширенням коронавірусної інфекції COVID-19. Проаналізовано механізм надходження таких медичних відходів у навколишнє середовище та їх вплив на організм людини. Досліджено проблеми з медичними відходами в Україні. Встановлено, що питання збору й утилізації медичних відходів в Україні залишається невирішеним. Запропоновано пріоритетний напрям для України щодо поводження з медичними відходами. Коригування класифікації медичних відходів дозволить створити розроблену систему потенційно небезпечних відходів, яка включатиме: роздільний збір, безпечне зберігання та транспортування, екологічно чисте захоронення з використанням корисних властивостей полімерних матеріалів, із яких можна отримати додаткові енергетичні ресурси. Основними завданнями поводження з пандемічними медичними відходами сьогодні є збір забруднених і потенційно забруднених полімерних відходів COVID-19 для запобігання їх потраплянню на звалища, розробка національної мережі переробки для ефективного контролю всіх інфекційних та інших небезпечних медичних відходів, що надалі запобігатиме використанню звалищ для утилізації відходів, створення баз для впровадження перевірених методів і технологій поводження з медичними відходами, зокрема екологічно безпечного циркуляційного піролізу, що дозволить знизити обсяги забруднення навколишнього середовища шляхом вдосконалення стандартів поводження з відходами.

Ключові слова: пандемія; засоби індивідуального захисту; небезпечні відходи; природне середовище; здоров'я людини; методи поводження.

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Problem statement. The COVID-19 pandemic has become a serious threat not only due to the spread of coronavirus infection, but with the emergence of a new global problem that is growing not only in Ukraine but also around the world – the generation of potentially hazardous medical waste, namely used medical personal protective equipment (PPE), so it is important to determine their place in the system of medical waste management, their composition and possible ways of disposal.

The article aim. Study of the characteristics of medical waste during the COVID-19 pandemic.

Methods, object and subject of the research. Methods – The study uses methods of analysis and classification.

Object – Waste management system during the COVID-19 pandemic.

Subject – Medical waste (composition, volume, hazard) during a pandemic.

Latest research and publication analysis. There is no well-established modern system of collecting and utilization of medical waste at all in Nikolaev as well as in Ukraine. Medical waste is all waste that came into contact with the patient, or a potentially infected person, or contact, generated in medical institutions, laboratories, research and biomedical centers, in the home, including – body tissues, used syringes, systems, blood bags, dressings, disposable utensils, and even leftovers. According to the Basel Convention (1998), in international waste management practice, medical waste resulting from the medical care of patients in hospitals, clinics and clinics is allocated to a separate group and is defined as hazardous [1]. The introduction of quarantine and the introduction of a state of emergency in the country has affected almost all spheres of

public life and business processes. The sphere of sea transportation and related businesses, from the employment of seafarers to the transshipment of cargo, the prohibition for crew members to leave the ship during its berthing in the port, mandatory 14-day quarantine for all ships, was not left out. recycling of household waste of the crew and more. During the COVID-19 pandemic with the growing demand for masks, gloves and other PPE, detergents and hygiene products, due to the fact that shops, cafes and restaurants, airplanes and ships used only disposable tableware and packaging, consumers preferred plastic products as an additional measure of hygiene, a new type of garbage was formed, which ended up in landfills or containers as solid waste (MSW), possibly potentially dangerous [2–4].

According to nonofficial statistics, about 1 million tons of medical waste is generated annually in Ukraine, of which more than 15% is hazardous. More than 90% of medical waste enters garbage cans and is disposed of in landfills without pre-treatment, sorting and disinfection [5]. 1 g of solid waste contains from 0,1 to 1 billion microorganisms, and in medical waste this number increases to 200–300 billion [6]. Disposal of medical waste at landfills leads to leaching of hazardous microorganisms by groundwater, and in case of decay and decomposition of the bioorganic component of waste, hazardous microorganisms can get to the surface with gases that are released, which can contaminate soil layers and create microorganisms in the natural environment (NPS). Together with the filtrate, formed in the body of the landfill, they seep into the soil and water, creating a serious environmental hazard to the environment. These microorganisms

cause infectious diseases, can be a source of various viruses and infections, COVID-19, AIDS, tuberculosis, hepatitis B and C, which can be transmitted by improper handling of medical waste, through objects, contaminated with blood or biological fluids or in results of direct illegal dumping of infectious waste and require special treatment and destruction of the yellow list of waste, and in interaction with biologically active synthetic compounds create a synergistic and cumulative effect.

Products of different chemical groups can be used for disinfection, which makes some waste hazardous, can cause poisoning or damage to the skin for people who collect or dispose this waste. In addition, medical waste in the vast majority are biologically active synthetic compounds, which have no analogues in nature, which complicates the process of their safe disposal [7].

The basic material (results). The spread of COVID-19 coronavirus infection has caused increased demand for disposable medical products: masks, gloves, disposable gowns, goggles, protective shields and similar wastes, which has led to negative social, economic, sanitary-epidemiological and other consequences. Hazardous substances, contained in used medical PPE, such as pathological microorganisms, even in small concentrations, pose an epidemiological danger because of a significantly higher total microbial count that they have. The problem of medical waste disposal needs to be addressed urgently, as they have a significant degree of infection, can cause outbreaks of infections and epidemics, and the environmental safety and public health depends on how they will be disposed [8; 9].

Waste management is one of the main issues not only of environmental but also

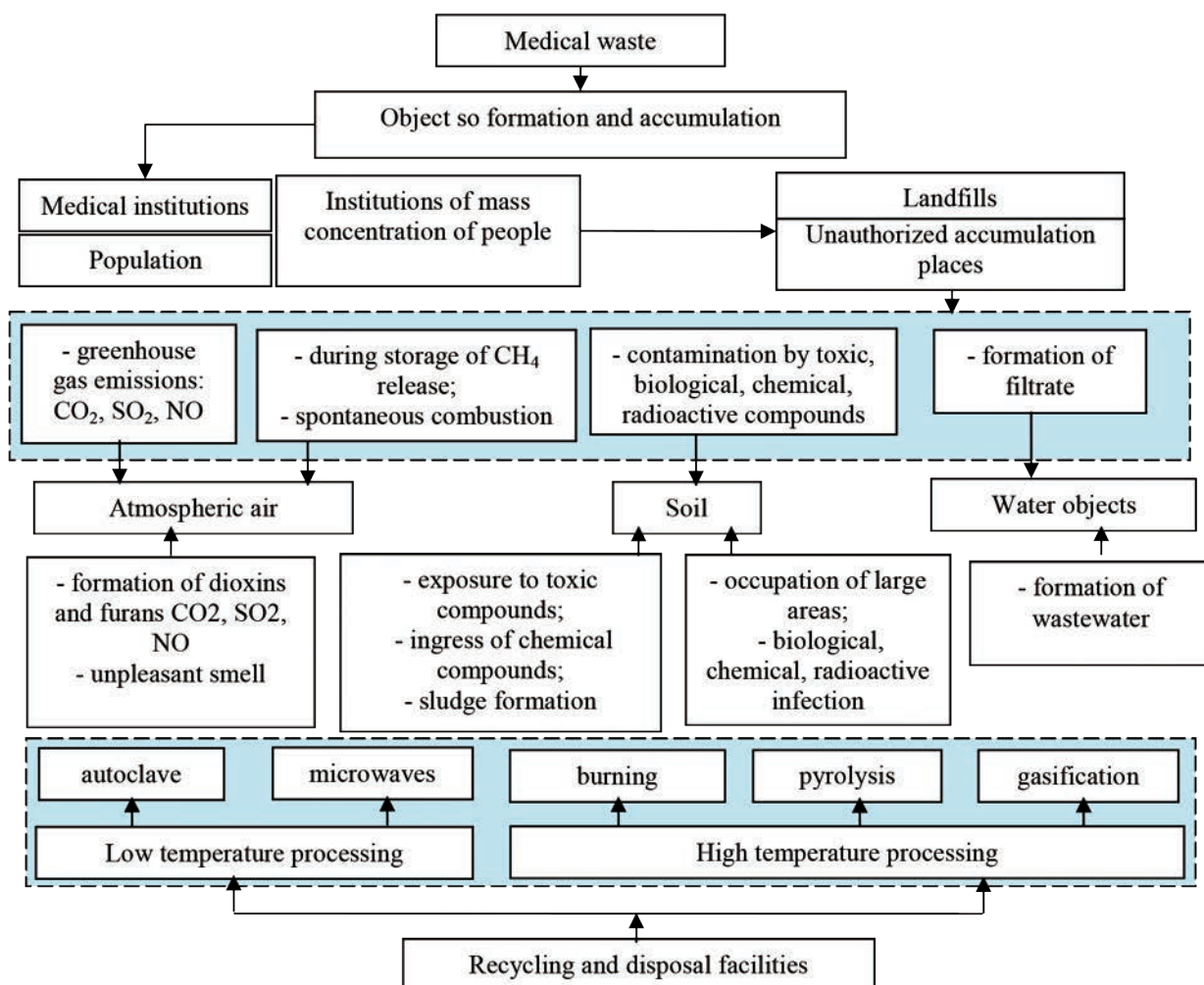


Fig. 1. Impact of medical waste and recycling facilities on the environment

epidemiological safety of the population of Ukraine due to the pandemic that caused a large amount of medical waste. They, in turn, can lead to poisoning by toxic chemical compounds in all conditions due to various biochemical processes (Fig. 1).

Medical waste, depending on the degree of their epidemiological, toxicological and radiation hazards, as well as possible negative effects at the stages of their treatment on the human environment in Ukraine are divided into 4 hazard classes [10] Fig. 2. But the situation with COVID-19 adds the category between categories A and B, this is potentially hazardous waste from infected patients who are at home in self-isolation or in reservation. And the ways of handling such waste are not defined yet, they end up in landfills with ordinary solid waste,

which creates a danger. An important factor in the management of such waste is to organize separate collection, storage and a high degree of personal protection of those involved.

To reduce the negative impact of medical waste on the environment and the population, it is necessary to separate hazardous waste, recycle it, comply with sanitary and hygienic requirements and use appropriate technology for disposal. According to the “Requirements for medical waste management” [11], the key issues of their management strategy are minimization, reduction of their generation, separation in places of formation, recycling, reuse, recycling and disposal, disposal and disposal. The algorithm of actions and the scheme of medical waste management are presented in fig. 3, 4.

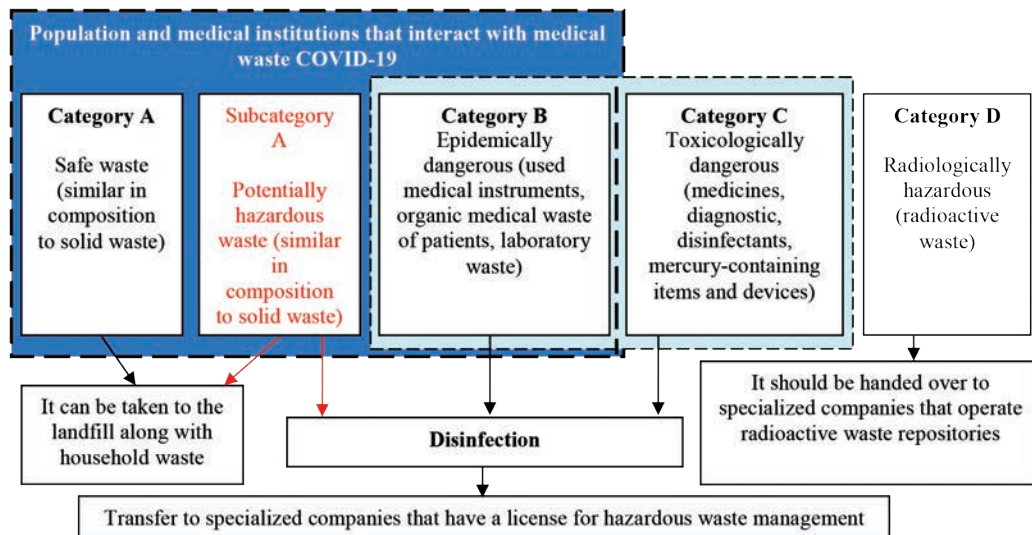


Fig. 2. Classification of medical waste by hazard classes

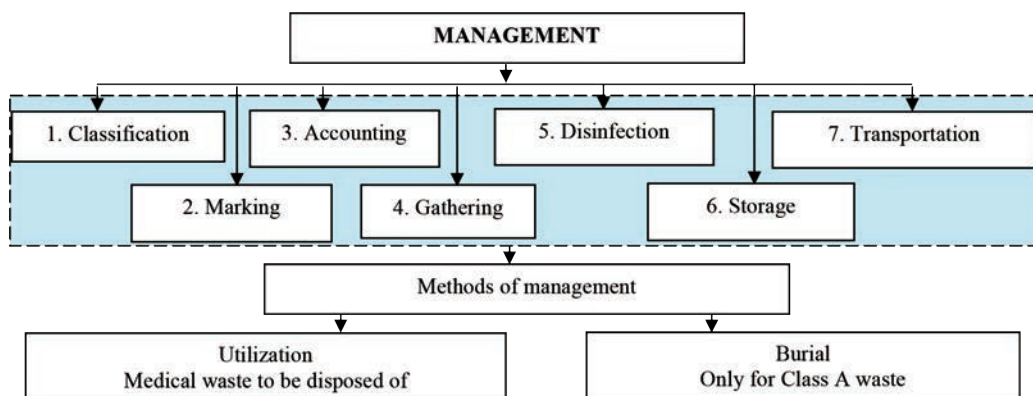


Fig. 3. Algorithm of actions at medical waste management

Medical waste from COVID-19 generated in hospitals is classified as category B – epidemic-hazardous, infected and potentially infected waste that was in contact with the biological environments of infected material.

Unfortunately, there are no up-to-date statistics on the total amount of medical waste, PPE and others, especially given the COVID-19 outbreak in Ukraine. The identified problems require significant structural changes in waste management, from the rules of their sorting, collection and treatment to the safety protocol for waste collection workers.

Against the background of the ongoing pandemic, ACR + recommendations were developed for masks, gloves, napkins and other contaminated waste, which should be in a double package and should be considered hazardous waste in case of infection with pathogenic microorganisms [12; 13].

The main approaches to waste management contaminated with COVID-19 are presented in fig. 5.

It is important to start work on developing a network of reverse epidemiological logistics for the treatment of medical waste during epidemic outbreaks. As with all viruses, the approach to removing contaminated and potentially contaminated COVID-19 waste is to disinfect and destroy it on site, namely in medical facilities. In developed countries, since the beginning of the pandemic, networks have been deployed to collect protective masks from the population. From the point of view of virologists regarding the use of means of protection, it is enough to disinfect them with a disinfectant [14].

Disposable medical PPE are medical devices made of non-woven materials and are intended for use by medical staff and patients to ensure safety in the process of providing various types of medical care. The use of disposable medical clothing in modern conditions allows to more effectively solve the problems of prevention of nosocomial infections and helps prevent occupational infections of medical workers.

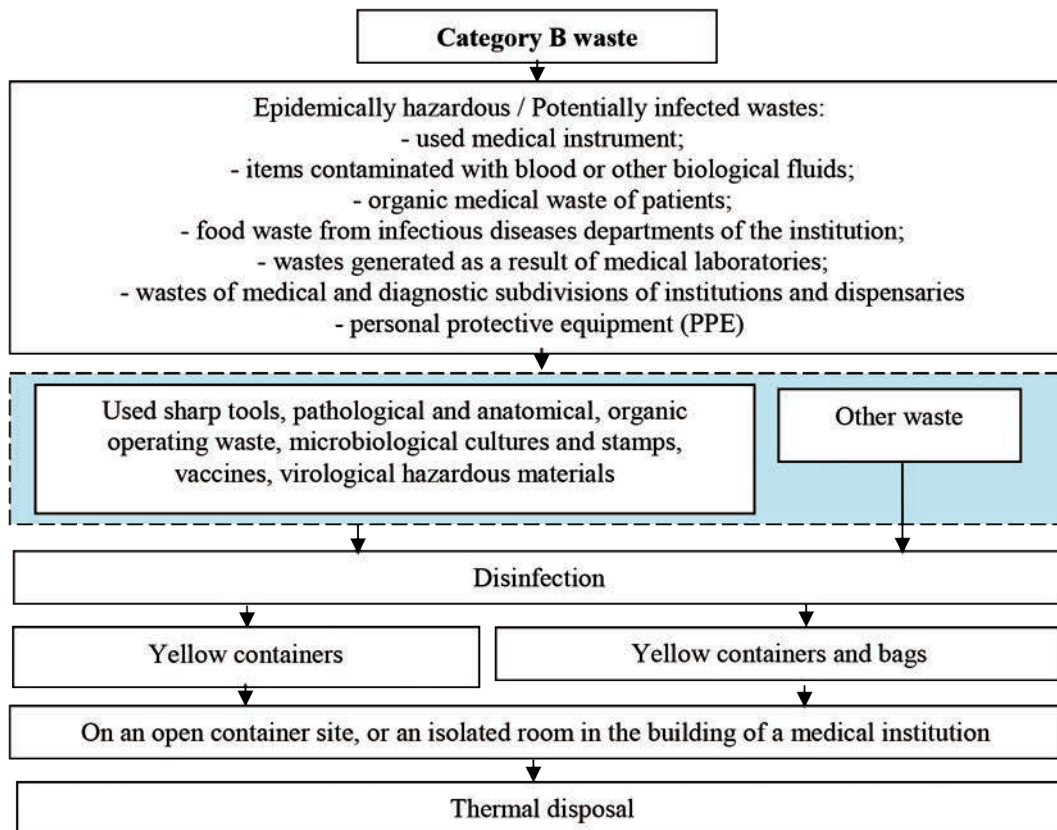


Fig. 4. Class B waste management scheme

Disposable medical clothing is widely used in surgical hospitals during surgery, in obstetrics and gynecology, in outpatient settings (dental care, cosmetology, etc.), as bed linen in infectious diseases hospitals and in anti-epidemic situations in conditions.

Materials used for the production of disposable medical clothing and linen must have sufficient barrier properties for the penetration of microorganisms (bacterial permeability not more than 3–5%), as well as meet a number of requirements: breathability, tear resistance, high moisture resistance, etc. Most of these requirements are met by multilayer nonwovens, as well as materials based on cellulose fiber, polyethylene and polypropylene fibers [15].

Nonwovens are used: multilayer nonwoven fabric CMC (spunbond-meltblown-spunbond), sontara (softes), taiwek, saprol, laminated nonwovens for medical use, which are made of polymeric materials (polystyrene, polycarbonate, polyethylene, polypropylene etc.) (table 1), which decompose for a long time in the natural environment. Even the production of gloves from a natural product (latex rubber) is not always environmentally friendly, due to

the addition of chemical impurities. Another problem is the fact that the vast majority of PPE is not subject to recycling or reuse.

When burning, such materials can emit such harmful substances as soot, carbon dioxide and carbon monoxide, etc. Decomposition products formed during oxide thermal destruction are toxic. Fine ash separated from gases requires appropriate treatment. During processing, the materials can emit styrene, benzene, ethylbenzene, toluene, carbon monoxide vapors. Thermal aging is accompanied by the release of aldehydes, ketones, hydrogen peroxide, etc. Combustible materials containing chlorine can form dioxins and furans, which are carcinogens, which is associated with adverse health effects. Combustion of materials high in lead, mercury and cadmium can lead to the spread of toxic metals into the environment [16].

Environmentally safe technology for the disposal of such polymer composite waste is pyrolysis using circulating processes.

The National Institute of Allergy and Infectious Diseases (CDC) and the Centers for Disease Control and Prevention (CDS) have reported that coronavirus lives on latex

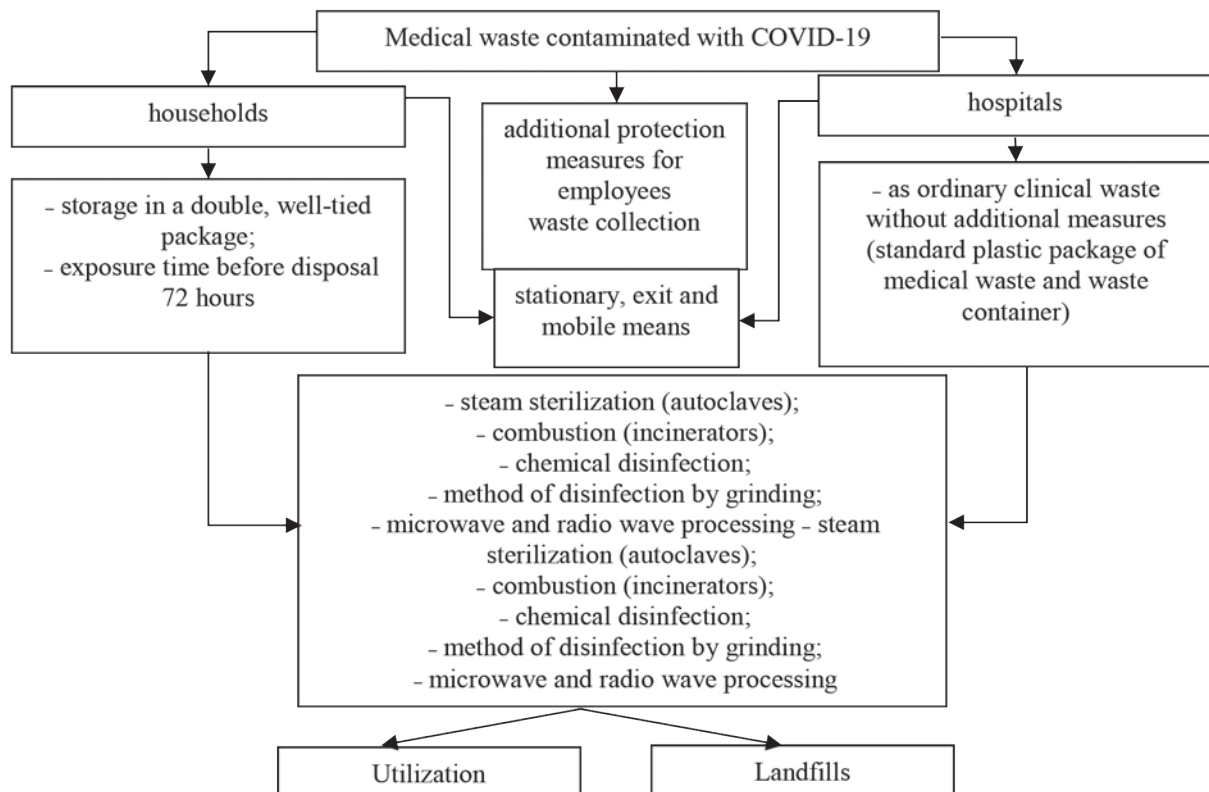


Fig. 5. Basic approaches to COVID-19 contaminated waste management

Table 1. Chemical composition of materials of medical personal protective equipment

Personal protective equipment	Material	Chemical composition	Formula
Disposable masks / respirators / bathrobes / shoe covers / hats / diapers	Spandbond	Polypropylene(PP)	$(C_3H_6)_n - 100\%$
	Spanlace	Polyester / polyethylene terephthalate (PET) Vickose Cellulose	$(C_6H_{10}O_5)_x - 50\%$, $(C_{10}H_8O_4)_n - 50\%$;
			$(C_6H_{10}O_5)_n - 70\%$, $(C_{10}H_8O_4)_n - 30\%$;
			$(C_6H_{10}O_5)_n - 80\%$, $(C_{10}H_8O_4)_n - 20\%$
		Polypropylene(PP)	$(C_3H_6)_n$
		(sometimes laminated with polyethylene (PE))	$(C_2H_4)_n$
	SMS (SSMS, SMMS, SSMMS)	Polypropylene (PP) meltblown – 100% – (polypropylene) S + M + S Spunbond + meltblown + Spunbond	$(C_3H_6)_n - 100\%$
	Thermobond	Polypropylene(PP)	$(C_3H_6)_n - 100\%$
	Airlade	Polyethylene(PE)	$(C_2H_4)_n$
		Polypropylene(PP)	$(C_3H_6)_n$
Vickose		$(C_6H_{10}O_5)_n$	
Cellulose		$(C_6H_{10}O_5)_x$	
Polycarbonate		$[-ORO-C(O)-]_n$	
Glasses/ medical protective shields	ABS	Acrylonitrile + butadiene + styrene	C_3H_3N C_4H_6 C_8H_8
	PET	Polyurethane foam	$C_8H_{16}N_2O_2$
	PVC	Polyvinylchlorid (PVC)	$(C_2H_3Cl)_n$
		Plastic/ polyethylene(PE)	$(C_2H_4)_n$
Overalls	Tieweek	Highdensitypolyethylene(HDPE)	$(C_2H_4)_n - 100\%$
Gloves	Latex	Emulsion of rubber particles in aqueous solution	$(C_5H_8)_n$
	Nitrile	Butadiene-nitrile vulcanized rubber alloy + latex not more than 5%;	butadiene C_4H_6 rubber $(C_5H_8)_n$
Gloves	Vinyl	Polyvinylchlorid (PVC)	$(C_2H_3Cl)_n$
	Polyethylene	Polyethylene(PE)	$(C_2H_4)_n - 100\%$
Disposable napkins / towels (Women's pads, baby diapers and nappies)	Sontara EC	Polyester / Polyethylene terephthalate(PET, PETP)	$(C_{10}H_8O_4)_n - 100\%$;
		Cellulose + polyester	$(C_6H_{10}O_5)_x - 49\% +$ $(C_{10}H_8O_4)_n - 51\%$
	Spanlace	Polyester / polyethylene terephthalate (PET) (C10H8O4) n viscose (C6H10O5) n cellulose (C6H10O5) x	$(C_6H_{10}O_5)_x - 50\%$, $(C_{10}H_8O_4)_n - 50\%$;
			$(C_6H_{10}O_5)_n - 70\%$, $(C_{10}H_8O_4)_n - 30\%$;
			$(C_6H_{10}O_5)_n - 80\%$, $(C_{10}H_8O_4)_n - 20\%$
		Polypropylene(PP)	$(C_3H_6)_n$
		(sometimes laminated with polyethylene (PE))	$(C_2H_4)_n$
	SMS (SSMS, SMMS, SSMMS)	Polypropylene (PP) meltblown – 100% – (polypropylene) S + M + S Spunbond + meltblown + Spunbond	$(C_3H_6)_n - 100\%$
	Airlade	Polyethylene(PE)	$(C_2H_4)_n$
		Polypropylene(PP)	$(C_3H_6)_n$
Vickose		$(C_6H_{10}O_5)_n$	
Cellulose		$(C_6H_{10}O_5)_x$	

[Author's development]

gloves and disposable masks for 7 days [17], so it is critical that medical organic waste from masks and gowns and gloves to medical equipment contaminated with COVID-19 have been disposed of in an environmentally sound manner.

To ensure the safe disposal of medical waste, local authorities have a responsibility to organize the collection of such waste from the public and medical facilities. It is necessary to inform the population, officials and employees of health care facilities about safe ways to dispose of medical waste and establish infrastructure for centralized collection of medical waste from the public and medical institutions, it is necessary to conduct surveys and train the population and health professionals to properly handle such waste. It is necessary to hold round tables with the leadership of the regions and, not least, to dispose of medical waste at such facilities that do not harm the environment. In this situation, the development and application of environmentally friendly energy-independent and waste-free technologies is necessary for the disposal of organic medical waste.

There are no specialized institutions or facilities for the treatment of such waste in most regions of Ukraine, therefore, there is a risk of their entry into conventional landfills with all possible consequences. Expenditures from the state budget for the purchase of containers and packages, vehicles for waste collection and temporary storage are insufficient. Very low fines for violating the rules of medical waste disposal do not solve the problem. Currently, the only way to overcome these problems is

the active implementation in Ukraine of the National Waste Management Strategy until 2030, which defines the main directions of state regulation in the field of waste management while taking into account European approaches based on the EU Directive. Prospects for further research are to develop rules for the management of medical waste generated in the home and medical institutions for their implementation at the state level.

Discussion of the results. Adjusting the classification of medical waste will create a developed system of potentially hazardous waste, which will include: separate collection, safe storage and transportation, environmentally friendly disposal using the useful properties of polymeric materials, it is possible to obtain additional energy resources.

Conclusions. The conducted researches allow to establish the main tasks of pandemic medical waste management which consist of:

- organization of collection of contaminated and potentially contaminated COVID-19 polymer waste to prevent their entry into landfills;
- development of a national recycling network for effective control of all infectious and other hazardous medical waste, which will help prevent further use of landfills for waste disposal,
- creation of bases for introduction of the tested methods and technologies of management of medical waste, in particular ecologically safe circulating pyrolysis that will allow to improve standards of waste management for the purpose of reduction of pollution of NPS.

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