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Main Aspects of a Proper Waste Management System Establishment and Other Environmental Measures in Health Care Facilities

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ABSTRACT

The article reviews the main stages of medical and pharmaceutical waste management system at a healthcare facility, namely collection, sorting, storage, deactivation, registration, transportation and removal of medical and pharmaceutical waste. Also, a microclimate system requirement for medical waste handling premises have been generalized.

A set of environmental measures at a healthcare facility has been proposed to improve the environment protection system. That will promote economic efficiency of the enterprise and undoubtedly improve the ecological situation within the country.

The obtaining of environmental, economic and social effects from the developed and implemented complex of environmental protection measures in a healthcare facility has been proven.

Introduction

In the international practice of waste management medical and pharmaceutical waste of hospitals, polyclinics, plasma centers and other medical institutions are identified as a separate group and according to the Basel Convention (1998) are defined as hazardous [1-3].

In Ukraine, 380-400 thousand tons of medical waste are generated annually, of which 100-120 thousand tons are hazardous. Hazardous medical waste includes sharp objects, infectious waste, anatomical and patholog-

ical waste, obsolete or expired chemical products, pharmaceuticals, and radioactive materials [3-5].

The problem of medical waste management, including pharmaceutical waste management, is only partially solved for Ukraine. Today, there is no coherent established system that would ensure all stages of management of this type of waste [5-8].

Environmental functions are implemented at HCFs by means of distributive regulatory, organizational, control and executive actions of employees, on which they are entrusted in accordance with local regulations in the field of environmental protection[9-11]. To reduce the negative impact on the environment, it is necessary to annually develop and implement organizational and technological measures that will improve the activities of HCFs on environmental protection and sustainable nature management [12-15].

Therefore, the purpose of the work is to formulate proposals for the establishment of a proper system for medical and pharmaceutical waste management and the development of a set of measures for environmental activities in health care institutions.

Materials and methods.

Analytical, statistical, systemic structural-logical and calculation methods, as well as the materials of the provided internal reporting documentation of the departments of the investigated health care institution are used in the work.

Results And Discussion.

The studies described in our article were conducted on the basis of a health care facility, specializing in the development and manufacture of innovative high-tech medicinal products from human donor blood, recombinant drugs, and products based on spore-forming bacteria. The company develops and produces technologically complex drugs both for those who just need to improve their health and for patients who need help in emergency situations: in resuscitation, during intensive care, in case of blood diseases and a number of oncological diseases. The company produces 20,000,000 packages of medicines per year and exports to 36 countries around the world.

The waste management system in the HCF consists of the following stages: collection and sorting of waste; waste labeling; disinfection, waste treatment; transportation and transfer of waste to site/inter-site (storage) containers within the enterprise where it is accumulated; waste accounting; waste removal for further disposal.

The company has developed and implemented a documented procedure "Medical and pharmaceutical waste management", which defines the procedure for collecting, sorting, storing, disinfecting, accounting, moving and removing medical and pharmaceutical waste; occupational safety requirements for medical personnel when handling medical waste.

Wastes that pose a danger to human health cannot be accumulated, temporarily stored, transported, destroyed together with other wastes. Waste collection is carried out directly by personnel, as close as possible to the places of their generation, in separate containers that are clearly distinguished visually by color and/or marking. In places of primary waste generation, personnel creates a stock of bags or containers for waste collection.

The need for consumables and containers for the collection and temporary storage of medical waste is determined by the head of the structural unit, proceeding from the need to replace bags and disposable containers at least once every 8 hours. The staff receives waste collection containers from the responsible person of the department and labels them in advance accordingly. The processes of moving waste from places of generation to places of temporary storage and/or decontamination can be mechanized (trolley, elevator). Removal of medical waste from the territory of the enterprise is carried out by transport of a specialized organization that has the appropriate license and on the basis of a concluded agreement.

Receiving, decontamination, temporary storage (accumulation) of waste, washing and disinfection of trolley racks, containers and other equipment used for the transport of waste should be carried out in a separate premise for medical waste management

(PMWM).

At rigging a PMWM the following should be considered:

- Equipment placement should be done in such a way to provide a free access to all the equipment;
- Temporary storage and waste deactivation premises should be equipped with bactericidal lamps or other devices for air disinfection;
- Premises of medical waste reception and temporal storage should be equipped with a balance. PMWMs should be cleaned at least once weekly using detergents and disinfecting agents. Requirements for the microclimate of the premises are given in Table 1.

Medical waste of category B is subject to mandatory decontamination (disinfection) by a physical method, which includes treatment with aqueous saturated steam under excessive pressure and temperature using special equipment – installations for disinfection of category B waste, in particular autoclaves used for waste disinfection at a sterilization temperature of at least 132 °C, for 60 minutes.

Medical personnel, whose workplaces generate medical waste of category B, collect it in solid (non-piercing) packaging (containers) or in disposable soft packaging (bags). Marking of containers for medical waste is carried out by the employee who collects them.

The used syringes are collected disassembled in a non-piercing container. Collection of category B waste in the places of its generation is carried out during the working shift. When using containers for sharp tools, it is allowed to fill them within 3 days.

For the collection of sharp objects, moisture-resistant non-piercing containers are used. The container must have a lid that fits tightly and makes unauthorized opening impossible.

For the collection of organic liquid waste of category B (blood and its components), sealed moisture-resistant containers are used, which make unauthorized opening impossible.

Works on the movement of disinfected waste to the premises of their temporary storage are organized by the supply and maintenance manager. Moving category B wastes that have not undergone decontamination (disinfection) outside the territory of the enterprise is not allowed.

Waste of category B after decontamination, for further disposal, is transferred to an enterprise that has a license to carry out operations in the field of hazardous waste management and has appropriate certified equipment.

Collection and sorting of medical waste in places of its generation are carried out during the working shift.

Accumulation and temporary storage of medical waste are carried out in departments, in specially designated areas specified in the scheme of medical waste management in each department.

The period of accumulation and temporary storage of medical waste in the departments should not exceed the duration of the working shift.

Disposable bags for the collection of category B waste shall ensure the possibility of safe collection of not more than 10 kg of waste in them.

The period of temporary storage of medical waste in the "dirty" zone of the site is determined taking into account the period of temporary storage in the department (excluding the collection period), which in the end should not exceed 24 hours.

The term of temporary storage of disinfected medical waste of category B in inter-site containers in the premise for the temporary storage of medical waste is determined under the schedule for their removal from the territory of the enterprise.

Containers with safe waste must be located on a special site situated on the territory of the enterprise at a distance of at least 25 m from the buildings and having a hard surface.

Also, the enterprise carries out preventive protection activities in two directions. The first is to identify the scope, elements, and results of preventive protection activities, the second is to determine their impact on the formation and assessment of the final performance indicators of the enterprise.

Objectives of the analysis of the first direction: general characteristics of the impact of the enterprise's activities on the environment; identification of the availability and technical condition of existing environmental facilities and equipment, their

Table 1. Requirements for the microclimate in the premises of medical and pharmaceutical waste management

No.	Name of premise	Internal temperature, °C	Air change rate		Multiplicity of exhaust with natural air exchange
			Inflow	Outflow	
1	Reception and temporary storage (accumulation) of non-decontaminated waste	16	-	1.5	2
2	Waste decontamination workspace	18-20	From the calculation of heat and moisture-excesses*	From the calculation of heat and moisture excesses *	Not allowed
3	Temporary storage of treated waste	16	-	2	Not allowed
4	Washing and disinfection of containers, racks, trolleys	18	3	4	Not allowed
5	Premises for temporary storage of containers, racks, trolleys	18	-	1	1
6	Warehouse of consumables	16	1	1	1
7	Sanitary facilities (changing room, shower, bathroom, storage of cleaning equipment)	23	Inflow from the corridor	75m³/h per 1 shower	2
8	Staff room with a workplace	20	1	1	1

Table 2. Capital and current environmental costs of the investigated enterprise for 2021 – 2022, thousand UAH

Costs	2021	2022
Ongoing costs	70	72
Capital expenses	30	28

compliance with the profile and volume of the main production and clarification of the conditions for the functioning of environmental services, that is, analysis of the organizational and technical level of environmental activities; analysis of the availability and use of natural resources; analysis of current and capital expenditures on environmental activities; analysis of the results of the activities to improve the use of natural resources and the quality of the environment, during which the effectiveness of environmental activities is assessed, it is found out whether it is justified to invest in it and whether the investments are sufficient.

When solving tasks related to environmental protection at the enterprise, priority is given to the set of measures that ensures the greatest restriction or complete cessation of the release of an adverse factor (chemical, physical, biological) into the environment.

To analyze the structure of environmental costs, a number of indicators have been introduced: the share of capital costs in the total cost of measures

Table 3. Current overhaul costs at the investigated enterprise for 2021 – 2022, UAH

Costs	2021	2022
Current costs of environment protection - total, including:	63,548.6	56,788.2
For the protection and rational use of water resources, including payments to other organizations for the reception and treatment of wastewater	4,015.2	4,147.5
For the protection of atmospheric air	4,147.8	4,586.2
The environment (land resources) protection from production and consumption waste	4,477.6	4,785.1
Expenses for overhaul of the main production facilities for environmental protection, including:	13,588.2	10,147.5
Structures and installations for wastewater treatment and rational use of water resources	7,412.2	6,852.1
Structures and installations for the capture and disposal of harmful substances,	2,855.3	1,472.1
Structures, installations, and equipment for waste disposal and neutralization	3,320.7	1,823.3
The average annual cost of fixed assets for environmental protection, including:	83,4201.0	67,6201.0
For the protection and rational use of water resources	365,056.6	531,760.8
For the protection of atmospheric air	269,491.2	36,032.1
To protect the environment from the production and consumption waste	208,653.2	108,468.1

for the protection of environment and rational use of natural resources; the share of current costs in the total cost of environment protection measures and rational use of natural resources; the share of costs for the protection of the air basin in the total cost of environment protection measures and rational use of natural resources; the share of costs for the destruction and disposal of solid and liquid medical waste in the total cost of environment protection measures and rational use of natural resources.

According to these indicators, it is possible to analyze the structure of the enterprise's environmental costs and trace the dynamics of changes in these costs. The dynamics of capital and current expenditures for several years can be traced based on Table 2.

Analyzing the dynamics of changes in current and capital expenditures, it can be concluded that, in general, the enterprise is on the right track for the development of environmental protection activities.

Thus, the current costs of environmental protection include the costs of materials, fuel, and energy necessary to carry out reactions to neutralize and deactivate harmful substances, and the capital costs of environmental protection include the costs of creating new and reconstructing existing fixed assets that reduce the impact of economic activities on the environment, the modification of pharmaceutical

Table 4. Volumes of pollutant emissions of the investigated enterprise before and after treatment

No.	Name of the pollutant substance	Quantity before cleaning, t/year	Quantity after cleaning, t/year
1	Production dust	5.1456	0.5648
2	Nitrogen oxide	1.4236	0.0685
3	Carbon monoxide	1.0158	0.0525

Table 5. Costs of installing the KonsTrack bag filter

No.	Type of works	Price, UAH
1	KonsTrack Bag Filter Price	295,000
2	Cost of installation works	32,000
Total		327,000

Table 6. Costs of installing new equipment

No.	Type of works	Price, UAH
1	Heating equipment AIR-BUS BV 690 FS MASTER	326,000
2	MAXUS E14 energy-saving lamps	13,000
3	Modern multi-tariff meter (three phases)	5,500
Total		344,500

Table 7. The amount of environmental tax after the introduction of the preventive measure at the investigated enterprise, UAH/year.

No.	Name of pollutant	Decrease in actual emissions after implementation of the environmental protection measure, t	Tax rates in 2022 UAH / t	Reducing the amount of the environmental tax after the introduction of the environmental protection measure
1	Production dust	3.722	96.99	360.99
2	Nitrogen oxide	1.3551	2,574.43	3,488.61
3	Carbon monoxide	0.9633	96.99	93.43
Total				3,943.03

production technologies, are carried out to reduce the impact. In other words, it is more profitable to increase investments in capital costs than to increase current costs, since capital costs are aimed at preventing pollution damage, and current costs are only aimed to neutralize emissions. The structure of environmental protection costs for 2021-2022 is shown in Table 3.

Since 2015, the share of current expenditures has been constantly increasing, and the share of capital expenditures has been decreasing compared to previous years. Based on the data obtained, it can be stated that in 2021–2022 the company invested more in the neutralization and deactivation of harmful substances than in the prevention of pollution. On the basis of the obtained assessment, it is possible to proceed to the protective measures that need to be carried out at the enterprise in order to improve the environment pro-

tection activities. To reduce the negative impact on the environment, it is proposed to introduce several organizational and technological measures. To reduce emissions into the air, the old equipment will be replaced with a new KonsTrack pulse regeneration bag filter.

KonsTrack bag filters with compressed air pulse regeneration are designed to clean air and process gases from solid particles. This type of filters belongs to the "dry" type dust collection equipment and has a higher efficiency of gas purification, compared to any type of electrostatic precipitators and wet gas purification devices.

Analysis of the available actual data shows that after the installation of the KonsTrack filter with compressed air pulse regeneration the production dust, nitrogen oxide, and carbon monoxide emissions in the air of manufacturing premises have reduced significantly (Table 4).

The costs for the implementation of environment protection and technological equipment are shown in Tables 5 and 6.

To reduce energy consumption at the enterprise, it is proposed to replace the AIR-BUS BV 690 FS MASTER heating equipment, install a modern multi-tariff meter (three phases), replace conventional lighting lamps with energy-saving MAXUS E14 lamps.

The total amount of costs for the implementation of organizational, technical and environmental protection measures at the investigated enterprise will be UAH 671,500. It can be said that increasing investments in capital costs is more profitable than increasing current costs, since capital costs are aimed at preventing harmful production emissions, while current costs are only targeted at neutralizing emissions.

The calculation of the amount of the environmental tax after the introduction of the environmental protection measure at the enterprise is given in Table 7.

It should be noted that effective environmental protection at the enterprise is combined with economic efficiency of production, i.e. such conditions of environmental protection activities are created at the enterprise when the enterprise has an interest in financing environmental measures and it is economically beneficial for the enterprise itself (Table 7).

Installation of new AIR-BUS BV 690 FS MASTER heating equipment and replacement of conventional lamps with energy-saving MAXUS E14 lamps will reduce electricity consumption by UAH 735,698. The economic efficiency of the proposed measures is:

EE=E-B=(3,943.03+735,698) - 671,500=68,141.03 UAH.

And the payback period will be:

T=B/E=671,500/739,641.03=0.91.

The funds spent in the amount of UAH 671,500 will be returned during one year (0.91). Each hryvnia spent on environmental protection measures by the enterprise will provide a reduction in the cost of environmental tax and a reduction in electricity costs by UAH 68,141.03. As a result of the set of environmental protection measures, the enterprise will receive an economic, environmental and social effect.

We can see the economic effect: a decrease in electricity costs, a decrease in the size of the environmental tax. The environmental effect is in energy saving and reducing the negative impact on the environment. Social: improvement of working conditions, respectively, reduction of morbidity, improvement of living conditions of the population of the area.

Conclusions.

The general requirements for the organization of a medical waste management system of a Ukrainian enterprise specializing in the development and production of innovative high-tech medicinal products from human donor blood, recombinant drugs, drugs based on spore-forming bacteria have been analyzed.

A complex of organizational and technological actions aimed at reducing the negative effect on the environment, reducing air emissions, and reducing energy consumption has been proposed.

As a result of the complex of environmental protection measures at the enterprise, an economic effect was obtained: a decrease in electricity costs, a decrease in the size of the environmental tax; an environmental effect: a decrease in the negative impact on the environment and social effect: an improvement in working conditions, respectively, a decrease in diseases, an improvement in the living conditions of the population of the area. □

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