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The assessment of environmental measures in healthcare institutions as a factor in improving the economic efficiency of production activities

In recent years, Ukraine has accumulated a number of urgent environmental problems, including the disposal of medical and pharmaceutical waste. This problem has appeared before society as one of the global ones, which threatens to increase the waste accumulation and its negative impact on the environment and human health.

Aim. To analyze and assess environmental measures implemented in healthcare institutions in order to determine their impact on improving the economic efficiency of production activities. The study aims to identify the relationship between implementing environmental initiatives and optimizing costs, increasing productivity, and improving the overall sustainability of healthcare institutions.

Materials and methods. Analytical, statistical, systemic structural-logical and calculation methods, as well as the materials of the internal reporting documentation of the departments of the healthcare institution under study were used in the work.

Results. The article determines the share of capital expenditures in the total amount of expenditures for environmental protection measures and the rational use of natural resources in the healthcare institution under study, as well as the share of expenditures for the destruction and neutralization of solid and liquid medical waste in the total amount of expenditures for environmental protection measures and the rational use of natural resources. Based on these indicators, the structure of the enterprise's environmental costs has been analyzed, and the dynamics of changes in these expenditures has been traced.

Conclusions. A set of environmental measures in a healthcare institution to improve an effective environmental protection system has been proposed, which will contribute to improving the economic efficiency of production and undoubtedly improve the environmental situation in the country. Obtaining environmental, economic and social effects from the complex developed and organizational and technological actions implemented in the healthcare institution has been proven.

***Keywords**: healthcare institution; environmental measures; environmental efficiency; environmental protection measures*

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Оцінка екологічних заходів у закладах охорони здоров'я як чинник покращення економічної результативності виробничої діяльності

За останні роки в Україні накопичились певні невідкладні екологічні проблеми. Йдеться, зокрема, й про утилізацію медичних та фармацевтичних відходів. Ця проблема постала перед суспільством, як одна з глобальних, що загрожує зростанням нагромаджень відходів і посиленням їх негативного впливу на довкілля і здоров'я людей.

Мета роботи – оцінити впроваджувані в закладах охорони здоров'я екологічні заходи щодо визначення їхнього впливу на підвищення економічної ефективності виробничої діяльності. Дослідження спрямоване на виявлення взаємозв'язку між впровадженням природоохоронних ініціатив та оптимізацією витрат, підвищенням продуктивності й покращенням загальної стійкості закладів охорони здоров'я.

Матеріали та методи. Під час дослідження застосовували аналітичний, статистичний, системний, структурно-логічний та розрахунковий методи, використовували матеріали наданої внутрішньої звітності відділів розглядуваного закладу охорони здоров'я (ЗОЗ).

Результати та їх обговорення. Стосовно досліджуваного ЗОЗ визначено питому вагу капітальних витрат та питому вагу витрат на знищення і знешкодження твердих і рідких медичних відходів у загальному обсязі витрат на заходи з охорони природи і раціонального використання природних ресурсів. За цими показниками проаналізовано структуру природоохоронних витрат підприємства та простежено динаміку змін цих витрат.

Висновки. Запропоновано комплекс природоохоронних заходів у закладі охорони здоров'я для вдосконалення системи охорони навколишнього середовища, що сприятиме підвищенню економічної ефективності виробництва й, безсумнівно, поліпшить екологічну ситуацію в країні. Доведено отримання екологічного, економічного та соціального ефектів від впровадження організаційно-технологічних дій у закладі охорони здоров'я.

***Ключові слова**: заклад охорони здоров'я; екологічні заходи; екологічна результативність; природоохоронні заходи*

Introduction. In the international practice of waste management, medical and pharmaceutical waste from hospitals, polyclinics, plasma centers and other medical institutions is classified into a separate group and, in accordance with the Basel Convention (1998), is defined as hazardous [1-3].

In Ukraine, 380-400 thousand tons of medical waste are generated annually, of which 100-120 thousand are hazardous. Hazardous medical waste includes sharp objects, infectious waste, anatomical and pathological waste, obsolete or expired chemical products, pharmaceuticals, and radioactive materials [3-5].

The problem of medical waste management, including pharmaceutical waste, has only partially been solved in Ukraine [5-8].

Environmental functions are implemented at healthcare institutions (HCIs) through distributive regulatory, organizational, control and executive actions of employees who are assigned to them in accordance with local regulations in the field of environmental protection [9-11]. In order 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 HCIs for environmental protection and sustainable use of natural resources [12-14].

The **aim** of the work is to analyze and assess environmental measures implemented in healthcare institutions in order to determine their impact on improving the economic efficiency of production activities. The study aims to identify the relationship between implementing environmental initiatives and optimizing costs, increasing productivity, and improving the overall sustainability of healthcare institutions.

Materials and methods. Analytical, statistical, systemic structural-logical and calculation methods were used. The study objects were data from special literature, accounting and management accounting of resources in the healthcare institution under study.

Results and discussion. The studies described in our article were conducted at the premises of a healthcare institution specializing in the development and manufacture of innovative high-tech medicinal products from human donor blood, recombinant drugs, products based on spore-forming bacteria. The enterprise 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 enterprise produces 20,000,000 packages of medicines per year and exports to 36 countries around the world.

The waste management system in the HCI consists of the following stages: waste collection and sorting; waste labeling; disinfection, waste recycling; transportation and transfer of waste to site/inter-site (warehouse) containers within the enterprise where they accumulate; waste accounting; waste removal for further disposal.

The enterprise 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 the medical personnel when handling medical waste.

The need for consumables and containers for the collection and temporary storage of medical waste is determined by the head of the structural unit based on 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 label them accordingly in advance. The processes of waste transfer from places of formation to places of temporary storage and/or disinfection can be mechanized (trolley, elevator). The 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 signed contract.

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

To analyze the structure of environmental costs, a number of indicators were introduced: the share of capital expenses in the total cost of environmental protection measures and the rational use of natural resources; the share of current costs in the total cost of environmental protection measures and the rational use of natural resources; the share of the costs of protecting the air basin in the total costs of environmental protection measures and the rational use of natural resources; the share of the costs for the destruction and disposal of solid and liquid medical waste in the total costs of environmental protection measures and the rational use of natural resources.

According to these indicators, it is possible to analyze the structure of the environmental costs of the enterprise and trace the dynamics of changes in these costs. The dynamics of capital and current expenditures over several years can be traced based on Table 1.

The current costs of environmental protection measures are increasing every year. In 2021, they amounted to 70 thousand UAH, in 2022 – 72 thousand UAH, and in 2023 – 74 thousand UAH. Capital expenses, on the contrary, are decreasing. In 2021, they were 30 thousand UAH, in 2022 – 28 thousand UAH, and in 2023 – 26 thousand UAH.

The enterprise is gradually increasing the financing of current expenses, but reducing investments in capital environmental protection measures. This may indicate that the enterprise is focused on supporting current

Table 1

Capital and current environmental costs of the enterprise under study for 2021 – 2022, thousand UAH

Costs	2021	2022	2023
Current costs	70,00	72,00	74,00
Capital expenses	30,00	28,00	26,00

environmental measures rather than modernizing them. Reducing capital expenses may lead to the depreciation of environmental protection facilities in the future. If this trend continues, the effectiveness of environmental protection measures may decrease. To ensure long-term sustainability, the company should review its investment policy in capital environmental projects.

Thus, the current costs of environmental protection include the costs of materials, fuel and energy needed to carry out reactions to neutralize and decontaminate 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, modification of pharmaceutical production technologies. They are carried out in order to reduce the impact. In other words, it is more profitable to increase investments in capital expenses than to increase current costs since capital expenses are aimed at preventing pollution damage, and current costs are aimed only at neutralizing emissions. The structure of environmental protection costs for 2021-2022 is shown in Table 2.

In 2022, total current environmental protection costs decreased compared to 2021. In 2023, expenditures on certain areas of environmental protection increased slightly. From 2021 to 2023, the cost of capital repairs of fixed assets steadily decreased. The largest reduction occurred in the financing of wastewater treatment facilities. The average annual cost of fixed assets decreased significantly in 2022, but began to increase in 2023. Expenditures on water resources protection, air and waste management are gradually increasing. This may be due to increased environmental requirements or tariffs. The enterprise maintains current environmental costs, but practically does not invest in the modernization of environmental protection facilities. This may lead to a deterioration of their condition in the future. A reduction in the volume of capital repairs may indicate an insufficient renewal of the environmental infrastructure of the enterprise. If this trend continues, existing facilities and equipment may lose efficiency. An increase in current expenses makes it possible to maintain environmental protection measures, but without modernization, their quality may gradually decrease. To prevent possible environmental risks, the enterprise should balance the financing of current and capital expenses. Investments in the renovation of environmental protection facilities will contribute to their stable operation in the future. Based on the assessment received, one can proceed to the environmental protection measures themselves, which must be carried out at the enterprise in order to improve environmental protection activities. To reduce the negative impact on the environment, it is proposed to implement a number of organizational and technological measures. To reduce atmospheric emissions, replace the old equipment with a new KonsTrack pulse regeneration bag filter.

The enterprise significantly reduces emissions of pollutants after the treatment (Table 3). The degree of purification of industrial dust is 89.0 %, nitrogen oxide – 95.2 %, and carbon monoxide – 94.8 %. This allows reducing the cost of environmental payments. The largest reduction in emission fees is observed for industrial dust – 42.5 thousand UAH per year. For nitrogen oxide, this indicator is 38.7 thousand UAH, and for carbon monoxide – 26.3 thousand UAH. The high level of purification indicates the efficiency of the waste treatment facilities. Regular maintenance and modernization of equipment will help to maintain these results in the future.

Table 2

Current overhaul costs at the enterprise under study for 2021 – 2022, UAH

Costs	2021	2022	2023
Current environmental protection costs – total, including:	63548.6	56788.2	57899,5
For the protection and the rational use of water resources, including payments to other organizations for receiving and treating wastewater	4015.2	4147.5	4325,4
For the protection of atmospheric air	4147.8	4586.2	4752,8
The environmental (land resources) protection from production and consumption waste	4477.6	4785.1	4899,4
Expenses for overhaul of the main production facilities in order to protect the environment, including:	13588.2	10147.5	8816,6
Facilities and installations for wastewater treatment and the rational use of water resources	7412.2	6852.1	5958,1
Facilities and installations for the capture and disposal of harmful substances	2855.3	1472.1	1272,3
Facilities, installations, and equipment for waste disposal and neutralization	3320.7	1823.3	1586,2
The average annual cost of fixed assets for environmental protection, including:	834201.0	676201.0	716271,8
For the protection and the rational use of water resources	365056.6	531760.8	495255,3
For the protection of atmospheric air	269491.2	36032.1	95122,3
For the protection of the environment from the production and consumption waste	208653.2	108468.1	125894,2

Table 3

The volumes of pollutants released by the enterprise studied before and after purification, as well as economic indicators

No.	Name of the pollutant	Quantity before purification, t/year	Quantity after purification, t/year	Degree of purification, %	Estimated reduction in emission fees, thousand UAH/year
1	Industrial dust	5.1456	0.5648	89.0	42,5
2	Nitrogen oxide	1.4236	0.0685	95.2	38,7
3	Carbon monoxide	1.0158	0.0525	94.8	26,3

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.

To reduce energy consumption, the company proposes to replace the AIR-BUS BV 690 FS MASTER heating equipment, install a modern multi-tariff meter (three phases), and replace conventional lighting lamps with energy-saving MAXUS E14 lamps. The costs of implementing environmental protection and technological equipment are shown in Table 4.

The company invested 671,500 UAH in environmental and energy-efficient equipment, including a bag filter, heating equipment, energy-saving lamps and a multi-tariff meter. As a result of the implementation of these measures, the volume of emissions of harmful substances has significantly decreased. The largest reduction was recorded for industrial dust (3.722 t), nitrogen oxide (1.3551 t) and carbon monoxide (0.9633 t). Due to this, the company reduced its environmental tax expenses by 3,943.03 UAH per year. The greatest savings were achieved by reducing emissions of nitrogen oxides – 3 488 UAH 61/year. Despite significant initial costs, the implementation of environmental protection measures contributes to the reduction of environmental pollution, improvement of environmental responsibility and optimization of costs in the long term.

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

$$EE = E - B = (3943.03 + 735698) - 671500 = 68141.03 \text{ UAH}.$$

EE – economic efficiency, UAH
E – tax savings, UAH
B – project costs, UAH

And the payback period will be:

$$T = B / E = 671500 / 739641.03 = 0.91.$$

The funds spent in the amount of 671,500 UAH will be refunded within one year (0.91).

The environmental and energy-efficient measures proposed will allow the enterprise to significantly reduce electricity consumption, which will lead to savings of 735698 UAH. In addition, the reduction of pollutant emissions will ensure a reduction in the environmental tax by 3943.03 UAH /year. The calculation of economic efficiency shows that after taking into account the costs of implementing measures in the amount of 671500 UAH, the net savings will be 68141.03 UAH. The payback period of the project will be 0.91 years, i.e. the funds spent will be returned in less than a year. Thus, the implementation of the measures proposed is economically beneficial and environmentally sound, contributing to cost reduction, improvement of environmental performance and increased energy efficiency of the enterprise.

Table 4

The costs for implementing environmental protection equipment and reducing the environmental tax

No.	Type of works	Costs, UAH / Emission reduction, t	Tax rate, UAH/t	Tax savings, UAH/year
1	KonsTrack bag filter (equipment + installation)	327000	-	-
2	AIR-BUS BV 690 FS MASTER heating equipment	326000	-	-
3	MAXUS E14 energy-saving lamps	13000	-	-
4	Modern multi-tariff meter (three phases)	5500	-	-
5	Production dust	3,722	96,99	360,99
6	Nitrogen oxide	1,3551	2574,43	3488,61
7	Carbon monoxide	0,9633	96,99	93,43
Total		671500		3943,03

Conclusions and prospects for further research

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

2. As a result of the complex of environmental protection measures at the enterprise, the economic effect, including reduction of energy costs, reduction of the amount of the environmental tax; the environmental effect, such as reduction of the negative environmental impact, as well as the social effect, namely improvement of working conditions, and therefore, decrease in morbidity, improvement of living conditions of the population of the area have been obtained.

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REFERENCES

1. Про приєднання України до Базельської конвенції про контроль за транскордонними перевезеннями небезпечних відходів та їх видаленням : Закон України від 1 лип. 1999 р. № 803-XIV. URL: https://zakon.rada.gov.ua/laws/show/803-14#Text.
2. Про схвалення Національної стратегії управління відходами в Україні до 2030 року : Розпорядження Кабінету Міністрів України від 08.11.2017 р. № 820-р. URL: http://zakon3.rada.gov.ua/laws/show/820-2017-%D1%80.
3. Громовик Б. П., Пузанова І. П. Дієва система збору від населення непридатних лікарських засобів як належна основа зменшення ризиків при утилізації і знешкодженні фармацевтичних відходів. *Ліки України*. 2016. № 3. С. 70-74.
4. Сагайдак-Нікітюк Р. В. Сучасні підходи до управління фармацевтичними відходами на різних рівнях влади. *Вісник фармації*. 2011. № 2. С. 63-65.
5. Global Pharmaceutical Industry – Statistics and Facts. Nov 22, 2024. URL: https://www.statista.com/topics/1764/global-pharmaceutical-industry/#topicOverview.
6. Study on the environmental risks of medicinal products / Executive Agency for Health and Consumers. 12 December 2013. URL: https://health.ec.europa.eu/system/files/2016-11/study_environment_0.pdf.
7. Pharmaceuticals in the environment: Global occurrence and potential cooperative action under the Strategic Approach to International Chemicals Management (SAICM). Dessau-Roßlau, 2016. 94 p. URL: https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/iww_abschlussbericht_saicm_arzneimittel_final.pdf.
8. Singh N., Ogunseitan O. A., Tang Y. Medical waste: Current challenges and future opportunities for sustainable management. *Critical Reviews in Environmental Science and Technology*. 2022. Vol. 52(11). P. 2000-2022. DOI: 10.1080/10643389.2021.1885325.
9. Strategic approach to pharmaceuticals in the environment. Roadmap. 26 May 2017. URL: http:// ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-2210630_en.
10. Household medical waste disposal policy in Israel / Z. Barnett-Itzhaki et al. *Isr. J. Health Policy Res.* 2016. Vol. 5. P. 48. DOI: 10.1186/s13584-016-0108-1.
11. González Peña O. I., López Zavala M. Á., Cabral Ruelas H. Pharmaceuticals Market, Consumption Trends and Disease Incidence Are Not Driving the Pharmaceutical Research on Water and Wastewater. *Int. J. Environ Res Public Health*. 2021. Vol. 18(5). P. 2532. DOI: 10.3390/ijerph18052532.
12. Fanasch P. Survival of the fittest: The impact of eco-certification and reputation on firm performance. *Business Strategy and the Environment.* 2018. Vol. 28(4). P. 611-628. DOI: 10.1002/bse.2268.
13. Stakeholders' perspectives and use of web-based knowledge support for environmental information on pharmaceuticals / E. Linder et al. *Exploratory Research in Clinical and Social Pharmacy*. 2023. № 11. P. 100303. DOI: 10.1016/j.rcsop.2023.100303.
14. Pharmaceutical Strategy for Europe (PiE). *European Commission*. Nov 25, 2020. URL: https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2173.

REFERENCES

1. Zakon Ukrainy «Pro pryiednannia Ukrainy do Bazelskoi konventsii pro kontrol za transkordonnymy perevezenniamy nebezpechnykh vidkhodiv ta yikh vydalenniam» № 803-XIV (1999, Lypen 1). https://zakon.rada.gov.ua/laws/show/803-14#Text.
2. Rozporiadzhennia Kabinetu Ministriv Ukrainy «Pro skhvalennia Natsionalnoi stratehii upravlinnia vidkhodamy v Ukraini do 2030 roku» № 820-r (2017, Noiabr 8). http://zakon3.rada.gov.ua/laws/show/820-2017-%D1%80.
3. Hromovyk, B. P., & Puzanova, I. P. (2016). Diieva systema zboru vid naselennia neprydatnykh likarskykh zasobiv yak nalezhna osnova zmenshennia ryzykiv pry utylizatsii i zneshkodzhenni farmatsevtychnykh vidkhodiv. *Liky Ukrainy*, (3), 70-74.
4. Sahaidak-Nikitiuk, R. V. (2011). Suchasni pidkhody do upravlinnia farmatsevtychnymy vidkhodamy na riznykh rivniakh vlady. *Visnyk farmatsii*, (2), 63-65.
5. *Global Pharmaceutical Industry – Statistics and Facts*. (2024, Nov 22). https://www.statista.com/topics/1764/global-pharmaceutical-industry/#topicOverview.
6. Executive Agency for Health and Consumers. (2013, December 12). *Study on the environmental risks of medicinal products*. https://health.ec.europa.eu/system/files/2016-11/study_environment_0.pdf.
7. *Pharmaceuticals in the environment: Global occurrence and potential cooperative action under the Strategic Approach to International Chemicals Management (SAICM)*. (2016). Dessau-Roßlau. https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/iww_abschlussbericht_saicm_arzneimittel_final.pdf.
8. Singh, N., Ogunseitan, O. A., & Tang, Y. (2022). Medical waste: Current challenges and future opportunities for sustainable management. *Critical Reviews in Environmental Science and Technology, 52*(11), 2000-2022. https://doi.org/10.1080/10643389.2021.1885325.
9. *Strategic approach to pharmaceuticals in the environment*. Roadmap. (2017, May 26). http://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-2210630_en.
10. Barnett-Itzhaki, Z., Berman, T., Grotto, I, & Schwartzberg, E. (2016). Household medical waste disposal policy in Israel. *Isr. J. Health Policy Res, 5,* 48. http://doi.org/10.1186/s13584-016-0108-1.

11. González Peña, O. I., López Zavala, M. Á., & Cabral Ruelas, H. (2021). Pharmaceuticals Market, Consumption Trends and Disease Incidence Are Not Driving the Pharmaceutical Research on Water and Wastewater. *Int. J. Environ Res Public Health*, *18*(5), 2532. http://doi.org/10.3390/ijerph18052532.

12. Fanasch, P. (2018). Survival of the fittest: The impact of eco-certification and reputation on firm performance. *Business Strategy and the Environment, 28*(4), 611-628. http://doi.org/10.1002/bse.2268.

13. Linder, E., Villén, J., Nekoro, M., Wettermark, B., & Sporrong, S. K. (2023). Stakeholders' perspectives and use of web-based knowledge support for environmental information on pharmaceuticals. *Exploratory Research in Clinical and Social Pharmacy*, (11), 100303. https://doi.org/10.1016/j.rcsop.2023.100303.

14. *Pharmaceutical Strategy for Europe (PiE).* European Commission. (2020, Nov 25, 2020. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2173.

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