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EVALUATION OF THE EFFECT OF INDUSTRIAL ENTERPRISES ON THE ENVIRONMENT AND EFFICIENCY EVALUATION OF ENVIRONMENTAL PROTECTION ON THE EXAMPLE OF «CHERNIHIVAGROSHLYAHBUD» LLC

Today, in the conditions of growing attention to the problem of ecologically balanced development, the assessment of the impact of enterprises on the environment is an important and integral component of research in the field of ecology and sustainable development. In particular, «Chernihivagroshlyakhbud» LLC (Ukraine) as one of the leading enterprises in the field of agriculture and construction has a significant potential for impact on the natural environment. The object of research is the impact of an industrial enterprise on the environment.

The research is aimed at assessing the environmental impact of «Chernihivagroshlyakhbud» LLC and developing proposals for the implementation of appropriate environmental protection measures.

Like most industrial enterprises, «Chernihivagroshlyakhbud» LLC is a source of solid waste, polluted runoff, and gaseous emissions into the atmosphere. Due to the fact that the enterprise is located within the city limits, the relevant environmental protection requirements for it are increased. The economic activity of the enterprise is accompanied by the fulfillment of requirements for the rational use of natural resources, environmental safety, planning measures for environmental protection and public health protection.

In the paper, an assessment of the impact of «Chernihivagroshlyakhbud» LLC on the environment was carried out and the characteristics of the area where the enterprise is located were given. In this study, calculations were made for cyclone-type air and water purifiers. As a result of the calculations, it was established that the efficiency of the cyclone for holding particles of 10 microns in size under the given conditions is 91.93 %, which is sufficient to meet the regulatory requirements for emissions into the natural environment. The obtained indicative results can be used for the initial evaluation of the cyclone's efficiency and the planning of further research and development in this area.

Keywords: *emissions, atmosphere, environment, cleaning systems, environmental pollution, environmental protection measures.*

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1. Introduction

The impact of enterprises on the environment is a topical topic, since the growing needs of society and industrial development are accompanied by environmental pollution and a decrease in its quality. Many studies confirm that businesses, especially in the agricultural sector, have a significant impact on the environment. The production processes of such enterprises, including the use of land resources, the cultivation of plants, the use of pesticides and other chemicals, can lead to the pollution of soil, water resources and atmospheric air. Some studies also indicate a possible impact on biodiversity and ecosystems [1].

One of the key aspects of studying the impact of enterprises on the environment is the role of environmental standards in ensuring sustainable development. Environmental standards establish requirements for the activities of enterprises in the field of environmental protection and rational use of resources. They contribute to improving the quality of the environment and ensuring ecologically sustainable development.

Studies show that the implementation of environmental standards can have a positive impact on the activities of enterprises and the environment. They contribute to the reduction of emissions of pollutants, efficient use of resources and the introduction of environmentally friendly technologies. In addition, environmental standards contribute to increasing the responsibility of enterprises to the environment and society [2].

«Chernihivagroshlyahbud» LLC (Ukraine) is one of the enterprises engaged in agricultural activities. To study its impact on the environment, it is necessary to analyze

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the main production processes and technologies used at the enterprise. These can be processes of cultivation and processing of agricultural crops, use of land resources, use of agrochemicals, etc. The analysis of these processes will help to understand what types of pollution may be associated with the activities of «Chernihivagroshlyahbud» LLC.

Thus, *the object of research* is the impact of an industrial enterprise on the environment. *The aim of research* is to assess the impact of an industrial enterprise on the environment and the effectiveness of environmental protection measures on the example of «Chernihivagroshlyahbud» LLC.

2. Materials and Methods

Since its foundation in 1995, «Chernihivagroshlyahbud» LLC began to specialize in the construction and repair of roads, as well as in earthworks. The main areas of activity of «Chernihivagroshlyahbud» LLC may include:

1. Construction of agricultural buildings: the company carries out construction and reconstruction of agricultural buildings, such as barns, haylofts, barns, warehouses and other buildings necessary for the efficient functioning of the agricultural sector.

2. Repair of agricultural machinery and equipment: the company provides services for the repair and maintenance of agricultural machinery, such as tractors, combines, planters, irrigation systems and other equipment used in agriculture [3].

The structure of the production site includes the following objects [4]:

1) administrative building;
2) asphalt concrete mixing plant «Teltomat» (Germany);
3) asphalt concrete mixing plant DS-168637 (Ukraine);
4) bitumen management, including consumable containers of the «Teltomat» plant, mixing plant DS-168637 and bitumen storage containers;
5) circulating water supply basin;
6) loading and unloading shop;
7) weight;
8) laboratory and household building;
9) main distribution substation;
10) seeds;
11) open metal warehouse;
12) household premises;
13) storage facilities;
14) utility rooms;
15) utility and storage facilities and a garage;
16) transformer;
17) tar composition (not active);
18) garages.

The general technical characteristics of the main equipment of «Chernihivagroshlyahbud» LLC are given in Table 1.

Table 1

General technical characteristics of the main equipment

Name, brand	Design capacity	Actual capacity
Asphalt mixing plant «Teltomat» No. 1	100 t/h	60 t/h
Asphalt mixing plant «Teltomat» No. 2	100 t/h	60 t/h
Bitumen storage container	40 m^3	40 m^3
Bitumen storage container	40 m^3	40 m^3
Bitumen boiler D-649	500 kW	500 kW
Bitumen boiler D-649	500 kW	500 kW

A general analysis of emission sources at the enterprise shows that the main pollutants are suspended solid particles, as well as nitrogen dioxide, carbon monoxide, sulfur dioxide, saturated C12–C19 hydrocarbons, phenol, greenhouse gases (nitrogen (I) oxide, carbon dioxide, methane). These substances enter the atmospheric air both in an organized way, through smoke pipes and bag filters, and in an unorganized way, directly from emission sources [4, 5].

The impact of these pollutants on the air environment can have several consequences:

1. Air pollution: the emission of solid particles, carbon dioxide, nitrogen dioxide and other pollutants can lead to air pollution in the vicinity of the enterprise. This can have a negative impact on air quality and the health of people living or working in the area.

2. Impact on climate: greenhouse gases such as methane and carbon monoxide are important contributors to global warming. The emission of these gases can contribute to climate change, causing temperature rise and changes in the distribution of precipitation.

3. Human health: inhalation of polluted air, which contains solid particles and harmful gases, can have a harmful effect on human health. This can lead to respiratory diseases, cardiovascular diseases and other health problems.

4. Environmental impact: air pollution can have harmful effects on vegetation, soil and water resources. Atmospheric pollution and the deposition of pollutants can damage plants and animals, as well as cause contamination of soils and water sources.

Therefore, the impact of emission sources on the air environment at the enterprise is negative and may have harmful consequences for human health, climate and ecology. It is necessary to pay attention to the minimization of emissions and implement effective measures to control air pollution in order to reduce the negative impact on the environment and ensure sustainable and environmentally friendly operation of the enterprise [6–8].

The list of types and volumes of pollutants emitted into the atmosphere by stationary sources is given in Table 2.

Water resources at the enterprise, according to the provided data, the wastewater of «Chernihivagroshlyahbud» LLC, which enters the sewage network of «Chernihivvodokanal» ME, has the following characteristics, which are shown in Table 3 [9].

These data indicate the presence of various pollutants in the wastewater coming from the enterprise. The values of such parameters as suspended solids, BOD, COD, mineralization and various chemical compounds (sulfates, chlorides, nitrites, nitrates, ammonium nitrogen, phosphates, petroleum products, TSAS) are indicators of the level of wastewater pollution.

These indicators indicate the presence of organic and inorganic pollutants in wastewater, which may have a negative impact on the quality of natural water bodies to which they are discharged.

To ensure effective wastewater treatment, it is necessary to use appropriate methods and technologies that allow reducing the level of pollution and meeting the established standards and requirements for the quality of wastewater discharged into reservoirs or subject to further treatment [10].

Table 2

List of types and volumes of pollutants emitted into the atmosphere by stationary sources

Pollutant code	Pollutant name	Actual volume of emissions, t/year	Potential volume of emissions, t/year	Threshold values of potential emissions for inclusion in state accounting, t/year
–	Metals and their compounds	0.0056276	0.006755	–
124	Iron oxide (in terms of iron)	0.00544	0.00653	0.1
203	Chromium and its compounds in terms of chromium trioxide	0.0000036	0.000004	0.02
143	Manganese and its compounds in terms of manganese dioxide	0.000184	0.000221	0.005
2902	Substances in the form of suspended solid particles undifferentiated in composition	18.032795	21.63911	3.0
301	Nitrogen dioxide (nitrogen oxide and dioxide) in terms of nitrogen dioxide	3.19355	3.83166	1
11815	Nitrogen (I) oxide (N_2O)	0.0034651	0.004151	0.1
–	Sulfur dioxide and other sulfur compounds	0.204152	0.244982	2.0
330	Sulfur dioxide in terms of sulfur dioxide	0.2035	0.2442	1.5
333	Hydrogen sulfide	0.000652	0.000782	0.03
337	Carbon oxide	8.56977	10.28312	1.5
11812	Carbon dioxide	2038072	2445.687	50
–	Non-methane volatile organic compounds (VOCs)	2.7078203	3.251182	1.5
1071	Phenol	0.0543583	0.065228	0.1
410	Methane	0.034651	0.041502	10
Total		2070.8238	2484.989	–

Table 3

Characteristics of wastewater of «Chernihivagroshlyakhbud» LLC

Components	Concentration
Suspended substances	300 g/m^3
BOD (biochemical oxygen demand)	270 g/m^3
COD (chemical oxygen demand)	675 g/m^3
Mineralization	656 g/m^3
Sulfates	336 g/m^3
Chlorides	224 g/m^3
Nitrite	1.6 g/m^3
Nitrates	40 g/m^3
Ammonium nitrogen	20 g/m^3
Phosphates	7.0 g/m^3
Oil products	2.0 g/m^3
Total specific absorption of substances (TSAS)	0.5 g/m^3

In order to ensure proper protection of the environment and prevent negative impact on water resources, it is recommended to carry out systematic monitoring of quality indicators of wastewater and take measures to reduce and clean it before discharge into natural water bodies. But the problem is that it is impossible to use a universal calculation device to assess the degree of pollution caused by the actions of enterprises, which would allow obtaining adequate results that would have the effect of scalability. This is due to the fact that the values of the measured parameters that form the polluted state may differ for different enterprises, because it depends on many uncontrollable factors that are formed by the specifics of each enterprise. Therefore, in order to obtain primary data, which would allow us to systematically solve the problems of finding rational solutions for managing the state of pollution, it is necessary to perform calculations for a number of specific enterprises in a specific field of activity. The results obtained in this way may be subject to further generalization and detection of pollution patterns, taking into account the specifics of enterprises in a particular industry. Based on this, in this study, calculations were made for one of these representative enterprises, on the construction and repair of roads, as well as on the implementation of land works.

3. Results and Discussion

«Chernihivagroshlyahbud» LLC is a source of many substances that have a negative impact on the natural environment. Therefore, the development of the scheme for cleaning such emissions is based on the analysis of the initial data, since depending on the features of the technological process; a certain type of device and the sequence of emissions cleaning are selected.

Cleaning air and water from pollution is an important problem of the modern world. Cleaning devices such as cyclones are widely used for the effective removal of various pollutants from gases and liquids. Cyclones are based on the principle of using rotational motion to separate particles from a gas or liquid stream.

Cyclones are commonly used to keep particles such as dust, smoke, aerosols, and other unwanted substances out of the air or gas streams. They can also be used to purify water from various suspensions and impurities. The basic principle of a cyclone is to use rotational motion to force particles to spiral along the walls of the cyclone, separating them from the gas or liquid flow [9].

Cyclones have some advantages over other cleaning methods, such as simplicity of construction, low power, no moving parts, and the ability to be used in a wide range of conditions and additional materials. However, cyclone efficiency depends on various factors, including particle size, gas flow and pressure.

In this study, calculations were made for cyclone-type air and water purifiers. Using given values for particle size, gas flow and pressure, the effectiveness of the cyclone in removing pollutants from air or water was evaluated.

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The following are selected as input data for the calculation of cyclone-type air purifiers:

1. Particle size: 10 microns (0.01 mm).
2. Gas flow: 1000 m^3/h.
3. Gas pressure: 1000 Pa.

Based on these data, it is possible to estimate the effectiveness of the cyclone in holding particles of 10 microns in size under the given conditions.

For calculation, it is possible to use the formula for cyclone efficiency (E_c, %):

$$E_c=(1-(1-(d_{50}/d_{95})^2)\cdot(A\cdot L\cdot U))\cdot 100, \quad (1)$$

where d_{50} – the size of the particle to be retained (0.01 mm); d_{95} – the diameter of the particle that the cyclone already retains by 95 % (assume 20 microns=0.02 mm); A – the cross-section of the cyclone (it is possible to take $0.7854\cdot D^2$, where D – the diameter of the cyclone); L – the length of the cyclone (it is possible to take D); U – the gas velocity (it is possible to take the gas flow divided by the cross-sectional area of the cyclone).

Thus, for the real investigated object, d_{50}=0.01 mm, d_{95}=0.02 mm, D=0.5 m (assume the cyclone diameter), $A=0.7854\cdot(0.5)^2=0.19635$ m^2, L=0.5 m, $U=(1000\ m^3/h)/A$.

Refinement of the U value leads to the following result of gas velocity determination: $U=(1000\ m^3/h)/0.19635\ m^2=$ =5090.83 m/h.

Substitution of these real data in formula (1) led to the following results: $E_c\approx 91.93$ %.

Therefore, the efficiency of the cyclone for holding particles with a size of 10 microns under the given conditions is 91.93 %.

The obtained preliminary results can be used for the initial evaluation of the cyclone efficiency and planning of further research and development in this area [11]. In particular, by changing the input data A, D, L, d_{50}, d_{95}, U according to a certain pattern, the efficiency values can be obtained according to these data sets. According to the regularities, it is possible to take the plan of a full factorial active experiment or a passive experiment. In the latter case, actual data from other enterprises of the same orientation can be taken, which will form a passive experiment plan, according to which the efficiency can be calculated according to formula (1). These results will form a matrix-column of the initial data, which can be used to construct a regression equation of the form:

$$E=f(A,\ D,\ L,\ d_{50}/d_{95},\ U),$$

where E – the efficiency of the cyclone in removing pollutants from air or water (%). However, the construction of such a regression equation will face the complexity associated with the need to estimate at least 32 coefficients. If to implement a passive plan, it will lead to the need to recalculate the dispersion matrix every time if any of the coefficients turns out to be insignificant. This will greatly complicate the procedure for finding the equation. An alternative solution can be the artificial orthogonalization of the plan of the passive experiment, which requires clustering of the input data in relation to the vertices of the hypercube of the plan of the full factorial experiment [12]. But at the same time, it should be taken into account that, strictly speaking, the two input variables in formula (1) can be considered as fuzzy numbers – d_{50}/d_{95} and U. Therefore, the procedure for constructing the regression equation should be preceded by the fuzzy clustering procedure [12], the algorithm of which is presented in Fig. 1.

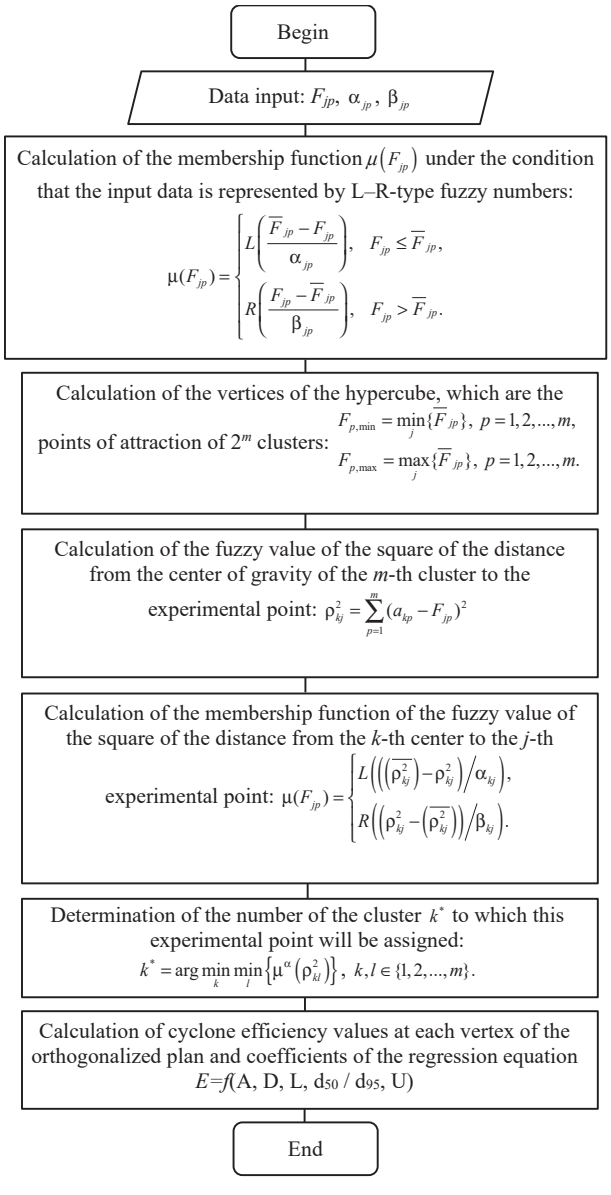

Fig. 1. Fuzzy clustering algorithm

In Fig. 1, the following notations are used: F_{jp} – the value of the fuzzy values d_{50}/d_{95} and U at the j-th experimental point, $\mu(F_{jp})$ – the membership function of the fuzzy numbers F_{jp}, $\overline{F}_{jp}$ – the modal value of the fuzzy number F_{jp}, $j=1,2,...,n$, $p=1,2,...,m$, α_{jp}, β_{jp} – the left and right fuzzy coefficients, m – the dimensionality of the factor space (m=5).

Thus, the algorithm provides a solution to the problem of constructing the regression equation for the fuzzy values of d_{50}/d_{95} and U. On the basis of this equation, it is also possible to solve the inverse problem – to find such values of the design parameters of the cyclone that ensure maximum efficiency under the conditions of restrictions imposed by the capabilities of the structures.

The limitations of the research are the specifics of the researched object itself, as well as the selected input data.

A conceptual decision to build a regression equation based on data collection from different enterprises of the same line of business will allow scaling the results of this study. Therefore, in the future, the study of emissions and discharges from «Chernihivagroshlyahbud» LLC and the effectiveness of their cleaning measures can be carried out for other harmful substances, as well as after the modernization of cleaning equipment.

4. Conclusions

Analyzing the emissions of harmful substances from the industrial site of «Chernihivagroshlyahbud» LLC, the following conclusion can be drawn: the concentrations of ingredients emitted by the enterprise do not exceed the corresponding maximum permissible values. Emissions into the environment ensure a satisfactory state of the environment in the area where the facility is located and outside the sanitary protection zone.

The specified assessment of the use of water resources indicates that the enterprise manages water resources within the limits of established norms and meets the requirements of the contract with the water supply organization. In addition, taking into account the absence of production effluents and negative impact on the water environment, it is possible to draw a conclusion about sustainable and ecologically responsible use of water resources by the enterprise.

Taking into account the non-agricultural nature of the use of the lands of the plant's sanitary protection zone, it is recommended to carry out a repeated survey of the soil for contamination, according to the expert assessment, with the existing production technology, no earlier than in 15–20 years. In order to reduce the man-made impact of emissions on the environment, it is necessary to improve the technological process at «Chernihivagroshlyahbud» LLC.

«Chernihivagroshlyahbud» LLC has a certain negative impact on the environment due to emissions of pollutants during laboratory research, operation of the boiler room, metalworking equipment and welding operations. However, there are opportunities to minimize this impact through the implementation of effective air purification systems, equipment maintenance, the use of environmentally friendly technologies and materials, as well as the involvement of environmental experts to develop a set of environmental protection measures. The implementation of these measures will help reduce the negative impact of the enterprise on the environment and ensure sustainable environmental work.

Conflict of interest

The author declares that he has no conflict of interest in relation to this study, including financial, personal, authorship or other, which could affect the study and its results presented in this article.

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Data availability

The manuscript has no associated data.

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