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INCREASING THE ENVIRONMENTAL SAFETY OF MUNICIPALITIES UNDER THE TECHNOGENIC LOAD OF PRODUCTION FACILITIES

The article analyses data on the impact of urban infrastructure on the environment, using specific infrastructure facilities as examples. It establishes that urban infrastructure facilities negatively impact the environment. However, their continued operation is feasible by developing and implementing environmental protection measures to improve environmental quality.

Keywords: *environmental safety, protection technologies, territories, environment, monitoring, assessment.*

Introduction

Urban infrastructure facilities are a set of structures, systems, and services that ensure the comfortable living of the city residents. Such facilities include roads, bridges, public transport, water and sewage systems, electricity, heat supply, communications, public buildings (schools, hospitals, administrative offices), parks, squares, and other public spaces. The impact of urban infrastructure on the environment is multifaceted and can carry a significant negative load. This heavy load can be due to emissions produced by vehicles, industrial plants, and energy facilities. It is also associated with untreated or insufficiently treated wastewater entering water bodies generated by transportation, construction works, and other urban processes. Deforestation of green areas and the development of territories cause biodiversity loss and changes in the natural environment. Urbanisation leads to soil compaction and changes in its chemical composition due to pollution with heavy metals, oil, and other substances. Cities have higher temperatures than surrounding rural areas due to the large number of asphalt and concrete surfaces that absorb and retain heat. The consumption of large amounts of water, energy, and other resources can deplete natural resources.

It is necessary to introduce environmentally friendly technologies, develop green transport, create and maintain green areas, improve the energy efficiency of buildings and structures, and carry out appropriate monitoring and control over the environmental state to reduce the negative impact of urban infrastructure on the environment.

Assessing the environmental impact of house-building plants is an important topic that is becoming increasingly relevant in the context of the growing environmental impact of the construction industry. House-building enterprises typically produce materials for construction, such as cement, concrete, and ceramic blocks, among others. These production processes can significantly impact the environment from various perspectives. One of the main issues is the emission of pollutants and toxic gases during production. For example, cement production can lead to significant emissions of carbon dioxide and other harmful substances that contribute to the greenhouse effect and air pollution. In addition, house-building factories can have a large water withdrawal, which affects the availability of water resources in the region and the ecosystem of water bodies. Inadequate water management can lead to groundwater levels decrease and the degradation of aquatic ecosystems.

It is possible to achieve a positive impact through introducing new technologies to reduce emissions and increase the energy efficiency of production processes. Given the growing need for construction and the development of urban infrastructures, it is essential to continuously assess the environmental impact of house-building companies and look for ways to reduce the harmful effects. It may include using more environmentally friendly production technologies, introducing energy-efficient processes, reducing water withdrawals and impact on water resources, and improving waste and pollution management systems.

Literature Review

Scientists from various fields, including ecology, engineering, urbanism, and environmental management, are studying the ecological impact of house-building plants (or construction companies). James Lovelock developed the concept of ‘Gaia’ [1], emphasising the interconnectedness between the Earth’s biological and abiotic components. Although his work primarily focuses on global ecological systems, it often includes discussions on the impact of human activities, including construction, on the environment.

The environmental impact of a house-building

plant can be significant and varies depending on several factors, such as the technologies used, adherence to environmental standards, and location. House-building plants can emit harmful substances into the atmosphere, including hydrocarbons and oxides of nitrogen and sulphur. These emissions contribute to air pollution and climate change, with potentially serious environmental effects.

The primary pollutants released into the atmosphere from house-building plants are:

– nitrogen oxides – formed during the combustion of fuel at high temperatures, nitrogen oxides can lead to smog, acid rain, and degraded air quality;

– sulphur oxides – produced during fuel combustion, sulphur oxides contribute to air pollution, metal corrosion, and other adverse effects;

– hydrocarbons – these substances may include pollutants such as benzene and toluene, which are potentially carcinogenic and can have harmful health and environmental impacts;

– particulates – dust and other toxic material emission can negatively affect air quality, human health, and ecosystems.

The researchers determine that enhancing the environmental and economic efficiency of the construction industry through innovative technologies can address both financial and ecological issues. The analysis indicates that 'green building' is one of the most promising areas of development, as it helps to eliminate inefficient and irrational business practices.

A prerequisite for implementing green construction is a regulatory framework that stimulates activities across all sectors and branches of the construction industry.

Additionally, the following are essential:

– government support through subsidies and incentives for the development of green building practices;

– the introduction of a fundamentally new investment mechanism to ensure financing from various sources for the industry;

– social programmes aimed at supporting resource-saving measures;

– modernisation of outdated technologies and equipment in enterprises [2, 3].

Forming the local ecological environment involves preserving the landscape (including soil and existing vegetation) surrounding the architectural project while considering its geological and climatic characteristics to create a comfortable microclimate [4].

To reduce their environmental impact, house-building companies can implement more energy-efficient technologies, use recycled materials, promote renewable energy sources, and minimise water usage.

Water pollution resulting from the accumulation of production waste, such as waste cement or other construction materials, can occur through runoff or seepage into the soil, leading to contamination of water sources and posing threats to local ecosystems.

House-building companies can significantly impact water sources through various types of pollution, including waste discharges into water bodies, groundwater contamination, soil erosion, and air pollutant emissions.

Improper handling and disposal of waste materials, used solutions, and other by-products can result in their accumulation in rivers, lakes, or seas. Inefficient storage and handling of chemicals can contaminate groundwater, which may subsequently affect water sources. Large construction projects can alter the landscape, increasing the risk of soil erosion and the transport of contaminated particles to water sources.

Air emissions can also contribute to water pollution, as some pollutants released into the atmosphere may settle on soil surfaces and transfer to water sources during rain or snowfall.

These forms of pollution can severely impact water ecosystems, posing threats to fish stocks, aquatic plants and animals, and the health and safety of local communities that rely on these water sources.

Analysing regulatory and environmental support and project urban planning documentation requires a comprehensive examination of various aspects, such as pollutant emissions into the air, water, and soil, resource use, waste management, impact on biodiversity, and more.

The Law of Ukraine 'On Environmental Impact Assessment' establishes the legal and organisational framework for assessing ecological impact to prevent environmental damage, ensure environmental safety, protect the environment, and promote the rational use and reproduction of natural resources. This assessment is crucial for decision-making processes regarding economic activities that may significantly affect the environment, considering state, public, and private interests.

Environmental Impact Assessment (EIA) is a thorough evaluation of the effects on the natural, social, and built environments and assesses the acceptability of the proposed activities.

In developing the EIA, it is necessary to use data on the current environmental state in the area where the planned activity will occur. It includes meteorological characteristics, background concentrations, site conditions, results of monitoring atmospheric air, soil, water bodies, and other relevant information, engineering surveys, cartographic materials, the design capacity of the planned facility, and other studies and analyses. Conducting an EIA is mandatory for large residential developments due to their potential significant environmental impact.

DBN A.2.2-3:2014 'Composition and Content of

Construction Project Documentation' outlines the basis for the EIA, stipulating that environmental impact assessment (EIA) is an integral part of the procedure for developing pre-project and project documentation. DBN A.2.2-1-2003 'Composition and Content of EIA Materials in the Design and Construction of Enterprises, Buildings, and Structures' and DSTU-N B B.1.1-10:2010 'Guidelines for the Implementation of the Environmental Protection Sections in Urban Planning Documentation. Composition and Requirements' regulate the composition and content of EIA materials. When planning and constructing cities, it is essential to conduct a comprehensive assessment, including the characterisation of the natural situation and the identification of natural and anthropogenic processes that need consideration to ensure environmental safety, following the Law of Ukraine 'On Basic Principles (Strategy) of the State Environmental Policy of Ukraine until 2030'.

Among the environmental factors with the most significant impact on redevelopment measures are noise and gas pollution from transport routes, followed by insolation and aeration conditions. The acoustic conditions of areas adjacent to residential and public buildings must comply with the requirements of the Law of Ukraine 'On Ensuring Sanitary and Epidemic Safety of the Population'.

Permissible noise levels for residential areas and public buildings, the characteristics of primary sources of external noise, and the methods for determining and reducing noise levels should follow DBN V.1.1-31:2013 'Protection of Territories, Buildings, and Structures from Noise'. Permissible sound levels and sound pressure levels in areas adjacent to residential and public buildings should not exceed the values specified in the sanitary standards DSP 173-96 and DBN V.1.1-31:2013 'Protection of Territories, Buildings, and Structures from Noise'. Performing acoustic calculations of expected sound levels and sound pressure in residential and public buildings and adjacent areas should be according to DSP 173-96 and DBN V.1.1-31:2013. Managing the acoustic regime in residential areas requires urban planning and construction measures, such as noise protection screens and adequate sound insulation of building envelopes.

The microclimatic assessment of city areas should address three key areas: ensuring adequate insolation for buildings and their surroundings, providing favourable conditions in terms of climatic factors (such as outdoor air temperature, wind, and solar radiation), and minimising heat losses in buildings while maintaining a rational thermal regime.

It is necessary to check compliance with noise, insolation, illumination, electromagnetic radiation, and gas pollution standards for improving sanitary and hygienic conditions. Over time, external factors affecting the ecological state of the urban environment, such as increased traffic intensity on the adjacent city and district highways, may deteriorate, leading to increased noise levels and air pollution in both street and intra-quarter spaces [5–8].

Currently, the problem of compliance with environmental safety requirements in the face of human-made pollution in urban areas can be considered one of the core research issues. The operation of house-building plants and unauthorised leaks of pollutants into the environment result in pollution rapidly migrating from the initial contamination sites. Therefore, compliance with environmental safety requirements and regulations allows us to identify the actual extent of environmental pollution. In this regard, it is necessary to assess the impact on the environment of urban infrastructure facilities.

Research Aim

The study aims to assess the environmental safety level in urban development areas by measuring pollution levels based on collected data.

Discussion of Results

Objects and research methods.

The object of the study was a house-building plant specialising in the manufacture of concrete products (wall panels, foundation blocks, floor slabs, elevator shafts, and other structures) and the production of rebar for the construction of residential buildings. According to the State Sanitary Rules for Planning and Development of Settlements, a document posted on the Verkhovna Rada website in the section on legislative documents and regulations, house-building enterprises are classified as Class III and have a sanitary protection zone (SPZ) of 300 metres.

The production process analysis allowed for compiling an indicative list of pollutants emitted into the air. Typically, house-building enterprises emit harmful substances into the air while producing building materials and construction activities. The main pollutant is carbon dioxide, the primary greenhouse gas formed by burning fossil fuels to produce the energy needed to manufacture cement, steel, and other building materials. Nitrogen oxides form during high-temperature combustion, particularly in cement kilns and vehicles used on construction sites. Sulphur oxides form when burning sulphur-containing fuels, such as coal and fuel oil, during the production of building materials. Dust particles emerge during the crushing, grinding, transportation of materials, and other construction activities (Fig. 1).

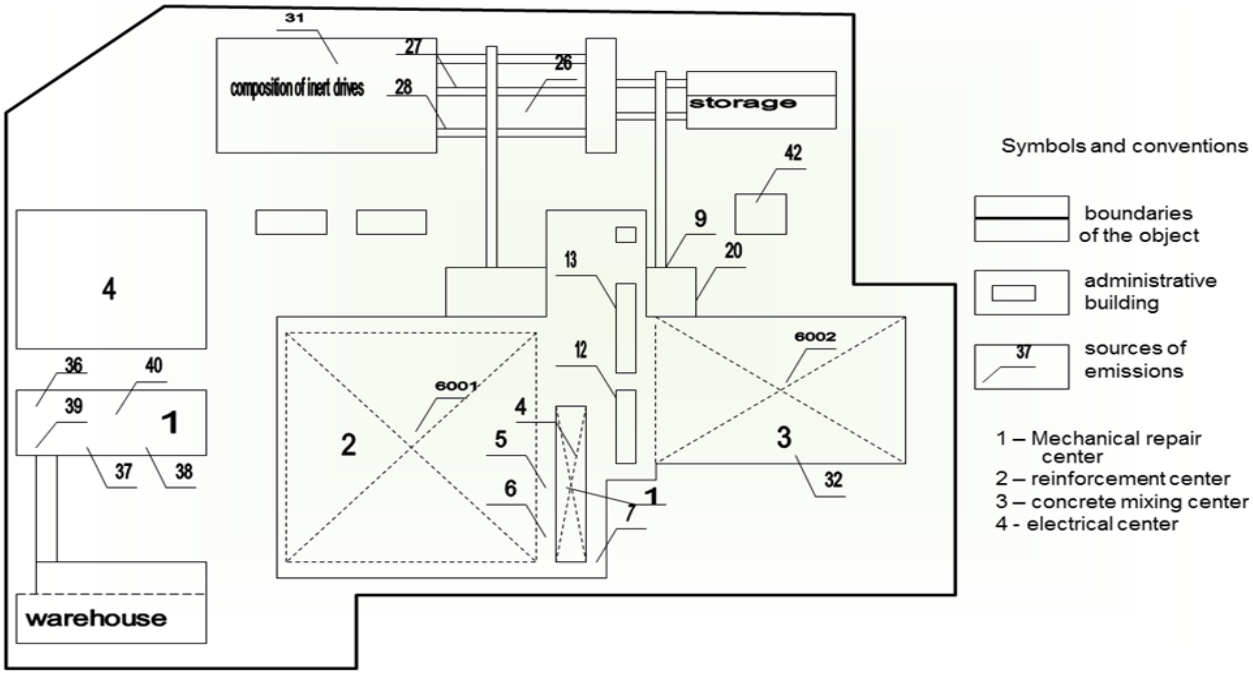

Fig. 1. Diagram of the location of emission sources at the house-building enterprise

Research methods.

Environmental Impact Assessment (EIA) [6] is a systematic process used to predict and assess the potential impacts on the environment of a planned activity or project. This method ensures identifying, predicting, evaluating, and reducing negative environmental impacts. Identifying the core aspects of pollution that require detailed analysis is a crucial step in the EIA process. It involves recognising the main types of pollution that may affect the environment from a project. The main aspects that usually require detailed analysis include, but are not limited to, air, water, soil, noise pollution, and waste management.

For air pollution, the process includes identifying potential air emissions, such as nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO), particulate matter (PM_{10}, $PM_{2.5}$), volatile organic compounds (VOC_s), and others. It also involves identifying stationary sources like workshops and boiler houses and mobile sources like vehicles. Determining the pollution impact zones and the temporal distribution of emissions is also crucial.

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Regarding water pollution, it is essential to specify types of pollutants, including chemical ones like heavy metals, pesticides, and oil products; biological pollutants like pathogens and biological waste; and physical pollutants like suspended particles. Identifying point sources, such as stormwater runoff from enterprises, and diffuse sources, such as agricultural runoff, is necessary. Additionally, assessing the impact on surface and groundwater, including possible changes in the hydrological regime, is also critical.

For soil pollution, determining types of contaminants such as chemical contaminants (e.g., pesticides, heavy metals), physical contaminants (e.g., microplastics), and biological contaminants is essential. Sources of contamination, such as industrial waste, agricultural chemicals, and household waste, must be identified. Analysing the potential impacts on soil quality and its ability to support vegetation is necessary.

Noise pollution assessment involves determining the primary noise sources, such as transport, industrial facilities, and construction sites. Measuring and modelling noise levels in the project area are required, along with assessing the potential impact of noise on human and animal health, including sleep disturbance, stress, and hearing impairment (DBN V.1.1-31:2013).

In waste management [9], identifying the types of waste the project generates, including solid, liquid, and hazardous waste, is crucial. Methods of waste collection, disposal, treatment, and storage need analysis. Assessing the potential impacts on soil, water, and air from improper waste disposal is also needed.

These aspects help to create a complete picture of possible environmental risks and impacts of the project, allowing for the development of effective mitigation measures.

Results and discussion.

Assessing the current state of environmental components requires collecting and analysing diverse data from different sources. Household construction enterprises significantly impact the environment, both directly and indirectly. The main aspects of this impact include using resources such as water, energy, and raw materials and generating pollutants. Construction and

the production of building materials require large amounts of water. Producing cement, steel, and other building materials is an energy-intensive process that increases fossil fuel consumption and greenhouse gas emissions. The extraction of sand, gravel, clay, and other materials for construction leads to the depletion of natural resources and landscape degradation.

Assessment of the impact of the enterprise on the air environment involves calculating the dispersion of pollutant concentrations in the atmospheric air according to the OND-86 methodology [10], which includes formulas derived from the solution of the turbulent diffusion equation; calculating the dispersion of pollutants emitted into the atmosphere by a single point, linear sources, and a group of sources, taking into account the influence of the terrain; determining the maximum concentrations of pollutants in a two-metre layer above the surface of the ground.

Assessment of the house-building enterprises' (HBEs) impact on water bodies is crucial to environmental monitoring and planning. This process involves analysing various factors and aspects that may affect water quality, water body ecosystems, and the overall condition of water resources. The main elements considered when assessing the impact of HBEs on water bodies include pollutant emissions, insoluble particles, and other contaminants.

Wastewater produced by HBEs can contain various chemicals, oil products, heavy metals, organic compounds, and other pollutants. The assessment includes an analysis of the composition of the wastewater, its concentration, and its potential impact on water bodies. Construction activities can cause soil, sand, and other insoluble particles to be washed into water bodies, leading to siltation and decreasing water quality.

Assessing the impact of HBEs on water bodies is a complex process that needs an interdisciplinary approach to ensure sustainable development and conservation of water resources. Evaluating water quality requires comparing the value of a water quality indicator with the general requirements or the concentration of a substance with its maximum permissible concentration (MPC). The assessment determined that the water in the body is not appropriate for fishery (highest) and domestic water use categories by many indicators.

For environmental safety, all water bodies are divided into classes: 1 – very clean, 2 – clean, 3 – polluted, 4 – dirty, 5 – very dirty.

Environmental assessment of surface water quality relies on using the 'Methodology for Environmental Assessment of Surface Water Quality by the Relevant Categories' [11]. This methodology draws on national and international experience in classifying and assessing surface water quality from an environmental perspective. It also accounts for new EU and UN requirements for improving water quality. For each block, the pollution index is calculated as the average value for the block [11, 12].

$$I_1^{kl} = \frac{1+2+3+2}{4} = 2\ ;$$

$$I_1^{kat} = \frac{2+3+5+2}{4} = 3\ ;$$

$$I_2^{kl} = \frac{2+4+3+3+4+4+5+1+3+3}{10} = 3{,}2 = 3\ ;$$

$$I_2^{kat} = \frac{3+6+4+4+6+6+7+1+4+5}{10} = 4{,}6 = 5\ ;$$

$$I_3^{kl} = \frac{3+2+2+3+3+3+2}{7} = 2{,}6 = 3\ ;$$

$$I_3^{kat} = \frac{4+3+3+4+5+5+3}{7} = 3{,}9 = 4\ .$$

Thus, the water belongs to the third class of water quality, the fourth category, and is slightly polluted, eutrophic, and β'.

Since surface runoff from cities and industrial sites is a significant source of pollution and fouling of water bodies, the impact assessment is carried out by estimating the amount of surface runoff from the site and comparing the amount of pollutants contained in it with regulatory standards. The composition of surface runoff from the site was calculated for a model area of 46.0 hectares.

The calculation used the average concentrations of pollutants. It indicates that the surface runoff contains increased suspended solids (Fig. 2).

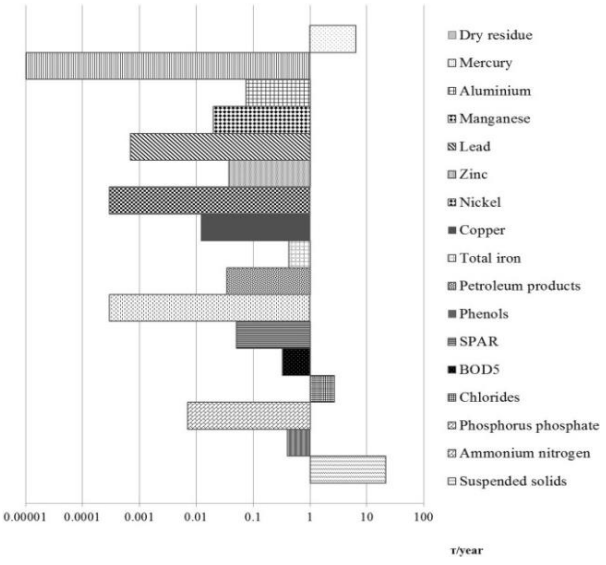

Fig. 2. Surface runoff load

Having data on the content of pollutant metals in soils allows for evaluating soil contamination by determining the extent to which their concentrations exceed background levels. It involves creating a series that ranks the excess concentrations in descending order. The study's results on the current ecological state of soils rely on generalised data regarding the impact of the house-building plant on the soil. The regional background levels of these metals in the soil serve as the criterion for assessing the degree of contamination.

The K_c coefficient measures the soil contamination level by a specific element. The total pollution index, Z_c, according to [13], represents the total content of chemical elements in the soil cover.

The soil contamination index at 3 points does not exceed 12 (Fig. 3).

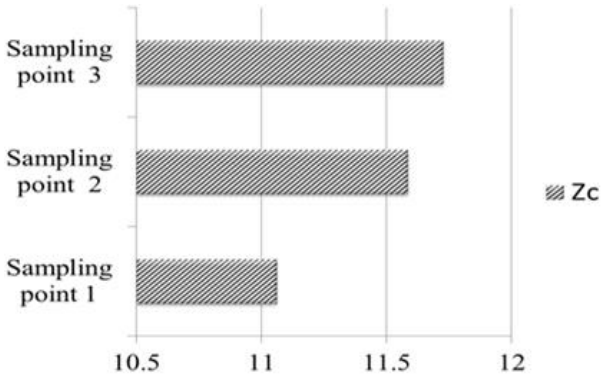

Fig. 3. Total level of soil contamination

This level of contamination is considered acceptable [13]. This indicator corresponds to the lowest levels of children's morbidity and minimal functional disabilities in the adult population.

The environmental impact assessment of the house-building plant determined that the impact of such facilities can pose a danger and worsen the state of the environment.

Conducting a SWOT analysis of the environmental impact of a house-building company is a relevant and crucial task for several reasons. It helps to systematically assess the internal and external factors affecting the company's environmental performance and facilitates informed decision-making for sustainable development.

A SWOT analysis allows for increasing environmental responsibility, identifying risks, and developing measures to address them. It also demonstrates the company's commitment to sustainable development and adherence to environmental standards. It can positively impact the company's reputation and strengthen its relationships with stakeholders, including customers, investors, and regulators (Fig. 4).

The studies conducted to assess the impact of the technosphere facility on environmental components provide the foundation for developing protection measures aimed at improving environmental quality.

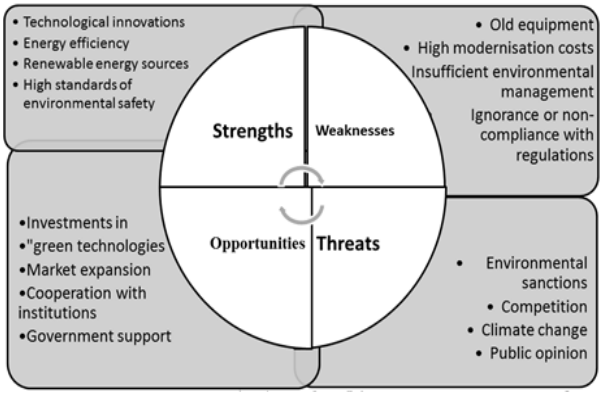

Fig. 4. SWOT analysis of the environmental impact of a house-building plant as a tool to support strategic planning

These measures are crucial for formulating strategies and making decisions focused on preserving the environment and human health, as well as for comprehensive restoration, following the Resolution of the Cabinet of Ministers of Ukraine No. 1159 of 14.10.2022 at the individual facility level.

Environmental protection measures should adopt a comprehensive, innovative approach and incorporate European experience and practices.

Thus, given that this industry is developing rapidly and is characterised by intense competition, considering the results of the ecological impact assessment of facilities when developing an innovative development strategy for urban infrastructure is essential for ensuring environmental safety [14].

Conclusions

The house-building plants specialise in manufacturing concrete products and rebar for residential construction. These plants belong to the third hazard class and have a regulatory sanitary protection zone of 300 metres.

The research and calculations assessed the water quality in the water body and evaluated the soil condition, including calculating the coefficient of total soil contamination. The primary impact source on surface waters is surface runoff, which includes rainwater, snowmelt, and irrigation wastewater. Using data on the composition and quantity of surface runoff, we calculated the runoff load from the enterprise's territory to the water body.

Based on the assessment of the environmental impact of the house-building plant, we developed and justified a set of environmental protection measures. Additionally, we conducted a SWOT analysis of the house-building plant's ecological influence to support strategic planning.

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ПІДВИЩЕННЯ ЕКОЛОГІЧНОЇ БЕЗПЕКИ МІСЬКИХ ПОСЕЛЕНЬ ПРИ ТЕХНОГЕННОМУ НАВАНТАЖЕННІ ВИРОБНИЧИХ ОБ'ЄКТІВ

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Оцінка впливу домобудівних компаній на навколишнє середовище є важливою темою, яка набуває актуальності в контексті все більшого впливу будівельної галузі на навколишнє середовище. Будівельні компанії зазвичай виробляють матеріали для будівництва, серед яких цемент, бетон, керамічні блоки тощо. Ці виробничі процеси можуть мати значний негативний вплив на навколишнє середовище з різних аспектів. Однією з ключових проблем є викиди забруднювальних речовин і токсичних газів під час виробництва. Наприклад, виробництво цементу може призводити до значних викидів вуглекислого газу, а також інших шкідливих речовин, які сприяють парниковому ефекту та забрудненню повітря. Позитивного впливу можна досягти, впроваджуючи нові технології для зменшення викидів та підвищення енергоефективності виробничих процесів. Крім того, домобудівні комбінати можуть мати великий забір води, що впливає на доступність водних ресурсів у регіоні та екосистему водойм. Неналежне управління водними ресурсами може призвести до зниження рівня ґрунтових вод, деградації водних екосистем та загрози біорізноманіттю.

Дослідження мало на меті оцінити рівень екологічної безпеки в районах міської забудови шляхом вимірювання рівнів забруднення на основі зібраних даних. Об'єктом дослідження був домобудівний комбінат, що спеціалізується на виготовленні залізобетонних виробів та виробництві арматури для будівництва житлових будинків. У процесі дослідження було проведено оцінку якості води у водному об'єкті та оцінку стану ґрунту, зокрема розрахунок коефіцієнта сумарного забруднення ґрунту. Основним джерелом впливу на поверхневі води виявився поверхневий стік, який включає дощові води, талі води та стічні води для зрошення. На основі даних про склад та кількість поверхневого стоку було розраховано навантаження стоку з території підприємства на водний об'єкт.

З огляду на велику потребу в будівництві та розвитку міської інфраструктури, важливо постійно оцінювати вплив домобудівних компаній на довкілля та шукати шляхи зменшення негативних наслідків. Це може бути використання більш екологічних технологій виробництва, впровадження енергоефективних процесів, зменшення забору води та впливу на водні ресурси, вдосконалення систем управління відходами та забрудненням. За результатами аналізу, розрахунків та оцінки впливу домобудівного комбінату на навколишнє середовище було розроблено та обґрунтовано комплекс природоохоронних заходів, обов'язковим елементом якого є SWOT-аналіз. Результати SWOT-аналізу дозволили сформулювати стратегічні напрямки розвитку з урахуванням екологічної безпеки.

Ключові слова: *екологічна безпека, технології захисту, території, довкілля, моніторинг, оцінка.*