Proceedings of the International Conference «European Green Dimensions: Fundamental, Applied, and Industrial Aspects», June 5–7, 2025

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FOREWORD

Dear colleagues!

This collection of abstracts represents the culmination of the International Conference "European Green Dimensions: Fundamental, Applied, and Industrial Aspects," held on June 5–7, 2025, at Petro Mohyla Black Sea National University in Mykolaiv, Ukraine.

In an era where the planet's vital signs are flashing red, the International Conference isn't just timely – it's a critical intervention. We're operating in a complex system, where the European Green Dimensions represents a bold attempt to recalibrate humanity's relationship with Earth. This isn't solely about policy; it's a call to reimagine our industrial DNA, redefine energy itself, and resuscitate ecosystems gasping for breath.

From the thermodynamics of climate change to the intricate web of biodiversity, and from the chemistry of wastewater to the physics of renewable energy, the conference's scope mirrors the interconnectedness of the challenges. It's a recognition that sustainability isn't a niche concern—it's the operating system upgrade our civilization desperately needs. This isn't an academic exercise; it's a solution-focused sprint. The urgency is palpable, and the stakes couldn't be higher.

The Proceedings covers such questions: European Green deal; Climate change; Energy efficiency, renewable energy; Conservation of biodiversity; Water resources management; Water quality, wastewater treatment; Protection of atmospheric air, environmental control and monitoring systems; Industrial and household waste management; Sustainable development and education for sustainable development. The issues of ecology and sustainable development are of paramount importance and growing urgency for the future of humanity, demanding innovative solutions and collaborative efforts.

The International Conference attracted participants from a wide geographical distribution, fostering a rich exchange of ideas and perspectives. The contributions herein reflect the diverse approaches and innovative solutions being explored across various contexts.

It is our hope that the ideas presented within these pages will spark inspiration for further research, and facilitate the building of bridges for future collaboration and partnerships among scientists and practitioners.

We extend our sincere gratitude to the Erasmus+JM Programme, whose funding made this important event and this publication possible.

Prof. Olena Mitrysova

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European Green Deal: Challenges for Ukraine in the Post-War Period

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The European Green Deal is a strategic initiative of the European Union aimed at achieving climate neutrality by 2050 through sustainable development, green innovation, and systemic transformation of the economy [1]. For Ukraine, alignment with the European Green Deal presents both substantial opportunities and considerable challenges, particularly in the context of the ongoing war and anticipated post-war reconstruction. On the one hand, it creates a framework for access to climate finance, green technologies, and deeper integration into EU environmental and energy policies. On the other hand, Ukraine must overcome structural barriers, including energy dependence on fossil fuels, outdated industrial infrastructure, limited administrative capacity, and the urgent need to harmonize national legislation with EU directives [2].

The war has severely damaged Ukraine's energy sector and ecological systems, further complicating efforts toward a green transformation. At the same time, post-war recovery offers a unique window to implement large-scale sustainable modernization, especially in energy, transportation, and urban infrastructure, aligned with the principles of the Green Deal. This paper examines the key challenges Ukraine faces in integrating into the European Green Deal framework and outlines potential strategies for rebuilding a greener and more resilient economy in the post-war period. Special attention is given to consideration of legislative harmonization, institutional reforms, and opportunities for sustainable infrastructure development, which can anchor Ukraine's long-term recovery within the EU's green transition goals.

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War-Related Impacts on Water Resources as an Additional Challenge Towards European Standards: Selected Communities of the Lower Dnipro

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The water infrastructure and resources of Ukraine suffered massive, at times irreversible damage during the full-scale Russian invasion [1]. This damage, exacerbated by existing environmental pressures and emergency humanitarian solutions which might become suboptimal in the long-term, requires immense resources and efforts in the context of Ukraine's European integration commitments. Some of the issues have already been addressed in the newly adopted RBMPs [2], while others call for keener attention.

The study relies on the state monitoring and statistical data, OSINT and remote sensing, as well as the data from humanitarian aid providers, such as ACAPS, UNICEF WASH Cluster, to identify key current water needs and issues in the selected communities of the Lower Dnipro affected by the hostilities. Attention is paid to identifying "hidden" impacts, such as persistent pollution hotspots and groundwater over-abstraction, though these matters demonstrate monitoring and data availability gaps. Legacy pollution [3] and tailing management seem to be neglected, while being important in the context of the European "zero pollution" ambition. Multiple humanitarian threats related to the hydrotechnical infrastructure attacks, including in the communities affected by the Kakhovka Dam destruction, are analyzed against the European barrier removal approach as a planned process with community discussions, compensation and mitigation measures, warning against populistic statements that such events per se may be seen as contributing to achievement of the Green Deal goals.

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Ensuring Sustainable Development of Ukrainian Communities on the Basis of the European Green Deal Through the Development of Renewable Energy

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Successful implementation of renewable energy projects in communities of Ukraine depends on a range of interrelated factors.

1. **Government Policies and Regulations**: financial support such as "green tariffs", tax credits, grants, and subsidies will encourage investments in renewable technologies. Clear and supportive regulations will facilitate the integration of renewables into energy markets.
2. **Economic Factors**. **Cost of Technology**: the decreasing costs of renewable technologies (e.g., solar panels, wind turbines) make them more accessible in Ukraine and all over the world. Access to Financing: availability of loans, investments, and international financial institutions willing to fund renewable energy projects.
3. **Diversification of Energy Sources**: Ukraine has to adopt renewables to reduce dependence on imported fossil fuels and enhance energy independence and security.
4. **Public Awareness and Acceptance:** public support can significantly influence the success of renewable projects; community involvement leads to higher acceptance.
5. **Education and Awareness**: Informing the public about the European Green Deal benefits for Ukraine can drive demand and support. A trained workforce is essential for the development, installation, and maintenance of renewable technologies.
6. **Grid Infrastructure**: A robust grid infrastructure is necessary to support the integration of renewable sources into the energy supply.

These factors often interact in complex ways, and their relative effectiveness can differ based on security issues, economic conditions, and labor force availability in different regions of Ukraine.

Educating for Sustainability: the Importance of Environmental Learning

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Environmental education plays a critical role in shaping the understanding and actions of university students, particularly those studying ecology. It provides foundational knowledge about ecological principles, biodiversity, and the impacts of human activity on natural systems. As future ecologists, students must grasp the interconnectedness of life and the delicate balance within ecosystems. Environmental education fosters awareness of pressing global challenges such as climate change, deforestation, and pollution. This awareness is essential for promoting sustainable practices. By incorporating interdisciplinary approaches, environmental education connects science with social, political, and economic dimensions. It also encourages critical thinking and problem-solving skills necessary for addressing complex environmental issues. Engaging students through fieldwork, case studies, and community projects enhances experiential learning and environmental stewardship. Education instills a sense of responsibility and empowers students to become advocates for conservation and sustainability. Moreover, it prepares them to contribute meaningfully to environmental policy, research, and education sectors. A strong educational foundation also nurtures ethical considerations and long-term ecological thinking. Universities serve as vital platforms for promoting sustainability through curriculum design and institutional practices. Integrating environmental education across disciplines broadens its impact and relevance. Ultimately, teaching environmental education to ecology students ensures they are well-equipped to tackle ecological crises and lead the way toward a more sustainable future.

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The State of Forest Belts Under War Conditions

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The forest belts are essential. They play many roles in the agricultural environment and in ecosystems. However, the war has a huge impact on them. We conducted a short investigation to assess the state of the forest belts in some parts of the Zaporizhzhia region. Our study reveals many damages in the forest belts. Due to various factors, the state of the forest belts today is dire, and almost all forest belts in Ukraine need to be restored once the war ends. The three main reasons for damage are fire damage, deforestation by humans, and the emergence of garbage dumps. Ongoing warfare and the damage caused by air attacks are significant factors contributing to the occurrence of fires near and within the forest belts. The need for hidden locations for military transport and the army leads to active deforestation in areas near active combat. Many of the trees are broken, making them more susceptible to diseases and serving as a source of infection for other trees and shrubs. Therefore, after the war ends, we must focus on the restoration of the forest belts, and this restoration must align with the Biodiversity Strategy for 2030 in the EU (Fig 1).

Fig. 1. The Forst Belt in Zaporizhzhia region

The Impact of Climate Change on Water Bodies in Vinnytsia Region

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Climate change is a key factor affecting water resources in regions like Vinnytsia. This thesis explores the relationship between global climate processes and the condition of regional water bodies, offering practical adaptation recommendations. The main causes of climate change (increased greenhouse gas emissions, deforestation, intensification of agriculture) and their consequences for the hydrological cycle, including changes in precipitation, lowering water levels and increasing the risk of extreme weather events, are identified. International experience in ecological water monitoring and its significance for Ukraine are also analyzed. Analysis of the ecological state of water bodies in Vinnytsia region revealed exceeding of maximum permissible concentrations of nitrates, phosphates, and heavy metal compounds in rivers, especially in areas with intensive agriculture. The impact of anthropogenic factors on the development of successional processes and loss of biodiversity was revealed. As a result of the research, the following measures were proposed to mitigate the impact of climate change: implementation of a local monitoring system, increasing the area of coastal protection zones, modernization of treatment facilities, implementation of sustainable water use and integrated water resources management.

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Integration of Ecological and Digital Technologies into the Forest Sector Reform in Ukraine: From Biodiversity to Carbon Neutrality

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Ukraine is reforming its forest sector in response to climate change and in alignment with the European Green Deal. The integration of ecological and digital technologies aims to enhance forest governance, conserve biodiversity, and achieve carbon neutrality.

Digitalization of the forestry sector – including the introduction of an electronic logging ticket system, digital cartographic platforms, and remote sensing technologies (LIDAR, satellite data) – is among the leading areas of reform [1]. These tools ensure transparency in timber circulation, improve resource management, and facilitate Ukraine's integration into European environmental and carbon trading mechanisms.

A core element of the reform is the establishment of a national carbon accounting system, enabling the assessment of climate impacts from forest management activities and supporting Ukraine's nationally determined contribution (NDC) to global climate goals. The LIFE UKRFOREST project envisages the introduction of voluntary carbon market mechanisms and investment incentives for afforestation and reforestation.

Ukraine is implementing a strategy to increase forest cover to 18 % [2], digitize the inventory of spontaneously afforested lands, create a unified electronic forest database, and expand forest seedling centers with closed root systems. The integration of ecological and digital solutions supports climate adaptation, sustainable development, and alignment with EU environmental standards.

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The Role of Environmental Law in the Era of Reindustrialization

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A report published by the United Nations Environment Programme and the Sabin Center for Climate Change Law at Columbia University found that climate change lawsuits have increased by 146% between 2017 and 2022 [1].

This reveals long-standing conflicts that have been going on for decades. In the history of environmental law, there have been many confrontations between indigenous peoples and economic objects managed by other peoples, often – global corporations. In our opinion, this has formed a certain pattern that does not always correspond to the real problem around which the conflict had arisen. Namely, it is quite common for the economic object to be managed by representatives of the same people living in the territory, or even representatives of the local residents themselves. As a result, the drama of "us versus them", which is often played out in the media, acquires excessive theatricality, which prevents us from seeing hidden risks [2].

In Europe and the US, the "us versus them" approach contributed to rapid deindustrialization once. In return, newly industrialized countries such as India and China rose in the GDP ranking, which actually weakened the global competitive position of post-industrial countries.

Ukraine, if it succeeds, will join the European Union and other Western unions now, at the stage of reindustrialization, but by inertia, many people who influence the processes think in the paradigm of a post-industrial society, focusing mainly on the interests and beliefs of people whose income and well-being is minimally tied to the actual production of goods. History shows that such development of the economy and the state as a whole is neither effective nor actually sustainable. As an alternative, we recommend developing cooperation between industries, nature reserves and local communities.

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Ecological State of the Aquatic Environment of the Territory of the Capstone Mining of the Korosten Pluton

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The paper focuses on environmental problems related with the extraction and processing of capstone in Ukraine. Was considered the territory of the Korosten pluton of the Volyn mega-block of the Zhytomyr region, which is represented by crystalline rocks of the Precambrian age. This area has the largest number of deposits (156 quarries) of gabbro, labradorite and granite. An integral part of anthropogenic impact is pollution of the aquatic environment. According to hydrological characteristics, the research area belongs to the area of distribution of fractured waters of the Ukrainian Shield and has a primary bicarbonate composition [1].

During environmental monitoring the qualitative state of water was analyzed by a mobile method. In total, we analyzed 150 samples from water bodies: rivers Zherev, Uzh, Ubort, Irsha, Irshanka; quarries near villages Grabivka, Haiky, Rudnya-Shlikhova, Terentsi, Liznyky, etc. Quarry waters are a mixture of surface, rain, melted and groundwater. The following characteristics are established: 1) running waters of rivers and working quarries – pH is 6-7 (close to neutral or slightly acidic), according to hardness indicators - soft or too soft; 2) in abandoned old quarries (10 years or more) water pH is 5-3 (acidic and strongly acidic); by hardness indicators - medium hardness; 3) on the wetlands around quarries the pH of the water is 8-9 (slightly alkaline, alkaline), in terms of hardness - soft. The aquatic environment is polluted with chemical compounds, fuels and lubricants, alkalis, phenols, etc. As an example, when receiving sawn products, a significant amount of pulp accumulates, which is transported to the nearest forest belts or abandoned quarries. Such data indicate that a long-term load on the aquatic environment of the mining area leads to a change in the salt composition of water, its alkalinity-acidity. For further use of water from quarries or discharge into surface drains, it is necessary to neutralize and additionally purify them.

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Bioeconomy for Achieving Sustainable Development Goals

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Bioeconomy is a paradigm and a tool for achieving sustainable development goals. The essence of the transition to sustainable development is the survival of mankind and simultaneous preservation of the biosphere. However, in order to survive, to preserve as a unique biological species, humans need to radically transform all areas of activity in the direction of reducing the significant pressure on the biosphere. In this context, the formation of a knowledge-based bioeconomy is a key strategy that meets the needs of society, as it ensures efficient use of resources on the principles of sustainability. According to some scientists, sustainable development is a process of harmonization of productive forces, guaranteed provision of satisfaction of the necessary needs of all members of society, subject to the preservation and gradual reproduction of integrity of the environment, creating opportunities for balance between its potential and the requirements of people of all generations. Since bioeconomy is a form of economic activity that is based on the balanced interaction of three systems – economic, environmental and social, which is determined by the processes of mutual exchange of renewable bioresources in order to ensure a high level of quality of life and preserve ecological balance for future generations, the transition to a bioeconomy can become, in our opinion, one of the main priorities of sustainable development. In general, the strategy of sustainable development is based on a very logical and understandable approach: for the sustainable development of humanity on a planet with limited resources, it is important not to exhaust these resources and not to exceed the planet's natural capacity for self-regeneration. The bioeconomy ensures the production of renewable biological raw materials and the transformation of these resources and waste into products with added value, in particular, into food, feed, bio-based products and bioenergy [1]. The formation of the bioeconomy is an important priority and the main vector in the concept of sustainable development policy, as it integrates economic and social components that are aimed at meeting the needs of both current and future generations.

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Electromagnetic Stress Measurements in City Mykolaiv in the Conditions of Military Operations

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The aim of this research is to develop scientifically grounded criteria for assessing the impact of electromagnetic radiation (EMR) on socio-ecosystems, as well as to design a corresponding monitoring program and data processing algorithm. Given the growing influence of anthropogenic electromagnetic fields particularly in territories affected by military activity there is an urgent need to establish a structured and interdisciplinary approach to environmental EMR assessment [1; 2]. To achieve this objective, the study employs a comprehensive methodology encompassing both data acquisition and analytical processing. Primary data on electromagnetic field intensity are collected using field-deployable instruments such as the Tenmars TM-192D EMF meter [3]. One of the key observation points was located near an individual heating installation, where local residents had previously reported frequent headaches and a persistent high-frequency noise (Fig. 1). This location was of particular interest, as it was expected to exhibit elevated EMF levels due to the operation of high-energy electrical equipment. Measurements at this site did indeed show indications of elevated field intensity, prompting further analysis. However, due to the spectral limitations of the Tenmars TM-192D, the exact frequency range of the detected emissions could not be confirmed. An algorithm was developed to process the collected data, which includes steps for geo-referencing, anomaly detection, and correlation with ecological and human health risk indicators.

Fig. 1 Measurements of EMF field using TM-192D.

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Applying the Grey Water Footprint to Assess Urban Micropollution

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Threats to water quality, especially in drinking water bodies, often come from crop protection products (mainly pesticides) and micropollutants such as pharmaceuticals and personal care products (PPCPs). Municipal wastewater treatment plants are a key source, as conventional technologies are not designed to effectively remove these substances.
PPCPs account for the largest share of micropollutant inputs and toxicity in wastewater, with pharmaceuticals accounting for 59% of the quantity and 48% of the chronic toxic load (EU, 2022).
Assessing the impact of these pollutants is complex and requires both removal strategies and knowledge of their environmental fate. Increasing attention is being paid to the gray water footprint (GWF), a component of the broader water footprint concept that quantifies the (hypothetical) volume of freshwater needed to dilute pollutants to meet water quality standards. Despite its limitations, the GWF offers a useful way to compare pollution types and assess environmental risks.
Initial applications of GWF focused on standard pollutants such as nutrients and organic matter. Only recently has attention been drawn to micropollutants. Several studies have assessed the GWF of pharmaceuticals, including antibiotics and contaminants of concern. However, most studies remain fragmented and lack comparisons with traditional pollutants. Therefore, it is now urgently needed to include micropollutants in water contamination assessments to better protect drinking water resources [1].

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The Role of the "Yelanetsky Steppe" Nature Reserve in Biodiversity Conservation of the Steppe Zone

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The territory of the "Yelanetsky Steppe" Nature Reserve is a landscape complex of ravines and dry valleys with preserved steppe, petrophyte-steppe and shrubby plant communities. Field floristic research was conducted between 2021 and 2024. Illustrations of many plant species are presented in the iNaturalist observation database (https://www.inaturalist.org/projects/pryrodnyi-zapovidnyk-yelanetskyi-step). As a result of the new inventory, more than 100 additional species and subspecies of vascular plants, previously unrecorded in the reserve, were added to the flora. Over the past five years, two new rare species from the Red Book of Ukraine have been discovered in the reserve's habitats: *Allium sphaeropodum* and *Colchicum triphyllum.*

The flora of the nature reserve includes 30 rare plant species listed in the Red Data Book of Ukraine, accounting for 34% of those growing within the Mykolaiv Oblast. 7 rare plant species are listed in the IUCN Red List, 12 in the European Red List, and two in the Annex to the Bern Convention (*Crambe tataria, Echium russicum*). 19 species are protected at the regional level. In total, the nature reserve hosts 38 plant species with national and international conservation statuses, which represents a relatively high conservation value. For comparison, the steppe "Askania-Nova" Biosphere Reserve lists 27 specially protected plant species; in the departments of the Ukrainian Steppe Nature Reserve: 20 in "Kalmiusky", 40 in "Stone Graves," 38 in "Chalk Flora," and 41 in "Khomutovsky Steppe". The Luhansk Nature Reserve lists 37 rare plants in "Provallia Steppe" Department and 31 in "Striltsivsky Steppe" Department, while the Opuk Nature Reserve in Crimea lists 25 rare plants. Thus, in terms of floristic and phytosozological richness, the "Yelanetsky Steppe" Nature Reserve ranks above average among Ukraine's high-ranking steppe conservation areas and serves as a regional and national biodiversity hub. The nature reserve plays an important role in preserving Ukraine's steppe ecosystems.

River Basin Management in Ukraine

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EU policy and strategy for environmental management, including natural waters, seeks to achieve sustainability in the water sector in the territory of its member states. One of the main EU documents in terms of water quality and water management is the Water Framework Directive [1]. Management is based on river basins and watersheds (the basin principle).

In the process of water resources management based on the basin principle, an important document is the river basin management plan [2].

In the process of environmental and economic reforms in Ukraine, prices for special use of water resources have been set, and economic responsibility for environmental pollution, including water bodies, has been introduced.

Ukraine's aspirations to become a member of the EU in the future require approximation of its legislation and improvement of the management system in the field of water resources use, protection and reclamation in accordance with EU requirements.

The main problem with the effectiveness of basin management is the creation and functioning of a financial mechanism that would guarantee a direct link between water use fees and the financing of priority water protection measures within the basin.

Currently, the process of approximating Ukrainian legislation to the European one is in an active phase. However, it can already be confidently stated that Ukraine has made sufficient efforts to legislate for the implementation of integrated approaches to water resources management based on the basin principle. At the same time, the problems of practical implementation of this principle in water resources management remain urgent.

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Effective Approach to Natural Resources Monitoring

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Model monitoring of natural resource management systems is designed to fulfill three main functions:

- providing information on the state of the process at the points where it is impossible to implement it by means of physical monitoring;
- providing information about the state of the process at any point in the accelerated time scale, that is, before it actually occurs and will be recorded by means of physical monitoring, taking into account the actual (limited) speed of physical, chemical or biological processes;
- forecasting (at any time) the development of the situation in selected conditions.

Model monitoring can be carried out only with the availability of adequate models (physical, mathematical, quasi-analogues). Since processes in a system occur under the influence of various factors, some of which are either poorly controlled, or completely uncontrolled, or even reliable information on their quantitative effect on the occurrence of certain processes is absent, and the environment is not characterized by a continuous homogeneity in structure, reactions to factors and external influences, all models used are empirical and their adequacy under specific conditions can be more qualitative than quantitative.

The above-mentioned approaches to increasing the reliability of control data ensure stable functioning of natural resource management systems and facilitate the adoption of substantiated decisions to minimize the consequences of man-made and natural disasters and accidents. However, their use in the absence of accepted patterns of system state, making them sensitive to external influences and focused on precise input information, requires new, non-standard approaches.

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Environmental Monitoring for Sustainable Development of Post-Liquidation Mining Areas

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The closure of mining and chemical enterprises in Ukraine left a legacy of environmental degradation, with vast diverse industrial wastes, including sulphur residues, phosphogypsum, flotation tailings, oil tars, and solid waste, alongside abandoned infrastructure [1]. These remnants pose ongoing risks of soil and water contamination, exacerbated by insufficient post-closure management. This study examines the role of environmental monitoring in enabling the sustainable redevelopment of such post-liquidation mining areas. Analysis of the areas reveals significant environmental challenges, including elevated levels of sulphates, heavy metals, nitrates, organic compounds, and other chemical pollutants in soil, water, and atmospheric systems. These conditions threaten surrounding ecosystems and limit land reuse potential. To address this, a sustainable redevelopment strategy is proposed, focusing on three key areas: (I) Ecological restoration. Deploying phytoremediation techniques with native plant species to detoxify soils and enhance biodiversity; (II) Water system management. Creating wetland-based filtration systems to treat contaminated runoff and restore hydrological balance; (III) Green energy development. Converting degraded areas into areas for renewable energy installations, such as solar panels on non-arable land, to support regional sustainability goals. Effective environmental monitoring is essential to this strategy. In contrast to current fragmented efforts, a comprehensive monitoring system would provide real-time data on soil, water, air quality, and ecological recovery, guiding reclamation efforts and preventing secondary pollution. This approach ensures alignment with global sustainability frameworks, prioritizing long-term environmental benefits.

It was investigated that the closure of Ukrainian mining and chemical areas underscores the need for systematic monitoring to convert post-industrial mining areas into sustainable, productive landscapes. This approach offers a way for rehabilitating similar areas, fostering environmental resilience, and economic revitalization.

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Hydrochemical Trends and Transboundary Challenges in the Western Bug River, Ukraine

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The Western Bug River, a transboundary watercourse shared by Ukraine and Poland, is critical for regional ecosystems and human activities. Increasing anthropogenic pressures, such as agricultural runoff and urban wastewater, threaten its water quality, necessitating detailed hydrochemical analysis to inform sustainable management and align with the European Green Deal objective [1; 2]. This study investigates spatiotemporal trends in key water quality parameters to address transboundary pollution challenges.

Using monitoring data from 2005 to 2024 across seven stations in the Lviv region, this study analyses hydrochemical parameters, including biochemical oxygen demand (BOD_5), dissolved oxygen (DO), total suspended solids (TSS), phosphates, ammonium, chlorides, nitrates, nitrites, and sulphates. Upstream rural areas exhibit stable water quality with low pollutant levels (median BOD_5 of 2.5 mg/dm³ at stations in Litovezh). At the same time, downstream urban and industrial zones show elevated contamination (median BOD_5 of 4.8 mg/dm³ at stations in Sokal). Pearson correlation analysis reveals strong interdependencies, such as BOD_5 and ammonium ($r = 0.85$), indicating common sources like untreated wastewater. Variable sampling frequency and limited spatial coverage hinder precise source identification and detection of short-term fluctuations, highlighting gaps in the monitoring system.

Enhanced monitoring with higher temporal resolution and broader spatial coverage is essential for effective pollution control. International cooperation between Ukraine and Poland is critical to address transboundary challenges and ensure the sustainable management of the Western Bug River, supporting regional ecological health and compliance with global sustainability goals.

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Developing Mediation Skills in Future Social Workers as Part of Education for Sustainable Development: Impact on Addressing Social and Environmental Issues

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In the face of global environmental and social challenges, education for sustainable development (ESD) plays a key role in preparing professionals who can promote sustainability [2]. Social workers, with their expertise in supporting individuals and communities, are central to this effort. Their role extends beyond traditional support to include addressing environmental justice and promoting sustainable practices.

Mediation — the facilitation of dialogue between conflicting parties — is a vital skill for social workers [3]. It enables them to resolve conflicts around issues like resource use, environmental degradation, and social inequality. Training future social workers in mediation strengthens their ability to support communities, foster cooperation, and build sustainable solutions involving diverse stakeholders [1].

Integrating mediation into social work education supports key ESD goals: peace, justice, equity, and responsibility [4]. It equips students to engage in collaborative problem-solving, particularly in marginalized communities facing disproportionate environmental risks.

Overall, embedding mediation into social work training empowers graduates to manage complex conflicts, support sustainable community development, and address the interlinked challenges of social and environmental change.

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Laser-Induced Breakdown Spectroscopy Application for Metallic Ions Detection in Natural Waters

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Providing the population with clean drinking water is a priority task worldwide according to the World Health Organization. This ecological problem is most acute today during the hostilities in Ukraine.

The current detection techniques for water analysis are based on optical and mass spectroscopy measurements and require long detection cycles, as well as specific chemicals which may cause secondary pollution.

Laser-induced breakdown spectroscopy (LIBS) is a novel atomic emission spectroscopic nanotechnology used to determine the elemental composition of a sample. LIBS has several advantages, including easy sample pre-treatment, fast operation, chemicals free during the process and identification of multi-state substances rapidly and remotely [1].

Experimental setup for the single-pulse LIBS consists of Q-switched Nd:YAG laser Continuum Minilite with a pulse duration of 10-15 ns, a repetition rate of 10 Hz, a maximum pulse energy of 850 mJ, and output at the wavelength of 1064 nm with the USB 4000 Ocean Optics Spectrometer.

In this work we focused on the application of chemical replacement combined with surface-enhanced LIBS (CR-SENLIBS) for the detection of metallic ions, such as Na^+, K^+, Cd^{2+} and Cr^{3+} in aqueous solutions and natural waters. The aqueous solutions of 30–210 μg/mL for NaCl and KCl, as well as of 2.5–50 μg/mL for $CdCl_2$ and $CrCl_3$ were dropped into Al plates and dried. LIBS spectra were collected immediately after micro-plasma generation. Experiments for Al plates also were conducted [2]. After conducting LIBS experiments with aqueous solutions, LIBS experiments were performed on samples of lakes, rivers, and seawaters in France.

These results show that CR-SENLIBS is a perspective method for improving the detection sensitivity of metallic ions in aqueous solutions, as well as for water quality monitoring in general around the world and especially for Ukraine in this difficult period of war.

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Improving the Informational Content of Radiation Monitoring of Atmospheric Air During the War

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The Russian aggression against Ukraine has exacerbated a number of issues related to the improvement of environmental and radiation monitoring of the atmospheric air. This is due to increased risks of radioecological accidents, threats of changes in the radiation situation, and release of radionuclides into the atmosphere as a result of constant shelling of the territories near NPPs by Russian missiles and drones [1]. The current radiation monitoring of atmospheric air in Ukraine is carried out mainly with the use of dosimetric stations that allow measuring the effective dose rate in the air, mSv/h; indicative measurement stations of the SaveDnipro type (measuring the effective dose rate in the air, mSv/h).
The results of observations of the effective dose rate in Mykolaiv at two observation points showed that the average value of the effective dose rate in Mykolaiv in 2023-24 was 0.12±0.02 μSv/h. As you know, radioactive iodine is an indicator of gas and aerosol emissions in case of damage to nuclear power units. We are working on the project "Improving the Informativeness of Radiation Monitoring of Atmospheric Air at Indicative Measurement Stations". The basic basis is sensors for indicative measurements of effective dose rate (mSv/h). They are supplemented by calibration of these stations with ^{131}I gamma lines (971 keV) They are also complemented by an automatic atmospheric air sampler and the collection and radiometry of precipitation samples from the atmosphere. After all, using the example of the movement of a radioactive cloud with ruthenium-106 in the Ukrainian airspace in September 2017 (due to its accidental leakage at the Russian nuclear fuel processing plant Mayak), the effective dose rate of atmospheric air did not increase, although ^{106}Ru was recorded in increased amounts in atmospheric air samples and atmospheric precipitation. This will allow prompt management decisions on iodine and prevention of the population; to have information.

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Modeling of Radiation Risk from Natural and Anthropogenic Sources of Ionizing Radiation in the South of Ukraine

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Over the last few years, studies have been conducted on the formation of radiation load on humans from technogenically enhanced radioactive sources of natural origin (TUIPP) spread in the region, as well as from gas-aerosol releases and liquid discharges of the South-Ukrainian and Zaporizhzhya NPPs (SUSNPP and ZNPP) [1]. For this purpose the radionuclide content in the surface layer of the atmosphere, atmospheric fallout was studied, migration processes of "station" radionuclides in water systems receiving liquid discharges of NPP radioactive substances were investigated.

On the basis of radioecological and dosimetric studies carried out in the south of Ukraine, the regional peculiarities of formation of radiation load on humans from technogenically enhanced radioactive sources of natural origin, artificial sources associated with gas-aerosol releases and liquid discharges of the South-Ukrainian and Zaporizhzhya NPPs, including radionuclide intake into irrigation water, as well as with the Chernobyl accidental release have been revealed.

Dose coefficients ("dose prices") of natural and anthropogenic sources of ionizing radiation in the south of Ukraine for the main biologically significant radionuclides and their mixtures were established for the first time, which makes it possible to promptly predict the radiation load on humans. This allowed modeling the formation of the expected for 70-year period of human life effective dose in the south of Ukraine from natural and anthropogenic sources of ionizing irradiation, as well as determining its levels. With the help of stochastic modeling models of radioecological risk of unit of influence of natural and technogenic factors of human exposure in the south of Ukraine were established.

The results of research allowed to develop a methodology of management of integral radiation load on a person from natural and anthropogenic radioactive sources with the use of countermeasures for its reduction within the framework of the optimization principle.

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Biotechnia as a Tool for Monitoring the Tyligul Estuary

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Artificial nesting platforms were introduced in the Tiligul Estuary (Odesa–Mykolaiv region) as a biotechnical measure for bird conservation and ecological monitoring. The estuary, 60 km long and up to 21 m deep, holds Ramsar and Emerald Network status and supports over 15,000 pairs of colonial waterbirds annually. However, increasing anthropogenic pressure — recreation, wind farms, and noise — threatens avian populations.

In 2021, seven artificial islands (1500 m² total area) were installed near Kobleve in shallow, human-free zones. They were rectangular or elongated in shape, covered with straw, and elevated to match water levels. In the first season, 195 pairs of five bird species nested successfully, including the Sandwich tern (Thalasseus sandvicensis) and the Red Data Book-listed pied avocet (Recurvirostra avosetta). Breeding success reached 90% (Fig. 1).

By 2024, nesting pairs had doubled to nearly 400, despite ongoing war-related disturbances. Six species were recorded, with a slight decline in diversity likely due to interspecific competition. The consistent presence of rare birds confirms the platforms' role in biodiversity support and their effectiveness as bioindicators of environmental change. Artificial islands thus represent a valuable tool for long-term estuarine ecosystem monitoring under growing anthropogenic stress.

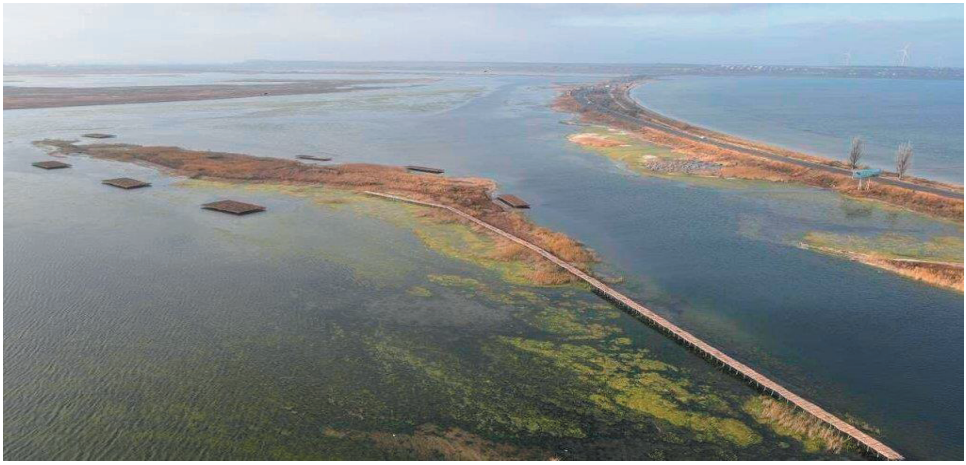

Fig. 1. Artificial Islands on the Tyligul Estuary.

Surface Water Pollution Assessment in the Dnipro River Based on Hydrochemical and Satellite Data

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The increasing significance of surface water pollution research within the Dnipro River Basin is attributed to intensified anthropogenic pressure from industrialization, agricultural activities, and urban development. Major pollution sources comprise untreated municipal and industrial wastewater, agricultural runoff, and domestic effluents containing both organic and chemical contaminants. A particularly pressing ecological issue is eutrophication, driven by elevated nutrient concentrations that disrupt the oxygen regime of aquatic ecosystems. To effectively research the state of water resources, it is essential to integrate advanced methodologies, including the application of satellite remote sensing and geochemical analysis, with the combination of statistical and machine learning techniques. Long-term measurements of key hydrochemical indicators, such as ammonium, phosphates, nitrates, nitrites, biological oxygen demand (BOD), and dissolved oxygen, enable the identification of trends in surface water quality dynamics. Satellite-based assessments utilizing water quality indices facilitate the detection and spatial analysis of eutrophication processes and the overall intensity of water pollution. The integration of remote sensing data with laboratory-based analyses yields a comprehensive and accurate assessment of the ecological status of water bodies, which is critical for informed and sustainable water resource management. A persistent long-term decline in water quality, particularly ammonium concentrations and BOD, has been observed across most surface waters of the Dnipro River [1; 2]. The surface water pollution is more pronounced during the vegetation period compared to the colder months of the year. Seasonal phosphate fluctuations exhibit maximum concentrations during August and September, aligning with eutrophication manifestations identified through satellite observations.

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The Digital Transformation of the EU as a Factor in Sustainable Development

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The European Union's leadership in digital transformation constitutes a pivotal determinant for sustainable development [1; 2]. A discernible consensus regarding the integration of the digital and green revolutions within the EU's economic paradigm fosters resilience and inclusive growth [2]. Digital technologies function as a catalyst for sustainable development by optimizing resource utilization, energy consumption, and the advancement of renewable energy sources [3]. These technologies stimulate innovation, enhance productivity, and improve transportation networks, thereby mitigating congestion and emissions [2, 3]. The European Green Deal [1] underscores the critical role of digitalization in the transition towards a climate-neutral and circular economy [2]. Furthermore, digital instruments bolster place-based policies by facilitating communication and the identification of novel opportunities for sustainable development at the regional level [3]. Consequently, the EU assumes a leading role in shaping a sustainable future through the integration of digital and green priorities.

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Strategies for Improving Pharmaceutical Wastewater Treatment Processes

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Water quality concerns are growing in significance globally, mainly because of the pollution of water sources with organic compounds, heavy metals and pharmaceutical waste.

Wastewater from pharmaceutical production is highly complex in composition. Given that the production of chemical and pharmaceutical products involves multiple stages, wastewater contains mineral salts, free acids and alkalis, along with a wide range of organic and inorganic compounds. These include products and intermediates formed during chemical and biological synthesis processes, as well as the extraction of active ingredients from plant and animal raw materials.

Modern technologies for treating wastewater containing pharmaceutical compounds can be categorized into two main groups:

- traditional methods: biological treatment, chemical methods, physical and chemical methods. Biological wastewater treatment systems, commonly used for treating wastewater, are often ineffective in eliminating pharmaceutical compounds and their metabolites;
- advanced methods: a combination of oxidation and ultrasound, or ultraviolet radiation; catalytic ozonation; combining of the coagulation process with the membrane bioreactor system; electrochemical processes.

An increasing amount of research is being dedicated to using advanced oxidation processes and new biotechnologies for treating wastewater contaminated with pharmaceutical compounds.

Advanced oxidation processes rely on oxidative destruction reactions triggered by various substances or factors. These methods are effective in reducing the concentration of persistent pollutants, including pharmaceutical compounds. Such technologies include the use of Fenton reagent. This method is based on the reaction of hydrogen peroxide with iron, which leads to the formation of hydroxyl radicals – powerful oxidizing agents that can degrade organic pollutants, including complex pharmaceutical contaminations.

These innovative techniques can considerably enhance wastewater treatment efficiency, minimize risks to ecosystems, and protect the environment from harmful contaminants.

Modern Water Resources Management in China

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Modern water resources management in China is carried out on a basin basis. There are 9 main groups of river basins (Fig. 1).

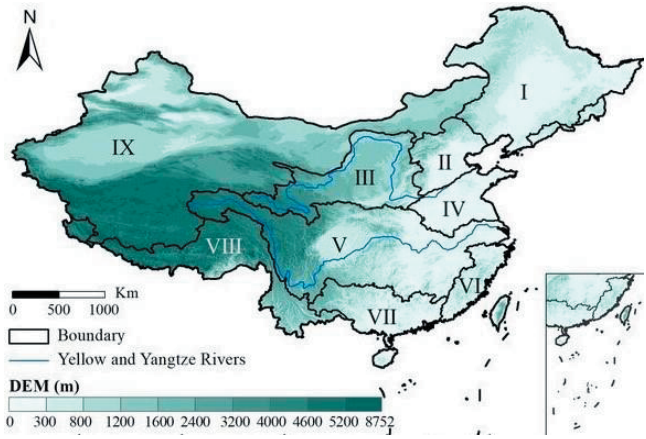

Fig.1. Locations of China's nine major river basins:
I – Songhuajiang and Liaohe (Song-Liao);
II – Haihe; III – Yellow River; IV – Huaihe;
V – Yangtze; VI – Rivers in Southeast China basin; VII – Pearl River;
VIII – Rivers in Southwest China basin; IX – Rivers in Northwest China basin [1].

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Formaldehyde Atmospheric Air Pollution in Mykolaiv City

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Formaldehyde is one of the most dangerous air pollutants in cities, with high toxicity and carcinogenic properties.
Purpose is to assess the dynamics of formaldehyde concentrations in the atmospheric air of Mykolaiv in 2015–2024 and to identify potential risks to public health.
The study is based on the analysis of the data of the Mykolaiv Regional Center for Hydrometeorology and their comparison with the MPC standards.
The average monthly concentrations of formaldehyde in most months exceeded the maximum permissible level (0.003 mg/m³). The highest values were recorded in the summer, especially in 2019 (up to 0.030 mg/m³), Fig. 1.
In 2024, there is a downward trend in the level of pollution, but the indicators still exceed sanitary standards.
The increased content of formaldehyde in the atmospheric air of Mykolaiv requires increased monitoring and implementation of environmental safety measures.

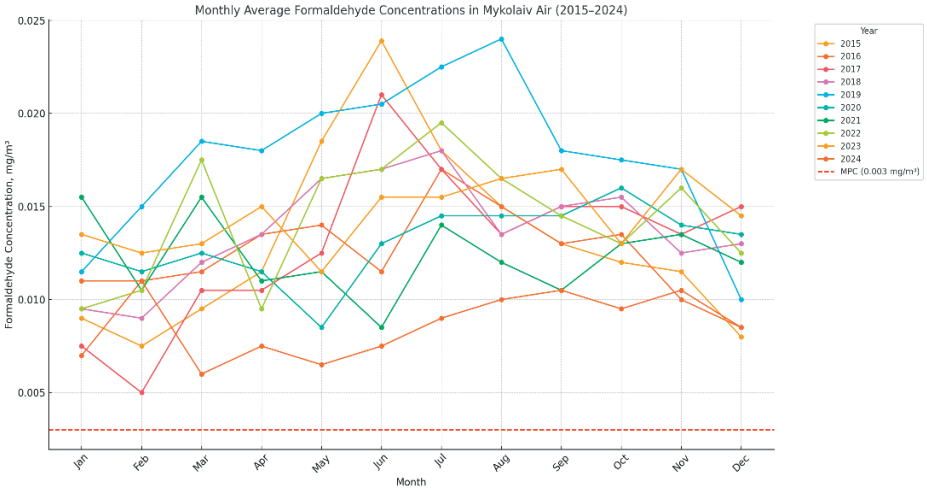

Fig. 1. Monthly Average Formaldehyde Concentrations in Mykolaiv Air (2015−2024).

The Role of Artificial Intelligence in Advancing Sustainability and the European Green Deal

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Addressing numerous environmental problems and achieving overall sustainability are among the primary challenges of the 21st century. Digital technologies, including Artificial Intelligence (AI), are crucial for achieving sustainable development, green economy goals, and social justice. However, like many modern technologies, AI can cause negative impacts on the environment and society as well. This study aims to explore the nature of AI's impact, focusing on the context of the European Green Deal and the implementation of green technologies in Europe.

Several initiatives and activities across Europe demonstrate the role of AI in supporting the Green Deal. In particular, the European Environment Agency is actively integrating AI into its work for environmental reporting and data analysis – such as gap filling for air quality data and using machine learning for water resource management. At the EU policy level, there is a focus on promoting research, development, and demonstration of AI systems addressing climate change. There is also a discussion around increasing transparency regarding the environmental impacts of AI, such as energy consumption and resulting emissions [1].

The EU has also recognized the critical link between the digital and green transitions, identifying them as key priorities. This concept of 'twin transition' is particularly important for positively directed AI [2]. So, we proposed a unique framework for assessing the level of compliance of the innovative projects and technologies with sustainability principles using T. Saaty's analytic hierarchy process in combination with AI. The basic version is implemented in the RStudio environment, which makes it easy to perform complex calculations. This framework can be used by both human experts and our AI experts developed with the prompt engineering approach.

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Autonomous Air Conditioner with Eco-Friendly Combined Thermoelectric-Evaporative Cooling for Crane Operator Cabins in Thermally Intensive Industrial Workshops

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The scientific work presents the concept of an autonomous air conditioner for crane operator cabins in heat-stressed industrial workshops, which uses combined thermoelectric-evaporative cooling. The system is based on thermoelectric Peltier modules and evaporative cooling using ultrasonic humidifiers, which allows for effective temperature reduction without freons or other environmentally harmful refrigerants. Theoretical studies of thermal loads in crane cabins in metallurgical workshops have been conducted [1; 2]. The development complies with the principles of "green" technologies, reducing the carbon footprint and energy consumption [3].

The air conditioner concept includes a two-stage cooling system. At the first stage, water is cooled using thermoelectric Peltier modules and evaporated by ultrasonic humidifiers (adiabatic cooling), creating cold, humid air. In the second stage, the air passes through the next chamber and is further cooled through a radiator that contacts the cold side of the thermoelements.

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Monitoring and Visualization of Renewable Energy Facilities in Ukraine Using Remote Sensing and GIS Technologies

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Renewable energy sources (RES) are the key to Ukraine's energy security and independence, and they should contribute to building up the country's energy potential and security in the post-war period.

Remote sensing and GIS can be used as modern tools for visualization and monitoring of renewable energy facilities. Among GIS technologies, both free and licensed resources can be used for such activities. To visualize objects, an accessible, and simple and free resource My Maps rom Google is used [1]. It allows you to put point and line objects on the map using predefined coordinates or addresses, as well as add the necessary information and images to the objects.

Another popular resource is the ArcGIS Online service from ESRI. ArcGIS Online contains thousands of maps, applications, and datasets from authoritative and commercial sources and makes them available to users, ready to use through ArcGIS Living Atlas of the World. With ArcGIS Living Atlas, you can search for the content you need to visualize remote sensing imagery on maps, analyze images, and overlay imagery data with other spatial information. The datasets available for use include Landsat, Sentinel-2, MODIS and other image archives. This service allows you to not only view archived satellite images in ArcGIS Living Atlas, but also visualize and analyze them in various ways. Image analysis can be used for research on objects of natural and anthropogenic origin that demonstrate quantitative changes over time. This also applies to renewable energy facilities. For this purpose, ArcGIS Online allows comparing detailed satellite images in the World Image Wayback application [2].

With the help of such approaches, it is possible not only to compare the construction process, but also the process of damage to certain objects that can be recorded using satellite images.

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Restoration of Indigenous Steppe Natural Habitats

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Within the framework of the project of the European Union's LIFE program "Conservation of Natural Heritage for Life in Ukraine − CoNaturLIFE Ukraine", initiated by the Czech Nature Conservation Agency, a component of restoration of indigenous steppe natural habitats (biotopes) is being implemented jointly with the Ministry of Environmental Protection and Natural Resources of Ukraine, in particular on the territory of the "Buzky Gard" National Nature Park.

One of the values of the "Buzky Gard" NPP is steppe areas and petrophyte complexes - places of concentration of rare species of flora and fauna. This applies to the habitats of EUNIS Annex I of Resolution 4 of the Bern Convention from group E (Grasslands and lands dominated by forbs, mosses or lichens): E1.11 Euro-Siberian rock debris swards, E1.22 R4-Arid subcontinental steppic grassland, E1.23 R4-Meso-xerophile subcontinental meadow-steppes [1].

At the same time, in the steppe areas, in conditions of a sharp decrease in pasture load over the past decades, there has been an active growth of shrubs. Such an invasion of shrubs into grassy groups in European countries is considered one of the most powerful factors of their degradation and requires the introduction of special measures [2]. Regulated grazing, mowing, physical or chemical methods of destroying shrubs and trees to preserve or restore meadow and steppe vegetation are used in other European countries, mainly in the territories of the NTURA2000 network [3]. The project proposes the restoration of steppe, meadow, wetland and other anthropogenically modified natural landscapes, the creation and restoration of hayfields and pastures, and the implementation of measures to restore indigenous natural complexes in protected areas.

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Monitoring of Mine Waste Dumps for Toxicity

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Mine spoil heaps — engineered mounds of barren rock remaining after coal extraction — undergo weathering, moisture exposure, and spontaneous combustion to generate acid drainage that mobilizes toxins and heavy metals into soils and waters (iron concentrations in mine waters have been recorded at 10–15 times permissible limits) [1; 2]. In the case of the Samarska spoil heap, aqueous extract pH ranged from 3.5 to 7.8, total soluble salt content reached 0.36–1.01 % (predominantly sulfate, chloride, and carbonate salts of Na and Mg), and spontaneous combustion released CO, SO_2, and carcinogenic PAHs [3]. These processes exacerbate soil erosion, increase groundwater mineralization, and diminish soil fertility, underscoring the urgent need for systematic monitoring using advanced analytical methods and for the implementation of reclamation measures to mitigate ecological risks.

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Access to Water During Armed conflicts: Environmental and Humanitarian challenges

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The issue of access to freshwater represents one of the most acute environmental and humanitarian threats of the 21st century. Amid rising population pressures, climate change, and ecosystem degradation, water increasingly becomes a source of interstate disputes. While such conflicts are often latent, in regions facing severe water scarcity—such as the Middle East, North Africa, and Central Asia—tensions frequently escalate into open confrontation [1; 2]. During armed conflicts, water supply systems acquire the status of critical infrastructure, essential for the survival of the civilian population. In the context of armed conflicts, water may be weaponized in various ways:

1. Tactical applications
2. Geopolitical leverage
3. Socio-humanitarian impacts

In contemporary warfare, water is increasingly employed either as a strategic instrument or targeted directly. Such actions disproportionately affect civilian populations and constitute violations of international humanitarian law [3]. Sustainable Development Goal 6 (SDG 6) seeks to ensure universal access to safe and affordable drinking water, enhance water use efficiency, and protect aquatic ecosystems. However, the outbreak of armed conflicts significantly impedes or entirely prevents progress toward achieving SDG 6. The achievement of Sustainable Development Goal 6 is only possible under conditions of peace, justice, and respect for human rights.

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Integration of Waste Recycling Technologies into Urban Sustainable Development Strategies

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Within the framework of the European Green Deal and the United Nations Sustainable Development Goals (SDGs), waste recycling is recognized as a key instrument for achieving climate neutrality, improving resource efficiency, and promoting the transition to a circular economy in urban settings [1].

The implementation of innovative recycling technologies facilitates the creation of closed material loops, reduces environmental pollution, and strengthens local economies. This issue is especially relevant to the achievement of the Sustainable Development Goals (SDGs), notably Goal 11 *«Sustainable Cities and Communities*» and Goal 12 «*Responsible Consumption and Production»*.

Sustainable urban development depends on the implementation of effective and integrated waste management systems. Modern recycling technologies not only help to reduce landfill volumes and greenhouse gas emissions but also support energy recovery and promote more efficient use of resources.

In light of the continuous increase in municipal waste generation and the limitations of traditional linear systems, integrating modern recycling solutions – supported by robust policy frameworks, digital technologies, and active public engagement – provides cities with a viable pathway toward circular models of resource management [1, 2].

The integration of recycling technologies into urban sustainable development strategies contributes to the reduction of anthropogenic environmental pressures, the advancement of the circular economy, the creation of green jobs, the improvement of urban resource management, and the strengthening of cross-sectoral cooperation through investment and digital transformation.

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Energy-Efficient Materials and Structures in Modern Architecture

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In the context of European integration and Ukraine's recovery, energy efficiency in the construction sector has become particularly relevant and requires the implementation of European standards. The development of energy efficient building practices is crucial for reducing energy dependency and achieving climate goals. Designing energy-efficient architecture requires an integrated approach that combines in-depth knowledge of the properties of modern building materials with the potential for their application in innovative structural solutions.

The educational and methodological manual «Energy-Efficient Materials and Structures in Modern Architecture» [1] developed by the Departments of Architectural Structures and Building Materials at KNUCA, is an example of such an interdisciplinary approach. The manual consists of three chapters: the philosophy of green building and the circular economy; glass materials and structures, with a focus on reducing embodied energy and recycling; and wood-based materials and structures, including wood processing by-products, with an overview of technologies to improve quality and energy efficiency. Glass and wood have been selected as key materials due to their natural properties, high energy saving potential and low environmental impact, making them essential for the development of energy efficient and ecological architectural solutions.

The integration of knowledge of modern building materials and their structural capabilities is fundamental to the creation of energy efficient and environmentally responsible architecture. Educational and methodological developments that consolidate this knowledge are essential tools for the training of professionals and the dissemination of best practices in the building sector. Further research is planned in the areas of energy efficiency and environmental safety of polymers, concrete, ceramics and metals, which will broaden the range of innovative materials available for green architecture.

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Digitization Improve ESG and Energy Efficiency

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ESG (environmental, social, governance) not only helps to increase enterprise value, but also helps to protect stakeholders' interests and reduce corruption and environmental pollution. Research shows that digitization enables companies increase governance (G) scores and further increase social (S) scores, but it doesn't improve companies' environmental (E) scores [1].

However, there is a way to improve environmental scores through a combination of digitalization and energy efficiency. Digitalisation offers the potential to increase energy efficiency through technologies that gather and analyse data before using it to make changes to the physical environment either automatically, or through human intervention. Data gathering technologies such as sensors and smart meters collect data on energy use and other conditions affecting energy use, like climate.

Data are processed into useful information through data analysis technologies such as artificial intelligence algorithms. Finally, the processed information is sent to devices that can effect physical changes to optimise energy use. Digital technologies are already widely used in all energy end-use sectors. More and more residential and commercial buildings are equipped with smart appliances and intelligent energy management systems [2]. This represents an increase in energy efficiency as traditionally defined: A reduction in energy used per unit of activity.

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Forecasting of PV Energy Production Using Machine Learning Methods

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The study presents a concept for short-term forecasting of electricity production from photovoltaic (PV) installations using meteorological data and machine learning methods. The analysis is based on real measurement data and focuses on the potential use of forecasts in managing energy consumption in households. A comparative approach was applied to selected predictive methods, and their effectiveness in increasing energy self-consumption was evaluated. Example applications of forecasts in the daily operation of prosumer installations are also presented. The findings may serve as a foundation for further development of solutions aimed at optimizing the use of renewable energy in decentralized systems. Effective short-term forecasting of PV energy production plays a key role in optimizing self-consumption in home systems operating under the net-billing model. This paper presents a comprehensive analysis of a real PV installation located in Poland. The predictive models were based solely on meteorological data (such as solar irradiance, air temperature, relative humidity, wind speed, and precipitation) and measured energy production values. Two approaches were used in the study: classical linear regression as a baseline model, and XGBoost as an advanced machine learning method. The paper includes a detailed description of the models' performance, a comparison based on a selected data sample, and an analysis of energy management strategies based on forecasts. Opportunities for shifting energy consumption in time were identified to align with periods of peak PV production, enabling a significant increase in self-consumption even without energy storage [1−3]. The study emphasizes the importance of integrating accurate PV forecasts with home energy management systems and represents a significant contribution to the development of intelligent solutions supporting decentralized prosumer energy systems.

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Integration of Artificial Intelligence and MCDM Methods in the Evaluation of Renewable Energy Systems in a Hybrid and Critical Perspective

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This article presents a modern view of decision support for the renewable energy sector by integrating Multi-Criteria Decision-Making (MCDM) methods and Artificial Intelligence (AI). Certain hybrid models are presented, e.g., AHP with machine learning, TOPSIS with fuzzy logic and deep learning, and VIKOR with neural networks. The use of metaheuristic algorithms (such as Genetic Algorithm, Particle Swarm Optimization, and Ant Colony Optimization) for weight and parameter optimization of MCDM methods is also elaborated. The integration of AI and MCDM enhances the flexibility, dynamics, and uncertainty tolerance in the solution analysis of intricate energy systems [1-3].

Despite their wide application, MCDM methods have several limitations. They often rely on subjective weighting of criteria, which affects the reliability of results. Moreover, most classical MCDM techniques are not well-suited to dynamic environments or the analysis of large datasets. They also lack adaptability and the ability to learn automatically. The inclusion of AI algorithms helps overcome these limitations by enhancing decision accuracy and enabling automation. This study highlights the potential of combining AI and MCDM to support the development of sustainable, intelligent systems driving the energy transition.

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European Green Deal

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The European Green Deal was presented on 11 December 2019 in the European Parliament by the President of the European Commission [1].
This course is set out in the form of a roadmap of measures designed to transform the European Union's economy into a sustainable and competitive economy. The objective of the European Green Deal is to develop and help implement changes in the EU Member States that will help Europe become a climate-neutral continent by 2050 [2].
The implementation of the course's objective is achieved by stimulating the development of a circular economy, improving people's health and quality of life, and transforming climate and environmental challenges. The European Green Deal is a strategic document that defines the European Union's policy for the coming years and covers all sectors of the economy in relation to climate change, agricultural and industrial policy, energy, trade, and biodiversity [3].
The main vectors of the European Green Deal are clean energy, sustainable production, climate action, sustainable mobility, sustainable agricultural policy, pollution reduction, and biodiversity. Thus, the European Green Deal is currently a crucial strategic document and a comprehensive means of practical achievement of the European climate neutrality goals.

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Electric Discharge Iron Tungstate as a Catalyst for Wastewater Purification from Azo-Dyes

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Freshwater shortage is currently a major problem for economic growth and development. Chemicals entering natural water bodies initiate carcinogenic, teratogenic, and mutagenic toxic effects. The Fenton reaction is an advanced oxidation process and uses iron ions and hydrogen peroxide in an acidic environment to decompose organic compounds. In the heterogeneous Fenton process, the catalyst that has penetrated the solid surface does not dissolve in the liquid being treated. This prevents iron ions from leaching out of the heterogeneous catalyst. The main advantage of this method is that the iron-based catalyst can be easily separated from the solution using a magnetic field for further reuse.
In this work, iron tungstate obtained by the electric discharge dispersion method was used as a catalyst for the Fenton process, and an experiment was conducted on the degradation of organic dyes in its presence. Data were obtained on the change in the relative concentration of methyl orange in an aqueous solution in the presence of iron tungstate obtained by the electric discharge dispersion method (Fig. 1).

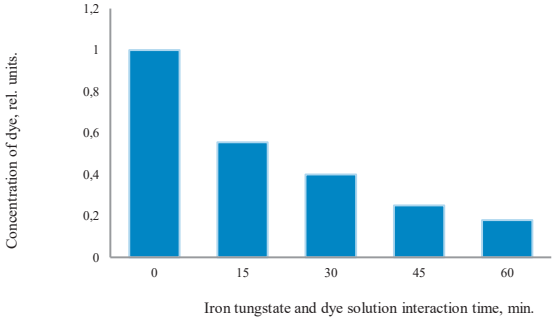

Fig. 1. Interaction of methyl orange solution with electrodischarge iron tungstate.

After only 60 minutes, 82% of the dye was degraded, indicating that a greater number of –N=N– bonds in the methyl orange molecule were destroyed. It is important to note that the degradation of methyl orange occurred without any external stimulating effects (e.g., light, elevated temperature, electric and acoustic fields), and an efficiency of 82% was achieved in 60 minutes. Thus, the iron tungstate obtained by the electric discharge dispersion method can be considered as a potential catalyst for the process of wastewater purification from azo-dyes by the heterogeneous Fenton reactions.

Current Status and Prospects for the Use of Biomass of Phytoenergy Crops to Ensure the Energy Security of Ukraine

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It is projected that by the middle of the 21st century, alternative energy will supply nearly half of all energy resources, with biomass accounting for more than 20%. If biomass is cultivated on underutilized or unused agricultural land, this share could increase to 25% for Ukraine. The use of biomass from sorghum and aster family crops as fuel represents a significant step toward the country's energy independence, which is especially relevant in the current context. Moreover, the combustion of biomass or the use of its processed products (such as alcohol or biogas) is entirely environmentally friendly. Given the consequences of the russian federation's military aggression, the prospects for the biofuel and bioenergy equipment market are expected to grow, along with the chances for successful implementation of alternative energy sources [1].

Currently, sweet (fodder) sorghum is mainly cultivated for silage and green forage. Including the grain yield, ethanol output per hectare significantly increases and can reach 7,000 liters or more per year. Additionally, sweet sorghum is better suited for mechanization of cultivation and seed reproduction processes.

Another aspect of addressing the competition between food and bioenergy production is that, unlike cereal crops, Jerusalem artichoke grows successfully on low-yielding and marginal lands, which are increasingly viewed as a valuable reserve for expanding the area under energy crops [2].

Therefore, an important strategy to enhance Ukraine's energy security – especially in rural areas – is the development of local energy systems based on the use of biomass from phytotechnical energy crops as an alternative energy source.

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Recent Advances in the Green Synthesis of Nanoparticles: Properties and Applications

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Nanotechnologies have found application in different areas, like sensorics, catalysis, electronics, and medicine, due to their unique physical and chemical properties. Developed surfaces, high reactivity, surface modification, and plasmonic properties allowed the design of nanomaterials with advanced properties for various purposes. Therefore, researchers intensively study and develop new, trustable protocols for synthesizing nanoparticles with controlled morphology. Green methods, using reagents with biological origins, became the object of special attention.

In this report, a review of recent advances in the preparation of metal and carbon nanoparticles using green methods will be presented. Thus, non-spherical gold nanoparticles prepared with leaf extracts of peppermint [1] and fruit extracts of juniper [2] have shown intensive absorbance in the near-infrared region. Together with biocompatibility, they belong to promising materials for use in nanomedicine (for example, photothermia). Silver nanoparticles prepared with fruit extracts of elderberry [3] were successfully utilized for the preparation of gold hollow nanoparticles with strong absorbance at 808 nm. This makes them prospective for further studies as part of the target drug delivery systems. Carbon dots, both Gd^{3+}-free and Gd^{3+}-doped, synthesized via the solvothermal method using urea, citric acid, and 3-(trifluoromethyl)aniline as precursors, were found to be non-cytotoxic [4]. This discovery suggests their potential application in biomedicine for magnetic resonance imaging and red fluorescence-based cell and tissue imaging.

Acknowledgment. The study is supported by project VEGA 1/0836/25 “Irregularly shaped noble metal nanoparticles for photothermal and sensing applications”.

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Erasmus+ International Credit Mobility KA171*:* Opportunities for Partner Countries

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This report shares our experience and presents some of the opportunities available within the Erasmus+ International Credit Mobility KA171 Program. Traditionally, the Erasmus+ programs supported mobility of graduate and PhD students, university teachers and staff between the countries of the European Union (EU). The new program covers the countries outside the EU. Students of all levels of study (bachelor's, master's, and PhD students) can take the opportunity to study individual subjects or complete a training internship abroad. Teaching and administrative staff of higher education institutions can also participate in activities to improve their professional level abroad through teaching, training, or hybrid (both teaching and training) mobility.

During 2019–2025, the Department of Ecology of the Faculty of Humanities and Natural Sciences at the University of Presov (Presov, Slovakia) conducted several successful mobility projects with Ukraine and Tunisia. The Ukrainian partner was the Department of Analytical Chemistry of the Faculty of Chemistry of Taras Shevchenko Kyiv National University (Kyiv, Ukraine), and a mobility project was implemented within the framework of the Erasmus+ Regional Cooperation KA171. The Tunisian partner was the Department of Chemistry in the Faculty of Science at the University of Monastir (Monastir, Tunisia).

What do partner universities need to do to become a member of the Erasmus+ program? First, you need a partner from an EU country. Only EU partners can apply for mobility projects once a year (usually in February). Second, you need a good idea for a mobility project. In their funding request, partners must clearly outline the benefits of this project's implementation for students, teachers, and staff at both partner universities. So, for example, planning the preparation of original educational materials (textbooks, methodical instructions, work plans for new subjects, etc.) will increase the quality of the project.

Acknowledgment. Authors are grateful to the Erasmus+ International Credit Mobility KA171 Program for the mobility grants between cooperating universities, the University of Presov, Slovakia, and the University of Monastir, Tunisia.

Evaluation of the Antimicrobial Properties of Phytosynthesized Metal Nanoparticles

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Nanomaterials are increasingly significant in various aspects of human life each year. Despite the clear advantages of nanotechnologies, their production often generates waste that can harm the environment. Green synthesis offers a promising alternative to conventional methods by using non-toxic, often natural compounds, resulting in non-toxic waste. Using plant extracts to synthesize nanoparticles satisfies green synthesis principles, employing natural substances as reducing and stabilizing agents.

Nanoparticles in nanocolloid solutions are stabilized by chemical compounds, which influence their interactions with living cells not only due to the material of the nanoparticles but also through the characteristics of their organic surroundings.

Silver and gold nanoparticles with irregular morphology were prepared using leaf extracts of peppermint (*Mentha Piperita*) [1] and fruit extracts of elderberry (*Sambucus Nigra* L.) [2]. Silver nanoparticles are found promising for the synthesis of hollow gold nanoparticles. Triangular and hexagonal gold nanoparticles with strong absorbance in the near-infrared region are considered to be promising for application as photothermal agents. Therefore, the studies of biocompatibility of green synthesized nanoparticles are the next key question which needs to be answered.

This report presents the study of the microbial growth of selected strains, *Pseudomonas putida* USM4, *Brevundimonas vesicularis* USM1, and *Pseudarthrobacter oxydans* USM2, in the presence of peppermint (*Mentha Piperita*) extract-mediated silver and gold nanoparticles.

Acknowledgment. The study is supported by the project APVV SK-PL-23-0032 “Microbial response to phytosynthesized metal nanoparticles”.

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Autoclaved Lightweight Artificial Aggregates from Bottom Sediment and Other Mineral Waste

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The research concerns the production of lightweight artificial aggregate from bottom sediments (BS), concrete dust (CD) and municipal solid waste incineration fly ash (FA) in the autoclaving process. A mixture of mineral waste in the proportion BS:CD:FA = 0.4:0.4:0.2 was mixed, granulated, dried and autoclaved at a temperature of 180°C and for 1 h. CaO in the amount of 6% by weight was added to the mixture The binder during granulation was water. The largest grains did not exceed 11.2 mm. Spherical agglomerates with a grain size of 5.6-8.0 mm dominated. The share of the <1 mm fraction was at the level of 14.3%. The aggregate grains were regular and were therefore classified as spherical according to BS EN 933-4:2008. Aggregate with the following parameters was obtained: 1.74±0.05 g/cm^3 (grain density); 1.02±0.03 g/cm^3 (bulk density), 33.6±2.03% (total porosity), 0.684±0.23 MPa (compressive strength) and 9.63±1.92% (water absorption). The obtained material can be classified as lightweight aggregate in accordance with BS EN 13055-1. According to the Franus guidelines [3], it can be used in lightweight non-structural concretes, lightweight mortars, geotechnics, horticulture, landscaping and thermal and acoustic insulation (Fig. 1).

Fig. 1. Lightweight artificial aggregate produced in autoclaving process.

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Reservoir Dynamics and Overregulation in the Southern Buh River Basin: Regional Analysis and Challenges

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In the course of the study, the volume of reservoirs in the Southern Buh River basin was studied; the ratio of the areas of the water mirror of the reservoirs of the river basin by region is determined; the dynamics of the capacity of the reservoirs of the Southern Buh River basin over a certain period, as well as the dynamics of the capacity of the reservoirs of the Southern Buh River within the Mykolaiv region, are evaluated; the density of reservoirs along the river bed is analyzed.

It is determined that the largest useful volume of reservoirs falls in the Mykolaiv region (34%) (Fig. 1). It is shown that the largest area of the water mirror is located in the Vinnytsia region (31%), and the smallest – is in the Kyiv and Odesa regions (2%). It is shown that the largest increase in the volume of reservoirs falls in the period of the 60s of the twentieth century. It is determined that the average density of artificial reservoirs is about one reservoir for every 10 km of the river, which indicates the critical overregulation of the river. A significant level of river regulation, along with several advantages, has environmental challenges, especially in the context of current climate change issues.

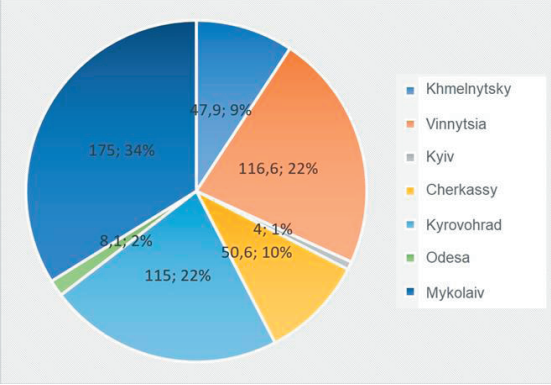

Fig. 1. Volume of reservoirs (million cubic meters /%) of the Southern Buh River basin region.

These issues require further research in the direction of studying the optimality of the volume of reservoirs because of maintaining the river's ability to self-regulate processes, preserving the unique hydroecosystems of the river, which should be taken into account in managing water resources.

Assessing Climate Change through Atmospheric Temperature Dynamics

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Atmospheric air temperature has been chosen as an integrated climate indicator, as it depends on geographical latitude, which determines the level of solar radiation, the characteristics of the underlying surface, and the specifics of atmospheric circulation. The latter is largely influenced by the proximity of the Black Sea. The temperature regime of the air is also affected by climate change, i.e., long-term trends in temperature variations caused by both natural and anthropogenic factors, including urbanization, industrial emissions, and land use changes.

The aim of this study is to analyze the dynamics of atmospheric air temperature as one of the key indicators of climate change and to identify the main factors influencing the state of water resources, using the example of Mykolaiv city and Mykolaiv region.

Between 1991 and 2024, the average annual temperature in the Mykolaiv region increased by 1.2°C, which is three times higher than the global warming rate. The highest recorded temperature was in 1998 (+40.1°C), while the lowest was in 2006 (−25.9°C). Recent years (2023–2024) have been the warmest in the entire observation period. The most significant temperature fluctuations occur during the summer months, with the average maximum temperature in August reaching +29.6°C, and the number of hot days steadily increasing each year. The data indicate a consistent rise in the number of days with temperatures exceeding +25°C over the analyzed period, which may be a consequence of global warming and climate change.

However, in certain years, the number of hot days may deviate from the trend due to natural climate variability and the influence of other climatic factors. Overall, the graph demonstrates a clear upward trend in the number of hot days, which serves as an important indicator of climate change in the region.

Implementation of European Environmental Legislation in the Field of Climate Change in the Mykolaiv Oblast Territory

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On June 18, 2021, the Supervisory Board of the European Union's international technical assistance project "Strengthening the Capacity of Regional and Local Authorities to Implement and Apply EU Legislation in the Fields of Environmental Protection, Climate Change Mitigation, and Infrastructure Development" (hereinafter referred to as the APENA 3 Project) selected Mykolaiv Oblast as a pilot region for implementing the main objectives and tasks of the APENA3 Project aimed at developing a climate change adaptation strategy for the oblast and an implementation plan for climate change adaptation. Mykolaiv Oblast is characterized as water-scarce and located in a zone of risky agriculture. During the military actions, Mykolaiv Oblast suffered destruction, and large areas were contaminated with explosive remnants, which also impact the environmental condition. A major challenge in 2023 was the destruction of the Kakhovka Hydroelectric Power Plant by Russian forces, which caused flooding of part of Mykolaiv Oblast within the Lower Dnipro River basin, as well as flooding and contamination of significant areas in Kherson Oblast. The indirect impact of this man-made disaster includes a reduction in the water surface area, which may affect regional precipitation levels.

On February 22, 2024, the Mykolaiv Regional Military Administration received the draft Climate Change Adaptation Strategy for Mykolaiv Oblast, developed within the framework of the APENA 3 Project, for review and comment. The draft Strategy consists of 5 sections: Section 1 – "Strategy Goals"; Section 2 – "Parameters of the Natural and Anthropogenic Environment"; Section 3 – "Climate Change Analysis Based on Scenarios Until the End of the 21st Century"; Section 4 – "Vulnerability and Risk Assessment for Sectors and Territories"; Section 5 – "Resilience Measures and Adaptation Costs". In Section 4, APENA 3 Project experts assessed the sensitivity of economic sectors or territories to all 32 climate impact factors. A risk assessment was carried out for sixteen economic sectors using a scale from 0 to 20 points for two time periods: the near future (2021–2040) and mid-century (2041–2060).

On August 12, 2024, the Ministry of Environmental Protection and Natural Resources of Ukraine—the beneficiary of the Project—published the Climate Change Adaptation Strategy for Mykolaiv Oblast on its official website, and on September 13, 2024, the finalized draft of the strategy was officially submitted to the Mykolaiv Regional Military Administration for approval in accordance with current Ukrainian legislation.

Currently, specialists of the Regional Military Administration are developing a draft Operational Plan of Measures for the 2026–2028 period to implement the Climate Change Adaptation Strategy for Mykolaiv Oblast for the period until 2033.

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Improving the Accuracy of Grinding Rotational Bodies as a Strategic Direction in the Development of the Mechanical Engineering Industry

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Grinding of rotational bodies is a key process in the production of high-precision components for the aerospace, automotive, energy, and medical industries [1; 2]. Improving machining accuracy ensures stable quality, cost-effectiveness, and environmental sustainability of production [3; 4].

Key factors affecting accuracy: geometry and wear of the grinding wheel; thermal deformations of the workpiece and tool [3]; vibrations, equipment setup accuracy, and choice of coolant/lubricant; material properties [2]; use of adaptive control systems [4].

Main ways to improve accuracy: innovative abrasives (CBN, diamond wheels) [3]; real-time automated process control [4]; adaptive technologies and machine learning [5]; optimization of the axis-crossing angle; temperature stabilization; digital twins and monitoring systems [3; 4].

Strategic guidelines: integrated digital control systems; eco-friendly lubricants and waste reduction [5]; modern education and training of specialists; energy-efficient technological solutions [4]; use of advanced materials to minimize deformations [2].

Conclusions. Improving the accuracy of grinding is a critical factor in the innovative development of machine building. The integration of automation, adaptive control, and digital technologies will enhance product quality, reduce production costs, and support environmentally sustainable manufacturing [1; 3; 4].

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Educational Course «European Green Dimensions» in Preparation of Ecologists

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One of the key challenges in modern education is shaping its content. Defining the theoretical foundations of an integrated approach holds scientific significance (by specifying its distinct features), social significance (by modernizing specialist training), and applied significance (by ensuring continuity between educational objectives and students' field of study). The study aims to develop an effective didactic system for interdisciplinary knowledge in natural science courses within environmental education, with a particular focus on professional orientation.

An educational experiment implementing the integrated approach demonstrated its effectiveness in enhancing students' knowledge quality. The research involved university students specializing in environmental sciences. A functional didactic system for interdisciplinary knowledge in natural science courses was developed. The study identified the levels, objectives, and key aspects of the integrated approach in environmental education. The integrated approach to education serves as a unique framework for designing educational content, revealing interdisciplinary connections while coordinating, unifying, and systematizing knowledge about fundamental natural science theories, key categories, and principles of the modern scientific worldview. The study confirmed the didactic effectiveness of the integrated approach in shaping the content of natural science courses. Future research should focus on refining the theory and practice of integrated natural science education based on the developed conceptual framework, as well as enhancing methodologies for assessing students' knowledge quality in integrated courses.

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Higher Education in the Context of Digitalization, Implementation of Sustainable Development Principles

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A questionnaire was proposed for the study, the purpose of which was: exploring the opinions of educational process participants on the current state of higher education in the context of digitalization, implementation of sustainable development principles, graduates' knowledge level, and labor market needs.

The survey reveals that lecturers constitute the majority of respondents, followed by students. Most lecturers have significant experience in higher education, with the largest group having 11−20 years of tenure. A strong majority of lecturers perceive a decline in the general knowledge level of students over the past years. Respondents generally assess the level of digitalization in their universities as medium. A majority believe that digital technologies are only partially utilized in the educational process. The prevailing view is that sustainable development principles are integrated partially, mainly within specific disciplines. A significant portion of respondents assess graduates' readiness for labor market demands as medium. Critical thinking and communication skills are considered the most necessary for graduates today. The lack of practical training and the misalignment of curricula with labor market needs are seen as the main challenges of modern higher education.

The main result of the survey is a clear indication of a perceived gap between the current state of higher education and the evolving needs of students and the labor market, particularly concerning the practical application of knowledge, alignment of curricula with job demands, and the comprehensive integration of digitalization and sustainable development principles, despite a general support for greater digital integration.

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Resource Potential of Demolition Waste by Main and Associated Components

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Mykolaiv region is a region that has suffered significant destruction due to hostilities and other destructive factors. As a result, the amount of waste generated because of the destruction of infrastructure, residential buildings, industrial facilities, etc. is increasing.
To assess the resource potential of waste, minimum tariffs for the cost of waste components as secondary raw materials were determined. Calculations of the total cost of waste components were made for the following communities: Bashtanka. Novyi Buh, Mykolaiv, Pervomaisk, Shyroke, Pryvilne, Snihurivka, and Shevchenkove.
The total cost of waste is about 25 billion UAH or about 600 thousand EUR. Based on the data obtained, a diagram of the main components of demolition waste in UAH equivalent is presented (Fig. 1).

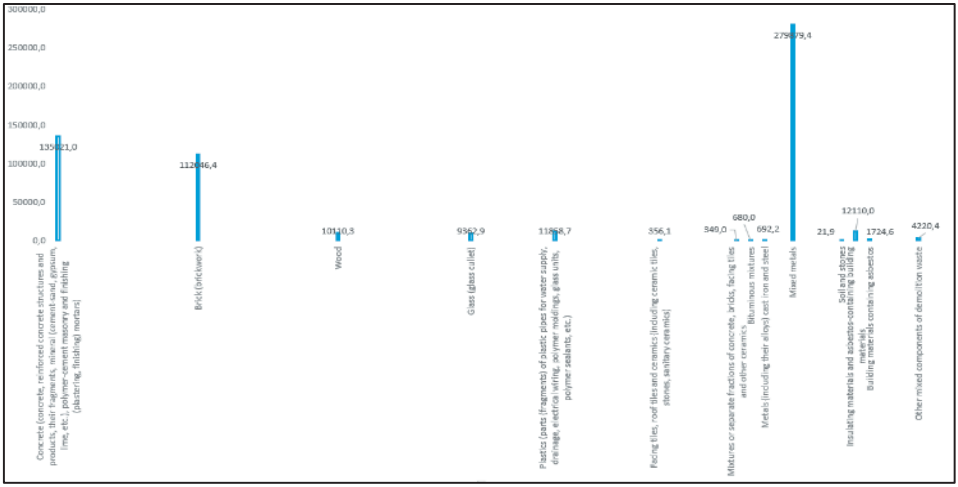

Fig 1. Waste components in communities (EUR).

Assessment of the resource potential of waste from destruction allows us to estimate the profit from waste after its processing or reuse. In addition, its processing, in turn, will reduce the burden on the environment, due to the reduction of landfill areas for their storage.

Acknowledgment. *We would great thank the Kyiv School of Economics for collaboration during the Project implementation.*

Strategy of Regional Dairy Subcomplex Development in the Context of European Integration

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The development of the dairy industry based on the concept of sustainable development is important in the context of deepening European economic integration. A set of steps to adhere to sustainable development approaches is a prerequisite for achieving competitive advantages not only in the EU common market, but also in the global dairy market, which is characterized by positive dynamics of consumption growth.

Dairy production standards are constantly increasing and concern not only economic, but increasingly social and environmental components. The issues of the dairy subcomplex development are studied in detail in the articles M. Ilchuk, O. Kozak, M. Kozak [1], T. Bozhydarnik [2], O. Petrychenko [3], M. Khorunzhyi, T. Kapas [4] and other scientists.

Modern trends in the development of the dairy industry allow enterprises of the Lviv region to effectively compete in the European market, taking into account the logistical advantages of access to the EU market. In Lviv region, the leading producers of dairy products are LLC «Dairy Company «Halychyna», LLC «Dairy Plant «Sambirsky», LLC «Komarno Cheese Plant», LLC «Mukko», PrJSC «Lvivskyi Kholodokombinat», LLC «Nabil», as well as numerous manufacturers of craft products. The listed enterprises provide the main volumes of milk processing in the Lviv region and they are interested in implementing sustainable development practices. Sustainable development involves not only investments in the technological and technical component of modernization of dairy processing enterprises to reduce the carbon footprint, water purification and energy efficiency of production from renewable sources. Change in business philosophy and compliance management in implementing and adhering to ESG practices are important in order to maintain the long-term competitive advantages of the Lviv region dairy industry under the global transformational challenges. According to the authors, a strategy for innovative restructuring of production in the regional dairy industry using green finance as a multi-sectoral area of technological and economic development based on adherence to the principles of sustainable development will ensure high competitiveness of dairy products in Europe and reduce environmental impact.

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Rebuilding of "Green" and Circular Systems of Agro-Industrial Markets in Ukraine

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The “green” revival of Ukraine involves the formation of circular market systems to ensure the secondary processing of materials in their sectors. The system of agro-industrial markets (hereinafter referred to as AIM) is transformed into a circular recovery system provided that segments of waste utilization and processing, as well as material reuse, function within each of its sectors. The presence of these segments complicates the structure of market systems due to the emergence of new direct and feedback relationships between entities, the reverse movement of processed materials, waste reuse, etc.

During the war, problems in the field of waste management were exacerbated due to the destruction of infrastructure and security threats. Direct losses in the field of waste management amounted to 95.36 million USD, the estimated cost of removing construction waste and rubble was 320.7 million USD, and losses of waste disposal enterprises were 11.9 million USD [1]. At the same time, international practices indicate the possibility of reducing such losses by obtaining benefits for the reuse of certain war waste.

Rebuilding of circular AIM systems involves the introduction of "green" production technologies on an innovative basis, in particular, precision farming practices, the use of crop rotation, the processing of agricultural and food waste, and the development of markets for organic goods. Also, the "green" revival of AIM systems should take into account climate risks in order to reduce vulnerability and increase the resilience of all key sectors and natural components to climate change. Rebuilding "green" AIM and their integration into international "green" value chains, taking into account national interests, will allow increasing the "green" added value created in the country and realizing the external resilience potential of AIM systems in Ukraine.

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Waste Disposal in Ukraine as a Component of Environmental Safety

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The problem of household waste disposal has always faced humanity. It became especially acute with the beginning of the rapid and large-scale development of industrial production, when, in addition to household waste, industrial waste began to be generated.
Today, the world continues to over consume natural resources, leading to their depletion. In addition, constantly growing production causes the accumulation of a large amount of waste that requires recycling and disposal. Every second, 3.8 kg of food waste is generated in the world.
In Ukraine, in 2022, various types of waste were generated in the amount of 203587.6 thousand tons [1]. Of the 40 thousand tons of plastic in Ukraine, only 6% is recycled. In European countries, the recycling rate reaches 70%.
Modern recycling technologies must meet the criteria of environmental friendliness, cost-effectiveness, and have a promising supply of raw materials for recycling technologies in terms of sales of recycled components from waste.

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Innovative Wastewater Treatment Solutions for Craft Breweries

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Craft brewing has become an important part of the local economy in many regions. However, the expansion of this industry is accompanied by a significant environmental challenge − the treatment of wastewater. Given the limited resources of small-scale breweries and strict environmental regulations, special attention must be paid to effective and economically viable wastewater treatment technologies.

Wastewater from craft breweries is characterized by high concentrations of organic matter, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and nutrients such as nitrogen and phosphorus. For every liter of beer produced, between 3 to 10 liters of wastewater are generated, often with contamination levels several times higher than domestic sewage [1]. Consider innovative methods of wastewater treatment. Microbial Fuel Cells (MFC). This innovative technology enables simultaneous wastewater treatment and electricity generation. Laboratory experiments demonstrated over 93% COD removal from craft brewery effluent using MFC systems [2]. Constructed wetlands represent an eco-friendly and energy-efficient solution, especially suitable for small or rural breweries. These systems have demonstrated up to 97% removal of BOD and COD [3]. Green Wall Biofiltration Systems. This novel approach combines plant-based filtration with microbial biofilms. Green wall systems achieved up to 78% BOD reduction and are adaptable for urban settings or as pre-treatment before discharge into municipal sewers [4].

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The Great Meadow as a Green Frontier of Climate-Neutral Europe

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After the destruction of the Kakhovka Hydroelectric Power Plant in 2023, Ukraine faced a large-scale man-made disaster that unexpectedly led to the emergence of a unique ecological phenomenon − the beginning of the revival of one of Europe's most magnificent natural landscapes: the Great Meadow (Velykyi Luh). On the former reservoir bed, new ecosystems are forming naturally, including fast-growing willow forests that are already demonstrating high biological productivity, resilience to climate fluctuations, and the ability to sequester carbon.

At present, this territory has become the largest forested area in southern Ukraine formed without human intervention [1]. According to our observations, as of 2024, more than 60 species of vascular plants have been recorded here. Young phytocoenosis shows active development dynamics, biodiversity, and the ability to perform phytoremediation functions by purifying soils from pollutants [2].

These newly formed ecosystems align with the key principles of the European Green Deal, particularly the goal of achieving climate neutrality by 2050 and the implementation of the "New EU Forest Strategy for 2030." They have significant potential for reducing greenhouse gas emissions, stabilizing the local climate, and supporting biodiversity.

In contrast, plans to restore the Kakhovka Hydroelectric Plant by re-flooding the area contradicts the principles of sustainable development and climate responsibility. Such an action would destroy ecosystems that have already proven their value as natural "carbon pumps" and eliminate opportunities for scientific research, ecological tourism, and the establishment of a world-class nature reserve.

Thus, the Great Meadow in its new form is not only a national natural heritage that has been given a second life but also an eastern green frontier that can become a symbol of Ukraine's participation in a climate-neutral future for Europe.

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The European Green Deal in the Context of Achieving Climate Neutrality

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According to the European Climate Law adopted in 2021, the legally binding target is to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels (Regulation (EU) 2021/1119). In 2022, greenhouse gas emissions in the EU decreased by 32.5% compared to 1990, indicating progress, but also highlighting the need to strengthen climate policies (EEA, 2023).
The EU's energy sector shows a steady trend towards increasing the share of renewable sources. In 2022, 22.5% of the EU's gross final energy consumption came from renewables.

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Accumulation of Radionuclides by Aquatic Plants in Water Bodies in the Vicinity of the South Ukrainian NPP

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Aquatic vegetation reacts very sensitively to the radionuclide composition of the water bodies in which it grows. This quality is often used to indicate the degree of radioactive contamination of the aquatic environment [1; 2]. Sometimes, during long-term radioecological monitoring of a particular water system, if there is an operational need to assess the existing radioecological situation in the controlling water body, data on the content of radioactive substances in algae and parameters of correlation relations between concentrations of radionuclides in water components: in water, in bottom sediments, in fish and algae are used [2]. The intensity of radionuclide accumulation by algae (*Cladophora fracta*) growing in the Arbuzynka, Mertvovid, and Pivdennyi Buh rivers was studied to assess its quality for indicating the level of radioactive contamination of the aquatic environment. The content of dose-producing radionuclides (90Sr, 137 Cs, 3H) in algae was measured and the dynamics of activity of these radionuclides in the hydrobionts of these rivers was assessed during the long-term intake of "stationary" radionuclides. It was established that the dynamics of radionuclide activity in filamentous algae of the surveyed water bodies clearly corresponded to the radiation situation in these water bodies, and the termination of discharge of industrial and domestic sewage from the Pivdenna NPP to the Arbuzynka and Mertvovid Rivers in 1993 significantly reduced the concentration of radionuclides in the aquatic organisms of these rivers. Over the past eight years, the radiation situation in the water bodies naturally and technologically connected with the South Ukrainian NPP has significantly improved.

The established dynamics of annual changes in the activity of these radionuclides in hydrobionts makes it possible to assess the extent and nature of the radiation impact of the South Ukrainian NPP on the adjacent water system over its thirty-year operation period.

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Assessment of Climate Change Effects on River Landscapes in the Ukrainian Carpathians Using GIS

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The river landscapes of the Carpathians are complex and sensitive ecosystems that play a vital role in maintaining biodiversity, water balance, and mountain ecosystem resilience. Climate change—manifested through rising temperatures, uneven precipitation, and more frequent extreme hydrometeorological events—has a significant impact on the morphology of river systems and surrounding landscapes. This study aims to assess the impact of climate change on the river landscapes of the Carpathians using Geographic Information Systems (GIS) and to develop adaptation strategies for their conservation. The research integrates satellite imagery (Sentinel, Landsat), digital elevation models, and climate data under RCP 4.5 and 8.5 scenarios. Analytical tools included QGIS, NASA Giovanni, Google Earth Engine, and ArcGIS Online. The methodology involved multi-layer mapping, spatial change detection, and geostatistical analysis. Findings reveal that climate-induced changes have caused localized transformations in river landscapes, particularly in the foothill areas where valley expansion is observed. Vulnerable zones were identified that require priority ecological management. GIS-based modeling allowed the creation of degradation risk maps and the justification of adaptation measures. Recommended strategies include establishing riparian buffer zones with native vegetation, restoring channel-floodplain systems, limiting land use in high-risk areas, and implementing systematic GIS-based monitoring. The study demonstrates the effectiveness of GIS technologies in assessing climate change impacts and supports their application in regional adaptation planning and environmentally sustainable spatial development.

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Analysis of the Dynamics of Atmospheric Air Temperature in Mykolaiv

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Analyzing the dynamics of air temperature allows us to identify trends and assess the extent of climate change over a certain period. This approach is important for the development of adaptation climate policy at the regional level.

The aim of the study is to determine the peculiarities and trends in the temperature regime of atmospheric air in the city of Mykolaiv based on the analysis of long-term meteorological observations.

To achieve this goal, we collected and processed data on the average daily, minimum and maximum temperatures, as well as the average daily amplitude of air temperatures for the period from 1980 to 2024. Seasonal and annual temperature fluctuations are analyzed. The research used data on air temperature in Mykolaiv for the period 1980-2024 from open sources, including weather archives of online resources and Ventusky's online weather map.

The results of the analysis show a steady trend of rising temperatures throughout the study period in Mykolaiv, which may indicate climate change (Fig. 1).

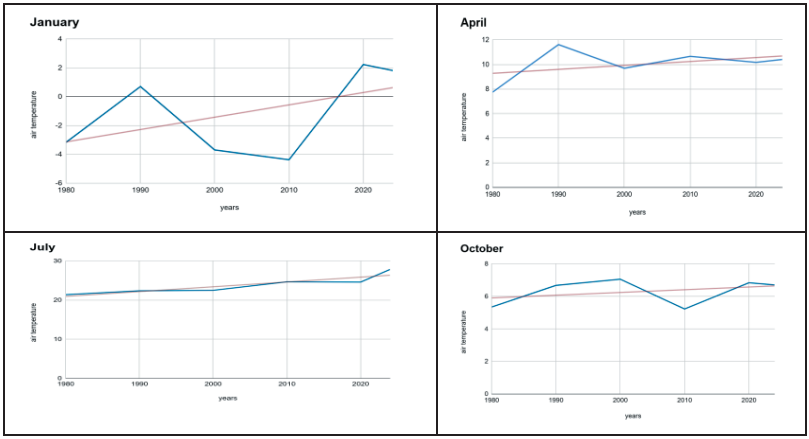

Fig. 1. Average temperature dynamics.

Assessment of Environmental Risks Associated with Meat Processing during Wartime Conditions

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The war in Ukraine has severely disrupted agricultural and food industries, creating significant environmental risks. Meat processing, as a key part of national food security, faces growing challenges related to biological waste management, chemical pollution, and water contamination. This paper analyzes the main environmental risks, assessment methods, and strategies for sustainable waste management in wartime conditions.

Wartime conditions have placed unprecedented pressure on Ukraine's agricultural sector, disrupting supply chains, damaging critical infrastructure, and complicating waste treatment operations. Meat processing facilities, in particular, must now operate under circumstances where environmental risks are greatly amplified.

One of the most immediate concerns is biological contamination caused by the improper disposal of organic waste. In conflict-affected areas, damaged infrastructure and disrupted waste collection services increase the risk of disease spread through uncontrolled decomposition [2]. Simultaneously, chemical pollution from the excessive use of disinfectants and inadequate wastewater treatment has escalated, particularly where military activity has destroyed treatment plants [3]. Furthermore, water contamination remains a critical concern. As reported by environmental monitoring groups, untreated meat processing effluents and damaged sewage systems contribute significantly to the degradation of local water bodies [1].

To effectively assess these growing risks, rapid environmental damage assessments are being employed, utilizing field sampling, satellite data, and predictive modeling [1]. Predictive modeling of contamination spread, particularly in areas lacking functioning infrastructure, helps authorities prioritize emergency responses.

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3D Printed Ultrafiltration Membranes: Preparation from Polylactic Acid and Practical Application

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3D printing allows one the production of membranes of any shape and size according to consumer requirements. The work solves the problem of studying the separation properties of filtration membranes, which, unlike the known ones, were obtained via one stage. Polylactic acid (polylactide, PLA) and its mixture with a pore former - sucrose served as the ink for the 3D printer. The fused deposition modelling technique was used for printing. The samples were investigated with SEM, AFM and FTIR methods, dzeta potential was also measured, porosity was determined with a technique of nitrogen adsorption-desorption. The membranes included three layers (namely this structure provides their mechanical duarbility), and each layer consisted of parallel strips, the width of which was determined by the diameter of the extruder nozzle (0.4 mm). The pores that provide filtration can be located at the joints of the strips. The membranes almost completely retain bovine serum albumin (BSA) macromolecules. The pore size is estimated to be 6-17 nm, in other words, the membranes show ultrafiltration properties. The membranes were used to concentrate polyphenols from an extract of orange peels and to recovery cationic and anionic dyes (methylene blue and reactive black 5, respectively) from aqueous solutions. It was found that the highest selectivity of the membranes is realized at a pressure of 0.5 (polyphenols, 90-98%), 1.5 (anionic dye, 90-96%) and 2.5 bar (cationic dye, 63-87%). Filtration leads to decolorization of weakly colored solutions. It was found that the membrane obtained from a mixture of PLA and a pore former is characterized by higher productivity, selectivity, and resistance against organic contaminants than a membrane made of pure polymer. It is assumed that the difference between the behaviour of the membranes is due to the peculiarities of the thermal destruction of PLA during printing, which occurs at 210^{o} C. The membrane obtained from the PLA-sucrose mixture evidently contains higher amount of surface carboxyl groups, which provide higher hydrophilicity. The mechanism of rejection is sieving (colloidal particles) and Donnan exclusion (low-molecular organic compounds).

Adsorption Treatment of Wastewater for the Removal of Dissolved Uranium(VI) Compounds

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Since nuclear power stations require considerable amount of uranium fuel, the actual problems are mining and processing of uranium-containing ores as well as the treatment of wastewater, which is formed during uranium recovery from the minerals (they are mined in Dnipropetrovs'k and Kirovograd regions). The necessity of the purification of mine waters and wastewater of mineral processing from water-soluble uranium (VI) compounds is approved at the legislative level. To prevent entering contaminated wastewater to the environment, adsorption is widely used – it is a common method for the recovery of U(VI) compounds. We performed a series of systematic studies with modeling chloride, nitrate, sulphate and carbonate solutions to ascertain the physicochemical regularities of U(VI) adsorption. The researches were focused on the solutions, which simulate wastewaters of uranium mining and processing. A number of adsorption nanomaterials have been proposed: polymer-inorganic ion exchange resins containing zirconium hydrophosphate and hydrated zirconium dioxide, composites of these inorganic compounds with graphene-like carbon materials, cellulose-based magnetic adsorbents, hydrated titanium dioxide modified with potassium cobalt hexacyanoferrate (II), silica modified with ZrO_2, polymer and polymer-inorganic fibrous ion exchangers containing hydrated tin dioxide. All these nanomaterials were tested both under batch and dynamic conditions, the optimal conditions of adsorption (solution pH, adsorbent dosage, contact time, temperature etc.) were established. Under these conditions, the removal degree of U(VI) reached 99.5-99.8%, the residual amount did not exceed the maximal allowable concentration. For instance, the main benefits of polymer-inorganic ion exchangers are their high capacity and multiple usage (at least 10 cycles of adsorption-desorption). Low dosage of zirconium-silica nanocomposites (0.4 g dm^{-3}) is necessary to decrease the U(VI) concentration down to the required level. Fibrous adsorbents demonstrate fast adsorption – the equilibrium state is achieved in 1−15 min. The composites based on inorganic compounds remove U(VI) compounds in a wide range of pH. All adsorbents are effective in the diapason of U(VI) concentration of 1−100 mg dm^{-3}.

Formation of the Foundations of Environmental Awareness: the History of Education for Sustainable Development in the Works of Global Scholars

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Responsible behavior among the population is one of the key factors in achieving the Sustainable Development Goals (SDGs), particularly SDG 4 – "Quality Education," which emphasizes the formation of sustainable consumption patterns and attitudes toward nature through education. Environmental education is recognized as a powerful means of cultivating environmental awareness and culture by fostering a conscious understanding of the interconnections within the "human – society – nature" system.

The topic of environmental education has garnered the attention of numerous scholars who have contributed to shaping its theoretical foundations, methodological frameworks, and practical applications. Among the most influential thinkers is David Orr, who advocates for the integration of environmental values into educational systems [1]. Stephen Sterling calls for a paradigmatic shift toward holistic and integrative learning in response to ecological crises [2]. Harold R. Hungerford and Trudie L. Volk focus on empirically grounded methods for promoting environmentally responsible behavior [3]. Daniela Tilbury emphasizes the strategic role of education in sustainable development and the importance of active public engagement in addressing environmental challenges [4].

In conclusion, contemporary research highlights the urgent need to reorient educational systems toward ecological responsibility. This includes adopting interdisciplinary approaches and enhancing public involvement in environmental education as essential steps toward achieving a sustainable future.

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Physico-Chemical Justification of Methods for Purifying Air from Gaseous Toxic Substances and Requirements for Catalysts for Respiratory Purposes

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The most common toxic gases are SO_2, H_2S, HF, P_2O_5, NO_x, NH_3, SiF_4 (1); PH_3, AsH_3, NO, CO, O_3 (2), which we classified according to acid-base (1) and redox properties (2). It follows that air purification from the listed substances can be implemented only through a series of sequential stages, namely, trapping of aerodispersed particles; chemisorption absorption of substances classified in group (1); catalytic neutralization of PH_3, AsH_3, CO, SO_2 and O_3 in the presence of catalysts fixed on various carriers, which can be metal complex compounds, as well as metal and metal oxide nanocatalysts. The intensive use of catalysis to solve environmental problems has contributed to the formation of a new scientific direction "Environmental Catalysis", within which theoretical and practical issues of developing effective catalysts for protecting the environment and humans are being addressed. The implementation of this aspect of environmental catalysis is associated with the design of highly effective catalysts for personal respiratory protective equipment (PPE) (gas masks, respirators, autonomous purified air supply systems) that ensure safe and comfortable working conditions. The analysis shows that the range of catalysts for PPE is very limited, which is due not only to the reluctance of companies to invest in the development of new catalysts, but also to specific requirements for such catalysts: ensuring stable air purification from toxic gaseous substances to the MPC and below with constantly changing inlet characteristics of the air flow; high catalyst activity with optimal contact time with the purified gas (no more than 0.04 s in a lightweight respirator); simple, cheap and environmentally friendly catalyst preparation technology; catalyst manufacturability in the design of respiratory protective equipment, i.e. being well adaptable to different geometric shapes; small weight and low aerodynamic drag; compliance with sanitary, chemical and toxicological requirements for PPE. The specified range of requirements for catalysts for environmental purposes, and especially for those used in life support systems, poses a number of complex tasks for us: development of highly efficient low-temperature catalysts; design of easily replaceable catalytic devices; implementation of comprehensive technical measures, including large-scale testing of products at relevant enterprises.

About the Impact of Climate Change on Birds

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The impact of climate change on bird species or populations is manifested as follows:
- shifting the timing of spring arrival to earlier dates [3; 4];
- shifting the timing of autumn departure to later dates [3; 4];
- shifting the boundaries of the nesting area in the direction of its expansion or contraction [5; 6; 7];
- shifting the boundaries of the winter range in the direction of its expansion [2];
- creating favorable conditions for wintering of individual individuals of species that did not winter before [2], etc.

During the 21st century, in the south of Ukraine, nesting Greater Flamingo (*Phoenicopterus roseus*), Cattle Egret (*Bubulcus ibis*), Spanish Sparrow (*Passer hispaniolensis*) [1; 5; 6], etc.

In the coming decades, we should expect an increased impact of climatic factors on the species composition, habitat status, biology, ecology, and changes in nesting and wintering areas and migration routes of birds in Ukraine.

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Research of the Irrigation and Soil Cultivation Impact on the Biodiversity of Soil Microorganisms at to Grow Corn in the Forest-Steppe of Ukraine

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Intensive agricultural technologies threaten the integrity of soil structure as an ecological habitat for microorganisms [1].

Our research was aimed at studying the patterns of irrigation and various agrotechnical methods (plowing, disking) influence on the number of the main ecologically functional groups of microorganisms in the rhizosphere of corn in the conditions of the Cherkasy region. It was found that the largest number of ammonifying microorganisms that provide the destruction of nitrogen-containing soil compounds developed in no-till plot (97.8 million CFU/1 g of completely dry soil). Populations of pedotrophic microorganisms that use water-soluble fractions of soil organic and inorganic substances for physiological processes were also more numerous in these plots. This is probably related to low content of organic nutrients, which is the trophic specificity [2].

The number of amylolytics, phosphate mobilizers and nitrogen fixers members of the ecological-trophic groups also decreased in the plots where plowing and disking were carried out. However, the number of oligotrophic microflora in these variants increased, which indicates an insufficient nutrients amount in the arable soil layer, since members of these microorganisms prefer depleted soils. The highest number of cellulolytic microorganisms was found in the variants where irrigation and soil cultivation were carried out (15.3 and 12.9 million CFU/1 g of completely dry soil). These microorganisms were likely sensitive to soil moisture.

Thus, it is necessary to develop and implement effective technologies that minimize the impact of modern agricultural technologies on soil microbial biodiversity taking into consideration the different sensitivity of ecological-trophic microorganisms groups.

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The Most Important Natural and Anthropogenic Factors of Climate Change in Ukraine and The Planet

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Climate change on planet Earth and the associated threatening changes in the biosphere have become an unchanging reality. Most environmental scientists identify two main factors for these changes: natural and anthropogenic. Today, two anthropogenic factors are the main sources of a sharp increase in temperature over the territory of Ukraine:
a) uncontrolled mass deforestation, destruction of forest belts, deciduous forests and grass cover on the slopes of gullies, streams and small rivers;
b) continuous plowing of the land.
These two factors are also the main cause of the disappearance of small rivers and the cause of the general dehydration of the ukrainian territory. In the future, this is the path to another catastrophe – a shortage of drinking water in Ukraine.
The disappearance of forest belts and microforests in the steppe zone will lead to the resumption of dust storms, which will destroy millions of tons of black soil over several years. These phenomena are catastrophic, and they are related to issues of state security. It is urgently necessary to adopt a long-term state program for large-scale afforestation of massive territories of the country to prevent such a scenario.
Afforestation of the steppe and forest-steppe must take place according to new principles, taking into account climate change, the problem of river drainage, and taking into account new knowledge in forestry and landscape science, and new needs of humanity. The implementation of the nationwide afforestation program must be carried out by state institutions, and the condition of forest plantations should be strictly controlled by the state's specialized service together with representatives of the active environmental public.
The rapid, large-scale implementation of this program will delay the dehydration of Ukraine for many years, reduce the dynamics of temperature increases in the territory of the state and preserve the invaluable gift of nature – Ukrainian black soils. All this will enable the people of Ukraine to live in relatively comfortable environmental conditions and maintain economic prospects for many more decades.

Biotechnology for Water Purification of Small Rivers

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Active industrial activity has led to significant vulnerability of the majority of ecosystems in Ukraine's rivers.

To effectively treat surface waters, in particular, the waters of small rivers, it is necessary to create additional bioengineering hydraulic structures. The intensification of polluted water treatment is based on the use of floating elements such as «rafts» and other additional devices placed on the dams of small rivers. The fibrous carrier «VIA» is attached to the devices, which increases the ability to biologically remediate water through the rapidly growing and tightly immobilised biomass of microorganisms – destructors of organic water pollution – and higher forms of aquatic organisms, which are trophically retained between the fibres of the «VIA».

This biotechnology makes it possible to treat any wastewater with a high concentration of pollutants to drinking water with specified parameters. This biotechnology should be used at all exclusively wastewater treatment plants (new, reconstructed) to reduce the load on the city's water bodies due to pollution by wastewater, as well as on natural and artificial water bodies. The proposed biotechnology has been successfully used at the wastewater treatment facilities of Motor Sich JSC since 2014 and is still in use today. According to the results of the implementation of this biotechnology at the local treatment facilities of the Motor Sich JSC motor-building plant in 2017, the efficiency of stormwater treatment from oil products was at the level of 85%, and the concentration of oil products decreased by 19 times compared to traditional methods.

Radioactivity Monitoring of Selected Plant Fruits During Tree Year Period

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According to the proponents of Slovakian nuclear powers in Jaslovske Bohunice and Mochovce, the risk of an accident in a reactor or during transport of spent fuel is not high, but consequences from such an accident may be devastating. In regard to a food market it is very important to determine the radioactivity values of small fruits to domestic and foreign customers. The aim of contribution is radioactivity determination of selected plant fruits, which are collected and cultivated in Slovakia. The gamma-spectrometric of the plant raw material by the HPGe detector with using of Cesium radionuclide (Table 1) was carried out at the State Health Institute, Department of Health protection against the Radioactivity, in Banska Bystrica, the Middle Slovakia.

Table 1 − The fruits of cultivate plants and their radioactivity [Bq.kg^{-1}].

	Radio-nuclide	Bio-mass	2019	2020	2021
Black Chokeberry *Aronia melanocarpa*	^{137}Cs	fresh	≤ 0.06	≤ 0.06	≤ 0.05
		dry	≤ 0.31	≤ 0.30	≤ 0.27
Elderberry *Sambucus nigra*		fresh	≤ 0.05	≤ 0.06	≤ 0.06
		dry	≤ 0.25	≤ 0.30	≤ 0.32
Highbush Blueberry *Vaccinium corymbosum*		fresh	≤ 0.07	≤ 0.06	≤ 0.07
		dry	≤ 0.52	≤ 0.45	≤ 0.50
Grape Vine *Vitis vinifera*		fresh	≤ 0.07	≤ 0.06	≤ 0.07
		dry	≤ 0.27	≤ 0.21	≤ 0.25

The regulation on the highest permissible radioactivity in food was notified in the EU in 2001. The highest levels of food radioactivity after a nuclear crash are presented in Table 2.

Table 2 − The highest permissible of food radioactivity [Bq.kg^{-1}]after a nuclear breakdown in Slovakia.

Radio-nuclides	Baby food	Milk products	Basic foodstuffs	Liquid food
^{134}Cs & ^{137}Cs	400	1,000	1,250	1,000

Conservation of Self-Seeded Forests as a Component of the European Green Deal Implementation in Ukraine

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The conservation of self-seeded forests in Ukraine, which emerge through natural regeneration of woody vegetation on abandoned lands, particularly former agricultural areas, represents a strategically important ecological priority. It aligns with the core principles of the European Green Deal and supports the integration of national conservation practices into the broader European sustainable development framework.

As a key element of decarbonization, spontaneous forests demonstrate superior carbon sequestration capacity, often exceeding that of artificial plantations (Lakyda et al., 2024). They contribute to biodiversity conservation by forming resilient phytocoenoses of native species adapted to local conditions. Acting as natural reserves and ecological corridors within fragmented landscapes, they correspond to the goals of the EU Biodiversity Strategy for 2030. These ecosystems also promote sustainable rural development and circular economy principles through ecosystem services and forest management (Stoiko et al., 2024).

To enhance the potential of self-seeded forests, their conservation should be integrated into regional climate adaptation strategies and community development plans. Key actions include forest inventory, assessment of carbon sequestration potential, regulatory development, and community involvement. This approach fosters synergy among ecological, economic, and social goals – crucial for the successful implementation of the European Green Deal in Ukraine.

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Investigation of Biologically Active Compounds in Berries of the Carpathians and the Black Sea Region as a Tool for Environmental Education

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Flavonoids are plant-based compounds with powerful antioxidant and anti-inflammatory properties, often linked to cardiovascular and cancer prevention. Rich sources include berries such as blackberry, raspberry, and blackcurrant. This study compares flavonoid content in berries from two Ukrainian regions: the Carpathians (Mount Khomyak) and the Mykolaiv region (Black Sea area).
To qualitatively assess flavonoids in berries collected in 2023 from both regions.
Carpathian berries had higher water content (e.g., raspberry: 86.5%), while Mykolaiv berries showed stronger pigmentation and more intense flavonoid reactions. Raspberry and blackcurrant displayed red-brown hues (high cyanidin), and blackberry extracts had a pink tint (suggesting quercetin). Ammonia tests confirmed flavonoid presence.
Regional conditions significantly affect berry composition. Mykolaiv berries may have a higher flavonoid concentration, while Carpathian berries offer a balanced profile. These findings support the use of such research in biology education, promoting environmental awareness and healthy living.

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Intelligent Systems for Monitoring the Atmospheric Air Quality in Ukraine

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In the context of escalating environmental threats, the issue of intelligent air quality control has become critically significant. The most urbanized centers of Ukraine (Kyiv, Kharkiv, Dnipro, etc.) face high pollution levels due to intensive traffic and industrial emissions. Integrating modern smart monitoring systems not only allows for the detection of pollution levels but also enables forecasting of its dynamics, thereby contributing to the protection of public health.

Automated monitoring stations equipped with high-precision sensors and artificial intelligence algorithms can analyze air composition in real-time. The application of laser spectrometry, gas analyzers, and big data technologies allows for the identification of primary pollution sources and the development of strategies for their mitigation. These solutions provide environmental agencies with access to more comprehensive data, facilitating effective decision-making.

The implementation of artificial intelligence in air quality forecasting opens new possibilities for managing environmental processes. Machine learning enables the identification of long-term pollution trends and the modeling of scenarios for reducing harmful substance concentrations. This fosters the development of intelligent environmental strategies that account for urban growth dynamics and societal needs.

Improving air monitoring systems requires active participation from governmental institutions, scientific organizations, and the public. Open access to environmental data and the involvement of citizens in monitoring efforts contribute to the formation of ecological responsibility. Collaborative efforts in implementing innovative solutions will ensure the sustainable development of urban environments and improve the quality of life for Ukraine's residents.

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Achievements and Challenges in the Application of Nanoparticles for Water Treatment

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Water pollution represents a major global environmental issue, necessitating the development of highly efficient purification technologies. Nanoparticles, owing to their exceptional chemical properties such as large specific surface area, catalytic efficiency, and adjustable reactivity, are emerging as powerful agents for advanced water treatment [1]. Recent advancements emphasize the adoption of green chemistry strategies in the synthesis of nanoparticles, aligning with the principles of sustainable development. Current research prioritizes the selective removal of heavy metal ions, persistent organic pollutants, and pathogenic microorganisms, leveraging the unique surface chemistry and catalytic potential of nanoparticles.

This study aims to review and critically assess the research achievements of the past decade, as well as to explore perspective for the future application of nanoparticles synthesized via plant extracts in water purification. Special emphasis is placed on the removal of heavy metal ions and organic pollutants.

Data extracted from the Scopus database indicates a substantial surge in research activity concerning the green synthesis of nanoparticles, with the number of experimental publications increasing dramatically from 5 to 605 between 2010 and 2024.

Four main types of nanoparticles have been developed, namely: metal nanoparticles, magnetic nanoparticles, semiconductor nanoparticles, and metal chalcogenides. Nanoparticles can effectively remove synthetic dyes and heavy metal ions, however, their environmental implications, particularly concerning aquatic ecosystems, remain inadequately understood and warrant further investigation. The incorporation of phytochemicals into nanoparticle synthesis offers considerable advantages, including improved control over particle morphology and size. Mechanisms for pollutant removal include reduction, photocatalysis, adsorption, precipitation, complexation, and ion exchange, influenced by pH and functional groups.

Thus, further research is needed on the role of plant biomolecules in the synthesis of nanoparticles and impact of nanoparticles on the environment.

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Adsorptive Removal of Paracetamol Using Activated Carbon

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Pharmaceuticals are extensively produced and often enter the environment through wastewater and improper disposal. Their accumulation in aquatic ecosystems adversely affects aquatic organisms and poses a risk to human health [1]. Various methods for removing pharmaceuticals from water include biological degradation, chemical oxidation, membrane technologies, and adsorption. Among these methods, adsorption is considered the most effective approach due to its high efficiency in contaminant removal; however, it requires highly efficient adsorbents.

The aim of this work is to experimentally determine the effect of adsorbent dosage and pH on the efficiency of adsorption removal of paracetamol (PRC) from aqueous solution using activated carbon (BAU-A).

Adsorption experiments were conducted under the following conditions: a contact time of 1 hour, an initial PRC concentration of 100 mg/L, and a temperature of 30 °C. Different adsorbent dosages, ranging from 0.5 to 4.0 g/L, were tested at pH 5.0. The PRC removal efficiency increased with increasing adsorbent dosage, which is attributed to the greater availability of active sites on the adsorbent surface. However, beyond an adsorbent dosage of 2.0 g/L, the increase in PRC removal efficiency became negligible. It is known that pH can affect the ionization of the weak electrolyte (pK_a (PRC)=9.38) and the charges on the adsorbent surface. In this work, the PRC removal efficiency was investigated over a pH range of 2.0 to 9.0 at an adsorbent dosage of 0.1 g/L. It was observed that the PRC removal efficiency varied between 72.3 and 75.8% across the studied pH range. This suggests that pH has little influence on the adsorption process, which is typically observed in systems where adsorption is independent of surface charge or the ionization state of the adsorbate [2].

The results of this study demonstrate that BAU-A is an effective adsorbent for the removal of paracetamol from water, thereby contributing to the mitigation of environmental problems associated with pharmaceutical contamination.

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Prospects of Using Chlorine-Containing Reagents for Water Disinfection

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One of the conditions for the social well-being of the population is the supply of good quality drinking water that is safe in epidemiological terms.
Chlorine-containing reagents are the most effective chemicals for water disinfection due to the post-effect, which guarantees bacterial safety of treated water for a sufficiently long time. The most commonly used disinfectant in Ukraine is chlorine or its compounds: chlorine dioxide, sodium hypochlorite, calcium hypochlorite, bleach, chloramines.
Currently, the regulatory framework in the field of industrial safety is being improved, tightening the requirements for the conditions of production, storage, transportation and use of gaseous chlorine. Technical highly concentrated sodium hypochlorite solution with an active chlorine content of 14-18 % is less dangerous. The safest and lowest-toxic for humans and easier to use chlorine-containing reagent is recognized as low-concentrated sodium hypochlorite, obtained directly at the place of consumption by passing an electric current through a solution of table salt.
From the viewpoint of ensuring epidemic safety of water engineering systems, all chlorine-containing reagents are almost equally reliable and effective. The advantages of using one or another reagent should be sought not in their “super bactericidal” effect, but in production safety, manufacturability, formation of by-products and their impact on the environment, on the treated water and public health, as well as cost-effectiveness.
The trend towards the massive use of sodium hypochlorite instead of chlorine has led to increased competitiveness of the proposed developments and the expansion of the circle of specialists and enterprises involved in this technology.
It has been established that in the production of electrolytic sodium hypochlorite, the main factors affecting the formation of active chlorine in the electrolyte are chloride concentration, duration of non-flow electrolysis or electrolyte consumption in the flow mode, chemical composition of the salt solution used. The most effective ways to reduce the rate of cathode precipitation formation are a reversal of electric current and decarbonization of water used for the preparation of salt solutions.

Environmentally Safe Chemical Technologies of Ukraine

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Environmentally safe chemical technologies in Ukraine are becoming increasingly important in the context of the global transition to sustainable development and the implementation of the European Green Deal. These technologies are aimed at minimizing the use and generation of hazardous substances, reducing energy consumption and using renewable resources.

The principles of green chemistry, formulated by Paul Anastas and John Warner, include preventing waste generation, maximizing atom economy, developing less hazardous chemical syntheses, creating safer chemicals and products, using safer solvents and reaction conditions, increasing energy efficiency, using renewable raw materials, avoiding chemical derivatives, using catalysts instead of stoichiometric reagents, developing chemicals and products for decomposition after use, real-time analysis to prevent pollution and minimize the likelihood of accidents [1; 5].

Various initiatives are being implemented in Ukraine to develop environmentally safe chemical technologies. In particular, the international GreenChem program, implemented with the support of UNIDO and Yale University, promotes the introduction of green alternatives to persistent organic pollutants, mercury and microplastics at industrial enterprises in Ukraine.

Ukraine also carries out activities aimed at increasing the awareness and competence of specialists in the field of green chemistry. For example, a course on green chemistry has been introduced at Taras Shevchenko National University of Kyiv, which promotes the training of specialists familiar with the principles of environmentally friendly chemical technologies [2; 6].

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Using Artificial Intelligence Tools in Ecology

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Today, humanity is facing large-scale environmental challenges: climate change, biodiversity loss, air and water pollution, land degradation. Traditional monitoring and analysis methods are often costly, slow, and inefficient. In such conditions, artificial intelligence (AI) tools are gaining particular relevance as an innovative approach to solving environmental problems.

AI is already being actively implemented in the following areas: environmental monitoring (processing data from satellites, drones, cameras, and sensors in real time); climate modeling (forecasting changes in temperature, sea level, and the frequency of natural phenomena); pollution analysis (identifying sources of air and water pollution using machine learning); biodiversity protection (recognizing species from images, studying animal populations and migrations) [1].

Using AI tools to track greenhouse gas emissions, manage resources, and assess environmental risks allows large companies to make data-driven decisions that minimize their environmental footprint. By providing real-time information on factors such as air and water quality, energy consumption, and carbon dioxide emissions, AI tools enable companies in various industries to address environmental issues and support a sustainable future [2].

In the future, AI tools will become an integral part of sustainable environmental development. It is expected that AI will be increasingly integrated into management decisions, the creation of smart cities, and global monitoring of climate change and biodiversity. It is also important to introduce AI into environmental education and training.

The use of artificial intelligence in ecology is not just a promising direction, but a necessary condition for an effective response to modern challenges.

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Methods of Processing Food Industry Waste

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The concept of Zero-waste in food technology is becoming a basic and necessary principle for the development of European society in the context of growing environmental awareness. It promotes innovation, stimulates the economy, creates awareness among consumers and helps ensure sustainable development. Modern food consumption and production are one of the main sources of environmental pollution and the generation of large amounts of waste. Therefore, producers and consumers must work together to find innovative approaches to reduce waste and conserve resources [1].

An interdisciplinary approach to reducing food waste is necessary to meet the global and national goals of reducing food waste by 50% by 2030. Modern researchers ventures to aggregate the latest research and technology in food science to extract valued components from food waste across the food chain [2]. Today, the following common methods of recycling food industry waste can be distinguished:

- animal feed (fruit and vegetable processing waste);
- composting of natural microbiological processes (fruit and vegetable waste, gelatin are used);
- filtration and hydration (apple and pear pomace is used in the production of baked goods and pharmaceuticals);
- fermentation (sugar and corn starch are used for decomposing plastics);
- incineration (fruit pits, leaves, nuts, shells are used as fuel);
- soil improvement (increasing soil fertility);
- production of biodiesel.

The most important of the environmental protection measures is the development of specific programs and actions that allow for the minimization of the negative impact of this industry on natural ecological processes. The global direction of environmental protection activities is the strict implementation of the requirements of scientific organization of production, the introduction of new technological developments.

The application of the Zero-waste concept in food technology is not only an effective method of reducing waste, but also a key element of sustainable development and environmental protection.

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Enviromental Impact and Flows of Waste Batteries in China

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This paper analyzes the environmental impact of waste batteries. This study uses a quantitative analysis method, combined with China's battery production, sales, and import and export data (2014-2023) from the United Nations Commodity Trade Database and the China Battery Association report [1]. The Weibull life distribution model is used to estimate China's waste battery generation, and the calculation method is also based on the average life and recycling rate of batteries [2]. China's battery imports are generally on a downward trend, while exports are on an upward trend, especially for lithium batteries (including primary batteries and lithium-ion rechargeable batteries). With the continuous increase in battery production, the number of batteries on the Chinese market has increased in the past 10 years, although some types of batteries have decreased due to replacement by other batteries. According to our calculations, waste lithium batteries and lead-acid batteries are the main contributors to the growth of waste battery production, accounting for 99% of China's approximately 10.5 million tons of waste battery production. Further research prospects are to introduce more variables to improve the waste battery generation prediction model through dynamic model optimization.

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New Ukrainian Green Construction Standards

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This year is significant for Ukraine and the World's green construction. Two new standards are prepared and delivered for public discussion: SOU OEM 08.002.41.032:20XX "System for environmental certification and ecolabelling according to DSTU ISO 14024:2018 (ISO 14024:2018, IDT). Public buildings. Environmental criteria and method for life cycle assessment" [1] and DSTU XXXX-20XX "Environmental protection. Green structures. Method of testing thermotechnical and gas exchange characteristics of vegetation layers" [2]. SOU OEM 08.002.41.032:20XX is aimed at voluntary rating the life cycle of public buildings at the stages of planning, designing, construction and commissioning of a construction object. One of the unique requirements is the integration of green structures, indoor and outdoor greening, into the building project to solve technical, environmental, social and economic tasks. Other unique statements are based on the experience of the russian-Ukrainian war: quick deactivation possibility for informative means for accessibility of construction objects and uninterruptible life support in case of broken outdoor supply systems. DSTU XXXX-20XX has no World analogues. It accumulates more than 10 years of Ukrainian experience in unique research of the positive effects of vegetation layers on green structures – the thermal insulation, cooling effect, and instant CO_2-O_2 gas exchange. A new reduced photometric value – phytolux (phlx) – is introduced, weighted by the typical spectrum of photosynthetic activity, achieving correspondence with lux under the solar spectrum. The standards have the potential for international implementation.

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Water Reservoir Pollution Control System

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For effective study and analysis of the state of the environment, and making appropriate decisions regarding its improvement, adequate information is necessary, which is associated with a huge number of measurements of various parameters carried out using automatic, constantly operating analyzers.

Water pollution leads to the death of flora and fauna of water bodies. Water resources are one of the most important and, at the same time, the most vulnerable components of the environment, which can change very quickly under the influence of human economic activity. When conducting analysis more than 3-4 times a day, it is economically feasible to use automatic systems for monitoring the state of the environment. In these systems, the cost of information is 2-6 times lower than when using laboratory methods.

The control of natural water bodies is complicated by the presence in them of hydrophysical fields of temperature, electrical conductivity, salinity, density, pressure and flow velocity, the parameters of which constantly change both with depth and in the horizontal plane and have a pronounced stochastic nature. Therefore, solving problems in the field of ecology, hydrophysics (hydrochemistry, hydrobiology, etc.) requires higher accuracy of the controlled parameters in the designed control means. Considering that the studied water-dispersed systems belong to rapidly changing thermodynamic systems, it is necessary that the measuring control system perceives quantitative measuring information directly from the control object in real time without prior transformation of the analyzed sample.

The proposed system for monitoring water resources pollution via radio channel consists of a computing center that collects, processes and analyzes measurement and diagnostic information received via radio channel from a network of automatic radio buoys. Each radio buoy automatically determines the integral indicator of water pollution and transmits measurement results via radio channel from the studied location of the water body (hydrological section) to the computing center for collecting, accumulating and processing measurement information.

The proposed automated system for monitoring and locating water resources pollution can be used in a wide spectral range for recording parameters of water environments in hydrophysical and ecological studies, conducting ecological monitoring of surface water parameters, in particular for the content of suspended solids.

The obtained optical information about the state of the light field inside the studied light-scattering water-dispersed medium is entered into the computer memory, where it is coordinated, processed and displayed on the monitor screen in the form of tables, analytical or graphical dependences of the brightness functions of the studied water-dispersed medium. In this case, special attention is paid to reducing the dynamic measurement errors that are dominant in hydrophysical studies.

Regulation of Discharges Through the Assessment of the Radioactivity Factor of the Southern Bug Ecosystem

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It is known that the ecosystem is capable of firmly and for a long-time retaining radionuclide entering it through active accumulation or passive sorption, or even fixing significant amounts of radionuclides for a long time [1]. The absence of this property in any situation means disruption of trophic relationships between ecosystem components, destruction of migration pathways and absorption of nutrients or their sorption, and hence ecosystem degradation. A measure of this property is the radioactivity factor, which is the ratio of the activity of radionuclides that are strongly sorbed by ecosystem components to the total radioactivity of this ecosystem. The upper limit is the degree of radionuclide activity that does not yet disrupt the functioning of the ecosystem, i.e., does not reduce its productivity, conditioning and reliability.

The preliminary assessment of radioactivity factors showed that due to different coefficients of ^{137}Cs accumulation by biota, bottom sediments and fish organisms, there is a difference in the values of the ^{137}Cs radioactivity factor depending on the river section: in the vicinity of Pervomaisk - 0.89, in the vicinity of Mykolaiv - 0.94. The difference in the ecosystem radioactivity factors calculated without taking into account the biotic component, i.e. for the winter period, is even greater: 0.73 in the Pervomaisk area and 0.81 in the Mykolaiv area.

Conclusion: when calculating the amount of ^{137}Cs entering the river and assessing the radiation situation, it is necessary to take into account unequal radioactivity indicators in different parts of the river, which can serve as an indicator of regulating radioactive discharges. According to the current approaches, the limit for environmental regulation of radioactive substances discharged into the ecosystem is a decrease in the radioactivity factor of the ecosystem by no more than 20%.

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Sustainable Tourism Development Through the Training of Tourism Industry Professionals

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Sustainable tourism development is one of the key challenges and priorities of the present day, especially in the context of increasing anthropogenic pressure, climate change, urbanization, and globalization. Achieving sustainable development goals in this sector is impossible without the high-quality training of professionals who not only possess specialized knowledge but also understand the principles of ecological, economic, and social balance [2]. The training of tourism professionals today requires new approaches that consider not only the needs of the labor market but also global challenges. Educational programs should aim to develop competencies in sustainable management, tourism planning, the green economy, intercultural communication, and digital technologies. A modern tourism specialist must not only be proficient in marketing and management tools but also comprehend the deep interconnections between tourism, the environment, and society.

Practice-oriented education, participation in projects, internships, and international mobility of students and teachers contribute to the formation of a new generation of professionals capable of adapting to changes, making informed decisions, and initiating projects aligned with the principles of sustainable development [1]. The preparation of such personnel also involves engaging instructors with real industry experience, implementing case methods, interactive learning, and supporting research activities focused on practical outcomes. Incorporating the principles of ethics, sustainability, equality, and environmental awareness into the educational process allows for the cultivation of professionals who will become drivers of positive change.

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Main Vectors of Increasing the Added Value of Nature Reserve Areas

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In the current conditions of socio-economic and environmental transformation, accompanied by the challenges of wartime, the issue of effective use of natural reserve areas (NRAs) resources is becoming particularly relevant. NRAs are a strategic resource not only in terms of environmental protection, but also as a base for sustainable tourism, post-war rehabilitation of the population, education, science, and the development of local communities in general. Thus, the main purpose of the functioning of NRAs is to obtain certain types of products of activity. And the search for ways to increase the added value of the total product of NRAs (Fig. 1) becomes an urgent issue.

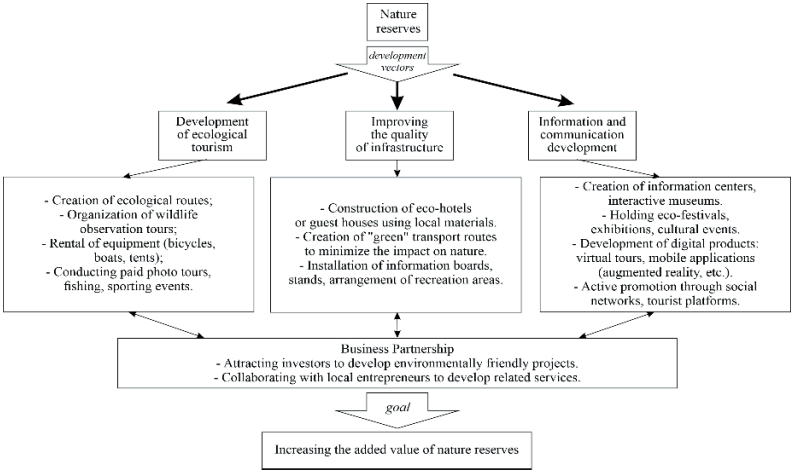

Fig. 1. Main vectors of increase in added value of PZT.

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Impact of Air Pollution on the Disease of The Population of Ukraine

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The most common harmful gaseous pollutants of the atmosphere are SO_2, SO_3, H_2S, NH_3, CO, CO_2, nitrogen oxides, benzapyrene, chlorine and fluorine compounds, and hydrocarbons. Among industrial aerosols, coal dust, ash, sulfates and sulfides of metals (iron (Fe), lead (Pb), copper) are found. (Cu), Zinc (Zn) etc.), silica, chlorides, compounds of Calcium (Ca), Sodium (Na), Phosphorus (P). The emissions also contain vapors of basic acids (HCl, H_2SO_4, HNO_3), mercury, and phenols. Protection of atmospheric air is one of the most urgent problems in modern technological society, since scientific and technological progress and expansion of production are associated with an increase in negative anthropogenic impacts on the atmosphere [1].

Harmful substances enter the human body through the respiratory system, digestive system, skin and mucous membranes. The entry of pollution through the digestive system, skin and mucous membranes can be controlled, while pollution into the body through the respiratory system is difficult to control.

When studying the structure of morbidity in the population of Ukraine, it is noteworthy that the most common disease is respiratory diseases (chronic bronchitis, occupational bronchitis, bronchial asthma, pneumoconiosis, allergic rhinitis, etc.), which affect about 11 million Ukrainians (Fig. 1) [2].

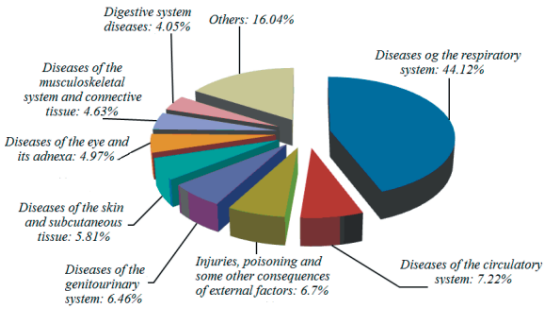

Fig. 1. Structure of primary morbidity among the entire population of Ukraine in 2017, %.

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Proceedings of the International Conference «European Green Dimensions: Fundamental, Applied, and Industrial Aspects», June 5–7, 2025 [Electronic resource], Mykolaiv : PMBSNU, 2025, 100 p.

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