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BOOR OF ABSTRACTS

Smart Green & Smart Blue

exploring nature-based solutions and ecosystem services approaches in environmental management, planning & policy

Open Science Conference

Lviv,
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Keynote speeches

1. Plant and landscape ecology

2. MOOCs for advancing multidisciplinary approaches in research training in sustainability studies

3. Nature-based solutions for resilient cities

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5. Green and blue for smart cities

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Keynote speeches

A multifunctional perspective of urban green networks

Miguel Villoslada.
Estonian University of Life Sciences, Chair of Landscape Management and Nature Conservation, Tartu, Estonia

Planning of urban green networks has emerged in recent decades as a valuable framework to ensure the ecological coherence of urban landscapes. These green networks encompass a great spatial diversity and ecological heterogeneity resulting from the coupled human and natural system. The particularities of urban ecosystems' structure and functions arise from the complex interactions between urban dynamics and ecological processes, leading to a patchy mosaic of different habitats. The spatial configuration, nature and structure of these green patches determine their function and the ecosystem services they provide (carbon sequestration, heat mitigation, flood regulation and pollination among others). Much like in rural or wilder environments, linear habitats in the cities act as wildlife corridors, and it is not unusual to find biodiversity hotspots containing rare and endangered species at the core of urban areas.

Only by adequately identifying, characterizing and accounting for the structural complexity of these functions, we are able to design and manage coherent and resilient urban green networks. Only by understanding the dynamics and interconnections between these green structures, we are able to recognize their value. In addition, the rapid increase in geospatial data availability and quality allows for the development of frameworks that incorporate a more functional approach into green network planning.

This presentation provides an introduction to the underlying functioning of urban green networks and the multiple benefits they provide. Additionally, a number of spatial datasets and tools will be presented.

Estimation of the parameters of stormwater runoff from the territory of the Lviv city at the inlet of the municipal wastewater treatment plant

Volodymyr Zhuk,
Lviv Polytechnic National University, Lviv, Ukraine

Complication of the rainfall parameters due to the global climate changes along with the intensive urbanization of the catchments, lead to the increasing of the requirements for the reliability of the municipal stormwater drainage systems. Statistical processing of the results of hydrometeorological observations in the city of Lviv for the period from 1945 to 2018 showed the increasing of the annual rainfall depth by 1.56 mm/year, resulting the total increasing 15.6% from the average value H_{mid}=730.2 mm. The frequency of extreme rainfalls is also increasing, for example 3 from 10 most intensive rainfalls in the Lviv city for the period 1945–2018 have been observed for the last 10 years. Statistical processing of daily values of the precipitation depths allowed obtaining the dependence of the estimated rainfall depth as a function of the return period.

Lviv has been intensively urbanized over the last 50 years, since the city's largest sewers were built. Baltic Sea drainage catchment of the Lviv city, affecting on the flow rate at the inlet of the Lviv wastewater treatment plant (WWTP), has grown to almost 60 km^2. At the same time, the proportion of water impervious areas has increased significantly. Such increasing has strong cumulative effect, so some growth of the total imperviousness leads to the noticeably more magnification of the effective imperviousness, causing the proportional increasing of the stormwater discharge.

Average annual volume of the surface runoff at the inlet of the Lviv WWTP is estimated in the range of 25–29 mln m^3 per year. These values correspond to 200–232 thousand m^3 per day, based on the mean value of 125 wet days annually in the Lviv city. Design capacity of the Lviv WWTP is 490,000 m^3/day, therefore, even for the average daily runoff, the total inflow of domestic and industrial wastewaters plus stormwater runoff is approximately equal to the maximum permitted capacity of the WWTP.

At the same time, WWTP should treat the maximum daily inflow. To accurately determine the maximum daily flow rates at the inlet of the Lviv WWTP, it is necessary to obtain systematic results on the distribution of the cover types within the Baltic Sea catchment, with particular emphasis on the relationship between total and effective imperviousness, and to perform computer hydrological modeling of the stormwater runoff, taking into account for the pervious part of the catchment the dependence of the infiltration rate upon the rainfall depth.

Blue-green infrastructure and cultural landscapes in urban planning: transformations in municipal governance practices

Viktar Kireyeu, *Erda Research, Technology, Education, The Netherlands*
Anton Shkaruba, *Estonian University of Life Sciences, Estonia;*
Hanna Skryhan, *Belarusian-Russian University, Belarus*

An effective communication between municipal authorities, city residents, and business owners is essential for the success in the transformation of municipal governance practices. Development of blue-green infrastructure and preservation of historical landscapes are the areas where this communication is particularly important. EU "ComManaging Municipallity – Communication and Management for Community Involvement in Municipal Governance in Belarus" (COMMA) project aimed to demonstrate ways of improving municipal governance and urban residents' well-being through cooperation between local authorities and communities, based on case studies from Mahilioŭ, Baranavičy, and Čavusy.

Mahilioŭ's historical district of Padnikollie is a large green area located in the valley of the Dnieper River. A significant part of the area is either flood-prone or within the protection zone around municipal water supply facilities; this helped to preserve the historical landscape of the area. For the most part Padnikollie is still a natural area in the middle of the city with a rich biodiversity, natural wetlands, meadows, lakes, and old trees. The city authorities expressed interest in re-development of this area to an amusement park with construction of highways, shopping malls and parking areas. The re-development started in 2014 and was put on a fast track in 2017. It was marked by conflicts with nature and cultural heritage conservation watchdog organizations and activists expressing concern over quick developments disregarding and destroying important archaeological artifacts, old trees and wetlands. At the same time, broader public was quite optimistic about these developments, as the area was not easily accessible and gave to many an impression of being unpleasantly wild. To ensure both sustainable management of Padnikollie landscapes and support from local stakeholders, there was a need in the EU experience in public participation and communication strategy development. This provided an interesting case study for the COMMA project, and a part of the district was selected for the project pilot initiative of creating a city arboretum with a community pharmacy garden.

By analyzing all stages of the pilot project implementation, we review existing institutions, new practices, and project outcomes. Our findings suggest that there are institutional gaps on national level caused by reluctance to adopt European practices in the field of development of blue-green infrastructure and preservation of cultural values of urban landscapes.

Soft and green measures to successfully restore a former Danubian side in the city of Vienna for recreational purposes

Hans Peter Nachtnebel
HyWa, Dept. Water-Atmosphere-Environment,
University of Natural Resources and Life Sciences,
Austria hans_peter.nachtnebel@boku.ac.at

Soft and green measures to successfully restore a former Danubian side in the city of Vienna for recreational purposes. Nachtnebel H.P., Fürst J. Institute of Hydrology and Water Management Dept. of Water-Atmosphere-Environment University of Natural resources and Life Sciences, Vienna, Austria The Danube river passes through the city of Vienna. In the past 150 years, the Danube river and its side arms together with its flood plain were heavily modified by engineering activities to reduce flooding, to promote navigation, to utilize hydropower and to support water based recreation. As a result, in the 1870'ties the former main branch of the Danube river has been transformed into a lake, which was intensively used for water-based recreation since about 100 years. The attraction of this water body is seen in its dimensions, in its location close to the city center and its easy accessibility. Engineering works in the 1980-90'ties, not directly related to water, modified the underground inflow and subsequently the water supply of this artificial lake. Because of this fact and additional impacts the water quality deteriorated drastically so that swimming had to be prohibited in the mid 1990'ties. The changes in the water balance together with a nutrient balance were assessed and green measures were analyzed to rehabilitate this large urban water body. It was proposed to re-establish the natural seasonal variability of the groundwater inflow to maintain the dynamic features of the system. A huge artificial wetland was created to clean the water input and to remove especially particulate phosphorous. Also, the roles of macrophytes in accumulating nutrients and of water birds in causing nutrient input was analyzed. As a result, several soft engineering measures were successfully tested and management plans were developed to improve growth of submersed macrophytes in order to extract nutrients by frequent harvesting. Over about 25 years various of these eco-measures were tested. Finally, the lake could be transferred from a turbid and algae dominated system into a clear macrophyte controlled lake. Today the urban water body is again intensively used for water-based recreation. The background, the physical conditions and the simulation results together with management plans will be described in this paper.

Ecological policy and management in Lviv (Ukraine)

Oksana Maryskevych, Iryna Shpakivska, Volodymyr Rozhak
Institute of Ecology of the Carpathians NAS of Ukraine (Lviv)

Ecological policy in Lviv within 2012-2025 periods is defined by the Complex Strategy of Lviv City Development. "High level of satisfaction with living conditions in town, that is comfortable, safe and has a high level of social safety net within the clean environment" approaching is forecasted within this Strategy priority – "City where is comfortable to live, study and work". Two Complex Ecological Programs for Lviv city which were developed by the Institute of the Ecology of the Carpathians NAS of Ukraine (2012-2016 years., 2017-2022 years) conform to this priority. Ecological policy management in Lviv is performed by the Branch of Ecology and Accomplishment (Department of urban planning) and Department of Engineering Household and Infrastructure of Lviv City Administration. Management of natural protected objects of state and regional levels is performed by the Department of Ecology and Nature Resources Lviv Region State Administration. Funding of the conservation measures performed by the City Conservation Foundation, City Development Foundation and international grants. Introduction of «SMART – Green" and "SMART – Blue" elements in town is carried out by approved "Complex strategy of Lviv town landscaping" (2018) and Inventory of surface water bodies (2014). These are the first steps that are only pinpointing the current situation. They can be taken as a basis for SMART technologies introduction with an aim to manage town plants and water resources. To make this possible we'll need the assistance of state authorities, municipal structures, businesses and citizens.

Challenges of Landscape Sciences in Environmental Management and Society

Kalev Sepp,

Miguel Villoslada, Anton Shkaruba Estonian University of Life Sciences

Landscape could be defined as a socio-ecological system that consists of natural and/or human-modified ecosystems, and which is influenced by distinct ecological, historical, economic, and socio-cultural processes and activities. Landscapes are increasingly being understood as multifunctional and dynamic entities of social and ecological systems; that is, spatially and/or temporally defined entities where multiple functions and values associated with natural, cultural and societal values are integrated in the interests of both existing and potential land users (Brandt and Vejre 2004, de Groot 2006, Angelstam et al. 2015).

In practice a landscape is often defined by stakeholders at a scale that is small enough to maintain a degree of manageability, but large enough to be able to deliver multiple functions to stakeholders with different interests. Many critical landscape functions are affected by human interactions with natural processes (Termorshuizen, Opdam 2009), such as climate change mitigation and adaptation, biodiversity, economic productivity, energy security, public health and wellbeing, social cohesion and aesthetic beauty (Bolliger et al. 2010). Consequently, policy-makers, scientists and practitioners have raised arguments for a landscape perspective in land-use planning and management where values, interests and needs are integrated. The development and ratification of the European Landscape Convention is an example in this direction.

At the landscape level, the main challenge is how to decide on the optimal allocation and management of the many different land use options. The sectorial planning paradigm in many European countries has prevailed throughout of the 20th century and resulted in a situation where a mono-functional land use strategy has been adopted as the most economically efficient (Brandt & Vejre 2004). Furthermore, there is often an incoherency in how various sector policies interpret the concept of 'landscape'. Even though sectors such as forestry, agriculture or water management are increasingly including sustainable development objectives in planning, their separate spatial, policy and strategic foci hinders sustainable landscape management across biophysical and jurisdictional borders (Farcy 2004).

Over the past decade, the term, the management and policy approaches underlying importance of landscape approach, are beginning to gain prominence as the limits of narrowly sectoral approaches become more apparent in our interconnected, crowded, resource-constrained and climate-chaotic world.

There has been remarkable growth in integrated landscape management activities on the ground and increased support by policymakers, businesses, and leaders to include ILM as a key component of their sustainable development portfolios. Several international organisations (FAO, UN, World Bank etc) and many national governments in Europe, Asia, South-America are recognizing the importance of integrated landscape management for long-term economic, social and ecological sustainability. As momentum builds for landscape thinking, planning and management, clearly articulating core landscape terms and concepts is necessary to advance communication and understanding.

Integrated landscape management (ILM) refers to long-term collaboration among different groups of land managers and stakeholders to achieve the multiple objectives required from the landscape. These typically include agricultural production, provision of ecosystem services (such as water flow regulation and quality, pollination, climate change mitigation and adaptation, cultural values); protection of biodiversity, landscape beauty, identity and recreation value; and local livelihoods, human health and well-being. Stakeholders seek to solve shared problems or capitalize on new opportunities that reduce trade-offs and strengthen synergies among different landscape objectives. Because landscapes are coupled socio-ecological systems, complexity and change are inherent properties that require management.

ILM ensures that by managing the underpinning natural resource base and ecosystem services in a coordinated way, societal needs can be met in the short and long term. Common characteristics of ILM include: generating an agreed vision among stakeholders of landscape goals; adopting practices that achieve multiple objectives; devising strategies to manage spatial and seasonal interactions across different land uses and users; linking institutions and establishing mechanisms for stakeholder dialogue, negotiation and action; and shaping markets, planning frameworks and policies to support desired outcomes.

Integrated landscape management offers specific advantages for implementation of the SDGs compared to sector-specific implementation plans:

1. ***Generate solutions that achieve multiple objectives at once.*** Adopting a landscape approach that systematically considers multiple sectors and diverse stakeholder needs enhances overall policy and program coherence and effectiveness.
2. ***Improve inter-sectoral coordination and cost effectiveness at multiple levels.*** Coordinated strategies and plans encourage synergies among national, sub-national, and local governments, and make best use of scarce financial resources by reducing redundancies.

3. ***Empower communities through multi-stakeholder processes.*** ILM is an inclusive, participatory process that engages all stakeholders, including women, youth, mobile communities, indigenous peoples, smallholder producers and other marginalized and vulnerable people.
4. ***Enhance transboundary and regional cooperation.*** An integrated landscape approach considers ecological connectivity, economic cooperation, and labour migration all in one framework.
5. ***Contribute to national and regional strategies for addressing climate change.*** By bridging science, practice and policy, climate smart landscapes can achieve mitigation, adaptation and agricultural production objectives while ensuring environmental sustainability.

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Application of the City Blueprint Approach: A case study of Ulaanbaatar, Mongolia

Altansukh Ochir,

National University of Mongolia
altansukh22@yahoo.com

pplication of the City Blueprint Approach: A case study of Ulaanbaatar, Mongolia Altansukh Ochir1, Enkhuur Munkhsuld1, Stef Koop2, Kees van Leeuwen2

1 School of Engineering and Applied Sciences, National University of Mongolia, Ulaanbaatar, Mongolia; enkhuurd@yahoo.com; altansukh22@yahoo.com

2 KWR Watercycle Research Institute, Nieuwegein, and Copernicus Institute for Sustainable Development and Innovation, Utrecht University, The Netherlands; Stef.Koop@kwrwater.nl; Kees.van.Leeuwen@kwrwater.nl

World population is growing rapidly; density of the urban area is increasing, and a number of mega cities are becoming a lot. More than half percent of world population is living in the urban areas which are called "cities." One of the prior requirements of urban inhabitants is the city with safe, clear and sufficient drinking and household water. Therefore, there is a demand to assess water management in cities all around the world. The City Blueprint Approach (CBA) which was developed by Kiwa Water Research Watercycle Institute, The Netherlands is a diagnosis tool for urban water management. In this study, the CBA was used to assess current situation of water management in Ulaanbaatar, a capital of landlocked Asian country, Mongolia. As a result, general issues or problem in Ulaanbaatar was determined. The Blue City Index of Ulaanbaatar is 4.0 and economic pressure has a great concern on water sector; water governance in Ulaanbaatar is not sufficient. Furthermore, there are some unsuitable indicators for developing cities of landlocked countries, because all indicators were based on the developed (European) and coastal countries. If CBA has extended and more clarified for different regions, countries with varies alternatives, CBA can be an integrated urban water management assessment tool is used worldwide. The result of research shows that there is strong demand to develop independent IWRM plan for the capital Ulaanbaatar. Because of, almost half of population of the country habitats in the capital, and the city area occupies only 8% of the Tuul catchment. Based on City Blueprint Approach, the frequent assessment framework for IWRM plan of Ulaanbaatar can be developed.

1. Plant and landscape ecology

Chemical composition of essential oils, oxidation on *Nepeta sibirica L* and and technology of cultivation

A. Amarjargal (ass. professor) , Sh.Altantsetseg [2],(Ph.D) N. Undarmaa[1]
[1]Khovd University
[2]Institute of Chemistry and Chemical Technology

3 kinds of Nepeta grow in Mongolia[4], 21 kinds in Russian [5] and 33 in Turkey[21].
Furthermore, in Iranian traditional medicine, N.cataric (catnip) is used to treat cold.
N.cataria L had also been used for cancer treatment, as well as for stomach diseases, cold, anemia, headaches.
Khovd aimag center, Jargalant soum is located (north latitude $48^{0}01$, north longitude $91^{0}38$) 1405m above the sea level, surrounded by mountains, and has 70 square.km land and 30 thousand populations.
Khovd University experiment base is located at north latitude $47^{0}58'19"$, and east longitude $91^{0}37'22"$and 1430m above the sea level. Experiment base is 5km away from Khovd city and has the land of 6 hectares. Its land has deserted steppe sandy soil.
In August 2018, we collected seeds of Nepeta sibirica L from the Kharkhiraa mountain range of Uvs aimag and cultivated open fields in Khovd aimag .
Nepeta sibirica L were cultivated at the experiment base of Khovd University.
According to this study, growth the Nepeta sibirica L in the room during the period of 5-10 months increased to 17.5-90%.
In the May-October period, the Nepeta sibirica L is growing over the field increased to 15-80%.
According to gas mass spectrum, the chemical composition of essential oils of Nepeta sibirica L was contained terpene-68.02% and terpenoid-27.97% .
Essential oils such as β-bourborene(14,19%), caryophyllene(9.51%) β–bisabolene(8.07%), caryophyllene oxide (12,17%) of Nepeta sibirica L are available in fragrance. It is therefore possible to plant Nepeta sibirica L in urban areas to reduce air pollution.
The antioxidant activity of the Nepeta sibirica L (method-DPPH) showed that the activity of ethanol extracts at 1,500 μg / ml was 5.153 percent, and the vegetation could be cultivated to reduce oxidation in the environment and increase the green area of the city.

Fluorescent monitoring of plants in ecological-phytocenotic zones of Lviv

[1]V. Mokryy, [1]I. Kazymyra, [1]O. Moroz, [1]I. Petrushka, [2] R. Grechanyk, [3]T. Grechuh

[1]Lviv Polytechnic National University, S. Bandera St., 12, 79013 Lviv, Ukraine; mokriy@ukr.net
[2]Department of Ecology and Natural Resources of Lviv Regional State Administration, Stryiska St., 98, 79026 Lviv, Ukraine; envir@loda.gov.ua
[3]I. Franko Lviv National University, Universytetska St., 1, 79000 Lviv, Ukraine; zag_kan@lnu.edu.ua

Modern concepts of ecosystem management at urban territories are based on the widespread use of complex monitoring studies. Complex monitoring of the vegetation cover is realized on the basis of correlation synthesis of biological, biometric and biophysical data.

The main goal of the research is the mathematical interpretation of data of rapid diagnostics of physiological parameters of plants of urban biogeocenoses. These parameters are measured by the fluorescence method and are necessary for the qualitative interpretation of the bioproductivity of green space. The activity of the photosynthetic apparatus was investigated on leaves and needles by the method of chlorophyll fluorescence. The mathematical models of graphs of the kinetics of chlorophyll fluorescence are built using the Graph2Digit program with further processing in Excel.

The investigation of parameters of chlorophyll fluorescence showed the differences in the luminescence intensity for trees taken under different urbogenic conditions. The maximum fluorescence intensity is observed in suburban forest plants, which are succumbed minimal impact of urbanization. The minimum value of fluorescence intensity is characteristic for street (outdoor) plants that are exposed to the highest anthropogenic load.

The decrease in the maximum induction of chlorophyll fluorescence indicates the changes in the activity of the donor part of the photosystem. The nature of the decrease in the fluorescence intensity makes it possible to evaluate the functioning of the photosynthetic apparatus by determining the vitality index. The value of the vitality index of the studied plant species decreases with the increasing influence of negative factors on plant growth and development. In street plantings the vitality index decreases by 2 times as compared to control samples.

The use of modern information-analytical methods and technologies for monitoring urban biogeocenoses is of practical importance. The determination of the specifics of degradation processes manifestation, which are recorded by the physiological and biophysical parameters of plants, is appropriate for the tasks of conservation of floristic diversity and preservation of the gene pool of urban plantings.

Medicinal and aromatic vascular plants within the territory of Lviv city (Ukraine)

Nataliya Horbenko,
Ukrainian National Forestry University, Lviv, Ukraine
Nataliya Derevyanko,
Institute of rice of NAAS, Antonivka, Kherson region, Ukraine

The materials reveal the importance of medicinal and aromatic plants in human life. The use of medicinal and aromatic plants (MAP) in Ukraine has a very long tradition. As people moved into cities and suburbs and embraced modern medicine and industrialized food, they lost their connection to nature, in particular to the plants with which humanity coevolved. The distribution of medicinal and aromatic plants in the Lviv region is described. The main collections of this scientific direction are described. The Collections of Medicinal and Aromatic Plants have been established at the three universities of Lviv, Ukraine. Collections are specialized in the direction of medicinal plants. Aromatic plants are included in the collection of medicinal, ornamental plants. The trends in the list of these plants in private collections are described. Main genera of medicinal and aromatic vascular plants within the territory considered. As the benefits from medicinal and aromatic plants are recognized, these plants will have a special role for the city humans in the future.

The use of the landscape segment of ecosystem services in management decisions

Maksymenko Nadiya,
V.N. Karazin Kharkiv National University

The European community has supported the postulate that environmental impact should be considered as the only complex system in which all processes are interconnected and interdependent. Moreover, it is not possible to separately adopt programs for greening water or land use. In this sense, the landscape is considered as the only object of all environmental programs, including areas such as ecosystem services research and the term "landscape services" is increasingly found in the literature.

Most of the Old World countries have legalized the need for a landscape planning procedure at the state level and are trying to bring its prospects to the post-Soviet space by initiating and financing scientific research in this area. As an adapted analogue of landscape planning, we propose to introduce a landscape-environmental planning procedure in Ukraine, which has certain advantages in implementation and the use of the results.

So, we focus our attention on the landscape segment as part of a wide range of ecosystem services research. The purpose of the study is to assess the location and feasibility of the landscape-environmental planning procedure use to develop management decisions for ecosystem services.

Let's consider the generalized model of implementation and adjustment of management decision in the field of nature management based on landscape-ecological planning. The prerequisite for its implementation is a previously conducted procedure of landscape-ecological planning for a specific territory, which allows us to use its results in further implementation of management activities.

The next step is to assess potential changes in the landscape conditions. The use of landscape-environmental planning allows us to use the benefits of basic landscape-ecological planning for each management decision (maps of environmental components, their ecological status, data on all sources of conflict and intensity of conflicts of nature, maps of landscape-ecological index of the territory, etc.).

Then management decisions' implementation are assessed, considering the processes it entails (reduction of water, soil, biodiversity quality, potential economic losses, including the impact on human well-being). The information about such changes in our model also serves as a basis for the development of new management decisions.

Ecosystem-based adaptation to climate change: pioneering new approach in Ukrainian biosphere reserves

Anatoliy Smaliychuk
Ivan Franko National University of Lviv,
Michael Succow Foundation

Biosphere reserves designed as "living laboratories" for testing and demonstrating of new approaches to integrated management and sustainable use of ecosystems and their services. One of the main global challenges, which threatens different ecosystems, biodiversity and humans is climate change. While the negative impact of climate change might cost a lot, adaptation to climate change not always requires large financial investments as well as deep technological intervention into ecosystems. An opposite to conventional adaptation practices, like building dam for flood-prevention, ecosystem-based adaptation approach implies utilization, strengthening and restoration of natural properties and functions of ecosystems those which can buffer negative consequences of climate change. With the project "Ecosystem-based adaptation to climate change and regional sustainable development by empowerment of Ukrainian Biosphere Reserves" we are presenting new approach to climate change adaptation in Ukraine. It aims at integrating an ecosystem-based adaptation approach to national and regional planning and action in Ukraine, leading to better adapted land-use and wide-ranging sustainable development.

The expected outcome of the is to empower three biosphere reserves in three different ecoregions – Desnianskyi, Roztochya and Shatskyi / West Polissia – for becoming role models that catalyse the introduction of a new type of participatory and adaptive ecosystem management in the wider landscape. Three main project outputs include: (I) increasing local knowledge on climate change, its impacts and ecosystem-based adaptation by (II) developing strategies, human capacities and networks, so that biosphere reserves can lead processes of participatory ecosystem-based adaptation-informed landscape planning and practices and (III) working out policy proposals for integrating principles of ecosystem-based adaptation into environmental legislation and ecosystem management. In the course of the project implementation citizen workshops and first round of expert workshops based of MARISCO methodology have been already conducted in each of three biosphere reserves. The second round of expert workshops dedicated to development of adaptation strategy for the biosphere reserves as well as small-scale adaptation measures on the ground are scheduled for the upcoming year.

Формування продуктивності лучної та степової рослинності у зв'язку зі зміною клімату

Польовий А.М., Божко Л.Ю., Барсукова О.А.
Одеський державний екологічний університет

В Україні в результаті інтенсивного сільськогосподарського використання земель степова рослинність у природному вигляді до цього часу збереглася тільки на схилах балок, масивах зі складним рельєфом, в заповідниках, на території колишніх військових полігонів, а також у передгір'ях Криму, на піщаних косах Азово-Чорноморського узбережжя та островах. Ділянки цілинних степів охороняються в заповідниках та заказниках.

Сучасний стан фітоценозів свідчить про їх високу здатність до стійкого та довготривалого існування, але під впливом антропогенних факторів різноманітність рослинного світу зменшується [1,2].

Наприкінці минулого і початку поточного століття науковцями відзначаються значні зміни кліматичних умов на всій Земній кулі через потепління. Під впливом зміни клімату змінюються агрокліматичні умови росту і формування продуктивності як сільськогосподарських культур, так і дикорослих фітоценозів.

Питанням дослідження параметрів запасів фітомаси, яка формується впродовж року, їх кількісної оцінки присвячені роботи [3,5,7,8,9]. Встановлено, що біомаса рослин в степу становить від 100 до 400 ц/га. Крім того також встановлено, що для рослинності степів співвідношення між живими і відмерлими органами становить біля 65 % на чорноземах і темно-каштанових ґрунтах і 35 % на каштанових ґрунтах

Кліматичні зміни на майбутнє розраховуються з використанням кліматичних моделей/

В цьому дослідженні для кліматичних розрахунків використовується набір сценаріїв, а саме Репрезентативні траєкторії концентрацій (Representative Concentration Pathways – RCP). Найбільш дослідженими сценаріями клімату майбутнього вважаються два з них: RCP 4,5 та RCP 8,5.

Аналіз впливу змін клімату на режим агрокліматичних показників розвитку і формування продуктивності лучних і степових фітоценозів виконувався шляхом порівняння середніх багаторічних величин (за період 1980 – 2010 рр) і величин, розрахованих за кліматичними сценаріями RCP4,5 та RCP8,5 по десятиріччях: 2021-2030 рр. (перший період), 2031-2040 рр. (другий період), 2041-2050 рр. (третій період). При цьому використовувались спостереження за ростом і розвитком трав, які роз-

повсюджені переважно в Степовій зоні України. Розглядались такі величини: тривалість періоду відновлення вегетації – цвітіння трав, середня температура за цей період, сума опадів, сумарне випаровування, випаровуваність, відносна вологозабезпеченість, гідротермічний коефіцієнт Г.Т. Селянинова (ГТК), сума фотосинтетично активної радіації (ФАР).

Розрахунки продуктивності трав виконувались за трьома видами урожайності: потенційна урожайність (ПУ), метеорологічно можлива врожайність (ММВ), дійсно можлива врожайність (ДМВ), природна врожайність (УВ) .

За середніми багаторічними даними сезонний розвиток трав починається в кінці березня За сценарієм зміни клімату RCP4.5 буде починатись на початку квітня в усіх трьох розрахункових періодах. За сценарієм зміни клімату RCP8.5 сезонний розвиток трав почнеться в перший сценарний період на 10 днів пізніше за середні багаторічні терміни, в другий розрахунковий період він почнеться на 6 днів пізніше, у третій період очікується, що початок вегетації майже співпаде з середнім багаторічним терміном.

Розрахунки за сценаріями RCP4.5 та RCP.5 показали, що надходження ФАР в перший розрахунковий період буде збільшуватись і становитиме відповідно 136 та 114 % від середньої багаторічної величини. В 2031 – 2040 рр. надходження ФАР буде ще вищим, особливо за сценарієм RCP4.5 і становитиме відповідно 142 та 130 % від середньої величини. В третій розрахунковий період надходження ФАР за сценарієм RCP4.5 буде вищим, ніж за сценарієм RCP8.5 і становитиме – 128 % від середньої багаторічної величини в той же час за сценарієм RCP8.5 воно становитиме 118 %..

ПУ всієї сухої маси трав при середніх багаторічних умовах складає 465 ц/га. За кліматичним сценарієм RCP4.5 відповідно збільшенню приходу ФАР значно зросте і очікувана величина ПУ. Протягом всіх сценарних періодів вона буде становити 124–148 % від середньої багаторічної величини. За сценарієм RCP8.5 ПУ всієї сухої маси теж впродовж усіх розрахункових періодів буде вищою середньої багаторічної, але нижчою,ніж очікувана за попередній сценарій і становитиме 120 – 130 % від середньої багаторічної (табл. 2).

Середня за період початок вегетації – цвітіння трав температура повітря за середніми багаторічними даними становила 13,1 °С. В разі реалізації сценарію RCP4.5 у два перші періоди середня температура очікуватиметься нижчою середньої багаторічної (12,1–12,5 °С). У третій період вона буде однаковою із середньою багаторічною. За сценарієм RCP8.5 середня

температура повітря у перший період буде на 1 °С вище базової, у другий та третій періоди на 0,3–0,4 °С нижче середньої багаторічної величини.

За кліматичним сценарієм RCP4.5 очікується збільшення сум опадів у перший період на 12 %, і значно більше у другий період на – 41 %. Кількість опадів у третій період очікується на рівні середньої багаторічної. Дефіцит вологи (E_0 – E) у перший період дещо знизиться від 91 до 84 мм, незначно підвищиться вологозабезпеченість (від 0,52 до 0,56 відн. од.). Також незначно зросте величина ГТК.У другому періоді за рахунок збільшення кількості опадів та понижених температур повітря можливе суттєве зменшення дефіциту вологи до 53 мм, значно покращиться вологозабезпеченість та підвищиться ГТК до 1,46 відн. од. Третій період буде характеризуватись як посушливий (ГТК становить 0,85): зросте дефіцит вологи до 102 мм, відповідно зменшиться вологозабезпеченість (до 0,49 відн. од.).

За сценарієм RCP8.5 сума опадів за період початок вегетації – цвітіння трав буде очікуватись нерівномірними змінами. У перший період кількість опадів буде дещо нижче базової величини (94 %). Для другого періоду очікується зростання суми опадів на 18 %. Кількість опадів у третій період очікується на рівні 129 % від середньої багаторічної.

Очікується також незначне зростання величини ГТК, який тим не менш характеризує ці періоди як посушливі.

Зміна волого-температурних показників при зміні клімату спричинить зміну продуктивності трав. Так, за сценарієм RCP4.5 площа листя наростатиме аналогічно динаміці площі листя при середніх багаторічних агрометеорологічних умовах. Її рівень буде загалом вищий від середнього багаторічного

За кліматичним сценарієм RCP8.5 формування листкового апарату буде йти аналогічно динаміці площі листя при середніх багаторічних агрометеорологічних умовах. Площа листя сформується трохи більша, ніж базова.

Інтенсивність фотосинтезу листя трав за сценарієм RCP4.5 в період інтенсивного наростання листкової поверхні (друга – четверта декади вегетації) у перший та третій періоди буде сягати 4,5–7,0 мг CO_2/дм^{2}год, що близько до середніх багаторічних значень. На фоні підвищених значень ФАР сформується і високий фотосинтетичний потенціал травостою в усі розрахункові періоди. За кліматичним сценарієм RCP8.5 інтенсивність фотосинтезу листя трав буде дещо вища від середньої багаторічної.

Фотосинтетичний потенціал за період початок вегетації – цвітіння за обома сценаріями сформується досить високий (87,5–105,4 м^2/м^2 за період).

Рівень ММУ всієї сухої маси трав за сценарієм RCP4.5 у першому періоді очікується на рівні 139 % від середнього багаторічного, який становить 218 ц/га, значно більшим він буде у другому періоді (146 % від середнього). Для третього періоду рівень ММУ буде дещо нижчим порівняно з першим та другим періодом і становитиме 117 % від значення середнього багаторічного.

За кліматичним сценарієм RCP8.5 за дещо підвищеної температури повітря (на 1 °С) та деякій нестачі опадів (на 6 %) у перший та другий розрахункові періоди рівень ММУ буде становити відповідно 265 – 276 ц/га всієї сухої рослинної маси, що дещо більше, ніж рівень ММУ травостою при середніх багаторічних умовах (218 ц/га).

Природна родючість ґрунту корегує рівень ДМУ трав. При середніх багаторічних умовах урожай надземної маси трав за вологості 16 % становить 3,5 т/га . За сценарієм RCP4.5 ДМУ для першого та другого сценарних періодів складатиме відповідно 122 % та 127 % від середнього значення. Для третього періоду очікується, що рівень ДМУ буде самим високим і складатиме 143 % від середнього.

При агрометеорологічних умовах першого та другого періоду за сценарієм RCP8.5 ДМУ буде складати відповідно 140 % - 146 % від середнього багаторічного.

Баланс гумусу за обома сценаріями на ділянках степової рослинності очікуватиметься позитивним і складатиме по періодах 0,504–0,528 т/га, а для третього періоду – 0,425 т/га, що відповідно становитиме 140 - 146 та 118 % від середнього багаторічного значення, при цьому за сценарієм RCP8.5 він буде нижчим, ніж за сценарієм RCP4.5 (табл. 2).

Урожай надземної маси трав при вологості 16 % становить 4,3 т/га за середніх багаторічних умов. За сценарієм RCP4.5 за агрометеорологічних умов першого та третього сценарних періодів він буде складати 108-115 % від середнього багаторічного.За розрахунками за сценарієм RCP8.5 урожай надземної маси трав для першого та другого сценарних періодів буде становити 4,2–4,5 т/га. В агрометеорологічних умовах третього періоду очікується, що урожай сягатиме 5,0 т/га, що складатиме 143 % від середнього значення.

Співвідношення надземної частини біомаси до підземної очікується на рівні 0,25.

Баланс гумусу за обома сценаріями на ділянках степової рослинності очікуватиметься позитивним і складатиме для двох перших сценарних пе-

ріодів 0,504–0,528 т/га, а для третього періоду – 0,425 т/га, що відповідно становитиме 140 - 146 та 118 % від середнього багаторічного значення.

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2. MOOCs for advancing multidisciplinary approaches in research training in sustainability studies

MOOC "The precautionary principle and sustainability transition": updated structure

Utkina K.B., *PhD, Assoc Prof.*[1],
Titenko G.V., *PhD, Assoc Prof.*[1],
Maksymenko N.V., *Doctor of Sciences, Assoc Prof.*[1],
Nekos A.N., *Doctor of Sciences, Prof.*[1],
Shkaruba Anton, *PhD*[2],
Kireyeu Viktar, *PhD*[3]

[1]*V. N. Karazin Kharkiv National University, Ukraine.*
[2] *Estonian University of Life Sciences, Estonia.*

[3] *Erda RTE, the Netherlands*

One of the key planned outcomes of Erasmus+ project "Integrated Doctoral Program for Environmental Policy, Management and Technology – INTENSE" is development of Massive Open Online Courses (MOOCs). MOOC is an online course aimed at unlimited participation and open access via the web. In addition to traditional course materials, such as filmed lectures, readings, and problem sets, many MOOCs provide interactive courses with user forums to support community interactions among students, professors, and teaching assistants, as well as immediate feedback to quick quizzes and assignments. MOOCs are a recent and widely researched development in distance education, first introduced in 2006 and emerged as a popular mode of learning in 2012 Early MOOCs often emphasized open-access features, such as open licensing of content, structure and learning goals, to promote the reuse and remixing of resources. Some later MOOCs use closed licenses for their course materials while maintaining free access for students. Currently MOOCs are becoming to be introduced in education process.

In the framework of INTENSE project it is planned to develop several MOOCs, one will be "The precautionary principle and sustainability transition". The leader is V. N. Karazin Kharkiv National University and all partners will make their contributions.

Currently the contents of the MOOC are under discussion; there were several

structures already discussed and the updated one will include the following modules and topics.

Module 1 - Development trends in context of sustainability

This module will include topics addressed to dynamics of resource use and impacts on the Earth sustainability, data measurements, indicators and uncertainties, social dilemmas / justice, economic challenges: shortage of resources, geo-political issues, limits to growth: ecosystems services, social-ecological systems approach, recent approaches to analyze and assess sustainability, precautionary principle.

Module 2 - Sustainability challenges and lessons to learn

This module is devoted to specific issues, like nuclear accidents, climate/land-use change (vulnerability of pastoral communities), delta problems, Natura 2000/Fragmentation of habitats.

Module 3 – Sustainable Consumption and Production

Module 3 will consist of such topics as personal sustainability, sustainable agriculture, fisheries, transport forestry, tourism etc

Module 4 – Social Justice

This module will consider various social aspects such as rural/local jobs for life, social conflicts during econetwork creation and development etc.

After development of MOOC materials it is planned to carry out approbation on pilot group of PhD students for identification gaps and areas for improvements.

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Методики та техніки формування змісту практик як складових навчальної дисципліни

А.Н.Некос, *доктор географічних наук, проф.*
К.Б.Уткіна, *кандидат географічних наук, доцент*
Харківський національний університет імені В.Н.Каразіна

Практичні та лабораторні заняття є базовими компонентами навчання та мають тісний зв'язок з лекційним матеріалом. Вони доповнюють теоретичний курс лекцій практичною складовою.

Проведення практикумів зав'язане на основі гуманістичної педагогіки, коли принципами є педагогіка взаємодії, де обидва учасники виступають як паритетні, рівноправні, в міру своїх знань і можливостей, партнери

Практичне (від грецьк. praktocos – діяльний) заняття – форма навчального заняття за якої викладач організовує детальний розгляд студентами окремих теоретичних положень навчальної дисципліни та формує вміння та навички їх практичного застосування шляхом індивідуального виконання студентом відповідно сформованих завдань.

Лабораторне (від грецьк. labor – праця, труднощі) заняття – форма навчального заняття, за якої студент під керівництвом викладача особисто проводить натурні або імітаційні експерименти чи досліди з метою практичного підтвердження окремих теоретичних положень даної навчальної дисципліни, набуває практичних навичок роботи з лабораторним устаткуванням, обладнанням, обчислювальною технікою, вимірювальною апаратурою, методикою експериментальних досліджень у конкретній предметній галузі.

Складаються практичні заняття з 3 етапів:

- *Підготовчий,* на якому здійснюється перевірка готовності студентів до виконання практичних занять викладач пояснює алгоритм виконання завдань, повідомляє тему та мету заняття, наводить посилання на використання першоджерел;
- *Основний,* під час якого безпосередньо виконується практична робота;
- *Кінцевий*, коли відбувається підбиття підсумків практикуму, надання завдань для самостійної роботи.

Викладач повинен дотримуватися *алгоритму* виконання практикуму:

- Актуалізація знань щодо теоретичних положень;
- Проведення контролю набутих практичних компетентностей;

- Орієнтація на самостійне виконання практичної роботи;
- Критерії оцінювання;
- Методологічна установка на виконання практичної роботи, надання; списку посилань, огляд методичних рекомендацій;
- Виконання практичних робіт, їх перевірка та оцінювання.

На початку виконання практикуму викладач повинен чітко сформулювати мету, завдання, роздати методичні матеріали до виконання практикуму та наприкінці здійснити контроль. Це все входить в обов'язки викладача. Саме від вміння правильної організації викладачем практикуму залежить ефективність та успішність заняття та формування необхідних практичних компетентностей. Хоча, як відомо, все ж самостійна робота є пріоритетною у виконанні практичних завдань. На практичних заняттях формується спрямованість студентів до самоосвіти, накопичення нових знань вміння захистити власну роботу.

Методики проведення практикуму можуть бути різноманітні. Це розрахункові роботи з використанням комп'ютерної техніки, опрацювання цифрового картографічного матеріалу, дешифрування космічних та аерознімків, використання комп'ютерних, ділових або дидактичних ігор, аналіз тематичних проблемних ситуацій, робота з різноманітними документами, польові натурні дослідження, а також колоквіуми, дискусії, експрес контрольні роботи.

Дуже ефективним при виконанні практикумів щодо вирішення проблемних ситуацій є використання так званого «мозкового штурму». Уперше його використав в університетській освіті американський психолог А. Осборн (1953 р.).

3. Nature-based solutions for resilient cities

Governance landscapes for water-related nature-based solutions in Belarus, Russia and Ukraine

Anton Shkaruba[1], Hanna Skryhan[2], Olga Likhacheva[3], Attila Katona[4], Oksana Maryskevych[5], Viktar Kireyeu[6], Kalev Sepp[1], Iryna Shpakivska[5]

1 Department of Landscape Management and Nature Conservation, Estonian University of Life Sciences, Tartu, Estonia
2 Department, Belarussian-Russian University, Mahilioŭ, Belarus
3 Department of Botany and Plant Ecology, Pskov State University, Pskov, Russia
4 Department of Environmental Sciences and Policy, Central European University, Hungary
5 Department of Ecosystemology, Institute of Ecology of the Carpathians of the National Academy of Science of Ukraine, Lviv, Ukraine
6 Department of Ecological Safety & Sustainable Development of Regions, Saint-Petersburg State University, Saint-Petersburg, Russia

In our research we focused on the barriers to the implementation of enabling environments for water-related NBS in Belarus, Russia, and Ukraine. All the issues that we identified could have been categorised into one of the following groups: (1) standards, blueprints, and regulations, (2) economic considerations, and (3) social and behavioural patterns. This supports the conclusions drawn by the previous literature with respect to the predominance of institutional, governance, social, and economic barriers. There is a high degree of consistency in the responses from all three cities in this study on the importance of these barriers and their interrelations. While these findings generally concur with those of previous studies, they manifest differently because of the differences in the institutional system. Discussing the barriers in terms of the implementation of lessons observed across the EU with respect to NBS, we recognised two additional barriers (by drawing a comparison with the EU), namely (1) low interest in NBS from high political floors and the mostly external character of support to NBS initiatives, with all the shortcomings associated with it, and (2) high levels of corruption comparable to the worst situations (Belarus) or far worse (Russia and Ukraine), that account for some hidden incentives for denying NBS options. Many of the barriers identified are considered difficult to overcome because of their systemic nature, because of how embedded they are within institutional practices, processes, and cultures, and because of the lack of strategies for dealing with such socio-institutional barriers in the region.

Although our approach of combined analysis of the national framework conditions and our in-depth analysis of the case studies does provide a clear understanding of the subject matter, we also realise that this study has its own limitations. A broader range of cases in all three countries would be necessary for a comprehensive understanding of the national and regional enabling environments for water-related NBS.

Nature-Based Solutions to Improve the Comfort of Living in Odessa

Kateryna D. Husieva, Tamerlan A. Safranov
Odessa State Environmental University, 15 Lvivska Str., 65016, Odessa, Ukraine

Topicality. Due to the peculiarities of socio-economic development, an unfavourable environmental situation has been formed in Odessa. The main challenges include: increasing air pollution; lack of quality water supply and efficient wastewater treatment system; incompleteness of coastal protection structures; intensification of dangerous exogenous geological processes; sharpening of the issue of waste management; unsatisfactory condition of the historic city centre, etc. In recent years, Odessa, as well as many cities in Ukraine, has been characterized by a decrease in population, and a high sickness rate and mortality. This necessitates the application of nature-based solutions to increase the comfort of living in this urban environment.

The study is aimed at identification of possible nature-based solutions that will contribute to the comfort of living of the urban population in the studied area.

Research results. The performed structural analysis allowed us to identify an adaptation strategy for the area under study, which should include such measures as: improvement of the healthcare system and social security services; development of environmentally safe recreational and entertainment opportunities; management and support of local health resorts; regulation of atmospheric emissions, waste water discharges and accumulation of municipal solid waste; limitation of fishing and navigation within the recreational zone, etc. One of the priority directions for city development, defined in the Strategic Development Concept 'Odessa – 2022' and the Strategy for Economic and Social Development of Odessa by 2022, – "Environmentally Safe City. City of Healthy People" – envisages provision of environmentally favourable living conditions, improved quality and accessibility of healthcare services and promotion of a healthy lifestyle.

Green areas are a buffer between urban complexes and natural ecosystems. They are effective filters for air purification, reduce wind force, regulate thermal regime, humidify the air, that is of great importance to health. In addition, they refine urban ecotopes and create aesthetic comfort for humans. At the same time, the provision of green spaces for public use in Odessa is only 7.4 m^2 per inhabitant, while the standard is 13.8. The most effective way of expanding green areas is to form a green belt of Odessa, i.e. a system of ecological corridors around the city centre that would connect green space at the coastal slopes with all existing parks, gardens and squares by green links, stripes of boulevards

and streets, and through establishment of new recreation zones instead of abandoned industrial areas.

Conclusions. In view of the adaptation strategy and the challenges of Odessa identified during the study, the current priority areas are: improvement of the air monitoring and protection system; modernization of water supply and drainage systems; introduction of the system for separate collection and recycling of municipal solid waste; urban green belt formation; extended use of alternative energy sources, including solar panels on rooftops and electric vehicles; reconstruction of coastal protection structures and a set of landslide prevention measures at the coastal zone.

The modern method of determining characteristics of the maximum rivers runoff as part multi-functional nature-based watershed management

Valeriya Ovcharuk, Eugeny Gopchenko, Zhannetta Shakirzanova, Maryna Goptsiy, Olena Todorova
Odessa State Environmental University

Corresponding author: Valeriya Ovcharuk, Odessa State Environmental University, 15 Lvivskay Str., valeriya.ovcharuk@gmail.com

In the context of integration of Ukraine into the European Union and in order to implement the provisions of Directive 2007/60/EC on assessment and management of flood risks to ensure development of a flood risk management plan, with transboundary river catchments taken account of, the task is to create methods for preliminary assessment of flood risks, determine the zones of possible flooding of the territories from the sources of origin that belong to various types, including flooding by the river water during the passage of high water levels from flooding rains and spring floods.

The methodology of the preliminary assessment of flood risks is based on the analysis of retrospective events of formation for the notable floods that led to significant negative consequences of water flooding and which correspond to the level of emergency situation, development of a catalogue for such events, generalization of the events for the boundaries of river channels and their floodplains and cartographic representation of the territories within the areas of the river basins in Ukraine that, in accordance with the normative documents, have potentially significant flood risks.

However, over the course of assessment of flood risks, long-term factors such as effects of the climate change are to be taken into account. It is in connection

with the conditions of climatic fluctuations and trends of changes in the water regime of rivers that scientific substantiation for the modern methods of determining characteristics of the maximum runoff in rivers, particularly, those ones which have not been studied in hydrological terms are required to provide determination of the potential territories of probable flooding from floods of various origin, including their formation on small rivers, which are not usually covered by data from hydrological runoff observations. Such a technique, which proposed OSENU for rivers of Ukrainian Carpathian, is to enable methodically grounded determination of the maximum amount of water and flood volume (the spring and the rain ones) of various probability of exceedance, such as 1%, 5%, 10%, 20%, 50% for any river in the territory, with the estimation of the values for the future perspective and the climate change taken account of. In this case, according to the Methodology of Preliminary Flood Risk Assessment, to establish the criteria for determining potential flood risk, a three-tier scale of points for the probability of flood occurrence used - 0,2% (low, not more than once every 500 years), 1% (average, not more than once every 100 years), 10% (high, once every 10 years or more frequently).

Nature-Based Solutions for extreme weather events induced by atmospheric blocking over the Ukraine territory

Lidiia Popova, Inna Khomenko,
Odessa State Environmental University

Society is increasingly impacted by persistent weather and climate related extreme events which can cause significant economic damages and increase mortality. Atmospheric blocking is one example of such persistent weather phenomenon which is often associated with extreme weather events including drought, heatwave, floods and cold air outbreak. It is frequently assumed that blocking initiates various extreme weather events, but Li et al. (2018) showed that atmosphere blocking intensify and sustain the associated extreme weather events across a spectrum of spatial scales and droughts, heatwave and urban heat island feedback in turn amplify blocking via the surface flux balance and radiation budget in a systematic way.

In this study the record-breaking 2015 heat wave in Ukraine was selected as a case study. During this period blocking and drought concurrently also took place. The NCEP/NCAR mean daily reanalysis data is used to detect blocking in the Northern Hemisphere as well as analyze the drought and heatwave connected with the blocking.

The obtained results indicated that high temperatures and the drought is largely contributed by the blocking-induced increasing surface insolation with more days of clear sky, significant subsidence-associated adiabatic warming, light winds and warm-air advection. Thus, it was revealed the atmospheric blocking intensifies the drought and the heatwave.

Under current climate change extreme weather events such as droughts and heatwaves will be more frequent and more intensive over territory of Ukraine (Shevchenko, 2014). Many sectors, but specially agriculture, ecosystems and human health, experience nonlinear increases in impacts and vulnerability during such events. Though impacts extend to other sectors (e.g., infrastructure), and sectors are not independent (Horton et al., 2016). Cities are specially affected by such extreme weather because the urban heat islands will generally enhance heat waves and droughts.

Atmospheric blocking is the most hazardous weather pattern since it is an intensive high-pressure system which exists for a long time and, as confirmed by this study, is accompanied by several anomalous weather events concurrently. To adapt urban and rural territories to extreme events induced by atmospheric blocking it is necessary to embrace both green and blue approaches for reducing risk and overall effects of climate change in human health and ecosystems. And in agriculture the agroecology concept may be applied which creates diversified agroecosystems that mimic natural systems as closely as possible to enhance sustainable production and self-reliance (Sonneveld et al., 2018).

4. Green and blue for smart cities

Transformations in urban-rural continuum: governing conflicting perspectives on landscape quality

Viktar Kireyeu,
Saint-Petersburg State University, Russia;
Matthijs Hisschemöller,
Erasmus University Rotterdam, Netherlands;
Bojana Bojanić Obad Šćitaroci,
University of Zagreb, Faculty of Architecture, Croatia;
Tara Freude,
Leuphana Universität Lüneburg, Germany;
Florian Guerin,
Université de Reims Champagne-Ardenne, France;
Olga Likhacheva,
Pskov State University, Russia;
François Mancebo,
Université de Reims Champagne-Ardenne, France;
Ilenia Pierantoni,
University of Camerino, Italy;
Sylvie Salles,
Ecole Nationale Supérieure de paysage de Versailles, France;
Massimo Sargolini,
University of Camerino, Italy;
Anton Shkaruba,
Estonian University of Life Sciences, Estonia;
Ana Sopina,
University of Zagreb, Faculty of Architecture, Croatia;
Timo von Wirth,
Erasmus University Rotterdam, Netherlands

Transformations in urban-rural continuum influence urban landscape quality as well as quality of life. Some transformations are desirable, such as greener urban landscapes. Some are inevitable, such as those caused by major technological, cultural, and environmental changes (e.g. emergence of landscapes dominated by renewable energy and blue-green infrastructure). Often urban landscape transformations come with conflicts involving many actors, interests and rapidly changing advocacy coalitions. The aim of this study, conducted in the

framework of EU Smart Urban Green project, is to articulate the underlying dimensions through which stakeholders evaluate their immediate environment, identify urban landscape quality features being appreciated the most, find different perspectives influencing the transformations in the urban landscapes, and highlight regional peculiarities.

The research was conducted in six European urban regions: Ancona (Italy), Drechtsteden (Netherlands), Grand Reims (France), Mahilioŭ (Belarus), Pskov (Russia), and Zagreb (Croatia). For the study, we used Repertory Grid Technique (RTG) combined with Multiple Correspondence Analysis (MCA). Throughout the six regions responses indicated strong appreciation of balance in land uses, availability of public green spaces, diversity of green areas in different parts of an urban region, and a good integration of green and blue elements into the city infrastructure. The interviewees were in favor of multi-functionality of urban spaces (when public space suitable for different leisure activities, promenade, etc.) and well developed sustainable public transportation, which makes any part of the city easy to access. There was dissatisfaction with over-planned and over-developed areas. Stony urban landscapes as well as monotonous multi-store residential blocks were perceived as hostile or even aggressive. Our findings also indicate that both in the EU and its eastern neighbors there are signs of transition from perspectives favoring traditional urban planning to those favoring co-creation and natural evolution of urban landscapes.

The main principles of integrated coastal zone management in Ukraine

Maryna Moniushko,
Odessa State Environmental University
e-mail: moniuszko@ukr.net

Today, in the conditions of active environmental management , the problems of providing economic, technogenic and ecological safety, as well as increasing the complex economic-ecological efficiency of using the resource potential of the coastal zone become important. The study of problems associated with the control of marine environmental management in the conditions of worsening economic, ecological and military conflicts is one of the most important tasks in developing the fundamental aspects of changing worldview in education and creating conditions for teaching on an integrated system for managing the coastal strip of the seas of Ukraine.

Ukraine is a maritime power and has access to the Black and Azov Seas - the most closed and distant seas from World Ocean. Compared to other Black Sea states, Ukraine has the longest coastline. The total length of the coastline of the Azov Sea is 1472 km, half of which (732 km) belongs to the coastline of Ukraine. The Ukrainian part of the Black Sea coastline (from the Danube Delta to Cape Takil in the Kerch Strait) is 1628 km. Approximately one third of the coastline (553 km) is attributed to stable or dynamically stable, but generally in the coastal zone is dominated by destructive processes, mainly abrasive. This creates losses of coastal lands, that is estimated to reach approximately 100 hectares each year. The dynamic of the coastline is manifested not only in the form of losses but also in the form of dry land expansion. This expansion occurs as a result of the takeaway by river flows and the deposition of suspended solids (in particular clay and sand minerals) in the delta parts.

The paper considers a number of problems on the way of sustainable development of the coastal zone. The Black Sea coast is constantly under the pressure of increasing population density, urbanization, increasing volumes of maritime transport, coastal erosion and pollution. In past years, as a result of increased tourism and unplanned urbanization in the coastal zone, coastal natural resources have been negatively impacted, that reflected the depreciation of natural landscapes, water quality, the state of beaches, vegetation, and the marine ecosystem. Also, the causes that destabilize the development of maritime territories can be attributed to the negative effects of certain natural factors, such as natural disasters, rising levels related to global climate change, etc. The possibilities of coastal zone development and developing of its resources

largely depend on the general political state of society, the degree of theirs socio-economic development, the level of education of the population, cultural traditions, etc. Therefore, one of the most important principles of integrated coastal zone management is the consideration of the coastal zone as a single natural, economic and social system, thus, the methodology is based on an multidisciplinary approach, that considers all processes in their relationship. In marine spatial planning in coastal and marine areas, it is important to establish what spatial incompatibilities may appear in the water area. The paper presents an assessment of the spatial compatibility of various types of marine uses. In some areas, spatial incompatibility is shown, that is, a situation where different types of uses cannot exist in one space. For example, from a safety point of view, wind farms on the open seas are incompatible with shipping lines; designated areas for fish spawning are incompatible with the extraction of sand and gravel. On the other hand, wind farms in the open sea are spatially compatible with some types of mariculture, since such uses do not interfere with each other. The spatial incompatibilities that grow with the Earth-Sea interaction are also shown, since, for example, coastal tourism, should have an unobstructed view of the horizon for aesthetic purposes.

The problem of balanced use of the Ukrainian coastal strip and the role mechanisms of planning and management in these processes, allows us to make some generalizations:

1) Particular attention should be paid to the study of natural resources and determining the prospects for their further development in the coastal and shelf zones of the Azov-Black Sea basin. This is a complex problem that requires the development of modern hardware and methodological support.
2) It is necessary to create a national oceanographic data bank. Formation of geoinformation system (operational situation assessment and archival data) of the Ukrainian sector of the Black and Azov Seas, that also has a high-resolution satellite-based monitoring unit.
3) Creation of a GIS database that will display cartographic information on the current state of use of marine and coastal resources and which is structured in the following sections: electronic navigation maps, maps of natural resource potential, maps of environmental sensitivity to oil pollution, thematic maps.

Vulnerability and adaptation of the built infrastructure to extreme weather events. Uzhhorod case study

Vladyslava Yatsenko, Inna Khomenko,
Odessa State Environmental University

Global climate change has already had observable effects on the environment. Effects that scientists had predicted in the past would result from global climate change are now occurring: loss of sea ice, accelerated sea level rise, more intense extreme weather events. All these effects of climate change have a significant negative impact on human life, especially in the big city because of the relatively high density of population. Cities located in mountainous area are particularly vulnerable to climate change, tailor-made adaptation measures for mountains should be developed. In such cities built environment is specially affected by climate change. The main potential vulnerability of the built environment to climate change is from extreme events; including floods and storms, and to a lesser extent heat-waves and drought.

In this study indices for extreme events proposed by Sillmann & Roeckner (2007) are used to assess climate change vulnerability of the built environment of Uzhhorod city, situated on the foothills of the Carpathian Mountains region and along the Uzh River. Database includes daily maximum, minimum, mean temperatures and daily precipitation amount.

Recently requency of floods in the Carpathian region of Ukraine has increased because of a significant reduction in water storage capacity of the area due to the reduction of the forested area by 2–5 times (Prykhodko, 2017). Moreover, for period in question the obtained results showed that slight increase in intense rainfall has been observed. All of the foregoing drivers lead to higher frequencies of floods in Uzhhorod. Floods may cause internal and external building damage. Therefore, in Uzhhorod it is necessary to apply some flood protection measures such as using flood resilience technology, sump and pump systems etc.

Compared with the climate normal the number of days with heat waves has increased 2-4 times in recent decades. Intensity and duration of the heat waves have increased. Moreover, during heatwave events, temperatures in city centres can be particularly high since the weather conditions associated with such events – e.g. low wind speeds and cloud-free conditions – also favour the development of the urban heat island effect. High temperatures can result in soil shrinkage and subsidence, particularly in clay soil areas and faster deterioration in concrete. It is not easy to find solutions to these problems, but some recommendation such as keeping trees with high water demand well away from buildings; avoiding variable conditions around the house and maintaining adequate moisture/watering, may be given.

The green infrastructure strategy for Kharkiv water management

Burchenko Svitlana, Maksymenko Nadiya,
V.N. Karazin Kharkiv National University

Kharkiv is located on three main rivers – Lopan, Kharkiv and Udy. All of them belong to the Siverskiy Donets' river basin. This river also is the largest water intake point – the Pechenigy Reservoir.

Given that Kharkiv is a large industrial city, the problem of sustainable use of water resources is important. The city is developing rapidly and there are increasing problems with water regulation. Outdated water, sewer, and storm water systems are not working enough. As a result, we have numerous accidents with excess water consumption, accidental discharges. During rainfall and snowfall, the storm water network does not cope with rainfall and meltwater volumes in almost all areas of the city.

Only technical solutions are quite complicated and expensive, such as the complete replacement of pipe systems. As an alternative to traditional water management systems, green infrastructure offers a cost-effective solution to many of our water woes, including how to handle flooding and storm water pollution.

The Green Infrastructure Strategy plans to achieve the best tool for environmental, economic and industrial use through natural solutions and reducing the amount of "gray" infrastructure often allowed for construction and organization. Therefore, the main goals of green infrastructure strategy for Kharkiv are: reduction of adverse effects of weather conditions; reduction of pollution of city rivers by surface runoff; reduction of water erosion of city soils.

Based on the methodology proposed in [Camino Liquete et al., 2015], it is proposed to base research on the definition of ecosystem services as one of the main criteria for the inclusion of territories in green infrastructure.

The second main criterion to design a GI is the existence and connectivity of ecological networks. All biotic functional groups need core areas where they can find living space, nourishment, nursery, and breeding zones.

5. Green and blue for smart cities

Managing Stormwater Runoff through Implementation of SUDS and Blue-Green Infrastructure: Examples from Scotland and Ukraine

Ganna Titenko[1], Vladimir Krivtsov[2]

[1]V.N. Karazin Kharkiv National University (Ukraine, Kharkiv)
[2]Heriot-Watt University (Great Britain, Edinburgh)

The problems of flood prevention and stormwater pollution are global water security issues that affect scarce water resources, and are particularly acute in the developing world. Stormwater runoff on housing and industrial estates is best tackled using passive landscaping features. The available techniques include e.g. grass filter strips, filter drains, swales, raingardens, retention ponds, permeable pavements, detention basins and green roofs, among others. Application of these techniques is central for the sister concepts of Low impact Development (LID), Sponge Cities, Water Sensitive Urban Design (WSUD), Blue-Green Infrastructure (BGI) and Sustainable Drainage Systems (SUDS). Installation of SUDS on new developments is compulsory in the UK and a number of other developed countries, but the legislation and standard practices in Eastern Europe and in the developing world are often lagging behind. Furthermore, the existing developments in the UK often lack such features, and their retrofit is subject to a number of technical and socio- economic barriers (1, 2). Recent research in the UK has improved our understanding of these barriers and associated opportunities, thus contributing to the progress towards the Global Water Security and achieving Sustainable Development Goals (SDGs).

According, to the current legislation, all the new developments in Scotland must have SUDS. The developers appear to be aware of that, but often go for installation of a limited number of features (e.g. permeable pavements in industrial estates; permeable pavements, and/or swales and basins in housing estates) largely ignoring other possibilities. About 75% of companies do not appear to know about the rules regulating pollution prevention and SUDS installation (1). Furthermore, there appears to be confusion with understanding SUDS purpose, benefits and technology (3).

It should be noted that in addition to the alleviation of water quality problems, SUDS retrofits also contribute to the establishment of a healthy BGI network (4, 5). When properly implemented, the BGI network provides a number of additional benefits, including biodiversity and amenity values, as well as helping to decrease the runoff

intensity thus alleviating flood risk. Combination of sound science, knowledge and experience exchange, appropriate policies, and practical use of scientific findings and recommendations by the practitioners will be necessary for further progress towards eradication of these problems. Considering the above, further efforts in Ukraine and other Eastern European countries should first of all concentrate on a combination of comparative studies and knowledge transfer related to all aspects of Blue-Green Infrastructure. Ukraine in general, and Kharkov Region in particular, have substantial experience in pollution prevention and water resources modelling and management - see e.g. (6-8) and references therein. However, much of this experience is documented only in grey literature and has not been disseminated via online-searchable journals. It should also be noted that some of the existing infrastructure is becoming outdated (9). Our presentation will aim to highlight a number of potential opportunities and initiate further discussion related to issues of water resource management and BGI developments.

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Smart green development context and urban regeneration of the city /Khovd/ Mongolia

B.Bayarkhuu, D.Nyamdorj,

Khovd State University, Mongolia

Mongolia is the world's 18th-largest country. Its square is 1,564,116 km^2

The Government of Mongolia has identified improving the resilience of communities to the impacts of climate change and transitioning to a greener development pathway as priorities in its National Green Development Policy (NGDP). Mongolia's energy sector is highly dependent on fossil fuels with over 90% of heating and electricity derived from coal. The resulting soil and air pollution is particularly acute in the peri-urban areas of Ulaanbaatar and other secondary cities, where poverty exceeds the national rate of 27%. Mongolia has therefore made commitments to increase renewable energy generation and improve urban planning and resilience in its NGDP and Action Plan, NDCs and Sustainable Development Vision 2030. While the supporting policy environment has improved, implementation and financing to address these challenges remain well below the levels needed to transition to inclusive green growth.

The "Smart and Green Development" is central theme, converging the two movements that have fundamentally transformed and will continue dominate the urbanization and planning sphere.

Prestige nature in the most part of Khovd aimg is well preserved, and the aimag is rich with natural resources and abundant renewable energy sources. Strong commitment and advantages create a unique opportunity to follow the green and smart development.

Khovd city is prone to climate change hazard due to its natural and climatic specifics. These include low fertility, large expanse of semii desert areas with arid climate, limited precipitation and increasing air temperatures exceeding the national average increase. Such natural features and other challenges well justify the choice for green and smart development.

Green development program will be implemented in the two phases. Outputs of green development:

- The GHG emission will be reduced over 15 percent of the baseline level
- Energy loss will be insulated
- Will be increased clean technology application, recycling of wastes, saving and reuse of natural resources
- Environmentally-friendly infrastructure network will be established

- Urban green infrastructure will change and increase plant species using in urban area
- Increase recreational area of urban
- Use river bank for recreation and its possibilities.

Improvement of the aquatic environment in Lviv Urban Systems through landscape planning

Yuriy Shandra, Volodymyr Shushniak

Ivan Franko National University of Lviv, Geography department

The city of Lviv is the area of the greatest concentration of water problems within Ukraine. The location of the city on the Main European Watershed, almost millennia-long exploitation of groundwater, main waterway transformation (the Poltva River) into a wastewater collector led to the death of many water bodies, which in turn transformed the components of the water balance. Rainwater and meltwater flow directly into the sewage system, although it is a multifunctional valuable resource that can be used rationally.

On the example of the Kleparivsky stream catchment area, we demonstrated the possibilities of a landscape planned approach to improve the aquatic environment of the Lviv city urban systems. The studies included: 1) analysis of landscape - hydrological features of the territory; 2) analysis of underground and surface water runoff transformation due to urban modification of landscape complexes; 3) solutions development for landscape planning structure optimization.

Substantiated according to the results of the research: 1) the importance of creating a landscape-hydrological reserve at the top of the Kleparivsky Stream; 2) purification possibility of surface water runoff; 3) ways of additional water supply providing to the reservoir on Pancha Street.

6. Urban health and pollution

Application of membrane technology to reuse wastewater from car wash stations in Hanoi – a case study

Khac-Uan Do[1], Hoang-Nam Nguyen[2], Xuan-Quang Chu[3]

[1] School of Environmental Science and Technology, Hanoi University of Science and Technology, Hanoi, Vietnam, uan.dokhac@hust.edu.vn
[2] Department of Environment, Hanoi University of Mining and Geology, Hanoi, Vietnam
[3] Center for Advanced Materials Technology, National Center for Technological Progress, Hanoi, Vietnam

Car wash service stations play a very important role in maintaining vehicles and keeping them in good condition. Washing activities may include, removal of coarse material, debris and dust using high pressure cleaning water and detergent mixture. Lot of water is wasted daily for the vehicle washing and servicing. High amounts of the organic polutants in the car wash wastewater cause a dissolved oxygen depletion in the receiving stream. In this study, a lab-scale membrane bioreactor (MBR) system with the ferrous sulfate ($FeSO_4.7H_2O$) addition was conducted to treat oily wastewater from a car wash station. The system was operated for over 120 days, in which 60 days of the stabilized phase and 60 days for the $FeSO_4.7H_2O$ addition. Based on the effluent characteristics of the system, the removal efficiencies of higher than 90% of chemical oxygen demand (COD) and 70% oily and grease (O&G) without the chemical addition. Subsequently, 98% COD and 93% O&G removal efficiencies with the chemical addition were obtained. The recalcitrant components were removed by the polishing effect of the $FeSO_4.7H_2O$ addition. Interestingly, adding $FeSO_4.7H_2O$ into the MBR system could be helpful in minimization of membrane fouling because the relative small particles, which are considered as a cause of the membrane fouling, could became bigger particles having less fouling tendency. A long operating period without the membrane fouling was achieved when $FeSO_4.7H_2O$ was added into the MBR system. The results of this study pointed out that the oily wastewater from the car wash station could be treated effectively by the MBR system combined with the chemical addition. The MBR system has a good potential for scaling up and is very promising alternatives for water reuse from the car wash station.

Keywords: oily wastewater, ferrous sulfate, membrane bioreactor, membrane fouling, water reuse.

Microalgae-based CO_2 sequestration solutions for Urban air pollution

Doan Thi Thai Yen ,Yen Doan

*School of Environmental Science and Technology, Hanoi University of Science and Technology, Vietnam. *Contact email: yen.doanthithai@hust.edu.vn*

Climate change is a real problem that becomes worse due to the increase of carbon dioxide emission in many countries all over the world. The solution of planting trees to take CO2 out of the air is working but it's not enough. Microalgae-based CO2 sequestration solution is use green microalgae to do the same jobs that trees do, buy way more efficiently, especially inside buildings or industrial zones. For microalgae to do the photosynthesis, they need to uptake CO2, which can help to sequestrate CO2 and indoor pollutant gases as well. When the microalgae consume carbon dioxide, it produces biomass which could be used in making bio-oils, fertilizers, bio-plastic or cosmetics, etc. A smart city could take the microalgal biomass and use it for fuels and others. In this paper, current integrated applications of microalgae for building inside and envelops will be displayed. Such concept opens various opportunities with mutual benefits for high performance-built environments, CO2 bio-fixation and cellular growth. Firstly, for green building design, the algae-facade has been integrated for building architect. The demonstrations are BIQ Building Hamburg and Marina city tower, Chicago. Secondly, microalgae-based CO2 sequestration solutions are performed in indoor machines/systems which could use the power of microalgae to fight urban pollution. For example, BioUrban, an air purification system like an algal tree, was created by Biomitech company for coupling with Mexican most pollution. In present, the second version of the machine has been developed and company's vision is to plant a BioUrban 2.0 'microalgae trees' in the UK, beginning in London. Besides the algal tree, the algal pictures or algal lamps have been developed recently to remove not only CO2 but also other pollution gases of indoor air. In this paper, the findings from our studies, such as CO2-absorption efficiency, types of indoor bioreactors, microalgae species, etc. are also presented. In additional of screening the application of microalgae-based CO2 sequestration solution and the prospective of current applications, the paper also points out the challenges when implicating. The algae-based solution demonstrates that algae can be integrated with buildings and house facilities and coupled with mitigation of air pollution. The benefits of the microalgae solutions through the combination of the technical and biological cycles within buildings become an innovative approach to sustainability by integrating environmental, energetic, and iconic values. Key words: microalgae-based solution, Estimation of the parameters of stormwater runoff from the territory of the Lviv city at the inlet of the municipal wastewater treatment plant.

The effects of meteorological factors on $PM_{2.5}$ and O_3 in an urban site in Hanoi

Bich-Thuy Ly[1,*], The-Anh Vu[1] and Huong Pham Thi[1], Yukata Matsumi[2], Yoshizumi Kajii[3], Yusuke Sakamoto[3], Trung-Dung Nghiem[1], Thu-Hien Nguyen[1]

[1]School of Environmental Science and Technology,
Hanoi University of Science and Technology, Hanoi, No.1 Dai Co Viet Street, Vietnam
[2]Institute for Space-Earth Environmental Research, Nagoya University,
Nagoya, Aichi, 464-8601, Japan
[3]Graduate School of Global Environmental Studies,
Kyoto University, Yoshida-Honmachi, Sakyo-ku, Kyoto, 606-8501, Japan

Corresponding author. Tel: + 84-4-38681686; Fax: + 84-4-38693551
E-mail address: thuy.lybich@hust.edu.vn

$PM_{2.5}$ and O_3 are serious air pollutants in Hanoi. It is observed that levels of $PM_{2.5}$ and O_3 in Hanoi varied largely up to hundred μg/m^3. The reason for large variation of the levels of $PM_{2.5}$ and O_3 is still under discussion. In this study, the effects of meteorological conditions on $PM_{2.5}$ and O_3 in an urban site in Hanoi are investigated by regression analysis. Daily levels in that day or/and previous day of relative humidity, wind speed, mixing height, and rain have significant correlation ($p<0.05$) with $PM_{2.5}$ levels. Whereas daily levels in that day or/and previous day of radiation, temperature, rain, wind speed, mixing height, pressure, relative humidity have significant correlation ($p<0.05$) with O_3 levels. The selected meteorological factors can explain for 50% variation of $PM_{2.5}$ in wet winter, 2017 and 64% and 54% in dried winter, 2016, 2017, respectively. And the selected meteorological factors can explain for 59%, 76%, 62%, 54% and 65% in dry winter 2016, 2017, humid winter 2016, summer 2016, 2017. $PM_{2.5}$; O_3; meteorological conditions

Solutions in Microalgae-based CO_2 sequestration for mitigating Urban air pollution

Doan Thi Thai Yen*, Pham Van Hoang, Le Van Duong, Nguyen Tan Lap
School of Environmental Science and Technology,
Hanoi University of Science and Technology, Vietnam.
*Contact email: yen.doanthithai@hust.edu.vn

Climate change is a real problem that becomes worse due to the increase of carbon dioxide emission in many countries all over the world. The solution of planting trees to take CO_2 out of the air is working but it's not enough. Microalgae-based CO_2 sequestration solution is use green microalgae to do the same jobs that trees do, buy way more efficiently, especially inside buildings or industrial zones. For microalgae to do the photosynthesis, they need to uptake CO2, which can help to sequestrate CO_2 and indoor pollutant gases as well. When the microalgae consume carbon dioxide, it produces biomass which could be used in making bio-oils, fertilizers, bio-plastic or cosmetics, etc. A smart city could take the microalgal biomass and use it for making fuels.

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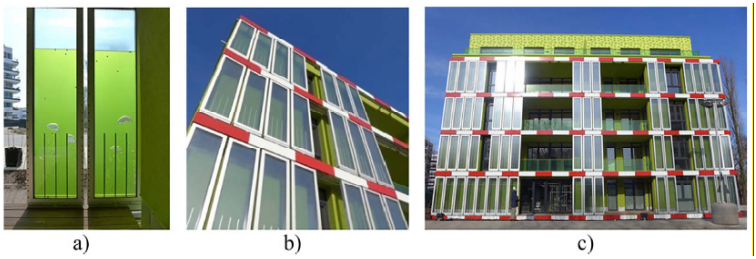
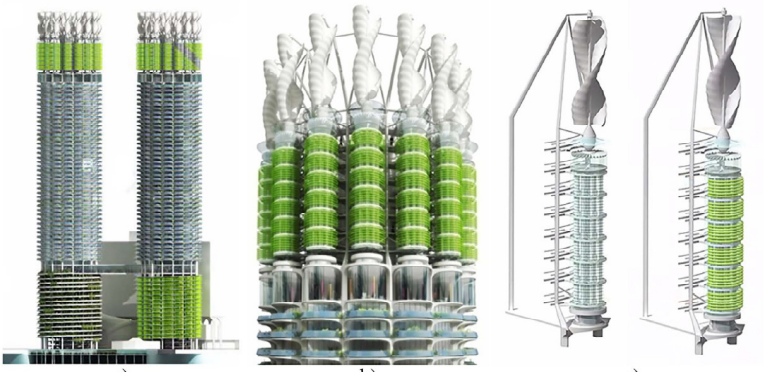
Key words: microalgae-based solution, green building, algal tree, CO_2 sequestration, indoor-air

Graphic abstract:



a) b) c)

Fig1. The BIQ building, the first algae-powered building in the world by Arup, Germany [1]



a) b) c)

Fig. 2. The Marina City tower, Chicago, US. [2]

Fig.3. Algae CO2 sequestration for both indoor or outdoor application [3, 4]

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Інститут екології Карпат
вул. Козельницька, 4, м. Львів, 79026
Державний природознавчий музей
вул. Театральна, 18, Львів, 79000