

# **3<sup>RD</sup> INTERNATIONAL CONFERENCE ON WATER MANAGEMENT AND ITS SURROUNDINGS THEORETICAL AND PRACTICAL ASPECTS**

**17<sup>TH</sup> – 18<sup>TH</sup> MAY 2023**

**UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN  
FACULTY OF GEOENGINEERING**

## **ABSTRACT BOOK**

### **HONORARY AUSPICES**



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prof. Paweł Wielgosz, Vice-Rector for International Affairs University of Warmia and Mazury in Olsztyn, Poland

assoc. prof. Elżbieta Zębek, University of Warmia and Mazury in Olsztyn, Poland

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14. Aneta Omelan
15. Renata Tandyrak

### HONORARY AUSPICES



## PRELIMINARY CONFERENCE PROGRAMME

WEDNESDAY, MAY 17<sup>TH</sup>

### Official opening of the conference and welcome speeches of invited guests

Chair: Agnieszka Dawidowicz

### Plenary session

1. **Agnieszka Dawidowicz**, Małgorzata Dudzińska (*University of Warmia and Mazury in Olsztyn, Poland*) Blue and green infrastructure in Olsztyn.
2. **Renata Augustyniak-Tunowska, Jolanta Grochowska, Renata Tandyrak, Michał Łopata** (*University of Warmia and Mazury in Olsztyn, Poland*) Professor Przemysław Olszewski – pioneer of lake restoration in Poland
3. Adam Senetra, Anna Żróbek-Sokolnik, Piotr Dynowski, **Marta Czaplicka** (*University of Warmia and Mazury in Olsztyn, Poland*). Underwater landscapes perception in terms of sight-aesthetic values – survey results
4. **Jörg Schlenstedt** (*Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft (LMBV mbH), Senftenberg, Germany*) Sustainable mining rehabilitation in a changing climate – Challenges in forestry/agricultural reclamation of dump sites and restoration of water regimes disturbed by mining
5. **Grzegorz Rachlewicz** (*Adam Mickiewicz University, Poznań, Poland*) Hydrological problems of the high Arctic – examples from Spitsbergen (Svalbard)

### coffee break and special program

### Keynote session I Sustainable development.

Chair: Krystyna Kurowska

1. **Jolanta Valčiukienė**, Daiva Juknelienė (*Vytautas Magnus University, Agriculture Academy, Kaunas Lithuania*) The ecological stability of the landscape in Lithuania
2. **Engida Gebre**, Kusse Haile, Girum Tenkir (*Mizan Tepi University, Mizan Aman, Ethiopia*) Is crop diversification beneficial to smallholder household food security: an empirical evidence from cash crop dominated areas of southwest Ethiopia
3. **Adam Dosekocz**, Jan Kuryj (*University of Warmia and Mazury in Olsztyn, Poland*) Analysis of waters flowing through the Trzcianiec, which are a tributary of the Wiar River
4. **Tojiddin Juraev** (*Institute of Natural Resources Management of the NRU "TIAME", Bukhara, Uzbekistan*) Conceptual Design in Rural Developing by Geometric Modeling
5. **Afshin Mottaghi**, Kamran Jafarpour Ghalehtemouri, Mosayeb GharehBeyg (*Political Geography, Kharazmi University, Iran*) Water resources economic scenarios and transboundary hydro-political concerns in Iran's eastern border areas
6. **Aziz Cumhur Kocalar** (*Niğde Ömer Halisdemir University, City and Regional Planning*) The faults of water resource management applications in Turkey-Niğde province agricultural fields

**Keynote session II Environmental disasters: legal and environmental consequences**

Chair: Anna Klimach

1. **Agnieszka Napiórkowska-Krzebietke** (*IRS-PIB, Olsztyn, Poland*) Causes and ecological consequences of the disaster in the Oder River
2. **Elżbieta Zębek** (*University of Warmia and Mazury in Olsztyn, Poland*) Legal consequences and remedial actions for damages caused in the water environment during the ecological disaster in the Oder River
3. **Anna Klimach** (*University of Warmia and Mazury in Olsztyn, Poland*) Katarzyna Bagan-Kurluta (*University in Białystok, Poland*) Can transmission facilities be built on land covered by flowing surface water in Poland?
4. **Abdullahi Alhaji Aliyu**, M. B. Banki, H. D. Musa, A. M. Kawu (*Federal University of Technology Minna, Nigeria*) Flood disaster vulnerability factors of the communities in the southern region of Niger state, Nigeria
5. **Abdullahi Alhaji Aliyu**, M. Dalil, J. J. Dukiya, E. T. Umaru (*Federal University of Technology Minna, Nigeria*) Flood trend and livelihood implications of the communities in the southern region of Niger state, Nigeria
6. **Kamran Jafarpour Ghalehtemouri**, Faizah Che Ros, Shuib Rambat (*Malaysia – Japan International Institute of Technology (MJIT) Universiti Tekno, Kampung Datuk Keramat, Kuala Lumpur, Wilayah, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra*) Assessment of pre-flood and Post-flood during rapid flash flood tragedy in Kuala Lumpur, Klang Valley Region 16 December 2021: An analysis based on the NASA-Landsat satellite

**Lunch break and special programme**

**Poster session.**

**THURSDAY, MAY 18<sup>TH</sup>**

**Keynote session III Water in post-mining and urban landscapes. Rising Sea Level.**

Chair: Anna Ostręga

1. **Anna Ostręga**, Anna Szewczyk-Świątek (*AGH University of Krakow, Poland*), Wojciech Świątek (*Cracow University of Technology, Poland*) The potential of the complex of post-gravel reservoirs in the Tarnów subregion (Poland) – analysis of the reasons for not carrying out the expected project
2. Kazimierz Rózkowski, Paulina Bańbuła, **Wojciech Bryś**, Anna Ostręga (*AGH University of Krakow, Poland*) Changes to the hydrographic network in the Brandka (WS-47 pond in city of Bytom) subsidence reservoir vicinity as a consequence of mining activity – consequences and challenges
3. **Muharrem Hilmi Erkoç**, Uğur Doğan (*Yildiz Technical University, Istanbul, Türkiye*) Changes in Sea Level Along the Black Sea Coastline: Performance Evaluation of the Mann-Kendall Trend Analysis Method
4. **Dogan Ugur Sanli**, Ece Uysal, Deniz Oz Demir, Huseyin Duman (*Yildiz Technical University, Istanbul, Türkiye*) Assessing the Performance of Annual GNSS Campaigns for the Management of Rising Sea Levels

**Keynote session IV Water recreation – linking people and nature**

Chair: Sylwia Kulczyk

1. **Zsombor Boromisza** (*Hungarian University of Agriculture and Life Sciences, Hungary*) Climate risk of shallow touristic lakes: a case study of Lake Velence (Hungary)
2. **Marta Derek**, Sylwia Kulczyk (*University of Warsaw, Poland*). How to use the concept of Cultural Ecosystem Services for tourism and recreation planning in Mazuria?
3. **Ilona Potocka** (*University of Adam Mickiewicz, Poznań, Poland*) Tourism lakescape – tourism potential of landscape of water space and its surroundings.
4. **Julia Cymerys**, Sandra Szmigel, Grażyna Furgała-Selezniow (*University of Warmia and Mazury in Olsztyn, Poland*) Tourist function of the shore zone of the łańskie, Pluszne, Wulpińskie and Ukiel lakes
5. **István Egresi**, Bianca Sorina Răcășan (*Babeș-Bolyai University Cluj-Napoca Romania*) Inland water resorts: Main motivations to visit and satisfaction with the experience (Case study: Băile Figa, Romania)
6. **Zsofia Turnai**, Bernadett Horváthné Kovács (*Hungarian University of Agriculture and Life Sciences, Kaposvár, Hungary*) Impact of accessing tourism subsidies on related service development in Somogy County, Hungary- regional study

**Coffee break and special programme**



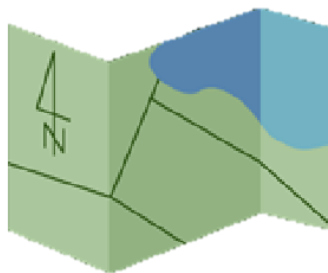
**Keynote session V Engineering and environment protection.**

Chair: Katarzyna Bernat

1. **Agnieszka Renman**, Johan Wikström, Gunno Renman (*KTH Royal Institute of Technology, Stockholm, Sweden*). Treatment of phosphorus-loaded lake by closed-circuit hypolimnetic withdrawal through filter media
2. Agnieszka Renman, Johan Wikström, **Gunno Renman** (*KTH Royal Institute of Technology, Stockholm, Sweden*). Capping with calcium-silicate sorbent for reduction of sediment-to-water fluxes of phosphorus
3. **Iwona Józefowicz**, Hanna Michniewicz-Ankiersztajn, Mirosław Rurek (*Kazimierz Wielki University, Bydgoszcz, Poland*). Functions of blue spaces of anthropogenic origin in cities - the example of Bydgoszcz
4. **Frederico Aragão**, Tom Jilbert, Gunno Renman, Agnieszka Renman, Leena Nurminen (*University of Helsinki, Finland*). Phosphorus retention mechanisms under a comparative performance analysis of Polonite and Rådasand for the treatment of hypolimnetic water of Lake Hönsan, Sweden
5. **Paulina Rusanowska**, Marcin Zieliński, Marcin Dębowski, (*University of Warmia and Mazury in Olsztyn, Poland*). Effect of addition of extracellular polymers from activated sludge to culture of cyanobacterial biomass *Arthrospira platensis*
6. **Zebo Babakhanova**, Gozal Tolipova, Odinakhon Faziljanova (*Tashkent Institute of Chemical Technology*) The Aral Sea crisis as an urgent need to improvement of the water resources management system in Central Asia

**Poster session**

**CONFERENCE SUMMARY**



## **PLENARY SESSION**

**CHAIR: AGNIESZKA DAWIDOWICZ**

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## **BLUE AND GREEN INFRASTRUCTURE IN OLSZTYN**

*Agnieszka Dawidowicz, Małgorzata Dudzińska*

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Management and Geography*

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Olsztyn is a unique city in Poland due to its location among forests and lakes. Within Olsztyn's borders, there are more than a dozen lakes and one of the largest parks in Europe - the City Forest. These assets make Olsztyn considered a "garden city" according to Howard's concept.

The vision of the garden city refers to the natural values of today's capital of Warmia and Mazury, but above all it represents the identity of Olsztyn, the historical capital of Warmia, which has been shaped over the centuries. Nowadays the region of Warmia and Mazury contains the highest number of nature reserves in Poland and is known as the "Land of a Thousand Lakes" (only within the administrative boundaries of Olsztyn there are 15 lakes which occupy 10% of the city's total area) and the "Green Lungs of Poland" (being the region with the highest forest coverage in Poland).

Management of such a city and its assessment in terms of quality of life and friendliness requires active monitoring of needs as a result of public consultation and management of spatial data. In support of these activities, a diagnostic of the open spaces of residential areas in Olsztyn in terms of their infrastructural and landscape friendliness to its residents was carried out. A survey was carried out in 2021. The results of the study show that regardless of the diversity of housing estates, most of them received a high rating precisely due to the availability of blue and green infrastructure, which are particularly important criteria affecting the quality of life and health of residents.

Keywords: blue and green infrastructure, GIS, real estate housing, public open space, city

**PROFESSOR PRZEMYSŁAW OLSZEWSKI – PIONEER OF LAKE  
RESTORATION IN POLAND**

*Renata Augustyniak-Tunowska, Jolanta Grochowska, Renata Tandyrak, Michał Łopata*

*University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Department of  
Water Protection and Environmental Microbiology*

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Prof. Przemysław Olszewski (1913- 1972), creator of Olsztyn limnological school, was influential limnologist - a graduate of the Jagiellonian University, who started limnological research in Olsztyn and actively participated in the creation of the Faculty of Fisheries of the University of Agriculture in Olsztyn. He initiated limnological studies of the Tatra lakes. After World War II, he had arrived to Olsztyn, and he directed limnological studies of Masurian lakes in the Department of Limnology, headed by him. However, he became famous in the world primarily as the creator of the concept of the first method of lake restoration in a technical scale - the hypolimnetic withdrawal method, also known as the "Kortowo method". The installation, often called the "Olszewski's pipe", started operating in 1956 on Lake Kortowskie. Olszewski's method was simple and, most importantly, this technical solution was cost-competitive. The Kortowo method has been implemented on many lakes around the world. The pipeline on Lake Kortowskie is still in operation today, making it the longest-running method of lake restoration in the world. The research on lake restoration is continued by the Department of Water Protection and Environmental Microbiology at University of Warmia and Mazury in Olsztyn.

Keywords: limnology, lake restoration, hypolimnetic withdrawal

## **UNDERWATER LANDSCAPES PERCEPTION IN TERMS OF SIGHT- AESTHETIC VALUES – SURVEY RESULTS**

*Adam Senetra, Anna Żróbek-Sokolnik, Piotr Dynowski, Marta Czaplicka*

*University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Department of  
Socio-Economic Geography  
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The assessment of landscapes is one of important aspects in the processes of studying tourist exploration and human activities triggering transformations of the underwater environment. It mostly enables to determine the attractiveness and choice of the area by tourists on the basis of the sight-aesthetic attractiveness of the area. Research on underwater landscapes and the sight-aesthetic assessment of them to date is very scarce and mainly concerns seas and oceans, not covering the inland bodies of water.

The aim of the study was to assess the sight-aesthetic value of inland bodies of water with the use of a developed point valuation method and a set of factors affecting it for the purposes of exploration tourism.

A questionnaire for assessing the sight-aesthetic value of underwater landscape of lakes was conducted among scuba divers from scuba diving centres and clubs in Poland. It implemented the direct comparison method described by Kendall, applied in the methodology for the assessment of terrestrial landscapes.

According to respondents, the most attractive elements of the aquatic environment are animals and submerged anthropogenic objects. The conducted study proved that landscape values are a significant factor in selecting components for exploration tourism and that there is a need for further research. The obtained results could be afterwards use to generate map of attractiveness of lakes for the purposes of underwater tourism.

**Keywords:** underwater landscape, perception, sight-aesthetic value, lake, point valuation method, questionnaire surveys

**SUSTAINABLE MINING REHABILITATION IN A CHANGING CLIMATE -  
CHALLENGES IN FORESTRY/AGRICULTURAL RECLAMATION OF DUMP  
SITES AND RESTORATION OF WATER REGIMES DISTURBED BY  
MINING**

*Jörg Schlenstedt*

*Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft (LMBV mbH)*

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Lignite mining has profoundly changed landscapes, natural areas and the water balance in Lusatia. The LMBV has been recultivating the areas of the former GDR lignite mining industry for almost 30 years. The increasingly noticeable effects of climate change require adjustments in recultivation procedures and have an impact on the water balance and thus on the resulting mining lakes. The targeted management of the available water is becoming increasingly important.

Keywords: sustainability, mining rehabilitation, water regime, climate change

## **HYDROLOGICAL PROBLEMS OF THE HIGH ARCTIC – EXAMPLES FROM SPITSBERGEN (SVALBARD)**

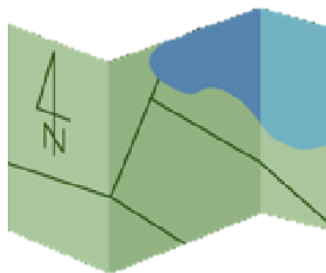
*Grzegorz Rachlewicz*

*Adam Mickiewicz University, Faculty of Geographical and Geological Sciences, Cryosphere  
Research Unit*

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The increased intensity of global warming in recent decades, particularly visible in the polar regions, implies a number of environmental effects, marked by the impact on the sensitive system of the cryosphere. Surface snow and ice resources, as well as dynamically reacting permafrost, are subject to limitation. This entails fluctuations in discharge from land with high variability, intensification of above-average processes, reduction of water storage affecting the current state and future of Arctic landscapes. The effects of these phenomena are shown on the example of changes observed in the geoecosystems of Svalbard, studied there locally and regionally by Polish scientists.

Keywords: cryosphere, hydrology, climate change, Spitsbergen, Arctic



## **KEYNOTE SESSION I SUSTAINABLE DEVELOPMENT**

**CHAIR: KRYSTYNA KUROWSKA**

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## **THE ECOLOGICAL STABILITY OF THE LANDSCAPE IN LITHUANIA**

*Jolanta Valčiukienė, Daiva Juknelienė*

*Vytautas Magnus University Agriculture Academy, Faculty of Engineering, Department of  
Land Use Planning and Geomatics  
e-mail: jolanta.valciukiene@vdu.lt*

Ecological stability of the landscape is an important indicator for supporting sustainable development-driven policies and suggesting associated decisions in land management. This study used CORINE Land Cover data to estimate the changes in ecological stability of the landscape in Lithuania since 1995. All the land cover types were ranked according to naturalness level, ranging from purely anthropogenic to natural landscapes. Spatial patterns of the increase or decline in landscape naturalness were investigated at the level of municipalities. Then, publicly available geographic data were mobilized to explain the reasons behind the trends observed. A minor increase in land cover naturalness in the whole area of Lithuania was observed; however, this increase was statistically insignificant. Nevertheless, statistically significant clusters with both increasing and decreasing levels of landcover naturalness were identified when moving to the level of municipalities. The trends in the development of ecological stability of the landscape and its naturalness were associated with the specificity of agricultural and forestry activities in the municipalities. The suitability of lands for agriculture due to soil, terrain, current land use specifics, and related drivers, such as the availability of land reclamation installations and the intensity of land use, were the main drivers for the declining level of land cover naturalness, usually concentrated in northern and central Lithuania. The ecological stability of the landscape did increase in less suitable areas for agriculture, i.e., in the more forested southeastern municipalities. The study emphasised the need for a systematic and spatially explicit monitoring of the land cover patterns and their changes as well as elaborated proposals for land management policies over the next decade, which were mostly in the line with current European Union and national strategies.

Keywords: land cover, CORINE, ecological stability, land cover change



**IS CROP DIVERSIFICATION BENEFICIAL TO SMALLHOLDER  
HOUSEHOLD FOOD SECURITY: AN EMPIRICAL EVIDENCE FROM CASH  
CROP DOMINATED AREAS OF SOUTHWEST ETHIOPIA**

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*Mizan Tepi University, College of agriculture and natural resources management, Agricultural  
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Crop diversification refers to the practice of growing more than one type of crop to address household food insecurity problems. As a result, this study aimed at examining the factors that influence smallholder farmers' crop diversification decisions and its effects for household food security in southwest Ethiopia. A total of 323 households were taken from four different zone found in southwest Ethiopia through multistage sampling technique. Herfindahl Index for measuring crop diversification was used. Crop diversification and the outcome variable were estimated by a conditional mixed recursive (cmp) approach that corrects selectivity bias. The study result indicates that the largest share of land is allocated to cash crop production. The mean diversification index in the study area was found to be 0.588. The model result indicates that household's decision to diversify crop and its extent was affected significantly by family size, educational level, livestock other than oxen, cooperative membership, distance from development agent, extension contact frequency land holding. Also, crop diversification was positively associated with household food security in addition to other common factors which affect them simultaneously. Generally, the study result indicates that growing of diverse crop is important for smallholder farm households to assure food security of their family member. Therefore, the study conclude that any attempts to enhance household food security should include farmer empowerment through rural infrastructure development; strengthen different supportive institution; delivering of proper training in relation to management of various crop production and strengthening of adult education.

Keywords: crop diversification, food security, herfindahl index, conditional mixed recursive, Southwest Ethiopia

**ANALYSIS OF WATERS FLOWING THROUGH THE TRZCIANIEC, WHICH  
ARE A TRIBUTARY OF THE WIAR RIVER**

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In the works is presented analysis of waters flowing through a village Trzcianiec located in the south-eastern Poland (in the administrative district of Gmina Ustrzyki Dolne, within Bieszczady County, Subcarpathian Voivodeship). The authors referred to available cartographic sources and used official geoportals and GIS solutions. The paper also discusses the technical aspects of the analysis, as well as practical issues and legislative changes in this area.

Keywords: waters of the Trzcianiec, tributary of the Wiar River, practical and legislation aspects

## **CONCEPTUAL DESIGN IN RURAL DEVELOPING BY GEOMETRIC MODELING**

*Tojiddin Juraev*

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The article is devoted to the application of geometric modeling in the design of building structures and engineering systems. The article provides a solution to the problem of developing the concept of a mobile agricultural settlement by justifying the use of geometric modeling methods. The proposed concept is innovative, as it provides a comprehensive solution to socio-economic problems. The analysis of the state of the problem was carried out, as well as the implemented projects and foreign experience over the last 50 years was studied. The Bukhara region of the Republic of Uzbekistan is considered as an example. An agricultural settlement intended for the cultivation of fruit and vegetable products was chosen as the object of modeling. The simulated object as a system is divided into elements and each element is modeled separately and all elements in the aggregate based on intra-system relationships. This approach makes it possible to ensure the mobility of each element and the entire system. In the proposed concept, the living area, the vegetable garden, as well as fences are mobile elements. Therefore, modeling is performed on these elements. The simulation was performed by operating with geometric parameters, namely the shape, position and dimensions of the system elements. Possible variants and various combinations of mobile elements according to geometric parameters are proposed, allowing the effective operation of this system.

Keywords: concept, geometric modeling, land plot, mobility, geometric parameters

**WATER RESOURCES ECONOMIC SCENARIOS AND TRANSBOUNDARY  
HYDRO-POLITICAL CONCERNS IN IRAN'S EASTERN BORDER AREAS**

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Since the main sources of some rivers are located in neighboring countries, the hydrological issues in the eastern part of Iran are critical. This study is the use of a positive mathematical programming approach to evaluate the consequences of an increase in water price, cropping pattern, and efficiency enhancement (reduction of water consumption) under various scenarios. The study also evaluates the characteristics of two groups of operators (operators of lands covering less than 5 hectares and operators of lands covering more than 5 hectares) and compares the results of the linear programming model with those of the positive mathematical programming model. The outcomes of scenarios involving an increase in water prices and a decrease in water consumption are evaluated using the positive mathematical programming approach. The study's originality lies in its application of the positive mathematical programming approach to the agricultural sector, specifically in evaluating the impact of water pricing policies on crop selection and irrigation water use. Using quadratic cost function calibration, three scenarios of water resource reduction (30%, 40%, and 70% reduction for farmers in group 1 and 10, 25, and 75% reduction for farmers in group 2) and price increase (increases of 70%, 80%, and 100%) were developed. The percentage for group 1 farmers and increases from 75%, 80%, and 100% for group 2 farmers were investigated. The calibration of the quadratic cost function revealed an increase in irrigation efficiency (reduction of water resources) as well as an increase in the region's cultivated area of water crops.

**Keywords:** water resources, economic scenarios positive mathematical programming, Iran

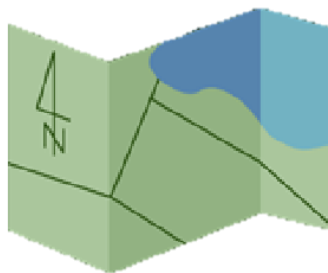
## **THE FAULTS OF WATER RESOURCE MANAGEMENT APPLICATIONS IN TURKEY-NİĞDE PROVINCE AGRICULTURAL FIELDS**

*Aziz Cumhur Kocalar*

*Niğde Ömer Halisdemir University*

Today, we are in a period of climate problems, so the water footprint has become a very important parameter for a long time. In the theoretical background of the study, the change in water availability in the world and Turkey is examined in general terms. The literature review delves into the sources of water scarcity issues, which are confirmed by field practice. Practices in the field point to the faulty managerial decisions of the water-related processes of the last 72 years and sometimes the ineffectiveness of the correct ones. The study explores the origins of technical land use neglect as well as practices on the ground, especially in Turkey. When we look at the diversity of the findings and field samples, the results on water scarcity are increasingly spreading in a negative direction. The city taken as an example in the fieldwork is Niğde in the Central Anatolia Region. The environmental relations of Niğde's irrigation dam ponds and especially Akkaya Dam Pond have also been chosen as the subject of the research. Niğde is a settlement center that is seen to have rich water assets in history in terms of water assets. However, today, the underground water level gradually decreases too much lower elevations, giving an alarm for years. In the future, the ponds that have been built recently may also face the danger of drying out because of the climate crisis. The study re-examines the problem of water scarcity, especially by focusing on this historical change in Niğde's water presence and the findings and field observations related to water management.

**Keywords:** agricultural land use planning, agriculture-food-water policies, water in post-mining, urban landscapes, city and regional planning

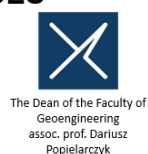


## **KEYNOTE SESSION II**

# **ENVIRONMENTAL DISASTERS: LEGAL AND ENVIRONMENTAL CONSEQUENCES**

**CHAIR: ANNA KLIMACH**

### **HONORARY AUSPICES**



## **CAUSES AND ECOLOGICAL CONSEQUENCES OF THE CATASTROPHE IN THE ODRA RIVER**

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The results on the causes and effects of the ecological disaster in the Oder River were published in the Reports prepared by a team of scientists in September 2022 and March 2023. A set of weather, hydrological and environmental factors, as well as those resulting from anthropogenic activity, was indicated as the cause of this event. They include e.g. high temperature; drought, which caused low water levels and their slow flow; high insolation in the river in July and August 2022, and high electrolytical conductivity and concentration of chloride, sulphate and sodium ions were recorded. According to the Reports on the Oder River, the simultaneous occurrence of these factors contributed to the creation of optimal conditions for the development of the so-called golden algae - *Prymnesium parvum* in the form of water bloom. In situations of competition with other species or a direct threat to its own development, it is capable of producing the so-called ichthyotoxins - primnesins, which have a neurotoxic effect on fish and benthic macroinvertebrates. The fish kills were recorded when the density of *P. parvum* was above 50-100 mln cells/L. The toxicity of *P. parvum* may increase in water temperatures lower than 30°C, pH higher than 7.5, electrolytical conductivity over 1500 µS/cm and in conditions with limited access to nutrients when the nitrogen to phosphorus ratio was of 3-10.



**LEGAL CONSEQUENCES AND REMEDIAL ACTIONS FOR DAMAGES  
CAUSED IN THE WATER ENVIRONMENT DURING THE ECOLOGICAL  
DISASTER IN THE ODER RIVER**

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The subject of the paper are the legal consequences of the ecological disaster that occurred in the Oder River, as well as legal instruments and corrective actions in the field of liquidation of damages in the water environment. In order to improve the effectiveness of the water management and protection system, especially in the event of a natural disaster in water reservoirs, as exemplified by the ecological disaster on the Odra River, changes are required in the water law in the field of monitoring, control, information system and duties of competent authorities, as well as development of appropriate procedures, which will contribute to faster response in such cases and more effective preventive and corrective actions.

Keywords: environmental law, ecological disaster, damage to the environment, legal instruments, duties of public administration bodies, Polish Waters

**CAN TRANSMISSION FACILITIES BE BUILT ON LAND COVERED BY  
FLOWING SURFACE WATER IN POLAND?**

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The purpose of the research is to examine whether it is possible to encumber land covered by flowing surface water in favour of a transmission network operator. (hereinafter: transmission undertaking) by way of a transmission easement. The term "flowing surface water" includes rivers and flowing lakes, which, according to the Central Statistical Office, cover approximately 2% of Poland's land area. These waters are located in both urban and rural areas and the transmission infrastructure may be underground, on the ground or in the air above ground. This applies to the transmission of all public utilities, including but not limited to water, gas, electricity and telecommunications. The transmission company should seek to acquire the right to the land on which the facilities are to be installed. This research seeks to address the issue of whether land covered by flowing surface water is a special type of land which may in some way affect the possibility of establishing a transmission easement.

Keywords: transmission easement, land covered with surface water, transmission facilities

## **FLOOD DISASTER VULNERABILITY FACTORS OF THE COMMUNITIES IN THE SOUTHERN REGION OF NIGER STATE, NIGERIA**

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Regional Planning*

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Flood disasters in developing countries remain one of the most devastating issues calling for serious attention by policy makers and scholars. Its occurrence is continually enhanced by excessive rainfall, urbanization and significantly by construction exercises of various magnitudes capable of further exacerbating its consequence on lives and properties. Therefore this study examines human-induced and community perception of flood vulnerability factors in the southern region of Niger state, Nigeria. The research adopted a quantitative research design approach with collection of numerical data on monthly water discharged from the major dams in the region, while the community perception data were collected through the use of questionnaire. Data on the community perception were collected from 1,040 households selected from 37 districts in the eight LGAs of the region. The data collected were analysed descriptively and presented in tables and charts alongside relative importance index (RII). The findings revealed that excessive rainfall and discharge from the dams in the region are the major physical and human factors contributing to flood disaster across the region with 0.89 and 0.95 RII values respectively. The study therefore recommends responsible land use regulation, community awareness and preparedness, effective dam management alongside sustainable regional development planning by governments at all levels in order to mitigate the recurrent flood disaster in the region.

**Keywords:** flood, vulnerability, dam management, communities, relative importance index

**FLOOD TREND AND LIVELIHOOD IMPLICATIONS OF THE  
COMMUNITIES IN THE SOUTHERN REGION OF NIGER STATE,  
NIGERIA**

*Abdullahi Alhaji Aliyu, M. Dalil, J. J. Dukiya, E. T. Umaru*

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The safety of life and properties of residents in the physical environment is continuously threatened by frequent and significantly constituting a lingering and dangerous environmental risks. This study assesses the impact of flood trend and livelihood implications on the communities in the southern region of Niger state, Nigeria, and proposes a physical development intervention that will mitigate the vulnerability of communities towards incessant flood disasters. A quantitative research design was adopted, and data were collected from 37 rural communities in the eight LGAs from Niger South Federal constituency, with a sample size of 1,040 households. The data collected were analysed descriptively and presented in tables and charts while Pearson's moment correlation was adopted to establish the relationship between floods disaster and livelihood variables (death, damage to properties and infrastructures) The study therefore reveals that flooding occurs more frequently in the years 2003, 2010, 2012, and 2020 respectively and some communities, such as Muregi, Kanzhi, and Sacci, were more frequently affected. The study further shows that flooding has also caused deaths, damage to personal properties, and infrastructure in the region, particularly in the communities mostly affected by the disaster. Hence the study recommends improve regional settlement planning, construction of flood-resistant infrastructures and regulations alongside afforestation across the entire region.

Keywords: flood disasters, livelihood, vulnerability, Niger South, rural communities

**ASSESSMENT OF PRE-FLOOD AND POST-FLOOD DURING RAPID  
FLASH FLOOD TRAGEDY IN KUALA LUMPUR, KLANG VALLEY REGION  
16 DECEMBER 2021: AN ANALYSIS BASED ON THE NASA-LANDSAT  
SATELLITE**

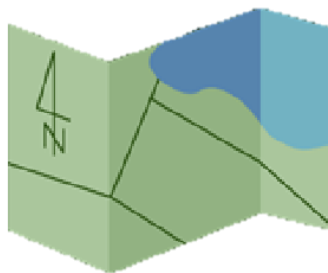
*Kamran Jafarpour Ghalehtemouri, Faizah Binti Che Ros, Shuib Rambat*

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The flooding that occurred from December 16, 2021, to January 19, 2022, spanning a total of 1 month and 3 days, had a significant impact on the Kelang valley region and Kuala Lumpur city. However, many studies have failed to effectively assess the spatial and temporal expansion of flooding in different urban areas of Kuala Lumpur. To address this, Landsat 8 data from NASA was utilized for pre- and post-flood detection in the affected areas. The Modified Normalized Difference Water Index (MNDWI) was calculated using the formula:  $MNDWI = (Green - SWIR1) / (Green + SWIR1)$ , where Green is the reflectance in the green band (band 3 for Landsat 8) and SWIR1 is the reflectance in the short-wave infrared band (band 6 for Landsat 8). The flood extent map was generated by applying a threshold value to separate water bodies from land areas based on the MNDWI index values. Additionally, descriptive methods were employed to support the theoretical foundation of the spatial expansion of surface water based on satellite observations. The results showed that the pre-flood values ranged from a high of 0.166226 to a low of -0.312616, while post-flood values ranged from a high of 0.0710963 to a low of 0.31455. Therefore, pre post-flood values changes around surface water bodies are significant also elevation and surface vegetation play very important role in controlling the flood intensity.

Keywords: pre flood, post flood, MNDWI, urban flood assessment, NASA, Landsat 8



## **KEYNOTE SESSION III WATER IN POST-MINING AND URBAN LANDSCAPES**

**CHAIR: ANNA OSTRĘGA**

### **HONORARY AUSPICES**



The Voivod of Warmia and Mazury  
Artur Chojceki



The Marshal of the Warmińsko-Mazurskie Voivodeship  
Gustaw Marek Brzezina



The President of Olsztyn  
Piotr Grzymowicz, PhD



The Rector of the University of Warmia and Mazury in Olsztyn  
assoc. prof. Jerzy Andrzej Przyborowski



The Dean of the Faculty of Geoenvironmental Engineering  
assoc. prof. Dariusz Popielarczyk



Państwowe Gospodarstwo Wodne Wody Polskie

State Water Holding  
Polish Waters



County Office  
in Olsztyn



Wojewódzki Fundusz Ochrony Środowiska i Gospodarki Wodnej w Olsztynie



The Regional Director for Environmental Protection in Olsztyn  
Agata Moździerz



Polish Limnological Society



Warmian – Masurian Regional Tourist Board



Polish Tourist and Sightseeing Society



Radio UWM FM  
Media patronage

**POTENTIAL OF THE COMPLEX OF POST-GRAVEL RESERVOIRS IN THE  
TARNÓW SUBREGION (POLAND) – ANALYSIS OF THE REASONS FOR  
NOT CARRYING OUT THE EXPECTED PROJECT**

*Anna Ostręga, Anna Szewczyk-Świątek, Wojciech Świątek*

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Engineering  
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The article presents the history of several years of work on a project involving the revitalization of a dozen (and ultimately several dozen) reservoirs after sand and gravel extraction in the Tarnów area. The designed functions were based on the natural and cultural potential of the places. They filled the recreational and tourist gap in the subregion. However, the implementation did not come to fruition. An attempt to determine the reasons is the subject of the article.

Keywords: post-mining reservoirs, revitalisation, tourism, nature, cooperation



**CHANGES TO THE HYDROGRAPHIC NETWORK IN THE BRANDKA  
(WS-47 POND IN CITY OF BYTOM) SUBSIDENCE RESERVOIR VICINITY  
AS A CONSEQUENCE OF MINING ACTIVITY - CONSEQUENCES AND  
CHALLENGES**

*Kazimierz Rózkowski, Paulina Bańbuła, Wojciech Bryś, Anna Ostreęga*

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The city of Bytom is located in an area rich in minerals. Mining development began here around the 12th century with the discovery of silver and lead deposits. In time, zinc appeared as further mined raw materials, followed by hard coal. In many areas, thanks to the stratigraphically and lithologically different environments hosting the deposits, there was a regional accumulation of resources in spatially distinct systems. In the overlying structural unit composed of, among others, Triassic formations, polymetallic mineralization, mainly zinc-lead, with admixtures of silver, appeared. In the structurally lower unit, composed of among others Carboniferous formations, coal seams were discovered several hundred years later. In the 20th century, a situation occurred in which coal mining began under the zinc and lead ore mines which were active until the 1970s. Overlapping impacts led to cumulative effects, in the form of, among other things, subsidence locally exceeding 30 meters. In one such area, on the border of Karb and Miechowice districts, a subsidence basin began to form around the middle of the 20th century. Progressive land deformation and mining drainage was accompanied by a remodeling of the river network manifested in the described area by the disappearance of the springs and upper section of the Bytomka River.

During the data analysis, available cartographic materials were traced from the late 19th century to the current state. Progressive subsidence, observed on successive maps, has led to the formation of the largest reservoir in the city, named Brandka, with an average area of about 32.5 hectares. Continued exploitation in the vicinity of the reservoir and plans for the next few years will, according to forecasts, lead to the enlargement of the reservoir and its connection with a small one located south of Brandka. As a consequence, water relations will be further transformed, and the area at risk of flooding will be enlarged. Already, some of the surrounding buildings, especially those located on the southern periphery of the reservoirs, are protected only by the action of the municipal services, which consists in monitoring and maintaining the ordinate of the water table at a set height, thanks to a forced drainage.

In view of the planned continuation of mining and the progressive threat, the available scenarios for solving the problem of regulating water relations in the expanding catchment of the reservoir began to be considered. Originally developed documentation included the construction of a dam, several dozen meters long, however, due to the change in conditions, this concept should be validated today, due to the current priorities. Three variants of the solution are proposed, tentatively named: 1) Classic. 2) Conservative. 3) The eco-progressive. Draft of these solutions is a kind of study of the perspective, and is a model example of the need for a holistic and multithreaded analysis of problems and consequences of their implementation.

**Keywords:** Bytom, mining exploitation, subsidence reservoirs, transformation of the river network, flooding

**CHANGES IN SEA LEVEL ALONG THE BLACK SEA COASTLINE:  
PERFORMANCE EVALUATION OF THE MANN-KENDALL TREND  
ANALYSIS METHOD**

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*Yildiz Technical University, Faculty of Civil Engineering, Geomatic Engineering  
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Analyzing the data accurately is crucial for tracking sea level changes and predicting future changes. This study mainly focused on the trend analysis for identified the changes in sea level using Mann-Kendall trend analysis method. The study area was selected the Black Sea coasts of Türkiye, which were thought to reflect the region's dynamics due to data density and tide gauge station distribution. Five tide gauge stations operate along the Black Sea coast of Türkiye as part of the Turkish National Sea Level Monitoring System (TUDES). The tide gauge data covers a 25-year period from 1998 to 2023, while satellite altimetry data covers a 30-year period from 1993 to 2023. Both data sets were analyzed separately, and trends were determined using the Mann-Kendall trend test. To test the performance of the Mann-Kendall method, a linear trend model was used with the least mean squares approach. The sea level trends were obtained using the Mann-Kendall trend analysis method with both tide gauge and satellite altimetry data showing an increasing trend along the Black Sea coasts of Türkiye and are highly compatible with the linear trend model. The sea level trend on the Black Sea coasts was estimated to be  $2.0 \pm 0.5$  mm/year using the linear trend method. Mann-Kendall/Sen's Slope also give the same values with linear trend approaching. The study indicates that data obtained from tide gauge stations along Türkiye's Black Sea coasts can be accurately analyzed and can assist in predicting future changes using the Mann-Kendall trend analysis method.

Keywords: sea level, trend estimation, Mann-Kendall, tide gauge, satellite altimetry

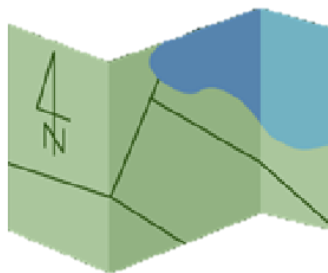
## **ASSESSING THE PERFORMANCE OF ANNUAL GNSS CAMPAIGNS FOR THE MANAGEMENT OF RISING SEA LEVELS**

*Dogan Ugur Sanli, Ece Uysal, Deniz Oz Demir, Huseyin Duman*

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Rising sea level is one of the most significant natural events threatening our near future. A geodesist plays a crucial role in managing the impacts of rising sea levels. Sea level has been measured by tide gauges in the last century, but due to the bias caused by crustal motion, GPS has been introduced to correct it. Later, sea level has been measured from space independently of the land by satellite altimetry. With the implementation of GNSS, research is ongoing to more accurately determine crustal motion. Sea level determined by the combination of tide gauges and GNSS is in agreement with the sea level measured by satellite altimetry today, with an accuracy of 3 mm/year. Studies are being carried out to more accurately determine crustal motion using GNSS, and this paper presents an example of this. Continuous or campaign GNSS measurements are used in determining sea level. Although the error in determining crustal motion using continuous GNSS has been studied in detail, additional research is still needed to determine the accuracy of crustal motion using campaign measurements. Due to various constraints, GNSS campaigns cannot be repeated as frequently as desired and they cannot be sampled as regularly as possible. This paper evaluates the accuracy of crustal deformation rates obtained from annual campaign measurements in comparison to those derived from continuous GPS when careful planning is employed in both measurement and analysis.

Keywords: sea level rise, tide gauge, GNSS campai, crustal deformation



## **KEYNOTE SESSION IV WATER RECREATION – LINKING PEOPLE AND NATURE**

**CHAIR: SYLWIA KULCZYK**

### **HONORARY AUSPICES**



## **CLIMATE RISK OF SHALLOW TOURISTIC LAKES: A CASE STUDY OF LAKE VELENCE (HUNGARY)**

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Urban Planning and Garden Art., Department of Landscape Protection and Restoration  
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European shallow lake used primarily for tourism are subjected to a large amount of environmental pressure, and climate change is adding new problems and aspects to them: a complex analysis of processes and connections is necessary to make appropriate decisions and strategies. In my study, using literature review and precedent analysis I have reviewed the climate risk of a Central European lake, as well as the natural conditions and landscape change processes determining its sensitivity. I analysed the ecological and economic effects of the record low water levels of 2021-22, focusing on processes. I determined which of the current land uses can be considered risky or sensitive in terms of climate change.

Keywords: climate change, climate risk, Lake Velence, tourism development, shallow lakes

## **HOW TO USE THE CONCEPT OF CULTURAL ECOSYSTEM SERVICES FOR TOURISM AND RECREATION PLANNING IN MAZURIA?**

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Cultural Ecosystem Services (CES) refer to the nonmaterial benefits people obtain from ecosystems. As the concept has been developed extremely fast since the end of the 1990s, there is a growing interest in using it in the planning process. This, however, is a great challenge, due to the relational character of the concept. The aim of this presentation is to show the potential of the CES concept for local planning. We will use the examples of two municipalities in northern Poland (Węgorzewo and Miłakowo): they share similar natural characteristics (postglacial, moraine landscape), but their use for tourism and recreation is very different. We implemented a mix of quantitative and qualitative methods. We took into account knowledge, attitudes, and opinions of different stakeholders, including local authorities, activists, representatives of different professions, inhabitants, and tourists. Participation mapping allowed spatial interpretation of the results obtained. The results show the value of CES diagnosis for local planning. The study reveals also the importance of detailed elaboration of goals and tools for obtaining meaningful and useful data.

Keywords: water tourism, water recreation, ecosystem services, Masuria

**TOURISM LAKESCAPE – TOURISM POTENTIAL OF LANDSCAPE OF  
WATER SPACE AND ITS SURROUNDINGS**

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and Recreation*

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Presented paper describes tourism potential of lakescape and is of a review character, based on literature and selected case studies of Polish lakelands.

The tourist lakescape is understood as the landscape connected with a lake and its immediate surroundings, where tourist phenomena occurs (Potocka 2013). Waterspace and its surroundings are the most attractive areas for tourism and leisure. The tourism potential is determined not only by visual-aesthetics values but other factors such as nearby cultural attractions, tourist infrastructure, local people approach, policy and management, etc.

When considering the potential of the landscape, it is important to remember that different tourist activities have different requirements towards landscape features, although there are some universal, positive values for all users, such as a high degree of naturalness of the environment or the presence of protected areas. Undoubtedly, the visual variety of the coastal zone and clean water will be a value for the lake landscape potential as well.

Key words: tourist lakescape, tourism potential, visual-aesthetic values of landscape



## **TOURIST FUNCTION OF THE SHORE ZONE OF THE ŁAŃSKIE, PLUSZNE, WULPIŃSKIE AND UKIEL LAKES**

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The second half of the twentieth century saw a significant development in tourism, including lake-related tourism. The lakeshore zone is a very attractive area for tourism, but it is also exposed to the negative aspects of human activity. The study determined the tourist attractiveness and tourist function of the shore zone of four lakes (Łańskie, Pluszne, Wulpińskie and Ukiel), located in the Olsztyn Lake District. A 100 m strip of land along the shoreline of the lakes was considered in the study. Three indices of tourist function development were calculated: the accommodation density index ( $P_A$ ), the additional infrastructure index ( $B_T$ ) and the dock density index ( $D_d$ ). Taking into account morphometric parameters, Lakes Łańskie and Ukiel were very attractive for tourism, while Lakes Wulpińskie and Pluszne were attractive. The largest number of accommodation facilities and additional infrastructure was located at Lake Ukiel. Very high  $P_A$  values were obtained for all lakes studied. They ranged from 173.1 (Lake Łańskie) to 712.9 (Lake Ukiel), indicating a very well developed tourist function. Lake Wulpińskie obtained the highest value of the  $B_T$  index (2.2), Lake Ukiel had a very similar value (2). The dock density index ( $D_d$ ), ranged from 2.1 to 6.8 (for Lakes Łańskie and Wulpińskie respectively). The tourist function in the shore zone of the studied lakes was strongly developed, indicating a significant load of tourist and recreational use on the lakes. This was particularly the case for lakes Ukiel and Wulpińskie.

keywords: tourist attractiveness, tourist facilities, tourist function indices

**INLAND WATER RESORTS: MAIN MOTIVATIONS TO VISIT AND  
SATISFACTION WITH THE EXPERIENCE (CASE STUDY: BĂILE FIGA,  
ROMANIA)**

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Tourism*

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The main objective of this study is to understand the motivation and satisfaction of visitors to an inland water resort in Romania in order to assess the success of this tourism operation in meeting customer satisfaction. Tourism motivation and satisfaction are two concepts that are widely studied; yet research on this topic in Eastern Europe is limited, especially when it comes to inland resorts. Băile Figa is a new water resort opened in July 2010, 3 km from the town of Beclean in northwestern Romania, on 15 hectares of land. The initial investment was €1.5 million and was funded through the European Union's regional development fund (REGIO 2007-2013). Data were collected in July 2019 using a convenience sampling method. In the end, 200 questionnaires were collected and further processed using the SPSS statistical software for social sciences. We found that the most important reasons tourists chose Băile Figa for their vacation were "access to cold and heated water pools", "the beauty of the surrounding environment" and "reasonable access fee". They were most satisfied with the accommodation units, water pools and beach facilities and least satisfied with treatment facilities and spa amenities. The results of this study can help us identify the main strength and weaknesses of the operation and should have significant management and marketing implications. Based on our results, the management of the destination could develop new products to meet the demand of the visitors and find new ways to market these products in order to attract the right visitors and to maximize the destination's appeal.

**Keywords:** inland water resort, travel motivation, tourist satisfaction

## **IMPACT OF ACCESSING TOURISM SUBSIDIES ON RELATED SERVICE DEVELOPMENT IN SOMOGY COUNTY, HUNGARY – REGIONAL STUDY**

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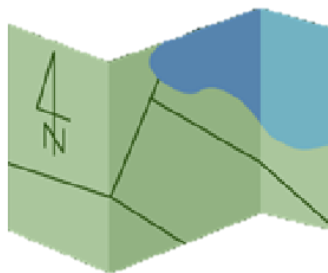
Nowadays, Hungarian settlements, in addition to maintaining a permanent population, also have to face various challenges in the economic, social and environmental fields in order to create the necessary financial cover for the operation of the settlement. In many cases, the economic and natural values of an area can only be saved by focusing on tourism.

The purpose of the research is to examine the development of accommodation in Hungary, in Somogy county, as a result of the European Union tourism subsidies used in the period between 2014-2019. The analysis was carried out using settlement series statistical data. The research method for exploring the territorial pattern is Moran's territorial autocorrelation indicator, or territorial regression.

Based on the results obtained, between 2014 and 2019, 80% of the settlements in Somogy county (Hungary) took advantage of the opportunities provided by the tourism tenders, however, accommodation expansion can only be seen on already developed touristic areas. The success of the tenders did not affect the population retention of the settlements. Based on the data received, no regional reorganization took place.

As a conclusion, it can be said that for the sake of the success of the tenders, it is necessary to involve the final consumers during the development of the long-term strategic concepts to be implemented, attention must be paid to the various communication channels, and in order to maximize profit and experience, it is worth making the tourism product usable all year round, so that in the future the awarded grants not only achieve success during the physical implementation, but also provide long-term benefits to the affected settlement.

Keywords: rural areas, tourism development, regional development, natural environment potential



## **KEYNOTE SESSION V ENGINEERING AND ENVIRONMENT PROTECTION**

**CHAIR: KATARZYNA BERNAT**

### **HONORARY AUSPICES**



## **TREATMENT OF PHOSPHORUS-LOADED LAKE BY CLOSED-CIRCUIT HYPOLIMNETIC WITHDRAWAL THROUGH FILTER MEDIA**

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A pilot-scale trial was conducted over 14 months where phosphorus (P)-enriched hypolimnetic water from Lake Hönsan, Sweden, was pumped to a filter-bag system housed in a container located on the lake shore. Months 1 to 6 the filter materials AOD slag and Polonite were tested, months 7 to 14 only Polonite. Two individual waterproof big-bags filled with 700 L of filter material were intermittently loaded with anoxic hypolimnetic water 3 times x 360 L/d, i.e. 1080 L/d/bag. The treated water was released via a pipe to the upper hypolimnion. The filter media, consisting of calcium silicates, showed good performance in removing dissolved and particle-bound P as well as existing metals and hydrogen sulfide. An 18-fold upscaling would remove 80% of the hypolimnetic water mass content of total P. The treated water was aerated to an dissolved oxygen concentration of 6 mg/L before its release to the lake's upper hypolimnion. Advantages and disadvantages of this method from a sustainability and technical point of view are discussed

keywords: eutrophication, water treatment, filter material, Polonite, AOD-slag

## **CAPPING WITH CALCIUM-SILICATE SORBENTS FOR REDUCING SEDIMENT-TO-WATER FLUXES OF PHOSPHORUS**

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Fluxes of sediment stored phosphorus (P) contribute to eutrophication of lakes. Various techniques have been tested to prevent the release of P, of which treatment with aluminum is the best known. We performed an in-situ experiment in Lake Hönstan, Sweden, where a bottom area of 100 m<sup>2</sup> was capped with 200 kg of the P-reactive sorbent Polonite<sup>®</sup>, i.e. a dose of 2 kg m<sup>-2</sup>. The sorbent particle size was 0 to 1 mm. The experiment lasted for 21 months. Moreover, four sediment–water columns were collected from the lake at a depth of 12 m. Two were capped with the same dose as the in-situ experiment and two were kept intact as reference. The columns were placed in a refrigerator and incubated for 30 days at 5 °C. The overlying water was bubbled with N<sub>2</sub> to maintain the columns in the anoxic state. The in-situ capping experiment showed a decreasing capacity of dissolved P removal while complete removal was observed during the incubation period. This comparative study suggests that results from incubation experiments may overestimate a sorbent's ability to impede P flux. However, the limited bottom surface that has been in-situ treated may have been affected by water inflow from the surrounding and untreated bottom area.

**FUNCTIONS OF BLUE SPACES OF ANTHROPOGENIC ORIGIN IN CITIES  
– THE EXAMPLE OF BYDGOSZCZ**

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Contemporary urban space is a conglomerate of many different physiognomic, morphological and functional elements that aim to meet the needs of the inhabitants. Blue spaces are undoubtedly one such element. They have many different functions (including ecological, educational, recreational, aesthetic or economic). This presentation aims to indicate what functions anthropogenic water bodies have in urban space.

The authors present the results of their research on water reservoirs created in post-mining pits existing in the Bydgoszcz area. Using cartographic methods, desk research and field observations, they classified water bodies of anthropogenic origin. The mine workings analysed were divided into three groups. The first group included post-mining reservoirs transformed, among other things, with the participation of local residents into areas with recreational functions. The second group included reservoirs subject to transformation within the framework of local spatial development projects (consulted with residents), which are ultimately intended to strengthen the city's green infrastructure. The third group, on the other hand, included reservoirs left in a quasi-natural state recognised by residents as enclaves of nature.)

keywords: urban space, blue spaces, Bydgoszcz

## **PHOSPHORUS RETENTION MECHANISMS UNDER A COMPARATIVE PERFORMANCE ANALYSIS OF POLONITE AND RÅDASAND FOR THE TREATMENT OF HYPOLIMNETIC WATER OF LAKE HÖNSAN, SWEDEN**

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Phosphorus (P) is a key nutrient limiting primary productivity in lakes. Hypolimnetic withdrawal (HW) is a method for restoration of eutrophic water bodies that aims to remove P from deep waters. The goal of this study is to investigate P retention mechanisms in two different filter materials used in HW applications (Polonite and Rådasand), under anoxic and oxic conditions. A saturated, upwards flow-through experiment with four columns was run with hypolimnetic water at KTH laboratory in Stockholm in December 2022. The columns were filled as follows: Column 1 – Polonite anoxic; 2 – Polonite oxic; 3 – Sand anoxic and 4 – Sand oxic. 200 L of water was taken from lake Hönsan during stratified conditions. Water was distributed from two vessels, where one was kept anoxic and the other was kept oxic. Results show that the predominant form of P in the source water is particulate, bound with ferric iron, suggesting oxidation between sampling and onset of the experiment. Polonite was highly effective in adsorbing P, and a small amount of particulate P released may be derived from the inflow waters or mobilized from the column. Rådasand acted as a bioreactor, releasing high amounts of phosphate. Rådasand retention was substantially lower, due to such biogeochemical effects and the lack of fines that could act as a trap for particulate P. Each column was sliced for sequential P extraction following SEDEX method (Ruttenberg 1992). The results show that most P is retained either sorbed or precipitated as iron-bound P. Results confirm the high sorption performance of Polonite, due to its considerable content of calcium oxide (40%, Renman and Renman (2022)), which is highly reactive with P. The second stage confirms that precipitation of Fe-P is an important pathway by which filter materials physically capture P, as high contents of CDB-extractable P are observed in both treatments.

References: Ruttenberg K.C (1992) Development of a sequential extraction method for different forms of phosphorus in marine sediments. *Limnol. Oceanogr.*, 37(7), 1460–1482; Renman A., Renman, G. (2022). Removal of Phosphorus from Hypolimnetic Lake Water by Reactive Filter Material in a Recirculating System – Laboratory Trial. *Water*, 14(5): 819 <https://doi.org/10.3390/w14050819>.

.Keywords: hypolimnetic withdrawal, lake restoration, phosphorus removal



## **EFFECT OF ADDITION OF EXTRACELLULAR POLYMERS FROM ACTIVATED SLUDGE TO CULTURE OF CYANOBACTERIAL BIOMASS ARTHROSPIRA PLATENSIS**

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Microalgae biomass is used to produce a number of valuable substances (astaxanthin, carotenes, unsaturated and polysaturated fatty acids, protein, bio-oil intended for the production biodiesel). An important, well-diagnosed, and proven problem of microalgae cultivation on an industrial scale is the lack of a simple and effective technology for separating the obtained biomass from the culture medium. The methods used so far, such as centrifugation, coagulation, and filtration, including membrane processes, are costly, time-consuming, and complicated. An alternative and competitive method of separating the microalgal biomass from the medium is bioflocculation. Bioflocculation is a process involving the formation of compact and heavy agglomerates made of microalgal cells using extracellular polymeric substances produced by microorganisms. The aim of the research was to assess the possibility of utilization of extracellular polymeric substances produced by the biomass of bacteria used in wastewater treatment (activated sludge) to densify the biomass of cyanobacteria *Arthrospira platensis*. Microalgae cultures were carried out in tubular reactors with an active volume of 4 dm<sup>3</sup>, equipped with a lighting and air mixing system in the medium described by Aiba and Ogawa (1997). The temperature in the photobioreactors was kept at 25±1.0°C.

The study analyzed the effect of the way of dosing and the dose of extracellular polymers on the biomass of cyanobacteria. For this reason, in the first variant, EPS was added every other day to the photobioreactor from the beginning of the cultivation, while in the second variant, EPS was added only at the end of microalgae/cyanobacteria growth. In these variants, the dose of 100 mg TOC/g of microalgae and 300 mg TOC/g of microalgae were introduced into the culture. Analyzes were performed during the culture and 24 and 48 hours after the addition of EPS. The study showed that the use of EPS to improve sedimentation properties had a positive effect on the culture of *Arthrospira platensis*. The results proved that during the cultivation EPS served as an external source of carbon. The EPS content in the control biomass of cyanobacteria and the biomass from the cyanobacteria culture to which EPS of the activated sludge was added during cultivation did not differ. The biomass of *Arthrospira platensis* was characterized by the presence of rhamnose, glucose, and galactose (25.1 mg/g, 11.4 mg/g, and 10.9 mg/g, respectively). At the EPS dose of 100 mg TOC/g of microalgae biomass added at the end of the *Arthrospira platensis* growth phase, the EPS content increased by 14%. In addition, the biomass was characterized by a better sedimentation coefficient of 68% compared to 53% in biomass without the addition of EPS. The greatest changes were observed in the culture of *Arthrospira platensis* with the addition of 300 mg TOC/g of biomass, biomass concentration increased from 4.2 g/dm<sup>3</sup> to 4.9 g/dm<sup>3</sup>, EPS content increased from 81 mg TOC/g dm to 96 mg TOC/g dm, while the sedimentation coefficient increased to 72%.

References: Aiba S., Ogawa T. 1997. Assessment of growth yield of a blue-green alga: *Spirulina platensis*, in axenic and continuous culture. J. Gen. Microbiol. 102, 179-182.

Keywords: extracellular polymers, cyanobacteria, bioflocculation, *Arthrospira platensis*

## **THE ARAL SEA CRISIS AS AN URGENT NEED TO IMPROVEMENT OF THE WATER RESOURCES MANAGEMENT SYSTEM IN CENTRAL ASIA**

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Water resources management is one of the most difficult challenges in the Central Asia region. The five Central Asian countries - Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan, as well as Afghanistan - have limited water supplies and are struggling to provide water to their growing populations and economies. In particular, Uzbekistan, due to its geographical location, is completely dependent on artificial irrigation. 85% of the volume of water resources required for the republic is generated and supplied from neighboring countries located in the upper reaches of rivers. Being located downstream of the rivers, Uzbekistan uses water from two main transboundary rivers - Syrdarya and Amudarya for the needs of its agriculture. The share of the agricultural sector in the country's GDP is relatively small (about 25%), but the sector plays an important role in terms of employment and food security. The total irrigable area in Uzbekistan is 4.3 million hectares, and agriculture is the largest consumer of water resources accounting for an average of 90-91% of the water used.

According to Report of World Resources Institute Uzbekistan was placed 25th out of 164 in the world's most water-stressed countries. Of the rest of the Central Asian states, Tajikistan and Kazakhstan ranked 51st and 60th, respectively, in the group of countries with high average water scarcity. Turkmenistan became the most dry country in the Central Asian region, taking the 15th line of the rating. The top five countries with critical water shortages include Qatar (1st place), Israel (2), Lebanon (3), Iran (4) and Jordan (5). The water shortage is a very pressing issue for Uzbekistan, given that the scarcity in certain regions, especially Karakalpakstan, might cause a social and environmental crisis.

In order to provide stable water supply to the population and all sectors of the economy of Uzbekistan, to improve the reclamation state of irrigated lands, to widely introduce market principles, mechanisms and digital technologies in the water sector, to ensure reliable operation of water facilities, as well as to increase the efficiency of land and water resources July 10, 2020 the Uzbek government accepted a Concept for the integrated development of water economy in Uzbekistan until 2030.

The Tashkent Institute of Chemical Technology (TICT) pays great attention to environmental problems, institute takes part in the implementation of the republican target program ""Aral"". Students and teachers of TCTI have participated in several projects related with planting poplars and other perennial plants in the Aral Sea region to strengthen the soil and reduce the amount of salty and sandy winds. Several research projects in the field of processing of salt deposits, obtaining on their basis target products for use in agriculture and other sectors of the economy, thereby improving the ecology in the Aral Sea region were implemented in TICT: Project F-7-31 Physicochemical analysis of marine and lacustrine salt deposits and the scientific basis for their complex processing (2012-2016); Project ITD 6-117 Development of resource-saving technologies for obtaining soda ash and ammonium sulfate from mirabilite and ammonium carbonate salts (2010-2012); Project A12-24 Development of a technology for producing burkeite based on sulfate salts of Karakalpakstan (2017-2018).

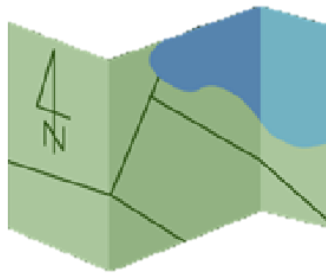
**3<sup>RD</sup> INTERNATIONAL CONFERENCE ON WATER MANAGEMENT AND ITS SURROUDINGS -  
THEORETICAL AND PRACTICAL ASPECTS; 17<sup>TH</sup> – 18<sup>TH</sup> MAY 2023 OLSZTYN, POLAND**

Large international organizations do not stand aside. For example, the EBRD in 2019 made a recording investment in 13 private and public sector projects in the amount of US \$ 576 million (517 million euros), the largest investment in the history of the Bank's work in the country. The reconstruction projects of the sewerage system in the Kashkadarya region (53.4 million euros) and the sewerage system in Khorezm (80.2 million euros).

Unfortunately, a common water use code per international standards is yet to be developed in Central Asia. The conflict potential in the water sector seems to be persistent and only worsens over time. The main constraint for the conflict is the lack of a single agreement between the Central Asian states on the rational use of transboundary rivers, i.e. construction of hydroelectric power stations, reservoirs for the development of individual economies. Until the Central Asian republics won't feel like a single ecological, economic, social, and political organism, the conflict potential will persist not only in the water but also in other areas.

Keywords: Aral, sea, disaster, shrinking, water management, Central Asia, Uzbekistan

**3<sup>RD</sup> INTERNATIONAL CONFERENCE ON WATER MANAGEMENT AND ITS SURROUDINGS -  
THEORETICAL AND PRACTICAL ASPECTS; 17<sup>TH</sup> – 18<sup>TH</sup> MAY 2023 OLSZTYN, POLAND**



## POSTERS

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### HONORARY AUSPICES



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Artur Chojecki



The Marshal of the Warmińsko-Mazurskie Voivodeship  
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The President of Olsztyn  
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The Dean of the Faculty of Geoengineering  
assoc. prof. Dariusz Popielarczyk



Państwowe Gospodarstwo Wodne Wody Polskie  
State Water Holding Polish Waters



County Office in Olsztyn



Wojewódzki Fundusz Ochrony Środowiska i Gospodarki Wodnej w Olsztynie



The Regional Director for Environmental Protection in Olsztyn  
Agata Moździerz



Polish Limnological Society



Warmian – Masurian Regional Tourist Board



Polish Tourist and Sightseeing Society



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## **TECHNICAL ASPECTS OF RESTORATION OF THE EUTROPHIC ŚWIĘTE LAKE IN POLAND**

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Święte Lake (in Odra, Wielkopolska voivodeship, N 52°05'06.83"; E 16°02'46.23") has undergone a reclamation process through a series of activities, which are intended to reduce its trophic status and improve physicochemical and biological indicators. First, the hydrological and catchment economy were put in order, then a pipeline system was built (filling and draining), which started 27.10.2020 r. At the same time, biomanipulation have been started to create the correct trophic pyramid in the lake. The next stage of the project will be the inactivation of phosphorus with the use of iron and aluminum coagulants.

The piping system consists of:

- a) the weir damming water in the Pintus ditch, located at the inlet of the ditch to the lake. The purpose of it is to direct the inflow water to the bottom of the northern part of the lake,
- b) filling pipeline, which ensures oxygenation of bottom water parts (northern deep).
- c) an outflow pipeline that directs highly fertilized and the most polluted, deoxygenated and gasified (H<sub>2</sub>S) water (southern deep) to the surface outflow.
- d) the weir damming water in the ditch at the outflow the lake. The purpose of it is to obtain adequate damming to force the flow of water in the outflow pipeline.
- e) a vertical curtain preventing the mixing of bottom water of both parts of the lake. In this way, separate hypolimnions of similar volume will form on both parts of the lake. Currently, the hypolimnion of the lake is on average less than 10 m deep and contains 278,500 m<sup>3</sup> of water, half of this volume (approximately 140,000 m<sup>3</sup>) should be considered for each pipeline as the minimum yearly flow volume.

The relation between the damming height, the hydraulic drop, the coefficients of hydraulic resistance and the length and diameter of the pipeline was calculated from formulas commonly used in fluid hydraulics and environmental engineering (Chezy, Colebrook-White and Manning formulas). Taking into account the morphometric conditions of the Święte Lake basin, it was calculated that the outflow pipeline should be approximately 340 m long, and the filling pipeline 230 m long. The damming heights required for the application of this method are small. Assuming a flow through the pipelines of 30-50 l/s, the required damming heights for 0.4 m diameters are about 0.1 - 0.25 m. The pipeline has been operating for over 2 years and positive effects are currently being observed.

Keywords: eutrophied lake, lake restoration, in-lake installation, inflow deepen, pipeline system.

**STUDY OF ROUGHNESS COEFFICIENT OF SEMI-LINED CHANNEL  
BASED ON SIMULATION OF WATER FLOW. A CASE STUDY OF  
DUSTLIK INTERCOUNTRY CANAL**

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Today, as a result of the deformation and filtration in the channel bed, the hydraulic efficiency and operational reliability of the irrigation networks in our Republic have decreased, and today the total efficiency of the irrigation network is 0.63 percent. Lining the channel bed can be a solution to increase efficiency, but the economic costs involved are causing delays in the work being done. When reconstructing irrigation canals, choosing a concreting scheme taking into account the deformation and type of filtration can be a solution to the problem. In case of limited filtration in main canals, concreting the side wall of the canal leads to economic and hydraulic efficiency. However, there is a problem of determining the resistance of surfaces with different roughness in the collateral calculations of two-sided concrete channels. In the article, based on the hydraulic elements of the Dustlik main channel, the hydraulic processes were modeled in the HEC-RAS 5.0.1 program, based on the results, it was determined that the roughness of the channel bed is equal to  $n=0.0199$ .

Keywords: irrigation channel, hydraulic efficiency, semi-lined channel, hydraulic calculation, roughness coefficient, HEC-RAS

## **MIROB – WATER GOVERNOR**

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In Uzbekistan, there are special professions dealing with water management, and these professions are called "Mirob". The article covers the history of the Mirab Institute, local customs and culture based on ethnological materials.

Keywords: water, water management. Mirab, Uzbeks, Fergana valley irrigation system

**ENVIRONMENTAL PROBLEMS OF WATER RESOURCES IN THE  
REPUBLIC OF UZBEKISTAN: CHALLENGES AND SOLUTIONS**

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The article considers environmental problems of water resources in the Republic of Uzbekistan and possible ways of their solution. The author draws attention to water pollution, inefficient use of water resources and international conflicts related to water sharing. The article proposes a comprehensive approach, including strict regulation of pollution, improvement of water use efficiency and development of international agreements with neighboring countries.

Keywords: water resources, ecology, water pollution, Uzbekistan, international conflicts, efficiency of use



**HYDROCLIMATIC CHANGES AND THEIR INFLUENCE ON RIVER  
CHANNEL MORPHODYNAMICS (EASTERN PART OF BALTIC SEA  
BASIN)**

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Climate change, and sometimes the syngenetic effects of climate change and human activities, are altering river discharge. Changes in river discharge, in turn, change the morphometric characteristics and vegetation patterns of the channel and river valley. Thus, even moderate river flows in the past can lead to dangerous flooding of the river valley.

Our research shows that since the 1950s, the lengthening of the window of opportunity between high floods has created favourable conditions for riparian and channel overgrowth, a gradual reduction in channel width and channel cross-section, leading to a reduction in channel capacity and a rise in channel water level. The observed trends in river channel change suggest that we may experience extreme floods in the future, which may be linked to the realignment of the river channel after a long period of low flooding.

Keywords: hydroclimatic change, morphometric indicators of the river bed, floods

## **FEATURES OF CREATING A CARTOGRAPHIC BASE AT A SCALE OF 1:2000 FOR URBAN TERRITORIES IN THE DIGITAL SOFTWARE**

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The features of creating a cartographic base at a scale of 1:2000 for urban areas using DIGITALS software are studied. The paper examines the issues of selecting sources of geodata, methods of data collection and processing, as well as approaches to determining the appearance of the map considering user requirements. The methods of creating topographic and planimetric maps, as well as geodata for their creation, are described. The aspects of data preparation for use in DIGITALS software and the requirements for their quality are identified. The result of the study is recommendations for optimal use of DIGITALS software for creating a cartographic base at a scale of 1:2000 for urban areas, using the example of the town of Horodyshche in the Cherkasy region of Ukraine, taking into account user requirements and the features of geodata.

It is noted that data accuracy and completeness are key factors for the proper functioning of DigitalS software, so it is necessary to carefully check input data and work only with highly qualified specialists. In addition, it is recommended to use the latest geodata and orthophotos for updating data on maps, rather than outdated ones. This will help maintain the accuracy and relevance of the data on the map. It is also important to have a powerful computer or device when working with large amounts of data in DigitalS software. This will increase the productivity and efficiency of the program.

Therefore, addressing issues with data accuracy and completeness, using the latest basis for updating data on maps, and utilizing powerful computers and devices are key recommendations for improving the performance of DigitalS software.

**Keywords:** cartographic basis, urban territories, DIGITALS software, geospatial data, geodetic works, digital terrain model, aerial photographs, generation of vector data, urban atlas, GIS technologies

## **THE IMPACT OF INVESTMENT REGULATION ON THE DEVELOPMENT OF THE TERRITORIAL MODEL OF FINANCIAL MANAGEMENT OF NATURAL RESOURCES**

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It is proved that an important institutional prerequisite for increasing the volume of investment support for attracting natural resources to the reproduction process is the formation of a territorial model of financial regulation of the use of natural resources as a complex of fiscal, monetary and licensing regulators, the subjects of which are local self-government bodies, their executive committees, regional divisions of state executive authorities. It is proved that the territorial model of financial regulation of the use of natural resources should fit into the policy of decentralization of the natural resource management system and environmental protection and should complement the national environmental and natural resource policy in terms of taking into account regional features of the placement of natural resource benefits and man-made impact on the environment. Studies have shown that in 2012-2021, there is an upward trend in the dynamics of local budget expenditures for environmental protection in general, as well as an increase in the share of local budgets in the total expenditures of the consolidated budget of Ukraine for the reproduction of natural resource potential and improving the quality of the environment. It is established that the real improvement of the situation with investment support for the modernization of the network of environmental infrastructure facilities will be provided when public financing of environmental projects at the level of territorial communities will be supplemented by diversification of investment sources at the expense of domestic private businesses and non-residents. It is proved that the key element of the territorial model of financial regulation of the use of natural resources should be a set of investment incentives, which will increase the interest of nature users in increasing the level of complexity of the use of natural resources, recycling of secondary natural raw materials, permanent reproduction of biodiversity and capacity building of ecosystem services of natural biogeocenoses. It is proved that an important component of territorial models of financial regulation of the use of natural resources should be methods and tools that will ensure the implementation of the basic provisions of international environmental conventions in the practice of domestic nature management, which will allow local self-government to increase the volume of investment in the modernization of the network of environmental infrastructure facilities at the expense of foreign governments and global environmental funds.

Keywords: territorial model, natural raw materials, local self-government, investments, funds, public budgets

## **ECONOMIC IMPACT OF LABOR MIGRATION ON DONOR COUNTRIES**

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The development of labor migration processes in the modern period shows that it is necessary to use a complex approach in order to assess the existing trends, both positive and negative impact on the labor force donor countries. In our present study, there is an attempt to develop a system of statistical indicators based on the determination of the results of labor emigration, through which it will be possible to monitor the impact of emigration on the economic development of the country and the quality of state management.

We studied the theoretical approaches in the leading foreign language literature in relation to the research topic, got acquainted with the best experience of the post-socialist countries, which were accumulated in terms of emigration of labor resources to the donor states. We got acquainted with the official data of the National Bank of Georgia and the National Statistical Service of Georgia about the migration of labor resources from the country, the enrollment of cash flows from abroad, we conducted a statistical study based on secondary information in order to determine the volume of estimated financial flows from emigration to Georgia and its (cash flow) estimated impact on the country's financial and general economic on stability. Based on the analysis of the obtained statistical information, we have made reasoned conclusions and proposals regarding the positive and/or negative impact of labor force emigration from Georgia, mainly in highly developed countries.

At the end, the typology of the economic results of the emigration of labor resources is proposed/given in the paper, an effective system of statistical indicators of the effective state management of the workforce in the donor countries is proposed.

**Keywords:** labor migration, workforce, remittances, Donor Country, economic outcome

## **WATER QUALITY IN THE GUADIANA RIVER & METEOROLOGIC CONDITIONS: A REMOTE SENSING APPROACH WITH SENTINEL-2**

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The Guadiana is a transboundary river between Spain and Portugal with ~17% of the overall basin area located in Portugal. It represents an essential source of water for agriculture and human consumption for the southern part of Portugal and is fundamental for the sustainability of the biodiversity on the region. Its water quality is critical not only for public health, but for the health of the surrounding ecosystem. Due to the semi-arid climate in Portugal, the water balance is particularly fragile. Drought is considered one of the most damaging natural hazards of the Iberian Peninsula and since the Guadiana river basin is located within the “climate change hot spot” region it is expected to become even warmer and drier based on future climate projections. For these reasons it is of particular importance to monitor water quality, the topic addressed on Project SIMG – Intelligent System for the Monitoring of Guadiana (financial support by PROMOVE o futuro do interior, BPI | „la Caixa” Foundation). In this preliminary study, we used a cloud computing platform (EO Browser), and applied custom scripts on Sentinel-2 MSI products (ESA/EU - Copernicus Programme) to analyse two different water quality parameters namely chlorophyll<sub>a</sub> and turbidity, and correlate them with data from air temperature and precipitation obtained from in situ measurements provided by Instituto Português do Mar e da Atmosfera. Eight spots along the region of interest of the project were selected to collect data from the Sentinel-2 products: the Guadiana river close to Mértola, and Pedrogão dam. Our preliminary results show the expected correlation between the water parameters and the meteorologic variables but, more interesting, it is possible to identify clustering on the data, identifying regimes with particular behaviours. The effects of hurricane Ophelia are also visible on the 2017 data analysed.

The preliminary results showed that (i) Sentinel-2 can be an effective tool for the Guadiana River water quality monitoring, providing valuable information for water resource managers and policymakers to make informed decisions about management and conservation strategies, and (ii) on a climate change scenario, where extreme events (e.g. heat waves, hurricanes) are more likely, water quality will be an important issue due to its correlation with weather conditions. Future work will address a wider time span and further correlation analysis using clustering methods. This research contributes to the development of more efficient and cost-effective methods for monitoring water quality in rivers and other bodies of water, which is essential for protecting human health and the environment.

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**3<sup>RD</sup> INTERNATIONAL CONFERENCE ON WATER MANAGEMENT AND ITS SURROUDINGS -  
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## **NEW TECHNOLOGIES IN WATER RECREATION CONCERNING BATHING SITES**

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Many lakes in Poland are characterized by a trophic state, which in the summer period leads to mass blooms of cyanobacteria, diatoms and green algae. These blooms prevent recreational use of water for several important reasons: exceeding the acceptable water quality standards set for bathing waters, causing a threat to human health and organoleptic characteristics adversely affected by recreation.

In order to restore the recreational function to eutrophied reservoirs and watercourses, an innovative method of water treatment in separate bathing zones was proposed. The subject of the method is the way of adapting fragments of reservoirs and watercourses for recreational purposes consisting in cleaning surface waters in cut-off parts of reservoirs and watercourses intended for recreational purposes.

Appropriate use of the method allows modern development of the bathing area with the installation of water recreation facilities, which at the same time constitute the elements of infrastructure used for water purification.

Keywords: bathing sites, recreation, new technology, lake

## **KAYAKING TOURISM IN THE SUWAŁKI AREA**

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The present study relates to kayaking tourism in the Suwałki area. The aim of the study was to analyze the factors determining the demand for kayaking tourism in the studied area. The research method was the questionnaire among the participants of kayaking tourism in the Suwałki area. The results showed that natural values were the most important factor determining the demand for kayaking in the area. The following factors were also important: quality of water of the river, the length of the trail, the intensity of tourist traffic, natural amenities on the trail, and hydrological conditions. In the opinion of respondents, the most attractive kayaking trails in the Suwałki region were Czarna Hańcza and Rospuda.

Keywords: kayaking tourism, Suwałki area, kayaking



## **APPLICATION OF GIS IN LAND MANAGEMENT: THE EXAMPLE OF UKRAINE**

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It is determined that the full-scale hostilities that occurred in Ukraine in 2022 resulted in significant losses in agriculture and rural areas. These losses pose a serious threat to the country's food security and may lead to crises in international food markets. More than 30% of the country's territory has been impacted by the effects of hostilities and at the end of 2022 is under occupation or remains dangerous for agricultural activities. Therefore, it is necessary to have timely and reliable analytical information and scientific-methodological justification for land management at different levels and for making effective management decisions. It is noted that for the purposes of research it is offered to extend the ideas of evidentiary policy (Evidence-based policy) for improvement of quality and validity of administrative decisions in the conditions of development of market land relations, formation of a new paradigm of land management, land cadastre and land monitoring.

In connection with the significant deterioration of conditions for statistical and operational accounting of actual land use, remote sensing of the Earth based on artificial intelligence and geoinformation technologies is of great importance as a tool for data collection and analysis. Therefore, the relevance of the need to form information requirements for management decisions in land use increases, which includes in this study:

- definition and clarification of land management functions, which determine the requirements for information and analytical support of management decisions;

- substantiation of methodological foundations for the collection and processing of geospatial data in land management and land policy, including, in addition to statistical reporting and available data from the State Land Cadastre, other information flows and methods such as remote sensing, agrosouting, surveys, monitoring of open registers and information platforms, cross validation of data collected and their subsequent analysis in the Big Data and Data Mining;

- creation and continuous updating of an appropriate information model of data, including the structure, composition of geodata, new information flows, ways of their creation, processing, analysis, delivery, visualization, interactive support for users in convenient forms;

- development of modern methodological approaches to modeling and forecasting of agricultural land use, which should provide support for management decision-making through modeling scenarios of long-term processes caused by internal and external social, economic, environmental, political internal and external factors.

For perfection of the institutional environment of regulation of land relations in Ukraine in the new conditions of management it is offered to consider as subjects of management of land resources: 1) bodies of the government (the Ministry of Agrarian Policy and Food, the State Service of Ukraine for Geodesy, Cartography and Cadastre and others); 2) bodies of local authorities (the united territorial communities); 3) agricultural enterprises (agricultural holdings, agricultural firms, farms, production cooperatives, etc.); 4) owners of land lots. For each of the subjects approaches to making managerial decisions were suggested taking into account their functional peculiarities that require appropriate information and analytical support.

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Presence of problems of information and analytical maintenance of management of the ground resources at a level of the state was proved, namely: absence of the high-grade quantitative and qualitative account of the lands; imperfection of methodology of the statistical reporting about a condition and changes in the ground fund; imperfection of the spatial analysis in information maintenance; absence of the complex system of monitoring of the lands (a legal condition, actual use, tracking of a qualitative condition of soils); presence of various types of errors of the lands; absence of a system of the maintenance of the lands; absence of an information system.

The methodological approaches developed in the research allow to carry out land resources management both on the state level and on the level of territorial communities. Informational and analytical support of land resources management is an important element of ensuring their effective use and can be used as a basis for further reform of decentralization and sustainable development of rural territories.

Problems at the level of territorial communities have been identified, namely: the lack of officially approved borders of communities, which does not allow to establish the boundaries of the rights and powers of local authorities; lack of support in making management decisions at the local level on the management of communally owned land; related to the inventory of unregistered land, administration and collection of land tax, management of communal property, management of investment attractive community land; failure to attract.

Keywords: land cadastre, land management, decentralization

## **EFFECT OF WATER SAVING ON IRRIGATION EROSION AND COTTON PRODUCTIVITY**

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In this article, the results of the scientific research work on prevention of soil erosion and high yield of cotton by using water-saving technology in the fields of cotton cultivation were mentioned. In order to obtain a high yield of cotton, the device of furrow bottom compaction was used, and a brief explanation of the use of the device was given. If the upper part of the soil (the place where water is supplied to the soil) is compacted with the help of the device, it will not be compacted proportionally to the end of the soil. Moreover, as a result of the use of the device for compacting the bottom of the irrigation furrow through the use of technology, it is possible to save up to 20% of water, save 600 kg of leachable soil from each hectare, and at the same time, the productivity can be increased by 18%.

Keywords: Water saving technology, furrow, compaction, compaction device, erosion, cotton, fertile layer, productivity

**CULTURAL DEVELOPMENT OF TOURISM AND RECREATION IN THE  
JORDAN RIVER BASIN: AN OVERVIEW OF CHALLENGES,  
OPPORTUNITIES, AND SUSTAINABLE PRACTICES**

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The study reviews the cultural development of tourism and recreation of the Jordan River Basin. The Jordan River Basin is known for its significant cultural and historical sites which attract tourists from all over the world. Despite the cultural and historical importance of the Jordan River Basin, the extent to which tourism has impacted the region's cultural landscape and the resulting changes that have transpired remain inadequately assessed.

The goal of this study is to review and evaluate the cultural development of tourism and recreation and their role in providing the cultural significance of selected sites in the Jordan River Basin area. As well as, providing a comprehensive understanding of the challenges, opportunities, and sustainable management related to the cultural significance of the region.

In order to analyze the cultural and historical significance of the Jordan River Basin and the role of tourism and recreation in the cultural development of the area. As well as, to examine the efforts made by local communities and governments to promote responsible tourism practices -including ecotourism and community-based tourism initiatives. The study is based on a comparative analysis of three cultural sites; the Baptism Site of Jesus Christ on the Jordan River, the Jerash archeological site in the Jordanian lands, and the Roman ruins of Gadara near the Yarmouk River. The comparison is built on several factors: Historical significance, cultural significance, accessibility, tourism infrastructure, conservation efforts, local community involvement, visitor demographics, and economic impact.

As a result, the three selected sites have contributed significantly to the local economy and have played an important role in the cultural development of the area. However, they present challenges to the preservation of the region's cultural heritage. The study suggests the importance of maintaining a sustainable plan to protect the region's cultural significance and highlights the efforts made by local communities.

**Keywords:** cultural development, tourism, recreation, cultural significance, historical significance, sustainable management

## **MONITORING THE WATER QUALITY OF THE GUADIANA RIVER WITH MULTISPECTRAL IMAGES FROM SENTINEL-2 SATELLITES**

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This work deals with the monitoring of the water quality using remote sensing multispectral images (MSI) from Sentinel-2 (ESA/EU Copernicus program) and in situ measurements, as part of the SIMG Project - Intelligent Monitoring System of the Guadiana, supported by PROMOVE o futuro do interior, BPI | „la Caixa“ Foundation. The main objective of this study was to use MSI to monitor the water quality of the Guadiana River and validate the observations with data obtained by in situ measurements with a multisensor probe, and laboratory analysis of physical-chemical parameters. For this, at selected measurement sites, several parameters were monitored with the probe (e.g. dissolved oxygen, conductivity, pH, salinity) and, simultaneously, water samples were collected for physical-chemical analysis in the laboratory. In parallel, a cloud computing platform (EO Browser) were used to develop scripts to produce maps of the distribution of relevant water quality parameters. This preliminary study showed that (i) the results obtained in the laboratory analyzes validated the data obtained through the probe within the estimated uncertainty and (ii) it was possible to use the scripts on the cloud platform to produce distribution maps of the relevant water quality parameters using MSI products from Sentinel-2. Future work will validate the probe for more parameters (e.g turbidity, CDOM, Chlorophyll a, Cyanobacteria), and provide more data to validate the results from the scripts, and provide information to improve the empirical models.

Keywords: remote sensing, Sentinel-2, multispectral Imaging, water quality, Guadiana River.

## **CHARACTERIZATION OF LIPID METABOLISM IN CHLORELLA SPP. IN RESPONSE TO ABIOTIC STRESSES**

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The increase in fossil fuel combustion and the environmental crisis has accelerated the need for sustainable alternatives. In this regard, microalgae can be attractive solutions for their rapid growth and higher lipid productivity. Specifically, different stress conditions induce lipid synthesis in microalgal cells. Here we investigated the lipid production during phosphorus-rich stress in the *Chlorella* spp. cells cultivated with air and with pure CO<sub>2</sub>. According to the observed biomass growth and lipid content, stress with pure CO<sub>2</sub> supply induces the highest lipid production. The highest lipid production was observed on the 2nd day of phosphorus-rich conditions. Also, profiling the fatty acid of the extracted lipid validates the variation in the types of fatty acid formation. High quantities of saturated and monounsaturated fatty acids were detected, which are required for biodiesel production. Our results confirm that in phosphorus-rich stress conditions, the biomass of *Chlorella* can be an excellent feedstock for producing biofuel.

Keywords: *Chlorella* biomass, phosphorus-rich stress, lipids production, pure CO<sub>2</sub>

## **THE EFFECT OF TIRE MATERIAL MICROPLASTIC ON THE STRUCTURE OF AEROBIC GRANULAR SLUDGE**

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Emerging contaminants such as microplastics (MP) are a growing problem for wastewater treatment systems. The presence of MP in wastewater treatment systems can affect system performance and biomass structure. This study aims to investigate the effects of MP from tire material on aerobic granular sludge's biomass structure and evaluate the potential consequences of MP presence for wastewater treatment plants and the environment. Five reactors were used for the study, including a control reactor (R1) and four reactors with different doses of MP (from 50 mg MP/L to 500 mg MP/L of wastewater). The results showed that the MLSS content increased from 4.7 g/L in R1 to 9.5 g/L in the reactor with the highest concentration of MP (R5). The tire material was found to be entrapped in the biomass structure, indicating that MP can accumulate and remain in the sludge. An increase in the number of filamentous bacteria in the reactors with higher concentrations of tire material was observed. Despite that, the sludge volumetric index in R5 was about two times lower than in R1, indicating a positive effect of MP on the settling ability of the biomass. The results suggest that high concentrations of MP can affect the physical properties of sewage sludge, potentially leading to problems in the operation of wastewater treatment plants. The presence of tire material in sludge is also of concern, as it limits the agricultural use of sludge due to the risk of MP accumulation in the environment.

Acknowledgment: The study was supported by the National Science Centre Poland (Grant Number 2021/43/B/NZ9/01300).

Keywords: microplastic, AGS, tire particles, wastewater treatment

**AGRICULTURAL WATER SECURITY AND MONITORING OF WATER  
LEVEL FLUCTUATION IN FOUR MAIN RESERVOIRS IN KOSOVO USING  
SENTINEL 2 IMAGERY**

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For the country's security and sustainable development, reservoir storage and water level investigation is essential. Kosovo relies on precipitation, snowfall, and artesian wells since it lacks swift rivers with significant carrying capacities. In particular, the majority of the nation's water sources for industry, potable water, agriculture etc. come by these four artificial lakes. Aim of this research is to make a comparison with agricultural statistical data estimations and artificial lakes area estimates. Water fluctuations of these reservoirs during 2022 and their potential uses for the future were researched. In order to calculate the lake area, we used NDWI and true colour of Sentinel 2 imageries which does provide spatial and temporal water storage and variations. Due to the size of the country, area of the lakes, Sentinel 2 was more appropriate. Lake of Badovc, Batllava and Ujëman had April as maximum surface coverage and November as minimum surface of water while Radoniq maximum surface in June and minimum in October. Overall, our findings indicate that weather factors, did affect water storage, as inlets have significant impact on these lakes' capacity. Study does demonstrate the surface water changed through the months and long-term monitoring could help predict water scarcity and drought monitoring.

Keywords: water source; NDWI, drought; reservoirs, lakes



## **LAND USE CHANGES AROUND ŚNIARDWY LAKE**

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Śniardwy Lake is one of the most recognizable lakes in Poland, it is also the largest reservoir of its kind in our country. Due to its spectacular size, it is called the Mazurian sea. There are 8 islands on Śniardwy Lake. Land use forms in Poland depend on natural conditions and socio-economic factors. The purpose of this article was to present the spatial distribution of land use changes that have occurred in the area around Śniardwy Lake.

Keywords: land attractiveness, land use changes, lake

## **SOCIAL FACTORS AS THE KEY DETERMINANTS OF THE LOCATION OF FARMLAND CONSOLIDATION SCHEMES – A CASE STUDY OF POLAND**

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Land intended for consolidation is identified by researchers and practitioners based on numerous parameters, where spatial factors usually play the most important role. The respondents were asked to describe the relationships between the groups of factors that determine the selection of sites for land consolidation project. Conclusions In Poland, social factors play the key role in the selection of land for consolidation due to the specific character of the procedures for initiating consolidation proceedings and evaluating consolidation requests. The weight of social factors significantly exceeds the weights of economic and environmental factors.

Keywords: agricultural land consolidation, agricultural land, land holdings

**THEORETICAL BASIS FOR COMBATING SOIL DEGRADATION FROM  
PROMISING ENDEMIC PLANTS ADAPTED TO SOUTHERN ARALKUM  
CONDITIONS**

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The article discusses the issues of ensuring environmental safety and environmental protection in the Aral Sea, rational use of natural resources, combating the negative consequences of climate change, highlights the results of an innovative approach to combating soil degradation by expanding the area of natural areas, especially the effective use of water resources, promising endemic plants adapted to the ecological conditions of the Southern Aral Sea in combating soil degradation.

Keywords: biodiversity, soil degradation, climate change, innovative approach, environmental factors, microbiological activity of soils, halophyte communities, salinity levels, south Aralkum

## **LOADING OF THE SHORE ZONE OF THE VÄNERN AND VÄTTERN LAKES IN SWEDEN WITH INFRASTRUCTURE FOR WATER TOURISM**

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Tourism is an increasingly important part of the Swedish service sector. In 2018 tourism consumption reached 29 million Euros. Sweden recorded 57 million tourists in 2021, including 5.8 million inbound tourists. Three most important nature environments for Nature Based Tourism operations in Sweden are rivers and waterfalls, forests and lakes. Water-based tourism and recreation is very popular in Scandinavia. In addition to sailing at sea, sailing on inland waters is also very popular.

Scandinavia's largest water complex is the Göta Canal, with the two largest lakes in Sweden (and indeed all of Scandinavia) - Vänern and Vättern. Lake Vättern, which is located in the south-central part of Sweden, is the country's second largest lake, with an area of 1,912 km<sup>2</sup>. Lake Vänern is Sweden's largest lake, with an area of 5,650 km<sup>2</sup>. The lake is located in the western part of the country, near the city of Karlstad. Sailing and boating on these lakes is a popular activity among locals and tourists alike. Both lakes have numerous marinas and harbors where boats and boating equipment can be rented. In addition, there are many sailing schools and clubs that offer both beginner and advanced courses for those who want to learn to sail. The lakes are also popular with fishing enthusiasts.

The aim of the study was to assess the load on the water part of the shore zone of the studied water complex with infrastructure related to water tourism and recreation. Three elements of this infrastructure were considered: marinas and harbors, piers and footbridges, and boat and yacht berths. These elements of infrastructure were classified and counted using Google Maps and Google Earth. The values of the three indices were calculated: Md - marinas density index, Dd-dock density index, Bd - boats density index. The indices were calculated separately for Lake Vänern, the Göta Canal together with Lakes Viken and Bottensjön, Lake Vättern together with Lake Alsen. Highly developed lakes are characterized by a high Dd index (value above 5). The values of the Dd index for all three studied sites ranged from 1.49 to 2.67. This means that the number of piers and footbridges in the shore zone of the entire studied complex was moderate. The situation was different for the Md and Bd indices related to the number of marinas and the number of berths for boats and yachts, respectively. Md index values above 5 (6.39) were recorded for the part of the study area consisting of Lakes Vättern and Alsen. In the other two parts of the studied complex, the value of the index ranged from 3.1 to 4.56. The Bd index took values from 5 to 11.9, which means that the entire studied water complex was highly developed in terms of the number of berths for boats and yachts. The above analysis clearly indicates that the tourist and recreational load of the water complex associated with the Göta Canal is primarily associated with sailing and boating. Many waterfront towns had numerous and extensive marinas that were not associated with any tourist and recreational facilities, such as sailing clubs, hotels or sports centres. This fact suggests that most of the boats and yachts in the study area are used by the residents of the lakeside towns themselves. However, tourists also represent a significant group of floating equipment users at the studied water complex.

Keywords: lake tourism, water recreation, dock density, marinas

## **INDUSTRIAL CONTAMINATION OF OLD RIVER BEDS AS A SOURCE OF THEIR EUTROPHICATION**

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The Vistula River is infamous for the high amounts of nitrogen and phosphorus compounds delivered to the Baltic Sea. This is caused primarily by point sources of industrial and municipal pollution (wastewater) and diffuse agricultural sources (runoff from arable lands). However, another source could be old river beds polluted by industry. The aim of the study was to analyse the impact of a nitrogen factory's chemical wastewater treatment plant on the water quality of nearby lakes. We selected eight water bodies, six close to the treatment plant, two as control sites 35 km upstream. Water samples were taken once a month for a year. Industry and climate change have had the greatest impact on water quality. The industrial pollutant was ammonium nitrogen ( $\text{NH}_4\text{-N}$ ). It entered the lakes through surface water (canals), the soil and through the air. The highest average annual concentration of  $\text{NH}_4\text{-N}$  ( $5.38 \text{ mg dm}^{-3}$ ) was recorded in the lake closest to the treatment plant reservoir, separated from it by a dike and with no permanent surface connection. This indicates a strong uptake of contaminants through the soil and groundwater. On the other hand, due to climate change, some of the studied lakes were drying up, which significantly increased the concentration of total nitrogen. During high river water levels, lakes located within the floodplain are inundated, and the accumulated substances enter the river waters. Our research shows that this kind of river valley lakes can be a significant diffuse source of nitrogen pollution (especially ammonium) and eutrophication of the Vistula River.

Keywords: industry, old river beds, eutrophication, river valley, Vistula

## CHANGES OF MICROBIOTA IN THE RIVER SYSTEM FLOWING THROUGH FOREST AND URBANIZED AREAS

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Identification of the type and of the main sources of microbiological contamination of surface waters, in the context of the growing pressure of man on the environment, should be a priority task in environmental research. The aim of this study was to determine changes the total count of bacteria (TCB) and faecal bacteria from the *Enterococcaceae* family in the Łyna River water flowing through north-eastern Poland in the area of forest and urbanized areas. Samples were collected from the sources of the river and from the river flowing through the city of Olsztyn 500 m downstream and upstream from the wastewater discharge point. Analyses of untreated and treated wastewater discharged to the Łyna River from the Łyna WWTP in Olsztyn were also researched. Total count of bacteria (TCB); bacteria from the genus *Enterococcus*, and species *Enterococcus faecium*, *E. faecalis* and *E. gallinarum*, were marked using fluorescence hybridisation *in situ* (FISH) and oligonucleotide probes EUB338, ENC176, ENU140, ENF191 and EGAC183. The water in the Łyna River flowing through forests, where anthropopressure was limited, had the lowest counts of labeled bacteria, which were from  $0.0003 \times 10^6$  cells  $1\text{mL}^{-1}$  (EGAC181) to  $2.0 \times 10^6$  cells  $1\text{mL}^{-1}$  (EUB338). In the river flowing through urban areas, counts of determined bacteria increased several-fold, depending on site of water sampling, and on the kind of determined bacteria. The highest mean counts of determined microorganisms were detected in untreated ( $0.17\text{-}216.1 \times 10^6$  cells  $1\text{mL}^{-1}$ ) and treated wastewater ( $0.021\text{-}45.2 \times 10^6$  cells  $1\text{mL}^{-1}$ ). The determined increasing counts of microorganisms from the river's springs through urban areas reflect the influence of various factors associated with the impact of point source (wastewater and sewage management) and nonpoint source (runoffs from urbanised area) pollution penetrating the Łyna River's ecosystem mostly because of anthropogenic activities. Identification of the most severe sources of microbiological pollution along the river's flow is particularly important because the river plays significant roles in economy, tourism and ecology for the whole region of Warmia and Mazury.

Keywords: river water, faecal bacteria, fluorescence hybridisation in situ (FISH), source, urbanised area

## **WATER SUPPLY MANAGEMENT IN HOMEOWNERS ASSOCIATIONS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT GOALS**

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Reducing water consumption is one of the key requirements for achieving sustainable development. This issue is included in the catalogue of global Sustainable Development Goals (Agenda2030). Goal 6 of Agenda2030 (clean water and sanitation) indicates the need to use water efficiently in all sectors, including homeowners associations, and to ensure sustainable water abstraction. The aim of this paper is to identify the problems associated with water abstraction in homeowners associations and the accounting of its costs to individual residential unit owners. The paper uses Desk Research analysis and in-depth face-to-face interviews with property managers who manage homeowners associations' properties.

Keywords: water supply, housing management, homeowners association, Sustainable Development Goals

## **ANALYSIS OF DIFFERENT IONOSPHERIC MODELS IN UAV GEOSPATIAL DATA ACQUISITION**

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Drones are currently becoming part of professional data acquisition systems for various purposes, also in water environment, mainly due to their relatively low production and purchase costs and ease of use. A key element for the acquisition of reliable and accurate data is the UAV navigation system. Their navigation is highly dependent on global navigation satellite systems (GNSS). For single-frequency receivers, remote sensing data and their quality is dependent on ground control points (GCPs). It is also possible to perform fully remote UAV surveys without the need for a GCP, this is particularly important in challenging terrain with difficult access i.e. bodies of water and their surrounding areas. To improve positioning quality of popular GNSS receivers installed on-board of UAVs, EGNOS augmentation system can be used.

The research presented in this study concerns the analysis of the positioning quality of a modified GPS/EGNOS algorithm. The calculations focus on the source of ionospheric delay data as well as on the aspect of smoothing code observations with phase measurements. The modifications to the algorithm concerned the application of different ionospheric models for position calculation. Consideration was given to the EGNOS ionospheric model, the Klobuchar model applied to the GPS system, the Klobuchar model applied to the BeiDou system, and the NeQuick model applied to the Galileo system. The effect of removing ionospheric corrections from GPS/EGNOS positioning on the results of the determination of positioning quality was also analysed.

**Keywords:** UAV, GNSS, ionospheric models



## **ENVIRONMENTAL CONFLICTS BETWEEN RECREATIONAL ACTIVITIES AND WATERBIRD HABITATS OF THE BALTIC COAST USING THE EXAMPLE OF DENMARK**

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The coastal zone of the Baltic Sea is important for recreational activities and is a place of special natural values including waterfowl habitat. Recreational activities can have negative effects on flora and fauna, which requires balancing both uses through integrated planning and management of coastal and marine zones. Effective integrated management and planning requires spatial and temporal knowledge of species in need of protection and outdoor recreational activities. This paper analyzes outdoor water recreation in Denmark in terms of activities, seasonality and geographic distribution, and provides a spatial-temporal overview of the overlap between coastal and marine recreational activities and waterbird species in need of protection. Statistics indicate that 77.6% of the Danish population participated in water-oriented outdoor recreational activities at least once during the year. The most common activities were moving along or staying on the coast (63.9%), swimming and bathing (34.4%) and observing nature and wildlife (20.3%). The overlap of recreation and waterfowl activities, creates potential conflicts on the coast. The results indicate a potential negative impact between recreation and waterbird abundance during spring and summer on the water. The results also indicate that most recreational activities use areas with no or low densities of waterbirds. Effective coastal and marine planning requires management tools that include educational and interpretive initiatives to improve coexistence. However, for detailed management, further research on spatial and temporal patterns, adaptation, conflicts and coexistence between recreational activities and waterbirds is urgently needed.

Keywords: coastal zone, avifauna, the impact of tourism, Baltic Sea

## **ANALYSIS AND COMPARISON OF TOURIST ATTRACTIVENESS OF THE MRAGOWO LAKE DISTRICT CITIES**

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Tourist attractiveness is a set of natural and anthropogenic qualities that attract tourists to an area. The purpose of this study was to analyze and compare the tourist attractiveness of cities located in the Mrągowo Lake District: Mrągowo, Szczytno, Reszel. Multivariate comparative analysis using synthetic measures was used to assess tourist attractiveness. Synthetic measures of natural and cultural tourist values and tourist infrastructure were used to determine the overall synthetic measure of tourist attractiveness. The study showed that Mrągowo has the highest tourist attractiveness, due to its unique natural resources, among other things.

Keywords: tourist attractiveness, tourist values, the Mrągowo Lake District

**ASSESSMENT OF THE INFLUENCE OF GROUND WATER DYNAMICS  
ON THE MELIORATIVE CONDITION OF IRRIGATED TERRITORIES ON  
THE BASE OF GIS. A CASE STUDY OF KARASUV RIVER BASIN**

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In the conditions of Uzbekistan, hydrogeological conditions in irrigated lands are undergoing dramatic changes. Natural streams have been replaced by artificial processes related to economic activity. The increasing of level of ground water is accelerating at the expense of precipitation, surface runoff (rivers, canals), irrigation water, water added from pressurized water below the non-pressurized groundwater. As a result, irrigation water and low-pressure water play a major role in groundwater recharge in irrigated areas.

On the basis of the research conducted in this direction, we were convinced that groundwater flows obey the laws of hydrodynamic regions, that is, the groundwater flow is divided into five naturally drained hydrodynamic regions. Along the direction of the flow the level and gradient of groundwater decreases, on the contrary, mineralization increases from the first region to the fifth. Visual classification was carried out by checking the accuracy and reliability of the results of the analysis while conducting our research in this research work. Certain results were achieved during field research in 2021-2022.

In our researches, the data obtained from observation wells in the areas near the Karasuv River, Orta Chirchik District, Tashkent region, were analyzed for each decade of the last five years. A total of 90 monitoring wells are analyzed.

Keywords: irrigation water, precipitation, underground water, reclamation conditions, salt washing, river basin, channel, GIS, hydrodynamics, mineralization, non-pressure water, hydrogeological conditions

**INVESTIGATING THE TERRITORIAL INEQUALITIES OF HUNGARIAN  
NATURAL HEALING FACTORS AS MEDICAL TOURISM TOOLS  
AFFECTING HUMAN HEALTH USING COMPLEX STATISTICAL  
MEASUREMENTS**

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Nowadays, the tourism is present as a dynamically developing sector in many areas of the world, which is an outstanding example of the interaction between the resources offered by the natural environmental, and people. As in many countries of the world, the medical tourism based on natural healing factors is of special economic and social importance in Hungary. The natural healing factors and the medicinal water treatment facilities based on them are available in different quantities and qualities in different areas of Hungary. These regional differences, as well as the changes in health and medical tourism trends happened in last years, to call attention to the modern planning of the affected settlements development especially the spa towns, which is essential for the harmonious and sustainable relationship of the natural environmental and people.

The aim of our research is to light on the importance of territorial differences in Hungarian natural resources as medical tourism factors, as well as to map and define the territorial inequalities of the most significant medical tourism factors, for which we applied the methods of regional research. Our results, calculated with the indicators of territorial polarization and territorial distributions, show that the Hungary medicinal water supply is relatively even from a territorial point of view, while the other natural healing factors show significant territorial inequality and concentration. In case of medicinal facilities, we measured low territorial inequality and concentration at the medicinal baths, while we observed relatively significant territorial inequality and concentration at the NEAK (National Health Insurance Fund) contracted medicinal water treatment facilities.

From the results we obtained, we came to the conclusion that the territorial differences in the natural healing factors created by natural influences also have a significant impact on the built environment, which also generates social and economic differences through medical tourism. These territorial differences and effects must be kept in mind during the planning and development of spa resorts involved in medical tourism.

Keywords: interaction, medicinal water treatment facilities, medical tourism, natural healing factors, territorial inequality

**VALUES OF THE MEDICINAL BATH PLACE ENVIRONMENT: THE  
IMPORTANCE OF MEDICINAL BATH PLACE-CHARACTERISTICS  
AMONG HUNGARIANS**

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The main topic of our research is the exploration of consumer attitudes related to the environmental values of Hungarian medicinal bath places, which can significantly contribute to preserving people's health and improving their quality of life. The actuality of our research is due to the fact that in our society, people pay more and more attention to health preservation and their personal well-being. The water usually attracts people, so the medicinal bath place environment appears as a defining element of the offer among tourists. The main goal of our research is to map out, with the help of consumer attitudes and preferences, the expectations of tourists regarding the characteristics of medicinal bath place. To achieve the goal of our research, we conducted primary research and a questionnaire survey. Data collected among the Hungarian middle-aged middle class (n=200) were processed with univariate descriptive statistics and bivariate analyses. In the course of our research, we came to the preliminary results that the most significant value proposition for the older age group is linked to the quality of medicinal services, while for the middle-aged, it is linked to the characteristics of medicinal bath place related to lifestyle changes. Furthermore, our results reveal that the expected values are largely related to personal needs and lifestyle.

Keywords: attitude, consumer, environment, medicinal bath place, value offer

## **RESTRUCTURING OF AGRICULTURAL LAND USE IN UKRAINE: DIRECTIONS OF DEVELOPMENT**

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**Motives:** About 70 percent of the land fund of Ukraine is agricultural land. Today, it is planned to reduce the agricultural development in Ukraine as a whole by 5 percent and the plowed area - by 10 percent. The purpose of the article is to determine new approaches and methods of land use organization, economic and land management mechanisms and tools for greening agricultural land use. The object of the study is Cherkasy region, where the ploughed area is 61%.

**Aim:** The purpose of the article is to propose ways to restructure agricultural land use. In order to reduce the plowing of the territory of Ukraine, arable land with degraded and unproductive soils should be used in soil-protective crop rotations, the area of field-protective forest strips should be increased to reduce the effects of climate change and erosive effects, and the areas under non-traditional agricultural land use should be expanded. The soils of the Cherkasy region are the most suitable in Ukraine for organic farming, but only 1.6 thousand hectares use organic technologies.

**Results:** The article substantiates the need to change the functional use of arable land with an area of 5343.9 thousand hectares, namely: 2049.9 thousand hectares - in soil-protective crop rotations; 208.0 thousand ha - expansion of areas under field protection forest strips, 2878.0 thousand ha - in the field of non-traditional agricultural land use.

**Keywords:** economics agricultural land use, land use development planning, oiliness, soil suitability, functional use

**TOURIST TRAFFIC ON THE GREAT MAZURIAN LAKES TRAIL IN THE  
YEARS 2013-2020 ON THE EXAMPLE OF THE GUZIANKA LOCK**

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Tourism on the lakes is very popular. The Great Mazurian Lakes Region is one of the most attractive regions in the country in terms of tourism and nature. The aim of this study was to characterize and analyze the tourist traffic on the route of the Great Masurian Lakes, with particular emphasis on the Guzianka lock in the years 2013-2020.

The analysis of tourist traffic through the Guzianka I lock was based on information contained in the logbooks of floating objects and data from the Topographic Database. To characterise tourist traffic on the whole route data on sailing infrastructure and data from the GUS on accommodation facilities in the region were used.

The study analysed the intensity of tourist traffic in the small territorial administrative units encompassing the Great Mazurian Lakes Route. The study showed that the region is highly valued by tourists, especially sailors. The Guzianka I lock in the years 2013-2020 served more than 130,000 vessels. A statistically significant decrease in the number of vessels passing through the lock in 2020 was shown due to the outbreak of the COVID-19 pandemic and the opening of the new Guzianka II lock in July 2020.

Keywords: lake tourism, Masurian Lake District, sailing, water recreation

## **TOURIST USE OF THE COASTAL SEA WATERS IN THE LOFOTEN AND VESTERÅLEN REGION**

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Lofoten and Vesterålen are island archipelagos in the Norwegian Sea off the north-west coast of Norway, separated from the mainland by the Vestfjorden Strait. The border between the archipelagos is the narrow Raftsundet strait. Lofoten is an archipelago of about 50 islands, among which the largest are Austvågøy, Vestvågøy, Moskenesøya, Flakstadøya, Gimsøya. The Vesterålen archipelago also consists of several large islands Langøya, Andøya, Hadseløya, Hinnøya (western part), Austvågøya (northern part) and numerous smaller islets. The total area of the Lofoten islands is about 1.300 km<sup>2</sup>, and the Vesterålen islands is 3.600 km<sup>2</sup>. The archipelagos are made up of rocks of volcanic and metamorphic origin, estimated to be 3 billion years old (some of the oldest in the world). The rocky massifs have steep, high walls, sharply defined peaks and jagged ridges. Short, narrow fjords cut into the massifs. Small sandy beaches are sometimes hidden in the bays of the fjords. The history of life of the inhabitants of the islands is written into this landscape, complementing it with a cultural landscape.

Lofoten and Vesterålen are visited annually by around one million tourists from all over the world, and the number of those interested in the region is constantly increasing. Most of them arrive on the islands by the sea. The coastal zone is used for transportation to the islands all year-round (ferries run less frequently during winter). Ferry crossings (with the possibility of transporting a car) take place from Bognes to Lødingen located on Hinnøya in the Vesterålen archipelago. The ferry crosses 20 times a day in summer and 10 times a day in winter. Ferry crossings to Lofoten take place from Bødo to Moskenes on the island of Moskenesøya, 8 times a day in summer and 2 a day in winter. In addition, there are also ferries from Bødo to the island of Røst and Værøy, and fast boats, called Nordlandekspressen, (without the possibility of transporting a car) from Bodø and Skutnuk to Svolver in the Lofoten Islands. The islands can be also reached once a day by the large luxury ferry Hurtigruten, a Norwegian ferry service, that runs daily along almost the entire length of the country. Once on the islands, further travel can be continued by land, as the larger islands are connected with each other by bridges and an undersea tunnel, though the smaller islands can still be reached only by the sea.

The islands have a rich tourist offer, both natural and cultural. Many of the tourist attractions are related to the use of the offshore waters around the islands. The waters of the fjords are the area of sightseeing and wildlife cruises, to watch sea eagles and puffins living on the slopes of the mountains surrounding the fjord, and seals swimming in the fjord waters. Watching of underwater life is carried out using underwater drones. The narrow, Trollfjord is the most famous fjord. Nature safaris are organized on boats, dinghies or catamarans in many other fjords as well, from where from where it is possible to go out to the high sea to watch orcas.

However, the best place to look around for whales is at Vesterålen, at the tip of the island of Andøya. The continental shelf is very short here (about 20 kilometres), and beyond its edge is a giant bluff into the oceanic depths, where whales live. Professional tours are organized here to watch these marine mammals (Andenes, Stø). At this area, most commonly occur: sperm whales, humpback whales, fin whales, porpoises, pilot whales, orcas and dolphins, at different times of the year.



### **3<sup>RD</sup> INTERNATIONAL CONFERENCE ON WATER MANAGEMENT AND ITS SURROUNDINGS - THEORETICAL AND PRACTICAL ASPECTS; 17<sup>TH</sup> – 18<sup>TH</sup> MAY 2023 OLSZTYN, POLAND**

Marine cruises also include other attraction of the region. Off the south-west coast of the island of Moskenesøya, the warm sea current (Golfstrom) heading north is pushed by powerful tidal currents arising between the Vestfjorden Strait and the North Sea, and a giant water whirlpool called Malström is formed. High-speed RIB motorboat trips through this dangerous area, also known as deep-sea rafting, are an attraction. The islands' offshore waters are also interesting Arctic sites for diving, surfing as well as sea kayaking.

Sea kayaking is very popular in the region. Both routes, in the fjords and in the coastal waters around the islands, received recognition from kayakers. A kayak trip on the Trollfjord and the route from Kabelvåg to Svolvær are the most popular areas for kayak tourism, which attract tourists by the possibility to watch varied, natural scenery.

Scuba diving is very popular in the region, and it takes place in the calm waters of the fjords or in their currents created during high tides. Attractive dive sites include Olderfjord, Ostenfjord, Austenfjord and the narrow Trollfjord, where drift diving is popular. Well-preserved wrecks also attract divers, however, the great variety of marine flora and fauna is the greatest attraction of diving in fjord waters. Underwater forests of seaweed, especially brown seaweed, rare fish species, lobsters and crabs, as well as starfish, sea urchins and colourful anemones can be seen even when just snorkelling.

Arctic surfing, windsurfing and kitesurfing in this region attract surfers from all over the world. The most popular surfing spots are Unstad off the island of Vestvågøy on Lofoten and Stokmarknes off the island of Hadseløya on Vesterålen. Waves suitable for surfing occur here almost every day of the year, and winds allow windsurfing and kitesurfing.

Lofoten and Vesterålen are also a well-known sea-fishing areas. The islands' coastal waters are home to around 100 fish species, including cod and other species that can be caught all year round. Tourist fishing centers are located in various parts of the archipelagos, usually on small islets such as Stormolla, Skrova, Røst, Vaerøy, and many others. The largest fishing areas occur at the waters between such islets.

The Lofoten and Vesterålen regions are also the area for commercial fishing for cod, which is air-dried without salt (stokfish). Racks prepared for this purpose are a part of cultural landscape on the coast, as well as the wooden, traditional houses (rorbu) built on rock shelves or on stilts driven into the sea water. The location of the rorbu right on the waterfront is linked to the history of fishing in the area. Traditional houses have been a part of the cultural landscape of the islands for centuries, and nowadays they are also a tourist attraction.

The tourist attractiveness of the coastal waters of Lofoten and Vesterølen is increased by the fact that the islands climate is much milder than other locations at the same latitude. The main reason for this anomaly is the warm sea current, flowing along the western coast of Europe - the Golfstrom (the Gulf Stream and its extension, the North Atlantic Current). It brings warm, surface waters from the south to the north, and sends cold, deep water back to the south. The current causes that in summer, it is even possible to enjoy sunbathing on the coasts and bathing in the sea, which temperature reaches 20°C. These islands are located behind the Arctic Circle, where the so-called polar day occurs in summer and winter is the time of the polar night. It is therefore possible to see the sun at midnight in summer and the aurora borealis in winter. The mere possibility of observing these phenomena attracts tourists from all over the world, and the use of the coastal sea waters is the basis for the development of tourism in this region.

Keywords: Tourism, sea coastal waters, islands Lofoten

## **A STUDY OF HOUSING CONDITION IN STUDENT VILLAGE, FEDERAL POLYTECHNIC, BIDA, NIGER STATE**

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Housing is of paramount importance to human existence as it ranked among the top three basic of needs of man aside food and clothing. The aim of the study is assess the housing conditions in the student village of Federal Polytechnic Bida, by taking stock of the existing housing features like accessibility, electricity supply, water supply, organized disposal method, drainage system, and functionality of facilities and maintenance of the buildings. Systematic random sampling procedure was employed in this study. The sample frame was 350 buildings, 20% of these 350 buildings which was 70 buildings represent the sample size for the students and 14 questionnaires which represent 5% of the 70 buildings were also administered to the house owners, in total; eighty four (84) questionnaires were administered. The findings from this study revealed that the housing condition in the student village fails to promote decent housing. Majority of the residents live in an in-conducive housing due to inadequate basic facilities; predominantly compound housing type, poor quality of building material, poor building expertise and neglect of renovation by landlords. Poor sanitary condition and open waste disposal contributes to environmental pollution. Government is, therefore, implored to exhibit an interest in rural housing by collaborating with house owners/ landlords to promote healthy housing in Nigerian rural areas. This can be through public private participation in the provision of essential social amenities, modern building materials subsidy, development control and physical planning law education to promote decency and functionality of the buildings.

**Keywords:** housing condition, water supply, shelter, accessibility, functionality, Student Village, Bida

## **RESTRICTIONS ON THE USE OF AGRICULTURAL LANDS IN UKRAINE FOR THE PROTECTION OF WATER RESOURCES**

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The object of the research is the process of establishing of water protection zones and coastal protective belts. The theoretical principles of establishing the boundaries of water protection zones and coastal protective belts around water bodies have been analyzed. The legal framework regulating restrictions on the use of agricultural lands in Ukraine, in particular, the establishment of water protection zones, were considered. It is noted that the size of water protection zones and coastal protection belts is regulated by the provisions of the Land and Water Codes of Ukraine. Water bodies as regime-forming objects are systematized according to the requirements for establishing boundaries of the coastal protection belts. The indicators of ensuring the availability of drinking water supply as part of the implementation of the Sustainable Development Goals in Ukraine were analyzed. It is substantiated that in Ukraine, regardless of the current legislative regulation of the use of agricultural land in the format of setting restrictions, which provides for the protection of water bodies from pollution and clogging and the preservation of their water content, there is a need for the actual establishing boundaries of water protection zones and coastal protective belts. Another aspect of restrictions on the use of agricultural land in this context is the lack of a compensation mechanism for landowners (land users) for the impact of restrictions on the profitability of their activities.

Keywords: water protection zones, coastal protective belts, water bodies, legislative regulation, Sustainable Development Goals

## **INFLUENCE OF PRE-TREATMENT WITH SOLIDIFIED CARBON DIOXIDE ON METHANE FERMENTATION OF AEROBIC GRANULAR SLUDGE**

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The technology of aerobic granular sludge (AGS) seems prospective in wastewater bio-treatment. The characteristics as well as compactness and structure of AGS have been proved to significantly affect the effectiveness of thus far deployed methods for sewage sludge processing, including anaerobic digestion. Therefore, it is deemed necessary to extend knowledge on the possibilities of efficient AGS management and to seek viable technological solutions for methane fermentation of sludge of this type, also by means of using the pre-treatment step. Little is known on the pre-treatment method with solidified carbon dioxide (SCO<sub>2</sub>), which can be recovered in processes of biogas upgrading and enrichment leading to biomethane production. This study aimed to determine the impact of AGS pre-treatment with SCO<sub>2</sub> on the efficiency of its anaerobic digestion (AD). An energy balance and a simplified economic analysis of the process were also carried out. The experiment was divided into two stages. In stage 1 (S1), AGS was pre-treated using SCO<sub>2</sub>. In stage 2 (S2), AGS was subjected to AD. S1 and S2 were divided into 6 variants (V), differing in the volume ratio of SCO<sub>2</sub> to AGS: V1 – control, V2 – 0.1, V3 – 0.2, V4 – 0.3, V5 – 0.4, and V6 – 0.5. AGS was cultured under laboratory conditions using the gravimetric selection method as a stress factor. After 120 days of the experiment, mature granules were obtained, which were used in further research works. Experiments were conducted with the use of SCO<sub>2</sub> in the form of granules 3.0±1.0 mm in diameter. Measurements of the volumes of biogas produced were carried out in a set of eudiometers. The initial OLR was 5.0 gVS/dm<sup>3</sup>. Measurements were conducted at 42°C. The volume of emitted biogas was read out every day until its production ceased. Biogas composition was controlled at the end of the process using a DP-28BIO gas analyzer. It was found that an increasing dose of SCO<sub>2</sub> applied in the pre-treatment increased the concentrations of COD, N-NH<sub>4</sub><sup>+</sup>, and P-PO<sub>4</sub><sup>3-</sup> in the supernatant in the range of the SCO<sub>2</sub>/AGS volume ratios from 0.0 to 0.3. No statistically significant differences were noted above the latter value. The highest unit yields of biogas and methane production, reaching 476±20 cm<sup>3</sup>/gVS and 341±13 cm<sup>3</sup>/gVS, respectively, were obtained in the variant with the SCO<sub>2</sub>/AGS ratio of 0.3. This experimental variant also produced the highest positive net energy gain, reaching 1047.85±20 kWh/tonTS. The use of the higher SCO<sub>2</sub> doses was proved to significantly reduce pH of AGS, thereby directly diminishing the percentage of methanogenic bacteria in the anaerobic bacterial community, which in turn contributed to a reduced CH<sub>4</sub> fraction in the biogas. The use of SCO<sub>2</sub> from the produced biogas could significantly improve the energy balance. Its production via technologies dedicated to biogas upgrading and its application for sewage sludge pre-treatment correspond with the idea of material recycling and directly inscribe into the assumptions of circular economy. This approach also supports the idea of reducing carbon dioxide emissions through its sequestration and use in a closed cycle.

Keywords: aerobic granular sludge, pre-treatment, solidified carbon dioxide, methane fermentation, biogas, methane

## **GEOLOCATION SUPPORT FOR OUTDOOR TOURISM (GSOT)**

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The "Geolocation Support for Outdoor Tourism" (GSOT) project is modernizing historical tourism through the integration of Augmented Reality (AR) technology with GNSS. This innovative approach enables the visualization of historical events at the sites where they took place. A prime example is the Battle of Grunwald, where tourists can now experience the historical event from 1410 through their smartphones. GSOT not only enhances the appeal of historical sites but also facilitates the management of museum spaces through online monitoring. This system, primarily associated with Polish historical sites, can be adapted for any location across Europe.

GSOT has successfully tackled several research and technological challenges, including the development of algorithms for scaling the trajectories of characters and objects during visualization, the creation of 3D objects and display optimization, the implementation of algorithms for fitting scenes based on mobile device sensors, and the integration of audio, text, and graphic layers with the user's GNSS-determined position. This has resulted in an interactive, immersive experience for visitors, with detailed information about historical events at their fingertips.

In conclusion, while it is impossible to commemorate every battle that has occurred throughout Europe's war-torn history, the integration of augmented reality with GNSS positioning offers a unique opportunity to create engaging content for any location. The successful implementation of GSOT confirms this, revolutionizing the way we experience history.

Keywords: augmented reality, tourist guide, history education

## **USE OF FOREST BATHING WATERS AS AN ALTERNATIVE TO DEVELOP TOURISM AND NATURE EDUCATION**

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Currently in Poland, as well as worldwide, there is a growing interest in the natural and health values of natural areas, including waters. Health, education, the opportunity to spend leisure time in nature, as well as the search for low-cost alternative leisure destinations, for many people is a determinant of modern trends in tourism, as well as an indicator of quality of life. In Poland, the shinrin-yoku (forest bathing) trend is gaining popularity. This is a Japanese modern term meaning immersion in the atmosphere of the forest, taking in the forest with all the senses "here" and "now." Despite the fact that scientific literature refers quite extensively to the health-promoting properties of naturalized areas, including aquatic areas, there is little mention of how the forest bathing trend can influence the development of tourism and environmental education. In our paper, we present some, in our opinion, of the most important factors that have a major impact in the development of tourism and environmental education in this interdisciplinary approach to forest bathing. The most important factors undoubtedly include: the popularity of forest bathing and its widespread use, a big plus is the fact that forest bathing does not require large financial resources to use natural areas, another factor is the health-promoting properties of being around water areas and the enhancement of the value of ecosystem services in keeping with the goals of sustainable development. Natural areas, through the presence of natural stimuli and stimulators (the sound of the wind, the sound of water, birdsong, etc.) support environmental education activities, at different times of the year, regardless of weather conditions. The widely available variety of tourist facilities makes it possible to use them for various purposes including, for example, therapeutic ornithology. The aforementioned examples of doubt demonstrate the need to promote the idea of water forest bathing in an interdisciplinary approach to tourism and environmental education.

**SCIENTIFIC ASPECTS OF THE FORMATION OF GEOINFORMATION  
SUPPORT FOR THE PURPOSES OF MONITORING AND EVALUATING  
THE DEVELOPMENT OF REGIONS IN THE CONDITIONS OF THE POST-  
WAR RECOVERY OF UKRAINE**

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This article examines the scientific aspects of geoinformation support for monitoring and evaluating the development of regions in post-war Ukraine. For more than twenty years, Ukraine has been in permanent search for an effective model of regional development, because as a state, the country was formed within the framework of territories that for a long time were part of different states and has 25 regions in its composition, which differ in natural conditions, the level of urbanization, and the structure of the regional economy ,

linguistic, historical, religious preferences, ethnic composition. In turn, the full-scale invasion of the Russian Federation into Ukraine on February 24, 2022 exacerbated the situation to the limit in all dimensions - social, economic, territorial. Therefore, the development of a new regional development policy using modern geo-informational tools requires a comprehensive analysis and assessment of the current situation related to the war and the situation in Ukraine as a whole, regions and territorial communities. The authors analyze the key challenges facing the country in terms of post-conflict recovery and discuss the potential benefits of utilizing geospatial data for informed decision-making. The article also highlights the importance of developing a comprehensive and accurate geoinformation system to support sustainable development and effective resource allocation.

Keywords: GIS, regional development, monitoring, evaluation, land management, spatial planning

## **RECREATIONAL VALUE OF SELECTED LAKES OF SZCZYTNO COUNTY**

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Water is often rated by recreationists as the most important attribute of their chosen setting for leisure and tourism activity, and recreational opportunities are a primary reason people choose to visit lakes. Lakes are an essential element of Szczytno County. This study focused on 15 lakes occurring within the county's territory. The lakes were selected to represent a range of area-based groups of reservoirs. During the present study recreational value of lakes was calculated by taking into account the morphometric parameters of water bodies as its location in the landscape and forested area. Studied lakes ranged in surface area from 5.5 to 869.3 ha. Comparison of recreational value of lakes was conducted within five groups selected. We further validate these values to recreation attractiveness. The relationship between habitat quality and the recreation attractiveness (points) was analyzed with Spearman correlations.

Keywords: recreational value, lakes, recreation attractiveness



## **THE USE OF GEOINFORMATION PORTALS TO CARRY OUT IMAGE RECOGNITION OF AIRPORT INFRASTRUCTURE ELEMENTS**

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Recognition, depending on the resources used, can be divided into several types. One of them is image recognition. The purpose of image recognition is to obtain a set of data about a given object. Currently, it is one of the most reliable sources of obtaining information, because the registered image is proof of the existence of a given object, phenomenon or event. This is possible thanks to the continuous development of image recording techniques. There are more and more geoinformation portals on the Internet, where we can find various types of knowledge resources. The aim of the work is to examine whether the use of such portals allows for image recognition of airport infrastructure elements.

Keywords: geoinformation portal, imagery intelligence, aerodrome

## **IMPACT OF THE COVID-19 PANDEMIC ON TOURISM TRAFFIC AND TOURIST BEHAVIOUR OF THE INHABITANTS OF THE WARMIŃSKO MAZURSKIE VOIVODESHIP**

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The outbreak of the COVID-19 pandemic in Poland led to the introduction of a number of travel-related restrictions. This led to changes in the travel planning and behaviour of the general public, including residents of the Warmian-Masurian Voivodeship. The aim of this study was to determine the changes in tourism and tourism behaviour of the inhabitants of the Warmian-Masurian Voivodeship. The main research tool used to collect data was a questionnaire. The research was conducted between May and July 2022.

The results of the research indicate that the COVID-19 pandemic had a significant impact on the tourism and tourism behaviour of the inhabitants of the Warmian-Masurian Voivodeship. During the pandemic, the vast majority of respondents (52.6%) decided not to go on a tourist trip, whereas before the epidemic their frequency was 2-3 times a year on average. The pandemic caused a change in the length of trips. Stays of 4-7 days were replaced by 1-3 days. The predominant direction of travel under the influence of the pandemic changed from international to domestic travel, influenced by the restrictions that were put in place to restrict movement. Hotels were the main choice of accommodation before the epidemic. The restrictions associated with the epidemic made holiday homes, where it is easier to maintain a sanitary regime and social distance, more popular. The main fears of residents of Warmia and Mazury before leaving (during the pandemic) were the fear of quarantine and the difficulty of returning. The decline in infections has led to the lifting of restrictions and greater freedom to travel.

Keywords: COVID-19 pandemic, tourist traffic, tourist behavior, Warmian-Masurian Voivodeship

**BUILDING CERAMICS BASED ON SLIDER DEPOSITS OF THE  
RESERVOIR OF UZBEKISTAN**

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In recent years, the developing industry of Uzbekistan is experi-encing a great need for affordable, high-quality, efficient raw materials for the production of ceramic building materials. The solution of these problems is in-extricably linked with the use of new mineral raw materials, secondary raw materials, as well as various waste products, instead of the natural raw materi-als used.

Keywords: silt, reservoirs, silt deposits, kaolinite-hydro, montmorillonite-hydro, montmo-rillonite-hydro

## **WATER TOURISM – KAYAKING**

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The aim of this research is to monitor canoe tourism against the background of the existing water potential in Poland. The research involves the analysis of the water network used for canoe tourism, in the field of tourism: senior, ecological, active, adventure: soft and hard. In addition to the assessment of various forms of canoe tourism, research related to various forms of their organization and their limitations is important.

The implementation of the research involves the analysis of spatial collections BDOT\_10 in the field of determining the water potential for the identification of possible waterways. Research based on the collections of the Land and Building Register (EGIB) allows to assess the forms of land development in the vicinity of land under water and their assessment in terms of tourism and ecology. Verification of the existing potential with their actual use is associated with a review of the offers of canoe tour operators. Identification of the organizers is possible through a review of data from the National Court Register (KRS). This is related to the review of associations of social organizations and entrepreneurship involved in the organization of active tourism. In addition, based on data from the Central Register of Economic Information (CEIDG), it is possible to monitor the number of natural persons conducting business activity supporting the organization of kayaking. The obtained data indicate a large and constantly growing potential in this area. In addition to these basic studies, a side goal is to determine canoe centers in Poland and the form of their functioning. In addition to research, based on the analysis of data sets, it is important to evaluate the activities of canoe tourism from own experience.

The results of the research indicate: high water potential conducive to canoe tourism – the largest in Europe; few entrepreneurs offering participation in an organized canoe event in the form of buying a tourist offer; turbulent development of entrepreneurship in the field of supporting the organization of canoeing trips; the existence of many local canoe centers with numerous possibilities for organizing canoeing events; lack of economic activity supporting the service of tourists on the trail. Own experience indicates the existence of difficulties in the implementation of kayaking trips, resulting from the lack of infrastructure supporting safe launching, landing and facilitation in moving kayaks when overcoming water structures on the trails. In addition, the problem is the existence of obstacles in the riverbed fallen trees (so-called dumps), barbed wire limiting watering holes for animals, low bridges, footbridges. These difficulties are often eliminated by local initiatives of entrepreneurs, supported by social work, with the participation of the Volunteer Fire Brigade (OSP).

Keywords: wather tourism potential, kayaking, tourism operators, canoe event

## **EFFECT OF PRECIPITATION ON HYDROLOGICAL INDICATORS OF THE RAISED BOG AND ITS SURROUNDINGS ACCORDING TO MULTIPLE TIMESCALE SPI**

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Long-term and seasonal fluctuations in precipitation determine the cyclical change of biotic and abiotic processes related to water resources. This interaction is particularly important in such precipitation-dependent environment as a raised bog. The aim of this study is to evaluate the dependence of the hydrological indicators of various raised bog habitats and adjacent water bodies on the amount of precipitation over different time periods.

The study was based on following data: 1951-2022 Varėna MS precipitation; 1991-2021 Ūla-Zervynos GS discharge; 2002-2022 measurements (8 to 20 years) in Čepkeliai peatland water table measuring wells in bog woodland, semi-open raised bog, open raised bog, lagg, surrounding continental dunes (mineral soil), and in a dystrophic lake. Pearson correlation coefficients between multiple timescale SPIs (standard precipitation index) and monthly hydrological indicators over the whole period of the surveys and in individual months were calculated.

The analysis showed that water table fluctuations in the raised bog habitats and in the dystrophic lake have a strong correlation with precipitation: in late spring-early summer there is a strong correlation with short-term precipitation (SPI1-SPI2); in the following months the correlation with short-term precipitation weakens and with longer-term (SPI4-SPI12) – strengthens; in late winter-early spring the values of the correlation coefficient are low or slightly higher only with long-term precipitation (SPI18, SPI24). The distribution of correlation coefficients between SPIs and river discharge has a similar pattern, but the values are lower and show a moderate correlation. The water table fluctuations in the measuring well on the dune adjacent to the raised bog (mineral soil) have a strong correlation only with long-term precipitation (SPI18, SPI24). The correlation between lagg water table fluctuations and precipitation is statistically insignificant in most cases, with only July and September water tables weak or moderately correlating with some SPI values.

Keywords: water table depth, precipitation, standard precipitation index

**RECOVERY OF PHOSPHORUS AND OTHER MINERALS FROM  
GREENHOUSE WASTEWATER FROM SOILLESS TOMATO CULTIVATION  
BY PRECIPITATION**

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The possibility of recovering phosphorus from greenhouse wastewater by alkalization was investigated. The alkalizing agents tested in the work were: sodium hydroxide, potassium hydroxide and ammonia water. The pH range tested during alkalization was pH 6.5-12.0. The amount of precipitated phosphorus from greenhouse wastewater depended mainly on the pH in the system. The type of alkalizing agent had a marginal effect on the process of phosphorus precipitation from sewage. The optimum pH of alkalization, guaranteeing high efficiency of phosphorus precipitation from wastewater (99%) with a relatively small dose of the alkalizing agent, is pH 9. The most efficient alkalizing agent (in terms of the amount of reagent used) turned out to be ammonia water.

Keywords: phosphorus recovery , greenhouse wastewater; phosphorus; precipitation

## **AQUATIC ANIMALS IN THERAPIES. DOLPHIN ASSISTED THERAPY - CONTROVERSY AND RISKS**

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Review paper Fiksdal, Houlihan and Barnes on studies claiming swimming with dolphins is therapeutic and beneficial for children with psychological disorders, released in 2012 found the majority of the studies to have substantial methodological deficiencies. Authors expressed urgent need for "clear, verifiable, and repeatable evidence" within psychology supporting therapies. To verify current controversies and different points of view on DAT we reviewed works referring the publication mentioned above. Twenty-eight such works on different issue have been listed in Scopus and Web of Science databases. Some of them indicate that contact with dolphins stimulates intellectual functions and ultrasound waves emitted during the echolocation of dolphins stimulate the brain and support the process of speech development. It is commonly accepted, although therapies with animals do not cure ASD, but it generate positive changes in the functioning of people with ASD. Undoubtedly they contribute to better social adaptation reducing anxiety and helps to reduce the feeling of loneliness, in general favours positive changes in people with different psychological disorders. When comparing DAT with therapies without dolphin the improvements in social and communicative skills is noticeable in both groups, with an advantage of the DAT group in some aspects like "frequency of vocalizations toward others" and "gestures". It was also proven that complex methods of neuro- sensory-motor activity sessions involving dolphins emerge positive effects in the functioning of the neuro-sensory systems in 2 weeks of application. On the other hand the meta-analyses indicated small effects related to improvements in social interaction and communication, there was little evidence for a relationship between dosage and effect size. Methodology in psychological investigations are still discussable (not only in DAT context), further research are recommended to confirm effectiveness of such therapies.

Hunting dolphins from the wild and holding them captive for any purpose is main concern at present not only due to current trends in social ethics but also due to risks of injury. Research on dolphins aggression proved that 83% of the studied population (55 adult females and their 88 calves observed for 1876 h or longer) had visible tooth marks and agonistic interactions occur for most individuals at least every two years. Authors suggest that combination of shifting ranges, ecological overlap and territoriality, all could made inter- and intra-species interactions more common. Research on how human-induced changes in marine ecosystems affect cetacean behaviour and their interactions with other species are reasonable nowadays. In controlled circumstances fulfilling the requirements of welfare and well-being, dolphins accompanied with their protectors do not attack according to recent data. Infections risks for humans during swimming and touching dolphins are not proved, lobomycosis transmission from dolphins is impossible in practice due to divergence of strains infecting humans and cetaceans. Bacterial diseases concern for researchers or veterinarians who can be infected during dolphin necropsy or other manipulations different from swimming.

If one imagine that a single dolphin can generate between 400,000 and 2 million USD per year depending on the frequency of use controversies has arouse. Thus, captive dolphins in the tourism industry annually generate between 1.1 and 5.5 billion USD plus additional income channels through merchandise it means a "multi-billion dollar industry". The claim that conservation is a primary purpose of the dolphins public display industry as a whole is unreal. Fewer than 5 to 10 percent of zoos,

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dolphinariums, and aquaria are involved in substantial conservation programs either in natural habitat or in captive settings, and the amount spent on these programs is often less than 1 percent of the income generated by the facilities.” Recent activity lined with establishment of whales sanctuaries especially promoted by Aquariums need not be at the cost of true conservation. Facilities suspected “green washing”, justifying huge incomes with conservation purposes don't have social approval. The trend to protect marine mammals in sanctuaries seems the most socially accepted form of their protection and presentation for educational purposes. There is also more probably to accept involving cetaceans in therapies and rehabilitation than for entertainment and customers fun. This is reasonable taking into account the biological and neurological latest results of medical research using indicators related to human physiology and regenerative processes, able to be modified during contact with dolphins. Transcranial focused ultrasound promote cognitive function in human. Considering this, authors presumed that ultrasound-improvement may be facilitated via neuroblasts of the adult brain. Recently, neuroblasts have been suggested to be crucial in immunogenicity and neuroplasticity of the adult brain. Authors underline the biological effect of ultrasound on the regulation of neuroblasts may be important at treatment for dementia.

Keywords: Aquatic mammals, Cetacea, echolocation



**WATER SUPPLY BILLING SYSTEMS IN MULTI-OWNED HOUSING  
MANAGEMENT: THE CASE OF A LARGE HOUSING COOPERATIVE IN  
POLAND**

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The paper will present the problems of water supply accounting in the management of multi-owned housing in Poland. The issue will be highlighted both from a legal and organizational perspective and from the perspective of good practices applied in housing management. The aim of the own research is to identify the water supply billing systems formed in multi-owned housing management in Poland. The research will be carried out in a selected large housing cooperative in Olsztyn. The methods used included a survey of legal regulations and organizational documentation, as well as a face-to-face interview method with competent employees of the cooperative. This made it possible to realize the set research aim and to formulate practical conclusions enabling the improvement of the system of water supply to multi-owned housing properties.

Keywords: water supply, billing systems, cooperative housing management, Poland

## **SIMULATION OF SWIRLING JET FLOWS BASED ON A TWO-FLUID TURBULENCE MODEL**

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This article presents the results of a two-liquid model for a swirling jet. The two-liquid model used in this work has been developed recently. In pioneering works it is shown that the basis for the construction of this model is the possibility of representing a turbulent flow in the form of a heterogeneous mixture of two liquids. Therefore, this model is derived based on the dynamics of two-liquids. These papers also show that the developed two-fluid model is able to adequately describe complex anisotropic turbulence. The fundamental difference of this model is that the two-fluid model is the equations of dynamics. The two-fluid model reduces computational costs and makes the methodology practical from an "engineering" point of view for modern computing resources. In the numerical implementation in convective terms, the control volume method was used, and the correction for velocity was carried out according to the SIMPLEC method. The numerical results obtained are compared with experimental data from the ERCOFTAC database. It is shown that the results of the two-liquid model are consistent with experimental data.

Keywords: swirling jet, two-fluid model, scheme against the flow, twist, QUICK scheme

**IMPACT OF CLIMATE CHANGE ON AGRICULTURAL LAND USE:  
PREDICTIONS AND MEASURES TO INCREASE RESILIENCE**

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The impact of climate change on agricultural land use has been considered. The main consequences of climate change, such as wildfires, droughts, increased frequency and intensity of rain and storms, desertification, and decreased water in rivers, have been analyzed. Foreign experience regarding adaptive measures aimed at forming resource potential and reducing risks in Ukraine has been examined. Strategic priorities of the current state of land use, taking into account its changes with projected climate changes, have been formulated. Practical measures have been proposed for the implementation of the concept of sustainable use of agricultural land, which requires the determination of ecological-economic priorities and the use of effective means to achieve environmental goals.

Keywords: land use, management of agricultural land, global climate change, ecology, crop yield, socio-economic development

**DEFINITION OF APPROACHES TO DEVELOPING LAND MANAGEMENT  
PROJECTS FOR CO-OWNERS OF MULTI-APARTMENT BUILDINGS:  
UKRAINIAN REALITIES**

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The allocation of land plots for the adjacent territories of multi-apartment buildings is an important and relevant issue for both residents of these buildings and local authorities, especially in large populated areas with existing dense development. The works related to the allocation of land plots for the adjacent territories of multi-apartment buildings rely on the use of a significant amount of normative and legal acts of Ukraine, which contain certain inconsistencies (collisions) regarding the rights to use such land plots and the content of the relevant land management documentation. This problem has become particularly important in modern Ukrainian realities, such as the existing state of war and the plans for post-war reconstruction of populated areas in Ukraine.

The article analyzes the cases and factors that affect the determination of rights to land plots under multi-apartment buildings and establishes the main requirements and improvements to the content of the relevant land management documentation with ""maximum"" consideration of existing norms of effective normative and legal acts of Ukraine and ""minimum"" changes to them. Three options for allocating land plots under multi-apartment buildings are identified for their acquisition in private ownership, permanent use or rental.

Methodical approaches have been developed that provide an opportunity to divide all multi-apartment buildings into three groups depending on their ownership. Taking into account the established ownership of multi-apartment buildings, proposals have been developed for determining the right to use the corresponding land plots, simplifying the requirements for the relevant land management documentation and establishing objective information for calculating the rent, which will positively affect the replenishment of local budgets. The proposed approaches can be applied in all cities of Ukraine.

Keywords: apartment building, land planning documentation, land plot, normative legal acts of Ukraine on land planning, residential area

## **DEGRADATION OF UKRAINIAN LANDS DUE TO MILITARY ACTIONS**

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The problems of using the land fund of Ukraine in the course of hostilities are highlighted. Attention is focused on the insurmountable factors of negative impact on the quality indicators of soils, crushing damage to the vegetation cover, the integrity of the soil cover is violated due to the movement of powerful military equipment. The issues of degradation of Ukrainian lands in the zone of active operations, which is expressed in the activation of such processes as wind and water erosion, are highlighted. A separate issue is the problem of demining agricultural land, which is impossible for Ukraine to solve on its own.

Keywords: land degradation, military operations, demining of farmland

## **DEVELOPMENT OF THE CONCEPT OF SUSTAINABLE DEVELOPMENT**

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The concept of sustainable development, which can be understood in two contexts. On the one hand, it is a set of tools leading to the achievement of the most desirable socio-economic development, while the second context, with a much broader meaning, is the understanding of sustainable development as a concept of the relationship between man and the environment. References to the paradigms of spatial management and spatial order have been included in the author's concept of sustainable development. When planning space, the author suggests using a scheme with an algorithm that optimizes the process, which is consistent with the definition of sustainable development, namely that it is a process aimed at satisfying the development aspirations of the current generation, in a way that allows the next generations to implement the same aspirations.

Keywords: sustainable development, spatial management

## **THE EFFECT OF TIRE MATERIAL MICROPLASTIC ON THE STRUCTURE OF AEROBIC GRANULAR SLUDGE.**

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Emerging contaminants such as microplastics (MP) are a growing problem for wastewater treatment systems. The presence of MP in wastewater treatment systems can affect system performance and biomass structure. This study aims to investigate the effects of MP from tire material on aerobic granular sludge's biomass structure and evaluate the potential consequences of MP presence for wastewater treatment plants and the environment. Five reactors were used for the study, including a control reactor (R1) and four reactors with different doses of MP (from 50 mg MP/L to 500 mg MP/L of wastewater). The results showed that the MLSS content increased from 4.7 g/L in R1 to 9.5 g/L in the reactor with the highest concentration of MP (R5). The tire material was found to be entrapped in the biomass structure, indicating that MP can accumulate and remain in the sludge. An increase in the number of filamentous bacteria in the reactors with higher concentrations of tire material was observed. Despite that, the sludge volumetric index in R5 was about two times lower than in R1, indicating a positive effect of MP on the settling ability of the biomass. These results suggest that high concentrations of MP can affect the physical properties of sewage sludge, potentially leading to problems in the operation of wastewater treatment plants. The presence of tire material in sludge is also of concern, as it limits the agricultural use of sludge due to the risk of MP accumulation in the environment.

Keywords: microplastics; granular sludge; biomass

## **PHYCOCYANIN EXTRACTION METHODS FROM ARTHROSPIRA PLATENSIS: A COMPARATIVE STUDY**

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This comparative study examines various methods for extracting C-phyocyanin from *Arthrospira platensis*, a type of blue-green microalgae commonly used in food as a protein supplement and in medicine due to its medicinal properties, such as anti-oxidation, anti-inflammatory, and anti-cancer properties that have potential therapeutic applications. C-phyocyanin can also be used in food as a colouring agent. This research was conducted in stages. In the first stage, microalgae cultures were grown in tubular reactors with a 2.5 dm<sup>3</sup> volume, based on the SAG culture medium dedicated to *A. platensis*. The cultivation was carried out at 30°C and in fluorescent light of 720 lumens. In the next stage, analyses of C-phyocyanin content and extraction yield were conducted using various physical methods and their combinations, including ultrasound, and mechanical stresses such as freezing-thawing and deep freezing-thawing in two different solvents. Prior to measuring C-phyocyanin, the samples were shaken in the dark for 24 hours, and later, the samples were centrifuged at 9000 rpm for 5 minutes. The supernatant was subjected to spectrophotometric analysis. The findings offer insights into the optimal conditions for extracting C-phyocyanin from *Arthrospira platensis* and provide valuable information for researchers and industry professionals working with this natural resource.

**Keywords:**C-phyocyanin, Physical methods, *Arthrospira platensis*, Ultrasound, Freezing, Deep-freezing, and thawing



## **DYNAMICS OF ORGANIC CARBON FRACTIONS IN URBAN FOUNTAINS**

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The aim of this work was to characterize the dynamics of organic carbon concentration originating from Olsztyn city fountains in correlation to seasonal changes and determination of factors affecting its content in water. The tests were carried out based on five fountains with a closed water circulation system. The analyzed objects are a fountain in the Central Park, Old Town, "Fish with a Child", "Symphony of Birds" and a fountain next to the town hall. The content of organic matter was determined by separating the TOC, DOC and POC fractions from water taken directly from fountains basins.

The statistical analysis of the results included: the mean, error and standard deviation to compare the concentrations of carbon forms in individual objects, the Fisher's NIR test to show the differences in the content of organic matter between the fountains and the seasonal variability of the examined parameters. The highest average POC concentrations were found in Old Town and "Symphony of Birds" (1.92 mgC•dm<sup>-3</sup>), in other fountains POC ranged 0.20-0.50 mgC•dm<sup>-3</sup>. The average concentration of DOC was lowest in Central Park (5.25 mgC•dm<sup>-3</sup>), and highest in the Old Town (12.00 mgC•dm<sup>-3</sup>). Fisher's NIR test confirmed significant TOC differences for "Fish with a Child" and all other fountains except Central Park. Seasonal variation was confirmed for the average POC concentration between the October study (0.11 mgC•dm<sup>-3</sup>) and the May and June studies (1.77 and 1.68 mgC•dm<sup>-3</sup>).

The effect of the research is that the content of individual carbon fractions is affected by the location of the fountain, seasonal changes resulting from the supply of plant detritus in the summer-autumn period (especially among fountains in parks), and activities related to anthropopressure. It was also noticed that water jets located near to compact buildings are more exposed to worse water quality. In addition, each of the tested objects has excessive TOC content similar to eutrophic reservoirs, which indicates the low efficiency of filtration and disinfection used.

Keywords: organic matter, TOC, DOC, POC, fountain, water quality, anthropopressure

## **SENTINEL-2 MULTI-SPECTRAL IMAGING FOR WATER QUALITY MONITORING: MODELS VARIABILITY & PORTABILITY**

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The use of remote sensing, in particular multi-spectral imaging (MSI), to monitor water quality of inland waters is now a common practice. Several models have been proposed to address different parameters, such as turbidity, chlorophyll and dissolved oxygen, to mention just a few. The methodology consists of adjusting in situ measurement data from different locations in rivers and lakes to a mathematical expression involving certain bands of MSI data cubes and adjustment parameters. The choice of the bands is made according to the spectral properties of each parameter under study. In this work we focus on one of such parameters, the chlorophyll, and compare the results from a set of models derived from Sentinel-2 (ESA/EU Copernicus program) MSI products. The models were implemented on a scripting language for the EO Browser cloud platform to generate the spatial maps of chlorophyll concentration, in order to evaluate the variability of quantitative estimates and thus assess the portability of those models. This study is part of project SIMG – Intelligent System for the Monitoring of Guadiana (financed by PROMOVE o futuro do interior, BPI | „la Caixa“ Foundation) that addresses water quality monitoring of Guadiana River in Portugal, using remote sensing MSI and in situ measurements to develop an integrated system. Our preliminary results support the necessity of a harmonization of the models in order to obtain coherent results from MSI products. This is important in the context of evaluating water quality from the perspective of water resource management, decision making, and public health protection.

Keywords: Sentinel-2, Remote Sensing, Multispectral Imaging, Water Quality, Chlorophyll

## **HYDROGRAPHIC STUDY OF RIVER BED EROSION OF THE WLOCLAWEK POWER STATION**

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The study presents hydrographic monitoring of alluvial Vistula river bottom changes behind the power station in Wloclawek in Poland. During the operation of the water power plant, there has been an engineering problem in the form of pothole formation on the river bed in the gravel-sand alluvium of the river. This has been caused by increased fluvial erosion due to a reduced water level behind the power plant, along with frequent changes in the water flow rates and water levels caused by varying technological and economic operation needs of the power plant. The original plan was to build eight water power plants north of Warsaw on the biggest Polish river, the Vistula river, which would optimize the hydraulic conditions of the river in relation to the ongoing erosion and sedimentation processes. Unfortunately, with regard to the financial situation, only one water power plant was built in 1970, the Wloclawek water power plant. As a consequence, the formation of potholes endangers the concrete structures of the water power plants and the threshold, which serves for partial water flow stabilization. Four years of geodetic/bathymetric mobile mapping of the riverbed carried out using integrated GNSS (Global Navigation Satellite System) and SBES (Single Beam Echo Sounder) methods were performed to identify potentially hazardous changes in the riverbed.

Keywords: bathymetric mapping of river bottom changes, GNSS/SBES measurements

## **CATION-EXCHANGE RESINS FOR WASTE WATER TREATMENT**

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There was given a possibility of obtaining new cation exchange resins based on styrene-furfural polymer. The object of the study was a polycondensation type phosphate cation exchanger based on a styrene-furfural polymer, which is obtained by the following method: the styrene-furfural polymer previously swollen in phosphorus trichloride was placed in a three-necked flask with a stirrer and a reflux condenser and phosphorylated with phosphorus trichloride as a catalyst using aluminum (anhydrous). The molar ratio of the reagents polymer: aluminum trichloride: phosphorus trichloride = 1: 2: 4. The conditions for the phosphorylation of this polymer were selected from the experiments accumulated in relation to the phosphorylation reactions of low- and high-molecular compounds. The resulting polymer had an exchange capacity for a 0.1N NaOH solution – 5,5-5,6 meq/g and contained 16,5% phosphorus. In order to elucidate the mechanism of sorption of the cations of these metals, we took the IR spectra of the cation exchanger in the H- and Na-form, saturated with copper ions.

Keywords: ion exchange, sorption, waste water treatment, cation-exchange resin

## **MATHEMATICAL MODELING OF THE TECHNOLOGICAL PROCESS OF CULTIVATION OF HIGH LIPID CHLORELLA VULGARIS MICROALGAE**

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In the article, the mathematical model of the technological process of growing *Chlorella vulgaris* and its main parameters obtained in the experiments were considered and analyzed, and developed the structural scheme of the stage of intensive cultivation of *Chlorella vulgaris*. The dependence of the biomass accumulation of *Chlorella vulgaris* on the growing time was obtained experimentally. In the experiment, it was shown that the nature of the kinetic curve corresponds to the Verhulst logistic equation for limited population growth. It has been shown that the process of substrate loss during periodic cultivation of *Chlorella vulgaris* is described by the equation.

When the biomass  $x$  concentration of *Chlorella vulgaris* reaches the maximum value  $E_p$ , growth stops. In the same way, it was found that the increase in the amount of lipids formed. It is shown that the process of inhibition of biomass growth with increasing concentration of substrate  $C$  can be described by Andrew's equation. The maximum specific growth rate during the cultivation of *Chlorella vulgaris* depends on the temperature  $T_k$  included in the formulas for calculating  $m_{\max}$ ,  $m(S)_{(I=\text{const})}$ ,  $m(I)_{(S=\text{const})}$ . The values of  $K_s$  and  $K_{\text{ing}}$  depend to a lesser extent on the temperature  $T_k$ , so it is based on the fact that the formula for calculating the maximum growth rate  $m_{\max}$  can be written as a power dependence on the growth temperature  $T_k$ .

Cultivation of *Chlorella vulgaris* Using the calculated concentration of potassium nitrate (3.2 g/l) in the Tamiya nutrient medium, the optimized medium composition was determined using the suggested macro and micronutrient ratios. The maximum concentration of microalgae cells in the optimized medium is 9-14% higher than the maximum concentration in the Tamiya nutrient medium, while the cost per cubic meter of the new nutrient medium is 1.92 times lower than that of the Tamiya medium.

**Keywords:** *Chlorella vulgaris*, mathematical modeling, microalgae, Tamiya, optimization, cells

**ANDIJAN REGION MONITORINGS THE POSSIBILITIES OF COLLECTOR  
DRAINAGE AND GROUNDWATER USE IN WATER-SCARCE AREAS AND  
THE DEGREE OF TURBIDITY AND SALINITY OF THE SURFACE WATERS  
OF THE IRRIGATED LAND AREAS**

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Water resources of Andijan region are recognized as sufficient in general, but the distribution of water resources is not the same across regions. The article provides information on the regions of Andijan region that have and are experiencing water shortages, the location and distribution of surface and underground water resources in the regions. In order to solve the problem of surface water supply to the water scarce areas, in the previous areas, the solution measures were applied in exchange for irrigation using collector drainage and underground water. Monitoring of surface depth and salinity level of irrigated land areas in Andijan region was carried out in 2007 and 2021. based on the results, the total amount of water received in 2021 was 2270.5 million m<sup>3</sup>, which shows a decrease of 555.5 million m<sup>3</sup> compared to 2826.05 million m<sup>3</sup> in 2013.

keywords: Water scarcity, monitoring, groundwater, surface water, collector drainage, groundwater table, water distribution, salinity, monitoring wells, mineralization

**METHODS FOR DETERMINING THE CAUSES OF THE DESTRUCTION  
OF AQUEOUS SOLUTIONS OF DIETHANOLAMINES AND RESTORING  
THEIR WORKING PROPERTIES**

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The causes of degradation of diethanolamine solution used for natural gas purification are analyzed. The factors influencing the physicochemical properties of ethanolamines and the amount of absorption have been studied. It has been established that substances that affect the efficiency of gas cleaning and reduction of an ethanolamine solution (heat-resistant salts, organic acids, bitsins, di-, tri, tetracompounds of amines) cause saturation and dehydration of the absorbent solution. Based on the results of the study and analysis of the above, methods for purifying ethanolamines used in gas purification from harmful compounds and extending their service life have been studied.

Keywords: diethanolamine (DEA), degradation, natural gas, solution purification, heat-resistant salts, cations, organic acids, bitsins

## **RESTRICTIONS AND ENCUMBRANCES IN THE USE OF LAND AS A TOOL FOR THE PROTECTION OF WATER RESOURCES**

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The current legislation of Ukraine regarding restrictions on the use of land and other rights to land is at the stage of formation, namely, it does not contain an optimal list of legal norms that could characterize restrictions and burdens of rights to land, their types, determine the grounds for their establishment and methods of their implementation, including from the point of view of water resources protection.

To analyse water protection restrictions on land use in accordance with current legislation and develop scientific methods of systematization of protection zones forming objects and water protection restrictions on land use.

A classification of water protection restrictions has been developed according to zones with a restricted land use regime.

Keywords: protection zones forming object, classification of restrictions, water bodies, land use, restriction's zones



## **ALQUEVA LAKE IN PORTUGAL: EXAMPLES OF TOURISM EXPERIENCES AROUND THE LAKE**

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A number of well-known tourism destinations around the world are based on lakes as the main attraction. Although is still difficult to determine the economic significance of lakes, lake tourism has been recognized as a relevant subfield of tourism studies. It is important to note that lakes are open water bodies, dams or reservoirs which might represent a valuable resource for a variety of human activities. In addition, lakes might also become an important resource for tourism development, based on their landscape features, flora, fauna and cultural attractions. Lakes offer a naturally defined core resource for tourism development (Hall and Härkönen, 2006). This is in fact a term that tends to be categorized by the location of the lake. Therefore, some authors prefer the term 'water-based tourism' since it relates to any activity or experience undertaken in or in relation to water (Jennings, 2011). For that reason, lake tourism is also grounded in creating unique experiences, strongly based on sensations, emotions, feelings that help to create memories associated with the lake itself. The study site of this work is based on the Alqueva man-made lake as an emerging destination in the Alentejo region in the south of Portugal with 250 km<sup>2</sup> (and also part in Spain). This work aims to: (i) discuss the concept and main characteristics of lake-destination areas applied to a particular lake in Portugal, Alqueva Lake; (ii) to present and describe some examples of well-organized tourism products related to several types of tourism, such as wine tourism, nature tourism, astrotourism, cultural tourism or nautical tourism that are being developed around the Alqueva Lake, adding value to the lake tourism experience; finally (iii) to introduce and briefly discuss, based on a literature review of lake tourism, important issues concerning the Alqueva Lake as a future lake-destination area.

Keywords: lake tourism; tourism experiences; Alqueva Lake

**MODERN CONSTRUCTION INDUSTRY OF UZBEKISTAN: TRENDS,  
PROBLEMS AND PROSPECTS**

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The article describes some specific features of construction industry in Uzbekistan. Presented a study of trends in development of the construction industry in Uzbekistan over the past few years, as well as the impact of growing population on need for investment in construction.

Keywords: construction industry, construction, indicators of construction

**DEVELOPMENT OF OPTIMUM COMPOSITIONS OF REFRACTORY  
ADHESIVE COMPOSITIONS BASED ON INDUSTRIAL WASTE WITH  
CLAY ADDITIVE**

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The results of petrographic studies of structure formation and the formation of the phase composition of the developed aluminophosphate refractory adhesive compositions  $\text{Al}_2\text{O}_3^*\text{-Cr}_2\text{O}_3\text{-H}_3\text{PO}_4$  at different temperatures with the addition of clay components are presented. It has been established that polarizing cristobalite tridymite and  $\text{AlPO}_4$  crystals of rhombic modification are observed in the phase composition of the composition of fired samples, which are thermally stable compounds that provide high performance properties when gluing refractory materials.

Keywords: adsorbent, aluminophosphate glue, amorphous phase, phosphotridymite, phosphocristobalite, adhesion

## **VEGETATION CONDITION INDEX RELATIONS WITH HYDROCLIMATIC INDICATORS IN RAISED BOG**

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Global environmental pressures related to climate change and anthropogenic activities (drainage, overgrazing, burning) continues to pressure the sensitive peatland ecosystems. These unique ecohydrological units require continuous monitoring of their vegetation and hydrological conditions. Therefore, the application of cost-effective remote sensing methods for assessment of peatlands' vegetation conditions and their relations with hydroclimatic indicators is becoming one of the most popular tools in wetland research during the last decades.

The aim of this study is to assess how the hydroclimatic conditions changes are reflected by Vegetation Condition Index (VCI) derived from the low-resolution satellite images (Terra MODIS 8-day composite product, 250 m resolution). Research was carried out during 2012-2022. In situ water table fluctuations during this period were measured at a well, located in the northwestern part of Čepkeliai raised bog, a pristine peatland in south-eastern Lithuania. Precipitation was estimated from Varėna WS data. Based on the VCI dates (cloudless images), measuring well data reflecting the highest and the lowest water table and precipitation of different duration (1-30 days) were selected for this research.

The patterns observed in the study suggest that at lower water table, VCI values reflecting extreme, severe and moderate drought conditions are recorded. In contrast, at high water table, VCI values tend to reflect wet conditions in wetland habitats. At the highest and lowest water table values tested, there were no significant differences between the amount of precipitation on the nearest days (1 and 2 days). In contrast, for longer durations (5, 10 and 30 days), the precipitation is significantly higher when the water table is closer to the surface of the peatland.

Differences in the seasonal variation of the VCI index between high and low water table have also been observed. At the beginning of the growing season, the differences in VCI values are not significant. However in the middle of the growing season (June-August), the higher VCI values are recorded when the water table is higher. It indicates the peak of plant biomass and good hydroclimatic conditions for normal enzyme activity and photosynthesis.

Keywords: peatlands, vegetation condition index, water table, precipitation

## **RECREATIONAL FUNCTION OF MUNICIPAL FOUNTAINS ON THE EXAMPLE OF OLSZTYN**

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Fountains are an important element of the urban landscape, offering many recreational and aesthetic values. Their presence in cities improves the quality of life of residents and attracts tourists. There are several fountains in Olsztyn, 9 of them are municipal facilities. There are natural fountains (the basin on the natural ground is supplied with water from natural surface runoff - Jakubowo reservoir), semi-natural (artificial, concrete basin, supplied with tap water and surface runoff during the season - Kusociński Park) and artificial (artificial basin, powered only with tap water) - Fish with a Child, Symphony of Birds - Podzamcze Park, Solar System - Central Park). Artificial fountains function are a tourist attraction. Some of them are recognizable architectural objects with modern sculptures by outstanding artists. Art introduced into a specific cultural space builds an emotional connection with this space, strengthens the value of the place and defines the collective identity. In addition to its aesthetic and artistic function, it is a sign that attracts tourists and helps build the city's brand. A novelty in the urban space of Olsztyn are the fountains of the cascade type (the least attractive in terms of recreation) and the Fountain of Freedom (a bug), still not very recognizable by the city's inhabitants. Spending time near the fountain is equated with rest, regeneration and is part of passive recreation. Useful recreational values include tourist attraction, meeting place, aesthetics, refreshment, relaxation. Fountains are attractive elements of the urban landscape, the water mirror reflects the surrounding landscape, optically enlarging it, and a specific microclimate is created nearby. The water spray from the fountain can cool the skin and provide relief on hot days, and the sound of flowing water is considered one of the best methods of relaxation.

Keywords: fountain, urban, recreation, landscape architecture

## **THERAPIES AND TREATMENTS USING FISH – RISKS AND CRITICISM**

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Therapies and treatments using animals and plants or their secretions are becoming increasingly popular. The use of Red garra, *Garra rufa* (Heckel, 1843) in ichthyotherapy or in fish-spa (a non-medical procedure for removing dead and hardened skin including pedicures), is a growing practice in last decade. It raises the question: are this therapy effective and completely safe for humans?

Several scientific studies suggest that "doctor fish" use may be beneficial for people with skin problems (including psoriasis), however other therapeutic agents can not be eliminated in patients treated so, there is a lack of randomized studies on ichthyotherapy as a monotherapy.

On the other hand, there are studies proved that treatments with *G. rufa* utilize can be hazardous to humans. The main risks we face to in fish-spa are associated with bacterial infections. It is known that skin infections can result from spa use, transmitted from fish to clients, through fish or water, or from client to client. While disinfecting the water would reduce the likelihood of infection, conventional methods of sterilisation and/or disinfection of water and equipment are not applicable because they would harming or kill the fish.

The regulations and warnings for fish-spa treatments vary from country to country. In Poland, there are no specific sanitary requirements dedicated to beauty salons offering fish-pedicures, so Sanitary-Epidemiological Stations in Poland have to inspect them the same way as the common SPA. Presented review on infections connected with *G. rufa* use suggests the need of such regulations development and implementation.

Keywords: *Garra rufa*, ichthyotherapy, fish SPA

## **CAN ALL ORGANIC SUBSTRATES BE USED FOR EFFECTIVE METHANE PRODUCTION?**

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One of the desirable methods for treating biodegradable organic substrates is anaerobic digestion (AD). The methane production (MP) from two organic materials, one from agri-industry and the second from a municipal wastewater treatment plant, was determined. In addition, the kinetics of organic matter (OM) removal was also analyzed.

The waste from mushroom production was taken from the mushroom production industry (northeast of Poland). The substrate was dried and ground to obtain homogenous material. The dry matter (DM) and organic matter (OM) in the WMP were 26.1 % and 64.8 % DM, respectively. Secondary sewage sludge was obtained from a secondary clarifier at full-scale wastewater treatment plant (northeast of Poland). The DM and OM in the SS were 4.8 % and 76.0 % DM, respectively. Because of high homogeneity, the material was used in a direct form. The experiment was carried out in an automatic methane potential test system (AMPTS) under the mesophilic condition of 36±1°C for 30 days at the organic loading rate of 10 kg OM/m<sup>3</sup>. Anaerobically digested sewage sludge used as an inoculum (I) was collected from a closed mesophilic chamber located at full-scale wastewater treatment plant (northeast of Poland). Inoculum had ca. 1.89% of DM, and the content of OM was ca. 69.52% DM.

The value of pH and TA in SS increased from 6.95 to 7.45 and 39.49 to 63.1 mval/L, respectively. However, with WMP, pH and TA were higher than SS; pH increased from 7.03 to 7.69 pH, and TA was in the range of 47.38-64.44 mval/L. At the beginning of the experiment, the OM content from WMP and SS were 67.39% DM and 72.33% DM, respectively. After 30 days, the OM content in WMP decreased slightly to 62.5 % DM; in comparison in SS, the OM content decreased rapidly to 65.09 % DM. The removal rate of OM (rOM) in the WMP and SS were found to be 0.46 % DM/d and 0.52 % DM/d, respectively. The maximum MP (51% of CH<sub>4</sub> content in biogas) of 38.64 L/kg DM (57.33 L/kg OM) from WMP was achieved on the 15th day. However, the maximum MP from SS (68% of CH<sub>4</sub> content in biogas) was more than 4.5-times higher, of 178.36 L/kg DM (234.69 L/kg OM), and this value was noted on 28th day.

The present study showed that SS has a much higher methane potential and can be used as a substrate for efficient methane production. In contrast, MP of WMP seems to be less valuable for anaerobic digestion. The lower MP of WMP correlated with a lower rate of OM, likely due to the fact that the organics in WMP were less degradable than in SS.

**Keywords:** anaerobic digestion, sewage sludge, waste from mushroom production, organic matter, methane production

## **ORGANIZATION OF THE LAND USE TERRITORY FOR ORGANIC AGRICULTURE**

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**Motives:** Today in Ukraine, the modern use of land resources does not meet the indicators of achieving the Sustainable Development Goals for various reasons, including the impact of the war. As in the pre-war period, there is a spread of unproductive, technologically polluted lands due to inefficient management decisions, excessive anthropogenic load on the land, a high level of agricultural land development, which in the near future will lead to a decrease in soil fertility to a critically low level. Currently, plowed land in Ukraine reaches 57% of the entire territory of the country, this is almost 80% of all agricultural land. This situation is caused by the suboptimality of the structure of cultivated areas, the neglect and underestimation of the real threat of degradation processes, the low level of application of organic fertilizers per unit of cultivated area, the lack of incentives for agricultural holdings and farmers to maintain soil fertility. We assume that organic farming is one of the ways to stop soil degradation, optimize the level of land plowing and balance anthropogenic load.

**Aim:** The aim of the research was to develop ecological and economic measures for the organization of land use for conducting organic farming and to carry out their ecological and economic justification. The object of the research was the lands of the Skvirsk research station of organic production of the Institute of Agroecology and Nature Management of the National Academy of Sciences of Ukraine.

**Results:** Our research established the presence of legal, socio-economic, environmental and material-technical problems that affect the organization of organic production at the current stage of land reform in Ukraine and in a certain way restrain it. It was analyzed that the existing system of land relations in Ukraine is built on the basis of lease, while a short-term lease agreement is not economically beneficial for producers of organic products. It was established that in the pre-war conditions of constant growth of areas occupied by the production of organic products, the main problem was the selection of land plots for the production of organic products and establishing their suitability. This problem has become even more acute due to massive soil pollution and contamination due to hostilities in Ukraine. In this regard, it is proposed to improve the method of determining the suitability of soils for organic farming in terms of increasing the number of agrophysical indicators. The need to apply crop rotation as one of the main measures of organizing the process of organic farming is substantiated. A crop rotation project has been developed - this is an ecological and economic justification of crop rotation and land management, which takes into account the soil and climatic conditions of the study area, the selection of the best predecessors, as well as the profitability of growing crops in this region. It has been established that the rational organization of organic production at all its levels can provide the following social benefits: economic - increased profitability and competitiveness of products, independence from external sources of financing and growth of net profits; ecological - preservation of natural biodiversity, reduction of man-made impact on the soil, prevention of water pollution; social - providing the population with high-quality food products, increasing the employment of the population in the countryside, developing rural areas, and, most importantly, improving people's health.

**Keywords:** land degradation, land pollution, land lease, crop rotation project, public benefits



## **CHANGES IN RECREATIONAL AND TOURIST FUNCTION AT THE VLTAVA RIVER ARTIFICIAL RESERVOIRS**

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The Covid-19 pandemic and its effects have triggered significant changes in travel behaviour. In addition to a major decline in international tourism, domestic tourism has recovered. It has not fully replaced the total volume of national tourism so far. However, from a regional point of view, and especially according to the type of destinations, regional targeting has changed significantly compared to the previous period. Urban destinations, which used to be the domain of foreign tourists, have been relatively orphaned, in contrast to destinations tied to natural attractions, which have seen an increase in the season. Even here, however, at a lower hierarchical level, we can observe the differentiation resulting from the existing localization and implementation conditions. A suitable example is the three largest water reservoirs of the Vltava Cascade – Lipno, Orlik and Slapy. Based on a detailed field survey, taking place in the period before and during the pandemic, as well as available statistical data, we can document different trends in the use of these destinations with regard to existing or planned infrastructure. This gives us the opportunity to discuss on concrete examples generally known phenomena that are usually neglected in tourism: slum, brownfield, greenfield. Changes in travelling behaviour – especially the orientation towards spending leisure time individually in a naturally attractive destination and second home tourism can affect the use of sites, which can now be defined as a tourist or recreational slum, brownfield but also as a tourist greenfield development.

Keywords: Vltava Cascade; water reservoirs; Czechia; tourism

## **OIL-WATER SEPARATION: THE LATEST DEVELOPMENTS IN FEMTOSECOND LASER-INDUCED PERIODIC SURFACE NANO STRUCTURING**

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Femtosecond (FS) laser-induced surface structuring is an effective means to create micro- and nanoscale structures on a material's surface. This single-step process is non-contact, maskless, and robust. It can remarkably modify the material's optical, chemical, wetting, and tribological properties. That's interesting! Wettability control is indeed a crucial aspect in various applications. Self-cleaning surfaces, for example, require a specific degree of wettability to repel unwanted liquids or particles. Anti-fouling surfaces also need to be able to resist wetting to prevent unwanted growth and accumulation of marine organisms. Likewise, anti-icing surfaces need to have a high degree of water repellency to prevent ice formation and in oil-water separation, wettability plays a crucial role in separating the two liquids effectively.

Oil spills, and industrial wastewater are significant environmental concerns that require effective solutions. One of the most promising methods for oil-water separation is membrane filtration, where filters are used to selectively separate oil from water. However, traditional membrane filters have limited effectiveness and are prone to fouling, which reduces their efficiency. To address these issues, researchers have been exploring the potential of femtosecond laser-induced periodic surface nano structuring (FLIPSNS) technology.

FLIPSNS technology enables the precise control of surface structures at the nanoscale level, resulting in surfaces that exhibit unique wettability properties. By patterning the surface of the membrane filter with specific nanostructures, the wettability of the membrane can be controlled, which enhances its ability to selectively separate oil and water. Recent breakthroughs in the development of FLIPSNS technology have demonstrated promising results for the creation of durable and robust oil-water separation membrane filters. This technology allows for the creation of intricate surface structures that provide the necessary wettability characteristics for effective oil-water separation. In addition, the FLINS process is highly repeatable and scalable, enabling its application in large-scale industrial settings.

**Keywords:** Laser-induced periodic surfaces structures, nano structures, oil–water separation

## **COMPARISON OF CO<sub>2</sub> UTILIZATION BY MICROALGAE DURING GAS FLOW IN SINGLE- AND MULTI-BIOREACTOR SYSTEMS**

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Intensive microalgae cultivation in control parameters can be used for effective CO<sub>2</sub> biosequestration. It is necessary to determine the optimal conditions for supplying gases to the nutrient medium for a more productive utilization process. Therefore, the presented work reveals the rationality of using recirculation of gas emissions in multi-bioreactor systems compared to single-bioreactor ones.

The single-bioreactor system (SBS) consisted of a container with a volume of 1 l, gas supply to the medium and mixing with the help of a magnetic stirrer, and a gas collector at the outlet. A multi-bioreactor system (MBS) is similarly designed, with the difference that the gas from the first reactor is fed to the second, from the second to the third, and so on. There is also a gas collector at the exit from the fifth reactor. For bubbling, a synthetic mixture was prepared, which is similar in CO<sub>2</sub> content to gas emissions: carbon dioxide (3-7%) and air (93-97%). The gas mixture was continuously supplied to the reactor systems in parallel at a rate of 0.15 l/min. Temperature 26°C, round-the-clock LED lighting (color temperature 9000 K, luminous flux 3800 lm, power 36 W). The concentration of the gas mixture was measured at the inlet and outlet of the reactor systems with analyzer Gas Data GFM430. *Chlorella vulgaris* culture was investigated by BBE AlgaeOnlineAnalyser Ver.2.6 E2, a spectrofluorometer for the measurement of chlorophyll. Used a standard nutrient medium according to Beyer. The Aqua Medic pH computer was used for pH measurements.

The research proved that using a gas mixture containing 3-5% carbon dioxide there is no significant difference in productivity and a rational solution is to use a single-bioreactor system. At the same time, the increase in gas concentration leads to the need for its recirculation, possibly even multiple times, up to its complete disposal. An important factor is the economic component, which requires additional research.

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Keywords: microalgae, biosequestration CO<sub>2</sub>, multibioreactor system

## **BIODEGRADATION OF POLYLACTID ACID AND STARCH BASED BIOPLASTIC UNDER THERMOPHILIC AEROBIC CONDITIONS**

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Bio-based and biodegradable polymers (commonly referred to bioplastics) have gained increasing attention as an alternative to petroleum-based plastics. Among these, materials based on polylactic acid (PLA) and starch (S) are particularly attractive as they have similar properties to conventional plastics.

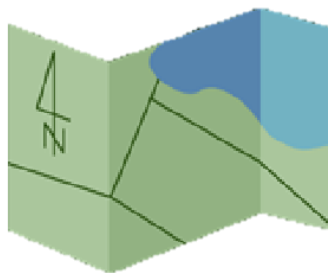
As the materials are labelled as biodegradable and compostable, composting should be a priority end-of-life scenario. In order to develop effective waste management, it is therefore necessary to test the biodegradation of these polymers under aerobic conditions. Two types of bio-based and biodegradable waste bags commercially available on the market were used: PLA- and S-based materials. The waste bags were cut into 0.5 cm x 0.5 cm pieces. Biodegradation was carried out under aerobic thermophilic (58°C) conditions. Mature compost (C) from biowaste from full-scale composting plant was used as inoculum.

The biodegradability of the bioplastics was determined based on the microscopic changes on their surfaces and organic mass (as volatile solids, VS) loss. For pictures, the pieces of bioplastics were removed from the inoculum, rinsed with distilled water and air dried. The microscopic images were taken until the bioplastic samples were too brittle for analysis. The fragments of bioplastics were analysed microscopically using a binocular microscope at a magnification of 1.5× and a polarising microscope (Nikon, Tokyo, Japan) at a magnification of 100×. Organic mass content (as VS) in C+S and C+PLA, and C alone was determined as a loss on ignition (LOI) at 550°C.

PLA- and S-based bioplastics biodegraded under thermophilic anaerobic conditions. However, the findings indicate that the S-based material is more susceptible to biodegradation than PLA because of longer time during which the pieces were visible in compost (20 days vs. 12 days) and slower decrease in VS content.

**Keywords:** aerobic biodegradation, bio-based polymers, microscopic analysis

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