

ABSTRACT BOOK GLOBAL WATER FUTURE

*A Holistic Approach to Water
Monitoring and Conservation*



**1st International Conference
_ 2025 _**

Editor in Chief: Julita A. Dunalska

PATRONAGE OF THE CONFERENCE



**PATRONAT INSTYTUCJONALNY
GDAŃSKI UNIWERSYTET MEDYCZNY**

PATRONAT HONOROWY:



**MIECZYŚLAW STRUK
MARSZAŁEK
WOJEWÓDZTWA POMORSKIEGO**

Global Water Future...

Water defines our future. It shapes our landscapes, sustains biodiversity, drives economies, and connects societies across continents. Yet despite its fundamental role, water is under increasing threat. Global demand has grown by around 1% each year for the past four decades and is expected to continue rising at a similar rate until 2050. At the same time, water scarcity and declining quality are endangering ecosystems, human health and sustainable development. In some regions, shortages are already resulting in measurable economic losses of up to 6% of gross domestic product (GDP).

The pressures of the Anthropocene are intensifying. Rapid population growth, industrialisation, changes in land use, and climate-driven disturbances are accelerating eutrophication processes and triggering harmful cyanobacterial blooms whose toxins pose severe ecological and health risks. These challenges cannot be solved by technology alone. A holistic, interdisciplinary, and global approach is required — one that combines cutting-edge monitoring tools, innovative engineering solutions and effective legal frameworks with the active participation of society.

With this in mind, the Center for Water Monitoring and Protection proposed the Global Water Future (GloWaF) conference. This inaugural international, interdisciplinary event brings together young researchers and their mentors to collaborate on creating knowledge and solutions for tomorrow's aquatic environments. The programme covers a variety of fields, including engineering, biotechnology, paleolimnology, toxicology, climate adaptation and geoinformatics, reflecting the complexity of the challenges we face, and the range of tools required to address them.

The collection of abstracts presented here not only illustrates the breadth of contemporary water research, but also the creativity and commitment of the next generation of scientists. By sharing their findings and perspectives, these researchers are contributing to a common goal: safeguarding the most vital resource on our planet, ensuring that water continues to be a source of life, resilience, and prosperity for future generations.

Prof. dr hab. inż. Julita A. Dunalska

Editor in chief

The Global Water Future – a holistic approach to water monitoring and conservation

1st international Conference

Borucino, 2025

CONFERENCE PROGRAMME

Wednesday, 17th September 2025 – Day 1

- 11:00 REGISTRATION
- 11:30 Opening and welcome
Prof. Julita A. Dunalska, PhD, University of Gdansk, Poland

Keynote lecture

- 12:00 ***Water ecosystems protection strategies - basic problems of Man- Nature relations***
Prof. dr hab. Jan Marcin Węśławski, Institute of Oceanology, Polish Academy of Sciences, Poland

Sesion 1 Chair: Dr Maciej Markowski, University of Gdansk, Poland

- 13:30 *Climate Refugees and the Water Crisis: Unique Challenges and Proposed Solutions*
Elżbieta Czapka, Sociology Institute, University of Gdansk, Poland
- The role of vernal pools and aquatic invertebrates in supporting waterfowl breeding success*
Basile Marteau, University of Helsinki, Finland
- 13:50 *Standardizing the taxonomic list of macroinvertebrates used for Lithuanian freshwater ecological quality assessment*
Diana Osadčaja, State Scientific Research Institute Nature Research Centre, Lithuania
- 14:10 *From single-species responses to ecosystem reactions – a modern approach to water quality assessment*
Zuzanna Sylwestrzak, University of Gdansk, Poland

Workshop 1 Chair: Dr Iwona Bubak, University of Gdansk, Poland

- 15:30 *Phytoplankton species diversity as an element of water monitoring*

Thursday, 18th September 2025 – Day 2

Sesion 1 Chair: Dr Włodzimierz Golus, University of Gdansk, Poland

- 9:30 *Hydrographic Network of Young Post-Glacial Landscapes and Its Contemporary Transformations: A Case Study of a Small Catchment in Poland*
Zuzanna Kroenka, University of Gdansk, Poland
- 9:50 *Ephemeral Water Bodies in the Context of Ongoing Suburbanization*
Julia Tarasek, University of Gdansk, Poland
- 10:10 *From single-species responses to ecosystem reactions – a modern approach to water quality assessment*
Zuzanna Sylwestrzak, University of Gdansk, Poland
- 10:30 *The role of peatland and lake paleoenvironmental data in bridging gaps in archaeological and historical records: an example from Poland*
Sambor Czerwiński, University of Gdansk, Poland

Sesion 2 Chair: Dr Andrzej R. Reindl, Medical University of Gdansk, Poland

- 11:30 *Chemical Contamination in Firefighting Wastewater: A Silent Threat to Aquatic Ecosystems?*
Kamil Pająk, Medical University of Gdansk, Poland
- 11:50 *Ecotoxicological assessment of firefighting wastewater – preliminary study*
Alicja Trawińska, Medical University of Gdansk, Poland
- 12:10 *Rare Earth Elements in water and food chains: a holistic review of human exposure and health implications*
Mateusz Podlasiewicz, Medical University of Gdansk, Poland
- 12:30 *Rare Earth Elements in Aquatic Environments – From Anthropogenic Sources to Human Exposure in a Climate Change Context*
Filip Tylanda, Medical University of Gdansk, Poland
- 12:50 *PFAS in aquatic systems - contamination patterns and human exposure risk*
Igor Gaszyński, Medical University of Gdansk, Poland
- 13:10 *Global distribution of perfluorinated compounds - evidence from the Antarctic*
Jakub Zduńczuk, Medical University of Gdansk, Poland

Sesion 3 Chair: Dr Sambor Czerwiński, University of Gdansk, Poland

- 15:00 *Monitoring of selected water quality parameters of labeia and recreational lakes to assess the level of pollution resulting from anthropogenic activity*
Klaudia Suliborska, Pomeranian Science and Technology Park Gdynia, Poland
- 15:20 *Enterophages as alternative indicators for water quality monitoring: a study in the Pomerania region of Northern Poland*
Agata Jurczak-Kurek, University of Gdańsk, Poland
- 15:40 *Geographic Information Systems and Remote Sensing in Urban Water Monitoring: Insights from the LifeCOOLCity Project*
Alicja Śniadach, University of Gdańsk, Poland

Friday, 19th September 2025 – Day 3

- 9:30 POSTER SESION
- Workshop 2 Chair: Dr Włodzimierz Golus, University of Gdansk, Poland**
- 10:30 *Between Lakes and Landforms: A Guided Walk in the Postglacial Landscape*
- 12:00 Conference summary, awards – end of the 1st GloWaF Conference

SCIENTIFIC AND ORGANIZING COMMITTEE



Prof. dr hab. inż. Julita A. Dunalska

full professor at the University of Gdańsk, Head of the Center for Water Monitoring and Protection. Her research focuses on the protection and restoration of lakes, nutrient cycling, organic matter transformation, and the effects of climate change on aquatic ecosystems. She is author or co-author of over 130 publications and numerous expert reports. A Fulbright scholar at the University of Wisconsin–Madison, she is an active member of several scientific organizations, including GLEON and the UNESCO IHP National Committee. She also served on the National Council of Water Management and as editor in the Polish Journal of Natural Sciences.



Prof. dr hab. Lidia Wolska

full professor at the Medical University of Gdańsk, Head of the Department of Environmental Toxicology. She is author and co-author of around 150 scientific publications and many methodological innovations in environmental analytics. Twice (2023, 2024) ranked among the 2% of the world's most influential scientists. She initiated and has long led the unique study program in Environmental Health in Poland. Her research focuses on One Health and the relationship between environmental quality, human health, and wellbeing.



Prof. dr hab. Monika Normant Saremba

oceanographer and professor at the University of Gdańsk, Head of the Department of Marine Ecology and the Laboratory of Ecophysiology and Bioenergetics. Her research addresses the biology and ecology of aquatic organisms, especially the adaptations of benthic invertebrates to natural and anthropogenic stressors. She also studies non-indigenous species and their ecological and economic impacts. She has conducted research in Germany, authored numerous scientific works, and actively contributes to marine environmental protection through ICES, HELCOM, and the Polish Academy of Sciences



Dr Włodzimierz Golus

limnologist and hydrologist at the Centre for Water Monitoring and Protection, University of Gdańsk. His research interests include the circulation of water and matter in natural and artificial reservoirs, processes of degradation and disappearance of small water bodies under human pressure and climate change, and the functioning of large coastal and urban lakes. He combines academic research with teaching and environmental education, actively promoting ecological awareness.



Dr Eng. Andrzej R. Reindl

assistant Professor at the Department of Environmental Toxicology, Medical University of Gdańsk. He holds a PhD in Earth Sciences (marine chemistry), a law degree, and is a certified court expert in environmental protection. His research explores toxic and genotoxic substances in the environment and their impact on human health and occupational exposure. He also works as an environmental risk management expert at the law firm PORT PRAWA, is a certified lead auditor of ISO 14001 and ISO 9001 systems, and author of numerous environmental reports and analyses.



Dr Elżbieta Czapka

assistant professor at the Institute of Sociology, University of Gdańsk, affiliated with the Center for Sustainable Development and the International Border Studies Center. Her research focuses on sociology of medicine, migration, health, and transnational care practices. She has broad international experience, including participation in COST Actions on migrant health and diversity in European health systems, and membership in several international networks. She has authored numerous studies on migrant integration and elderly care in multicultural societies, combining academic research with active engagement in policy dialogue and social initiatives.



Dr Maciej Markowski

head of the Laboratory of Geographic Information Systems at the University of Gdańsk and Software Application Developer at Boeing Poland. He holds a PhD in Earth Sciences and has over 17 years of experience in GIS technologies, spatial data transformation (ETL), and geospatial analyses. His expertise includes GIS, remote sensing, and navigation data for environmental analyses and application development. He has authored numerous publications, participated in national and international projects, and serves as Head of Postgraduate GIS Studies and member of the Polish National Committee for the International Cartographic Association.



Dr Sambor Czerwiński

paleoecologist specializing in palynological analysis to reconstruct environmental changes based on lake sediments and peat. His work focuses on human impact on vegetation over the past 2000 years, with research areas in Poland, Germany, Western Siberia, and Greenland. He teaches at the University of Gdańsk, offering courses such as Biogeography, Soil Science, and Environmental Reconstructions, integrating research with education.

KEYNOTE LECTURE



Water ecosystems protection strategies - basic problems of Man- Nature relations

Prof. dr hab. Jan Marcin Węśławski

Director of the Institute of Oceanology, Polish Academy of Sciences (IOPAN), Sopot, Poland

Prof. Jan Marcin Węśławski is a marine ecologist specializing in Arctic coastal ecosystems, biodiversity, and the effects of climate change on marine food webs. He graduated from the University of Gdańsk (M.Sc. 1979, Ph.D. 1984, habilitation 1993) and was appointed Professor of Biological Sciences by the President of Poland in 2000. Since 2018 he has served as Director of IOPAN, where he previously headed the Department of Marine Ecology (1993–2017).

He has conducted extensive research in the Arctic, particularly on benthic and pelagic crustaceans, sandy shore ecology, and integrated coastal zone management. He has led and contributed to numerous international projects, including ADAMANT, ACCESS, DWARF, GAME, and GLAERE, addressing the ecological consequences of deglaciation, plastic pollution, and boreal species expansion in the Arctic.

Prof. Węśławski is the author of more than 200 peer-reviewed publications and a recognized expert in Arctic marine science, actively engaged in international collaboration on polar research and biodiversity conservation.

Climate Refugees and the Water Crisis: Unique Challenges and Proposed Solutions

Elżbieta Czapka

Sociology Institute, University of Gdańsk

**Corresponding author: elzbieta.czapka@ug.edu.pl*

The phenomenon of water refugees is becoming increasingly relevant as climate change exacerbates water scarcity globally. This demographic often faces substantial challenges related to resource allocation, social integration, and legal recognition. Identifying these unique challenges and proposing effective solutions is essential for developing a robust framework to support water refugees and the communities that host them. Water refugees often experience a myriad of challenges, particularly in regions where water scarcity is acute, such as the Middle East and parts of Africa. This situation underscores the critical need for sustainable water management strategies that can withstand climate impacts. The time to act is now, as the frequency and intensity of climate-driven migration will only increase in the coming years.

To address the multifaceted challenges faced by water refugees, several solutions could enhance sustainability and integration, i.a. Integrated Water Resource Management (IWRM) and Community Involvement in Water Governance. The paper gives an overview of the possible solutions on how to deal with the challenges related to water crisis and water refugees.

The role of vernal pools and aquatic invertebrates in supporting waterfowl breeding success

Basile Marteau^{a*}, Janne Sundell^b, Céline Arzel^c, Petri Nummi^a

^a Department of Forestry, University of Helsinki, P.O. Box 27, FI-00014 Helsinki, Finland

^b Lammi Biological Station, University of Helsinki, Pääjärventie 320, FI-16900 Lammi, Finland

^c Department of Biology, FI-20014, University of Turku, Finland

**Corresponding author: basile.marteau@helsinki.fi*

In Fennoscandia, the decline of invertivorous waterbirds in recent decades is worrying and may be linked to deteriorating foraging conditions. Fewer wetlands are suitable for dabbling ducks as many shallow lakes and wetlands have been drained for agriculture or forestry. Moreover, not all boreal lakes are suitable for rearing ducklings due to limited food resources; aquatic invertebrates are crucial for young ducklings. Therefore, temporary wetlands can be good habitats as they are generally abundant in aquatic invertebrates. However, the relationship between duckling, food availability, and habitat remains poorly understood and rarely studied in detail. Vernal pools are small temporary wetlands, usually filled with precipitation in autumn and winter. They dry seasonally, making them fishless ponds devoid of large aquatic predators. In this research, we used imprinted mallard ducklings (*Anas platyrhynchos*) to study the effect of aquatic invertebrate availability on duckling growth. Ducklings were divided into two groups and assigned to forage in either lakes or vernal pools. Ducklings foraged at the study sites for four hours daily and were weighed before and after. Aquatic invertebrates were sampled with traps emergence and activity traps. Results showed ducklings' daily weight gain was linked to macroinvertebrate availability. Temporary ponds were richer in aquatic macroinvertebrates than lakes, and more ducklings survived in temporary ponds due to the absence of fish predation. However, no significant relationship was found between ducklings' weight and habitat type. We highlight the crucial role of aquatic invertebrates in ducklings' mass gain and the importance of temporary wetlands for duckling success.

This work was supported by a grant from the Ministry of Agriculture and Forestry of Finland (Maa- metsätalousministeriö).

Standardizing the taxonomic list of macroinvertebrates used for Lithuanian freshwater ecological quality assessment

Diana Osadčaja

State Scientific Research Institute Nature Research Centre, Akademijos Str. 2, LT-08412 Vilnius, Lithuania

**Corresponding author: basile.marteau@helsinki.fi*

One of the main instruments governing European water management is the Water Framework Directive (WFD), which emphasizes harmonizing typology, water assessment methods, and quality elements. The WFD also regulates the reliability, accuracy, and comparability of assessment results between countries. However, taxonomic requirements for biological quality elements used to assess water quality (e.g., macroinvertebrates) are not regulated, leading to potential differences in taxonomic lists used between countries. To address this gap, we have developed a national standardized operational taxa list (OTL) of macroinvertebrates for Lithuanian freshwaters, which reflects the current taxonomic nomenclature and will contribute to more comprehensive and accurate assessments of ecological quality by combining ecological and molecular information. The impact of Lithuanian OTL on WFD-mandated ecological quality ratios (EQR) was assessed by comparing reported EQRs with recalculated EQRs after standardization. We analyzed data of 82 macroinvertebrate communities from natural rivers monitored between 2015 and 2022 under the WFD. The selected river sites reflect the wide-ranging conditions (five river types) and all ecological status classes from high to bad. The EQR of each site was recalculated and compared with values originally reported by the Lithuanian Environmental Protection Agency. We also compared original reported EQRs with EQRs recalculated after standardization with the online tool freshwaterecology.info (FWE), which serves as a European-wide instrument. A comparison of the EQRs calculated before and after standardization showed overall consistency, with the main differences in EQR stemming from the standardization of mollusc taxa and the calculation of DSFI metric. The impact of removing higher and specific taxa on EQR remained minimal; however, this effect was more pronounced in samples with non-standardized Lymnaeidae taxa, leading to differences in the ecological quality status after standardization with our OTL. The results highlight the importance of standardized taxonomic list in improving the accuracy and comparability of ecological assessments over time and space, and provide a basis for accurate biodiversity research in Lithuania and other European countries.

From single-species responses to ecosystem reactions – a modern approach to water quality assessment

Zuzanna Sylwestrzak

University of Gdansk, Faculty of Oceanography and Geography, Al. Pilsudskiego 46, 81-378 Gdynia, Poland

*Corresponding author: zuzanna.sylwestrzak@ug.edu.pl

The impact of human activity on the environment can be effectively monitored based on international guidelines such as the Water Framework Directive (2000/60/EC). This document highlights the necessity of conducting comprehensive evaluations to assess water quality not only on the basis of physicochemical and hydromorphological parameters, but primarily through the analysis of biological elements. Standard toxicity tests, carried out on algae monocultures in laboratory conditions, are a commonly used tool in environmental research and natural sciences (Zhu et al. 2021). They allow for the comparison of the reactions of specific, well-characterized organisms to the effects of various chemicals, which is particularly useful in the initial assessment of the toxicity of new compounds. However, these tests reflect only the responses of individual species, failing to capture the full range of biological interactions occurring in the natural environment. The most reliable results in studies on the impact of anthropogenic pressure are obtained by analyzing entire ecological formations, not individual species. Complex communities, including organisms with various environmental requirements and ecological functions, allow for a more complete representation of the effects of pollution and ecosystem disturbances (Pennesi & Danovaro 2017). In this context, microphytobenthos, as a biologically and functionally diverse community, is a valuable tool for assessing environmental changes – it takes into account both the direct impact of toxic substances and indirect impacts resulting from interspecies interactions.

This study aimed to assess the impact of glyphosate (in the form of Roundup®) on Baltic microphytobenthos and on selected strains of microalgae: *Bacillaria paxillifera* and *Navicula perminuta* – diatoms typical of brackish and marine waters. The aim was to determine whether the presence of accompanying microorganisms and interspecies interactions affect the response of microalgal ecosystems to glyphosate. The study involved two series of tests: on single cultures of *B. paxillifera* and *N. perminuta*, using two concentrations of glyphosate: 0.045 g·dm⁻³ and 0.85 g·dm⁻³, on natural microphytobenthos communities, at concentrations of 0.0452 g·dm⁻³, 0.85 g·dm⁻³ and 8.5 g·dm⁻³.

The results showed that microphytobenthos communities are more resistant to glyphosate than single microalgae strains. In tests on monocultures, a concentration of 0.85 g·dm⁻³ caused a reduction in cell density exceeding 90%. In the case of microphytobenthos communities, even high concentrations (8.5 g·dm⁻³) did not lead to a drastic decrease in numbers, and in some taxa, such as *N. perminuta*, an increase in numbers by over 850% was observed. The presence of accompanying organisms played a special role, limiting the negative impact of the herbicide, e.g. in the case of *B. paxillifera*. In addition, processes of replacing sensitive taxa with more resistant forms were observed, which indicates the high resistance of microphytobenthos communities as a functional whole to anthropogenic disturbances.

References

1. Zhu, Y., Zhong, X., Wang, Y., Zhao, Q. and Huang, H., 2021. *Applied Biochemistry and Biotechnology*, 193(6), pp.1945-1966.
2. Pennesi, C. & Danovaro, R., 2017. *Marine Pollution Bulletin*, 125(1-2), pp.56-65.

Hydrographic Network of Young Post-Glacial Landscapes and Its Contemporary Transformations: A Case Study of a Small Catchment in Poland

Zuzanna Kroenka, Włodzimierz Golus

University of Gdansk, Faculty of Oceanography and Geography, Al. Pilsudskiego 46, 81-378 Gdynia, Poland

**Corresponding author: wlodzimierz.golus@ug.edu.pl*

Research on hydrographic networks provides insights into the functioning of natural systems within a given area. The northern part of Europe was covered by an ice sheet during the last glaciation, which largely shaped the present-day hydrographic network. A distinguishing feature of this region is the poorly developed river network and the widespread presence of lakes. An exception to this pattern is found in moraine uplands, which are often characterized by a relatively low number of lakes. One example of such a region is the catchment of the Struga Rąty. It exhibits a typical initial-stage hydrographic network composed primarily of endoreic depressions and first-order streams. Within the moraine plateau areas, endoreic areas occur whose extent varies depending on the catchment's retention capacity. It is in these areas that surface runoff is initialized, and periodic water surpluses are discharged via the marginal zone into the bottom of a subglacial channel, where a more permanent river network is observed. As a result of human activity, this hydrographic system is undergoing degradation. The disappearance of Lake Rąckie has been observed, primarily due to extensive drainage works conducted within the subglacial channel, accompanied by an increase in the number of endoreic areas. Additionally, there has been a noticeable increase in both the number and length of first-order streams, as well as a rise in the stream order of Struga Rąty. A decline in the number and surface area of wetlands has also been recorded—an outcome of the regulated water conditions within the catchment. These transformations are confirmed not only by recent satellite imagery but also by historical cartographic materials.

Ephemeral Water Bodies in the Context of Ongoing Suburbanization

Julia Tarasek, Włodzimierz Golus

University of Gdansk, Faculty of Oceanography and Geography, Al. Pilsudskiego 46, 81-378 Gdynia, Poland

**Corresponding author: wlodzimierz.golus@ug.edu.pl*

Small and ephemeral water bodies, such as “ghost ponds” and other transient hydrographic objects, are widespread across postglacial landscapes and are especially vulnerable to land-use changes and climate variability. Their small size and wide spatial distribution, combined with strong dependence on the surrounding terrestrial catchment, make them highly sensitive to both direct and indirect anthropogenic pressures. Seasonal drying and historical drainage for agriculture and forestry are among the main threats to their physical functioning, intensifying chemical and physical stressors. The accumulation of these pressures poses a significant risk to the ecological stability and biodiversity of the surrounding catchment areas.

In this context, ephemeral water bodies, often overlooked in spatial planning, can be effectively identified through the combined use of historical cartographic materials and modern GIS-based techniques. This approach allows detecting former water bodies that have been altered, filled, or degraded over time, but still retaining visible topographic depressions and hydrological memory. Their spatial patterns often overlap with current or expanding suburban zones, highlighting their relevance for integrated land management. Incorporating these transient ecosystems into planning and restoration strategies provides a cost-effective way to support biodiversity, enhance water retention, and mitigate ecological impacts of suburban expansion

The role of peatland and lake paleoenvironmental data in bridging gaps in archaeological and historical records: an example from Poland

Sambor Czerwiński

University of Gdansk, Faculty of Oceanography and Geography, Al. Pilsudskiego 46, 81-378 Gdynia, Poland

**Corresponding author: sambor.czerwinski@ug.edu.pl*

In recent years, high-resolution methods for reconstructing past environments have become increasingly common. These approaches focus on capturing environmental changes as precisely as possible, both by placing events accurately within the chronological framework using absolute dating and by reducing temporal gaps between samples. Peat and lake sediments offer valuable insights into the long-term impact of human activity on the environment.

Combining various proxies such as pollen, coprophilous fungi, microcharcoal, testate amoebae and plant macrofossils has proven to be an effective way to detect past anthropogenic influences and associated hydrological changes. In many cases, this high-resolution multiproxy approach can enhance or even revise existing archaeological knowledge. This is particularly important in areas where archaeological evidence is sparse or discontinuous, making it difficult to establish clear timelines.

This presentation discusses the possibilities and limitations of high-resolution palaeoecological research, drawing on selected case studies from the Greater Poland region. Data obtained from peatlands and lakes in this area help to fill important gaps in archaeological and historical records, especially regarding human-induced environmental changes over the past two millennia.

Chemical Contamination in Firefighting Wastewater: A Silent Threat to Aquatic Ecosystems?

Kamil Pająk, Maciej Tankiewicz, Lidia Wolska, Alicja Trawińska, Andrzej R. Reindl

Medical University of Gdansk, Faculty of Health Sciences, Department of Environmental Toxicology, Dębowa 23A Str, 80-204 Gdansk, Poland

**Corresponding author: kamil@tom-kom.pl*

Firefighting operations in industrial and urban environments generate substantial volumes of wastewater containing hazardous substances with significant ecotoxicological potential. Although water pollution has become a subject of growing concern, runoff resulting from firefighting activities remains an underexplored and poorly regulated source of environmental contamination. This study investigates the chemical composition and environmental relevance of firefighting wastewater, using samples collected after a fire incident in Central Poland involving a warehouse complex that housed both carpentry and automotive repair facilities.

Advanced analytical techniques, including gas chromatography–tandem mass spectrometry (GC-MS/MS) and inductively coupled plasma–tandem mass spectrometry (ICP-MS/MS), were employed to identify and quantify a broad spectrum of persistent organic pollutants and heavy metals. The analyses revealed the presence of poly- and perfluoroalkyl substances (PFAS) at a total concentration of 170 ng/L, along with 15.5 ng/L of the sum of seven indicator PCBs. Notably, polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) were also detected, reaching concentrations of 0.4884 ng/L and 2.316 ng/L respectively, with a calculated toxic equivalent (TEQ) for dioxins at 0.26. Additionally, six priority polycyclic aromatic hydrocarbons (PAHs, WHO list) were < 191 ng/L.

These substances are well-known for their environmental persistence, resistance to degradation, and capacity for bioaccumulation, posing long-term risks to aquatic ecosystems. Comparison with ecotoxicological thresholds and water quality criteria indicates that even limited releases of such wastewater may result in significant and lasting ecological damage. The levels of PCDFs and PCBs in particular point to a toxicological burden capable of affecting aquatic organisms at multiple trophic levels. Given their potential to accumulate in sediments and living organisms, and their chronic effects even at low concentrations, these compounds present a silent but serious threat to environmental health.

Our findings underscore the urgent need to recognize firefighting wastewater as a high-risk pollutant source, rather than a transient by-product of emergency response. Current environmental protection strategies largely neglect the specific risks associated with fire-related chemical discharges. This study calls for the integration of post-fire wastewater monitoring into environmental risk management protocols and regulatory frameworks. Only through the development of comprehensive, interdisciplinary approaches that combine advanced chemical analysis with ecological risk assessment can we ensure adequate protection of aquatic environments in an era of increasing fire-related disturbances.

Ecotoxicological assessment of firefighting wastewater – preliminary study

Alicja Trawińska, Andrzej R. Reindl, Lidia Wolska, Kamil Pająk, Maciej Tankiewicz

Medical University of Gdansk, Faculty of Health Sciences, Department of Environmental Toxicology, Dębowa 23A Str, 80-204 Gdansk, Poland

*Corresponding author: alicja.trawińska@gumed.edu.pl

Urban and industrial fires pose not only immediate threats to human life and infrastructure but also lead to the release of complex chemical mixtures with potential long-term impacts on aquatic ecosystems. One of the often-overlooked consequences of fire suppression is the generation of contaminated wastewater, frequently discharged into surrounding environments without prior treatment or risk assessment. While post-fire air pollution and solid residues have been extensively studied, the ecotoxicological implications of firefighting effluents remain largely unrecognized.

This study presents a preliminary assessment of the environmental hazard posed by such wastewater, based on a real-world fire incident in Central Poland (Wielkopolskie Voivodeship), where a warehouse and production facility, including a carpentry workshop and automotive repair operations, was destroyed by fire.

To evaluate the impact of the resulting wastewater on aquatic environments, we employed a combined methodology integrating chemical analysis and standardized bioassays. The chemical profile of the samples revealed a complex mixture of pollutants, including petroleum-derived hydrocarbons, brominated flame retardants, heavy metals, and by-products of incomplete combustion—compounds known for their persistence and potential synergistic toxicity, which complicate traditional risk assessment approaches.

Ecotoxicological evaluation involved a suite of bioassays targeting different trophic levels and biological endpoints. Luminescent bacteria (*Aliivibrio fischeri*) showed significant inhibition of luminescence at the lowest tested concentration (10%), with peak effects exceeding 90%. Chronic exposure tests with *Heterocypris incongruens* revealed a 28% increase in mortality and a 3% growth inhibition after six days. Additionally, *Sinapis alba* seedlings exhibited a 26.83% reduction in root elongation, indicating phytotoxicity. The use of multiple test organisms: bacteria, invertebrates, and plants, ensured a robust and ecologically meaningful assessment.

Our findings demonstrate the limitations of relying solely on chemical analysis when evaluating complex effluents. The observed biological responses confirm that firefighting wastewater constitutes a significant environmental hazard capable of disrupting aquatic ecosystems, even at low concentrations. This study underscores the importance of integrating bioassay-based approaches into fire response protocols and regulatory frameworks. Such interdisciplinary methods provide a more comprehensive picture of environmental risk and support the development of effective mitigation and management strategies. Further research is needed.

Rare Earth Elements in water and food chains: a holistic review of human exposure and health implications

Mateusz Podlasiewski, Filip Tylanda, Andrzej R. Reindl

Medical University of Gdansk, Faculty of Health Sciences, Department of Environmental Toxicology, Dębowa 23A Str, 80-204 Gdansk, Poland

*Corresponding author: mateuszpodlasiewski05@gumed.edu.pl

Rare Earth Elements (REEs) are increasingly prevalent in aquatic ecosystems due to growing global demand in electronics, renewable energy, agriculture, and medical applications. Their release into the environment occurs both from natural weathering and anthropogenic sources, including mining, wastewater, and gadolinium-based contrast agents used in imaging diagnostics. As highlighted in recent studies, REEs are now present in surface and groundwaters, sediments, and even drinking water, raising concerns regarding their environmental fate and toxicological potential. From a One Health perspective, their presence at multiple levels of the aquatic environment suggests implications for both ecosystem functioning and human health.

Emerging evidence confirms that rare earth elements (REEs) can bioaccumulate in aquatic organisms and undergo trophic transfer across marine food webs. Studies have demonstrated REE accumulation in marine phytoplankton and macroalgae, followed by uptake in invertebrates, bivalves, and fish. Research by Reindl and Falkowska (2021) revealed detectable Σ REEs concentrations in the muscles of Baltic herring (0.076 ± 0.047 mg/kg) and European sardine (0.191 ± 0.163 mg/kg), with a clear dominance of heavy REEs (HREEs). Importantly, REEs were found to penetrate reproductive tissues via vitellogenesis and spermatogenesis, with higher transfer to ova (TF = 3.0) than seminal fluid (TF = 2.1) in sardines, and a reverse pattern observed in herring. Complementary data from Reindl et al. (2025) confirmed the presence of Σ REEs in the blood of Baltic grey seals across life stages. Lactating females showed elevated REE concentrations (median = 1.101 mg/L) compared to non-lactating ones (median = 0.456 mg/L), suggesting increased exposure or mobilization during reproduction. While REEs transfer to pups was limited during lactation, it increased after dietary shift to fish, reinforcing the hypothesis of dietary exposure and trophic transfer. In both mothers and pups, HREEs were predominant, and estimated daily intakes of REEs and trace elements were notably higher in adult females.

These findings support the One Health approach, showing that pollutants like rare earth elements (REEs) can build up in marine animals and reach humans through seafood. Although we don't yet have enough data from human studies, animal research suggests that REEs can disrupt internal organism function. The health effects of REEs depend on the dose, chemical form, and environmental conditions like pH and organic matter. Because REEs are persistent and can accumulate in living organisms, they are considered emerging contaminants of concern. Climate change may make things worse by releasing more REEs into the environment through melting glaciers and thawing permafrost.

Based on current evidence, there is a clear need for better monitoring of REEs in the environment and more research on how these elements may affect human health, particularly through long-term exposure via the food chain.

References

1. Reindl, A. R., & Falkowska, L., 2021. *Journal of Trace Elements in Medicine and Biology*, 68, 126803.
2. Reindl, A. R., Wolska, L., Grajewska, A., Kucharska, K., Kalicki, M., & Pawliczka, I., 2025. *Science of the Total Environment*, 980, 179540.

Rare Earth Elements in Aquatic Environments – From Anthropogenic Sources to Human Exposure in a Climate Change Context

Filip Tylanda, Mateusz Podlasiewski, Andrzej R. Reindl

Medical University of Gdansk, Faculty of Health Sciences, Department of Environmental Toxicology, Dębowa 23A Str, 80-204 Gdansk, Poland

*Corresponding author: filip.t@gumed.edu.pl

Rare Earth Elements (REEs) are a group of 17 chemically similar elements increasingly used in high-tech industries, clean energy, and modern medicine. Despite their natural abundance, economically viable deposits are geographically concentrated, and their extraction generates environmental concerns. Anthropogenic sources such as mining, industrial effluents, electronic waste leachates, and medical applications (e.g., gadolinium-based contrast agents) are leading to a measurable rise in REE emissions into the environment. Concurrently, REEs are becoming crucial in biomedical imaging, cancer treatment, and diagnostic nanotechnology, increasing the likelihood of environmental and human exposure. In aquatic environments, REEs originate from both geogenic weathering and anthropogenic inputs. Once released, they undergo complex interactions involving pH, salinity, and dissolved organic matter, affecting their mobility, speciation, and bioavailability. Recent studies show trophic transfer of REEs in freshwater and marine systems, from phytoplankton and macroalgae to invertebrates and fish, raising ecological concerns (e.g. Amyot et al., 2017). Their persistence and capacity to bind with particles and accumulate in sediments make REEs emerging pollutants of global concern.

Glacial melting and permafrost thaw due to global climate change significantly enhance the mobilization of REEs from bedrock in newly formed periglacial terrains. A case study by Reindl et al. (2024) conducted on King George Island (Antarctica) revealed elevated concentrations of rare earth elements (REEs) in meltwater streams, with total REE levels reaching up to $11.6 \mu\text{g}\cdot\text{dm}^{-3}$. The highest concentrations were found where the water interacted with REE-rich volcanic bedrock. The study also documented significant bioaccumulation of REEs in cryptogamic flora, particularly in the species *Prasiola crispa*, which exhibited concentrations around $80.7 \mu\text{g}\cdot\text{g}^{-1}$ dry weight.

Human health data are scarce, primarily limited to a few case reports on occupational exposures to select REEs such as cerium and lanthanum, while epidemiological studies are lacking. REE-associated health effects are believed to operate through modulation of oxidative stress, similar to mechanisms known for other transition metals. Observed adverse outcomes include growth inhibition, cytogenetic alterations, and organ-specific toxicity. Interestingly, REEs may exhibit hormetic dose-response relationships, showing protective or stimulatory effects at low concentrations and toxicity at higher levels. Additionally, the speciation of REEs influenced by environmental pH plays a critical role in their toxicity, with evidence suggesting that acidification enhances REE toxicity, notably in acidic soils and mining-impacted areas.

Climate change is accelerating the natural release of REEs in polar and periglacial regions while industrial demand and emissions continue to rise globally. This dual pressure increases the risk of REEs accumulation in aquatic ecosystems and potential trophic transfer impacting human health. Given their environmental persistence, biological activity, and emerging toxicity profile, REEs should be considered as priority contaminants in global environmental monitoring.

References

1. Amyot, M., Clayden, M. G., MacMillan, G. A., Perron, T., & Arscott-Gauvin, A., 2017. *Environmental Science & Technology*, 51(11), 6009-6017.
2. Reindl, A. R., Wolska, L., Piotrowicz-Cieślak, A. I., Saniewska, D., Bołalek, J., & Saniewski, M., 2024. *Science of The Total Environment*, 926, 171540.

PFAS in aquatic systems - contamination patterns and human exposure risk

Igor Gaszyński, Jakub Zduńczyk, Andrzej R. Reindl

Medical University of Gdansk, Faculty of Health Sciences, Department of Environmental Toxicology, Dębowa 23A Str, 80-204 Gdansk, Poland

*Corresponding author: Igor35@gumed.edu.pl

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a broad group of synthetic chemicals characterized by a fully fluorinated carbon chain bonded to a carboxylic or sulfonic acid functional group. Due to their amphiphilic properties and extremely strong carbon–fluorine (C–F) bonds, PFAS are resistant to biological, chemical, thermal, and photolytic degradation, making them exceptionally persistent in the environment. The Organisation for Economic Co-operation and Development (OECD, 2018) identified 4,730 PFAS-related CAS numbers, while the U.S. Environmental Protection Agency (USEPA, 2020) listed over 9,000 PFAS compounds based on structural criteria. PFAS were first synthesized in the early 1950s, with PFOA and PFOS used in industrial processes such as Teflon manufacturing. However, environmental detection at trace levels only became feasible in the 1990s due to advances in analytical chemistry. Scientific attention increased in the 2000s, particularly following the voluntary phase-out of PFOS production. By 2009, growing concerns about environmental contamination and health risks led to intensified research on PFAS sources, transport mechanisms, and toxicological effects. The widespread use of PFAS in firefighting foams, textiles, carpets, food packaging, and non-stick or stain-repellent coatings has contributed to their global distribution. Due to their high mobility, PFAS are now commonly found in water, sediments, and aquatic biota worldwide. Elevated contamination levels have been reported near sites of intensive aqueous film-forming foam (AFFF) usage, such as airports and military facilities, as well as in agricultural regions using contaminated water for irrigation or livestock.

Consumption of seafood from contaminated waters has emerged as a significant route of human PFAS exposure. Recent research by Reindl and Wolska (2024) revealed the presence of both carboxylate and sulfonate PFAS in muscle and liver tissues of Baltic cod sampled between 2017 and 2023. The highest mean concentrations were observed for PFOS in liver (11.47 ng/g ww) and for PFDA and PFNA (1.43 and 1.25 ng/g ww, respectively), with increasing temporal trends noted especially after 2019, suggesting accumulating environmental burden and potential for biomagnification. Estimated Weekly Intake (EWI) calculations based on cod muscle consumption indicated average adult exposures of 1.84 ng/kg body weight/week, reaching up to 3.46 ng/kg/week. For children consuming 100 g of cod meat, weekly exposure ranged from 1.02 to 4.17 ng/kg. Notably, adult consumption of cod liver resulted in maximum exposure levels of 6.45 ng/kg/week—exceeding the tolerable weekly intake (TWI) recommended by EFSA as early as 2018 (Reindl and Wolska, 2024).

From a public health perspective, these findings underscore the importance of seafood as a dietary source of PFAS exposure. Long-term low-level exposure, particularly in populations with high fish consumption, may contribute to immunotoxicity, metabolic disorders, and increased cancer risk. Continuous monitoring of PFAS in fishery products, combined with holistic health risk assessments in the One Health framework, is essential for protecting both human and environmental health.

References

1. OECD 2018.
2. U.S. Environmental Protection Agency. 2020. PFAS master list of PFAS substances (Version 2).
3. Reindl, A. R., & Wolska, L. 2024. *Environmental Research*, 263, 120127.

Global distribution of perfluorinated compounds - evidence from the Antarctic

Jakub Zduńczuk, Igor Gaszyński, Andrzej R. Reindl

Medical University of Gdansk, Faculty of Health Sciences, Department of Environmental Toxicology, Dębowa 23A Str, 80-204 Gdansk, Poland

*Corresponding author: Jakubzdunczuk@gumed.edu.pl

Per- and polyfluoroalkyl substances (PFAS) are synthetic organic pollutants known for their exceptional environmental persistence, mobility, and bioaccumulation potential. Their extensive industrial and consumer use has led to global contamination, including remote and ostensibly pristine regions such as the Antarctic. Due to its extreme isolation, minimal direct anthropogenic activity, and unique meteorological dynamics, Antarctica offers an unparalleled opportunity to study long-range pollutant transport and deposition mechanisms. In this context, Antarctica functions as an early warning system for environmental pollution with potential impacts on human health. From a holistic perspective, environmental health cannot be separated from the health of humans and other organisms, hence the need for a One Health approach, integrating ecological, animal, and public health concerns at a global scale. PFAS are now recognized as one of the most pressing challenges in modern environmental toxicology. Their chemical stability, global mobility, and tendency to bioaccumulate allow them to reach even the most isolated ecosystems on Earth. Although their main emission sources are located in industrialized regions, PFAS have been detected in water, sediments, and living organisms across all continents, including Antarctica.

Recent studies have demonstrated PFAS deposition in Antarctic snow and ice, particularly in coastal regions. These findings highlight the role of atmospheric deposition and snow accumulation processes, influenced by katabatic winds and marine aerosols, in introducing PFAS to polar ecosystems. Moreover, PFAS show clear bioaccumulation potential even in Antarctic wildlife. In a multi-species analysis of penguin guano, feathers, blood, and eggshells, as well as tissues of seals and seabirds, 29 PFAS compounds were screened. PFOS and PFPeS were the most frequently detected, with PFOS concentrations reaching 2.31 ng/g dw in Adélie penguin guano and 2.14 ng/g dw in chinstrap penguin guano. PFPeS levels peaked at 2.74 ng/g dw in chinstrap samples. PFOS was also found in the blood plasma of southern giant petrels and elephant seals (up to 3.52 ng/ml), and in fur seal pups, indicating trophic transfer across multiple levels of the Antarctic food web. Importantly, PFAS were also detected in penguin eggshells, suggesting maternal transfer and direct exposure pathways relevant to early-life stages of polar fauna (Reindl et al., 2025).

The detection of PFAS in a broad range of biotic matrices across trophic levels in such a remote environment raises concerns not only for local ecosystem health but also for global environmental safety. Antarctica serves as a sentinel region for assessing the planetary reach of persistent pollutants. Within the One Health framework, which integrates environmental, animal, and human health, PFAS contamination in polar ecosystems exemplifies the transboundary nature of chemical risks. These findings support the argument that protecting remote ecosystems from anthropogenic pollution is essential to preserving global ecological integrity and safeguarding human health in a truly holistic sense. Long-term monitoring in indicator regions like Antarctica is therefore critical for informing international regulations and advancing sustainable chemical management under frameworks such as the Stockholm Convention.

References

- 1 Reindl, A. R., Lidia, W., Pawłowski, J., Hoszek-Mandera, K., Beldowska, M., Fudala, K., ... & Panasiuk, A., 2025. *Environmental Research*. doi.org/10.1016/j.envres.2025.122475

Monitoring of selected water quality parameters of lobelia and recreational lakes to assess the level of pollution resulting from anthropogenic activity

Klaudia Suliborska¹, Joanna Ratajczyk¹, Daniel Kostovski¹, Jolanta Grzenkowicz-Wydra¹, Rafał Ronowski², Krzysztof Banaś²

¹ Pomeranian Science and Technology Park Gdynia, Bio Laboratory, Aleja Zwycięstwa Street 96/98, 81-451 Gdynia,
² Faculty of Biology, Department of Plant Ecology, Laboratory of Freshwater Ecology, University of Gdansk, Wita Stwosza Street 59, 80-308 Gdansk

*Corresponding author: k.suliborska@ppnt.pl

Lobelia lakes are mostly small, landlocked water bodies that have maintained an oligotrophic status due to their small catchment areas. They contain plant communities of Boreal-Atlantic relicts, including rare, endangered, and legally protected isoetid species in Poland, such as *Lobelia dortmanna* L., *Isoëtes lacustris* L., *Isoëtes echinospora* Durieu, and *Littorella uniflora* L. (Baciąg, et al. 2011). These plants have highly specific habitat and nutritional requirements as well as they occur in lakes characterized by low calcium concentration, high water acidity, and poor buffering capacity. Moreover, they play a crucial role in inhibiting eutrophication of lakes. Due to their landscape values, the areas of reserves with lobelia lakes are known for numerous cycling and hiking trips. Moreover, the clean waters of the lakes encourage tourists to illegally bathe, which may significantly contribute to the pollution of the lake waters. Additionally, lakes located close to agricultural areas are undergoing eutrophication due to the agricultural use of the catchment area and the development of summer housing on former agricultural land. Other important anthropogenic threats include inappropriate fishing and forestry practices, as well as close proximity of lobelia lakes to roads, parking lots and railway tracks.

Lobelia lakes, being lakes with low pH and low calcium concentration, are most exposed to changes in the structure of aquatic plant communities. Pollutants, especially domestic and farm sewage, can form complexes with various chemical substances present in water and, as a result, lead to physicochemical changes in lobelia lakes, such as: increasing their fertility and alkalinity, which may lead to the disappearance of conditions necessary for the growth of protected isoetid species. Additionally, water shading that hinders the growth of isoetids may be caused by the influx of humic substances, which change the water color to brown. The effect of eutrophication is the occurrence of water blooms and changes in physicochemical conditions, which in turn cause the disappearance of vegetation characteristic of lobelia lakes.

The aim of this study was to compare and evaluate the physicochemical parameters of water quality in various subtypes of lobelia lakes in relation to recreational lakes in the period from May 2024 to July 2025 (before, during and after the tourist season). The water samples collected from lobelia lakes located within the boundaries of the reserves: "Moczałło", "Jezioro Głębocko", "Jezioro Celtskie Małe", and "Pelcznica" were examined. Physicochemical parameters of water samples, such as pH, electrical conductivity, turbidity, colour, and amount of total dissolved solids were determined. Additionally, the concentration of chlorophyll *a*, BTEX, (benzene, toluene, ethylbenzene, *p*-xylene, *m*-xylene, *o*-xylene), polycyclic aromatic hydrocarbons (PAHs) and the mineral oil index were measured by spectrophotometric technique, HS-GC-MS and GC-FID, respectively. The obtained results allow for an assessment of the water quality of the Lobelia lakes and the determination of whether humic substances or other pollutants resulting from anthropogenic activity enter these waters. Moreover the results of this study will provide an answer to the question of whether the introduced nature conservation plan and the degree of protection of reserves in Poland are sufficient or require verification?

This research was supported by the Voivodeship Fund for Environmental Protection and Water Management in the project titled: "Assessment of selected water quality parameters in lobelia lakes".

References

- 1 Baciąg K., Rekowska E., Banaś K. 2011. *Oceanological and Hydrobiological Studies*, 40(2), 30-36.

Enterophages as alternative indicators for water quality monitoring: a study in the Pomerania region of Northern Poland

Agata Jurczak-Kurek¹, Joanna Całkiewicz², Ewa Kotlarska³

¹ Department of Evolutionary Genetics and Biosystematics, University of Gdansk, Wita Stwosza 59, 80-308 Gdansk, Poland

² Department of Fisheries Oceanography and Marine Ecology, National Marine Fisheries Research Institute, Kołłątaja 1, Gdynia, 81-332, Poland

³ Genetics and Marine Biotechnology Department, Institute of Oceanology of the Polish Academy of Sciences, Powstańców Warszawy 55, 81-712 Sopot, Poland

*Corresponding author: agata.jurczak-kurek@ug.edu.pl

Water quality is a critical determinant of public health, environmental sustainability, and economic stability. One of the primary challenges in water quality management is the contamination of aquatic systems with human and animal faecal waste, which can introduce enteric microbial pathogens. Traditional microbial water quality assessments rely on faecal indicator bacteria (FIB), such as *Escherichia coli* and intestinal enterococci [1]. However, their limitations, including the inability to distinguish between human and non-human sources of contamination and their lack of correlation with human viral pathogens, have led to the exploration of alternative microbial indicators [2].

Bacteriophages, viruses that infect bacteria, have emerged as promising candidates for water quality monitoring. Certain bacteriophage groups exhibit survival characteristics similar to enteric viruses, making them valuable indicators of faecal contamination [3]. Among these, somatic coliphages, F-specific coliphages, Bacteroides-infecting phages, and Enterococcus phages have been extensively studied. While somatic and F-specific coliphages are abundant and easy to detect, their limited host specificity reduces their efficacy in microbial source tracking (MST). In contrast, Bacteroides-infecting phages and Enterococcus phages (enterophages) have demonstrated higher host specificity and stability in environmental samples, making them potential MST candidates [4].

This study investigates the abundance of enterophages, a novel faecal indicators, in raw and treated sewage at two Wastewater Treatment Plants (WWTPs) in Pomerania, Poland, serving a population of 1.2 million inhabitants. Using the ISO-standardized double agar layer (DAL) method, we compared enterophages with other biological indicators, including coliphages, *Escherichia coli*, and enterococci. We observed that, although enterophages were present, they formed smaller plaques than coliphages, which complicated detection. Despite this, the study identified a strong presence of *E. coli* in both raw and treated wastewater, with lower concentrations of enterophages, consistent with other global studies. Enterophages were found to be less abundant than bacterial indicators and coliphages, suggesting a potentially more specific human source. The concentration of enterophages in treated sewage decreased significantly, supporting their potential as indicators of untreated sewage contamination in water bodies. Our results also revealed that enterophages counts in raw sewage were higher than those reported in tropical regions, possibly due to differences in methodology and bacterial strains used. Furthermore, correlation analyses indicated that microbial indicators in raw sewage were linked with chemical parameters such as temperature and orthophosphates, which may influence their presence. The study concludes that while enterophages are viable alternative faecal indicators, their low abundance in treated wastewater highlights the need for further research, including survivability studies and the development of molecular detection methods. This research contributes to the understanding of enterophages in temperate climates and underscores the importance of regional collaboration in optimizing faecal contamination monitoring methodologies.

By enhancing our understanding of enterophage distribution and reliability as faecal contamination markers, this study contributes to the ongoing efforts to refine microbial water quality assessment methods and improve water monitoring and conservation strategies.

References

- 1 Jebri, S., Muniesa, M., Jofre, J. 2017. In: Rose, J.B. and Jiménez-Cisneros, B. (eds), *Water and Sanitation for the 21st Century: Health and Microbiological Aspects of Excreta and Wastewater Management (Global Water Pathogen Project)*.
- 2 Wheeler, A.L., Hartel, P.G., Godfrey, D.G., Hill, J.L., Segars, W.I., 2002. *J. Environ. Qual.* 31, 1286–1293.
- 3 Santiago-Rodriguez, T.M., Tremblay, R.L., Toledo-Hernandez, C., Gonzalez-Nieves, J.E., Ryu, H., Santo Domingo, J.W., Toranzos, G.A., 2012. *Appl. Environ. Microbiol.* 78, 5160–5169.
- 4 Toribio-Avedillo, D., Blanch, A.R., Muniesa, M., Rodriguez-Rubio, L., 2021. *Viruses.* 13, 1089.

Geographic Information Systems and Remote Sensing in Urban Water Monitoring: Insights from the LifeCOOLCity Project

Alicja Śniadach

GIS Center, Faculty of Oceanography and Geography, University of Gdansk, Poland

**Corresponding author: alicja.sniadach@ug.edu.pl*

Geographic Information Systems (GIS) have proven to be valuable tools for analyzing and managing urban water conditions. GIS can assess hydrological aspects of cities, evaluate green infrastructure effectiveness, and prepare data for water flow modeling (Sokolchuk, 2023). It enables the creation of thematic maps displaying water quality parameters and drinking water quality indices, facilitating monitoring and management of water supply systems (DeepChand et al., 2022). GIS also allows for simultaneous analysis of environmental, socio-economic, and health data to assess health risks related to water supply vulnerability (Barcellos, 2000). Furthermore, GIS technology supports the development of integrated platforms for water quality management, analysis, monitoring, and early warning systems from source to faucet (Li et al., 2010). These applications of GIS in urban water management contribute to improved decision-making, more efficient daily management, and emergency response capabilities for water issues in cities.

This presentation highlights the use of GIS and remote sensing technologies in urban water monitoring, with a specific focus on the Water Conditions Module from the LifeCOOLCity project, funded by the EU LIFE programme under the Mission on Adaptation to Climate Change. The module integrates spatial, satellite and aerial data to evaluate water availability, green space condition, and soil moisture in urban environments as well as modelling rainwater dispersal for flood prevention. These tools support cities in identifying vulnerable areas, planning adaptive measures, and ensuring sustainable water management. The results underscore the potential of spatial technologies to enhance resilience and guide evidence-based policy-making in the face of climate change.

This research has been conducted within the LifeCOOLCity project, funded by the European Union LIFE Programme under the Mission on Adaptation to Climate Change in conjunction with the National Fund for Environmental Protection and Water Management (NFOŚiGW).

References

1. Barcellos, C. (2000). *Cadernos de Saúde Pública*, 16(4), 905–914.
2. DeepChand, K., Mehta, S., Sharma, A. (2022). *Environmental Monitoring and Assessment*, 194(5), 1–15.
3. Li, R., Wang, Y., Zhang, Z. (2010). *Water Science & Technology*, 62(7), 1560–1568.
4. Sokolchuk, A. (2023). *Urban Water Journal*, 20(1), 34–47.

Groundwater temperature as a basis of a human induced recharge in small catchment. Case study of Zdzierowita catchment in SW Poland

Sebastian Buczyński, Tomasz Olichwer, Marek Wcisło, Robert Tarka, Marek Błachowicz

Institute of Geological Sciences, Department of General Hydrogeology, University of Wrocław, pl. Uniwersytecki 1
50-137 Wrocław, Poland

*Corresponding author: marek.wcislo@uwr.edu.pl

Catchments of mining areas are often under strong human pressure. Significant deformation of the water balance and the chemical composition of catchment waters is a serious problem in many areas of the world especially in small catchments where changes are most evident. One important example is the Zdzierowita catchment, located in the area of Europe's largest copper ore mine.

The catchment area of the Zdzierowita watercourse covers 25.1 sqkm. It is recharged from precipitation and by artificial means. It drains the foreland of the western section of the embankment of the Mining Wastes Utilisation Object (MWUO) Żelazny Most - Europe's largest mining waste disposal facility. In the estuary section of the Zdzierowita River, the following flows are recorded: mean discharge, $Q = 114$ l/s, mean from minimal annual discharge, $Q_{mm} = 34$ l/s.

The water under sediments of the Żelazny Most reservoir is characterized by high concentrations of elements from technological processes, mainly chlorides and sulphates. "Żelazny Most" has a modern monitoring and warning system, but the heterogeneous geological structure causes the streamwater to be contaminated by supra-sedimentary waters migrating in the subsoil of the landfill. The catchment is built up by Quaternary-age sediments, strongly glaciectonically disturbed, so the amount and flow paths of pollutants are difficult to determine (Kalisz et al. 2009). An innovative tool to support the piezometer measurements was a thermal analysis to determine the filtration rate of water flowing from the reservoir into the catchment via Quaternary aquifers.

Measurements were carried out with data loggers in the observation network of the western foreland of the MWUO Żelazny Most at 12 measurement points, at varying depths. Groundwater temperatures showed sinusoidal variations throughout the year and expired at depths of 12-15 m. Preliminary investigations showed that groundwater infiltrating from the reservoir and dams has a higher average temperature than water in the foreland piezometers. Groundwater in the dam and its immediate surroundings showed an annual mean temperature of 11.6-10.8 °. In the foreland, the average temperature was lower, ranging from 10.6-9.5 °. Curves of temperature change over time at different depths were developed for each measurement point. The measurements taken and the data collected formed the basis for calculating the infiltration intensity based on an analysis of the heat flux and its spatial variation using Taniguchi's (1993) method (Stallman, 1965). This method is based on profiling water thermic and recording changes in groundwater temperature at specific depths. The calculated mean recharge value for the 12 piezometers according to the Taniguchi method was 1004.0 mm/yr. The area of altered water composition in the Zdzierowita catchment is 1 680 000 sqm. In view of this, the brine infiltration rate was determined to be 5.3 l/s. Artificially infiltrated waters account for approximately 4.6% of the averaged flow of Zdzierowita.

References

- 1 Kalisz, M.; Worsa-Kozak, M.; Barańska – Buslik, A.; Cygan, S.; Czmiel, J.; Dziedziak, T.; Jastrzębski, J.; Konsencjusz, D.; Markiewicz, A.; Merta, A.; et al. *Dokumentacja Hydrogeologiczna Rejonu Składowiska Żelazny Most; KGHM Cuprum Sp. z o.o.—CBR: Wrocław, Poland, 2009 (ang. Hydrogeological documentation of the Żelazny Most landfill area), KGHM Cuprum Sp. z o.o. CBR Wrocław.*
- 2 Stallman R.W., 1965. *J. Geophys. Res.*, 70, 12 (pp. 2821-28270). <https://doi.org/10.1029/JZ070i012p02821>

The influence of environmental conditions on the growth rate of *S. cephalus* L. and *L. leuciscus* in two San River basin populations

Łukasz Jurczyk, Justyna Koc-Jurczyk, Agnieszka Podolak, Monika Marut

Institute of Agricultural Sciences, Environment Protection and Management, Faculty of Technology and Life Sciences, University of Rzeszów, Cwiklińskiej 1a St., 35-601 Rzeszów, Poland

*Corresponding author: ljurczyk@ur.edu.pl

In the fisheries nomenclature, the so-called lands of trout, grayling, barbel and bream are distinguished in the course of the river. The distribution of individual species depends on their, sometimes very narrow, environmental requirements; however, such rheophilous species as chub *Squalius cephalus* or dace *Leuciscus leuciscus* can adapt to a wide range of physicochemical and biological parameters of the stream. The basic and useful measure of well-being in this case may be the rate of growth. This study aimed to compare the growth rate of fish inhabiting two closely located, but isolated, sites with different conditions. The material for the study came from angling catches, and the sampling period covered July and August. Scales for the study were taken from the left side of the fish's body, at the height of the lateral line above the anal fin. In total, material was collected from 80 fish, whose total length (*longitudo totalis* – TI) ranges from 15 to 47 cm. To determine the age and growth rate of chub and dace from the San and Solinka rivers, TI were measured to the nearest 0.1 cm, and scale rings were measured using a microscope with the following parameters: W10 x 15.5 MM, objective lens – 4/0, to the nearest 0.01 mm. The age of fish was determined using the Dahl–Lea method, and the growth rate of fish was determined using two popular mathematical models: Ford–Walford and von Bertalanffy. The mathematical models used in the study to predict the growth rate of fish allowed the state to determine that chub caught from the studied section of the Solinka grew faster than those from the San. In both rivers, chub grew the fastest in the first years of life. The observed differences may result from more favourable thermal and oxygen conditions in Solinka. The influence of possible migrations from Lake Solina in search of food and lower angling pressure in Solinka cannot be ruled out. Conducting ongoing research on the growth rate of this species of fish in mountain waters may prove to be particularly important concerning the processes of climate warming or lowering water levels.

Supported by funding from the Ministry of Science under the Regional Excellence Initiative Programme. Contract No. RID/SP/0010/2024/1.

Assessment of the phytotoxicity of leachates from municipal non-hazardous waste landfills using duckweed (*Lemna minor*) as a test model

Justyna Koc-Jurczyk, Łukasz Jurczyk, Agnieszka Podolak, Agnieszka Ruść

Institute of Agricultural Sciences, Environment Protection and Management, Faculty of Technology and Life Sciences, University of Rzeszów, Cwiklińskiej 1a St., 35-601 Rzeszów, Poland,

*Corresponding author: jkoc@ur.edu.pl

Landfill leachate poses a real threat to the environment. It is mainly produced when rainwater seeps through municipal waste landfills and washes out mineral and organic compounds. It contains significant amounts of potentially harmful substances, such as heavy metals, various xenobiotics and compounds formed during waste degradation. Their complex composition makes it difficult to predict their biological impact using the physical and chemical parameters required by law. Leachates can enter both groundwater and surface water, which is why it is important to identify their toxic effects on organisms living in these environments when assessing environmental risk.

The study aimed to determine whether duckweed (*Lemna minor* L. 1753) could be used as a test organism in phytotoxicity studies of leachates from landfills containing non-hazardous and inert waste. A series of leachate dilutions were prepared for the study by mixing them with mechanically filtered pond and tap water. The *Lemna minor* used in the study as a phytotest was collected from a pond in a rural area within the Lemno-Spirodeletum polyrrhizae aquatic vegetation complex. The duckweed was sorted and acclimatised to laboratory conditions in a tank containing mechanically filtered pond water. The tank was placed in a sunny location without additional lighting for a period of 14 days at a temperature of 23°C (±2). To observe changes in the growth rate and condition of the plant, it was scanned from above using a Kodak camera. The exposure time for all test series was 21 days.

Water lettuce proved to be a useful model organism with which to study the impact of raw sewage. It exhibited high sensitivity to the presence of added raw sewage concentrations in the substrate. In addition to death, symptoms of chlorosis and necrosis were observed on the edges of leaf segments on the shoots. At concentrations below 50%, the growth of new segments was initially inhibited and, over time, survival rates began to decline significantly. Lower concentrations only inhibited duckweed reproduction without causing shoot death. Exposure to concentrations below 12%, however, showed that leachates may stimulate duckweed reproduction.

Supported by funding from the Ministry of Science under the Regional Excellence Initiative Programme. Contract No. RID/SP/0010/2024/1

Long-term Hydrological Changes in the Watershed of a Mountain River: A Case Study of the Bystrzyca Łomnicka River, SW Poland

Michał Grzeńkowiak

University of Wrocław, Faculty of Earth Sciences and Environmental Management, Institute of Geography and Regional Development, plac Uniwersytecki 1, 50-137 Wrocław

*Corresponding author: 345064@uwr.edu.pl

Since the 1970s, the Bystrzyca Łomnicka River catchment, located in the Bystrzyckie Mountains of southwestern Poland, has experienced an increase in average annual temperature of over 1.5°C, reflecting broader climatic trends. This study examines the catchment's long-term hydrological response to changing meteorological conditions, with a focus on trends in temperature, precipitation, and discharge.

Although total annual precipitation has remained relatively stable, annual river discharge has shown a statistically significant decreasing trend (−2.32 mm/year; $p = 0.040$). According to linear regression, discharge declined from approximately 519 mm in 1973 to 405 mm in 2022 ($R^2 = 0.085$). Simultaneously, the difference between precipitation and discharge has increased significantly (+3.13 mm/year; $p = 0.004$, $R^2 = 0.16$), suggesting an intensifying role of evapotranspiration, likely linked to rising temperatures and extended vegetation periods. Importantly, no major land cover changes have occurred in the catchment during the study period.

Although anecdotal evidence suggests an earlier onset of snowmelt, no statistically significant shift in the timing of annual peak discharge was observed during the study period ($p = 0.68$). However, an increasing trend in the Markham seasonality index suggests that river discharge has become progressively more concentrated within a narrower period of the year.

These findings raise important concerns regarding the long-term viability of the planned hydropower reservoir. Reduced discharge and the potential for increased evaporation from the reservoir could significantly impact future water availability. At the same time, this study provides valuable long-term hydrological data from a relatively understudied mountain basin, offering insights that can support more accurate water resource management and climate adaptation strategies at the regional scale.

References

- 1 Siwek, G. (2018). *Seasonality and multiannual variability of floods: case study from Eastern Poland*. ITM Web of Conferences
- 2 Shi P., Liu J., Yang T., Xu C.-Y., Feng J., Yong B., Cui T., Li Z., Li S. (2019). *Water*, 11(12), pp. 2435–2459.

Evaluating the impact of catchment parameters stormwater discharge capacity and using a small urban catchment as an example

Robert Tarka, Tomasz Olichwer, Sebastian Buczyński

University of Wrocław, Faculty of Earth Sciences and Environmental Management, Institute of Geography and Regional Development, plac Uniwersytecki 1, 50-137 Wrocław,

*Corresponding author: tomasz.oliczwer@uwr.edu.pl

Management of stormwater in urban catchments is often a critical factor for the sustainable development of urban areas. The observed intensification of precipitation as a result of observed climate change often causes overflowing of sewer systems and flooding of areas, causing significant property damage. One sustainable method of managing stormwater is surface infiltration with retention. Proper design of stormwater infiltration facilities ensures that the risk of flooding in urban catchments is reduced. However, this is not possible without taking into account key catchment parameters. The authors of this paper have developed a new method to assess and classify urban areas for their ability to manage stormwater through infiltration into the ground using infiltration basins and trenches. The proposed methodology is based on available archival data on the lithological formation and permeability of soils, the lithological formation of formations in the aeration zone, and the depth of aquifer. The model considers 3 factors, such as depth of water tables (D), impact of vadose zone (I) and soil media (S), hence the name DIS (Tarka et al. 2025). Based on the DIS value, 5 classes of land suitability for rainwater management were proposed. The developed method was tested on a catchment area of 16.41 km², located in the city of Wrocław, one of the largest in Poland. It was assumed that with a DIS value below 1 there is no possibility of draining water into the ground, while above 2.5 there are good and very good conditions that allow the construction of infiltration basins or trenches. The DIS values determined in this way in the test area change from 0.028 to 4.466. The average value is 1.663, while the median is 1.561. The surface area of terrain in the Ługowina catchment with bad suitability for rainwater management using infiltration basins and trenches (DIS <1) is 8.1 km², which accounts for 49.4% of the catchment area. Areas with conditional rainwater drainage into the ground comprising very poor to moderate classes with DIS values of 1 to 2.5 cover an area of 7.99 km² to give 48.7%. Areas with good conditions of rainwater drainage capacity (DIS >2.5) cover only 0.311 km² (1.9 % of the catchment area). This indicates that in the major part of the Ługowina catchment area there are unfavorable conditions for rainwater management using infiltration basins and trenches. Due to its measurability and ease of application, the DIS method can be recommended for wide dissemination and use in practice. The developed methodology makes it possible to provide city planners or developers with data on the possibilities of managing stormwater on site and assist in making decisions related to land use.

References

- 1 Tarka R., Buczyński S., Olichwer T. (2025). *Hydrogeology Journal*, 33, pp.49-61

Water for a sustainable world: achieving Sustainable Development Goal 6 through integrated strategies for monitoring and protecting water resources

Agnieszka Podolak¹, Justyna Koc-Jurczyk¹, Łukasz Jurczyk¹, Zuzanna Sylwestrzak^{2,3}

¹ Institute of Agricultural Sciences, Environment Protection and Management, Faculty of Technology and Life Sciences, University of Rzeszów, Cwiklińskiej 1a St., 35-601 Rzeszów, Poland,

² University of Gdansk, Faculty of Oceanography and Geography, Al. Piłsudskiego 46, 81-378 Gdynia, Poland

³ Medical University of Gdansk, Faculty of Health Sciences, Department of Environmental Toxicology, Dębowa 23A Str, 80-204 Gdansk, Poland

*Corresponding author: apodolak@ur.edu.pl

Water is one of the most important resources on Earth, with biological, ecological, social, economic and cultural significance. Despite covering most of the Earth's surface, it is a non-renewable resource on a local scale and is becoming increasingly scarce. Only a small percentage of the world's water is fresh, and only a fraction of that is available to humans. In the face of climate change, population growth, and intensive economic activity, water resources are under increasing threat. As a fundamental life-sustaining resource, water requires special protection and effective monitoring in terms of both quality and quantity. Water is a central element of Agenda 2030 and is strongly linked to many of the Sustainable Development Goals adopted by the United Nations. The main water-related goal is to ensure access to safe water and sanitation for everyone, and to manage water resources sustainably.

This study aims to analyse the feasibility of achieving Sustainable Development Goal 6 (SDG 6), 'Clean water and sanitation', by implementing integrated strategies to monitor and protect water resources from an interdisciplinary perspective. In the face of mounting challenges stemming from climate change, urbanisation, environmental pollution and the overexploitation of natural resources, the adoption of comprehensive water management methods is imperative. These measures combine modern technologies with ecological knowledge, public policy and social engagement. Current issues include limited access to safe drinking water and adequate sanitation in various regions of the world, as well as threats resulting from the degradation of water ecosystems. This study will present tools used in integrated water monitoring, including physico-chemical and ecotoxicological methods, remote sensing systems, in situ sensors, and satellite technologies, as well as predictive models that support decision-making in water management. Institutional and social aspects are also important, including the significance of appropriate legal frameworks, water policies and international cooperation in implementing SDG 6, as well as environmental education and local civic initiatives in supporting a sustainable approach to water management.

In summary, achieving Sustainable Development Goal 6 requires a holistic approach that integrates knowledge and action from various fields and levels – from local to global. Effective implementation of integrated strategies for monitoring and protecting water resources is essential for ensuring water security and promoting sustainable socio-economic development and environmental protection on a global scale.

Supported by funding from the Ministry of Science under the Regional Excellence Initiative Programme. Contract No. RID/SP/0010/2024/1.

Micronuclei in erythrocytes of the Baltic Grey Seal - microscopic analysis as a tool for genotoxicity assessment in the One Health context

Andrzej R. Reindl¹, Lidia Wolska¹, Katarzyna Kucharska², Agnieszka Grajewska³, Mirosław Kalicki⁴, Iwona Pawliczka⁵

¹ Medical University of Gdansk, Faculty of Health Sciences, Department of Environmental Toxicology, Dębowa 23A Str, 80-204 Gdansk, Poland

² Institute of Biology and Earth Sciences, University of the National Education Commission, Krakow, Poland

³ Institute of Meteorology and Water Management – National Research Institute, Gdynia, Poland

⁴ Gdansk Zoological Garden, Gdansk, Poland

⁵ Hel Marine Station, University of Gdansk, Hel, Poland

**Corresponding author: Andrzej.Reindl@gumed.edu.pl*

The One Health concept is a transdisciplinary framework that recognizes the fundamental interconnectedness between the health of the environment, animals, and humans. Nowhere is this more evident than in the Baltic Sea, a semi-enclosed and pollution-sensitive ecosystem subjected to chronic anthropogenic stress. Industrial runoff, agricultural pollution, and maritime activities introduce contaminants that disrupt biodiversity, impair animal health, and pose potential risks to humans, primarily through bioaccumulation of toxins in seafood.

To address this, we applied the micronucleus (MN) assay on grey seal (*Halichoerus grypus*) erythrocytes as a sentinel approach to assess marine genotoxicity. Micronuclei, which arise from errors in chromosome segregation or structural damage during cell division, serve as sensitive biomarkers of genome instability and DNA damage. Their presence in erythrocytes, easily accessed through minimally invasive blood sampling, provides an effective method to detect cumulative genotoxic stress in marine top predators.

In our pilot study, we used classical light microscopy to examine erythrocyte smears from grey seals inhabiting the Southern Baltic Sea. The presence of micronuclei in a subset of cells confirmed genotoxic exposure in this population. Despite being time-consuming, manual microscopic analysis proved highly reliable and specific, especially given the complexity of marine mammal blood cytology, where immature and enucleated cells may confound automated detection methods.

This research fills a critical gap in marine pollution monitoring, which has historically focused on lower trophic organisms. As long-lived, fat-storing, and high-trophic-level mammals, grey seals serve as ideal bioindicators of long-term contaminant exposure. Monitoring DNA damage in these species offers not only insight into ecosystem health, but also early warning signals relevant for public health risk assessments.

By integrating micronucleus analysis into environmental monitoring programs, we contribute to the development of One Health-oriented strategies for water protection. The microscopic MN assay, when applied to sentinel species like the grey seal, offers a powerful tool to detect invisible yet significant genetic impacts of pollution, supporting science knowledge, based conservation and sustainable resource use across ecosystems.

The application of Citizen science in water protection and restoration

Julita A. Dunalska, Rafał Głuszewski, Marek Orlikowski

Center for Water Monitoring and Protection, University of Gdańsk

**Corresponding author: julita.dunalska@ug.edu.pl*

Interest in citizen science is growing worldwide due to increased public awareness of the importance of protecting natural resources. Continuous development of knowledge about the functioning of the aquatic environment and the changes taking place is crucial for identifying threats related to the degradation of aquatic ecosystems. One of the most effective ways to communicate information about caring for the natural environment is through volunteering, which strengthens the relationship between the scientific community and the public. An example of this is the 'Volunteering for Lakes' project, which was implemented by the Center for Water Monitoring and Protection, University of Gdańsk in 2023. Professor Julita Dunalska is the originator and coordinator of the project. The aim of the project is not only to raise public awareness, but also to create a professional database on the trophic status of lakes. This will enable changes in lakes to be observed and will thus allow for a better understanding of environmental problems. The training courses offered as part of the project provide additional knowledge about the progressive eutrophication of waters in the context of climate change, intensification of agriculture, and anthropogenic pressure — particularly tourist pressure. All activities are intended to popularise knowledge of lake ecology and biodiversity, and to change people's attitudes towards nature, thereby promoting conscious and responsible interaction with and use of natural resources. Furthermore, the project's objectives align with those of the National Environmental Policy (PEP 2030), which specifically aims to ensure sustainable water management, including providing clean water access for society and the economy, and achieving good water status.

GLOBAL WATER FUTURE



Gdansk University
Water Monitoring and Protection Center
Jana Bażyńskiego 4 Str., 80-309 Gdańsk, PL
Department in Borucino, Borucino 77, 83-323 Kamienica Szlachecka, PL

<https://cmiow.ug.edu.pl>

<https://glowaf.eu>