8. und 9. Oktober 2025 in Magdeburg

8. a 9. října 2025 v Magdeburku

Magdeburger Gewässerschutzseminar 2025

Magdeburský seminář o ochraně vod 2025

Wasserbewirtschaftung im Einzugsgebiet der Elbe gestern, heute und morgen ~ Tagungsband

Hospodaření s vodou v povodí Labe včera, dnes a zítra ~ Sborník

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Magdeburger Gewässerschutzseminar 2025
Magdeburský seminář o ochraně vod 2025

Das Magdeburger Gewässerschutzseminar 2025 dient auch der Information der Öffentlichkeit im Rahmen der Umsetzung der Wasserrahmenrichtlinie (RL 2000/60/EG) und der Hochwasserrisikomanagementrichtlinie (RL 2007/60/EG) in der internationalen Flussgebietseinheit Elbe.

Magdeburský seminář o ochraně vod 2025 je i součástí informování veřejnosti v rámci implementace Rámcové směrnice o vodách (2000/60/ES) a Směrnice o vyhodnocování a zvládání povodňových rizik (2007/60/ES) v mezinárodní oblasti povodí Labe.

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Odborné příspěvky

Magdeburger Gewässerschutzseminar 2025

Magdeburský seminář o ochraně vod 2025

Absicherung des Wasserdargebotes und der Ökosystemfunktionen

Zabezpečenost vodních zdrojů a funkcí ekosystémů

The Amendment of the Water Law of the State of Saxony-Anhalt

Michael Janssen, Wiebke Veelken

1. Objective of the Amendment

The increasing frequency of extreme weather events (heatwaves, droughts, heavy rainfall and flooding) as part of climate change has severe consequences for humans and nature and necessitates action.

In particular, water resources have proven to be highly vulnerable. Prolonged dry periods have caused groundwater levels to drop, surface waters to dry up, and overall water availability to decline significantly. This has had serious consequences for aquatic ecosystems, agriculture, industry, and the supply of drinking water.

At the same time, extreme weather events have intensified water-related risks. Notable examples include the floods in Saxony-Anhalt in 2013, 2017, and most recently in 2023/2024.

The omnibus act includes draft laws to amend the Water Law of the State Saxony-Anhalt (WG LSA), the Nature Conservation Act of the State of Saxony-Anhalt (NatSchG LSA), the State Implementation Act of Saxony-Anhalt on the Wastewater Charges Act (AG AbwAG), the Act on the Establishment of a Public Law Institution "Dam Operation Saxony-Anhalt" (Dam Operation Act), and consequential amendments to the Ordinance on Deviating Responsibilities in the Field of Water Law (WasserZustVO).

The focus of the legislative project is the amendment of the Water Law of the State of Saxony-Anhalt. The draft "Act to Improve Water Management in the State of Saxony-Anhalt" establishes the necessary legal foundations for the development of climate-adapted and modern water management in Saxony-Anhalt. The draft is currently under parliamentary procedure.

2. Key Provisions

Section 52 WG LSA: This section aligns with Section 39 of the Federal Water Resources Act (WHG), incorporating water retention into water maintenance. This expands the concept of maintenance and represents the core regulation of the reform, introducing a paradigm shift from water drainage to water retention.

Section 36a WG LSA (Water Retention and Continuity): It clarifies Section 34 WHG to make implementation clearer for authorities. Put simply, the provision aims to regulate when continuity in water bodies must regularly be restored and when it can be waived by designating so-called priority water bodies.

Section 28a WG LSA: There is currently a tension between Section 33 WHG and Section 34 WHG.

On the one hand, when damming a surface water body, the minimum water flow must be ensured (Section 33 WHG), on the other hand, the continuity of the water body must equally be guaranteed (Section 34 WHG). Section 28a WG LSA provides conflict prevention by creating a legal basis for water authorities to order suitable measures to ensure the minimum water flow and thus appropriately balance the requirements with any continuity obligations.

Section 54a WG LSA (Experimentation Clause): This Section is a unique provision within German water law, designed to make water maintenance more effective and economically viable while creating a management model that accommodates diverse interests. It allows maintenance authorities to carry out time-limited measures that technically improve flow or retention conditions, even if these measures formally depart from conventional water maintenance regulations. The provision was modeled after Section 157 (1) KVG LSA.
Section 50 (1) WG LSA: It introduces a regulation on riparian buffer zones of 5 meters in urban areas, granting municipalities the authority to implement deviations. This measure protects water bodies, regulates water drainage, and optimizes water maintenance.

Section 78a WG LSA establishes the priority of infiltration or percolation of rainwater over direct discharge or discharge via sewer systems into surface water bodies.

Section 22 (2) Nature Conservation Act of the State of Saxony-Anhalt (NatSchG LSA) regulates “temporary nature”. The Amendment of Section 22 (2) sentence 1 NatSchG LSA is introducing a legal basis for an agreement between the nature conservation authority and the maintenance obligor regarding the temporary suspension of maintenance.

These provisions are a key step in modernizing water management in Saxony-Anhalt, addressing environmental challenges and the need for resilient infrastructure in response to climate change.

3. Timeline

The draft law is currently undergoing parliamentary procedure and is expected to be passed shortly (likely after the summer break).

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Healthy landscape of the Pilsen Region

Jakub Rataj, Marie Vítová

Climate change in the Czech Republic and elsewhere in the world is manifested by an increase in the average annual air temperature, changes in the distribution of annual precipitation, increased evapotranspiration and extreme hydro-meteorological events. The effects of climate change are also being felt more acutely due to inappropriate management of the landscape. As a result of intensive (conventional) farming, there is a loss of soil edaphon, pedocompaction (soil compaction), reduced retention and infiltration capacity, increased surface run-off, soil erosion, loss of naturally functioning river landscape and others. The large number of growing built-up and paved areas that together with other factors, reduce biodiversity, connectivity and increase landscape fragmentation, also plays a major role.

Regional strategy for adaptation measures for water retention in the landscape and priority areas

In response to these problems, in 2021 the Pilsen Region decided to respond through the Healthy landscape project, which addresses the adaptation of the landscape to climate change. The project developed the strategic Regional strategy for adaptation measures for water retention in the landscape concept document, which builds on the national adaptation strategies. As this is a strategy that primarily addresses water retention in the landscape, the input units were selected as the 4th order (according to Strahler) river basins, of which there are 825 in the Pilsen Region.

The results of the multi-criteria analysis showed a total of 20 priority areas (PAs) that the project prioritises. These priority areas are the most problematic in the Pilsen Region in terms of negative impacts of climate change and inappropriate management. On the contrary, there is the greatest potential and need for adaptation measures to be implemented. Within the framework of these PAs, landscape studies are gradually being prepared, which propose specific adaptation measures. The aim of the project is therefore to improve the condition of the landscape through the implementation of specific adaptation measures resulting from the landscape studies. It is important that the landscape becomes more adaptable, diverse, stable and resilient to the negative effects of climate change.

Landscape studies in selected priority areas

Comprehensive land-use studies not only focus on water retention in the landscape, but also on the biodiversity, natural values, permeability and habitability of the landscape, land use, urban structure, settlement green system, historical and cultural values. The aim of these studies is to identify the main problems or, on the contrary, the potentials and values of the territory, and on the basis of these to propose specific adaptation measures to be implemented. The studies are the basis for the preparation of municipal land-use plans, for the preparation of plans for common facilities within the framework of comprehensive land development and for other land-use planning and decision-making documents.

When creating a landscape study, the analytical part of the study is prepared first, where all available data on the area is thoroughly examined. Spatial analytical documents, erosion and hydrological data and the status of the Territorial Ecological Stability System are all essential. The discovered facts are verified and refined by detailed field research. This is followed by public consultations with local stakeholders in the area and the design part of the study itself. The primary output of the design part is the main drawing, in which all proposed measures are plotted. Each measure has its own card, which contains more detailed information about the current state and the proposal itself, including a drawing above the cadastral map.

What are the adaptation measures?

- restoration of historic dirt roads
- planting of tree plantations, orchards and avenues
- restoration of vernal pools and wetland biotopes
- construction of small dams and other water retention measures in forests
- revitalisation and eco restoration of watercourses
- blue-green infrastructure

The first area where a landscape study was prepared was the Radbuza river basin from Dobřany to the outlet of the České údolí reservoir (CHP 1-10-02-1020-0-00). This was followed by the smaller Úhlava catchment area from Bezděkov to Klatovy (CHP 1-10-03-0360-0-00). Two further studies concern the basin of the Zlatý brook near Přeštice (CHP 1-10-03-0730-0-00) and the Chuchla catchment area north-west of Holýšov (CHP 1-10-02-0710-0-00). A landscape study of the Srbický brook catchment area is currently being prepared.

Implementation of the proposed measures resulting from the landscape studies – Healthy landscape advisory body and project partner

The completed spatial study is linked to the preparation of the implementation of the proposed measures and the subsequent support to local governments and local actors. The Healthy landscape project includes a so-called advisory body, whose ambition is to help with the project preparation of the proposed measures, preparation of an overview of funding sources and administration of the grant application up to the implementation itself.

Since the project was initiated in 2021 and the first studies were completed in 2024 and 2025, there are not many measures resulting from the landscape studies to be implemented. For the time being, the most frequent projects are tree planting, restoration of historic field paths or planting of orchards. Gradually, however, the project is also getting to the implementation of wetlands and other minor measures such as flood control and anti-erosion measures.

Our Healthy Landscape Partner eco-label has become part of the Healthy landscape project. Thanks to this eco-label, we can recognise companies in the Pilsen Region that have decided to actively cooperate in the Healthy landscape project. The partnership represents a unique opportunity to bring the private sector and public institutions together to invest jointly in environmental measures in the landscape.

Currently, the partner has supported, for example, the expansion of the grazing area in the Janovský Wetland Nature Reserve, the construction of an artificial island for nesting birds in the Zbynické ponds Nature Reserve and the revitalisation of the island for nesting birds in Podstránský pond.

Furthermore, the Pilsen Region currently offers three subsidy titles, namely for increasing species diversity, protection of species, biotopes and habitats, arboricultural treatments of important trees and planting of trees. The last support is individual subsidies, through which it is possible to support landscape studies outside the selected priority areas and the implementation of specific projects not resulting from landscape studies.

Healthy landscapes and other activities

In addition to the Regional strategy and follow-up landscape studies, Healthy landscape is engaged in many other activities. Education of the general public, including children, is an integral part of the project, as without the support and understanding of the public, the implementation of measures to support landscape adaptation cannot be promoted to a greater extent.

That is why it is important to participate in scientifically oriented public events or conferences. The project has established close cooperation with the University of West Bohemia in Pilsen and other universities. It communicates with the public through social networks and websites

Cooperation with other entities is also important. Regular meetings of the so-called Implementation Group are held within the project, whose representatives are, for example, the Agency for Nature and Landscape Protection of the Czech Republic, Vltava River Basin, s.p., Forests of the Czech Republic, s.p., State Land Office, Regional Development Agency, Association of Towns and Municipalities of the Pilsen Region, Bishopric of Pilsen. Healthy landscape also cooperates with other projects (LIFE FOR MIRES, LIFE Adapt Brdy) to gain new experience and know-how.

Conclusion

We have set ourselves the ambitious goal of preparing our landscape for the future. If we proceed at the current pace, we will not be able to solve the landscape problems across the county until many decades from now. Therefore, we see the role of the project as initiating and inspiring especially for landowners, farmers and local governments. All those who have the greatest influence on the state of the landscape. We see the issue of restoring or maintaining a stable, diverse and healthy landscape to sustain all landscape functions over the coming decades as a major challenge. But at the same time we see it as a huge opportunity.

Fig. 1: *Janovský Wetland Nature Reserve*

Fig. 2: *Restoration of the historical dirt road with planting of trees in Milínov*

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Transformation of riverine nutrients and dissolved organic matter from source to sea

Norbert Kamjunke

1. Approach

Transformations of nutrients and organic matter are of considerable importance in large rivers on their way to the sea, but studies investigating a river system from source to sea are scarce. We tested the hypotheses: (1) dissolved nutrients are incorporated by phytoplankton and transferred into particles with increasing river length, (2) terrestrial components will dominate in upstream regions, (3) oxygen and aromatic content and molecular mass of DOM will decrease towards the tidal and coastal parts, and (4) chlorophyll a concentration and salinity are important environmental drivers of nutrient dynamics and DOM composition. We investigated the Elbe River in Central Europe from the headwaters via the lowland river and the tidal region towards the coastal waters in the North Sea (Fig. 1).

Fig. 1: Sampled river stretches of the Czech Elbe (light blue), German freshwater Elbe (green), tidal Elbe (red and orange) and German Bight (dark blue).

2. Results

Chlorophyll a concentration and oxygen saturation increased longitudinally in the river but showed distinct minima in the estuary upstream of the salinity gradient. Dissolved nutrients were taken up by algae in the freshwater part but were released again at algal die-off, and a part of the nitrate was used for denitrification [1]. Organic carbon composition was characterized by compounds of terrestrial origin in the upstream region. The dominance of components with high O:C ratios and low H:C ratios in headwaters moved towards components with low O:C ratios and high H:C ratios in seawater (Fig. 2). Furthermore, the number of double bounds, aromaticity, and molecular mass decreased with increasing river stretch. The proportion of organic nitrogen components increased in the estuary and coastal regions.

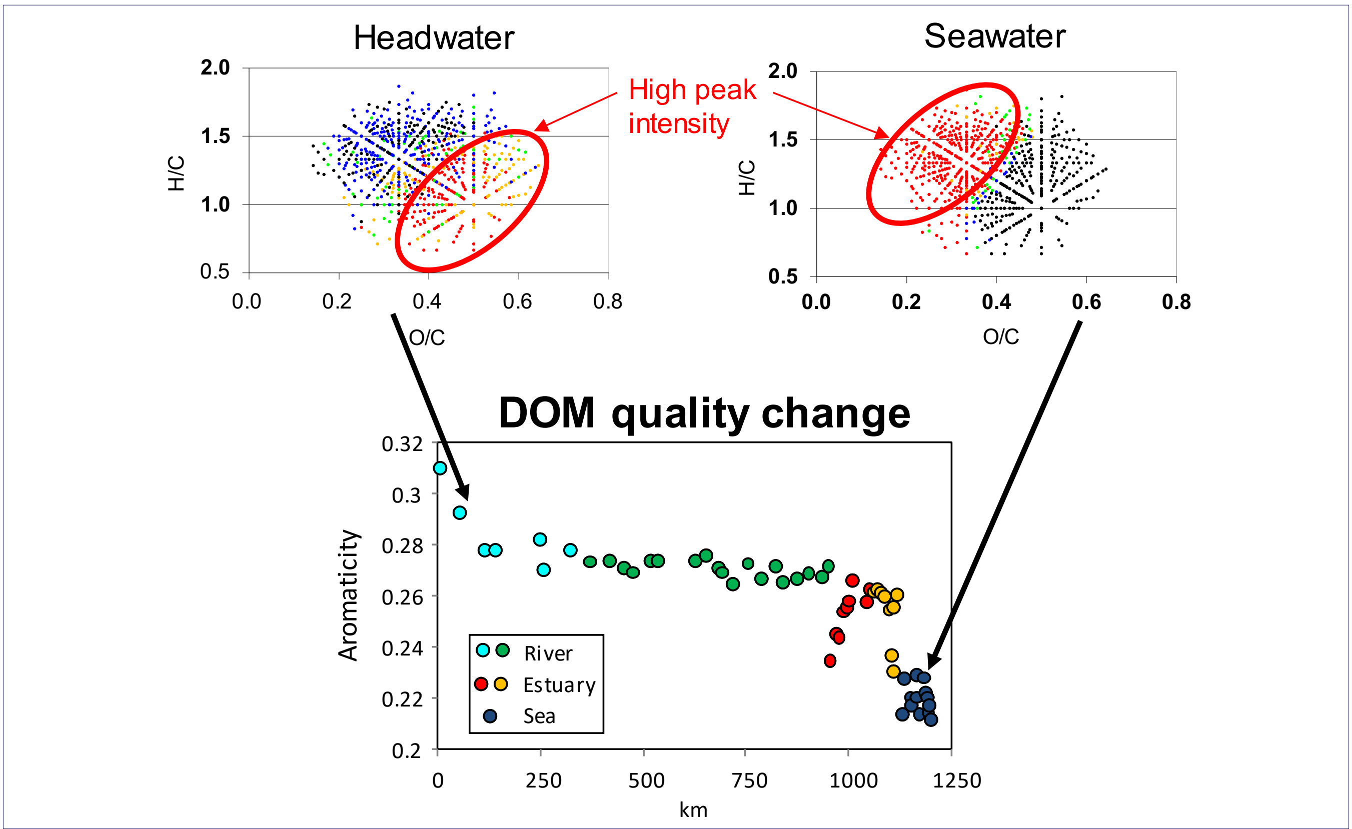

Fig. 2: Ratios of H:C and O:C of dissolved organic matter in Czech Elbe headwater and German Bight seawater (upper part), and aromatic content of dissolved organic matter along the Czech Elbe (light blue), the German freshwater Elbe (green), the tidal Elbe (red and orange), and the German Bight (dark blue) (lower part).

3. Implication for coastal waters

The high spatial resolution provided a unique data set and enabled the detection of pronounced gradients. Overall, our unique data set helps understanding the dynamic transfer of nutrients and demonstrated a distinct sequence of DOM transformation along the land-ocean gradient highlighting the large activity of riverine and estuarine systems in terms of organic carbon dynamics [2].

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Analysis of the impact of drought on water quality in watercourses

Libuše Barešová, Radek Vlnas, Vít Šťovíček, Vít Kodeš

1. Introduction

The PERUN project, under the direction of the Czech Hydrometeorological Institute, is focused on the prediction, assessment, and study of the sensitivity of selected systems to the effects of drought and climate change in the Czech Republic. Furthermore, it investigates the impact of drought on water quality in watercourses with the objective of defining watercourse sections that are sensitive to this stressor. The analyses are principally based on data from the operational monitoring of the state-owned companies Povodí.

This paper presents the findings of analyses of physico-chemical parameters in relation to the hydrological situation in watercourses. The objective of this study is to present empirical findings, with a particular emphasis on evaluating the impact of point sources of pollution, especially wastewater treatment plants (WWTP), in the context of increasing climatic extremes.

2. Methods

To identify watercourses susceptible to water quality deterioration during periods of drought, a selection of gauging stations was used where Q_{355} decreased by more than 10% between the reference periods of 1981–2010 and 1991–2020 (205 stations) [1]. Subsequently, these stations were allocated to water quality monitoring sites. Afterwards, a selection of profiles was made, comprising those with extended time series of observations of physico-chemical parameters (54 sites exhibiting a greater than 10% reduction in Q_{355} and a minimum of 30 years of observations). The statistical significance of the trends in the time series of summer (June-August) concentrations of the physico-chemical and chemical parameters was examined.

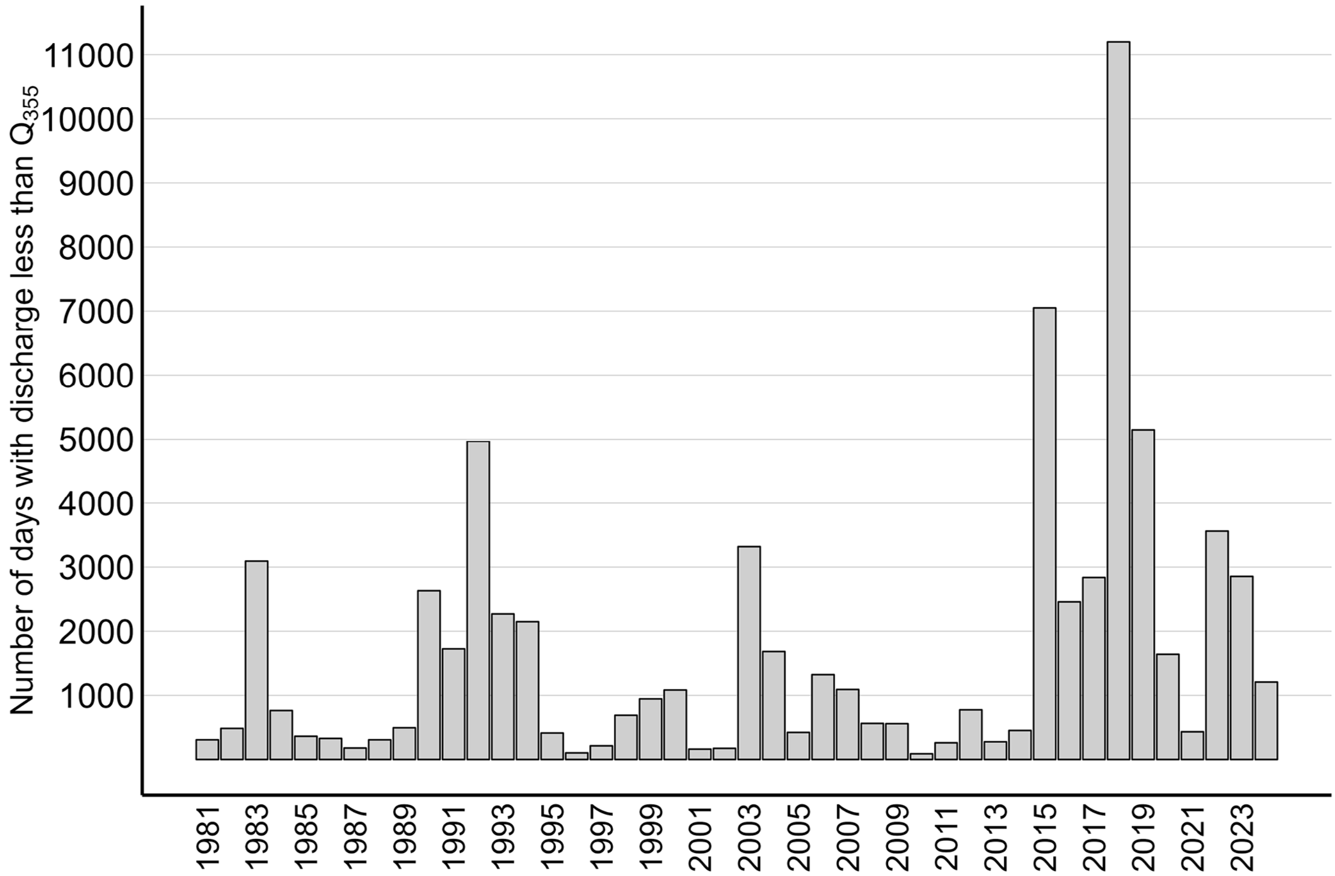


***Fig. 1:** Sum of the number of days with discharge below Q_{355} at 210 water gauging stations in the period 1981–2024*

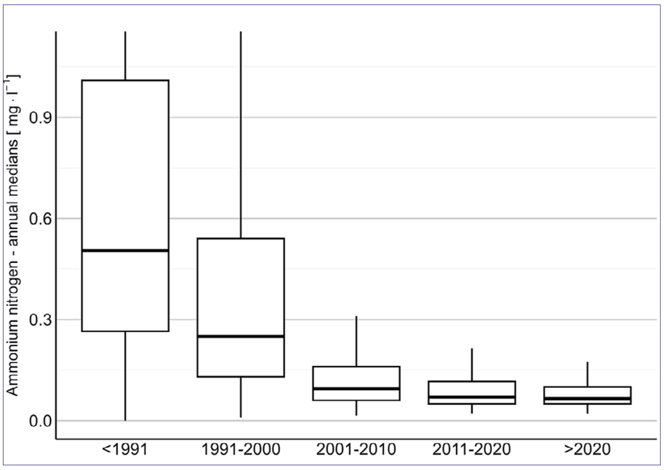
To assess the relationships between concentrations of physico-chemical parameters and flow, the profiles that appear to be the most problematic in terms of achieving good ecological and chemical status were selected. The third river basin management plans indicated that these sites showed unsatisfactory chemical status and failed to achieve objectives for general physico-chemical and specific pollutants. Concurrently, biological components were classified as ecological status classes 4 or 5 (macrozoobenthos) or 3 to 5 (phytobenthos or phytoplankton). In these profiles, Spearman rank-correlation coefficient between the values of the measured concentrations and the average daily flow on the day of sampling was examined.

The total number of days with discharge lower than Q_{355} at 210 water gauging stations during the period 1981–2024 was also calculated. (Fig. 1). The present study investigated the relationship between the number of occurrences of "dry" days in a given year and the evolution of concentrations of physico-chemical parameters at sets of sites that had complete time series from 2010 to 2024.
To conduct a more extensive analysis, water quality monitoring sites were selected in both upstream and downstream locations of the WWTP. The distance between the monitoring sites and the WWTP was typically up to 5 kilometers. The behaviour of selected water quality parameters was studied, with the focus on the location of the monitoring site and the year or month of monitoring.

The physico-chemical and chemical parameters assessed included the following: water temperature, pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total phosphorus, phosphate phosphorus, nitrate nitrogen, ammonium nitrogen, chloride, conductivity, and adsorbable organically bound halogens (AOX).

3. Results

Statistical testing is significantly hindered by the fact that by 2010, there had been a substantial decrease in pollution due to the large-scale construction of wastewater treatment plants and sewage disposal systems in municipalities. Consequently, the evaluation of shifts in water quality across diverse reference periods, exclusively attributed to rising water temperatures and declining flows, is not feasible for certain parameters, primarily nutrients. Some parameters such as chloride exhibit stability with a modest increase over the past decade (Fig. 2).



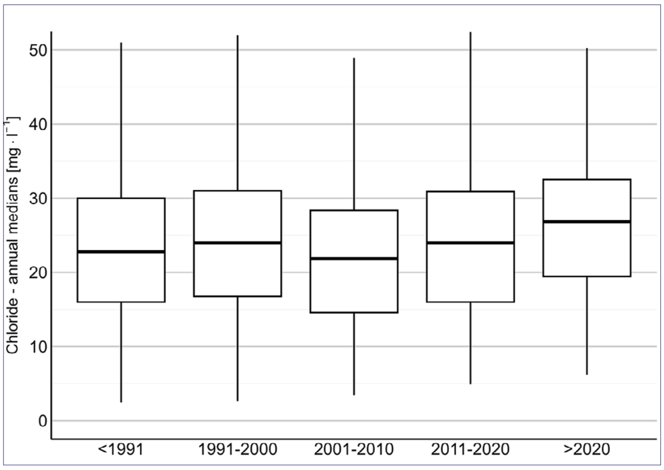


***Fig. 2:** Trends in ammonium nitrogen and chloride concentrations across 54 profiles with complete time series data*

The Spearman correlation coefficient between the measured concentrations and the average daily flow on the sampling day exhibited relatively high negative values for the parameters conductivity (r_{Sp} = -0.75) and chloride (r_{Sp} = -0.6), while higher positive correlations were found for pH (r_{Sp} = 0.31) and nitrate-nitrogen (r_{Sp} = 0.3). Furthermore, a higher negative correlation was identified for total phosphorus (r_{Sp} = -0.33) and water temperature (r_{Sp} = -0.28).

The year 2018, which was characterized by the highest number of dry days (Fig. 1), also exhibited the poorest water quality among the studied profiles. Statistically significant differences in data from representative water body profiles were observed for chloride (Fig. 3) and temperature (increasing trend with dry years), for nitrate nitrogen (Fig. 3) and AOX (decreasing trend).

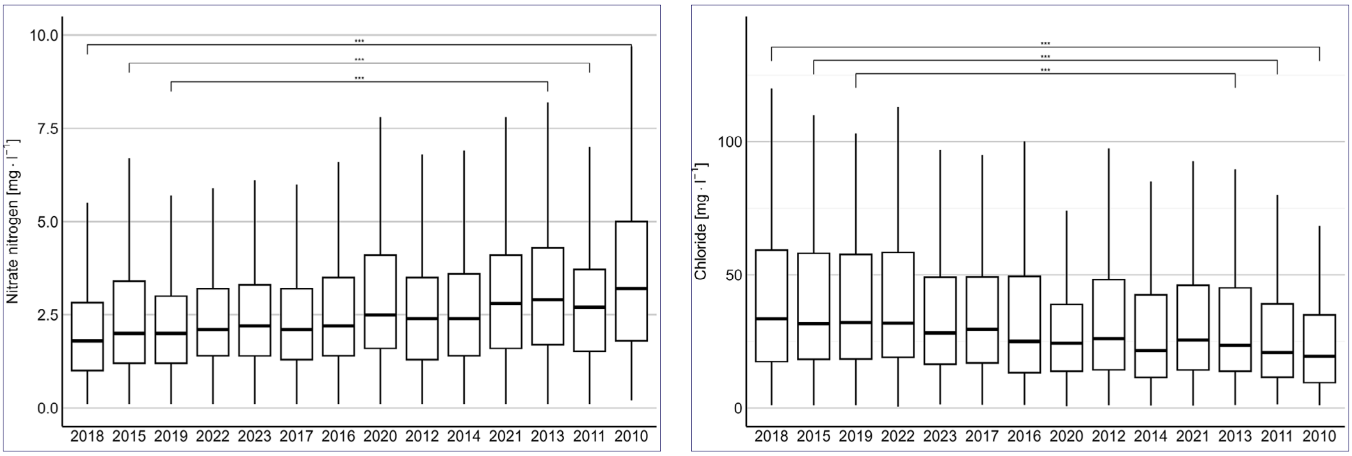


Fig. 3: *Chloride and nitrate-nitrogen concentrations in July-September on 91, resp. 242, selected profiles with complete time series data. The years on the x-axis are arranged in descending order based on the number of days with discharge less than Q_{355} (Fig. 1). *** – statistically significant difference between two boxplots (Wilcoxon test)*

Statistical analyses revealed significant disparities in water quality parameters, including chloride, total phosphorus, phosphate phosphorus, and ammonium nitrogen, among monitoring sites situated upstream and downstream of the WWTP. These disparities were observed in all years examined from 2010 to 2024. For all parameters, there are increases in concentrations downstream of the WWTP, with the exception of AOX, where there is a decrease. This increase is particularly pronounced after the year 2015. Conversely, alterations in the parameters of water temperature, dissolved oxygen, and chemical oxygen demand were predominantly negligible. The situation is of particular interest with regard to ammonium and nitrate nitrogen in terms of individual months of the year (Tab. 1). In the months of August and September, or July, the differences upstream and downstream of the WWTP for ammonium nitrogen are less significant than in the other months, in contrast to nitrate nitrogen. Concurrently, a substantial disparity in water temperature and pH is observed during these months. This finding serves to substantiate the accelerated decomposition of organic matter during this particular part of the year (see also [2]). Ammonium nitrogen is the primary product of organic matter decomposition and is subsequently oxidized to nitrite and nitrate.

Tab. 1: *Statistical significance of differences in concentrations in monitoring profiles upstream and downstream of the WWTP in individual months of the year (n.s. – not significant, * p<0.05, ** p<0.01, *** p<0.001, **** p<0.0001)*

Month	T	pH	O2	BOD5	CHOD	Ptot	P-PO4	N-NO3	N-NH4	Cl	COND	AOX
1	n.s.	*	n.s.	**	n.s.	****	****	n.s.	****	****	***	n.s.
2	n.s.	***	n.s.	****	n.s.	***	****	n.s.	****	****	**	*
3	n.s.	**	n.s.	n.s.	n.s.	***	****	*	****	****	****	***
4	n.s.	n.s.	n.s.	n.s.	n.s.	***	****	n.s.	****	****	*	n.s.
5	n.s.	n.s.	*	*	n.s.	****	****	***	***	****	***	n.s.
6	n.s.	n.s.	***	*	n.s.	****	****	**	***	****	**	n.s.
7	**	***	n.s.	n.s.	n.s.	****	****	****	**	****	*	n.s.
8	****	***	n.s.	n.s.	n.s.	****	****	****	*	****	*	*
9	**	***	n.s.	n.s.	n.s.	****	****	****	*	****	****	n.s.
10	n.s.	**	n.s.	n.s.	n.s.	****	****	****	n.s.	****	**	*
11	n.s.	n.s.	n.s.	n.s.	n.s.	****	****	****	***	****	***	**
12	n.s.	*	n.s.	*	n.s.	****	****	n.s.	**	****	**	**

4. Conclusion

Significant changes in long-term hydrological values have led to an increase in the share of treated wastewater in the flow of watercourses [3]. However, the long-term implications of these changes on water quality remain uncertain due to the numerous technical measures implemented in the past to mitigate pollution discharges.
As the flows decrease, there is a significant increase in total conductivity, chloride, total phosphorus, and water temperature. Consequently, elevated values of these parameters are observed in "dry" years, defined as years with the highest number of days exhibiting flows below Q_{355}.

A comparison of the water quality in the monitoring profiles upstream and downstream of the WWTP discharge reveals the greatest increases in chloride, total and phosphate phosphorus, and ammonium nitrogen concentrations. A notable increase in water temperature and pH downstream of the WWTP is observed during the warmer months, accompanied by a more rapid decomposition of organic matter. This results in smaller differences for ammonium nitrogen, and conversely, larger differences in its concentrations during the colder months. However, phosphorus and chloride concentrations exhibit a marked increase downstream of the WWTP throughout the year.

The issue of nutrient loading of watercourses has been a subject of concern for a considerable period. However, it is imperative to acknowledge that the majority of our streams still fail to attain the benchmarks for good ecological status [4], particularly with regard to the parameter of total phosphorus (salts and total conductivity are not evaluated within the context of ecological status). An elevated phosphorus concentration results in augmented biomass formation in slow-flowing segments of watercourses (weirs) or reservoirs. This phenomenon is accompanied by a subsequent decomposition process that results in anoxic conditions, leading to ecological accidents, such as the death of aquatic organisms, which is becoming increasingly prevalent.

The data being processed originates from standard surface water monitoring and is therefore not expected to capture most sudden rainfall-runoff events where untreated wastewater is discharged [5] [6]. Consequently, the actual situation may be even more problematic. A somewhat neglected aspect is the occurrence of salinity problems in regions experiencing heightened frequency of flows along the hydrological drought boundary. An increase in chloride content can result in a number of consequences, including the proliferation of salt-tolerant species, disruption to the natural composition of aquatic communities and loss of species diversity. A notable example of this phenomenon is the overgrowth of the alga Prymnesium parvum in the Polish section of the Oder River in 2022, which led to a mass fish mortality event.

It is evident that the implemented measures are inadequate, despite the existence of effective measures [6] [7]. Simultaneously, the most significant development is the proposed legislation amendment, which would align the stipulated limits in Government Regulation No. 401/2015 with the objectives of maintaining the good status of water bodies. This amendment would also address the implementation of more stringent limits for best available technologies in wastewater disposal.

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Anthropogenic modification of riverscapes reduces the resilience of floodplain water bodies to drought

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Central Europe has recently experienced a series of droughts between 2018 and 2023, a manifestation of climate change that is likely to become more frequent in the future. In addition, long-term anthropogenic river modifications such as groyne construction, channelization and diking have increased river incision, lowered floodplain water levels and disconnected semi-aquatic ecosystems. Here, we investigated the effects of drought in 36 floodplain water bodies near the Elbe River in Magdeburg, depending on their degree of connectivity to the main river. Water samples were collected during spring mixing and summer drought in March and September 2022 and analyzed for major ions, stable water isotopes, chlorophyll a, oxygen and hydrogen sulfide concentrations. Water quality, fish kill observations, and water levels contributed to a scoring system for assessing impairment and habitat loss. The change in water isotope composition between spring and late summer served as a measure of evaporation and thus the potential significance of climate change. We found critically high chlorophyll a and low surface oxygen concentrations in water bodies connected to the main river less than 50% and 10% of the time, respectively, over the past 100 years. Severe impacts, such as fish kills and desiccation, primarily affected waterbodies with less than 10% connectivity. Larger water bodies with low perimeter-to-area ratios showed fewer signs of degradation than smaller water bodies. We conclude that anthropogenic river modifications leading to increased incision of riverbeds reduce the resilience of floodplain waterbodies to climate change.

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The current state of the landscape at the site of the disappeared pond system in the Doubrava river basin and the possibilities of its change concerning to ongoing climate changes

Pavel Richter

1. Introduction

Today, the Elbe Lowland (a part of the Elbe River basin) in the Czech Republic suffers from a lack of groundwater, and there is a large seasonal desiccation of small watercourses, mostly straightened and deepened ones. This problem will most probably worsen in the future due to the expected continued occurrence of extreme climate events. It is therefore necessary to focus on the restoration of landscape elements that have a positive effect on the water regime, as well as on the actual management of water in the landscape [1].

The main goal of the research, the results of which are presented in this paper, was to map the development of the disappeared ponds landscape in Polabí, based on the interpretation of archival maps. The development of the pond landscape in the Doubrava basin is specifically presented here. This location has already been partially mentioned in a study of the landscape development of the Nové Dvory and Žehušice municipalities [2]. However, in this article, the development of the pond system in the lower Doubrava river is described in more detail and separately, not as part of the assessment of a larger territorial unit.

2. Location of disappeared pond system

The disappeared pond system is located in the Elbe basin (Fig. 1) in the 1-03-05 Doubrava third-order basin in the cadastral areas of Sulovice, Žehušice, Horka u Žehušic, Rohozec u Žehušic, Lišice u Sulovic, Brambory, Bílé Podolí, Zaříčany, Bojmany, and Habrkovice in the Kutná Hora district [3]. The predominant soil types in the Doubrava basin are chernozem arenic and cambisol arenic. In the Doubrava floodplain, it is modal and gley fluvisol [4]. Based on the geomorphological division, the majority of the monitored area is located in the Žehušice basin geomorphological district, which is part of the Central Elbe Table geomorphological unit [5].

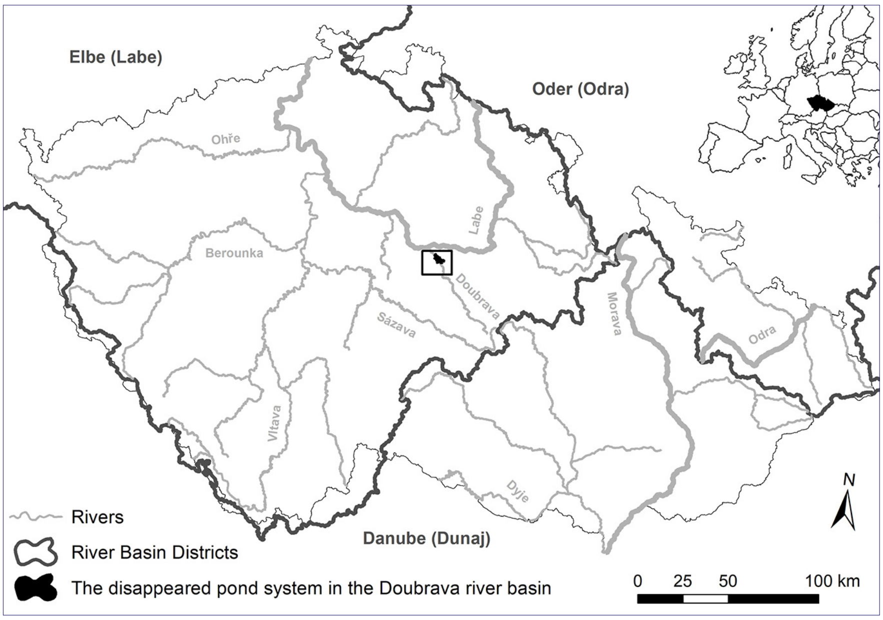

Fig. 1: *The disappeared pond system in the lower part of the Doubrava river basin in a hydrological context*

3. Methodology

The first step was the selection and subsequent comparison of the current and historical state of disappeared pond systems in Polabí, based on map interpretation. The next step was a field survey of these locations to verify their current condition. For the primary detection of pond occurrences, a map from the 1st military mapping was used, which is available as part of the oldmaps application of the Geoinformatics Laboratory at the Faculty of Environment, J. E. Purkyně University in Ústí nad Labem [6].

The current Basic Topographic Map of the Czech Republic 1:10,000 (BTM 10) and the current Orthophoto map of the Czech Republic were used to show the current state. Both maps are provided as a WMS service from the ČÚZK Geoportal [7]. For a more accurate understanding of the landscape development between the state recorded on the 1st military mapping map and the current state, a map from the

2nd military mapping was used. This map is accessible as a WMS service from the INSPIRE National Geoportal [8]. In order to approximate the state of the landscape before the 1st military mapping, especially with regard to the very occurrence of ponds rather than their exact location, the positionally inaccurate map from Müller's mapping was used, which is most easily accessible on the map browser of the archives of the Land Survey Office [9].

4. Results

The pond system on the Doubrava river basin lay largely on the Čertovka watercourse and was fed by a system of canals from the Doubrava river. Müller's map of Bohemia shows a system of five ponds on the Čertovka watercourse. However, the situation on this map is significantly different from that of the 1st military mapping; the shape of the ponds is very different, and the location is not completely accurate.

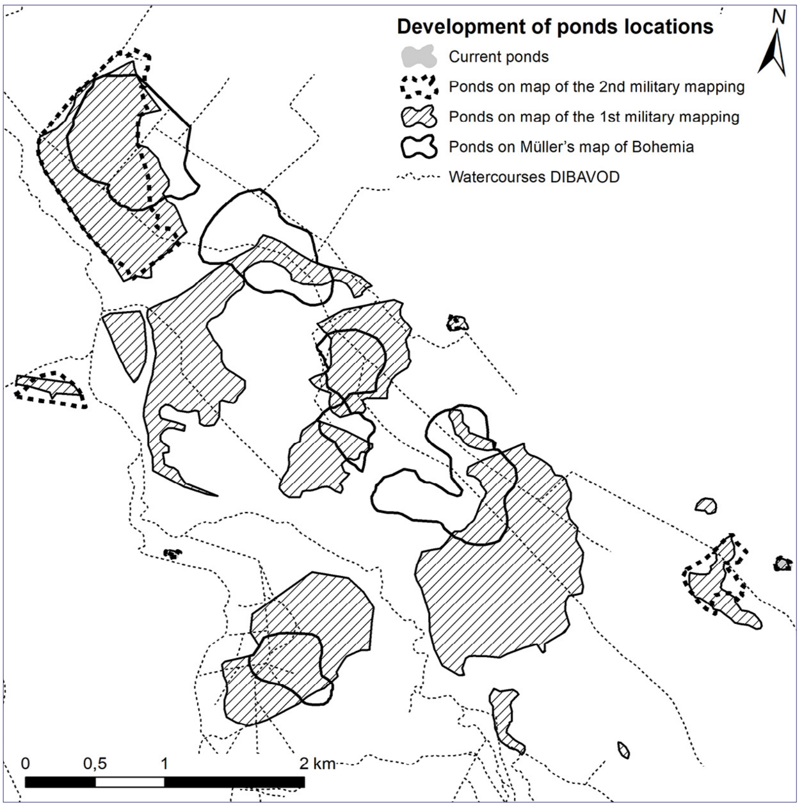

Fig. 2: *Changes in the ponds in the lower part of the Doubrava river basin, from Müller's mapping to the present*

Fig. 3: *Current state of the landscape at the site of the disappeared Podolský pond (May 2025)*

In this site, a total of 16 ponds with a total (approximate) area of 449 ha were recorded on the map of the 1st military mapping. The maximum area of one pond was 116 ha, the minimum 0.25 ha, and the average 28.6 ha. Six ponds with a total area of 107 ha were recorded on the map of the 2nd military mapping. The maximum area of one pond was 87 ha, the minimum 0.15 ha, and the average 17.9 ha. Currently, there are only two water bodies classified as ponds with a total area of 0.91 ha. The area of Koukalecký pond is 0.68 ha, and the pond in Žehušice chateau park is 0.23 ha. The average area of the current pond in this site is therefore 0.46 ha (Fig. 2). Other current water bodies in the studied area are not ponds; they have been created by sand mining or have a concreted bottom.

At the site of this disappeared pond system today, there is mainly arable land, periodically waterlogged in some places, and to a lesser extent, built buildings, permanent grassland, small concreted water reservoirs, straightened and deepened watercourses with surrounding greenery (including reeds) Around the dam of the disappeared Podolský pond, a wetland-type water area is currently being restored, but a lot of smaller area than the area of the disappeared pond (Fig. 3). This area was restored without human intervention, only by natural processes, and is not officially declared a pond [1].

5. Conclusion

Archival maps and documents may inspire landscape planning. These apply to waterlogged sites as the basis for restoring ponds, wetlands, and springs or for determining (verifying) suitable places to allow succession [10]. However, the restoration of the ponds to their original size is not possible because part of their area is already built-up, or deve-

lopment has spread to the immediate vicinity of the historical location of the ponds. However, according to extant reports, these vast disappeared ponds were mostly shallow and very muddy, and formed predominantly swamps [11]. If we only take into account the current state of the landscape, the site of the disappeared pond system in the lower part of the Doubrava river basin would be suitable for building small wetlands (ponds, pools, wet meadows), in particular on small, waterlogged sites in the place of today's arable land, whether they are only waterlogged, or with reeds. On the site of the former ponds are fertile soil types; however, if the crop sown on a waterlogged site does not grow and is eventually replaced by reeds, it would be appropriate to use this fact for the restoration of wetland habitats as stable water-retaining elements in the landscape. Establishing some territorial protection would be useful in areas with already restored wetland vegetation.
The results presented here could be a practical guide for building small water reservoirs (ponds) and other wetland habitats (wet meadows) in place of the disappeared ones, as the historical location of such elements is a very strong argument for their restoration. These landscape elements are also part of the solution for adaptation to the issues caused by climate change. In the case of landscape restoration in places of disappeared ponds and other wetland sites, both water retention and landscape biodiversity increase [1]. This fact is in line with the EU Biodiversity Strategy 2030 [12], which is a valid long-term plan to protect wildlife, stop ecosystem degradation, and restore biodiversity in Europe.

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Reviewing the security of surface water supplies from water reservoirs under the climate change conditions

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1. Abstract

The ongoing climate change is already evident in data monitored by the state enterprise Povodí Vltavy, the administrator of water management structures, as well as in data provided by the Czech Hydrometeorological Institute. Among the managed water structures are reservoirs designed for the accumulation of surface water intended for treatment into drinking water. On its own initiative, and subsequently under the methodological guidance of the Ministry of Agriculture, the state enterprise Povodí Vltavy commissioned the development of new water management solutions for all water supply reservoirs, considering the anticipated future climate developments This paper aims to present the input data and methods employed and to discuss the results for the most significant water supply reservoir in the Czech Republic, the Švihov Reservoir on the Želivka River.

2. Water supply reservoirs

Water reservoirs intended exclusively for drinking water supply and reservoirs the main purpose of which is to store surface water for drinking water treatment (although these reservoirs also serve other purposes subordinate to the main purpose) are referred to as water reservoirs under the law of the Czech Republic. According to the Water Act (No. 254/2001), Sec.30 (13), the Ministry of the Environment set out a list of water reservoirs by means of a decree. The relevant document is Decree No. 137/1999, and the state enterprise Povodí Vltava has the right to manage the following 11 water reservoirs listed in tis Decree: Římov on the Malše, Karhov on the Studenský stream, Husinec on the Blanice, Staviště on the Staviště stream, Švihov on the Želivka, Lučina on the Mže, Nýrsko on the Úhlava, Žlutice on the Střela, Klíčava on the Klíčava stream, Láz on the Litavka, Pilská on the Pilský stream and Obecnice on the Obecnický stream.

3. Water management design of a reservoir

The stages of designing and engineering of a reservoir already consider the water management solution of the reservoir. This concerns the statistical analysis of the flow rate conditions of the water stream on which the reservoir is to be constructed while taking into account its relevant intended purpose. If its storage function is reviewed, this analysis is intended to answer the question of whether the allocated storage volume will be able to secure the required surface water abstraction with a reasonable degree of security along with minimal outflows from the reservoir. In simple terms, whether enough water can be impounded during periods of high water yield to be used during dry spells. In order to do so, use is made of historic data from the period before the water reservoir construction, i.e. once the water reservoir is put into operation, it meets its purposes to an extent corresponding to the hydrological conditions applicable in the previous period.

The constructed water reservoirs used to be operated, mostly for decades, without these water management solutions being reviewed. There was no need to do so as the hydrological regime did not change too much and water deficits were considered as isolated extremes that would fade away and return only after some extensive periods of time. However, this approach was changed by the societal discussion about climate change – and then by reality: the dry periods in 2015–2019.

In response to this development, the state-owned enterprise began to gradually review the water management solutions of the reservoirs, primarily water reservoirs, but also some multi-purpose reservoirs (those not used for water supply purposes). The historic period that was used dated from 1980 to the year preceding the statistical analysis. Most of the reservoirs successfully passed this review but some did not. However, water abstraction for treatment into drinking water was not endangered as the review concerned both the permitted abstraction rate and abstracted water volumes corresponding to the reality. It should be added that water consumption in the Czech Republic has decreased significantly (often by half) compared to the time when most of the water reservoirs were constructed and put into operation and, as a result, all reservoirs have sufficient reserve capacity for the current (and long-term) water abstraction rates. As regards those reservoirs that did not achieve the required level of security of permitted water abstraction rates, at least the required level of security of abstracted volumes was met.

Since the available historic data is usually not available for a sufficiently long time interval (several decades are not sufficient), the analysis is performed using synthetic time series. This is based on the fact that the rainfall-runoff process is influenced by a number of factors which are also so difficult to measure that this can be considered as a random process, considering a slight simplification. If the water management solutions to the water storage function are considered in monthly steps (average monthly flow rates), we can generate randomly long time series using a random number generator. We usually choose 1000 years, thus generating 12,000 random numbers. A statistical analysis (mean, median, quantiles, etc.) is conducted for such generated synthetic series (100 of them will be generated for verification purposes) and the results will be compared with a similar analysis of the actually measured historic series. The series whose statistical analysis results are most similar to the results of the historic series analysis is then used to review the water management solution. By applying this procedure, we can model the reservoir using more periods of water deficit than what could have been measured during the historic series collection. The period when the data was collected (either before the construction of the reservoir or during its operation) could have shown higher water yields for random reasons than it may turn out to be in the future. All these considerations stem from the assumption that the hydrological conditions do not change.
Special attention must be drawn to the fact that such derived long modelled series do not represent a forecast of the hydrological regime in the distant future but they make it possible to calculate the current variability of the run-off process more reliably than the input real series. These series can often contain only one or two design low-water-yield periods which is very insufficient for making a reliable assessment of the storage function of multi-year reservoirs.

4. Climate change

The basic input data for developing the average monthly flow rate series affected by climate change is the study entitled "Medium scenario of climate change for water management in the Czech Republic – Povodí Vltavy, state enterprise" drawn up by the TGM Water Management Research Institute, v.v.i. (2019). As part of this study, a medium climate change scenario was developed for multiple time horizons in the 21st century.
The results of model simulations according to this study resulted in the quantification of relative changes in the basic meteorological and hydrological parameters crucial for developing the reservoir water management solution and assessment of the security of its purposes. These relative changes are available in the form of change coefficients for individual calendar months for the relevant time horizons. Sets of change coefficients were prepared individually for all 3rd order hydrological basins in the Vltava River basin.
The change coefficients were quantified relative to the reference period of 1981–2010 and are set for all time horizons identified in the study. For the needs of the water management solution, the time horizons of 2041 to 2060 and 2061 to 2080 were selected with regard to further use. The baseline real time series for the period from 1980 to 2019 represents the current hydrological conditions and the conditions in the nearest future with sufficient reliability.
The change coefficients for air temperature are designed as additive, which means that air temperatures are modified by adding the given coefficient for the relevant calendar month. On the contrary, as regards the rainfall-runoff to/from the basin, these are multiplicative coefficients, and the modification of these parameters is made by multiplication.

5. The Švihov reservoir

The Švihov reservoir dam is located on the Želivka River, 4 km from the confluence with the Sázava River. Its catchment area covers 1,178.3 km^2, the average long-term annual flow rate in the dam profile is 6.93 m^3.s^{-1}, the maximum permitted water abstraction is 7.7 m^3.s^{-1} with the average totalling 5.25 m^3.s^{-1}. The purpose of this water reservoir is to supply drinking water to the capital of Prague, the Central Bohemian region and to parts of the South Bohemian and East Bohemian regions.
The dam body is straight, it is an earthfill dam with an upstream earth sealing. The dam height above the valley bed reaches 58.3 m, the crest length is 860 m. The functional structures of the dam consist of a combined facility and access bridge, waste tunnel, stilling basin and waste channel. The combined facility consists of two water intake towers, a communication tower and an emergency shaft spillway. In the intake towers there are two separate branches of water intakes abstracting water from the reservoir at five levels. Two separate bottom outlets are used to transfer water. To transfer flood level flows, an emergency shaft spillway is inserted between the intake towers and

the communication pillar, and the waste tunnel is connected to its elbow. There is also a small hydroelectric power plant in the machine room of the water reservoir; the flow through which is only possible at higher inflows; the water supply function of the reservoir is prioritized.
The impoundment of the Švihov water reservoir reaches 39.1 km. The total volume of the reservoir is 309 million m^3 and the flooded area is 1602.64 ha. The circumference of the reservoir reaches more than 150 km. Sanitary protection zones have been declared to protect the water quality.
An integral part of the Želivka water reservoir includes the Trnávka, Sedlice and Němčice reservoirs, whose purpose is to capture fluvial deposits and sediments carried by the water stream of the upper stretches of the Želivka River and its tributaries Trnávka and Sedlický streams.

6. Water management solutions taking into account the climate change

Following the dry spells of 2014–2019, the state enterprise Povodí Vltavy commissioned the Faculty of Civil Engineering of the Czech Technical University to develop a water management solution for the Švihov water reservoir storage function. The study was prepared in 2020 and updates the previous water management solution from 2015. The study input data was expanded to include a significant dry period from 2014 to 2019. The result resulted in validating the security of the reservoir storage function, i.e. ensuring surface water abstraction from the reservoir for the Želivka water treatment plant using several scenarios of climate change development.
The assignment of the study is in accordance with the resolution of the Government of the Czech Republic of 29th July 2015, to prepare for the implementation of measures aimed to mitigate adverse impacts of drought and water scarcity and to task the Ministry of Agriculture with developing a Master Plan of possible adaptation measures for an average climate change scenario in river basins where there is a risk of significant water shortage with regard to the currently issued water management plans.
The results of the analyses show that in the time horizon of 2041–2060, the long-term average inflow to the Švihov reservoir will be at the level of 89% of today's value and in the time horizon of 2061–2080 even at the level of only 57% of today's value. The change in water yield distribution during a year is also important. The model predicts a relatively significant reduction in the water yield in the summer and a partial increase in outflow in the winter. According to the model, changes in air temperatures are relatively very significant with corresponding impacts on water surface evaporation losses.
The identified impact of climate change in these scenarios indicates a significantly adverse long-term trend of decreasing average monthly flow rates compared to the reference period of 1981–2010 (in the case of the time horizon of 2061–2080 with a decrease in the flow rate to the outflow limnigraph profile of up to approximately 43%).
The water management solution indicates that the permitted average water abstraction value of Op = 5.25 $m^3.s^{-1}$ is not ensured with the recommended security (Pt ≥ 99.50%) even given the current climate conditions (Pt = 99.29%). For the time horizon of 2041–2060, Pt = 97.09%. As regards the time horizon of 2061–2080, Pt = 53.38% and water abstraction of 5.25 $m^3.s^{-1}$ cannot be ensured.

7. Conclusion

Based on the analysis of the reservoir regime function and given the security of Pt ≥ 99.50%, water abstraction can be ensured in an average volume of Op = 5.20 m^3 s^{-1} for the current climate conditions considering the applicable storage volume. For the climate change time horizon of 2041–2060, water abstraction of approximately 4.75 $m^3.s^{-1}$ can be ensured with the required security. For the climate change time horizon of 2061–2080, water abstraction of approximately 3.00 $m^3.s^{-1}$ can be ensured with the required security. This value practically corresponds to the current actual water abstraction.
Considering the fact that neither the current conditions nor the conditions of expected climate change ensure the required security recommended by the standard (Pt ≥ 99.50%) for the permitted water abstraction value of Op = 5.25 $m^3.s^{-1}$, the following reservoir storage function level control stages have been introduced. The reservoir control levels have been gradually optimized, limiting the water abstraction to a level of 4.00 $m^3.s^{-1}$ (ensuring the current actual water abstraction values with a margin) and to a level of 2.00 $m^3.s^{-1}$ (as the operating minimum needed to keep the water treatment plant in operation).
Based on the developed water management solution while taking into account climate change, the control levels for limiting surface water abstraction for the Želivka water treatment plant have been included in the Švihov water treatment plant on the Želivka operating regulations:

Level control stage no. 1 – levels ranging from 377.00 m a.s.l to 357.27 m a.s.l. – water can be abstracted up to the average permitted level of **5.25 $m^3.s^{-1}$ without restrictions**.
Level control stage no. 2 – level ranging from 357.27 m a.s.l. to 343.10 m a.s.l. – water abstraction must be limited to **a maximum value of 4.00 m $.s^{-1}$**.
The analysis of the water resource security from the perspective of ensuring water supplies is currently given great attention in the Czech Republic. Experience from the dry seasons of 2015-2019 shows that sufficiently robust (large) water resources are necessary to bridge such a long period. The only water resource is the water reservoir that can manage water in an intended manner according to human needs.
Considering the fact that the preparation and construction of water reservoirs takes a very long time under current conditions it is necessary to pay attention to assessing the existing water resources well in advance in order to have sufficient time to prepare new resources.

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The model system of the largest Central European drinking water reservoir Švihov and its river basin

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1. Introduction

The Švihov water reservoir is the largest drinking water reservoir in the Czech Republic. Effective protection of the reservoir requires monitoring the amount of pollutants and their concentrations in water catchments and their transport to the reservoir. To get an idea of the overall pollutants flow a simple, water balance and nutrient balance model (MIKE BASIN) was created for whole Želivka river basin. More detailed, spatially distributed modelling system (MIKE SHE) was used for simulations of hydrological regime, runoff formation and pollution concentration changes in surface and subsurface domains of selected pilot catchment of the whole reservoir catchment.

The 3D numerical model (MIKE 3 FM) schematizes the entire 39 km long reservoir. The model was calibrated using data obtained from multiple field measurements conducted by the research common team, combined with observed long-term data series. The calibrated model is ready to be used for simulations of flow characteristics and pollutant propagation in the reservoir under different hydrological, temperature and meteorological conditions and different pollutant concentrations and scenarios.

The simplified version of the 3D model is used for short-term prediction of pollution spreading within the reservoir itself. The forecast model system is fully automated and results are automatically generated in pre-defined areas and formats.

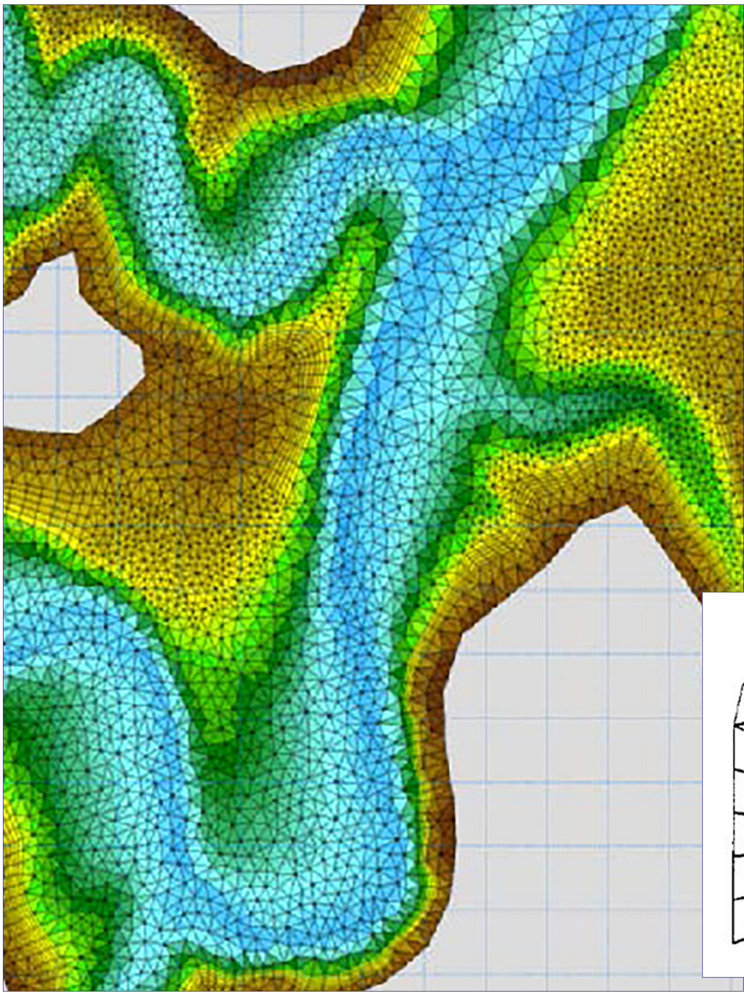
2. Spatially distributed modelling in Želivka river basin

Želivka river basin (1190 km^2) is the drainage area of the Švihov water reservoir. River basin area is formed by crystalline bedrock with only minor local groundwater bodies, covered mostly by cambisols. At present, 54 % of the catchment area is used for agriculture, out of which 77 % is made up by arable land. Intensive agriculture, together with the high proportion of artificially drained land, puts this source of drinking water at risk from accelerated surface and subsurface runoff and associated pollution. The complex approach to water balance and pollution concentrations modelling was adopted in several levels of temporal and spatial resolution.

Main nutrients (nitrogen and phosphorus) flux variability along river branches and main tributaries were calculated for period 2015–2021, covering whole river basin area. MIKE BASIN model, consisting of 476 km of river reaches, 159 subcatchments and utilizing data from 21 flow gauging station and 27 points of concentration sampling, was used. A monthly-based maps of nutrients concentration along river network were established, identifying main pollution sources in whole river basin area.

Complex hydrological modelling system MIKE SHE was used for more detailed simulations. Model of Martinický potok (113 km^2) was established for dynamic simulations of discharge and concentrations input into Švihov water reservoir by this tributary. Fully distributed modelling approach allows to simulate impact of various complex scenarios of future changes in this catchment area at appropriate spatial resolution. Further on, detailed simulations of pesticide concentrations dynamics in surface water, drainage water and shallow groundwater at the selected microcatchment (1.4 km^2) in fine resolution (computational grid cells 16x16m, time step 1 hour) were conducted. A complex MIKE SHE WM + AD model was used focusing mainly on short -time episodes of pollutant infiltration through soil profile, leaking into small water streams. River basin modelling work aims primarily to simulations of different measures impact to short-term as well as to long-term pollutants concentration dynamics in surface water. Model results may serve as boundary conditions (simulated dynamic changes of flow and concentrations) for 3D model of the water reservoir.

3. 3D numerical model of flow and pollution transport in the Švihov reservoir



The 3D numerical model (MIKE 3 FM, ca. 1.3 million unstructured space elements – Fig. 1) has been created based on detailed DEM of the reservoir and schematizes the flow and transport of pollutants throughout the reservoir area, including tributaries affected by the backwater effect.

The numerical model was successfully calibrated and validated using data obtained from multiple field measurements (velocity profiles, discharges, wind directions and velocities) conducted by common team of DHI and CzechGlobe, combined with selected periods of observed long-term series provided by the Vltava River Basin Authority and Czech Hydrometeorological Institute – example of calculated and measured velocity fields are described in Fig. 2.

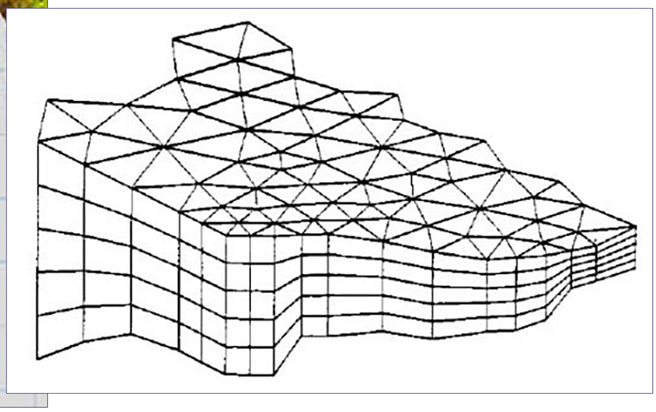


Fig. 1: *Computational mesh used for modelling (MIKE 3 FM)*

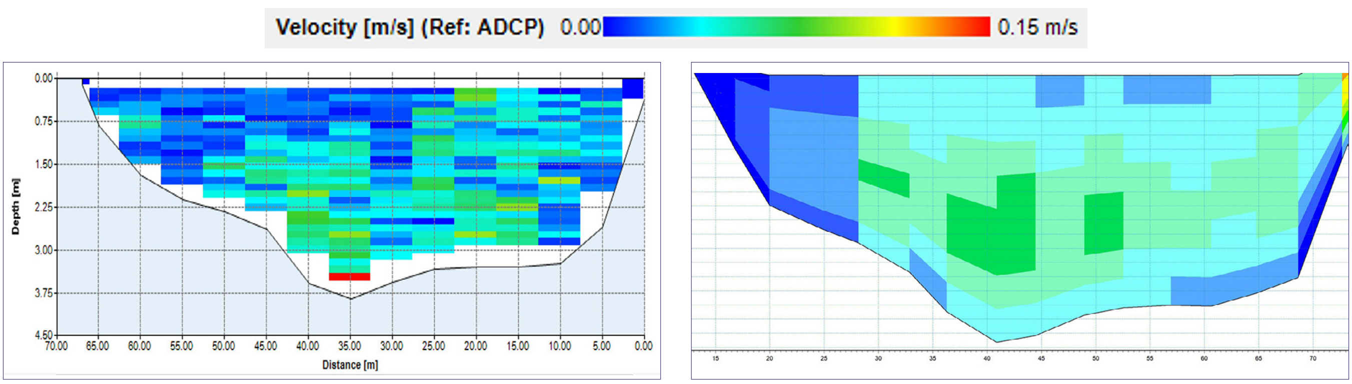


Fig. 2: *Observed (left) and calculated (right) cross section velocity distribution at Q = 5.6 m³ s⁻¹*

The aim of the model was to describe flow characteristics and potential pollutants spreading in the reservoir under various hydrological and meteorological conditions, various pollutant sources (placement) and different pollutant concentrations and scenarios.

An example describes a scenario of a traffic accident on the bridge crossing the reservoir when the tanker truck with pollutant falls on the reservoir bed; subsequently, the pollutant outflows from the tanker. Pre-defined conditions of the scenario are: summer period, low inflow into the full reservoir, mainly western wind. A sample picture, showing spreading of the pollution in certain depth is on Fig. 3.

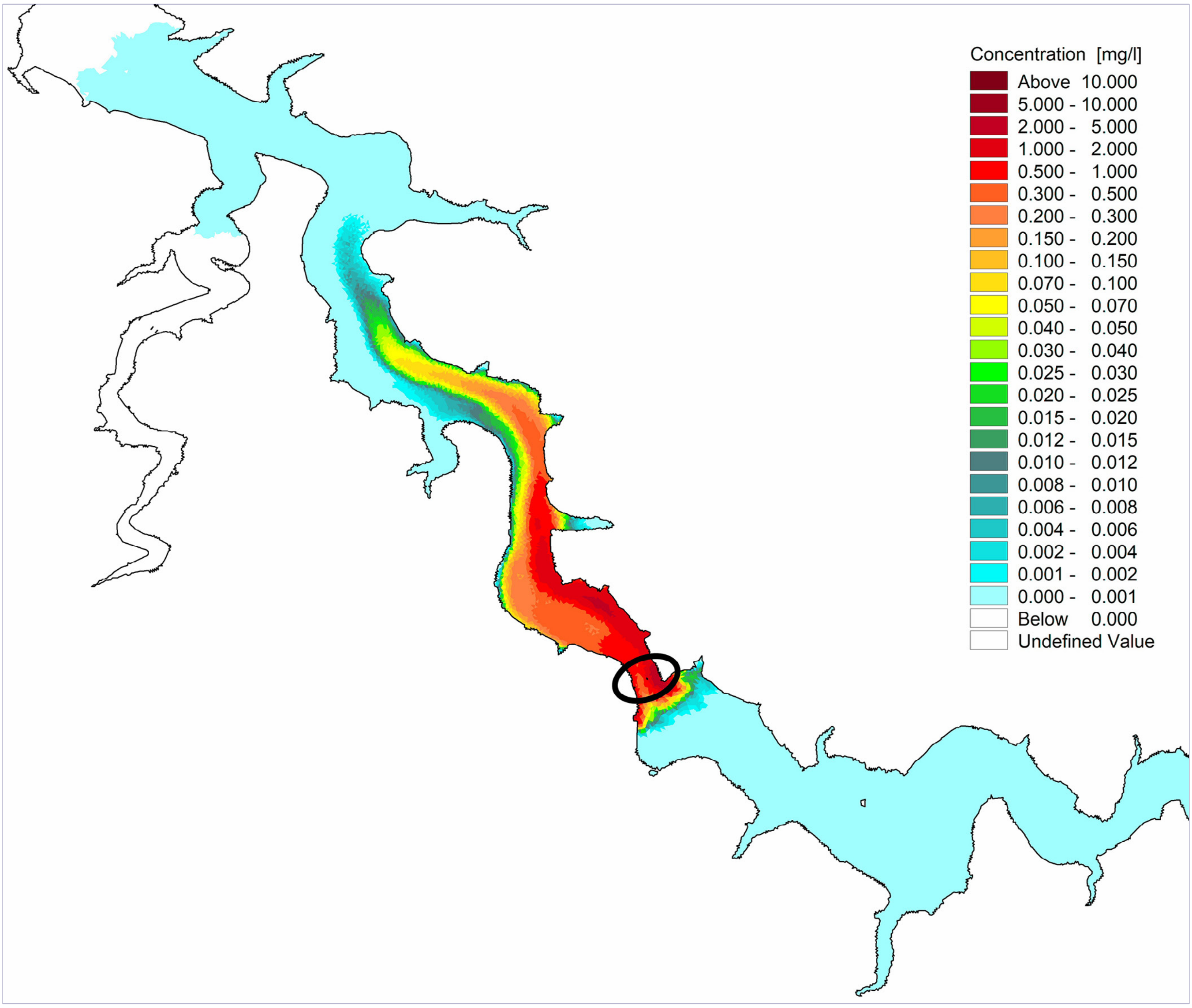
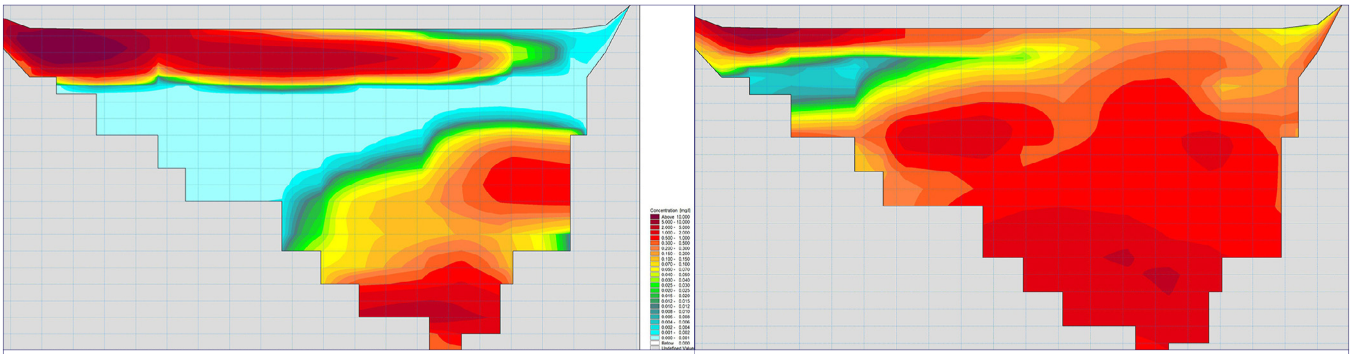


Fig. 3: *Pollutant spreading after 120 hours from the accident in the depth of 11 m; point of accident signed by black ellipse*

In order to obtain model results from many scenarios in acceptable time and to use it also for short-term forecasting, the model horizontal computational mesh has been significantly simplified. The important step after such procedure was to verify that results from simplified model shows good agreement with results from original model. Many test scenarios were carried out and the analysis of the results showed good agreement between the two versions of the models and therefore the simplified model can be used for detailed simulations and short-term prediction.

4. 3D model for short-term prediction of pollution transport within the reservoir

The simplified version of 3D numerical model is used to model short-term prediction of concentration and pollution propagation in time from any point in the reservoir area (e.g., in case of unexpected ecological disaster) to inlet structure for drinking water treatment plant. The forecast model system is fully automated, and forecasted input data is prepared automatically in a daily cycle. The system is activated by specifying the source and inflow of the pollutant and automatically starts a multi-day simulation of pollutant transport in the reservoir. The process is repeated as necessary with updated input data. Pre-defined formats of results can be easily obtained from the model for management purposes of Vltava River Basin Authority and hence optimal operation can be done according to forecast simulation results.
The example figure below shows a predefined/fully automated output from a forecast model system that has been loaded with a theoretical accident impacting a reservoir.



30 hours after the accident | 42 hours after the accident

Fig. 4: *Theoretical accident on a road bridge over a reservoir, profile 430 m downstream of the bridge*

5. Conclusion

With the help of developed and thoroughly tested numerical models, the Vltava River Basin now has a robust and comprehensive set of tools to support both long-term and short-term decision-making processes. These tools enable accurate predictions of future scenarios and provide essential support for strategic planning in the field of water resources management. In addition, the short-term forecast model serves as an important operational tool to facilitate timely decisions related to water intake regulation and provides essential support for early warning systems and response measures in the event of environmental events or emergencies. Overall, these models significantly enhance the preparedness, resilience and capacity of Vltava River Basin to sustainably manage water resources under different conditions.

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Development of a Drought Alert and Prediction System in the Czech Republic

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1. Introduction

In recent years, the frequency and severity of droughts in the Czech Republic have significantly increased, driven by rising temperatures and cumulative precipitation deficits [1, 2]. This situation has led to growing demand for timely assessment and early warning of drought onset and development. The amendment to the Water Act (Act No. 544/2020 Coll.) introduced mandatory drought management and forecast services, requiring the Czech Hydrometeorological Institute (CHMI) to regularly provide clear and easily accessible information about drought risks to regional authorities and municipalities with extended powers (ORPs) [3, 4]. In response, CHMI developed an official drought information (alert) system aimed at supporting early warning, minimizing drought impacts, and facilitating decision-making.

2. System Description

The drought alert and prediction system builds on the existing Integrated Warning Service System (SIVS) operated by CHMI and is fully integrated into the HAMR platform (Hydrology × Agronomy × Meteorology × Retention). The system combines real-time monitoring and predictive capabilities for surface water and groundwater [3]. It provides weekly updates, including alert maps and video summaries that highlight key developments and forecasts for the upcoming period. Data are processed centrally at forecasting center of CHMI and disseminated through the HAMR web portal and the Common Alert Protocol (CAP). The system ensures that information is accessible to all relevant authorities for effective drought management.

3. Methodology

Surface water drought assessment is based on a set of 135 reference water-gauging profiles selected for their representativeness, data quality, and minimal anthropogenic influence. The primary indicator is the 7-day average discharge in relation to Q_{355d} (the 355-day low flow), derived from the 1991–2020 reference period. Weekly warnings are issued if discharges are expected to reach or fall below this threshold.

Groundwater drought assessment uses 332 reference objects, including wells and springs that represent important hydrogeological structures across the country. Drought thresholds are defined by the 95% quantile of long-term monitoring data from the 1991–2020 period. If groundwater levels or spring discharges drop below this limit, a drought alert for the corresponding ORP is triggered.

A combined drought alert is issued at ORP level by synthesizing the surface water and groundwater assessments. The alert map visualizes drought conditions as follows: Yellow: drought identified in either surface or groundwater. Orange: drought identified in both components simultaneously.

4. Implementation and Results

Following a test phase starting in autumn 2022, the system has been fully operational since the 2023 vegetation season. Weekly drought alerts are typically issued on Tuesday afternoon, valid through the end of the week, and are published on the HAMR portal. The figures demonstrate the relationship between the number of ORPs where drought alerts were issued and those where drought conditions were subsequently confirmed by measured data in 2023 and 2024 (Fig. 1). In most cases, the spatial extent of alerts slightly exceeded the area where drought conditions were recorded, reflecting a precautionary approach to ensure timely warnings ahead of potential drought intensification. The system has successfully provided early warnings even under challenging conditions, such as periods of alternating dry spells and intense local rainfall or during the snowmelt season.

In 2024, additional variants for evaluating drought alert information within the Drought Information System were tested. It was found that drought alerts for groundwater were issued relatively frequently. Therefore, the occurrence of alerts was also assessed using a stricter threshold corresponding to Q_{355d}. Applying the Q_{355d} limit resulted in a reduction in the frequency of drought alerts (Fig. 2).

When assessing the entire period of issued drought alerts so far, i.e. 2023–2024, it is evident that the difference between the number of drought alerts for surface water and groundwater is not as large as initially expected (Fig. 2). Moreover, in operational practice, alerts evaluated during the autumn-spring season are annulled, similarly to the approach applied for surface waters. Groundwater monitoring objects with long-term exceedance of threshold limits were also identified and will be replaced by more suitable objects where possible.

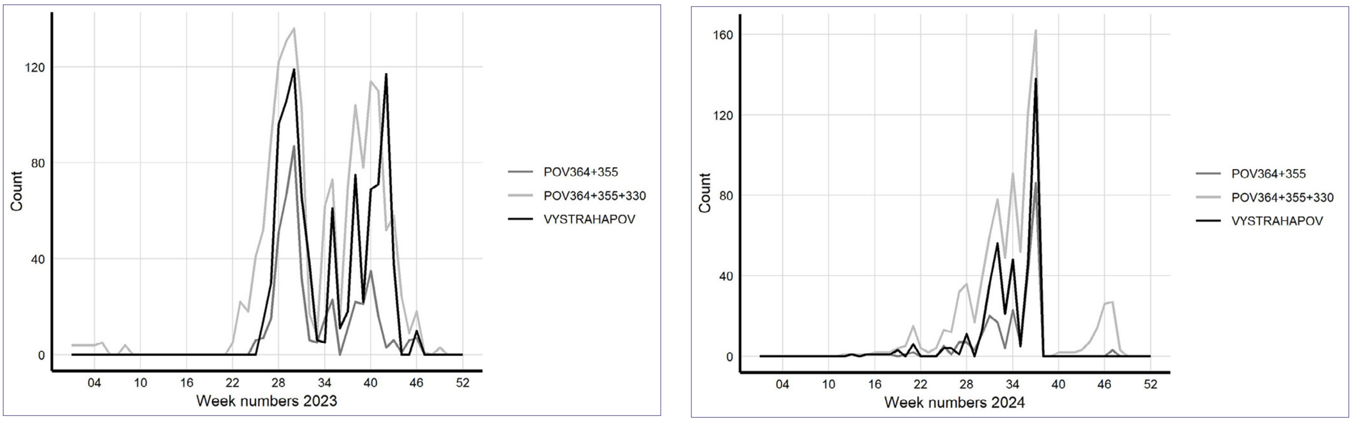

Fig. 1: *Count of ORPs under drought alert for surface waters (VYSTRAHAPOV) compared to ORPs where drought conditions were confirmed by measurements. POV364, POV355, and POV330 represent the number of ORPs where the 7-day average discharge fell below the Q_{364d}, Q_{355d}, and Q_{330d} thresholds, respectively. POV364+355 and POV364+355+330 show the total number of ORPs where these thresholds were exceeded in 2023 (left) and 2024 (right).*

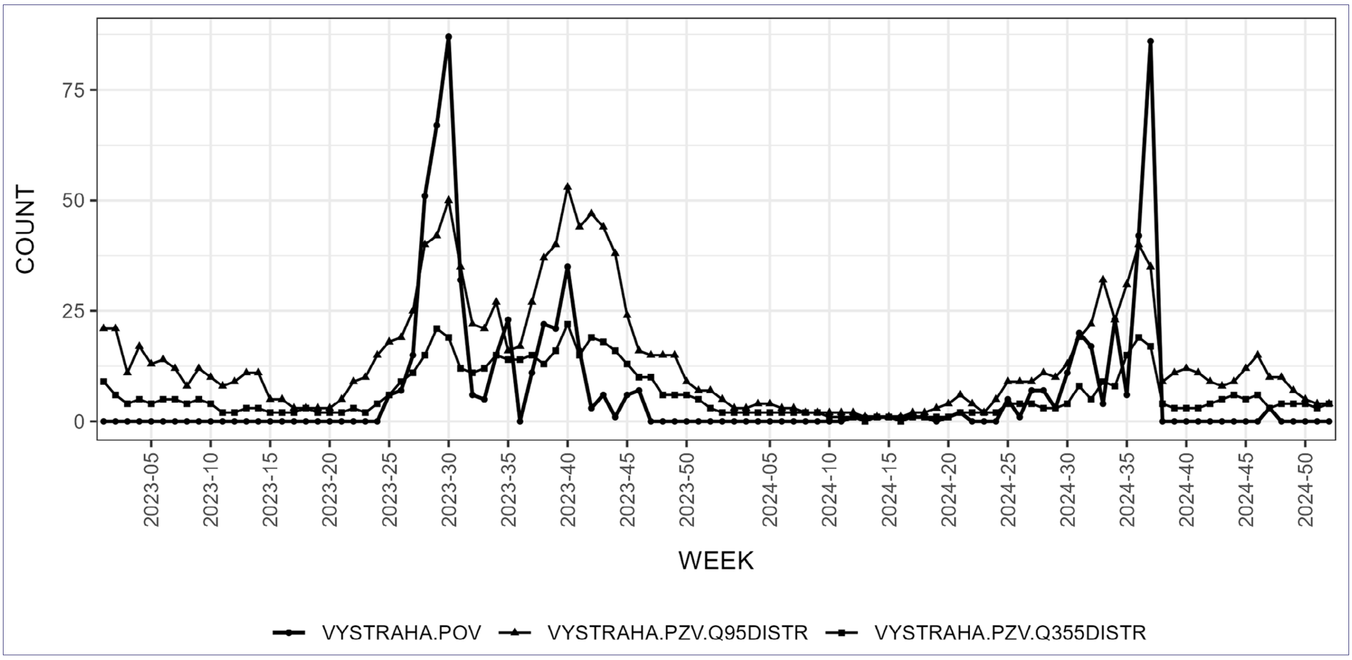

Fig. 2: *Count of ORPs under drought alert in the period 2023–2024. Surface waters: VYSTRAHA.POV; groundwater: VYSTRAHA.PZV.Q95DISTR (95% quantile threshold), VYSTRAHA.PZV.Q355DISTR (Q_{355d} threshold based on theoretical distribution function).*

5. Conclusion

The drought alert and prediction system operated by CHMI has strengthened drought risk management and early warning capabilities in the Czech Republic. Regular weekly updates, validated through automatic evaluation processes, provide essential support for decision-making by regional authorities. The system contributes to minimizing drought impacts and enhancing resilience to changing climatic conditions. Further development will focus on improved automation, refinement of drought thresholds, and enhanced communication tools for users.

Acknowledgement

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Fachbeiträge

Odborné příspěvky

Magdeburger Gewässerschutzseminar 2025
Magdeburský seminář o ochraně vod 2025

Die Elbe als Wasserstraße

Labe jako vodní cesta

MGS
Magdeburger Gewässerschutzseminar
2025
Magdeburský seminář o ochraně vod

River Elbe/Labe – current hydrological status and future projections

Jörg Uwe Belz, Enno Nilson

1. Basic characteristics of the flow regime of River Elbe

The long-term average annual runoff-depth (period 1961–90) for the entire basin of River Elbe is around 189 mm/a, which is about 1/3 of the annual precipitation sum. Compared with the corresponding value for the entire territory of the Federal Republic of Germany, which is given as 327 mm/a [1], the Elbe basin can thus be characterised as a catchment with relatively low outflow and limited water resources.

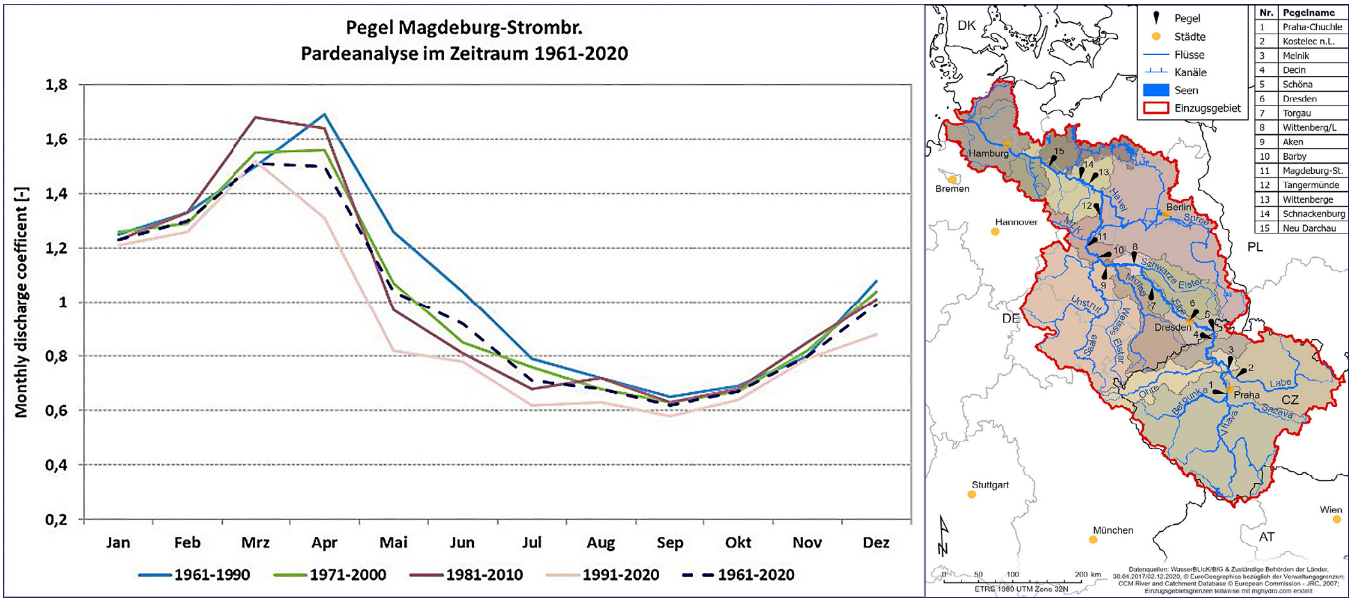

Fig. 1: *Gauge Magdeburg Strombruecke (Elbe): Intra-annual discharge curve based on monthly discharge coefficients according to Pardé for the entire period from 1961 to 2020 and in differentiation for 30-year-sequences, moving with a time shift of 10 years*

The nivo-pluvial flow regime of the Elbe River varies only little along its length. It is characterized by regularly high discharge conditions in late winter and early spring and low water availability in late summer and fall. Less consistent than the spatial behavior is the temporal behavior of the Elbe's flow regime since the beginning of the 20th century: In earlier times, changes in the Elbe's discharge pattern took the form of seasonal redistributions. Water availability, determined overall using the respective MQ(a) (=annual mean discharge), remained largely stable [2], [3]. But this changed in the more recent years. Using the Magdeburg gauge as an example, it can be shown, that since 1961 declines in discharge occurred, particularly since 1991 and affecting the spring and summer months (Figure 1).

2. Discharge-determining processes

The decisive factors in runoff generation (not only in the Elbe region) are naturally precipitation and evaporation. Using the example of gauge Neu Darchau (Elbe), trend analyses of the discharge values MQ(a) and the time series of the respective regional averages of the hydrometeorological variables precipitation, temperature and evaporation show the above-mentioned downward tendency in discharge since 1961, although these cannot be confirmed statistically as a significant trend. This decreasing tendency in MQ(a) is offset by a significant increase in regional precipitation totals, which alone should actually lead to an increase in water availability. This imbalance can basically be explained by losses in the water cycle as a result of rising temperatures, which induce higher evapotranspiration. (cf. Table 1).

Belz et al. [4] also describe further significant runoff-modifications through intermediate storage and temporal-spatial redistribution in the form of snow, soil and groundwater, as well as anthropogenic water uses (drinking and industrial water, including transfers, groundwater use, sewage treatment plant operation, pumping stations, etc.). Another important process variable with supraregional effects here is the change in surface water availability due to drainage water from three large lignite mining regions.

Tab. 1: *Trend analysis on annual series of MQ(a)- and important hydrometeorological process variables*

Neu Darchau/Elbe	period	Trend FQS/M-K	alpha
Temperatur (a)	1961–2020	1/+	0.05
Evapotranspiration (a)	1961–2020	1/+	0.05
Precipitation (a)	1961–2020	1/+	0.05
Discharge MQ (a)	1961–2020	0/-	0.05

Explanatory note:
0/+ Mann-Kendal not significant, increasing
0/- Mann-Kendal not significant, decreasing
1/+ Mann-Kendal significant, increasing
1/- Mann-Kendal significant, decreasing

Reservoir construction and its management are of particular importance for the Elbe's discharge patterns. Most dams are located in the Elbe's tributary areas and are so small that, as individual reservoirs, they have no detectable influence on the river's water flow. But the effect of large dams, especially the Vltava cascade, is to be assessed differently. These serve as multi-purpose reservoirs and, among other things, also raise low water levels. Figure 2 shows, inter alia, the result of a non-parametric jump analysis on the NM7Q(a) series (NM7Q(a)= lowest average discharge over seven consecutive days in a year) of gauge Barby (Elbe), using methods according to [5] and [6]. A significant breakpoint can be identified at the time of 1964/65, corresponding exactly with the completion of the Vltava cascade (Orlik dam). Since then, systematic low water enrichment of the Vltava has been practised with the aim of achieving a minimum water flow of 40 m³/s in Prague. These additional water volumes, which can amount to approximately 30 to 35 m³/s during extreme low water phases at the Czech-German border profile, have an impact on low water levels far into the German stretch of River Elbe [7].

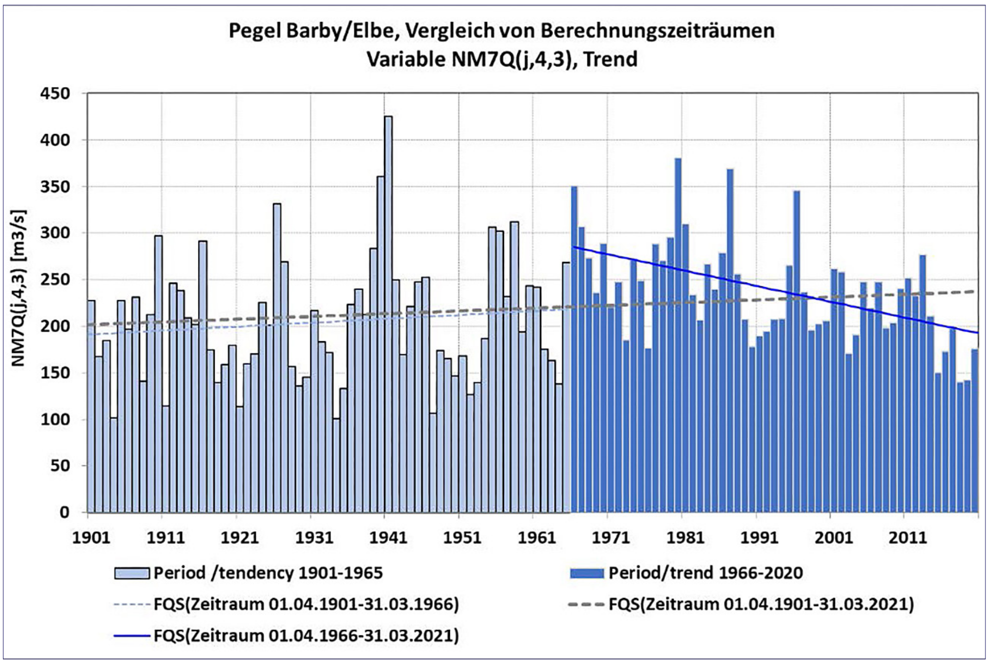

Fig. 2: *Gauge Barby (Elbe): NM7Q(a) in the period from 1901 to 2020 with varying trend significance (FQS-/M-K) over the entire period (grey) and in two sub-periods differentiated by breakpoints. The breakpoint corresponds with the launch of the Orlik dam.*

In view of the breakpoint-differentiated trend analysis, it is obvious, that low water discharges in the 55 more recent years all-in-all occur at a higher level than before the construction of the Vltava cascade. But on this higher level, they are decreasing significantly. This stands in line with the development of the flow regime, explained in Chapter1.

3. Climate Change effects

When it comes to precise quantification and attribution approaches to explain identified anthropogenic or climate change driven developments, classical statistical analysis alone is often insufficient. Supplementing it with suitable modelling tools appears necessary not only for forecasting, but also for further penetration of the process structure.

Figure 3 exemplarily displays the results of a hydrological simulation attempting to isolate and assess the effect of Czech reservoirs on the low flows at the German gauging station Dresden based on a hydrological model with implemented reservoir management rules. However, the results are difficult to verify because information on the exact daily management practice is lacking. Further necessary understanding of the system arises from coordinated scientific cooperation involving work on data bases, empirical analysis and model-based projection approaches.

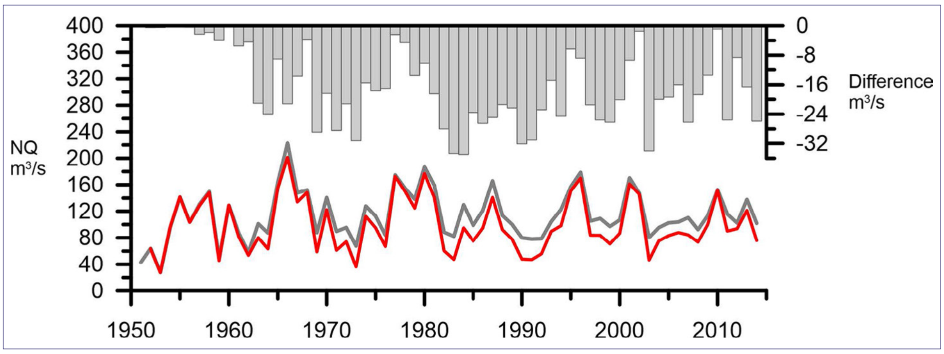

***Fig. 3:** Gauge Dresden (Elbe): NQ(a) in the period from 1951 to 2015 simulated with a hydrological model for the international Elbe catchment (LARSIM-ME) including (grey line) and excluding (red line) reservoirs in the upstream catchment. Grey bars indicate the reservoir effect as difference between the simulations. Data: BfG.*

Studies on hydrological impacts of climate change often differ among others with respect to the climate scenarios used, the number of projections selected for the uncertainty assessments, the steps of technical data treatment (regionalization, bias correction), hydrological models, and the evaluation statistics (time periods, indicators). These differences make comparisons between studies difficult and hamper integrated assessments in the international Elbe catchment.
Also, the scenarios and modelling tools develop over time. Figure 4 shows results from three different scenario and model generations associated with the 4th, 5th, and 6th IPCC-reports published in 2007, 2013, and 2021, respectively [8], [9], [10].

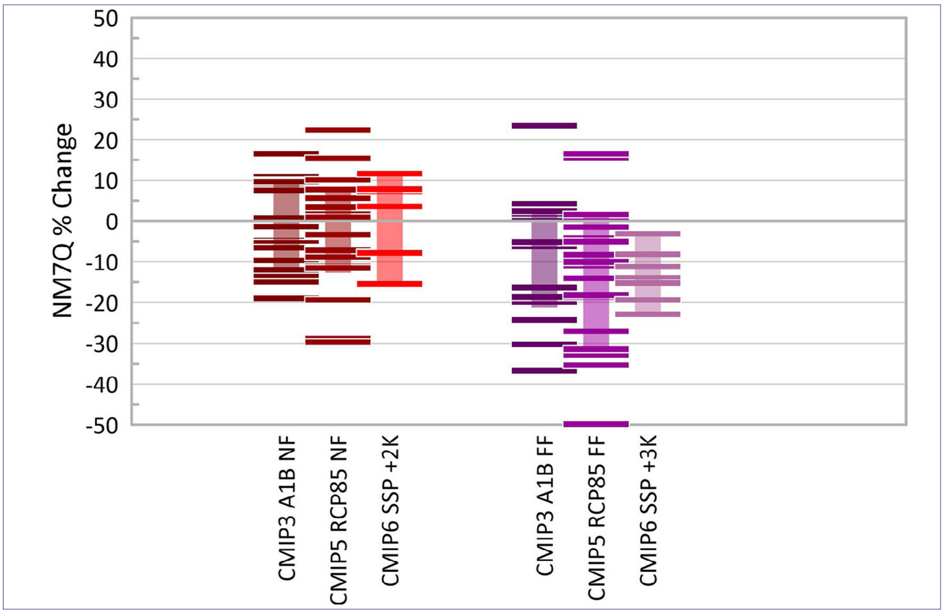

***Fig. 4:** Gauge Dresden (Elbe): Changes of annual low flow indicator NM7Q projected with three different generations of data and models associated with IPCC ARs 4, 5, and 6 (SRES-A1B-CMIP3-ENSEMBLES-HBVD, RCP8.5-CMIP5-CORDEX-LARSIM, and SSP-CMIP6-NULKEUS-LARSIM, respectively). Left plot, red: Results for the near future (NF, 2031–2060 vs. 1971–2000) and a +2K-world (vs. 1961–1990); right plot purple: Results for the far future (FF, 2071–2100 vs. 1971–2000) and a +3K-world (vs. 1961–1990).*

The discharge projections are based on regional climate models and were generated in departmental research programs and services of the German ministry of transport (KLIWAS, “Network of Experts”, DAS-Core Service “Climate and Water”; [11], [12], [13]. Between these three generations differences exist with respect to scenarios (SRES, RCP, SSP), ensembles members (20, 20, 7), and hydrological models used (HBV, LARSIM, LARSIM). Furthermore, the CMIP6 data are based on time slices representing “Global Warming Levels” of +2 K, and +3 K and thus follow a different procedure of scenario development [14].
Summing up the information in Figure 4, it can be noted, that (a) the overall spread of results is large and differs between different mode generations, while only a few members cause a large portion of the spread, and (b) that some features of the projected changes remain stable over different CMIP-versions. These are highlighted by the

vertical bars in Figure 4 which capture the range between the 15th and 85th percentile of the larger ensembles and the min-max-range for the small ensemble. In the near future (2031–2060 or + 2K world) projections show changes (relative to period 1971–2000) centered around zero with a range of +10% to -10% in the multi-annual low flow values. In the distant future (2071–2100 or +3K world) low flows are projected to decrease by most models, with change signals down to 20 % or 30%.
These main messages and other related to mean flows and flood flows have been communicated on different levels within the Elbe catchment and beyond. They support national and international adaptation strategies.

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Morphological conditions of the Elbe in Saxony-Anhalt

Aline Gransee

1. Introduction

In accordance with the objectives of the European Water Framework Directive (WFD), all surface water bodies within the European Union are required to achieve at least a good ecological and chemical status or potential. The assessment of ecological status is determined by biological quality elements, such as macroinvertebrates, fish fauna and aquatic vegetation. Supporting quality elements, namely hydromorphological, chemical, and physico-chemical parameters, are applied to verify and support the results of biological assessments and to identify potential causes of ecological degradation [1].

Among these supporting elements, hydromorphology plays a central role in the evaluation and monitoring of surface waters. The structural characteristics of rivers and streams are particularly relevant for understanding hydrological connectivity, sediment transport, habitat diversity, and anthropogenic alterations of the river corridor.

2. Mapping and Methodological Approach

In Saxony-Anhalt, the morphological conditions of the Elbe and its main tributaries were mapped in 2020 using the "Mapping guidelines for small to large watercourses" developed in North Rhine-Westphalia [2] for the first time. The methodological approach in the "NRW procedure" is based on the recommendations of the Federal/State Working Group on Water [3] [4]. All rivers were recorded both through an overview procedure and during an on-site survey. The hydromorphological classification of the water bodies is based on the German river typology where the Elbe is categorised as “type 20 sand-dominated river” [5].

The Elbe's watercourse in Saxony-Anhalt comprises a length of 304 km. The mapping of river morphology is carried out in segments of 1,000 m. According to the survey form, 25 parameters are recorded, which are grouped into 6 main parameters. By calculating arithmetic means, a further aggregation is performed to assess the riverbed, banks, and surrounding land areas, as well as to derive an overall evaluation (Table 1). Each parameter is rated against the reference condition, allowing for a classification into one of seven condition classes ranging from “un-modified” to “completely modified” (Table 2).

Tab. 1: *Possible aggregations of the evaluation (adapted from [2])*

Evaluation of the main parameters	Possible aggregations of the evaluation	
HP 1: Course development	Riverbed section	Overall assessment
HP 2: Longitudinal profile		
HP 3: Riverbed structure		
HP 4: Cross-sectional profile	Bank section	
HP 5: Bank structure		
HP 6: Riparian land use	Land section	

Tab. 2: *Definition of structural classes (adapted from [2])*

Structural class	Structural class	Degree of modification
	1	unmodified
	2	slightly modified
	3	moderately modified
	4	clearly modified
	5	heavily modified
	6	very heavily modified
	7	completely modified

3. Results for the Elbe in Saxony-Anhalt

The results of the 2020 morphological survey reveal that the Elbe within Saxony-Anhalt deviates from the natural reference state (Figure 1).

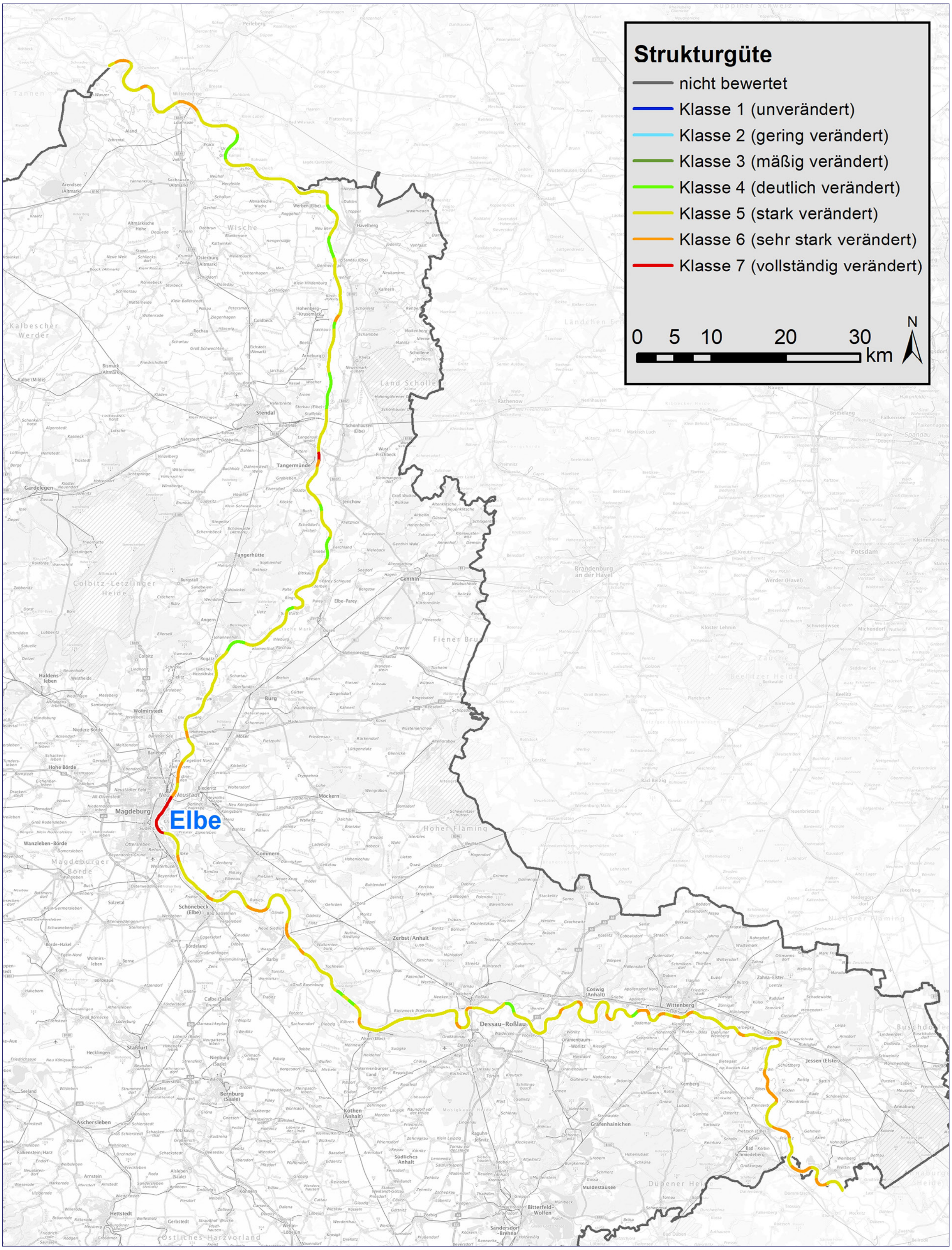

Fig. 1: *Overview map of Elbe in Saxony-Anhalt and its morphological condition (overall assessment classes: 1 unmodified, 2 slightly modified, 3 moderately modified, 4 clearly modified, 5 heavily modified, 6 very heavily modified, 7 completely modified)*

The overall evaluation of morphological condition classifies more than 90 % of the Elbe river as heavily to completely modified . Less than 10 % of the river stretches can be classified as clearly modified. The evaluation of riverbed section show a high degree of modification with 88.5 % of river stretches being categorised as heavily to very heavily modified. The bank section is even more modified with 96 % of river stretches being heavily to very heavily modified. The riparian land use is less modified with up to 75% of river stretch surroundings being slightly to clearly modified (Figure 2).

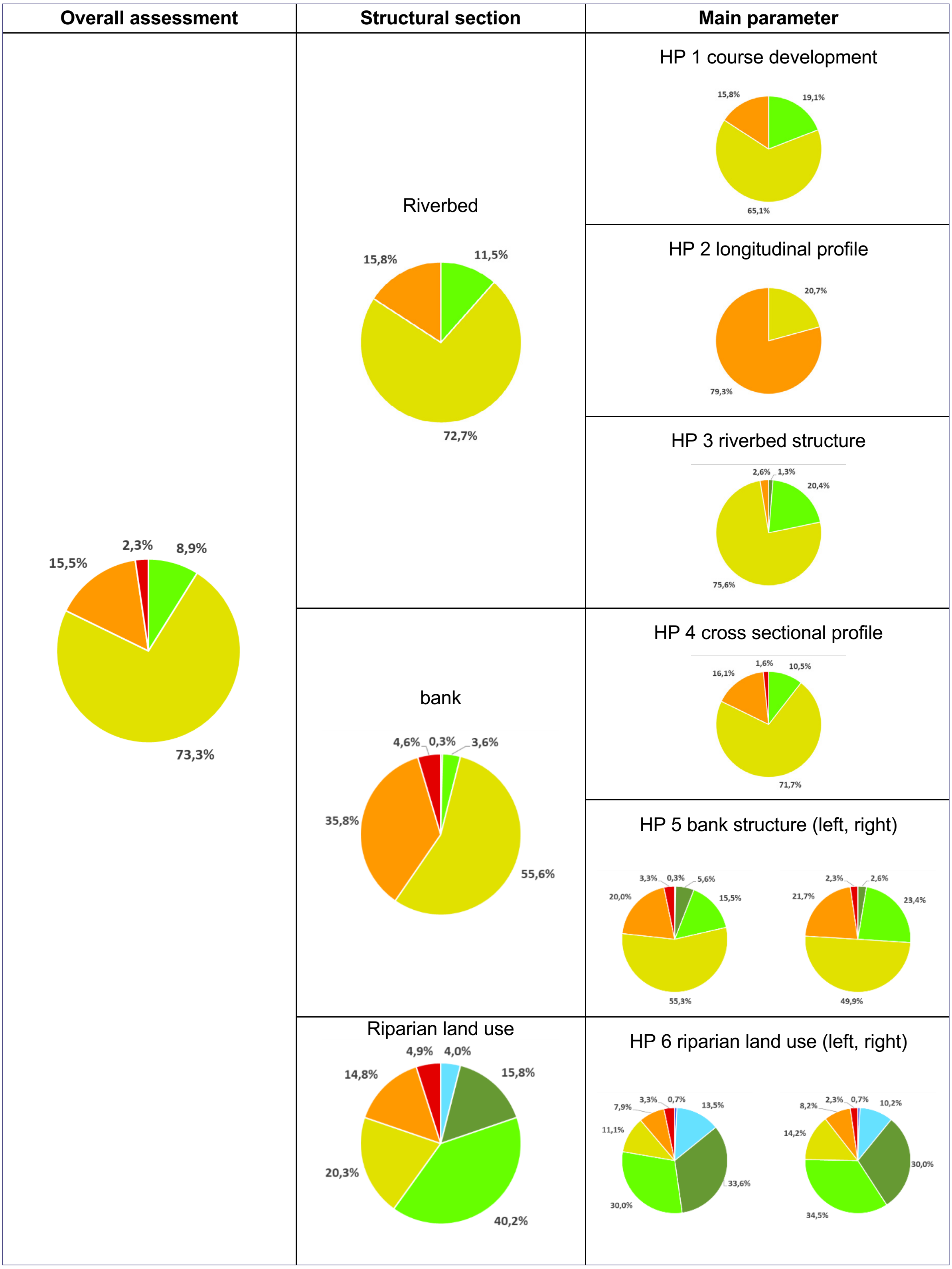

Fig. 2: *Evaluation results of Elbe morphology (HP = main parameter; german: Hauptparameter)*

4. Implications and Outlook

The Elbe within Saxony-Anhalt shows deviation from its natural reference state. The observed morphological deficits vary in extent and type along different river sections, but recurring issues include channel straightening, bank fixation and disconnection of floodplains. The modifications are driven by anthropogenic use such as navigation infrastructure, land use and flood protection measures. These anthropogenic modifications have reduced habitat diversity and disrupted the river's natural dynamics. In many areas, the river lacks the structural heterogeneity required to support a high ecological status, particularly for sensitive biological communities.

The findings of the morphological assessment are not only important for the classification of ecological potential under the WFD but also provide a sound basis for water management planning. The identified deficits inform the development and spatial prioritization of targeted measures within the Programme of Measures (german: Maßnahmenprogramm), which is a core component of the River Basin Management Plan.

Future steps include the integration of morphological restoration into broader ecological and hydrological improvement efforts. This may involve the reconnection of side channels and floodplains, or the application of nature-based solutions to enhance habitat complexity. The mapping data also serve as a reference point for monitoring progress over time and evaluating the effectiveness of implemented measures.

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Prospects of a Free-Flowing Elbe: Navigation, Trends and Potential

Iris Brunar, Martin Pusch

1. Introduction

The approximately 600 kilometers of free-flowing Elbe between Ústí nad Labem and Geesthacht is strongly characterized by low water, which can occur at any time of the year. In addition, the usual spring floods have been absent since 2014, as the rising temperatures mean that less precipitation falls as snow and snowmelt is therefore largely absent.

Transportation on the Elbe, which was still a much-used waterway in the GDR era, declined sharply in the early 1990s when the broad swaths of industry collapsed in the new federal states and the demand for transportation, particularly of bulk goods, fell. The economy underwent a profound structural change. At the same time, the low water phases became longer and more extreme.

In addition, the economy reduced its storage capacities and increasingly demanded "just in time" deliveries. As the Elbe waterway cannot offer this reliability, more and more shipping companies turned their backs on this transport route. In 1998, only 1.8 million tons were transported. The year 2011 with 0.8 million tons of cargo transported was used as the basis for the currently valid assessment of the Elbe in the Overall Elbe Concept (OEC) [1]. Since 2018, the actual volumes of goods transported have only fulfilled this planning basis to a fraction, at just 0.1 to 0.2 million tons (Fig. 2).

The longer and hotter dry periods of recent years have had a tremendous impact on the Elbe's floodplain landscape. Due to the lack of flood periods in the recent past, the Elbe has reached its floodplains less frequently and therefore has been unable to supply them with water. The ongoing erosion of the riverbed, the greatest ecological challenge on the Middle Elbe, further intensifies this. This erosion is a consequence of the accelerated flow velocity caused, among other things, by the narrowing and straightening of the riverbed for navigation purposes, so that the Elbe is digging deeper and deeper into its mobile bed of sand. The river and floodplain are decoupled as a result of the drop in water level, causing the landscape to dry out. This has a considerable negative impact on the water-dependent biodiversity of the river landscape as well as on forestry, agriculture and navigation. Unfortunately, despite the addition of bed load, it has not been possible to stop deep erosion.

2. Data Sources and Evaluation

To investigate the navigability of the Elbe publicly accessible data on fairway depths from the website www.elwis.de was used, which is operated by the Waterways and Shipping Administration (WSA) [2]. The navigability of the different Elbe stretches and periods can be directly compared using the fairway depths. Water level data is not suitable for this evaluation. Not only because they would have to be converted, but also because the ratio of water level to fairway depths changes due to the moving riverbed of the Elbe.

The time periods from 2004 to 2013 and 2014 to 2023 were compared here, as the years 2004 to 2013 served as the basis for analyzing the fairway depths in the OEC.

However, the data on Elbe fairway depths published on www.elwis.de, are unfortunately not complete. In the period 2004 to 2013, around 50 data sets are missing for each Elbe section. As the data was averaged over 10 years, there may be an inaccuracy of +5 days. Since the aim here is to make basic statements and show trends, the result is not unduly influenced. In addition, measurements on the Elbe sections E4, E5, E6, E7 and E8 did not begin until 19.2.2004. This is relevant for the representation of the fairway depths <1.40 m in this period, as extreme low water with values below one meter prevailed at the beginning of 2004. For section E4, the days <1.40 m could be inferred from E1, E2 and E3. For sections E5, E6, E7 and E8, the days below 1.40 m could not be reliably determined and were therefore not shown.

Between 2014 and 2023, the fairway depths were not measured on the sections E1, E2, E3, E4 and E9 during the low water phases in 2018, 2019 and 2023. According to the WSA, no measurements could be taken due to the extremely low water levels. For the sections E4 and E9, however, the days on which the fairway depth was below 1,0 m could be clearly assigned to the <1 m range. Sections E1, E2 and E3 also fell below the fairway depth of one meter. However, due to a lack of measurements, no exact number of days could be specified for these stretches and were therefore not shown.

The volume of goods transported was evaluated using survey data from two WSA counting stations, of relevance to the free-flowing Elbe [3, 4, 5]. However, the counts at Schmilka on the German-Czech border were discontinued in 2008. In 2022, the counts on the Magdeburg stretch were discontinued. In response to a request from BUND to the WSA on February 23, 2023, it was pointed out by email that the administration no longer wished to publish reliable figures for the years 2020 to 2022. Due to a lack of staff, the figures could only be documented partially. This means that there is currently no longer a counting station that continuously records the volume of goods transported on the free-flowing Elbe. The Federal Statistical Office collects data by area and is not able to make any statements about transportation on the free-flowing Elbe.

In addition, the transshipments (in tons) of the seven ports of the Sächsische Binnenhäfen Oberelbe GmbH (SBO) port association, which are located upstream of Magdeburg, were used. These include Industriehafen Roßlau (until 31.3.2024), Mühlberg, Torgau, Riesa and Dresden as well as Děčín and Lovosice in the Czech Republic [6]. A basic trend of the transports carried out can thus be determined. The port of Magdeburg has a canal connection and does not depend on the Elbe waterway.

3. Transport Objectives of the Overall Elbe Concept

According to the OEC adopted by the federal and state governments in January 2017, the various management and utilization objectives on the Elbe – i.e. transport, water management and nature conservation – are to be realized with equal priority: *“The aim is to reconcile the environmentally compatible transport use of the inland Elbe and the water management necessities with the preservation of the valuable natural area.”* Further: *"The fairway depth of the inland Elbe should ... for 345 days [per year] ... be improved to at least 1.40 m below GlW 2010 (reliability of use), insofar as this does not hinder the fight against riverbed erosion and corresponding projects also serve the objectives of NATURA 2000 and the WFD."* [1]

The OEC defines the Equivalent Water Level (GlW) as follows – abbreviated here: *“The Equivalent Water Level (GlW) is a statistically calculated reference water level from which the existing or target water depths of the Elbe can be determined...”*. The current GlW 2010 is based on a low discharge-equivalent for the years 1991–2010. This means that if this discharge is not given – and this has been the case on over 60 days a year since 2014 according to the WSA – then the target fairway depth of 1.40 m will not be achieved – even if the target riverbed had been established. This means that the fairway depth target defined in the OEC cannot be equated with the creation of a real fairway depth of 1.40 m on 345 days. The GlW value should be reviewed and adjusted at regular intervals (every 10 years), as “the discharge conditions and the Elbe bed are not unchangeable” [1]. However, this has not yet been the case.

4. Navigability of the Elbe in the periods 2004 to 2013 and 2014 to 2023

The free-flowing Elbe is divided into nine sections, E 1–E9, whose length and navigability vary [2]. In the period from 2014 to 2023 and beyond, the navigability of the Elbe was characterized by even more extreme and longer-lasting low water than in the previous decade [2]. The target fairway depth of 1.40 m has not been reached for an average of three to five months per year since 2014, depending on the section. Frequently, the water level even fell below a fairway depth of one meter for several months (Fig. 1a).

In past plans as well as in the OEC, it was assumed that it would be possible to deepen the navigation channel by up to 20 cm. However, the number of days on which the fairway depth fell short of 1.20 m shows that even if the navigation channel had been deepened by 20 cm compared to the current state, the Elbe would not have been navigable for up to three months of the year (Fig. 1a).

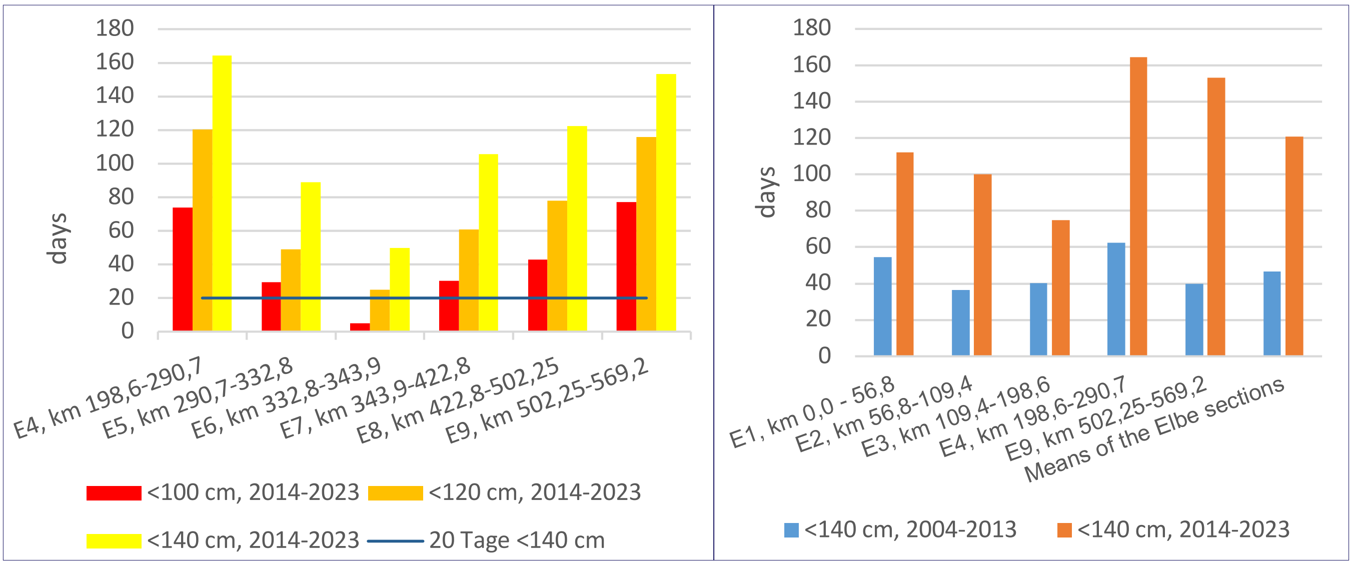

Fig. 1: *Days below three fairway depth levels in the period 2014 to 2013 (left); Comparison of the days below 140 cm for the periods 2004 to 2013 and 2014–2023 (right) [2]*

The average number of days below the fairway depth of 1.40 m in the period 2004 to 2013 compared to the period 2014 to 2023 has more than doubled on average for all sections of the Elbe (Fig. 1b). From the 1990s to the end of 2014, around 1,700 groynes with medium to major damage were repaired [7]. This proves that the view repeatedly expressed that the poor navigability is due to a lack of construction measures is unfounded. Construction work on the river continued even after 2014.

5. Transportation on the Free-Flowing Elbe

Even after the sharp drop in transport volumes following the political changes, the decline in freight transportation continued. From 1998 to 2020, transportation on the Elbe fell by over 90 % (Fig. 2). In addition to the changing demands of the economy, one reason for this is the limited fairway depths and the increasingly long periods of low water, which do not allow for reliably plannable transportation. However, the deepening of a waterway does not necessarily lead to higher transport volumes. For example, even after the largely completed billion-euro German Unity

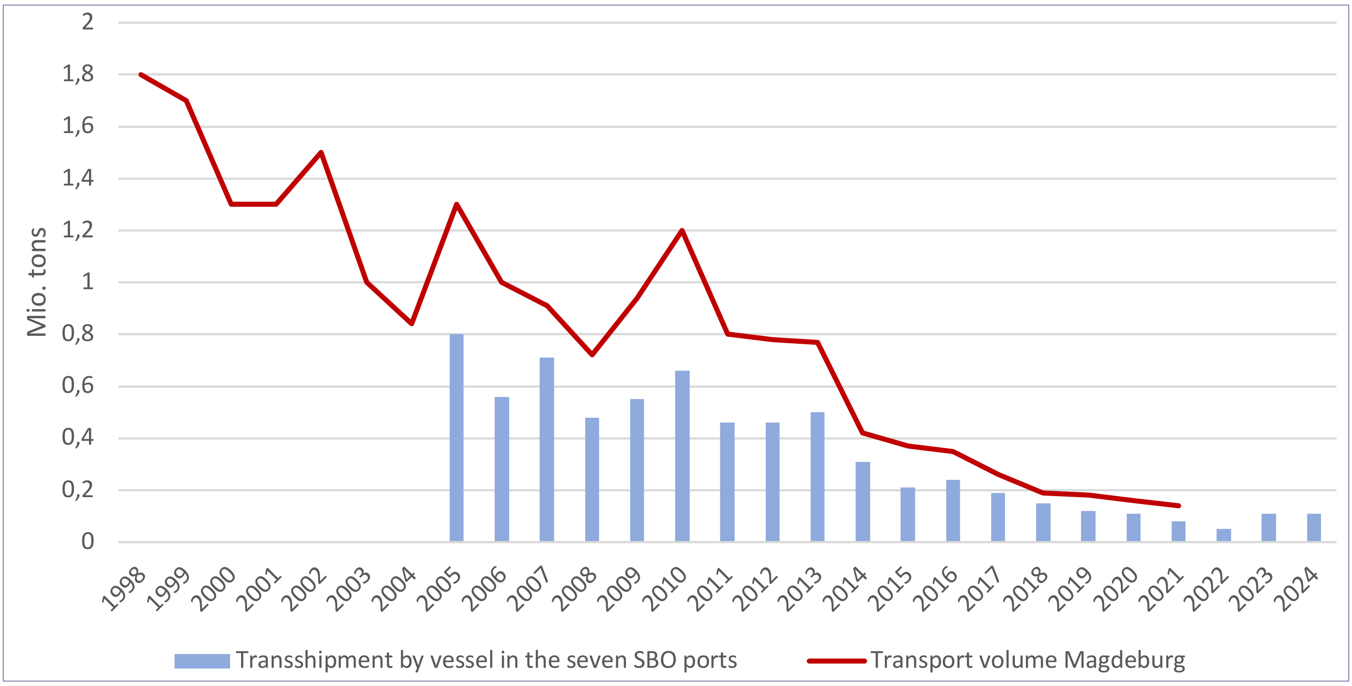

Fig. 2: *Transport volume on the Elbe at Magdeburg and transshipment by the SBO port association [3, 4, 5, 6]*

Transport Project (VDE) No. 17, which created excellent conditions for freight transport by ship with the construction of the trough bridge near Magdeburg and the expansion of the Elbe-Havel Canal, transport volumes decreased by a substantial 33 % between 2014 and 2023 (Hohenwarthe lock counting station) [8, 9].

6. Conclusion

The low water problem has worsened significantly since the adoption of the CCR and the beginning of the implementation in 2017. Since then navigability has deteriorated considerably – despite the major construction measures. The ecological condition of the Elbe floodplains, especially the rare hardwood floodplain and the oxbow lakes, is worrying [10]. An expansion to slightly improve navigability is not appropriate for economic and ecological reasons, especially as it can be assumed that the traffic objectives cannot be achieved. In addition, insisting on creating a certain fairway depth contributes to accelerating the drying out of the landscape. The implementation of binding ecological objectives is made considerably more difficult or even impossible. The OEC therefore urgently needs to be fundamentally revised and at least adapted to current conditions. In order for the state to fulfill its precautionary duty to protect this unique river landscape, the good ecological status according to the WFD must be achieved and deep erosion stopped and reversed, as provided for in the OEC.

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Which Elbe do we want in future? – Ways towards a multifunctional and climate-resilient Elbe

Martin Pusch, Iris Brunar

1. Historical evolution of navigation in the German section of the Elbe

The course of the River Elbe in Germany has been historically channelized with the aim of transporting goods economically by ship. Transport of goods by navigation flourished since the establishment of chain-boat navigation on the Elbe in c. 1870, which was later replaced by paddle steamboats and Diesel driven self-propelled barges. The Treaty of Versailles guaranteed Czechoslovakia a right of passage by inland navigation, which obviously referred to the size of barges of that time, and to contemporary hydrological conditions.

Since the 1990s, the transport of goods has dropped steeply due to the decline of industries in the region with demand of bulk cargo. The former transport of bulk cargo could not be replaced by container transport, as shallow water depths don't allow a fully loading of barges, which renders transport unreliable and uneconomic. On top of this, climate change is extending periods of low flow (see article by I. Brunar).

In the same period, the German Federal Waterways and Shipping Administration (WSV) has tried to support navigation by huge efforts in river training, especially the reconstruction of damaged groynes, and the new construction of embankments. Despite these efforts, with costs for the navigational management of the Elbe of estimated several 100 Mio EUR since 1990, the goal of flourishing inland navigation not only has been failed, but in contrast the transport of goods is continuously decreasing (see article by I. Brunar). However, still in 2017 a programme of measures (Overall Concept for the Elbe, GKE) has been agreed with the aim '*to harmonise the environmentally compatible transport use of the inland Elbe and the water management requirements with the conservation of the valuable natural area.*'

2. Undesired side effects of river engineering

Navigation in the German lowland section of the Elbe is enabled by narrowing the river channel by nearly 7000 groynes. Their purpose is to concentrate river flow at low water levels to a certain fraction of the original width of the river bed in order to increase flow velocity and subsequently bottom shear stress there. This leads to an intended depth erosion (incision) of the river that allows the use of barges with more draught, and hence loading capacity. However, after 130 years, incision has lowered the river bottom of the Elbe in some sections by 1–2 m already, which is much more than intended. This is partially due to the fact that sediment transport from upstream and from tributaries has been much reduced by the construction of embankments, groynes and dams. Moreover, the relative increase of the height of the groynes is accelerating incision, as concentration of flow nowadays not only occurs at low flow conditions, but also at higher flow rates, with higher forces acting at the river bottom. The construction of groynes has hence led to incision that which has become virtually uncontrollable despite the artificial addition of bed load by barges.

Currently it is planned to increase sediment addition to 120.000 t – 175.000 t per year, partially taken from groyne fields. As sediment addition by barges is limited by low water conditions on the Elbe, higher amounts could only be added with other techniques, as e.g. use of a conveyor belt or instream sediment deposits, or by re-enabling lateral erosion of the Elbe by (partial) dismantling of groynes.

Incision of the river bed results in draining the groundwater in adjacent floodplains at times of low discharge of the Elbe, hence affecting some of the most valuable floodplain forests in Central Europe (Fig. 1). In addition, the summer water flow of the Elbe is decreasing significantly due to the climate crisis, which is exacerbating the hydrological situation and further impairing navigability.

Beyond the effects related to incision, the channelization of the Elbe has led to a reduction of self-purification capacity, as sediments in groyne fields are microbially relatively inactive, while moving subaqueous sand dunes repre-

Fig. 1: *Left: Dead hardwood riparian forest near Dessau in the UNESCO Middle Elbe Biosphere Reserve. Right: Dead solitary oak trees in the Dessau-Wörlitz Garden Kingdom, being a UNESCO World Heritage Site (Photos: I. Brunar)*

sent hotspots of microbial degradation of organic matter [1, 2, 3]. As the Waterways and Shipping Administration is also filling up pools (local depressions of the river bed) with stones, such maintenance measures of the Elbe are also affecting the habitats (flow refugia) of riverine fish, especially of large specimen.

3. Legal objectives relevant for the management of the Elbe

Many Natura 2000 areas in the Elbe Biosphere Reserve regrettably are in a moderate to unsatisfactory conservation status only, with receding groundwater levels representing one of the major impacts.

While the river channel of the Elbe has been seen by the WSV exclusively as a navigational waterway for decades, with exclusive application of related management goals, it is now accepted that the EU Water Framework Directive is applicable to the Elbe, too. In addition, in 2021 the WSV has received the responsibility by law to perform even larger hydromorphological restoration measures of the Elbe's river channel that serve the goals of the EU Water Framework Directive. Actions to improve the ecological status are needed, as this is mostly only moderate. Considering the status biological quality elements, phytoplankton is classified poor due to eutrophication [4], which already starts in the >25 impoundments of the Elbe in its Czech section. Aquatic macrophytes are assessed to be in moderate status in some water bodies, while benthic invertebrates even attain a good status in some of them. Fishes are assessed to be in good status, while however this assessment mostly ignores the absence of self-sustaining populations of migratory fish species as salmon, allis shad and European sturgeon.

In that situation, the EU Water Framework Directive urges member states to take measure to reach the good ecological status. Exemptions are only possible under certain circumstances, as detailed in Art. 4:

'Member States will not be in breach of this Directive when … all the following conditions are met:
(a) all practicable steps are taken to mitigate the adverse impact on the status of the body of water; …
(c) the reasons for those modifications or alterations are of overriding public interest and/or the benefits to the environment and to society …, and
(d) the beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.'

Hence, it is required that 'all practicable steps are taken' especially as the small use for navigation does not represent an 'overriding interest' any more. Consequently, measures have to be taken that mitigate the relevant pressures on the Elbe ecosystem, as nutrient input and hydromorphological alterations. As for the nearly 7000 groynes, a systematic approach needs to be taken to mitigate the high shear stress to the river bottom by adapting the shape of the groynes, as lowering them according to the incision of the river bed, and by enabling secondary flows near the river bank by establishing notches in the groynes. Especially a series of notched groynes with notches of c. 15–20 m width may enable significant flows at higher water levels, hence reducing shear stress in the river bed accordingly, and providing new near-natural, shallow and dynamic river habits, as e.g. realized on the Rhine (https://de.wikipedia.org/wiki/Tomateninseln)

4. Towards a more multifunctional and future-proof Elbe

By channelization of the river course and construction of dikes separating the river from its floodplains in favour of agriculture, some important landscape ecological functions have been lost, although these are becoming more important again in the 21st century, as water, flood and pollutant retention, climate regulation, biodiversity protection and recreational opportunities. The whole palette of important ecosystem services provided by rivers and floodplains encompasses more than 15 ecosystem services (Fig. 2, left), and may be quantitatively assessed in a non-monetized way by the 'River Ecosystem Service Index' (RESI) (www.resi-project.info)[5].

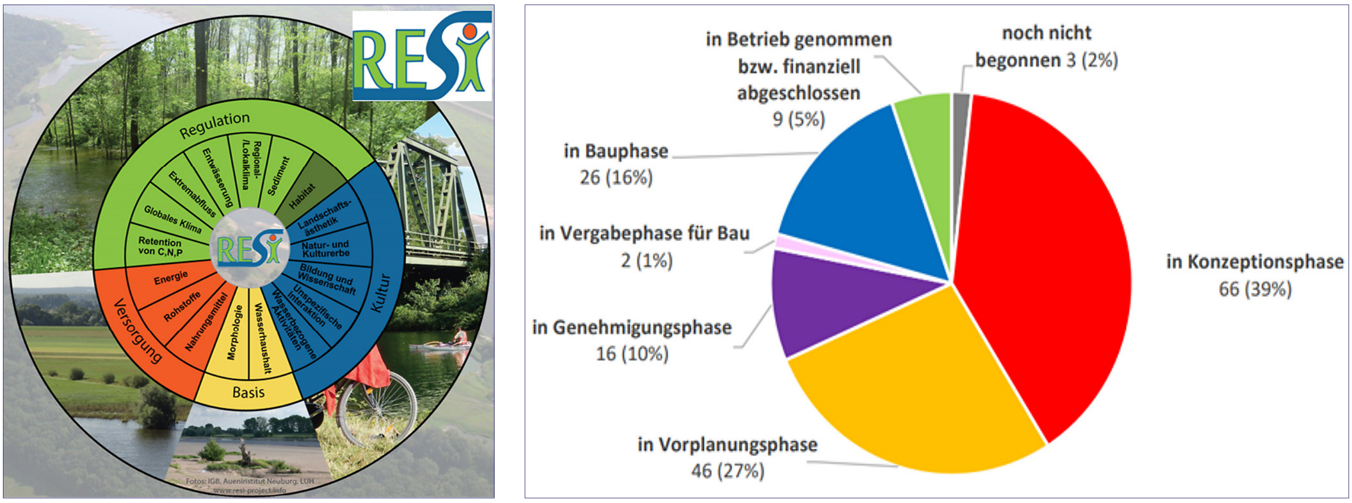

Fig. 2: *Left: Palette of ecosystem services provided by rivers and floodplains, as assessed by the 'River Ecosystem Service Index' (RESI), www.resi-project.info (Graphics: G. Costea/IGB). Right: Implementation status of the German National Programme for Flood Protection as for 2023 (LAWA 2023, www.lawa.de/documents/230531-broschuere-10-jahre-nhwsp-barr_2_1685951721.pdf*

Such ecosystem services available at the Elbe represent an important economic prerequisite for the further development of the neighbouring regions in terms of drinking water supply, flood protection, agriculture, mining restoration, industry, hydrogen-based energy management and nature tourism. As summer droughts are occurring more frequently with climate change, improved seasonal storage of water in aquifers represents an urgent necessity, but which will be only be possible if those aquifers are not drained by the nearby incised Elbe channel. In addition, retention of flood waters in re-activated floodplain forests has still to be implemented along German rivers in many places (Fig. 2, right), which calls for a multifunctional and participatory way of implementation, especially by application of the approach of nature-based solutions [6].

In order to improve the multifunctionality and climate resilience of the Elbe landscape in response to the requirements of the 21st century (cf. Fig. 3), flow regulation must be adapted accordingly. incision must be stopped and reversed by adding bedload, establishing bedload depots and by creating natural bedload sources on steep banks, aiming to stop the seemingly eternal, costly task of artificial sediment addition. By lowering, notching and partially dismantling the groynes, essential river habitats can be regained at the same time. Further embankment removal and reactivation of flood channels need to enable the targeted infiltration of Elbe water into aquifers. This means a comprehensive work programme for the WSV which represents the only institution with expertise and staff capacity to implement this. In an integrated concept of implementation of nature-based solutions, floodplain areas may even become eligible for the payment of nature credits to owners. Hence, a restored diverse river and floodplain structures will not only provide multiple benefits to residents, but also increase the attractiveness of the Elbe for water and nature tourism [7, 8].

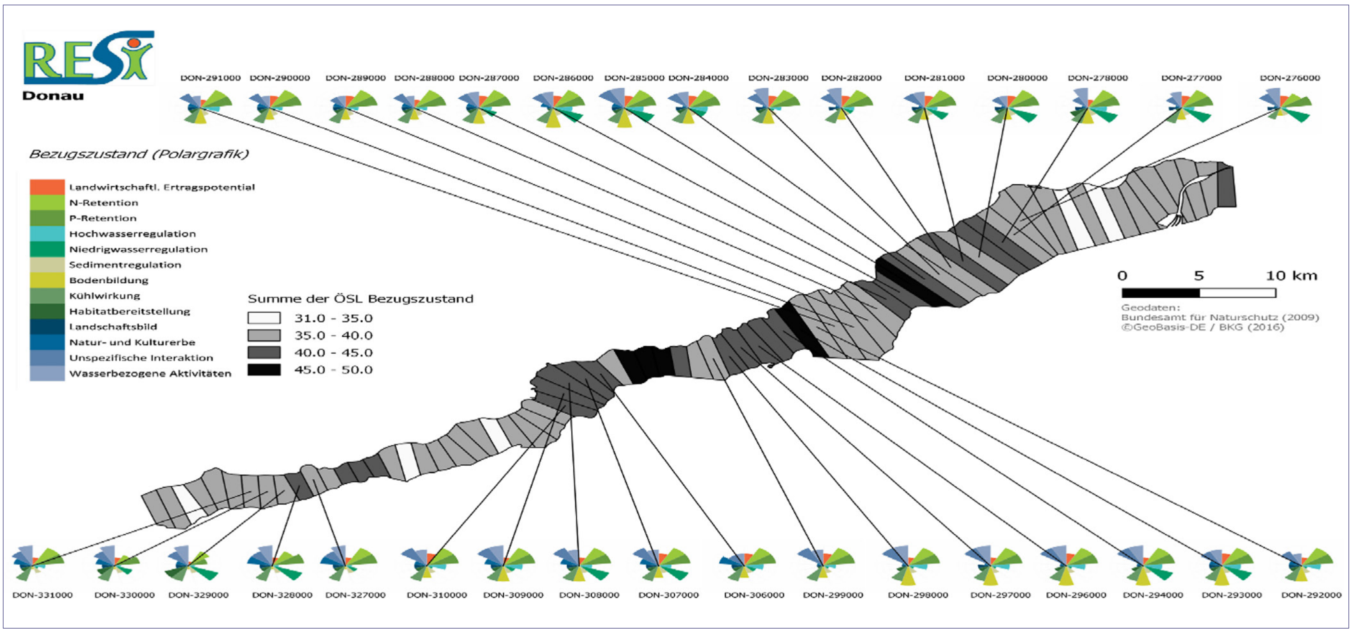

Fig. 3: *Visualization of the multifunctionality of a river-floodplain corridor, exemplified by a 80 km section of the Danube River in Bavaria. (from: Podschun et al. 2028). Grey slices represent a 1 km long compartment of the floodplain each, and polar graphs visualize the extent of availability of various ecosystem services.*

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The Elbe Waterway as part of the European Inland Waterway Network

Vojtěch Dabrowski

The Elbe-Vltava Waterway, as the most important waterway of the Czech Republic, provides service to important economic areas of the Czech Republic and at the same time accessibility to important economic areas of other European countries, including connections to seaports through an environmentally friendly and low-energy transport mode. Given the fact that water transport offers low transport tariffs, it is also important for the competitiveness of domestic exporters and for the price of goods for domestic end consumers. The Elbe-Vltava Waterway is included in the core network of the Trans-European Transport Network (TEN-T) according to Regulation (EU) No. 2024/1679 of the European Parliament and of the Council of 13 June 2024 on Union guidelines for the development of the Trans-European Transport Network (TEN-T) and forms part of the Rhine-Danube corridor.

The Elbe Waterway in the Czech Republic is in total 247 km long – from the Czech Republic/Germany border to Pardubice. However, it is not fully navigable along its entire length. In the area of the Přelouč lock, approximately 2 km are innavigable, including a non-functional lock chamber, and a further approximately 40 km long section from the state border to Ústí nad Labem (Střekov lock) does not have sufficient navigation parameters, navigation conditions are not maintained by weirs and depend fully on the current flow, and therefore for a significant part of the year it does not allow the passage of vessels with larger drafts.
23 locks have been built on the waterway so far (this number does not include the current Přelouč lock, which is not operational).

On 01.01.2025, the Agreement between the Government of the Czech Republic and the Government of the Federal Republic of Germany on the maintenance and development of the international inland Elbe waterway entered into force. This Agreement aims to regulate the issues of determining the target parameters of the Elbe waterway in the Czech Republic and the Federal Republic of Germany. On the Czech side, the parameters of the waterway resulting from the currently valid conceptual documents in the field of inland navigation are to be ensured on the Elbe section from Ústí nad Labem to the state border between the Czech Republic and the Federal Republic of Germany. In the subsequent section, the section between Ústí nad Labem and Týnec nad Labem will then ensure the existing parameters of the waterway with a navigation depth of 230 cm, and at the same time, in the section between Týnec nad Labem and Pardubice, measures will be taken to enable a navigation depth of 230 cm up to the destination port in Pardubice.

On the German section of the Elbe, the basis for the fairway parameters is the "Strategic Concept for the Development of the German Inland Elbe and its Floodplains" (Overall Elbe Concept). In this context, the current maintenance target on the international inland Elbe waterway is a fairway depth of 140 cm at the current reference water level (GlW 2010) with a variable fairway width.

The Agreement further establishes in Article 6 a joint mixed commission, which will be established for the purpose of supervising compliance with the content of the Agreement, in particular with regard to the fulfilment of the specified parameters of the Elbe waterway. The activities of this joined mixed commission were launched in June 2025 with its first meeting, which took place in Děčín.

Through the Elbe waterway, the domestic waterway network is connected to the dense network of Western European waterways in Germany, Belgium, the Netherlands, France and Switzerland, including seaports. The most frequently visited seaports are Hamburg, Amsterdam, Rotterdam, Antwerp and Bremen, and the inland ports of Magdeburg, Dresden, Riesa, Aken, and others.

The navigability of the Elbe in Germany is absolutely crucial for a functioning water transport system in the Czech Republic, especially to Magdeburg, from which it is possible to access Western European waterways via the canal bridge near Magdeburg.

The Danube waterway is also accessible from the Czech Republic via the Rhine-Main-Danube connection, and the Polish waterways via the Elbe-Havel Canal. Domestic customers are also asking for water transport to these destinations, but due to the difficulty of reversing the load on vessels during these transports, they are not yet fully economically viable.

Identification of bottlenecks on the part of the Elbe-Vltava waterway included in the TEN-T:
Basic problems of water transport in the Czech Republic:

- no continuous waterway
  - there is no continuous navigable Elbe waterway from Germany to Pardubice;
  - there is no Děčín navigation level (unreliability of the section without weirs);
  - there is no navigability to Pardubice (actual continuity of the waterway);
  - in the center of Prague, the Smíchov lock chamber is overloaded, which practically interrupts the waterway during periods of high demand for navigation (some segments of navigation cannot pass within an acceptable waiting time);
- other restrictions within the infrastructure of waterways;
  - restriction of drafts on partial parts of the Vltava waterway to 1.20 m, which fundamentally limits the usability for freight transport (efficiency) and a draft of 1.20 m even for passenger ships (impassable for large ships);
  - limited drafts on the Elbe below 2.20 m;
  - limiting the underpass height on the Vltava to Prague to only 5.40 m, restricting the passenger ship segment and container transport, including the need for dangerous handling during passage);
  - partial limitation of the underpass height on the lower Elbe (Štětí¨area);
  - lack of reliable marking of some bridges, including markings for navigation with the help of radar;
  - lack of an additional network of protected places for vessels during floods that cannot reach a protective port (e.g. due to the great distance, the need for several crossings, the risk of malfunction or overloading of some locks);
  - lack of or inadequate waiting berths at locks. This is a significant problem especially for berths for small vessels, which are missing in many locks, mooring devices are not suitable for small vessels and undesirable and dangerous interaction with large vessels occurs;
  - lack of turning areas for vessels and convoys of the largest permitted dimensions;
  - in the long term, the inability to allow vessels with a width of 11.40 m to pass on the Vltava;
  - insufficient network of slipways for launching vessels into the water and pulling them to land;
- erroneous perception of water transport as unnecessary and dysfunctional, in the case of waterways as unsuitable for navigation due to their location on the upper reaches of rivers, lack of insight into their multifunctional character;
- low use of alternative fuels and electromobility as a path to decarbonization;

Freight water transport Freight water transport in the Czech Republic has a relatively small share of transport modal split (less than one percent of the total volume of freight transport). However, the potential for the use of water transport is significantly higher; its current limited use is caused by a number of factors. The most significant reason is the insufficient reliability of navigation conditions due to the unfinished infrastructure of waterways – this infrastructure is primarily concentrated on the waterways of the Elbe and Vltava (Elbe-Vltava waterway).

The Elbe-Vltava waterway is part of the TEN-T network. Regulation (EU) No. 2024/1679 sets out the Czech Republic's obligation to complete the transport infrastructure, the so-called TEN-T core networks, by 2030, multimodally in the areas of rail, road, water and air transport, and at the same time to ensure the interconnection of these networks in multimodal nodes. At the same time, the Czech Republic was to fulfil its obligation to complete the remaining part of the TEN-T network in accordance with applicable EU legislation.

Freight water transport in the Czech Republic is primarily used in the context of exports from the Czech Republic to abroad, or imports from abroad to the Czech Republic. This situation results from the fact that, due to its specific properties, water transport is particularly suitable for the transport of goods over long distances and for the transport of oversized loads.

Due to the geographically limited network of waterways, it is not possible in many cases to ensure door-to-door transport of goods, which often have to be transshipped in order to cover the first and last kilometers of their journey. This does not apply to the transport of goods from port to port, where the need for transhipment is eliminated and the costs of transporting goods are significantly reduced, which brings competitive advantages to companies located in the immediate vicinity of waterways. Business activity can therefore be targeted towards waterways. Overall, however, it can be stated that shipping is best used as a component of combined transport, i.e. as part of multimodal transport chains.

Hamburg is a key port for the Czech Republic. The Czech Republic has leased the port area in the port of Hamburg for 99 years until 2028 with an option for a further 50 years; it also owns a certain part of the area. Intensive negotiations are currently underway with the German side on the form of use of the port of Hamburg by the Czech side after 2028.

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The German Inland Elbe – capabilities and limits for shipping

Tobias Gierra

1. The German Inland Elbe as a waterway

The German Inland Elbe stretches from the Czech-German border (El-km 0) to the Geesthacht barrage (El-km 585.9). It is a dedicated federal waterway along its entire length and is owned by the federal government, regulated by federal laws and regulations (e.g. WaStrG, BinSchAufgG, BinSchStrO) and managed by the Federal Waterways and Shipping Administration.

Shipping on the Elbe had been operated long before the river was developed and was always hampered by periods of low water. The river had been regulated with the construction of dykes, rectification and cutoffs, initially mainly to protect against floods. The basis for a planned improvement in navigation conditions in the mean-water area was laid in the 19th century. After the extremely low water levels of 1904 and 1911, additional regulation projects were added in the low water range. Until 1945, it was not possible to fully implement the intended measures to regulate mean and low water, which could not be made up for during the period of German division due to the many maneuver areas and the inner-German border area. By 2002, many of the severely damaged or destroyed structures had been restored, steadily improving navigation conditions. The flood event in August 2002 led to a moratorium on expansion and maintenance. It was not until 2005 that the maintenance of the Elbe could be continued with an increasing proportion of ecological adjustments to the structures. Today, the Waterways and Shipping Office Elbe is responsible for maintaining the riverbed of the Inland Elbe and its structures [1].

The river regulation system of the Inland Elbe consists of groynes, longitudinal structures and bank protections as well as ground, bed and bank sills. In total, there are approx. 330 km of longitudinal structures and bank protections as well as approx. 6,900 groynes from El-Km 121 onwards, which have construction heights in the mean-water range and were built using paved, rubble or alternative construction methods (e.g. deadwood groynes, technical-biological bank protection). In contrast, bank sills are low-water structures and ground or bed sills built across the flow direction in the river bed. Together, these river regulation structures serve to make better and more reliable use of the natural discharge for transportation, bank protection and evenly sediment flow. In this way, a dynamic equilibrium between the water level and the river bed could be established with better usable water depth at low and mean discharge levels. However, the lack of low-flow regulation in some sections of the Elbe and gaps in mean-flow regulation lead to bed rise due to bed-load deposits [2, 3] and other effects that are atypical for alluvial lowland rivers, such as alternating bars [4]. In other sections, a continuous deepening of the bed can be observed due to over-regulation [3].

2. Capabilities for shipping

The usability of the Elbe for traffic is mainly determined by the geometric parameters of channel depth, channel width and bridge clearance. The channel depth is the most important influence. In principle, the Inland Elbe is categorised as waterway class Va according to its navigability above Wittenberge and can therefore be used by motor vessels and push tows up to 110 m long and 11.4 m wide. Below Wittenberge, it is class VIb, meaning that motor vessels up to 140 m long and 15 m wide and push tows up to 195 m long and 22.8 m wide can navigate here. The Inland Elbe is part of the trans-European transport network (TEN-T Core Network). It is part of the "Rhine – Danube" European transport corridor since 2024 and is closely interwoven with the TEN-T corridor "North Sea – Baltic". It is therefore not only a waterway in the focus of the European Union, but also the only nautical access to the European waterway network and seaports for the Czech Republic.

It is not only the Elbe's good connection to other waterways that is crucial for the transportation of goods, but especially to the road and rail transport. Most ports on the Inland Elbe have a direct rail connection and many offer a direct connection to the autobahn network. Containers and bulk goods can be loaded onto other modes of transport at all ports. Flexible transportation on all three transport routes protects against supply bottlenecks that can arise due to route obstructions on land or water, and can guarantee a reliable and nationwide supply at competitive prices. The goods loaded are predominantly bulk goods as well as large and heavy goods transports (GST), such as generators or parts of wind turbines, with a large catchment area. With sufficient fairway depths, there would also be potential for three-layer container traffic between Hamburg and Riesa, which is not possible via the Elbe Lateral Canal.

As a combination of federal waterways, the Binnenelbe and the Elbe Lateral Canal have a larger impact on transport strategy than either of them individually and form a reliable and flexible transport system. By using them, a broader spectrum of usage requirements can be covered and route-related deficits compensated for, as well as ensuring a reliable hinterland connection to the Port of Hamburg. The Elbe Lateral Canal scores mainly with its constant water conditions, in contrast to the higher bridge clearance, the larger possible ship types and no delays due to lock waiting times on the Inland Elbe. If the Elbe Lateral Canal is closed due to pending maintenance, repair or new construction work on locks, ship lifts or sections of the route, the Inland Elbe can continue to maintain traffic as far as discharge conditions allow. Conversely, the Elbe Lateral Canal can handle some of the traffic of the Inland Elbe during low water phases.

On 17th January 2017, the “Overall Strategy for the Elbe”, the so-called “Gesamtkonzept Elbe” (GKE), was adopted by the federal ministries responsible for transport and the environment and nine of the federal states in the Elbe catchment area. Its aim is to harmonise water management requirements, the protection of the valuable natural habitat of the river and floodplains and environmentally friendly transport use, thereby providing a positive development perspective for the condition of the Inland Elbe. With the GKE, the federal and state representatives agreed with environmental and trade organisations as well as citizens' initiatives and churches to maintain the Inland Elbe as an important part of the European transport network and thus support the economy. Since then, the traffic maintenance objective on the Upper and Middle Elbe up to the Geesthacht impoundment area has been to ensure a continuous navigation channel depth of at least 1.40 metres below the low reference water level GlW2010. The statistically determined equivalent water level GlW2010 is based on the equivalent discharge (GlQ) of the 1991/2010 annual series with a underrun period of 20 ice-free days. Thereby a channel width of at least 50 metres is aimed for. In some sections, however, fairway width restrictions (≥ 35 m) with single-nave directional traffic are also accepted. [5]

During the outlining of the GKE, 19 objectives were formulated for the four work packages of water management, nature conservation, river regulation and riverbed stabilisation as well as transportation and sorted into five separate thematic areas with overarching objectives. Issues that could not be dealt with conclusively in the GKE were summarised in the supplementary thematic area of future considerations. The six thematic areas form the guiding principle of the GKE and are to be treated equally. Measures to realise the objectives of one thematic area must not hinder the objectives of the other thematic areas. The tasks of thematic area S ‘Improving navigation conditions’ include adapting or locally expanding the existing river regulation system to enable reliable use even at low water. Therefor the structures should be adapted as far as reasonably possible from an ecological point of view, e.g. by creating notches in groynes and by dismantling parts of the structure or bank protection. Topics relevant to shipping are also included in the future considerations, such as the further shift of large and heavy goods transport from road to waterways, the use of digital data (AIS/RIS) and systems to improve the economic efficiency of shipping, the examination of economic frame conditions for smaller transport units and shallow-draft vessels, the mean-water optimisation for transportation or the adaptation of water management to the consequences of climate change, e.g. by optimising storage management to increase the reliability of shipping conditions.

In 2017, the German Bundestag called on the Federal Government in its resolution on the implementation of the “Overall Strategy for the Elbe” to reach agreements with the Czech Republic on the fairway parameters of the inland Elbe and its maintenance as part of an intergovernmental agreement. This intergovernmental agreement on the maintenance and development of the international inland waterway Elbe came into force on 1st January 2025. The two nations thus confirm their intention to use the Elbe more intensively for the transport of goods, to coordinate the waterway planning of both nations and to harmonise transport use with the objectives of the European Water Framework Directive. The GKE and the regulations it contains on fairway parameters and the equal priority of all objectives and tasks of its guideline are decisive for the implementation of this agreement on the German inland Elbe. The Waterways and Shipping Office Elbe is therefore planning measures as part of an integrative approach in such a way that they achieve or maintain the traffic-related objective of a fairway depth of at least 1.40 metres below GlW2010 with variable fairway width and at the same time serve ecological and water management objectives.

3. Limits for Shipping

To ensure that cargo or passenger ships are able to navigate the inland Elbe unhindered, the river needs to carry enough water so that the navigation channel is sufficiently deep. The navigation channel must also be sufficiently wide so that the permitted ship types can navigate safely even in narrow river bends and pass oncoming traffic unhindered. In addition, the bridges need to be high enough to allow ships with large loads or high superstructures to pass underneath. Their actual usability for shipping mainly depends on the depth and width of the navigation channel. The flow control system is intended to ensure this use in the long term and for the entire inland Elbe. However, due to the natural displacement of material in the riverbed, the navigation channel is still too narrow or too shallow in places. Periods of low water amplify this problem and can occur throughout the year.

The inland Elbe has always been a river with long periods of low water, which usually occur in late summer and early fall. The dams built in the catchment area reduce extreme low water situations. Nevertheless, low water phases continue to occur, so that the GlQ is often underrun for longer than statistically determined. These deficits in the water supply could only be mitigated by very rigid management of the existing reservoirs or by the construction of new reservoirs with large volumes in the German catchment area.

On top of the low water phases, there are also local shallows in the navigation channel. These are caused by uneven sediment flow and often occur at the sides of the navigation channel, but sometimes also across the entire width of the waterway. The Inland Elbe is divided into the stretches E1 to E9, starting at the German-Czech border and ending at the beginning of the backwater area of the Geesthacht barrage near Lauenburg. The sections E4 (Elster estuary to Saale estuary) and E9 (Dömitz to Lauenburg) are particularly affected by local shallows due to their distinct morphodynamics. The shallowest parts of the navigation channel determine the depth of the navigation channel for an entire section of the waterway and influence shipping traffic for entire transport links on the Elbe – in the case of the E4 between Dresden and Magdeburg and in the case of the E9 between Magdeburg and Hamburg. Although the maintenance of the river regulation system has already achieved the maintenance target of at least 1.40 m below GlW2010 on over 90% of the Inland Elbe, the remaining shallows still reduce the reliability of the inland Elbe as a traffic route as agreed with the GKE. In the case of shallows at the sides of the navigation channel, it can be restricted on a case-by-case basis, taking into account the space requirements of the vessels. Vehicles with a length of up to 137.00 m and a width of up to 11.45 m can navigate with a channel width of 35 m in directional traffic in large parts of the Elbe. However, this width is usually not sufficient for longer or wider vehicles and for passing traffic.

The structural state and impact analysis and, if necessary, adaptation of the structures of the flow control system is the key to reducing local shallows. However, due to the large number of structures, this can only be done gradually. Currently, for example, only 35% of the groynes are at the design height (BWSoll2010) due to the age of the structures and the historical changes of the riverbed; 48% of the groynes upstream of the Elster estuary are too high and 65% in the Lower Middle Elbe are too low.

4. Conclusion

The Inland Elbe is mainly a free-flowing, dedicated federal waterway that is influenced by the natural water supply and distinct morphodynamics. It was agreed with the GKE to maintain the Elbe as a shipping route and to improve it by eliminating navigational limitations. Although the maintenance target agreed by consensus in the GKE has already been achieved in most parts of the Inland Elbe, the remaining shallows restrict entire transport links. This endangers contractual delivery dates and leads to a loss of trust among customers and competitive disadvantages due to rising transport costs for commercial users of the waterway. The Elbe is also a lifeline for the local shipyards, which produce the majority of all new inland waterway vessels in Germany.

With the regular, agreed maintenance of the river bed with its structures and their river regulating function are preserved in order to guarantee the agreed navigation conditions. Supplementary bed load management can also be used to remove local sediment deposits that determine the depth of the navigation channel. In stretches where neither structural maintenance nor bed load management can guarantee reliable navigation channel depths (e.g. El-km 508–521), adjustments to the river regulation system are necessary. For that the "Overall Strategy for the Elbe" identifies options for measures that can also support the ecological development of the river. Thereby the prohibition of deterioration of the value-determining habitat types and species of the respective Natura 2000 site, the prohibition of deterioration and the requirement to achieve the objectives of the status of the surface water bodies are taken into account and more than just minor impacts on flood protection are avoided.

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Potential and limitations of the „GKE“ for nature conservation

Guido Puhlmann

With ist beautifully preserved river landscape, the Elbe is one of the most ecologically rich and valuable environment in Central Europe for the preservation of natural biodiversity. The alternating high and low water levels characterize the Elbe's floodplain landscape, which is largely preserved by Central European standards. Regularly occurring floods can still cover large areas of the landscape, although the long-standing human influence on the structure of the Elbe and its floodplains have caused significant hydromorphological and ecological changes.

The extensive floodplain forest of the Steckby-Lödderitzer Forest is unique in Germany. It was first granted nature reserve status in 1955 and 1961. Respectively, before receiving international recognition in 1979 by UNESCO as one of Germany's first two biosphere reserves, covering 3,850 hectares. Later the reserve was expanded to include the Dessau-Wörlitz Cultural Landscape in 1988. It was enlarged again in 1990 as part of the "silverware of German unity" and legally designated as the Middle Elbe Biosphere Reserve In autumn of 1997. By then it included approximately 43,000 hectares of protzected riverlandscape. UNESCO internationally recognized a roughly 400 km long cross-border stretch of the Elbe River, as an extension of the existing area, to form the Elbe River Landscape Biosphere Reserve. Today four national biosphere reserves are embedded within this region: The Lower Saxony Elbe Valley, the Elbe-Brandenburg River Landscape, the Mecklenburg Elbe Valley, and the Middle Elbe Biosphere Reserve. Schleswig-Holstein also has a small share of the UNESCO Elbe River Landscape Biosphere Reserve, which currently covers a total area of 342,84 hectares.

The EU, the federal government, and the federal states are obligated to protect the interconnected European ecological network "Natura 2000." In particular, the preservation and restoration of the value-determining habitat types (HRT) and species must be ensured. The Elbe River basin is a key focus within Germany, with its high proportion of Natura 2000 sites, covering almost 90,000 hectares. Comparing Germany's major rivers with selected floodplain habitats, the Elbe River basin has the largest area covered by hardwood floodplain forests (HRT 91F0) in the country, with more than 9,000 hectares. Of particular note here are the extensive occurrences in the recent floodplain in the Middle Elbe region, which are still characterized by a favorable conservation status. With regard to habitat type 91E0*, which includes both willow floodplain forests and alder-ash floodplain forests, the Elbe river basin has the second largest share, after the Danube. This also applies to the most common grassland type in German floodplains, the lean lowland hay meadows (habitat type 6510), which cover an area of more than 9,000 hectares. The very rare stinging umbel floodplain meadows (habitat type 6440), which account for only 1% of grassland nationwide, are concentrated in the Elbe river basin. They cover an area of around 3,000 hectares, particularly around Dessau and Tangermünde, as well as in the floodplains of some tributaries in the Lower Middle Elbe region.

Near-natural river banks are still a common feature along the Middle Elbe. On unfortified sections of the river bank, lateral erosion appears and temporary islands are created by the relocation of sandbanks.

Large backwaters of the recent floodplain (habitat area 3150) also have their largest national share in the Elbe river basin. In addition, numerous floodplain species listed in the Habitats Directive and the EU Birds Directive occur in the Elbe river basin. The Elbe beaver *(Castor fiber albicus)*, which occurs there as an indigenous subspecies of the beaver *(Castor fiber)*, reaches its highest population density in the Middle Elbe region. For the Elbe beaver and the otter, the Elbe serves as an important supra-regional link between the individual populations.

The nature conservation value of the Elbe region is also reflected in the fact that there are three UNESCO RAMSAR sites (wetlands of international importance) on site oft he Mittelelbe Biosphre Reserve. According to the Elbe River Basin Association (FGG), a total of 1,137 water-dependent area, FFH areas with a total area of 8,605 km² and 28 water-dependent linear FFH areas with a total length of 1,689 km² were registered in the German Elbe catchment area by 2002. Additionally, a total of 136 water bird sanctuaries with a total area of 8,118 km² were registered by 2002. In the course of this the existing FFH areas and bird sanctuaries are partially overlapping.

"Gesamtkonzept Elbe (GKE)".

On January 17, 2017, the "Overall Strategy for the Elbe", the so-called "Gesamtkonzept Elbe" (GKE), was adopted by the federal ministries responsible for transport and environment and nine of the federal states in the Elbe catchment area. Its aim is to harmonize water management requirements, the protection of valuable natural habitat of the river and floodplains, and environmentally friendly transport use, while providing an overall positive development perspective for the Elbe river.

The following deficits for nature conservation were identified in the current analysis of the "GKE":
- Deficits due to floodplain and landscape use
- Conservation status of the habitats of the recent floodplain
- Conservation status of the floodplain grassland
- Deficits due to riverbed erosion and foreland elevation
- Deficits due to power and hydraulic engineering, waterway maintenance, and flood protection
- Pollution
- Impairments due to recreational and leisure use and tourism

Since the end of the 1990s, changes in the landscape water balance and runoff conditions in the entire Elbe catchment area have been precisely observed towards increasingly dry conditions.
Since the very dry years from 2017, a sometimes "rapid" landscape change along the Elbe and its floodplains, which is now undoubtedly caused by climate change, has been evident. In particular, highly water-dependent species, such as amphibians and aquatic insects are suffering under the conditions. Species accustomed to times of better water supply, such as oaks *(Quercus robur)*, are experiencing major adaptation problems. In addition, "novel" tree diseases such as ash dieback affecting *Fraxinus excelsior* and maple species are leading to large-scale tree losses. From 2013 to 2023 there were no significant flood events over a long period, for the first time in traceable history. This meant that parts of the extensive floodplains lacked the previously large "regular" flooding.
The above-mentioned deficits and problems identified as a result of centuries of land use limit the resilience of the river-floodplain system to the aforementioned challenges and thus also the ability to adapt to climate change.
Eliminating these deficits as far as possible while utilizing the unique potential of the "GKE" is the most important generational task and challenge for the preservation and development of the unique ecosystem along the German Inland Elbe.

Implementation of the "GKE".

The "GKE" has been implemented by the federal and state governments, as well as business and environmental associations, starting in 2017. The equal treatment of the objectives of water management, shipping/waterways, and nature conservation forms the framework for action and sets limits for the respective interests. Using waterway maintenance and activities to reduce riverbed erosion as examples, the interactions between nature conservation and waterways are identified and briefly presented below.
A key component of the "GKE" are guidelines for the work packages of water management, nature conservation, riverbed management/riverbed stabilization, and transport. The following Guidelines A, B, and C for nature conservation (NA) and B, C, and D for riverbed management and riverbed stabilization (ST/SO) are closely linked in terms of content and practical implementation.

NA A. Achieve favorable conservation status for habitat types and species in the riverbed and riparian zone (Natura 2000 conservation objectives, aquatic ecological functions), improve water structure (promote morphodynamics, reduce fixed bank structures)
NA B. Improve horizontal (lateral) connection of floodplain waters and tributaries for a more ecologically effective connection between river and floodplain (Natura 2000 coherence, floodplain ecological functions)
NA C. Avoid further vertical decoupling through deep erosion to restore the functional coupling of river and floodplain (Natura 2000 conservation objectives and coherence, floodplain ecological functions), near-natural water level dynamics
ST/SO B. Riverbed stabilization through cross-sectional widening (including forelands according to the riverbed stabilization concept) and optimization of the river control system in the mid-water zone to reduce erosion, subsequently stabilizing water levels, and to even out sediment transport

ST/SO C. Riverbed stabilization by reducing the bedload deficit
ST7SO D. Ecological optimization of river structures while maintaining/improving the control function

Waterway maintenance as part of the implementation of the "GKE".

Since 1990, waterway maintenance has been closely coordinated between the Waterways and Shipping Authority, the district authorities, and the biosphere reserve. The latter has been gradually expanded from 40 to 400 kilometers of river during this time. Since then, valuable experience has been gained through the ecological redesign of more than 200 structures, particularly regarding success factors, design principles and designoptions. Since 2017, maintenance has been carried out in accordance with the aforementioned GKE guidelines and action options on 600 kilometers of the German inland Elbe.

Opportunities:

- Experience has shown that the competent, preferably proactive implementation of river management guidelines "almost always automatically" leads to a positive contribution to the implementation of the aforementioned nature conservation guidelines.
- The fewer horizontal and vertical river structures that limit river and floodplain dynamics are present, the better is the ability of dynamic and structural processes to function.

➜ Due to these processes typical river and floodplain structures will be continually reshaped.

According to our shared experience, success factors for maximum exploitation of ecological design options are:

- Proactive use of the experience and knowledge potential of all actors, combined with trusting collaboration – Only good, courageous engineers open to unconventional ideas can produce good solutions.
- Courage to use trial and error methods, possibly with subsequent adjustments; local failures are defined as an important experience that has to be analyzed.
- "Climate reserves" must be defined and, where possible, considered and incorporated. The ecological adaptations of the structures should still function decades from now.
- The generational change within the respective workforce must be supported in terms of content and professionally organized in a precautionary manner. Promote knowledge transfer, action- and negotiation skills.
- All available options for erosion control must be exploited in the erosion zone.
- A resilient, long-standing or existing relationship of trust between the stakeholders is very helpful.

Fig. 1: *Landside groyne opening near Lutherstadt Wittenberg – partially dried out at low tide but with water-filled scours, notch depth may need to be adjusted downwards.*

***Fig. 2:** Very successful groyne opening and double island-layout at low tide (near Apollensdorf/Wittenberg), regular breeding ground for oystercatchers and sandpipers.*

***Fig. 3:** Buckling-groyne with opening at low water, near Vockerode (below the A9 bridge) – Groyne opening must be lowered further, remnants of former bed reinforcement at the notch base and the landward embankment will be removed in the process.*

Limits of ecological design in context of waterway maintenance:

- Maintaining the functioning of the Elbe federal waterway with the agreed objectives of the GKE sets limits on the ecological transformation of the waterway as a whole and of individual structures.
- A significant minimum number of functional structures with a secure regulatory function will continue to be required to maintain navigation.

The fundamental contradiction between the more static conditions necessary for the waterway within minimum limits, which limit the dynamics of the flowing water, and the ecologically necessary dynamic conditions remain despite the "GKE". The scope for action between these two poles, jointly but reliably defined by the "GKE", are far greater than before. They can and must be designed by outstanding engineers!

Containment of bed erosion – implementation of bed stabilization concept as part of the "GKE".

Controlling riverbed erosion is of vital importance for the ecological functioning of the water-dependent river/floodplain ecosystem in the UNESCO Biosphere Reserve and the UNESCO World Heritage Dessau-Wörlitz Garden Realm. Erosion control is also a key task of the Federal Waterways Administration. Mrs. Kühne, WSA Elbe, will present this joint approach in more detail later on during this event.

Opportunities:

- The shared interest in erosion control led to the joint development of the Elbe Riverbed Stabilization Concept. Furthermore it initiated the joint implementation and joint work in the Federal-State Working Group on Riverbed Stabilization since 1996.
- The annual bedload addition effectively reduces the bedload deficit, a major cause of riverbed erosion.
- The contributions of existing waterway structures to erosion are effectively reduced as far as possible and in some sections, as part of maintenance and special measures.

Limitations:

- The need to constantly ensure the safety and ease of navigation in all river reaches, as a key task of the federal waterway, limits the timing, duration, and extent of bedload addition in years of low discharge.
- Maintaining the federal waterway fundamentally limits the possibilities for the reconstruction and dismantling of erosion-promoting river structures, as well as large-scale erosion mitigation options associated with changes in flood protection. However, what is already possible in this area under the conditions of the waterway is in itself a task for generations that exceeds the planned duration of the "GKE".

Conclusion.

Within the framework of the "GKE", the Waterways Administration provides significant support for the conservation and development of the floodplain ecosystem in the Elbe river. Compared to nature conservation authorities and NGOs, the Waterways Administration has extensive technical and human resources and is therefore a strong partner for the implementation of future projects.

The resulting opportunities for both interests are defined by the "GKE" for the coming decades and represent a generational task as an opportunity and obligation (the equally significant three-way synergies with the water management sector are not detailed here but are at least briefly mentioned).

This requires contributors on both sides who are open to the continuous development of new solutions and the further improvement of techniques that have been tried already. If all protagonists can maintain and expand the existing relationship of trust in the search for working solutions with mutual understanding and mutual appreciation, the interests of society along the Elbe will be exceptionally well served. All in all the "GKE" offers a reliable framework and a unique historical opportunity.

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Possibilities and limits for reducing bed erosion of the river Elbe

Elke Kühne

On the Middle Elbe between the towns of Mühlberg and Coswig/Anh., the bed of the Elbe has deepened by an average of one meter over a period of more than 100 years. These erosion trends, which continue further downstream to the mouth of the Saale, pose an increasing threat to the stability and thus the functionality of the river control system. Erosion also has a negative impact on the groundwater balance close to the banks and the floodplains with their sensitive habitats as a result of the drop in mean water levels.

In 2009, the Waterways and Shipping Administration, together with the states of Saxony and Saxony-Anhalt, developed the riverbed stabilization concept. This identified measures to curb river bed erosion, which were to be implemented as part of structural repairs and on a larger scale in pilot measures on the Elbe.

The overall Elbe concept was adopted in 2017 to support this. In it, the containment of river bed erosion was formulated as one of the main tasks for implementing the GKE.

The implementation of the riverbed stabilisation concept for the Elbe between Mühlberg and the mouth of the Saale is being technically supported by a working group consisting of representatives of the General Directorate for Waterways and Shipping (GDWS), Magdeburg office, the Elbe Waterways and Shipping Office (WSA), Dresden office and the Federal Institutes of Hydrology and Hydraulic Engineering (BfG and BAW) as well as representatives of the states of Saxony and Saxony-Anhalt

Current work is focussed on the implementation of bed load addition and management as well as their evaluation and continuous adaptation. Structural measures include the ongoing repair work on groynes, revetments and parallel structures as well as bed stabilisation measures, which are adapted to the current water levels and provide additional flow relief for the fairway area by installing sinks. Another set of measures includes the planning and implementation of pilot measures. The Klöden pilot measure is currently being planned. It includes structural measures at the river structures, river bed stabilisation measures and in the foreshore area and thus affects the entire discharge cross-section. Due to their complexity and the inclusion of the foreshore areas, these measures require a planning approval procedure under current law.

1. Bedload management

Bedload management in the erosion section basically comprises

- Relocations (“channel dredging”):
    - Over 90 % of these relocations are returned within 5 km of the extraction site,
- Bedload addition with material from:
    - Gravel pits and similar
    - Tributaries (below the erosion section)
    - Aftercare after extreme flooding outside the erosion section (Upper Elbe)
    - Activations/removals in side areas outside the strike lines, in particular groyne fields.

The results for the period 2018 to 2024 are presented here.

In addition to bed load relocation, which is carried out in accordance with shipping requirements along the river Elbe, bed load addition is carried out in accordance with defined addition rules. These rules are directly dependent on the discharge conditions and therefore the bed load in the Elbe. For the section from Elbe km 121 to Elbe km 198.6, these are summarized in Table 1.

In the years 2018 to 2024, a total of 830 kt and an average of around 119 kt per year were moved. Around a third of this (280 kt (brutto)) can be regarded as bedload additions, of which around 274 kt (netto) can be regarded as erosion-reducing. In 2023 and 2024, additional external additions of material from outside the Elbe and its tributaries totaled 150 kt. In comparison, the average annual load for this period at the Aken gauge is 133 kt per year.

Tab. 1: *Rules for the addition quantities depending on the water level for Elbe section from Elbe – km 120.913 to 198.5 section*

Water level	Addition	Average addition duration [days on which the water level is reached or exceeded]			discription
level Torgau	quantity				
cm	t/d	Jahresreihe	Jahresreihe	Jahresreihe	
		2003/2012	2011/2020	2001/2020	
ab 170	300	130	130	168	W1 start of addition
ab 200	450	110	95	129	W2
ab 220	600	89	77	110	W3
ab 290	900	46	35	60	W4
ab 400	1200	21	10	22	W5
bis 620	----	----	1	2	HSW – Stopp

In 2018 and 2019, material from the interim storage facilities on the Upper Elbe was mainly used as bed load input (76 kt in total). In addition, in all years except 2020, a total of 49 kt (netto) of material was added from the side areas (groyne field clearing), construction measures (excess sandy or gravelly material from old groyne cores) and port dredging. This was taken into account with 25 %. As this material was already in the bed load cycle. Figure 1 provides an overview of the quantities of bedload added as a result of bedload management and thus the sum of bedload addition and bedload relocation.

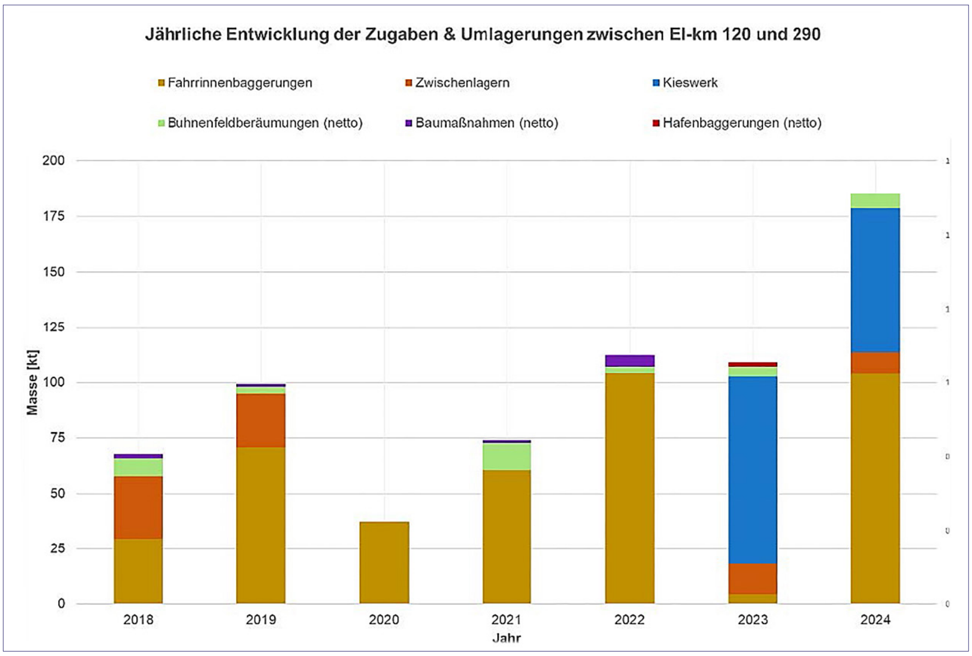

Fig. 1: *Addition and transfer volumes in the erosion section in the period 2018 to 2024*

As there have been frequent periods of prolonged low water in the recent past and this can also be expected in the future, alternative methods were sought to add the necessary quantities to the Elbe. In 2023 and 2024, the first tests were carried out with landfill on revetments. The sediment is placed on revetments to a height of approx. 1 metre above the top edge of the revetment. During floods, the river can absorb the material and thus compensate for the bedload deficit according to the actual water flow. Figure 2 shows an example of the filling of a sediment dump over time.

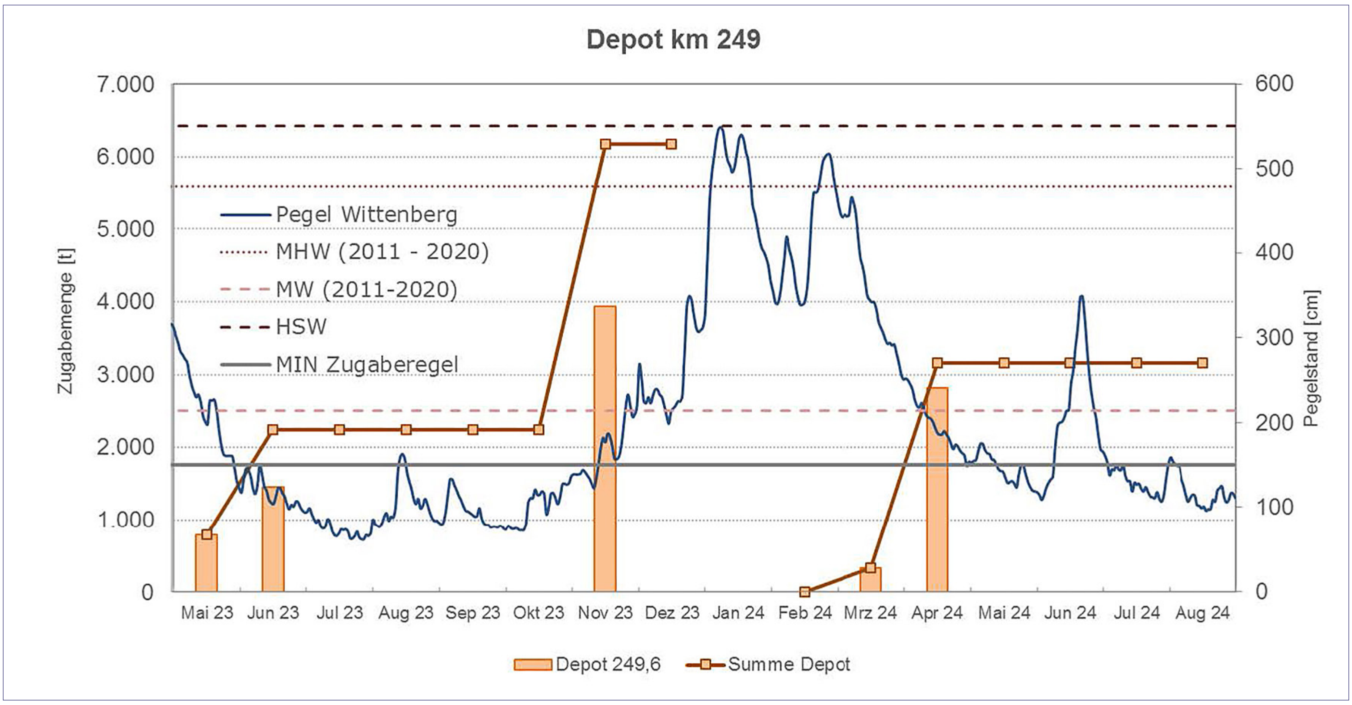

Fig. 2: *Illustration of the depot filling at Elbe km 249*

2. Building restoration

In the last seven years, 55 groynes in the erosion section have been adapted to the current water level conditions. In addition, sinks have been built into the groynes to relieve the discharge cross-section or channels have been constructed for the flow behind the control structures. These measures improve the flow through the groyne field areas and initiate redistribution processes in the groyne fields, which counteracts siltation. Figures 3 and 4 show adapted groynes with their hydraulic effect.

Fig. 3: *Groyne no. 5, El km 247.385 left Date 10.04.2024, Wittenberg level = 175 cm*

Fig. 4: *Groyne 31, El km 187.397 right Date 22.05.2024, Torgau level = 102 cm*

3. Pilot project Klöden

The Klöden pilot measure is located in the upper Middle Elbe and covers the section El-km 184.0 to El-km 198.5. In 2020, the original study area, which stretched from El-km 185.5 to 196.6, was extended by 3.4 km. Since the end of the 19th century, the section has been characterised by severe river bed erosion with deepening totalling approx.

1.6 m, which has had a negative impact on the use of the Elbe as a waterway as well as on the natural environment of the Elbe. On the basis of model studies on solids transport and discharge behaviour, the BAW examined and evaluated the short-term and long-term effects of the optimised variants of measures developed by the 'Working Group on the Implementation of the Riverbed Stabilisation Concept'. The results were available in 2024.
The majority of the WSV's planned erosion-reducing measures will be implemented by adapting the existing control system as part of the structural maintenance in accordance with §8 BWaStrG. These are groyne adjustments in height and length, the installation of sinks and channels, the opening of parallel structures, the dismantling of unneeded parts of the structure and measures to secure the bed such as the installation of ground sills or coarse grain enrichment. Furthermore, measures are planned that involve the utilisation of foreshore areas and therefore require planning approval in accordance with § 9 BWaStrG. These are the bank excavation in the Klödener Bogen, the conversion of a revetment into a backflow parallel structure and the connection of flood channel structures. The documents required for this planning step are currently being compiled.
The entire package of measures is being planned jointly with the federal state of Sachsen-Anhalt and the Heinz Sielmann Foundation, which is realising the connection of the Bösewig oxbow lake and the Klödener Riss in the project area as part of a large-scale nature conservation project.

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'Elbe Reststrecke' – Opportunities and Limitations of Development Projects

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1. Introduction

The 'Gesamtkonzept Elbe' (GKE) is the strategic concept for the development of the inland Elbe River and its active floodplains from the German-Czech border to the Geesthacht barrage. According to the GKE, the inland Elbe River will not be developed solely to improve navigation conditions; however, river engineering measures are accepted if they serve ecological, water management as well as transport objectives and reconcile them effectively [1]. This guiding principle also applies to conflict-prone stretches, such as the 'Elbe Reststrecke' (approx. Elbe-km 508 to 521). In this stretch, extending up to about Neu Darchau (approx. Elbe-km 536), navigation is particularly challenging due to the presence of so-called free alternate bars, which form in the 'Elbe Reststrecke' and migrate periodically downstream [2]. This hinders the establishment of a stable navigation channel with a depth of at least 1.40 metres below the equivalent water level (GlW 2010), a low flow reference water level. The ecological status of the surface water body (SWB) including the 'Elbe Reststrecke' has been classified as moderate [3], indicating that good ecological status, one of the objectives of the Water Framework Directive (WFD), has not yet been achieved. The Waterways and Shipping Administration (WSV) has initiated a project for the sustainable development of the 'Elbe Reststrecke' and its banks. This project is designed to improve both hydromorphological conditions of the river and its banks and navigation conditions for freight and passenger shipping as well as sport and leisure shipping, taking advantage of the strategic framework outlined in the GKE and the 2021 amendments to federal waterway and water management legislation.

2. Need for Interdisciplinary Action, Objectives and Constraints

The 'Elbe Reststrecke' and its banks are located in the former German-German border area in the federal states of Mecklenburg-Western Pomerania and Lower Saxony, roughly between Damnatz and Hitzacker (Elbe). In the section of the Lower Middle Elbe River (approx. Elbe-km 508 to 521), the low water regulation was not carried out in the coarse and fine river training. As a result, the regulation line – defined as the distance between the theoretical connection of the right and left groyne heads – is currently approximately 25% wider than in the neighbouring river sections. Due to the greater width-to-depth ratio, resulting from the unfinished river training, free alternate bars form in the 'Elbe Reststrecke'. These large-scale (length > 500 m; height up to 3 m), mobile morphological bedforms migrate periodically downstream at speeds ranging from 200 to 600 meters per year to about Neu Darchau (approx. Elbe-km 536) [2]. Due to their size and dynamics, these alternate bars represent an obstacle to navigation and require increased maintenance effort, for example with regard to the continuous relocation of navigation signs. Due to the migrating alternate bars, it is not possible to provide a stable fairway with a depth of at least 1.40 metres below the equivalent water level (GlW 2010) and a width of approx. 50 m. The river section E9, which is part of the core network of the Trans-European Transport Networks (TEN-T), is the limiting section in terms of fairway depth on the route from Wittenberge to the Geesthacht barrage (inland waterway class VIb).

The ecological status of the SWB including the 'Elbe Reststrecke' has been classified as moderate [3]. As a result, the SWB is at risk of failing to achieve good ecological status, one of the objectives of the WFD. Alterations to structural, i. e. morphological, characteristics and associated impacts on the water flow and level regimes (i.e. hydrological characteristics) are among the pressures to all SWBs in the Elbe River basin district (Elbe RBD). Main pressures on the SWB 'Elbe (Geesthacht to Rühstädt)' include physical changes to the riverbed and its banks, which result in changes to habitats. Among others issues, required standards for good status under the WFD of the supporting quality element 'morphology' are not met [3].

2D modelling of the Lower Middle Elbe River between Wittenberge and Geesthacht identified five bottlenecks between the dykes that have a negative impact on the 'Elbe Reststrecke' in the event of flooding (HQ_{100}) [4]. For example, there is a reduction of width between the dykes to 72 % at Strachau (approx. Elbe-km 518). The modelled HQ_{100} flood event shows a change in water surface gradient. Above the bottleneck, a backwater effect occurs with increased water levels and a lower gradient. In the flow pattern, the modelled depth-averaged flow vectors with higher flow velocities confirm the bottleneck [4].

The project area is a designated protected area in the EU-wide ‘Natura 2000’ network. To address the ongoing decline in wild species and natural habitats across the EU and to conserve biodiversity, the Birds Directive (1979) and the Habitats Directive (1992) were adopted. Core provisions in both of these relate to the designation of protected areas for certain threatened species and habitat types of community interest. The aim of the Habitats Directive, for example, is to conserve biodiversity in the European Union to ensure that species and habitat types are maintained, or restored, to a favourable conservation status. In the ‘Elbe Reststrecke’, some of the characteristic habitat types, such as ‘Rivers with muddy banks with Chenopodion rubri pp and Bidention pp vegetation’, are not yet in a favourable conservation status [5].

The deficits mentioned show that there is a need for interdisciplinary action here. The WSV is pursuing the goal of implementing the ‘Gesamtkonzept Elbe’ in this section of the river. According to its sovereign responsibility, the WSV aims to improve both the navigation conditions and the hydromorphological conditions. The measures aim to achieve a stable navigation channel with a depth of at least 1.40 metres below the equivalent water level (GlW 2010) and a width of approx. 50 metres at the equivalent water level (GlW 2010) in accordance with the maintenance target. The planning also aims to implement hydromorphological measures in the river and its banks in line with the updated Programme of Measures for the Elbe RBD, published under Article 11 of the Water Framework Directive (WFD), which outlines actions required to achieve good ecological status in the SWB ‘Elbe (Geesthacht to Rühstädt)’ [6]. In addition to the objectives, planning constraints were defined which refer to conditions that limit the scope or possibilities of planning, such as the availability of land.

3. Current State of the Planning Process

In 2022, a conceptual preliminary study was published for the implementation of the ‘Gesamtkonzept Elbe’ in the ‘Elbe Reststrecke’ and its banks, which was developed in cooperation with the responsible authorities for river regulation and transport, water management and nature conservation. The WSA Elbe, together with the Federal Waterways Engineering and Research Institute (BAW) and the Federal Institute of Hydrology (BfG), is currently preparing a variant study as the second part of the study agreed under the GKE on the options for adapting this section of the Elbe in line with transport and ecological goals. In 2022 and 2023 in particular, the WSV invited regional stakeholders and the public to several events in the project region to contribute their expertise and local knowledge to finding solutions.

The variant study will publish, among others, the planning variants for the development of the ‘Elbe Reststrecke’ and its banks as well as the criteria for their evaluation. All variants include river training measures to improve the structural characteristics of the Elbe River including its banks and to improve the connectivity of the river and its floodplain, for example the (partial) removal of bank protection and the reconnection of oxbow lakes. The oxbow lakes are reconnected to the Elbe River below mean low water (MLW) in a slightly meandering course with different bed and bank slopes. The planned connection at both ends resets them an early state of succession allowing them to develop near-naturally over time. The variants differ in the design of the river training measures intended to narrow the regulation line. All variants include the extension of existing groynes at MLW. In variants 2 and 3, traditional groynes, i. e. the stone structures extending from the bank into the river, will be removed and replaced by longitudinal training walls (LTWs) in some areas. The positioning of the LTWs is parallel to the flow along the new regulation line. The LTWs create a main channel and a secondary channel that already carries flow at mean low discharge (MLQ), influencing water flow and sediment distribution. They are designed to meet the maintenance target in the main channel of at least 1.40 metres below the equivalent water level (GlW 2010), i. e. to provide a fairway of sufficient depth and width. The replacement of groynes with LTWs improves the structural characteristics and associated impacts on the water flow and level regimes. This helps to reduce flood peaks and improves hydromorphological conditions by creating different currents and diverse habitats in the secondary channel. In variant 3, the river training structures are further ecologically optimised, e.g. through island-like LTWs with different widths and heights as well as chevron-like and notched groynes. Variant 3 also provides for an increase in structural diversity through the safe installation of deadwood and the addition of gravel in the reconnected oxbows and the secondary channels of the LTWs.
Extensive research, including numerical and physical modelling [7] and field studies, has been conducted to understand the effects of LTWs on flow, sediment transport, and river morphology. The LTW in the Oder River near Reitwein is one example of how this research has been successfully put into practice (see Fig. 1).

Fig. 1: *Longitudinal training wall (LTW) in the Oder River near Reitwein. Aerial image looking upstream taken by the WSA Oder-Havel on 23 August 2024 with different currents and diverse habitats in the secondary channel (W = 141 cm [+8 cm to MLW] at reference gauge Frankfurt1 (Oder), 23 August 2024 09:30)*

4. Discussion of Opportunities and Limitations

The 'Gesamtkonzept Elbe' (GKE) is a supplementary coordination and planning instrument that aims to identify joint solutions in the interdisciplinary consideration of water management, ecological and shipping interests. In 2017, the federal and state governments adopted the GKE as the guiding framework for the next 20 to 30 years of administrative planning. The GKE and its follow-up process are a suitable framework for action to develop joint sustainable solutions. The task now is to implement mutually acceptable solutions in local projects. The integrated planning for the implementation of the GKE in the area of the 'Elbe Reststrecke' and its banks by the WSV taking into account current data and, for example, climate change, is an opportunity for sustainable development in this region. The 2021 amendments to federal waterway and water management legislation have expanded the responsibilities of the WSV. This increases the scope for action and the opportunities for the WSV to implement measures that improve navigation and hydromorphological conditions in a coordinated and holistic way. Desired dynamic development processes represent a particular challenge for planning and modelling by BAW and BfG. However, limitations exist to self-dynamic development, for example in terms of land availability. The Elbe River and its floodplains are a valuable natural habitat. Accordingly, the conservation and restoration of habitats and habitat types in the river and its banks represents both a constraint and an opportunity to make the 'Elbe Reststrecke' and its banks fit for the future as a joint task, for example through targeted cooperation between the responsible authorities.

Public participation is a crucial component for the successful planning and implementation of projects. The public participation carried out in recent years for the development of the 'Elbe Reststrecke' and its banks in the region demonstrates that it can generate valuable opportunities, while also facing practical limitations. As a result of the discussions with stakeholders on finding joint solutions, local knowledge and expertise have been incorporated into the planning and have improved it. However, considerable human and financial resources were required for the extensive public participation to find joint solutions in several local events. Thus, cost-effectiveness also becomes a limiting factor in public participation.

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Low-Flow Impacts on Middle Elbe Navigation: A Hydro-Economic Modeling Approach

Lukas Folkens

1. Reference to the Original Article

This contribution is a condensed version of an article by Folkens et al. published in Water in 2024 [1]. The contents reproduced here therefore refer directly to this original article and should not be understood as a detached scientific study. For a complete presentation of the contents, particularly the comprehensive description of the hydro-economic model approach and the results, please refer to the original article.

2. Background

The dry summers of 2018 and 2019 caused new low-flow extremes in many European watercourses, both in terms of duration and height. Due to climatic changes and anthropogenic factors, these phenomena are also expected to intensify in the future [2,3]. Hydrological droughts reduce the water levels in rivers and thus impair the transportation of goods and passengers. The hydro-economic model presented here quantifies the resulting economic damage with a focus on navigation on free-flowing waterways. It considers hydrological and economic input variables, presents damage functions and quantifies capacity utilization states and downtime costs. A simulation was carried out for the period from 2012 to 2020, using the middle Elbe as a test example. The main results are reproduced here.

3. Model Approach

The key parameters for navigation are draught and fairway depth. Based on a 1D hydrodynamic river model, the damage model is combined with economic data (transport volumes, ship types with draughts, cost rates), as can be seen in Figure 1.

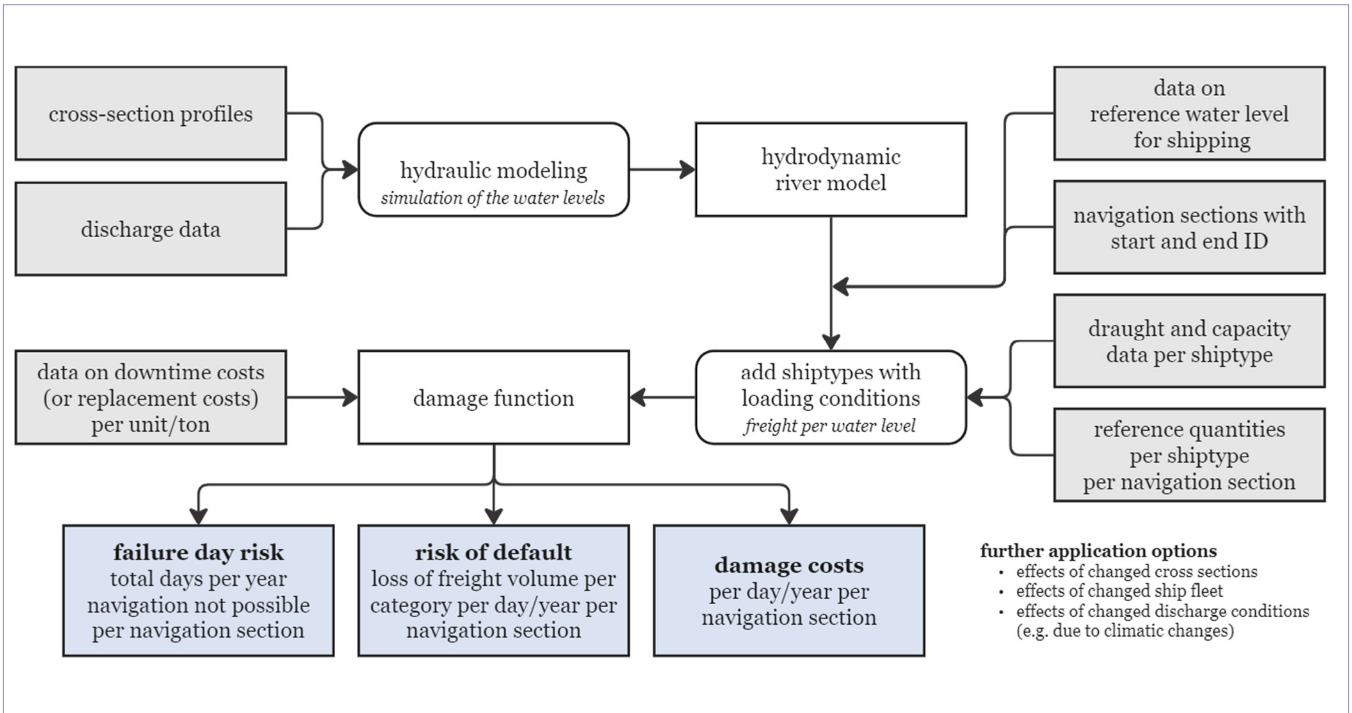

Fig. 1: *Hydro-economic modeling approach to assess low-flow impacts on river navigation. [1]*

The model calculates the utilization of ships and the associated economic losses for defined river sections based on the undercutting of defined reference water levels (e.g. the equivalent low water level GlW). This interdependent damage function is calculated using differences between possible and actual transport capacity and their evaluation with specific damage cost rates. As an example, Figure 2 shows the utilization states of a cargo ship with a maximum load capacity of 1500 t.

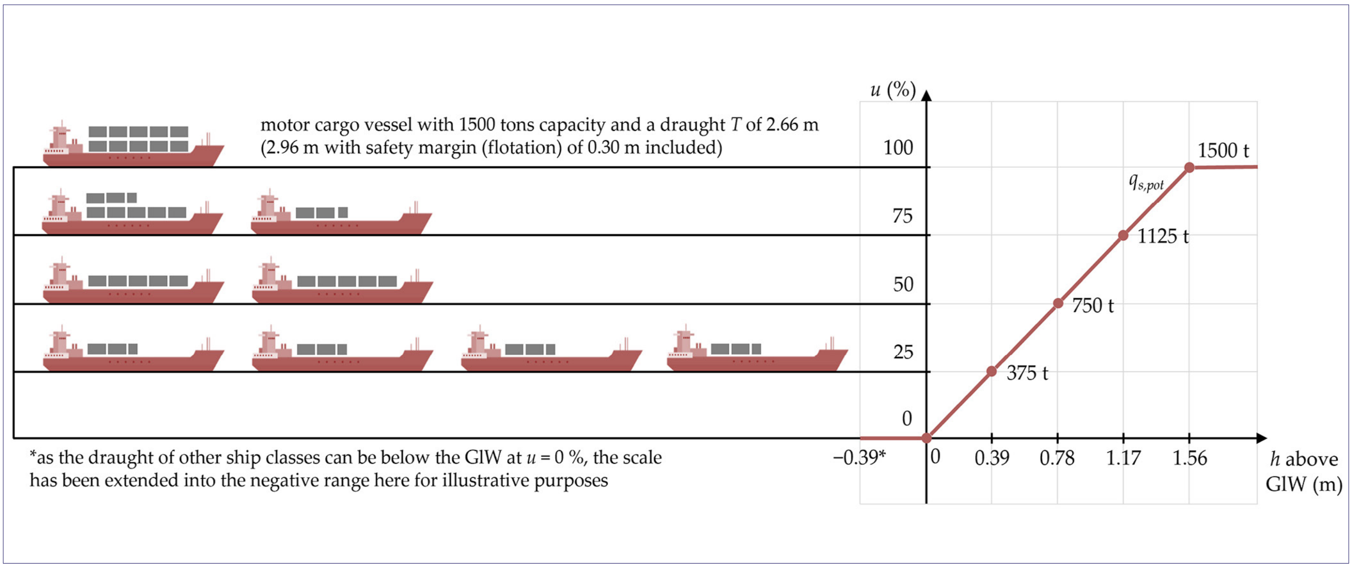

Fig. 2: *Utilization of a motor cargo ship with a capacity of up to 1500 t at different water levels above GIW. [1]*

This approach allows statements to be made about capacity utilization at certain water levels and therefore also about days of downtime. The tons that are not transported can be valued economically using the damage cost rates.

The model approach is variable in its application, which means that input variables such as reference water levels, ship types, cost rates and the like can be adapted by users depending on the application.

4. Results for the Middle Elbe

The model approach was tested for the study area of the middle Elbe, which stretches from Riesa (km 96.0) to the Geesthacht barrage (km 585.9) and includes river sections E3 to E9. In this area, the river can be characterized as a free-flowing lowland river whose water supply is subject to natural seasonal fluctuations. In the characteristic low-flow year of 2018, the Elbe had a fairway depth of less than 1.40 m in some sections on more than 230 days a year and was therefore impassable for most cargo ships for two thirds of the year. Data on the historical days of low-flows can be found in the Electronic Waterway Information Service (ELWIS) of the Federal Waterways and Shipping Administration of Germany (WSV) [4]. Especially calibrated for extreme low-flow years, our hydrodynamic model reproduces these scales well for the relevant years and shows a variance of 0 (E9) to 10 (E6) days for the individual sections in 2018. Critical sections with particularly frequent reference value shortfalls are E8 and E9 (e.g. between Dömitz and Hitzacker), which can, however, be bypassed via the Mittelland Canal and the Elbe Lateral Canal.

Various ship types (motor cargo ships, pushed barges) with typical draughts were modeled for freight transport. Data from the transport volume visualization tool TraVis of the Federal Waterways Engineering and Research Institute (BAW) was used for the reference transport volumes. Depending on the water situation, there is a reduction in the load and thus the transport volume (see Figure 2). The resulting losses were assessed using various damage cost rates (e.g. EUR 8.50/t according to Jonkeren et al. (2007) [5] or EUR 200/t according to an AI estimate).

Figure 3 can be used as an example to illustrate the results for freight navigation. The section analysis shows that E8 and E9 were consistently the most critical areas, which is due to the hydrological conditions described. As can be seen from the figure, the average damage values are close together over the years, except for the flood year 2013. The highest average annual damage occurred in 2018, 2019 and 2020.

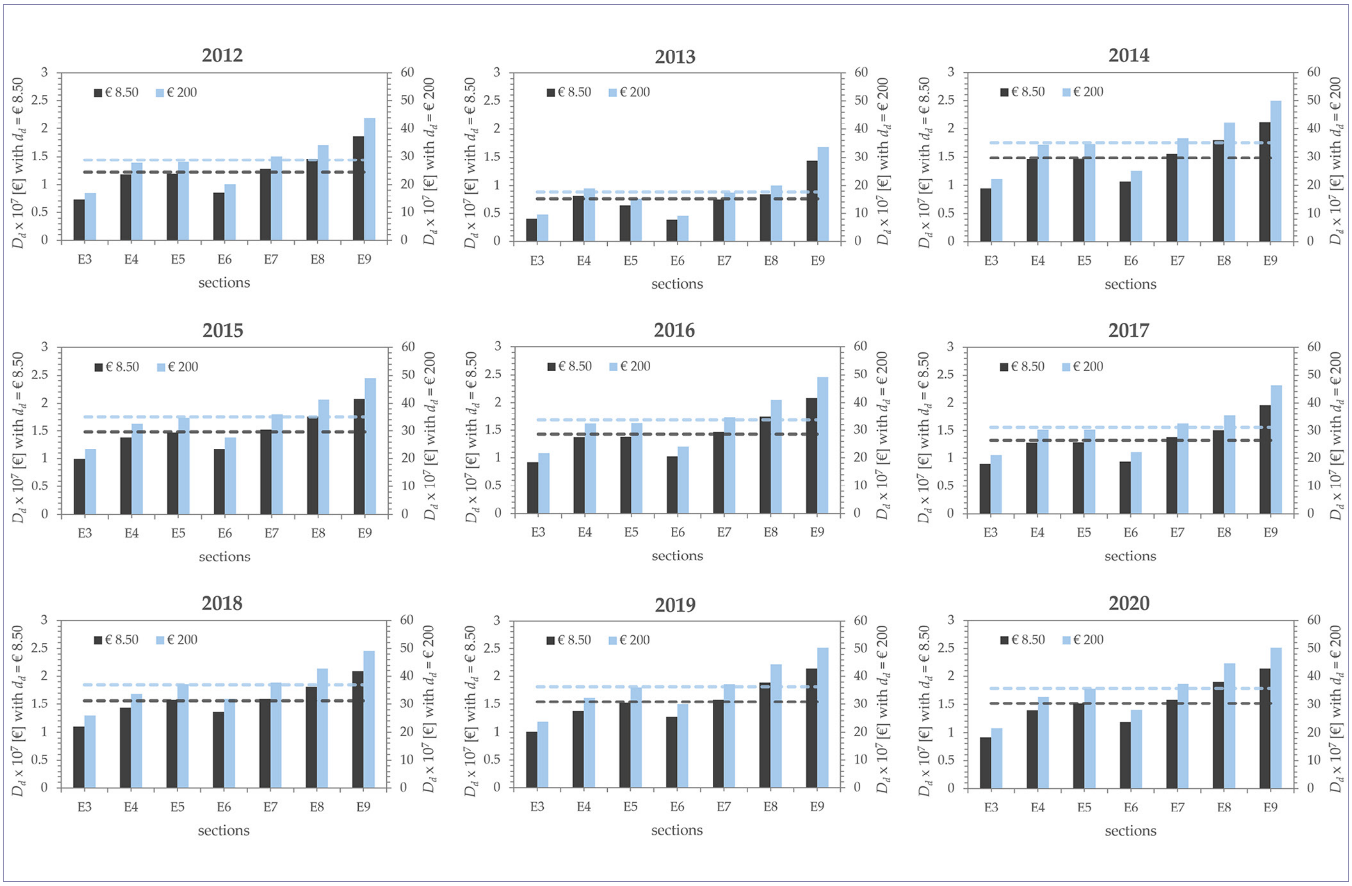

***Fig. 3:** Damage costs Dd,sec,year (10 million EUR/a) for cargo shipping in Elbe sections E3 to E9 for the years 2012 to 2020 calculated with the transport volumes of 2010. [1]*

Considering the cost rate of EUR 8.50 per ton, this results in costs of EUR 16 million for 2018, for example. However, it is striking that 2014 also had similarly high costs as the extremely low-flow years. This is because, although there were only a few GlW shortfalls overall in this year, the water levels were only just above the GlW for long stretches of the year, meaning that navigation was also severely restricted. This is further illustrated by Figure 4.

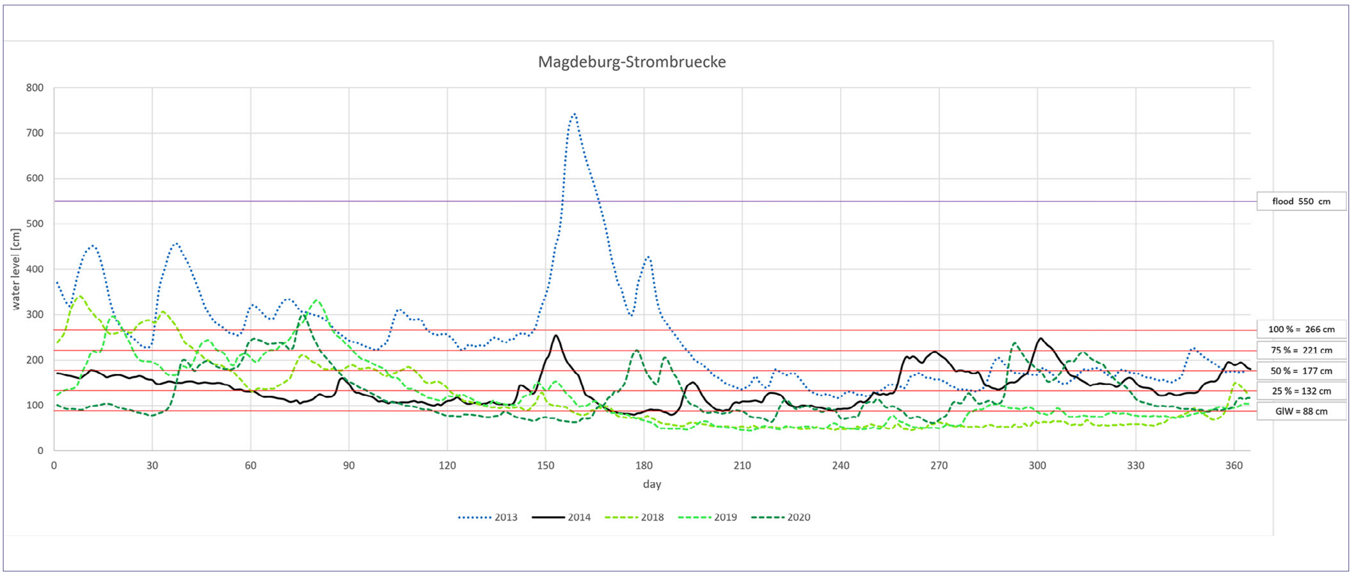

***Fig. 4:** Modeled water level hydrographs for the years 2013, 2014, 2018, 2019 and 2020 for the Magdeburg-Strombruecke gauge with load conditions for a motor cargo vessel with a maximum carrying capacity of 1500 tons. [1]*

Using the example of the extreme low-flow year 2018, the GIW shortfalls affected almost the entire second half of the year, but high utilization levels of up to 100 percent were achieved in the first half of the year. In contrast, although there were only a few GIW shortfalls in 2014 overall, there were also only short periods with high utilization levels.

For the modeling of tourist shipping, data from the WSV for the Magdeburg city route was used as an approximation for the entire study area. A different picture emerges here, as tourist ships require lower fairway depths overall (≈ 1.20–1.40 m). As a result, the extreme low-flow years are more significant in this analysis. With an assumed loss of EUR 50 per passenger (incl. ticket and catering), the highest losses (EUR 5.6 million) were calculated in 2018. In 2013, on the other hand, no damage costs were incurred in sections E3 and E6 according to the model. In addition to sections E7 to E9, section E4 stood out as particularly vulnerable in the section analysis.

5. Conclusions

The model approach presented offers a practicable option for the monetary assessment of low-flow damage for free-flowing waterways such as the middle Elbe. It shows that not only extreme water level shortfalls, but also long-lasting moderate restrictions cause relevant damage. For the years 2012 to 2020, the modeled losses add up to EUR 152 million (freight and passengers, at EUR 8.50/t). Concrete applications arise, for example, for the development of ship types suitable for low-flow, the modeling and evaluation of various discharge scenarios (e.g. inclusion of climate projections) or the evaluation of maintenance measures. As part of a holistic risk assessment, the model approach can help decision-makers to understand the interactions between waterway management and the economy and to develop resilient adaptation strategies. Uncertainties so far include the accuracy of the GIW data (change due to sediment dynamics), the assumptions on damage cost rates and the actual utilization of ships.

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Environmental and Climate Impacts on Sediment Management in the Port of Hamburg

Judith Sprenger

1. Seaports are at the heart of the energy transition

Modern, sustainable, safe and efficient seaports are an important component and necessary prerequisite for economic success, security and the successful implementation of energy and climate targets. Not only does the security of supply for the population depend on efficient connections between ports and international trade routes, but seaports also play a key role in defence in the event of disasters and crises.

The shift away from fossil fuels towards other energy sources means significant changes for seaports, as ports are used to tranship energy sources, consume energy and generate electricity themselves. Ports are indispensable for the construction and operation of offshore wind farms, which make a significant contribution to achieving climate targets. However, they are themselves undergoing a transformation process: terminal equipment and car and truck fleets are being converted to more environmentally friendly drive systems, and in the cruise and container sectors, they are providing shore-side electricity to support climate-neutral shipping. Alternative fuels and electrification are playing a major role here [1].

In order to ensure security of energy supply, especially for industry, energy sources other than fossil fuels will be needed in the future, for example hydrogen and its derivatives. The aim is to develop German seaports into hubs for imports and production sites for green hydrogen [2]. The Elbe seaports are becoming more significant for green energy initiatives and the strategic importance of these ports is growing as they adapt to sustainability goals. The following challenges arise for maintaining the functionality of seaports as the heart of the energy transition in the future.

2. Demand for water

However, the production of hydrogen requires a lot of water, and it is not only farmers who fear new competition for already scarce water resources. The Elbe is already one of the lowest-flowing river basins in Europe [3] and the succession of dry years in 2018, 2019 and 2020 represents an unprecedented extreme situation since weather records began [4].
There have recently been a number of developments in the Elbe catchment area that could affect the future availability of water resources. These include hydrogen production, the flooding of lignite mines and the discussion about new sources of water supply for the Spree region, including the greater Berlin area, planned industrial settlements with a predicted high water consumption, and the planning of further water retention measures in the Czech Republic. The demand for irrigation in agriculture has also increased measurably in Germany in recent years. This is likely to rise significantly in many regions of Germany by 2100, meaning that it will no longer be possible to meet demand from groundwater alone [5].

3. Water is of vital importance to ports

The effort of maintaining water depths in the Port of Hamburg and its sea access is also largely determined by the water supply in the Elbe. This is because the intensity of sedimentation – and thus the amount of dredging required – depends to a large extent on the discharge of headwater via the Geesthacht weir into the tidal Elbe. If the water supply in the Elbe is low, the flushing effect of the ebb tide is reduced. Sediments are then no longer carried out of the Lower Elbe and the port into the North Sea by natural means. This must be compensated for by intensified dredging activities in order to ensure the accessibility of the port from the sea. The dredged sediments must be relocated. The aim here is to achieve effective sediment discharge and reduce small-scale circulation management. The goal therefore remains to minimise sediment and dredging cycles that are detrimental to the entire tidal Elbe.
It will therefore become even more important in the future to remove sufficient maintenance dredged material from the Elbe estuary. If natural sediment transport to the mudflats and foreshores of the coast takes place at relocation sites located below the upstream transport zone – or if targeted relocation to these sites is carried out – the dredged material would be of benefit to coastal protection and would dampen the rise in tidal range in the estuary.

4. Water quality – and sediment quality

As the Water Framework Directive deadline of 2027 approaches, it is becoming clear that Europe's waters continue to be impacted by chemicals, predominantly by atmospheric pollution, diffuse pollution from e.g. agriculture and point sources such as from wastewater discharges, and leakage from industrial wastelands or (historical) mining. In 2021, only 26.8% of Europe's surface water bodies achieved a good chemical status. In particular, progress in reducing pollution and implementing key measures for an improved chemical status, such as the remediation of sites at risk of remobilisation, has been limited [6]. As a result, pollution will continue to be transferred from sources or known contaminated sites to the lower reaches of rivers, ports and the sea.

With regard to 'ubiquitous persistent, bioaccumulative and toxic' substances (uPBT) in particular, the European Commission's evaluation of the third River Basin Management Plans has once again highlighted the large gap between the current situation and the objectives. uPBTs continue to be one of the reasons why good environmental status with regard to pollutants has not been achieved in 80 % of marine areas under the Marine Strategy Framework Directive [7].

The limited progress made and the enormous and continuing challenges with regard to pollution and nutrients not only pose a problem for environmental aspect but also have an impact on industry and port operations (EU competitiveness).

5. Climate change

The maintenance of the port depends on a number of framework conditions (Figure 1) that are likely to develop unfavourably under the effects of climate change. Not only does the accelerated rise in sea levels play an important role here, but also the fact that climate change, through changes in precipitation in the middle and upper Elbe and the resulting upper water discharge, has a major influence on sedimentation in the Elbe and in the port, and, through an increase in water temperature and a decrease in oxygen content, can lead to an increase in exclusion times for maintenance – and thus to restrictions in accessibility.

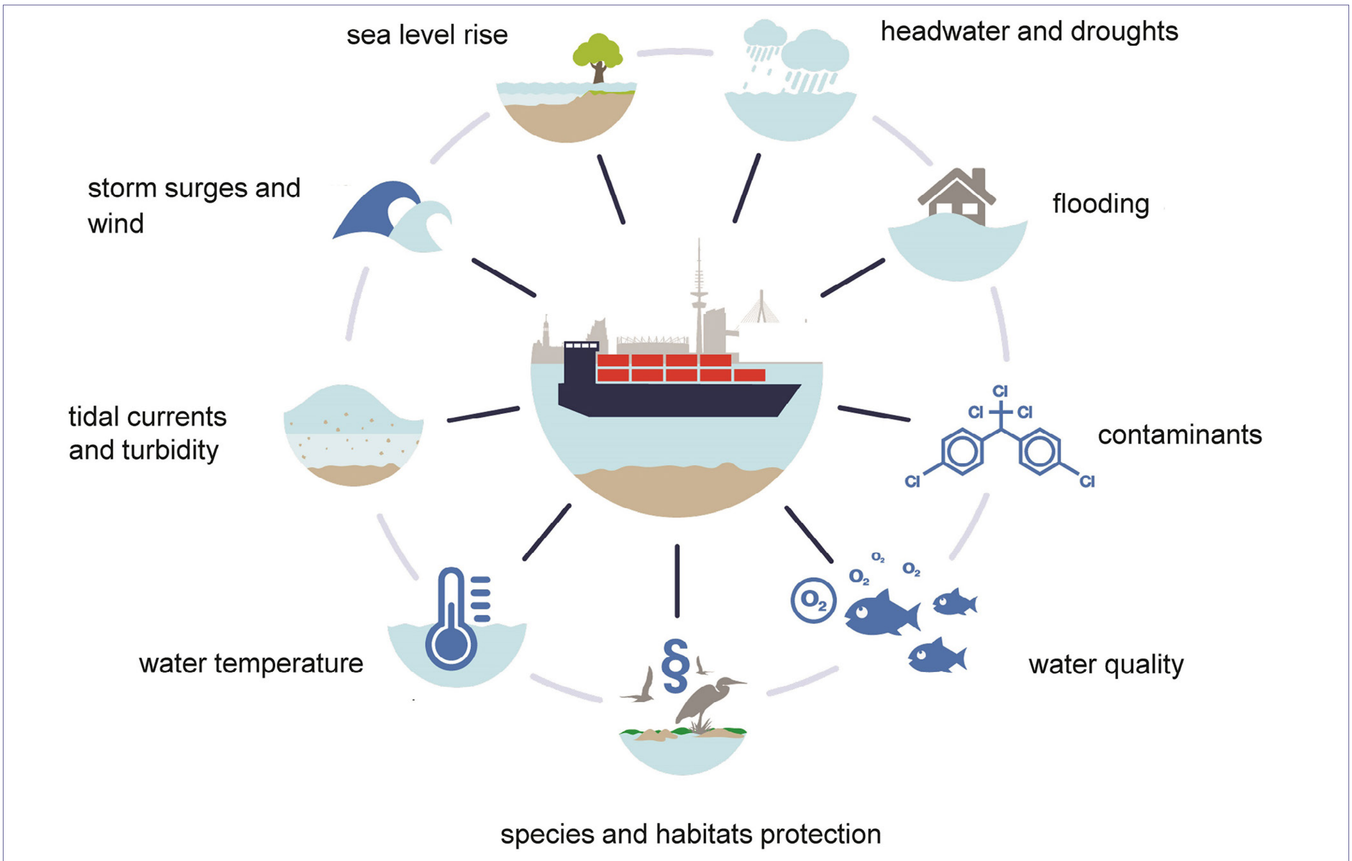

Fig. 1: *Overview of framework conditions influencing sediment management in the Port of Hamburg*

The factors that are influenced by the predicted climate change via different impact pathways are listed below:

1. Sediment transport in the tidal Elbe and port (Figure 2): Increased upstream transport is favoured by a stronger flood current dominance, on the one hand due to reduced headwater discharge from the middle Elbe, and on the other hand due to sea level rise and the seaward influence on tidal dynamics and storm surges. Sea level rise not only raises the tidal wave, but it also influences the shape of the tidal curve. In many areas, flood current velocities increase more than ebb current velocities. Increased flood current dominance can lead to a shift in the brackish water zone and the maximum turbidity.

2. Pollutant content of the sediments to be dredged: The input of pollutants from the Middle and Upper Elbe is determined on the one hand by the headwater discharge and on the other hand by flood events that remobilise specified pollutant-containing sediments (see consequences of the flood events of 2002 and 2013).

3. Oxygen content in the tidal Elbe and port: The oxygen content is the result of oxygen production and consumption. Biological oxygen production is determined directly and indirectly by the temperature and algae growth or the amount of algae biomass in the middle Elbe and upper tidal Elbe. Microbiological oxygen consumption processes and oxygen solubility in water are controlled by temperature. Water residence times and organisms present in the water body (bacteria, algae and algae-consuming zooplankton) are controlled by the surface water discharge.

4. Water ecology, in particular the species spectrum of plants and animals: The occurrence and distribution of plant and animal organisms are also controlled by temperature, among other factors. Climate change can lead to a change in the species spectrum, e.g. by allowing introduced species that were not previously found in the Elbe to survive under changed environmental conditions, spread and possibly displace other species that are considered worthy of protection under European environmental directives. Furthermore, changes in hydromorphological parameters can lead to changes in habitat types according to the Birds and Habitats Directives (deterioration, loss).

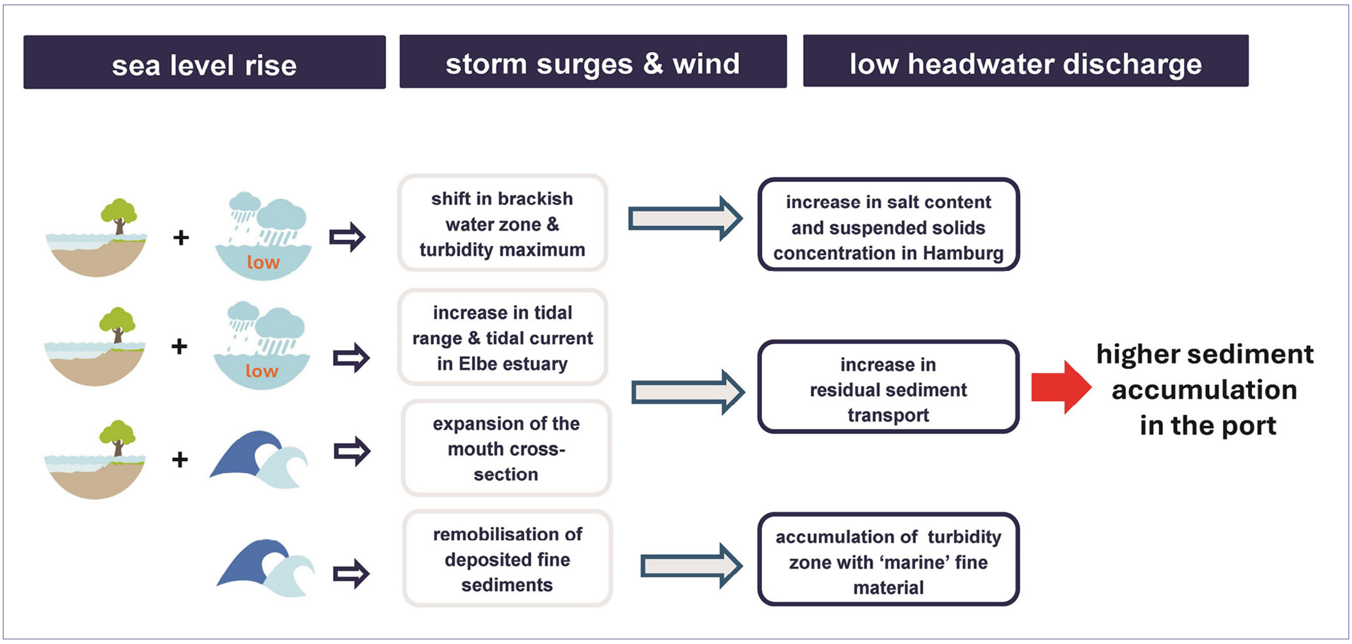

***Fig. 2:** Effects of climate change on sediment transport and quantity in the Port of Hamburg*

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Fachbeiträge

Odborné příspěvky

Magdeburger Gewässerschutzseminar 2025

Magdeburský seminář o ochraně vod 2025

Monitoringstrategien und Gewässerbewirtschaftung

Strategie monitorování a hospodaření s vodami

Magdeburger Gewässerschutzseminar MGS 2025 Magdeburský seminář o ochraně vod

Progress in the WSV toward improved hydrological monitoring of the Elbe

Danielle Kitover

The Federal Waterways and Shipping Administration (WSV) is responsible for ensuring safe and efficient water transport and tourism along Germany's rivers, canals and coastal areas. To fulfill this role, a reliable network of gauges exist along the 600 km stretch of the Elbe River as well as its federal tributaries, the Havel and Saale. Measurements of water level and flow rate form not only the basis for hydrological statistics, but also serve as prerequisite information for the operation, maintenance and development of these waterways. Two examples are presented to highlight how hydrological monitoring is exercised within the WSV.

PEGELONLINE

Since 2002, the WSV has been publishing hydrological data (water level & discharge) for both inland and coastal gauges of the federal waterways via the PEGELONLINE web application. User selection of the over 680 hydrological gauges can be done either via map or table. A recent enhancement to the website is the ability to see in real-time the categorized water level (low, average, high) as well as total number of gauges in each category (Figure 1).

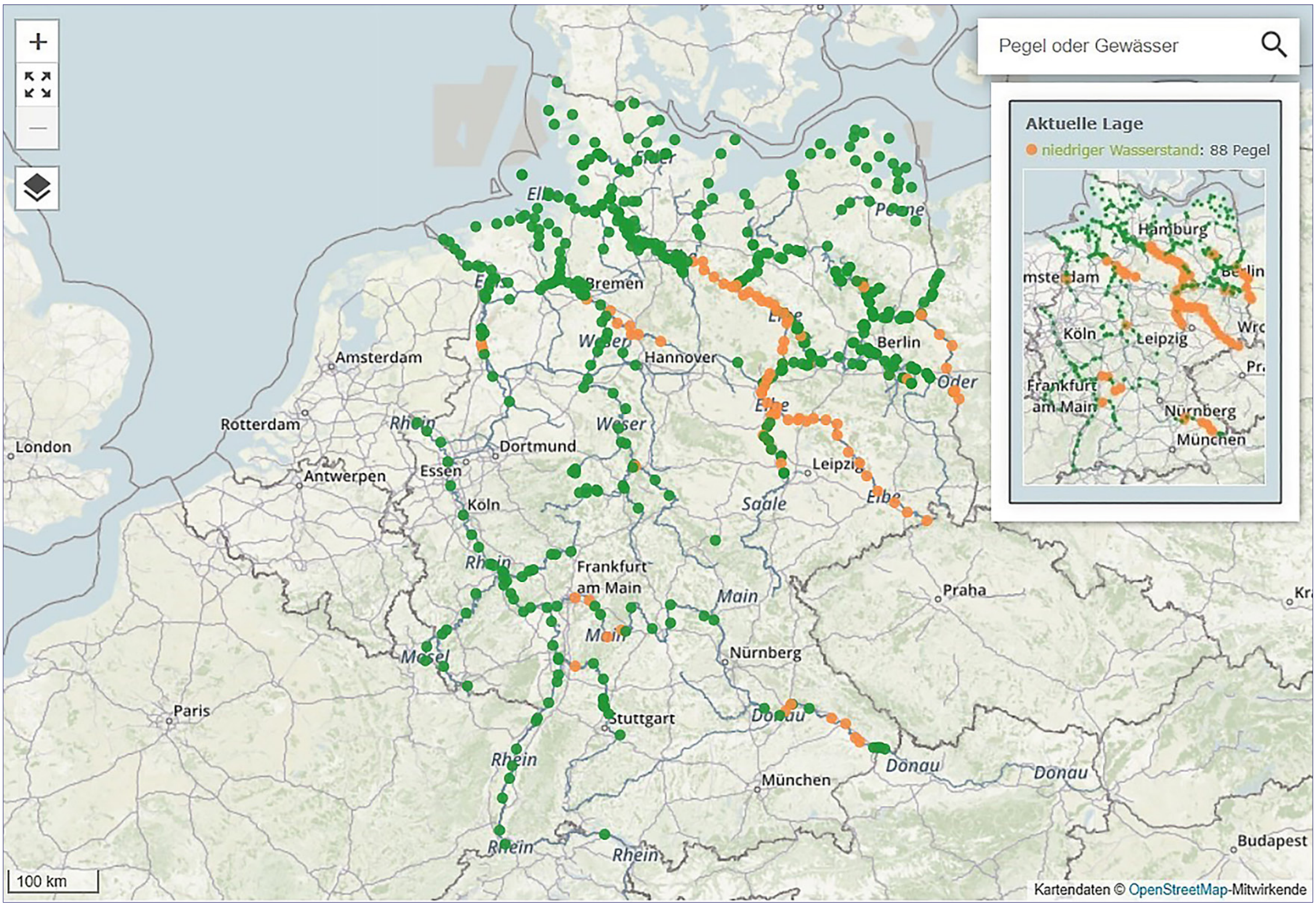


Fig. 1: Map of WSV-gauges, categorized based on water level, from the homepage of PEGELONLINE. A new feature indicates total number of gauges per category embedded in the overview map.

Not only does PEGELONLINE offer public access to real-time gauging station data but also has been recently enhanced to include longer time series in line with the German open data law under the Data license Germany – Zero – Version 2.0. This license allows the data from PEGELONLINE to be used, reused and distributed completely free of charge and applies for both commercial and non-commercial use. Data is available by download starting from the year 2000 to present.

PEGELONLINE will soon be fully operational under a real-time data infrastructure (EDIS) (Figure 2), where rather than data being requested individually it will be sent directly to users' end devices as a push notification by subscription. This function will reduce traffic to the site, which is currently accessed 6 million times a day, by 20 to 25 percent. This makes the flow of data faster and more secure, even at peak use such as during extreme events. In turn, real-time hydrological data can be smoothly transmitted to linked information services such as LHP (Länderübergreifendes Hochwasser Portal/Cross-border flood portal) and ELWIS (Elektronische Wasserstraßen-Informationsservice/Electronic waterway information service). This improved data transmission will be particularly beneficial in areas affected by tides, where water levels change rapidly.

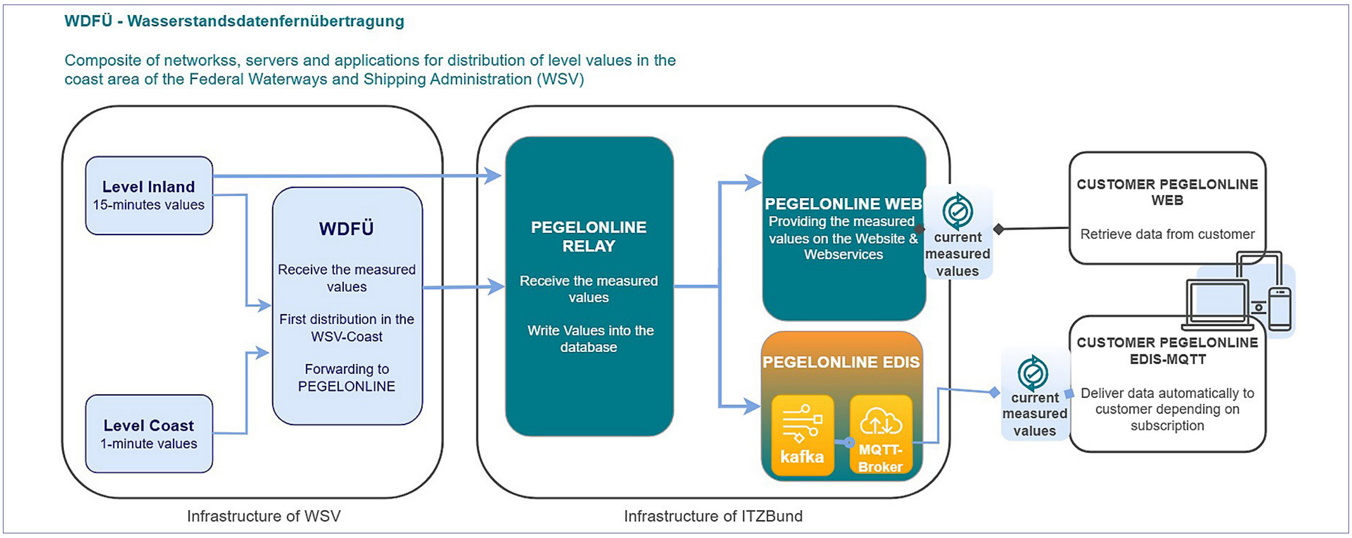
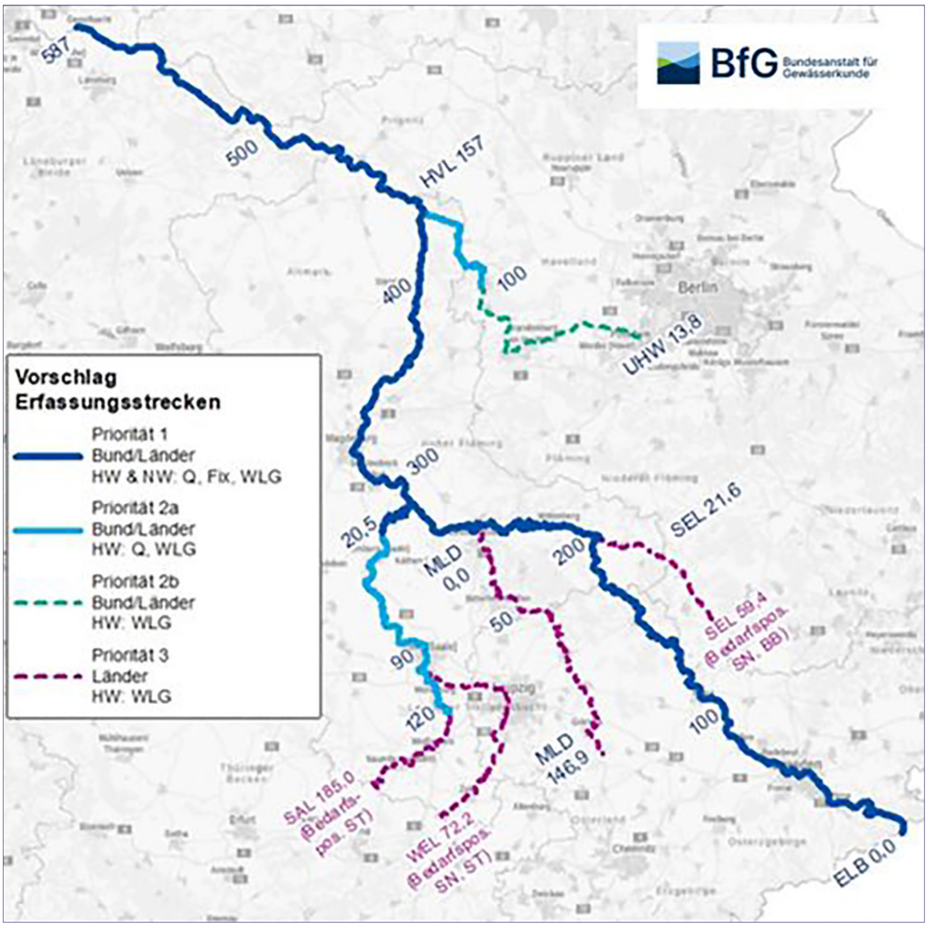


Fig. 2: *Depiction of data transfer using real-time data infrastructure (EDIS) based on Kafka, brokers and MQTT.*



MEE

The WSV is currently participating in the design and planning of the federal-state cooperative measurement program (MEE – Mengenbestimmung Extreme Elbe/Quantitative Measurement Extremes Elbe), which ensures that discharge measurements (TMP-Q), river longitudinal profiles (TMP-Fix), and situational maps and water-land-boundary detection (TMP-WLG), are carried out both efficiently and at high technical standards during extreme events (flooding and drought conditions) on the Elbe (Figure 3). The discharge measurements cover approximately 20 gauges along the Elbe and Saale. The longitudinal profiles and water-land-boundary determinations (plus some tributaries as needed) will also cover a major stretch of the Elbe (km 0 – 587).

Fig. 3: *Geographical coverage of the MEE Program.*

The core of the MEE program is establishing a previously agreed and coordinated chain of actions before, during, and after an extreme hydrological event on the Elbe occurs. Regardless of the type of measurement (discharge, longitudinal profiles, or situational maps and water-land-boundary detection), the series of actions is divided into four successive stages. The first stage (Stage 0) is no immediate action and only serves to maintain an updated program and have the program partners meet and update the plan on a regular basis. Stage 1 covers the period when the first information to a forecasted event is announced and therefore to prepare the program partners for measuring. In this stage, the partners are waiting for the water level to reach the trigger point at a designated gauge. Stage 2 is the point by which the cooperation partners determine if a measurement should be implemented or not and if so, all relevant contacts are informed. Stage 3 is then when measurement and subsequent evaluation takes place. Figure 4 depicts the series of stages for measuring discharge during a flood event. Similar sketches exist for longitudinal profiling and water-land boundary evaluation for both flood and low water level/drought events.

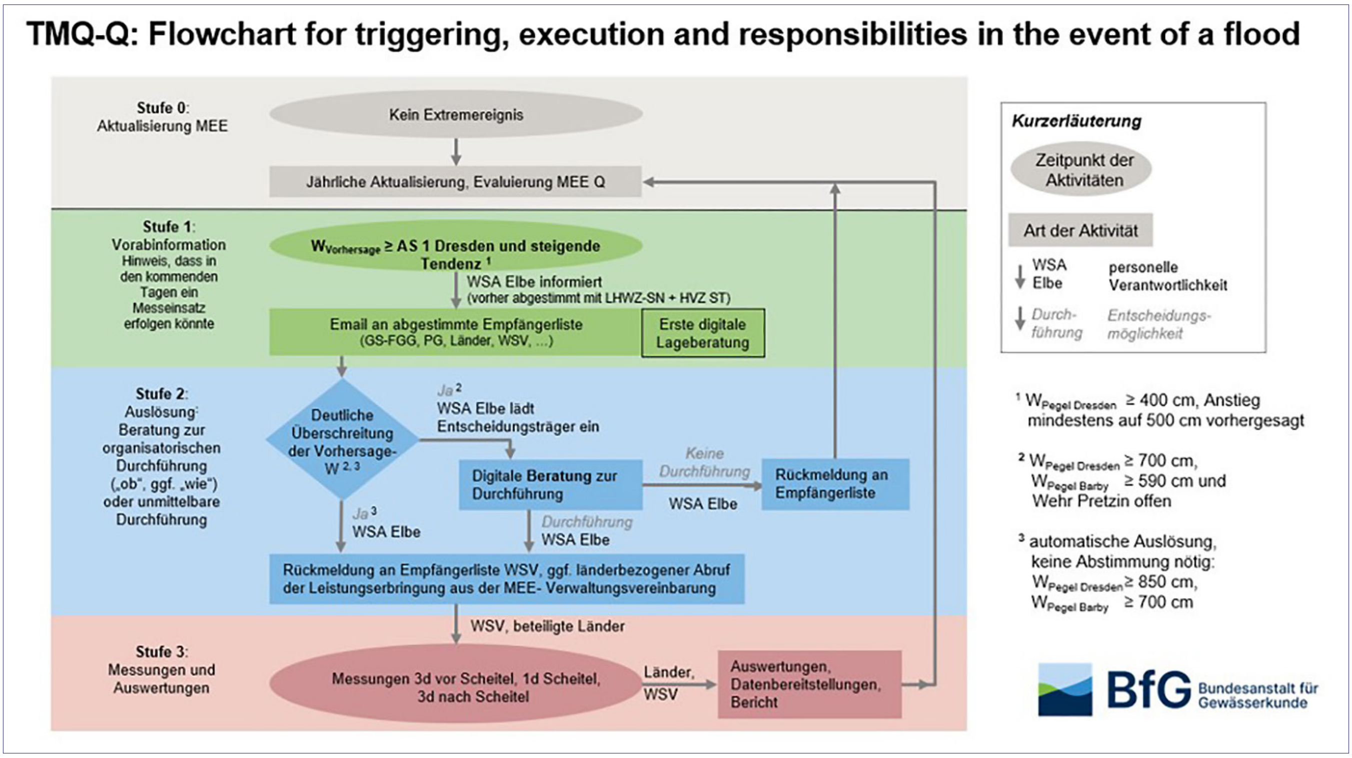


Fig. 4: *Example flowchart for decision making on discharge measurements in the event of a flood.*

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Water management balance assessment in watersheds with higher proportion of water bodies under conditions of climate change

Magdalena Nesládková, Ondřej Ledvinka

Abstract

Recent results of the surface water management balance assessment in the Vltava River basin have highlighted the increasing importance of accurate estimate of the component of evaporation from water surface (E_{ws}). Long-term average monthly values of E_{ws} often underestimate the real values during summer months in recent years. This underestimation subsequently may cause misleading interpretation of the results of surface water management balance assessment, especially in watersheds where the proportion of water bodies exceeds Czechia's average, such as in the Lužnice River basin. To address this issue, Povodí Vltavy, state enterprise, has launched a three-year project focused on monitoring E_{ws} using a floating evaporimeter on a pilot site in the Lužnice River basin. The floating evaporimeter is placed directly on the water surface of a monitored water reservoir. The study is carried out by the T. G. Masaryk Water Research Institute, p. r. i. (TGM WRI). The aim of the study is to derive an empirical equation for calculating E_{ws} for a pilot site based on other more easily observable climatic or hydrologic variables. The study will also verify the suitability of empirical equations previously derived for the Hlasivo evaporation observation station (Lužnice River basin; TGM WRI), where other types of evaporimeters are used.

1. Introduction

Since 2001, the concept of water balance has been part of the Water Act in the Czech Republic. This concept includes the hydrological balance and the water management balance assessment. Since 2003, water board enterprises have been publishing annual reports presenting the results of water management balance assessments of surface water quantity, surface water quality, and the quantity and quality of groundwater. The basic principle of assessing surface water quantity is the comparison between the mean monthly observed discharge and the so-called 'unaffected' or natural discharge at a network of monitoring profiles. The natural discharge is calculated using data on water usage within the catchment area. These data include withdrawals of surface and groundwater and discharges exceeding 500 m³ per month or 6,000 m³ per year, as well as changes in surface water accumulation in reservoirs with a capacity over 1 million m³. The changes in surface water accumulation are evaluated based on monthly reports on reservoir water levels. A change in water accumulation in a particular reservoir is computationally divided into two components: the amount of water either accumulated in the reservoir or released into the watercourse (i.e., a decrease or increase in accumulated volume), and water loss through E_{ws}. E_{ws} for a particular water reservoir is represented in the calculation by a long-term monthly values (12 values), which were either derived according to a technical standard or evaluated and provided by the Czech Hydrometeorological Institute (CHMI).

As became evident during the period from 2015 to 2019, which was characterized by significantly above-average air temperatures and below-average precipitation [1], long-term estimates of E_{ws} introduce a certain degree of inaccuracy into the surface water quantity balance calculations. Rising air temperature leads to increased E_{ws}, which further intensifies the impacts of drought on stream discharges [2]. Underestimating E_{ws} in water management balance calculations distorts the results, as the amount of water that likely evaporated is computationally allocated as water released from water reservoirs into watercourses. This affects the final estimated value of natural discharge for the given month. This inaccuracy is mostly pronounced during the summer months, when E_{ws} reaches its peak. Underestimation of the E_{ws} rate in the natural discharge assessment is more significant in watersheds with a higher proportion of water bodies. In the Vltava River basin, this particularly concerns tributaries of the Vltava River in the South Bohemian Region, where extensive pond systems are located as well as the Vltava River itself with the water reservoir Lipno. This paper provides a more detailed description of the improved estimation of E_{ws} for the Lužnice River basin (up to the Bechyně water-gauging station), where water bodies cover more than 3% of the area – nearly three times the national average. The ponds in the Lužnice River basin are primarily used for fish farming and only in some cases also for retention purposes. These reservoirs do not contribute to maintaining minimum residual flows during dry periods.

2. Initial results of monitoring of E_{ws} using a floating evaporimeter at the pilot site

Following the insights gained from the prolonged drought between 2015 and 2019, a three-year monitoring was launched in 2024 in the Lužnice River basin in cooperation with the TGM WRI. E_{ws} is monitored using a floating evaporimeter placed directly on the water surface of water reservoir Karhov in the Lužnice River basin. The floating evaporimeter consists of a mechanical structure that includes a measuring container with a diameter of 620 mm, floats and wave breakers, and electronical equipment [Fig. 1]. The water level in the measuring container is regulated by a bidirectional pump. The evaporimeter is powered by two solar panels. E_{ws} is measured by a precise water level sensor. There are several other sensors placed on the evaporimeter measuring a wide range of climatological and hydrological variables, including sensors for relative humidity and air temperature, wind direction and speed, water temperature, a heated rain detector, and a probe for measuring net solar radiation. At the location where the evaporimeter is anchored, the water temperature profile in the reservoir is also measured [3]. The goal of the study is to derive an empirical equation for calculating E_{ws} in this specific location using more easily observable variables. It also aims to verify the applicability of empirical relationships developed through long-term research at the Hlasivo evaporation station (TGM WRI), where different types of evaporimeters are used.

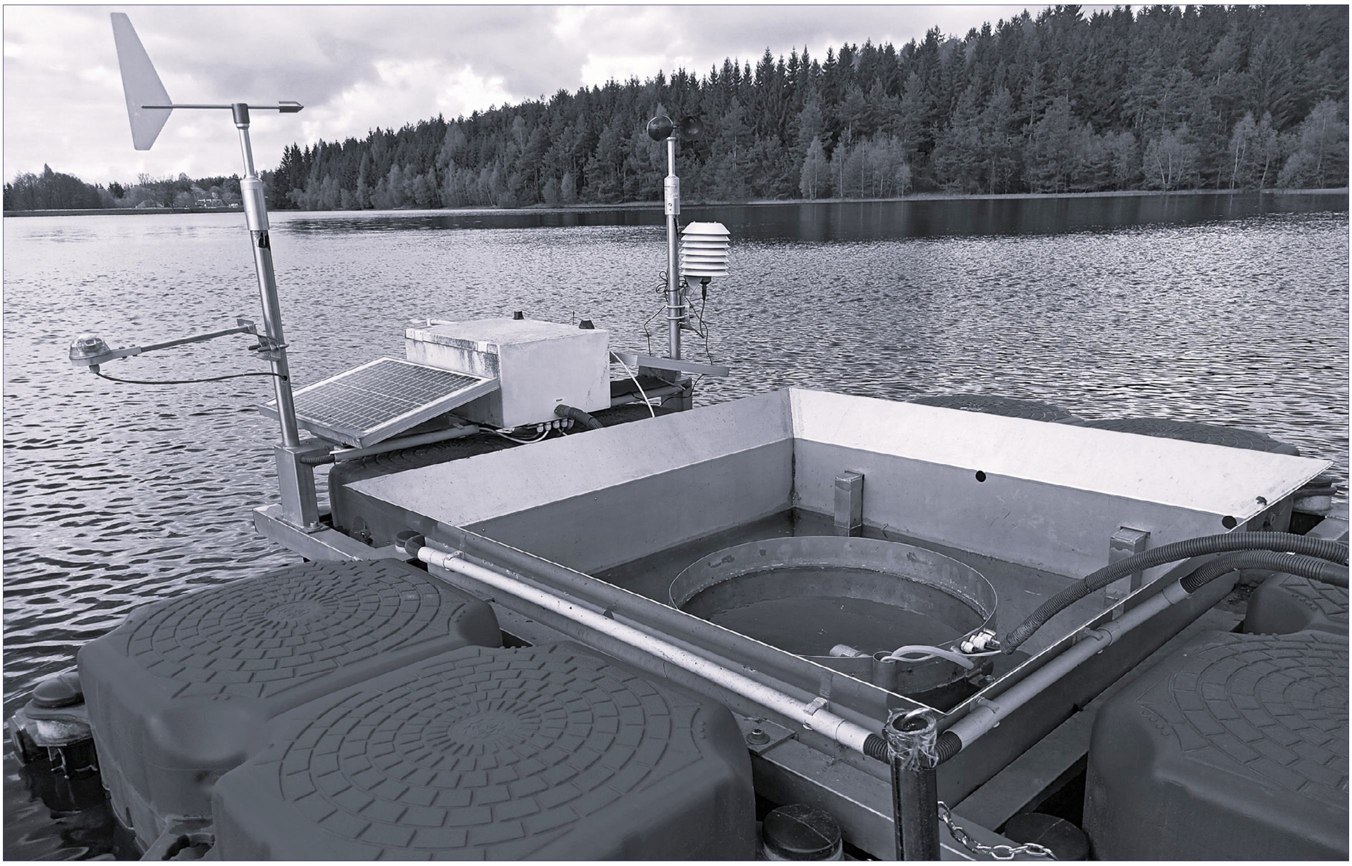

Fig. 1: *Floating evaporimeter placed at Karhov water reservoir measures changes of water level in the inner cylinder and other, meteorological, variables.*

Empirical equations for E_{ws} estimation derived from data obtained at the Hlasivo monitoring station [4] are:

$$E_{WS} = 0.4834^{(0.0936 \cdot Tw)} + 0.7129 \cdot WS - 1.0594 \quad (1)$$

$$E_{WS} = 0.0824 \cdot Ta^{1.289} \quad (2)$$

$$E_{WS} = 0.0407 \cdot Tw^{1.4366} \quad (3)$$

$$E_{WS} = 0.0157 \cdot R^{1.0148} + 0.0209 \cdot Ta - 0.0017 \cdot R - 0.069 \quad (4)$$

where

E_{ws} … mean daily intensity of evaporation from water surface [mm/day]

T_w … mean daily temperature of water within the evaporimeter [°C] (validity range 6.2–25.5 °C)

WS … mean daily wind speed [m/s] (validity range of monthly data 0.7–2.4 m/s)

Ta … mean daily air temperature [°C] (validity range of monthly data 3.7–21.7 °C)

R … mean daily solar radiation [W/m^2] (validity range of monthly data 54.0–266.5 W/m^2)

Results from the first year of the monitoring indicate that, in 2024, the observed E_{ws} was nearly 100 mm higher than the long-term estimate used in water balance calculations [Tab. 1]. The average evaporation from the pilot site, which has a surface area of approximately 23 hectares, was 6.4 l/s during the monitoring season (from April to November). In June and July, it reached 10 l/s on average. The total water loss due to E_{ws} from April to November 2024 amounted to 136,000 m³ (i.e., nearly 6,000 m³ per hectare of water surface). All empirical equations derived at the Hlasivo monitoring station underestimated E_{ws} observed at the pilot site. For 2024, the lowest average relative error was achieved using Eq. (3), which is based on water temperature observed in the evaporimeter. Eq. (2), based on air temperature, also provided acceptable results. Less satisfactory estimates were obtained with empirical Eqns. (1) and (4). In the case of the wind speed-based calculation, the main issue was a measurement error in the first month of monitoring. For Eq. (4), the discrepancy likely arose from the difference between net solar radiation measured by the floating evaporimeter (incoming minus reflected radiation above the water surface) and total solar radiation measured at the Hlasivo monitoring station (total solar radiation above ground) [3].

Tab. 1: *Comparison of measured data and estimates obtained by empirical equations*

Monthly evaporation	measured data	Eq. 1	Eq. 2	Eq. 3	Eq.4	long-term data	water surface area	water loss (measurement)	water loss (long-term data)	evaporation from free water surface (measured)
2024	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[ha]	[m³/ month]	[m³/ month]	[l/s]
April	61.1	28.0	45.2	40.0	61.6	35.0	23.0	14055	8051	5.4
May	77.5	92.5	70.5	73.7	73.2	62.0	22.9	17781	14225	6.6
June	107.0	111.1	94.1	99.6	91.6	80.0	23.0	24614	18403	9.5
July	118.3	125.2	111.1	116.6	92.6	100.0	23.0	27214	23004	10.2
August	120.7	126.3	116.6	116.7	83.6	95.0	22.9	27619	21738	10.3
September	70.8	87.0	76.8	67.9	48.2	65.0	22.1	15643	14361	6.0
October	24.6	57.4	42.0	36.9	24.2	40.0	23.0	5659	9202	2.1
November	14.2	13.4	7.5	8.6	9.0	22.0	22.9	3249	5034	1.3
sum	**594.2**	**580.1**	**568.0**	**547.0**	**483.9**	**499.0**		**135834**	**114018**	**avg = 6.4**
mean relative error (MRE)		**0.31**	**0.23**	**0.18**	**0.18**	**0.313**		**Δ**	**21816**	

3. Effects of revision of the estimate of evaporation from water surface in the Lužnice River basin in 2024

To improve the accuracy of calculation of water management balance of surface water quantity in 2024, the CHMI provided a database of average monthly air temperatures for the polygons of the inundation areas of all 80 reservoirs included in the water balance calculation for the Vltava River basin. The results of this refinement for the Vltava River basin will be processed as part of the water management balance calculation scheduled for summer 2025. For the purposes of this contribution, a preliminary evaluation was carried out to refine the estimate of E_{ws} in the Lužnice River basin. In the Lužnice River basin, there are 29 reservoirs included in the water management balance calculation (i.e., with a volume exceeding 1 million m³), with a total inundated area of 39.33 km² (average in 2024) and a total volume of 97.6 million m³ of accumulated water (according to the operational rules of the water reservoirs). Based on long-term data on E_{ws}, which have so far been used in the water management balance calculations, the water loss due to E_{ws} from these reservoirs in 2024 amounted to 23.4 million m³, corresponding to an average discharge of 0.743 m³/s. When using Eq. (2) based on known monthly air temperature values, the estimated water loss due to E_{ws} is 27,8 million m³ of water, i.e., 0.880 m³/s on an annual average. The most significant underestimation of E_{ws} flux was observed in August (difference in monthly water loss expressed as flow rate 0.63 m³/s), September (difference of 0.43 m³/s), and October (difference of 0.44 m³/s). For comparison, the mean monthly discharge observed at the monitoring profile on the Lužnice River (the Bechyně water-gauging station) was 4.39 m³/s in August, 75.1 m³/s in September, and 44.7 m³/s in October (floods occurred in Czechia in September). For the months of January, November and December, the empirical equation could not be applied, as the average air temperatures in these months were below 3.7 °C, which is the lower limit of validity range of the applied empirical equation. For these months, E_{ws} was neglected. Conversely, for these months, E_{ws} estimate based on long-term data was higher than zero.

4. Discussion and conclusion

It is assumed that in 2025, the calculation of the water management balance of surface water quantity will be carried out experimentally, also using a refined estimate of E_{ws} for the entire Vltava River basin. An evaluation of the impacts of this refinement on the resulting values of the natural ('unaffected') mean monthly discharge will also be conducted. Based on preliminary results obtained for the Lužnice River basin, it can already be stated that the significance of the E_{ws} flux increases, particularly during periods of hydrological drought. Refining this E_{ws} flux leads to a more accurate estimate of the natural mean monthly discharge at control profiles. The results of the 2024 evaluation of E_{ws} in the Lužnice River basin showed that the total water loss due to E_{ws} accounted for nearly one-third of the total volume of the assessed water reservoirs. With rising air temperature, the importance of E_{ws} flux increases as a factor influencing the water management balance of both the reservoirs and the downstream watercourses.

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Use of Remote Sensing Methods within the FGG Elbe Project TESA

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Background

The Elbe Estuary experienced three distinctly different ecosystem states over the last four decades, a polluted, a transitional and a recovery state (Rewrie et al., 2023a) as a response to geopolitical changes in Germany and across Europe encompassing the Elbe River catchment (Kempe, 1988; van Beusekom et al., 2019; Rewrie et al., 2023a), which resulted in European management strategies (Ehlers, 1990) the establishment of wastewater treatment plants (Netzband et al., 2002), closures in industrial and agriculture sectors, and an overall improvement in water quality (Rewrie et al., 2023a; 2023b). These ecosystem state changes significantly impacted biogeochemical processing, including primary production and respiration. As a result, the driving factors that control oxygen, carbon and nutrient dynamics and fluxes in the estuary and at the land-sea interface were significantly different in the 1980s compared to present day (Rewrie et al., 2023a). Since 1997, during the recovery state, primary production and respiration, and normal estuary function were reestablished and particulate organic carbon (POC) produced in the upstream regions drives the remineralization of POC, generation of dissolved inorganic carbon (DIC) and oxygen consumption in the Port of Hamburg (Rewrie et al., 2023b). Primary production in the upper estuary and upstream regions and the significant summer uptake of DIC drives seasonal inorganic carbon dynamics hundreds of kilometers downstream in the outer estuary (Rewrie et al., 2025). Therefore, quantifying the variability of primary production in the Elbe Estuary and lower Elbe River is essential for quantifying the carbon cycling and oxygen dynamics from land to sea.

Primary production in the tidal Elbe River and regions upstream of the Geesthacht Weir is sustained by nutrient enrichment (Kamjunke et al., 2021; Dähnke et al., 2022) and provides labile POC that is subsequently remineralized in the Hamburg Port region, consuming oxygen in the process. High water residence times caused by the deep main fairway, in concert with large organic matter inputs from the Elbe River, promote the formation of summertime oxygen deficit in the Hamburg Port region (Schöl et al., 2014). The spatio-temporal extent of the oxygen deficit is not equally distributed each year, and, for example, the minimum oxygen zone extended above the Hamburg Port region to Bunthaus in 2022. The FGG Elbe project "Temporary Oxygen Deficit in the Tidal Elbe and Lower Middle Elbe (TESA)," addresses the causes and impacts of the seasonal oxygen deficit in the Elbe Estuary. The regional significance of this low oxygen valley includes adverse ecological issues, such as hindering fish migration and disrupting lamprey species, which depend on being able to migrate from the sea into the flowing waters of the Elbe River catchment area as part of their life cycle (FGG Elbe, 2015). To identify the main drivers for the inter-annual variability in the extent of the oxygen deficiency zone, high-resolution time series data for several stations covering the period 2014–2024, thus excluding the 2013 Elbe flood (Voynova et al., 2017), will be analyzed. Primary production and its balance with respiration to estimate the net ecosystem metabolism (NEM) will be used to assess the dominating factors that modulate the variability in oxygen and ecosystem health in the Elbe Estuary. In addition, satellite data will be used to fill the gaps between monitoring stations in recent years improving the data foundation to examine of the spatial variability in the metabolic activity along the upper stretch of the estuary.

Earth Observation (EO) methods offer a valuable extension to in-situ observations by providing spatially comprehensive and temporally frequent data across the entire Tidal Elbe and Lower Middle Elbe. The Planet SuperDove satellite constellation, with its 3 m by 3 m spatial resolution and daily revisit capability, enables quasi-continuous surveillance of water quality parameters. Using a physics-based retrieval process (Kiselev et al. 2015), multispectral data from Planet SuperDoves is used to derive key water quality indicators such as chlorophyll-a concentrations, turbidity, characteristics of suspended particulate matter, yellow substances and others.

Aims and Objectives

The aim of the TESA project is to assess the changes in the extent of the oxygen deficit by evaluating dissolved oxygen and chlorophyll-a measurements and determine the variability in primary production and NEM upstream of the Hamburg Port at Bunthaus and beyond in 2022 to 2024, thus including the unusual oxygen event in this region in summer 2022.

To resolve NEM variability, high-frequency dissolved oxygen and ancillary biogeochemical data from two research stations 1) at Bunthaus, Germany, upstream of the Port of Hamburg and 2) at Tesperhude, Germany, in the lower Elbe River will be used to quantify the gross primary production (GPP) and NEM at the land-sea interface. Chlorophyll-a (chl-a) data derived from satellite will be used to estimate primary production and respiration rates using the phytoplankton biomass technique (Chapra, 1997; Voynova et al., 2015). To estimate primary production rates further upstream from Bunthaus, the Elbe stretch from Tesperhude to Bunthaus will be partitioned into shorter sections and primary production rates will be calculated for each sub-section using satellite-derived chl-a data. This will allow us to obtain qualitative trends in NEM along the Elbe Estuary between Tesperhude, Geesthacht and Bunthaus.

The use of satellite-based approaches supports the TESA project by enabling retrospective and real-time analysis of high-resolution chlorophyll estimates, along the estuary and the tidal river. The ability to observe chlorophyll-a concentrations from space across large spatial domains allows for the estimation of primary production rates in regions where in-situ measurements are more difficult to obtain or for which no data is available. This is particularly relevant for identifying and characterizing how much primary producers and locally produced OM contributes to the oxygen deficit zones.

The satellite-derived chlorophyll-a concentrations will be validated against in situ data recorded at Tesperhude, Geesthacht and Bunthaus. This validation will support the development of empirical models that link chlorophyll-a concentrations to oxygen levels, enabling the extrapolation of a limited set of stationary observations to an estuary-wide assessment. Through this integration, EO methods will enhance the spatial and temporal resolution of water quality monitoring in the Elbe Estuary and contribute to a more comprehensive understanding of the drivers of oxygen dynamics. Furthermore, a comparative analysis between the primary production rates based on dissolved oxygen and on satellite derived chl-a will be conducted to ensure the reliability of the use of the remote sensing data.

The integration of EO data also facilitates the detection of spatial patterns in primary production and NEM, which are critical for understanding the biogeochemical functioning of the lower Elbe River and the Elbe Estuary. Satellite observations can reveal upstream productivity hotspots and downstream oxygen deficit zones, offering insights into the transport and transformation of organic matter and nutrients. Furthermore, the retrospective analysis of satellite data allows for the evaluation of historical events, such as the 2022 low-oxygen event.

In addition, primary production calculated with the water quality model QSim (Schöl et al., 2014) will be compared against the in situ and EO-based estimates to evaluate the different approaches.

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Emergency Service of Povodí Ohře, s. p. – One Year After the Emergency Amendment to the Water Act: Practical Experience and Challenges

Tomáš Bruna, Jindřich Hönig

1. The 2024 "Emergency" Water Act Amendment – Practical Experiences

The amendment to the Water Act, No. 182/2024 Coll., effective from July 1 and August 1, 2024, brought about the most significant legislative change in the field of environmental emergencies since 2001. The aim of this amendment was to create a comprehensive legislative framework for addressing water-related emergencies. Key innovations include continuous monitoring of discharged wastewater, a digital register of outfalls, and the clear definition of competencies among the various entities involved in resolving emergencies according to the Water Act.

Unfortunately, on behalf of Povodí Ohře, state-owned enterprise (hereinafter "Povodí Ohře"), we must state that the creators of the emergency amendment to the Water Act opted for a "top-down" approach. Although Povodí Ohře actively participated in all discussions regarding the proposed amendment and provided substantial comments, most of its fundamental objections, which were based on real and practical experience, were not heard.

Our main reservations concerned the unclear delineation of competencies between the Fire and Rescue Service of the Czech Republic (FRS) and water authorities (§ 41 para. 4). While the FRS coordinates rescue and liquidation work, the water authority manages the actual remediation of the emergency. Fortunately, current practice has shown that there are no jurisdictional disputes between water authorities and the FRS. However, this could change if a serious emergency occurs where there is suspicion of wrongdoing. In such a case, jurisdictional ambiguities could arise (management of liquidation work vs. management of remediation work).

We consider the de facto exclusion of the Czech Environmental Inspectorate (CEI) from emergency issues to be a major flaw. According to the current regulation (§ 41 para. 7), the CEI can take over the investigation of causes and the management of emergency remediation work, which, unfortunately, does not happen in practice. Our long-standing and empirically supported view is that the investigation of causes and the management of emergency remediation work should indeed be carried out by the CEI. The Inspectorate is more professionally competent, has greater flexibility in its workforce, and is a state institution not subject to the influence of local self-government. In contrast, water authorities suffer from higher employee turnover, leading to lower expertise. The fact that, although a water authority represents state power, its employees are effectively managed and remunerated by local self-government significantly impacts the willingness of water authorities to impose corrective measures in a negative way.

Sampling during emergencies can be considered contentious. According to § 41 para. 5, sampling is provided by the basin administrator. However, the law does not state at whose expense. Principally, and also legally (§ 17b of Act No. 77/1997 Coll., on State Enterprises, as amended, and § 2924 of Act No. 89/2012 Coll., Civil Code), we consider it unacceptable for the basin administrator to cover the costs of sampling for the purpose of investigating the causes of an emergency. In our opinion, the law should clearly define that the costs not only of sampling but also of other activities of the basin administrator (transport, flow augmentation, etc.) should be borne by the party responsible for the emergency.

We consider Section 42, which deals with remedial measures, problematic. The legal provisions only account for ideal situations, meaning when the party responsible for the emergency cooperates fully and without delay. In cases where the responsible party performs the imposed measures inadequately, fictitiously, or with significant delays, the law is almost toothless. The stumbling block is that water authorities lack their own financial resources. This prevents them from hiring expert firms to implement the necessary remedial measures. Theoretically, local self-government, i.e., the city, could provide the financial means. Especially when necessary remedial measures reach costs in the hundreds of thousands or millions of Czech crowns, local self-government often lacks the will to provide financial resources. Even in exceptional cases where self-government is willing to address this issue, the release of funds is tied to a procedurally demanding approval process, which leads to damages caused by delays. A practical example of such a stalemate is the emergency resolution from May 2024 near the village of Andělská Hora (see below).

A similarly complicated situation arises in the case of an emergency with an unknown perpetrator. In such a case, the water authority has the option to use § 42 para. 4 and impose remedial measures on an expert entity, with the costs to be covered by the region. In practice, this mechanism is not utilized due to numerous ambiguities and uncertainties. A prime example is an emergency that occurs on a Friday evening. The emergency is serious and threatens a water reservoir. It's estimated that the remediation costs will amount to 1 million CZK. In such a situation, a water authority official (a regular employee) is unable to bear the weight of the situation and order an expert company, as they don't know how the region will approach the situation on the next working day. If the official were to secure an expert company that would start remediation work, it could happen, for example, that a few days later an as-yet-unknown and impecunious perpetrator of the emergency is identified. In such a situation, the region would refuse to cover the remediation costs. The expert company would then demand payment from the water authority, i.e., the local self-government (city). A much more effective system would be one where the CEI would immediately decide on-site about remediation funded, for example, by the State Environmental Fund. In such a case, there would be legal certainty for all involved that the costs would be covered without the need to anticipate how the local or regional self-government would react to the decision.

In response to the emergency amendment to the Water Act, Povodí Ohře has strengthened its operational capabilities. Our emergency service has been equipped with six emergency vehicles prepared for taking samples during emergencies. As part of our emergency readiness, the availability of these vehicles and staff is ensured 24 hours a day, 365 days a year. In addition to the ability to collect samples for laboratory transport, we have equipped our emergency and on-call technicians with measuring technology for direct field measurement of pH, oxygen, and ammoniacal nitrogen. Nevertheless, Povodí Ohře is unable to independently ensure, for example, groundwater sampling. In such cases, we will still have to rely on external suppliers.

2. Unipetrol Emergency

On November 23, 2024, in the evening, a fire broke out at the ethylene unit within the Unipetrol RPA complex. This led to a subsequent leakage of firefighting water (firefighting foam), contaminated with a diverse mixture of organic pollutants, into the Bílý Potok stream (a tributary of the Bílina River). Although it should have been evident to the responsible party that the firefighting water would end up in the Bílý Potok, into which the ethylene unit's storm drain system discharges, Povodí Ohře was only informed on November 24 at 7:19 AM. The responsible party estimated the volume of firefighting water to be 1,350 m^3.

Unfortunately, Unipetrol RPA failed to take sufficient measures to contain the firefighting water within the complex (e.g., blocking sewer inlets, blocking storm drain outfalls). While some of the firefighting water was diverted to the on-site wastewater treatment plant, the contamination of the Bílý Potok and subsequently the Bílina River was still massive. Upon Povodí Ohře's arrival at the emergency site, it was discovered that Unipetrol RPA had not even set up a stable emergency profile on the Bílina River. This was only rectified after Povodí Ohře's request. Firefighting foam was captured at the emergency profile. Due to the use of firefighting foam, oil substances were emulsified, making their separation on the surface impossible. In this situation, increasing the flow rates in the Bílina River appeared to be the most effective measure. Povodí Ohře therefore proceeded with several flow rate increases at the Jiřetín weir, from the original 0.64 m^3/s up to 2.16 m^3/s. In addition, Povodí Ohře cooperated with the Fire and Rescue Service, the Czech Environmental Inspectorate, and the Police of the Czech Republic, carrying out inspections of both affected watercourses and taking samples of water and dead fish. Despite all efforts, an estimated thousands of fish of various species and ages died.

Due to the delayed notification of the emergency by the perpetrator, the highest concentrations of pollution were only detected in the Bílina River near the Chanov small hydropower plant (i.e., 10 km downstream from the emergency site), by which point significant dilution of the pollution had already occurred. Nevertheless, compared to blank samples taken upstream of the emergency site, the concentration of many pollutants was found to be 3–4 orders of magnitude higher. For example, the sum of PAHs was 0.044 μg/l upstream of the emergency site and 69 μg/l 10 km downstream and after significant dilution.

Tab. 1: *The table below provides a simplified overview of selected monitoring results during the emergency.*

Location	Detergents (µg/l)	PAU (µg/l)	TOL (µg/l)	Benzen (µg/l)	BTEX (µg/l)
Bílina MVE Chánov	8900	69	2100	2700	5300
Bílina nad Bílým potokem	<50	0,044	0,46	0,25	0,71

Povodí Ohře's costs related to the collection and analysis of samples taken during the emergency exceeded 100,000 CZK. Despite repeated requests, Unipetrol RPA, the party responsible for the emergency, has not covered these costs. Furthermore, the responsible party has not yet been fined nor have any subsequent measures been imposed, such as the construction of a system to capture firefighting water instead of discharging it into the watercourse.

Fig. 1: *Emergency profile on the Bílina watercourse downstream of Bílý Potok*

3. Andělská Hora Emergency

On May 7, 2024, a traffic accident occurred on Road No. 6 near the village of Andělská Hora. A passenger vehicle entered oncoming traffic and collided with a truck. As a result of the collision, approximately 500 liters of diesel fuel leaked from the truck into the adjacent terrain within the catchment area of the Stanovice water reservoir. This happened in the immediate vicinity of the Telenecký Potok stream, which is a tributary of the Lomnický Potok stream, ultimately flowing into the Stanovice water reservoir.

The driver of the passenger vehicle was at fault for the traffic accident and died at the scene. However, according to the Water Act, the operator of the truck was considered the party responsible for the emergency due to the diesel fuel leak. On site, the basin administrator and the water authority estimated that the costs of necessary remedial measures (remediation) would exceed 500,000 CZK.

Given that the truck operator was not at fault for the traffic accident, they refused to order the costly remediation at their own expense. In this situation, and under the threat of damages due to delay (endangering the water reservoir), the water authority could not immediately order a remediation company. This was because they lacked certainty as to whether the local self-government would approve the order for remediation work.

Based on serious and justified concerns (endangering the water reservoir), the basin administrator themselves requested the water authority to assign the implementation of remedial measures to the state enterprise Povodí Ohře at the expense of the responsible party. In this particular situation, this was the only possible solution that prevented the endangerment of a crucial water source. However, it's important to state that this solution was not in full accordance with the valid Water Act, posing a significant risk to the state enterprise Povodí Ohře in the event that the responsible party failed to cover the remediation costs.

The intervention itself primarily involved the excavation of contaminated soil (totaling 105 tons) and its disposal at a landfill. Additionally, it included the containment of contaminated water and its removal for specialized disposal (3 m³), along with other tasks such as constructing a collection pit and using sorbent materials on the ground and in watercourses.

4. Kystra Emergency

On April 5, 2025, a transfer valve failed on a hose leading from a wastewater holding tank at the Novák – papír s.r.o. paper mill in the cadastral area of Kystra. As a result, approximately 250 m³ of industrial wastewater and 10 m³ of sewage overflowed onto the paved areas of the complex. These contaminated waters then entered the unnamed watercourse IDVT 10235998 via storm drains and the sewage system. This unnamed watercourse, after about 1.7 km, flows into the Podšibeniční Potok stream (IDVT 10231235). To speed up the clean-up of the area, the contaminated surfaces were flushed with clean water. However, this action directly led to all the leaked pollution flowing into the unnamed watercourse and subsequently into Podšibeniční Potok. The pollution extended as far as the confluence with the Ohře River, where it was diluted.

Novák – papír s. r. o. promised to remediate the contaminated watercourses, but only partially carried out this process. Given the high levels of pollution in the discharged water (see Table 2), immediate remediation was crucial. The party responsible for the emergency installed two wooden weirs in the Podšibeniční Potok streambed to prevent further downstream transport of pollution. Subsequently, they cleaned the streambed of Podšibeniční Potok, working upstream from its confluence with the Ohře River. Despite repeated inquiries from our side, the entire length of the affected watercourses has not been cleaned to date. Unfortunately, the lack of strong enforcement from the water authority also meant that effective remediation did not occur, and the pollution (at least in the upper section) was eventually remediated by natural biological processes. Due to the low water levels in both watercourses (the streambeds are mostly dry), the pollution did not wash into higher-order streams, nor were there other significant negative ecological consequences. Currently, the lower of the two weirs has been removed. The responsible party plans to shut down production during the summer months and implement a technology change, including the construction of a wastewater treatment plant.

Fig. 2: *Unnamed watercourse after pollution leak from paper mill*

Tab. 2: *Discharged wastewater values into the unnamed watercourse*

Measured values of wastewater at the beginning of the accident		
Parameter Name	water outflow from the paper mill	Nameless creek
Chemical oxygen demand with dichromate mg/l	20000	640
Conductivity (at 25 °C) mS/m	1020	478
Dissolved oxygen mg/l		0,1
Anionic surfactants mg/l		2,6
pH	6,6	7,8
Undissolved solids dried at 105 °C mg/l	3240	57
Ammoniacal nitrogen mg/l		3
Ammonium ions mg/l		3,9
Total phosphorus mg/l		1,72
Boron mg/l		2,1
Calcium mg/l		545
Iron mg/l		1,22
Magnesium mg/l		112
O_2 saturation with oxygen %		1
Chromium mg/l	0,033	
Aluminum mg/l	13,5	

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Phosphorus, nitrogen and another pollutants in the Czech Elbe

Josef K. Fuksa

1. Introduction

Water quality and downstream transport of classical pollutants show dramatic changes leading to a stable present situation. Now we can review the 50 years course and compare it with data from beginning of the industrial/pollution period. Basic data were published by F. Ullik for profile Decin (Tetchen) just upstream the standard profile Hrensko/Schmilka in 1877 [1] and by F, Schulz for Vltava up- and downstream Prague in 1913 [2]. Their methodology is comparable to present one and their original data were only recalculated to a standard format. Standard monitoring of Czech rivers quality started "step by step" after year 1960 and up to the year 2009 data were open to public. Since 2009, data were obtained on request from river basin administrators (Povodí Vltavy and Povodí Labe). In addition, MKOL/IKSE Tables of water quality ended to the year 2010, too. For transport values, concentrations were multiplied by mean daily flows for individual sampling days and the year sum was then calculated based on 12 representing situations in equal intervals. Data are presented as means of ten-year periods to show changes in a most simple way. In the period 1981-90, the pollution reached a maximum and started to decrease. End of at the iron curtain brought a significant improvement: Many inefficient and water polluting companies disappeared and new wastewater treatment plants were constructed or upgraded. After a significant improvement, the situation remains stable. But "new pollutants" appear, especially pharmaceuticals, and eutrophication resist, leading to growing importance of organic carbon produced instream by phytoplankton beside of that discharged by WWTPs. With the Climatic Change long (e.g. over seasonal) dry periods appear, followed by floods and sewerage overflows activity. And summer temperature maxima increase. We deal here with rivers of Strahler order 7–8, representing basins of Vltava and Elbe upstream the confluence, and with the Czech Elbe basin as a whole.

2. Time course of indicators of water quality

Concentrations and transport of nitrogen compounds show a sharp increase of ammonia concentrations in the "pollution period" and then a decrease under the 1900 level. Nitrate nitrogen was quite non-significant in 1900, but now high loads are permanently transported to the oceans, as in the whole Europe. With present absence of low-oxygen situations practically no denitrification in the river could be expected.

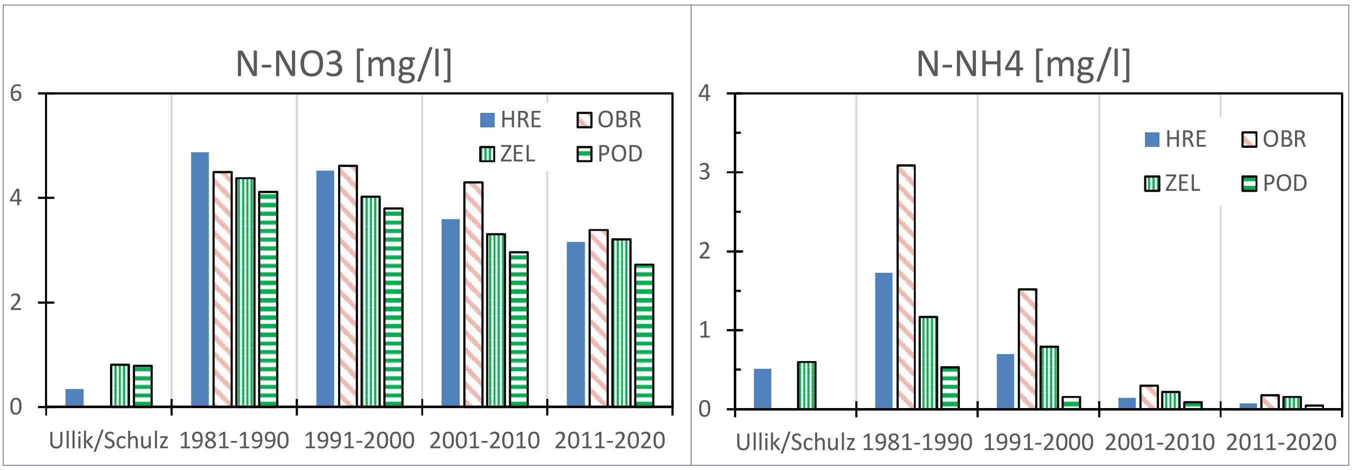

Fig. 1: *Concentration of nitrate and ammonia nitrogen – ten-year means. Profiles: HRE – Hrensko, OBR-Obříství (Elbe upstream m the confluence), ZLE – Zelčín (Vltava upstream the confluence) POD – Vltava upstream City if Prague.*

Permanently decrease concentrations and transport of sulphate, according to decrease of fertilizer use and atmospheric deposition in the basin [3], chloride level remaining stable, but substantially higher than historical ones [1]. Concentration of degradable organic carbon expressed as BOD-5 decreased to a new situation when the seasonal cycle copies the cycle of phytoplankton biomass, expressed as Chlorophyll-a concentrations (Fig. 2). Naturally, we do not have "1990 data" of BOD. Evidently even the present level of phosphorus is well over a value limiting the phytoplankton and diatom maxima between May and June occur, accompanied by minima of reactive phosphate phosphorus (P-PO4, filtered samples), not by changes standardly controlled P-tot (unfiltered samples). Later maxima appear rarely, even during the temperature peak. On other profiles the same situation occurs. Even in profiles on Vltava the phytoplankton cycles do not correspond with "reservoir" cycle in the upstream Slapy reservoir [3].

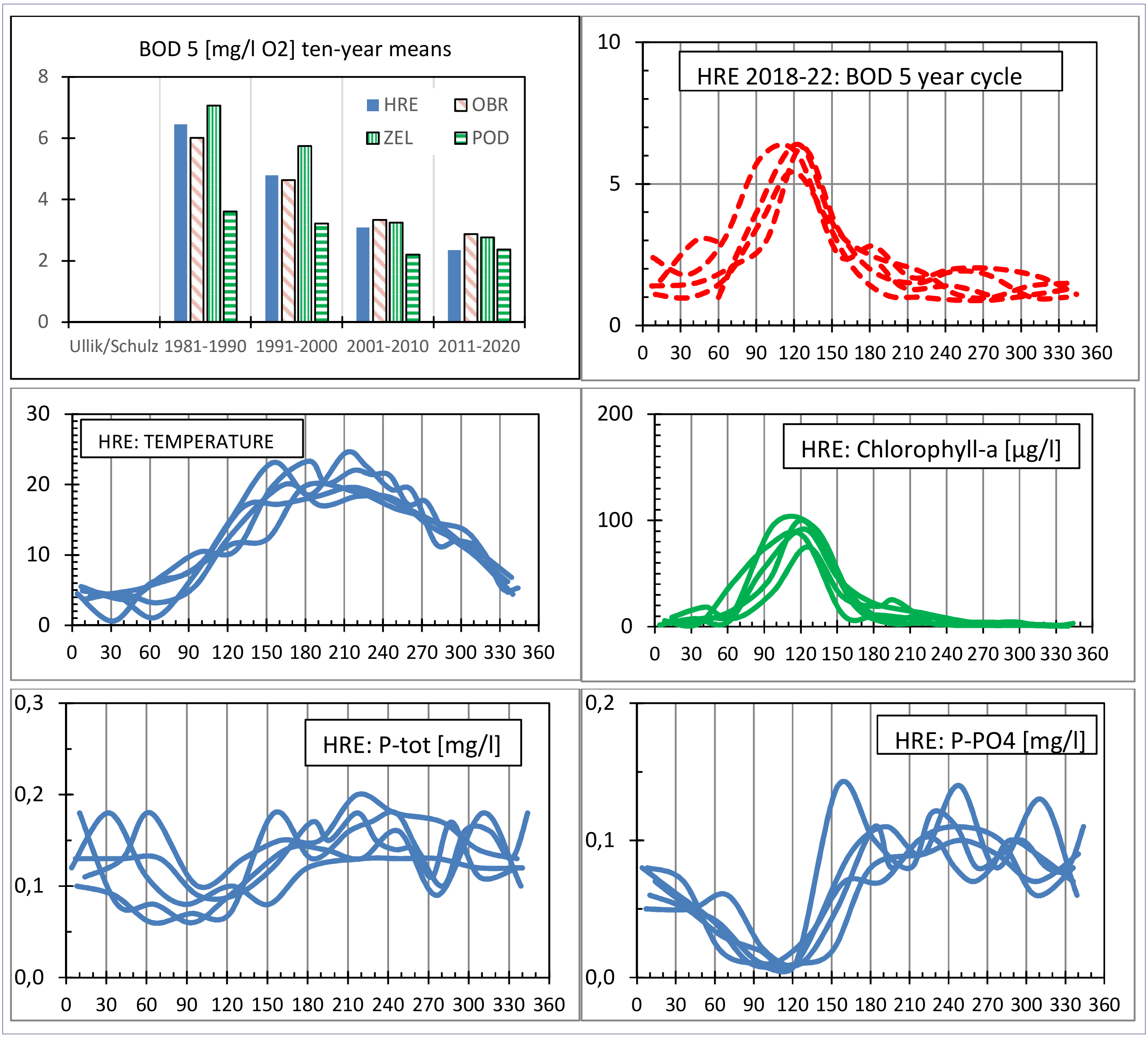

***Fig. 2:** Ten-year mean of BOD 5 (for profiles see Fig. 1) and seasonal cycles of BOD 5, water temperature, chlorophyll-a, total and phosphate phosphorus in the profile Hrensko 2018–2022. X-axis: No. of the sampling day in the year.*

For pharmaceuticals, we presented the production and transport on the last Magdeburg seminar [4]. 6,1 tons of Metformin per year are transported yearly through Hřensko profile, followed by Allopurinol/Oxypurinol (5,5 t/yr) and antidepressivum Gabapentin (1,5 t/yr). For resistant drugs, data from all profiles studied show strong correlation of transport data to the number of inhabitants in basins upstream. Sources of pharmaceuticals are only WWTPs and we can expect a very similar pattern of their consumption in German Elbe basin. To compare Czech data with German ones on FGG Elbe Datenportal [5] is not simple in fact. The problem is (1) that German sources (WWTPs) discharging directly to the Elbe are relatively small (as ratio of number of inhabitants to mean discharge in the profile) and (2) distances between measuring stations are substantially longer than the Czech ones.

3. Sources of pollution and expectations

Transport data (in tons per year) could be compared with “production” of pollution, e.g. discharging from WWTPs in basins upstream the controlled profiles (year sums of inflow and discharge are available for all Czech WWTPs). The first problem of such budgets is that fluctuations of river flow values during the year cycle are much higher than concentration cycles. For nitrogen, budgets show only small part (<20%) of “discharge” in the whole river transport. Very likely most of nitrogen transported by rivers comes from the landscape, e.g. from non-point sources. However, the cycle of nitrogen is connected with atmospheric compartment, so we should only remain on level of speculations. Nevertheless, we should expect that present loads of nitrate nitrogen would persist also in near future, intensifying eutrophication of oceans. Thus, ideas how the WWTPs and sewerage systems could be upgraded to decrease nitrogen transport seems dubious as yet. What is interesting, data on ammonia of F. Ullik [1] show the same pattern as at present – higher values during winter and minima during warm part of the year. For phosphorus, making budgets is obviously more simple, because we can expect that all phosphorus coming once to the river course will travel downstream and its losses could be connected with transient sedimentation and incorporation to biomass. Standard efficiency of Czech WWTPs is over 80% of phosphorus produced by population. Generally, there are some technological reserves, which could improve the efficiency and they will certainly start active with implementation of the new EU Directive 2024/3019/EC. In thze lowland/downstream profiles we deal with here, the Ptot share of WWTPs discharge in the river transport fluctuates in a wide range (see Tab. 1). Primary factor of fluctuation is not the WWTPs discharge but variability of flow in rivers accepting treated wastewater. But different data for the Obříství profile (OBR, Elbe upstream the confluence) could be attributed to different character of the river course – Elbe upstream OBR (confluence with Vltava) is a lowland river, compared with narrow channel with narrow floodplain of Vltava and of Elbe between the confluence and Hřensko. However, it is clear that most of phosphorus transported originates from WWTPs discharges. WWTPs data do not include unknown and nearly unpredictable share of sewerage overflows, but their discharge data recalculated per number of inhabitants show a well acceptable value of specific production of Ptot cca. 2 g per person per day. Therefore, it seems that the increase of phosphorus abatement efficiency in present WWTPs will lead to a decrease of phosphorus level in rivers, even though the sewerage overflow part of discharge is very hard to estimate and eliminate. The question of proper limits (values and entire construction of limits) of phosphorus discharge and river concentrations remains, of course. Emerging problem is a relative independence of phytoplankton biomass/production on the Ptot level, as demonstrated in Fig. 2. The phenomenon deserves some more attention, especially as to proportion of Ptot and P-PO4 during the season and relations to not very frequent and exact data on phytoplankton abundance and species composition. Knowledge based on studies of stratified reservoirs obviously does not bring adequate answers.

Tab. 1: *Percentage of Ptot transported through measuring profiles in total WTPPs discharge in their basins.*

	%	%	%	%
	P celk.	P celk.	P celk.	P celk.
	HRE	OBR	ZEL	POD
2018	77,2	28,0	79,8	68,3
2019	64,0	21,3	68,9	71,5
2020	49,9	23,0	58,7	59,9
2021	47,6	15,9	37,6	37,8
2022	63,2	21,4	54,3	51,7

As to the downstream transport, we suppose the situation is comparable with the river continuum. At present Czech Republic does not produce and transport extraordinary load downstream. Concentrations of “factors of pollution” upstream are comparable with German ones and increase of budgets is attributable simply to growing river – values of flow and number of inhabitants, living in fully comparable “comfort”, connected with comparable production and treatment of waste.

4. Conclusions/Mission

1. Levels of “classic factors” of pollution significantly decreased in the period 1990-2000 and are stable now.
2. Ammonia nitrogen levels are lower than those in “pre-pollution period”, but high and permanent load of nitrate appeared and persists. Origin of nitrate should be attributed to non-point sources.
3. Sulphate loads permanently decrease even now, chloride ones remain. Nevertheless, their levels are substantially higher than in the “pre-pollution period”.
4. Values of BOD 5 substantially decreased. Last 15 years they show a dependence on cycle of primary production of river phytoplankton as an instream organic matter source.
5. Substantial part of river phosphorus should be attributed to discharge from WWTPs. Present phosphorus levels (standardly controlled Ptot) obviously exceed limits controlling the river phytoplankton production.
6. Levels of persistent pharmaceuticals copy the consumption by population.
7. “Does the Elbe pollution still decrease?” Maybe the question could the question be answered as YES. However, we need more data and maybe more modern methods of assessment.

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Tire and road wear particles in rivers: Interaction with trace elements deteriorate the chemical water quality – experiments under environmental conditions

Angus Rocha Vogel, Yannik Kolberg, Swetlana Swonarjow, Wolf von Tümpling

1. Introduction

The total emission of tire wear particles (TWP) for Germany is estimated to be 100,000 t a^{-1} [1], meaning approximately 1–2 kg a^{-1} per capita [2,3]. This amount is likely to increase since the amount of cars is still increasing, surpassing 50 Mio registered passenger cars in Germany [4]. Moreover, a conversion of all cars into electric vehicles could lead to an increase in TWP emissions since electric cars are on average ca. 20 % heavier than cars with combustion engines [5]. The European Union's proposed new emission standard (Euro 7) that came into action mid-May 2024 (Regulation (EU), 2024/1257 [6]) wants to set limits for TWP for the first time from July 2026. Until today, no values are given for the limits [6].

Up to 20,000 t a^{-1} of TWP are emitted into the aquatic environment in Germany [1]. Investigations regarding tyre particles in water systems mostly focus on the ecotoxicological effects of the particles itself or their potential leachates [7,8]. Additionally, water pollutants (antibiotics [9], heavy metals [10,11]) may adsorb on the particle surface, adding another risk.

Our research activities therefore focus on the adsorption of trace metals to the particle surface of tire and road wear particles (TRWP) after entering rivers under environmental relevant conditions. Various TRWP samples from streets, tunnels and kart lanes are in use, in order to cover the variety of TRWP. Additionally, different river samples were used to resemble the variety of the Elbe Catchment. In order to assess the binding behaviour of heavy metals in and on TRWP, BCR extractions were conducted.

2. Materials and Methods

We used different tire-related materials: *Tire and road wear particles including road sediment* (TRWP+RS) from a normal traffic lane, from the middle and the entry of the Elbtunnel. This material contains TRWP and further road related particles as well as other fine particles from the road. In addition to that, TRWP from two kart tracks (KBP) were in use and we made "own" tire wear particles by filing an old tire (TWP/f). Water samples were taken from the Freiberger Mulde, Rothenfurth, as an example of a river containing elevated amounts of trace elements. Other water samples came from the rivers Elbe (Magdeburg), Saale (Halle) and Bode.

The water samples were filtered to 0.2 µm. 16.7 mg tire-related samples were incubated with 1 L filtered water sample for 24 h. Previous investigations showed that the highest adsorption was reached within 6 h and the equilibrium within 24 h. For investigating the effect of salinity, NaCl was added to the solution to match certain rivers in the Elbe Catchment.

After the experiments, the particles were separated from the solution by filtration (3.0 µm), dried in a desiccator and digested in a microwave with reverse aqua regia ($V(HNO_3):V(HCl) = 3:1$). The content of trace elements was determined by ICP-MS/MS and afterwards evaluated by using the classification system of the LAWA (Bund/Länderarbeitsgemeinschaft Wasser) [12].

The bioavailability of trace metals in tire-related samples was analyzed using an improved and adapted BCR extraction procedure by Ure *et al.*[13]. Shortly, 500 mg of sample was weighed into centrifuge tubes. Sequentially the particles were mix with different solutions followed by shaking over night and washing afterwards. After the last extraction, the remaining particles were digested as described above. Four fractions can be distinguished after the BCR extraction: F1, light extractable fraction with 0.11 mol L^{-1} CH_3COOH; F2, reducible fraction with 0.5 mol L^{-1} $NH_2OH \cdot HCl$; F3, oxidizable fraction with 8.8 mol L^{-1} H_2O_2 and 1.0 $(COO)NH_4$; F4 residual fraction.

3. Results and Discussion

Assuming that after rainfalls the different tire-related particles remain as suspended matter in river systems one can apply the classification system of LAWA for evaluation the potential risk of the particles before and after experiments and potentially adsorbed trace elements on the water quality. The results are given in Tab. 1.

Tab. 1 *Theoretical classification of priority trace elements (Cr, Ni, Cu, Zn, Cd, Pb) and As* by the LAWA (*ARGE ELBE) system for suspended matter [12] for tire-related samples before and after 24 h incubation experiment. Comparison with the classification of suspended matter in the river Elbe [14]. TRWP+RS: tire and road wear particles including road sediment; NET: samples from the Elbtunnel; TWP/f: tire wear particles produced by filing; KBP: samples from different kart tracks.*

	TRWP+RS[a] Traffic lane		NET #1[a] Neuer Elbtunnel entry		NET #3[a] Neuer Elbtunnel centre		TWP/f[a] Laboratory		KBP #1 Kart track gas powered		KBP #2 Kart track benzine powered		Elbe[14]
	before experiment	after experiment	before experiment	after experiment	before experiment	after experiment	before experiment	after experiment	before experiment	after experiment	before experiment	after experiment	suspended matter
Cr	I	III	III	III	III	III-IV	I	I	III	III	I-II	II	II-III
Ni	II	III	II-III	II-III	II-III	III	I	I-II	II-III	II-III	I-II	II	II
Cu	III	III	IV	III-IV	IV	IV	I	I	III	III	III	III	II-III
Zn	III-IV	IV	III-IV	IV	IV	IV	IV	IV	IV	IV	IV	IV	III-IV
As	I-II	II-III	II	I-II	II	II	I	I	I	II	I-II	II	II-III
Cd	I-II	IV	II	IV	II	IV	I	II-III	I-II	III-IV	II-III	IV	III-IV
Pb	I-II	II	II-III	II-III	II-III	II-III	I	I-II	II	II	III-IV	III	II-III
TWP content	12%		9.4%		22%		97%		69%		71%		---

[a]already published in Rocha Vogel *et al.* 2024 [15]

water quality class	I	I-II	II	II-III	III	III-IV	IV

In order to assess the potential risk of tire-related materials poses on the chemical water quality regarding trace elements, we compare the theoretical classification for them with the classification of suspended matter in the river Elbe. Whenever a theoretical class is higher than for the Elbe, a risk is assumed. Clearly comparing the different materials with the suspended matter, an endangering mainly for Zn and Cu could be observed. Moreover, samples from the tunnel contain higher amounts of trace elements potentially due to the poor ventilation of tunnels and an accumulation of trace elements inside tunnels.

After the adsorption experiment a different picture is drawn. A significant adsorption of the investigated elements (except for Cu) on the all materials was observed. Therefore, this would lead to a deterioration of the chemical water quality of the suspended mater referring to Cr, Ni, Zn, As and especially Cd.

Regarding the Elbe catchment, the salinity chances from source to mouth. Especially in the coastal part, the salinity is expected to have an influence on the adsorption of certain trace elements. For the sample NET #3 (*tire and road wear samples from the Elbtunnel*), out of the priority elements only the adsorption of Cd and Zn is observed to be dependent on the salt concentration, weakening with higher Cl^- concentrations as shown in Fig. 1 [16]. At 12.0 g/L Cl^- (= tidal Elbe) no significant adsorption of Cd and Zn was detectable. It is assumed that both metals form $[MCl_4]^{2-}$ complexes that are soluble and mobile as reported by Norrström et al. [17]. The negatively charged TRWP surfaces is estimated to only allow ionic interaction with cations but not with chlorido complexes, thus weakening the adsorption capacity of Cd and Zn. Hence, under environmental conditions it might be possible that Cd can be transported on TRWP+RS as suspended matter from areas with high heavy metal concentrations and later released in areas with high salinity [16].

This observation is also of interest for the treatment of rain runoff water from streets and highways with regard to the use of de-icing salt in winter.

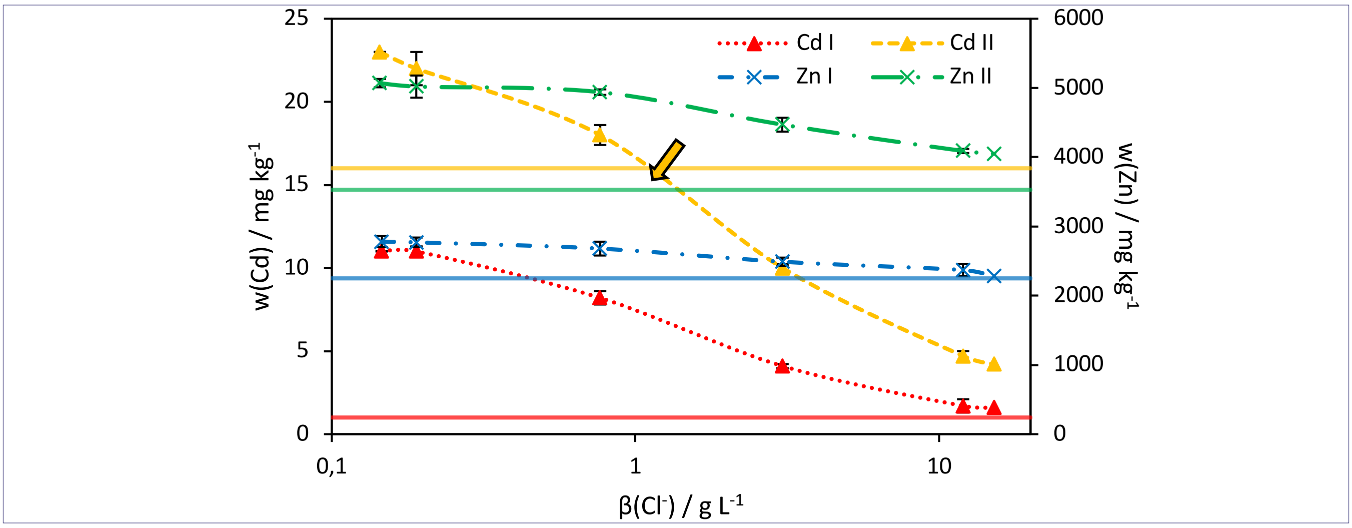

Fig. 1 *Comparison of the dependency of the adsorption of Cd and Zn to NET #3 on the β_{Cl^-}. I indicating adsorption experiments with "pristine" NET #3, II indication adsorption experiments with previously incubated NET #3. Solid lines in the corresponding colour mark the element content before adsorption experiment. Dotted lines represent the obtained trend. The inserted arrow indicates the potential concentration, from where a dissolution of Cd from NET #3 occurs. Taken vom Rocha Vogel et al. [16].*

Until now the exact binding properties of the different trace elements on TRWP are not known. First assumptions from this work state that an electrostatic interaction as well as the high surface functionality are the main drivers for adsorbing trace elements [11,18].

A suitable procedure for assessing the binding properties of trace elements for sediment samples is the sequential extraction procedure developed by Ure et al. [13]. Until now this procedure has not been adapted for tire-related samples. For quality assurance, one can compare the element content of the pseudo total digestion with the sum of element contents for the four extraction steps (s. Fig. 2). As can be seen, for almost all elements present the differences are within the range of the standard deviation. Hence, the BCR procedure is suitable for tire-related samples to investigate the binding properties.

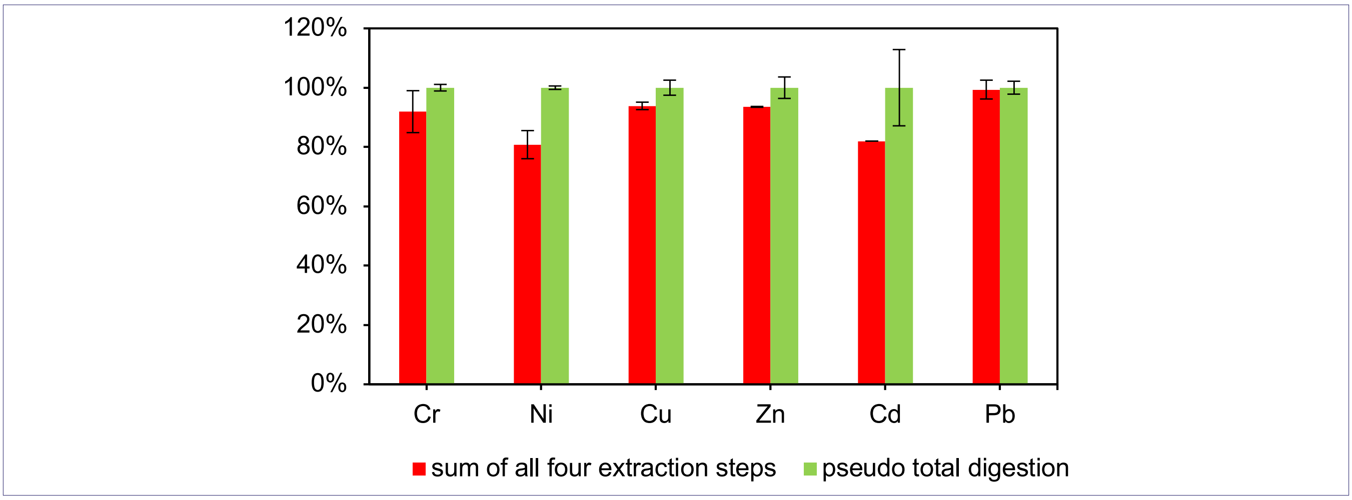

Fig. 2 *Relative comparison of the sum of all four extraction steps with the pseudo total digestion (set at 100 %) for NET #3 as an example for tire-related samples. Average values including first standard deviation.*

4. Outlook

All these findings are relevant not only for river catchment areas like the Elbe but also for runoff water treatment or water retention systems. Future monitoring strategies should consider this to prevent potential water management restrictions.

5. Acknowledgements

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Quo Vadis Chemical Water Monitoring?

Lars Duester

1. Abstract

Industry, research and administration run wastewater and surface water monitoring, largely independently of each other. The motivation ranges from the very basic fulfilment of legal requirements with a manageable number of parameters to approaches that follow the utopia of a complete understanding of the chemical status of our rivers, including the ability to predict this status taking climate and social changes into account. If we take the multitude of different hydraulic engineering and chemical anthropogenic influences on our rivers as a basis for our considerations and add the increasing impact of climate driven changes, it is foreseeable that society's demands on our ability to record and predict the current chemical status of water bodies will continue to increase. The fundamental questions are: are we well enough prepared for the things to come? And if not, is not a much closer interaction between those who monitor water chemistry in Europe needed? To foster the discussion, the presentation analyses the current status from the perspective of the chairman of the Monitoring Expert Group of the International Commission for the Protection of the Rhine and head of the Environmental Radioactivity and Monitoring section of the Federal Institute of Hydrology that maintains more than 40 monitoring stations across Germany. It aims to identify potentials, deficits and challenges in order to take a look at the potential future of our water chemistry monitoring. Legal, analytical and data communication aspects as well as possible conflicts of interest are outlined, with a special focus on automation (online/atline) and an attempt is made to combine these framework conditions into a realistic picture of our common future chemical water monitoring.

2. Introduction

The increasing complexity of our living environment with various natural or man-made disasters and pressures, demands more effective warning and forecasting approaches. Examples for such pressures are water temperature changes or salinity driven disasters, e.g. [1] or [2]. In this context, more comprehensive frameworks that combine open-source automation solutions with intensified knowledge exchange between different scientific fields and interest groups are needed to better face existing and future challenges.

An option is to build on the idea of developing innovative monitoring concepts by fostering analytical and data processing innovation e.g., by adapting existing open-source hard- and software applications for analytics and data evaluation. This allows us to accelerate knowledge sharing and to further foster the development of automated data processing and evaluation techniques in a feedback loop. Innovation is urgently required for a close to real-time data provisioning in various fields. In addition, analytical methods are needed that cover a wide range of chemical species in a single run to remain timely as close as possible to the flowing waves in our catchments. An example from the past was the Oder disaster in 2022 where the Federal Institute of Hydrology was able by combining approaches like non-target, polymerase chain reaction and multi-element analyses to timely deliver a broad set of results and information to exclude potential causes and to include reasons.[2–6]

3. Key steps for network transformations in Europe

Open-Source Automation Solutions and data provision: The use of open-source hard- and software applications that can be easily modified, shared, and integrated within existing systems is a future key issue. This approach ensures flexibility, reduces costs, and accelerates innovation to a certain extend. However, core pieces of the monitoring will remain in the hands of device manufacturers, here a further miniaturisation, increase of robustness as well as lower acquisition and maintenance costs of devices are needed. To improve the public availability of data, legal frameworks like the EU Data Governance Act [7] or the potentially released Forschungsdatengesetz (Research Data Act) in Germany [8] are first steps. However, for environmental data, also contributions from different private sectors are needed. As an example, data from interest groups who provide treated wastewater to our rivers and those who extract water to provide drinking water would be extremely beneficial, if integrated into virtual meta monitoring networks. Figure 1 illustrates some examples of public and private components that are already available in different monitoring approaches.

Intensified Knowledge Exchange: To increase the impact of our monitoring frameworks and to foster intelligent adaptable structures, we must create virtual meta monitoring networks across borders (countries and stakeholders) to address whole catchment areas and to gain as much benefit as possible from already existing monitoring activities. This is only possible if we improve the collaboration between different scientific fields and interest groups to promote actively, top down and bottom up, knowledge sharing.

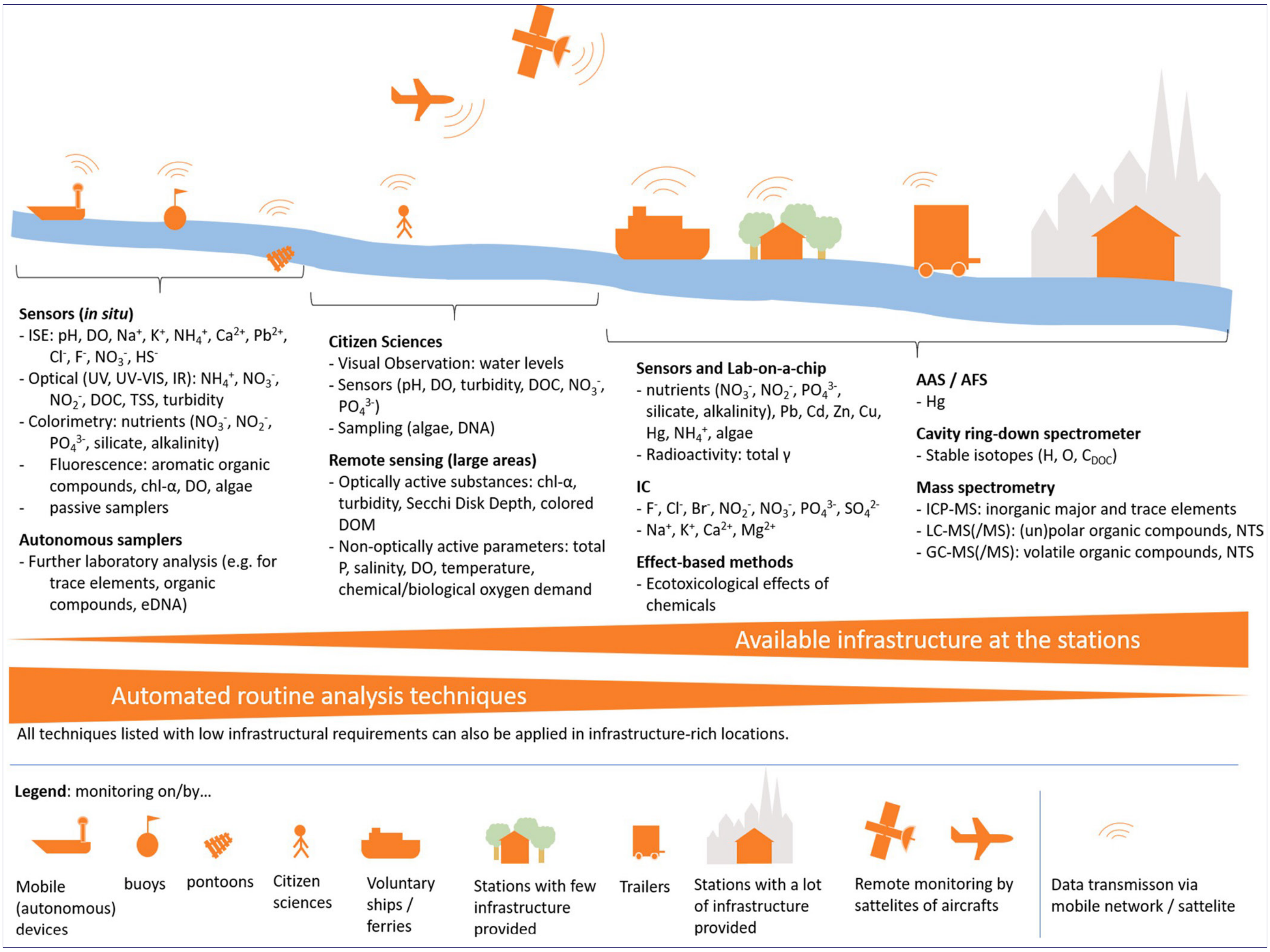

Fig. 1: *Summary of techniques and parameters available for chemical real-time surface water monitoring. These are in situ techniques with monitoring from boats, buoys and pontoons, data collection through citizen science and remote sensing, as well as techniques currently known from laboratories requiring more infra- structure which is provided in ships, trailers and monitoring stations, taken from Arndt et al. 2022.[9]*

4. Conclusions

As already published by Arndt et al 2022 an increasing need of cooperation and scientific exchange between different interest groups such as authorities, researchers, and industry are important and are going to be even more important in times of increasing uncertainties.[9] This collaboration can foster innovation processes and create branched virtual meta monitoring networks where every single branch benefits from close to real-time data provisioning of the predecessor activity. One fundamental goal on the work level is to shift from sample transport to data transport by applying more and more on- and atline approaches, which will save energy, time and money in the long term. It may analytically enable us to be as close as possible to real-time processes and changes of the flowing waves in our catchment. It creates high-time-resolution data sets for machine learning approaches, already demanded by many scientists at the moment, but rarely found in our existing monitoring systems. In addition, especially by making use of multiparameter/multianalyte fingerprints in high-time-resolution data sets, the chance is given to achieve more comprehensive and thereby better: (i) protection of human and the environment, (ii) tools to solve conflicts on the distribution of water resources at an early stage, (iii) knowledge levels of stakeholders and the public. However, we must consider that detection of trace-level concentrations of pollutants and unknown substances is often a highest concern in industrialised catchments, whereas in other areas much more fundamental approaches are very urgently needed to fill the gaps in our networks. The development of difference between monitoring networks must therefore be combated and we must make the best out of what we can get from all data sources.

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Posterpräsentationen

Posterová sdělení

Magdeburger Gewässerschutzseminar 2025

Magdeburský seminář o ochraně vod 2025

Protecting transboundary waters: Why does it matter?

Markus Ahnert, Jakob Benisch, Annika Schubert, Sara Schubert

1. Introduction

The release of pollutants into the environment is a cross-border issue. In particular, discharges from municipal wastewater treatment plants, agriculture and industry into watercourses represent sources of pollution with cross-border effects. Many people are still unaware that water pollution is ultimately caused mainly by human activity. The present project aims to tackle this issue in the cross-border region Saxony-Czech Republic.

Water pollution and water demand are becoming serious problems due to population growth, industrial expansion, and the effects of climate change – the project region is no exception from these pressures. In addition to applicable EU regulations (e.g. the EU Water Framework Directive and the EU Urban Waste Water Treatment Directive[1], [2]), Saxony and the Czech Republic have separate legal, administrative and procedural approaches to wastewater discharges that are not coordinated with each other. However, the objectives of regulatory monitoring may differ between the two countries by limit values of pollutants or the operation of wastewater treatment plants.

To face these future challenges, we need suitable specialist personnel, thinking and acting across borders. At the same time, the general public must be sufficiently informed about the issues to support the necessary measures in terms of both content and funding.

2. Presentation of the IDEAL project

The Elbe connects the Czech-Saxon border region with neighbouring areas. Despite living and working so close to each other, there are still many differences in actions and awareness of our influence on the environment. To address this, universities and water management associations from Saxony and the Czech Republic have joined forces to work on the IDEAL project (Importance of Water Education in the European Elbe/Labe Region [3], [4]). The project's main topics (see also Fig. 1) are divided into the following four areas:

- Education and training of academics and professionals
- Methods for monitoring surface water and wastewater
- Cooperation with stakeholders
- Raising Awareness in the broad public (Citizen Science)

The first essential step is to harmonise knowledge of water pollution, the influence of settlements, the relevant stakeholders and country-specific boundary conditions. This involves comparing methods and tools in university education and in the practice of water and wastewater companies in both countries.

Technical methods are exchanged and compared during joint courses, workshops and excursions in the project area. All partners have specific technical expertise and complement each other in order to comprehensively assess the impact on water bodies. Web-based offerings are created using self-collected and publicly available data for use in public relations work.

The findings have been compiled into various measures and products designed for specific target groups, with the aim of raising awareness of the impact of human activity on our waterways. Participating universities are establishing a network for joint training in the water sector. The professional associations DWA and CzWA are collaborating across the border in the areas of further training and public relations. Together, they are developing and using suitable communication and interaction formats to raise awareness of the issue among professionals and the general public, e.g. via social media channels. Activities in the field of citizen science also contribute to this.

Successful water protection in the project area can only be achieved through cooperation between the two countries. Our project aims to harmonise and complement existing activities, particularly in the areas of education, training, and general environmental awareness, in order to raise awareness of our shared responsibility for the future of our water.

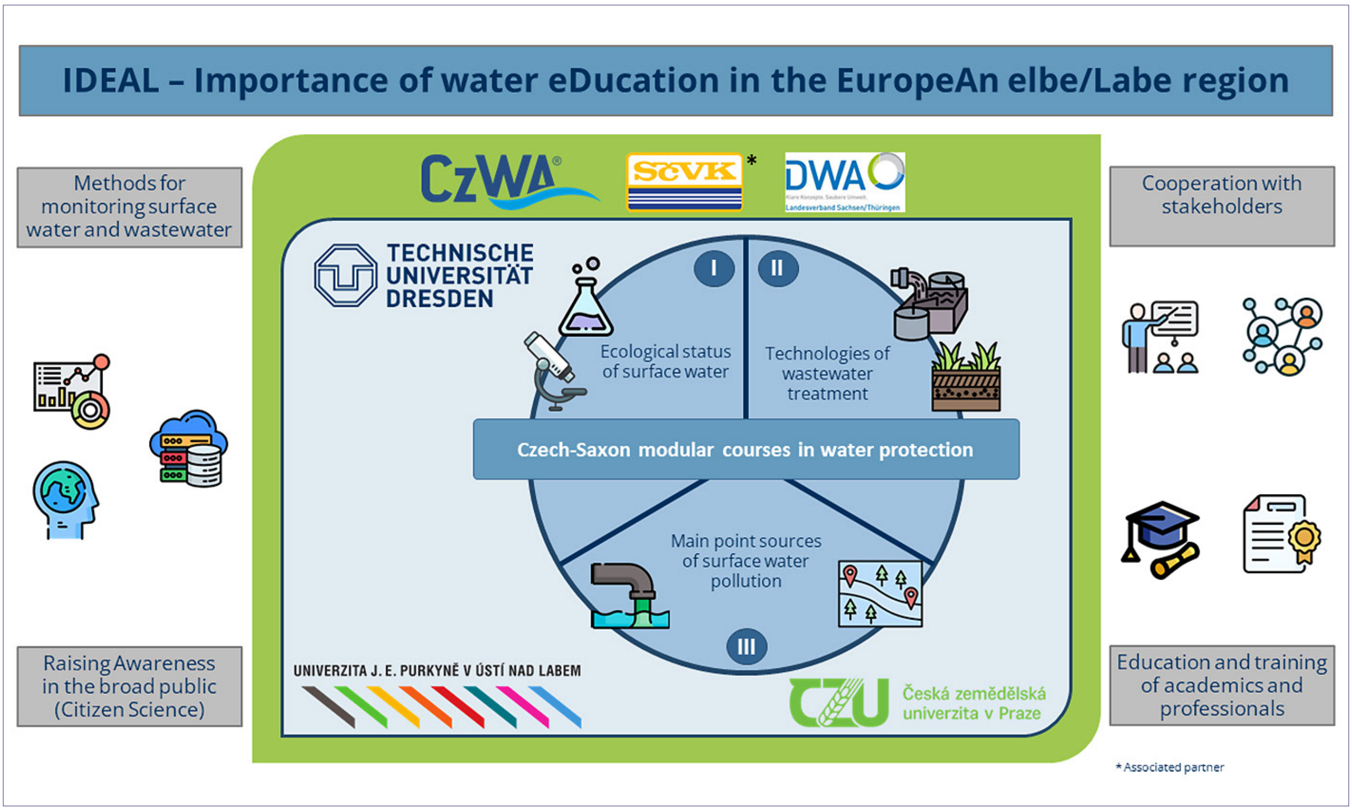

Fig. 1: *Main scopes of IDEAL project*

The wastewater associations DWA and CzWA intend to use the project as a basis for long-term cooperation in the border region. Existing communication and exchange formats in both countries are to be supplemented by a cross-border component.

The project also aims to make university education even more relevant to the current requirements of the labour market. To this end, close cooperation with the wastewater associations will be established. This will also help to ensure that skilled workers in the region are trained to meet regional and local needs.

3. First results

The following activities are already started or in direct preparation:

- Praxisforum for first exchange of requirements of existing methods, regulations, relevant issues e.g. phosphorus eliminations, use of substances/pharmaceuticals (EU-UWWTD) in May 2025 in Dresden
- Identification of suitable monitoring rivers and WWTPs in border region, first sampling campaigns in spring and summer 2025
- Development and launch of a lecture series at TUD about “Water without Borders” starting at October 2025.

4. Acknowledgments

We would like to thank the EU programme Interreg Saxony – Czech Republic for funding our joint project (project number 100736356) and the administrative support of the European Project Center at the Technische Universität Dresden.

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Is there a need to manage drought risk in Saxony?

Veit Blauhut

Among its neighbours, Saxony experienced several extreme drought events within the last ten years. The consecutives years of 2018, 2019 and 2020 approved as exceptional multi-annual low flow event for several river catchments but also as the worst multi-annual groundwater drought on record. Accordingly, a diversity of direct and indirect drought impacts were reported raising the question of Saxony's resilience to drought.

The foci of this Saxon-wide study are, to investigate and quantify the system-specific impacts of drought and low flow, to illustrate system-specific perception on its risks and to elaborate recommendations for action to foster resilience to the hazard. An analysis of system-specific statistical information, text mining approaches and personal interviews unites diverse data to a spatial and temporal referenced dataset. Risk perception and recommendations for action are elaborated in over 70 interviews, three workshops and several expert consultations.

The results reinforce the envisaged aim of the Free State of Saxony, to manage hydrological drought risks. Moreover, the variety and intensity of past drought impacts call to extend this aim to a comprehensive drought risk management; an idea carried by drought impacted representatives.

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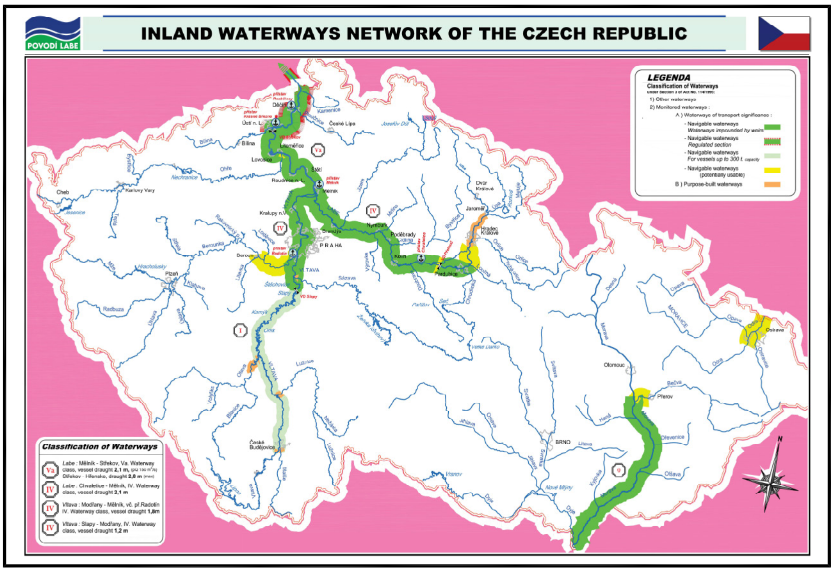
POSSIBILITIES AND USES OF THE ELBE WATERWAY

The Elbe Waterway – a Major Transport and Development Artery

The Elbe waterway represents a key transport corridor linking the Czech Republic with the European network of inland waterways. As part of the Trans-European Transport Network (TEN-T), it provides a direct connection to major seaports in Germany, particularly Hamburg, and integrates into the broader European logistics system. This waterway holds strategic importance not only for freight transport but also for the development of the regions it passes through.

At present, the Elbe is primarily used for transporting bulky and bulk cargo, such as construction materials, agricultural commodities, and energy resources. In addition to freight transport, the Elbe is gaining importance in passenger transport – especially in tourism. Numerous tourist vessels, excursion boats, and river cruises bring thousands of visitors to the region each year, drawn by the natural beauty of the Elbe Valley, its historic towns, and cultural landmarks.

The development of the Elbe waterway is the subject of long-term planning. Key goals include ensuring year-round navigability, modernizing port infrastructure, and improving interconnections with the railway and road networks. These measures aim to enhance the competitiveness of water transport, promote sustainable mobility, and contribute to the economic development of the regions along the Elbe.



The planned network of waterways of the Austro-Hungarian Empire, presented at the seminar on water transport held on 12 December 1900 in Vienna.

The European Agreement on Main Inland Waterways of International Importance (AGN) entered into force on 26 July 1999. In the legal system of the Czech Republic, it was published in the Collection of Laws under No. 163/1999 and has been in effect since the aforementioned date. According to Article 1 of the Agreement, the Contracting Parties undertake to adopt its provisions as a coordinated plan for the development and construction of a network of inland waterways.

Regulated Section Ústí - Hřensko (Czech border with Germany) on The Elbe

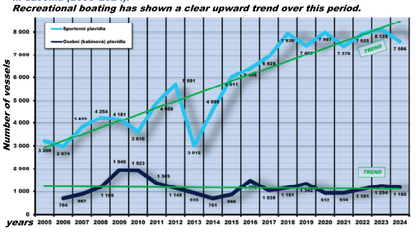
Natural Elbe Riverbed Pavement
In certain sections of the lower Elbe, a natural riverbed pavement can be found – a geological and hydrodynamic formation composed mainly of larger pebbles, gravel, and stones deposited by natural fluvial transport. Some solitary stones can reach enormous sizes.

Dried-Up Waterway
Condition of the Regulated Section of the Elbe River in Ústí nad Labem during the Dry Year 2018. In 2018, an exceptionally dry year, the riverbed of the regulated section of the Elbe in Ústí nad Labem experienced record low water levels of 108 cm, corresponding to a discharge of only 62 m³/s.

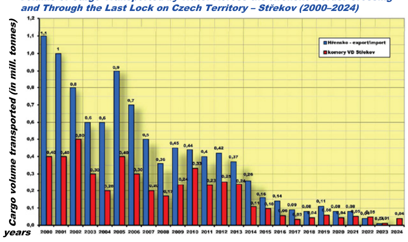
The Beskydy Tugboat
is the most powerful paddle tug on the Elbe River, built in 1956. It is used for towing and rescuing vessels, especially in challenging sections of the river, including operations on German territory. This unique vessel has faced several threats to its existence over the years, but has always been preserved and remains in operation to this day.

Use of the Elbe Waterway in the Context of Climatic Conditions

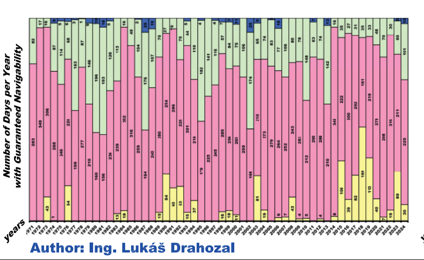
Development of Recreational Boating and Passenger Water Transport on the Elbe in Czechia (2005–2024).
Recreational boating has shown a clear upward trend over this period.



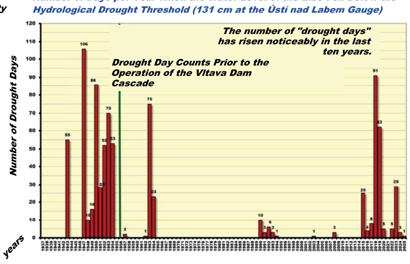
Volume of Cargo Transported by Water Across the Hřensko Border Crossing and Through the Last Lock on Czech Territory – Střekov (2000–2024)



Navigability of the Regulated Elbe Section Depending on Hydrological Conditions
Yellow - Navigation Halted, Pink - Restricted Navigability - Green - Full Navigability



Number of Days per Year When the Water Level of the Elbe Fell Below the Hydrological Drought Threshold (131 cm at the Ústí nad Labem Gauge)



Elbe Waterway:

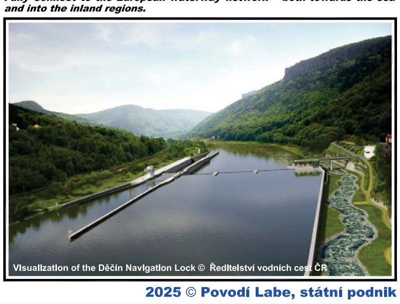
What Lies Ahead

Děčín Navigation Lock
The Key to Unlocking the Full Potential of the Elbe Waterway

The Elbe River is part of the Trans-European Transport Network (TEN-T) and serves as a natural transport corridor between the Czech Republic and seaports. However, a 40 km stretch between Děčín and the German border has long been unnavigable due to low water flow – navigation is halted here for up to half the year. This situation limits the economic potential of inland water transport, which offers an ecological, safe, and high-capacity alternative to road and rail.

The project will also include:
A small hydropower plant (47 GWh/year), Fish passes, riverbed revitalization, and the creation of new habitats, No risk of flooding or land inundation, instead, it will improve the urban environment, stabilize water levels.

By constructing the weir, the Czech Republic will:
Increase the competitiveness of its exports through more affordable and reliable transport,
Reduce the burden on rail and road infrastructure,
Fully connect to the European waterway network – both towards the sea and into the inland regions.



Author: Ing. Lukáš Drahozal

Issues of decabromodiphenyl ether (PBDE-209) in sediments of the Czech Upper Elbe River

Martin Ferenčík, Stanislav Král, Gregor Vohralík

1. Introduction

The poster deals with the occurrence of PBDE-209 in the upper part of the Elbe River above Hradec Králové, where extreme findings in sediments in the hundreds to thousands of micrograms per kilogram are found. Decabromodiphenyl ether (decaBDE, PBDE-209, CAS 1163-19-5) has been used as a flame retardant (together with antimony trioxide) in large quantities in many applications (plastic parts in automotive, aerospace, household electrical appliances, household polypropylene textiles, building insulation materials (non-combustible membranes and foils for roof and facade systems), geosynthetic textiles used in road and railway tunnels, etc.). In 2017, it was added to the list of Annex A of the Stockholm Convention on Persistent Organic Pollutants due to its hazard and persistence. Due to its high stability, hydrophobicity and wide range of usage, PBDE-209 is one of the most abundant substances found in solid matrices of the aquatic ecosystem (sediments, suspended matters).

2. Data and Method

PBDE-209 is analysed by GC-NCI-MS method with negative chemical ionisation (methane as reagent gas) on a short capillary column (15 m, 0.25 mm inner diameter, 0.1 um film thickness) [1]. PBDE-209 is being monitored by Povodí Labe in sediments of the River Elbe and its main tributaries since 2010. The results of this monitoring at the highest location of the Elbe River with high concentrations at the Hořenice profile (river kilometre 1021.2) are shown in the Figure 1. Concentrations (in ug/kg DW) were in the interval of 300 to 16 000 with the median of 4 000.

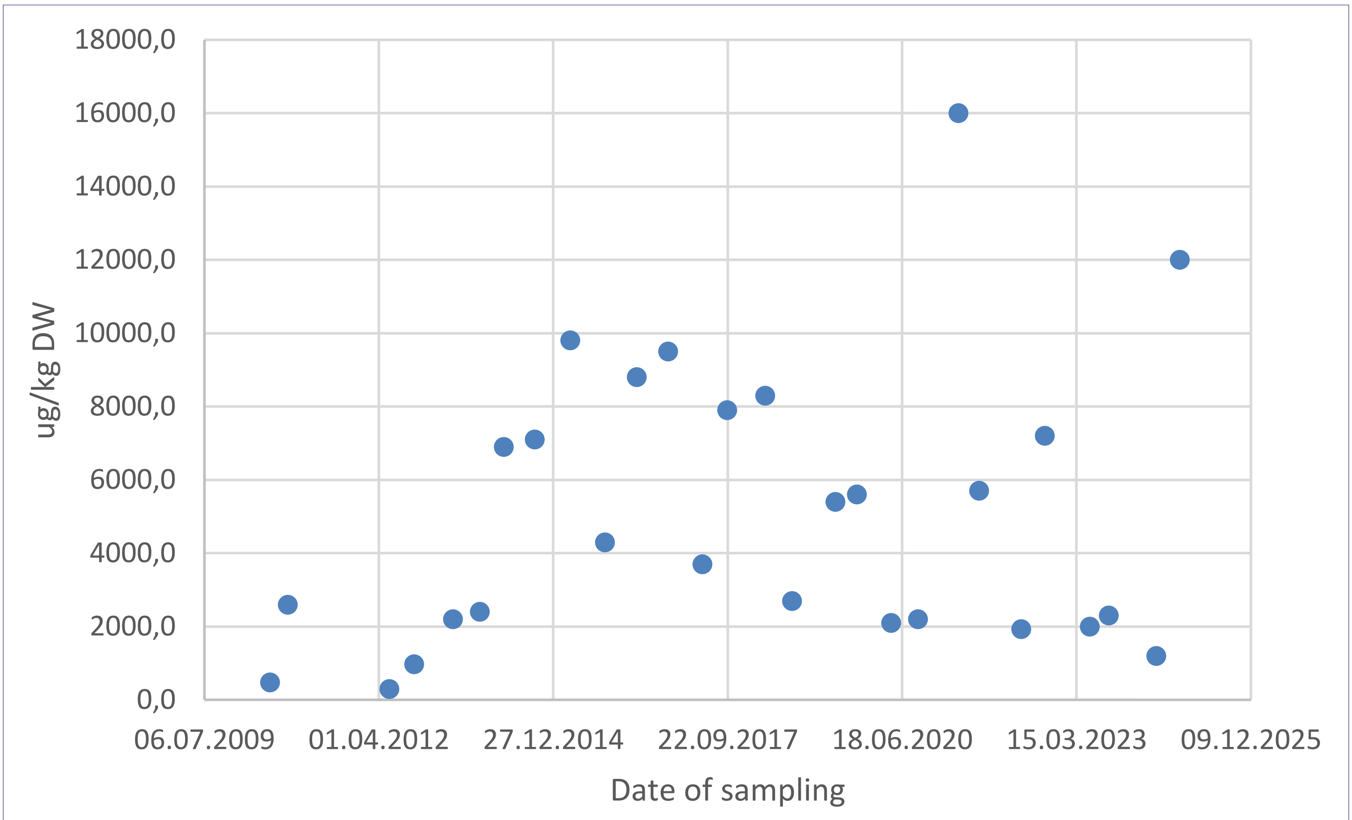


Fig. 1: *Concentrations of PBDE-209 in sediment at profile Hořenice during 2010-2024*

Project MaSEL [2] provided more detailed information on the quantity and quality of sediments in the weir impoundments of the Czech Elbe. A part focused on PBDE-209 revealed, that possible source is located between Labe Verdek (river kilometre 1039.6) and Labe Heřmanice (river kilometre 1012.7). Further detailed monitoring to locate the source of contamination was proposed based on previous results and took place in 2025. The selection of sampling sites was designed using the sewer line layout of town Dvůr Králové nad Labem (the map will presented on a poster). Results of this monitoring are summarised in the Table 1.

Tab. 1: *Concentrations of PBDE-209 [ug/kg DW] in sediment, solid material from sewer line and sewage sludge samples from Dvůr Králové nad Labem*

Sample Location Number	1	2	3	5	6	7	8	9	10	11	12	13
Sampling site	Sewer Line B	Sewer Line B	Sewer Line A	Sewer Line L	Sewer Line C	Sewer Line B	Sewer Line B	Elbe Verdek	Elbe Dvur Králové nad Labem	WWTP DKnL	Industrial WWTP	Industrial WWTP
Sample description	above industrial plant	odběr: OV MěVak	shaft boatyards	Žižkov	shaft Bus station	below industrial plant	Luční street	sediment up the Dvur Kralove	Sediment Below WWTP DKnL	Mixed municipal and industrial sewage sludge	excess sewage sludge	sewage sludge, activation
PBDE 209, (ug/kg)	<50	70	<50	<50	<50	38000	21000	<20	2900	14000	310	110

3. Conclusions

Detailed monitoring helped to identify the source of contamination with PBDE-209. A big company producing plastic materials (for example geotextiles) with lower level of flammability has several producing units spread within the town of Dvůr Králové nad Labem. Waste Water Treatment Plant (WWTP) located inside of one of the industrial zone with three producing units contained increased PBDE-209 levels (samples 12, 13). Municipal sewer line B was highly contaminated just below two producing units of the company (sample 7).

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Methane ebullition from freshwater aquaculture pond and the corresponding natural organic matter composition in sediments

Peter Herzsprung, Carolin Waldemer, Matthias Koschorreck, Oliver J. Lechtenfeld

1. Introduction

Methane (CH4) is a potent greenhouse gas and its atmospheric concentration has almost tripled since pre-industrial times and is currently still increasing. Aquaculture is one of the fastest growing sectors of food production by covering over 8 Mio ha. Recently extreme high methane ebullition has been detected in a fishpond (Gerstenteich near Bautzen, Saxony) [1]. In order to find out potential drivers of methane production a transect of sediment samples between the feeding site and the open water area was analysed for gradients of natural organic matter (NOM) composition [1]. High resolution of NOM elemental composition was achieved by coupling ultrahigh performance liquid chromatography with ultrahigh resolution mass spectrometry.

2. Study Site and sampling

The 1.2 ± 0.3 m deep Gerstenteich with an area of 2.5 ha, was located near Bautzen, Germany. According to the operator, the freshwater pond was constructed more than 400 years ago. After being drained in winter, it was semi-intensively stocked with 580 kg ha-1 of two-year-old catfish (Silurus glanis) and tench (Tinca tinca) in March 2021. A stationary, automatic pellet feeder dispensed a certain amount of fish feed with a protein content of 45% into the water below when triggered by fish.

Sediment samples were taken from the uppermost 5 cm using a gravity corer (UWITEC, Austria). The sediment was stored anaerobically in Anaerocult® A bags (Merck Millipore, Germany) and transported to the laboratory under refrigeration for further analyses. The freeze-dried sediment samples were dissolved in ultra-pure water (Integral 5, Merck, Darmstadt, Germany) at a ratio of 1:10, shaken for about 12 h and centrifuged for 4 min. The supernatant was filtered through 0.45 µm syringe membrane filters to obtain aqueous sample extracts for water extractable organic matter (WEOM) analysis. The arrangement of the 12 sediment sampling points, of those 3 in the feeding centre and 9 outside (radial pattern around the automatic pellet feeder, a sediment transect), was described in [1].

3. Chemical analysis

The total protein content was analysed photometrically after extraction with sodium hydroxide [2].

For WEOM analysis, aqueous extracts were diluted 1:10 with ultrapure water and measured in random order by liquid chromatography ultrahigh-resolution mass spectrometry (LC-UHRMS), using 100 µL for injection into the LC. The LC column outlet was connected to Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS, solariX XR, Bruker Daltonics, Billerica, U.S.A.). Details are described in [3]. After calibration, molecular formulas (MF) were assigned for the mass range 150 – 1000 Da with an error threshold of 1 ppm using in-house software considering the following elements: $^{12}C_{0–60}$, $^{13}C_{0–1}$, $^{1}H_{0–122}$, $^{16}O_{0–40}$, $^{14}N_{0–8}$, $^{32}{}_{S0–3}$, and $^{34}S_{0–1}$. Further details addressing formula assignment, chromatographic segments/retention times (RTs) and data arrangement are described in [1].

4. Results and discussion

The measured sediment protein content correlated significantly (n = 12 sediment sampling points) with the observed CH4 ebullition (R^2 of 0.58, $p < 0.05$, indicating protein as a driver of CH_4 ebullition in the investigated fish pond. Anaerobic protein degradation occurs in steps as the hydrolytic exoenzymes proteases and peptidases break down the macromolecules first into oligopeptides and amino acids, which are then further degraded or incorporated into the microbial biomass. The LC-UHRMS analysis sheds light on the details of the differences in organic matter quality (here WEOM) in the investigated fish pond sediments. From the 12 samples a simplified “two samples” model was generated. The three samples from the feeding centre were combined to sample “F” by calculation of median values from peak magnitudes formula by formula [1]. The nine samples outside were accordingly combined to sample “W”. From the resulting peak magnitude median values, a two sample inter sample ranking (ISR) was calculated [1]. The display of the first ranking means to show the components having higher relative abundance, the second ranking means lower abundance. The results are shown in Fig. 1.

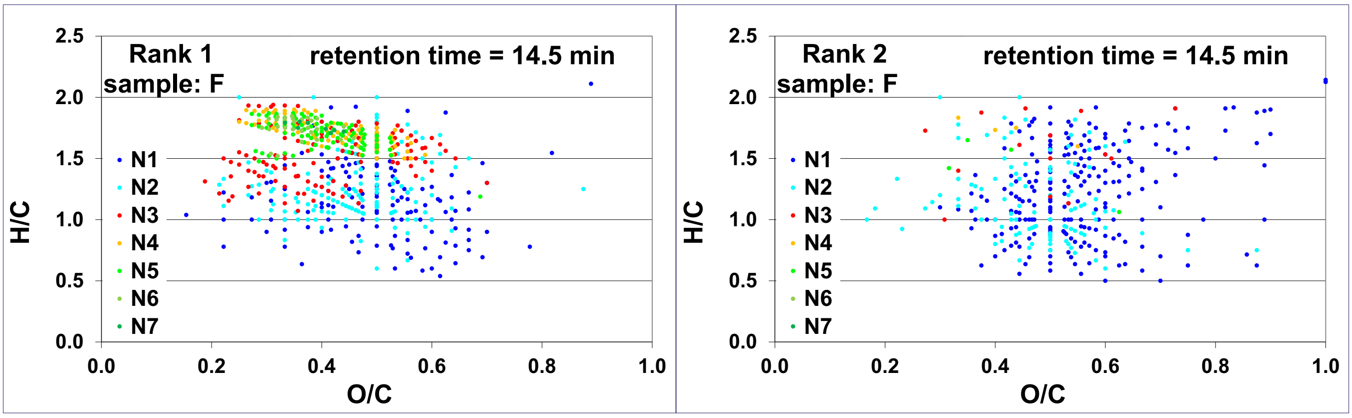

Fig. 1: *Van Krevelen diagrams showing inter sample ranking (2 ranks) of combined samples "F" (feeding centre) and "W" (outside). Top left: CHNO showing higher abundance at site "F" compared to site "W". Top right: CHNO showing lower abundance at "F". Bottom left: CHO, CHOS, CHNOS showing higher abundance at "F". Bottom right: CHO, CHOS, CHNOS showing lower abundance at "F".*

Many CHO and CHOS (results not shown) and CHNO which contain one or two nitrogen atoms had lower abundance in "F" compared to "W" (Fig. 1 right). However, CHNO which contain several nitrogen atoms (3–7) show higher abundance at "F". Many of them can be found (Fig. 1 left) in the protein-like region of the van Krevelen diagram (0.2 < O/C < 0.5 and 1.5 < H/C < 2.0). Those high abundant CHNO (at "F") could be shown to be potentially composed from amino acid combinations using Chem Spider software [4]. As an example, for the component $C_{24}H_{42}N_6O_9$ several amino acid combination solutions were found [1]: Val-Val-Asn-Asp-Leu; Ala-Val-Glu-Ile-Gly-Ala; Leu-Ile-Ala-Gly-Gly-Glu; Val-Pro-Asp-Lys-Thr. This suggests that the sediment is containing considerable amounts of protein-like substances at the feeding site, explaining the high amounts of greenhouse gas emissions.

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Identification of pollution sources of Czech-Saxon border rivers

Lucie Jašíková, Hana Mlejnková Zvěřinová, Eva Juranová

1. Introduction

Water and its protection is one of the major challenges for our society, and in the context of a changing climate, the issue of water protection has become even more crucial and necessary. In the Czech-Saxon border area, there are numerous water bodies that are not in good water status according to the Water Framework Directive (2000/60/EC) [1]. The water quality of these water bodies is assessed separately in the German and Czech parts. Particularly in the border areas, it is therefore difficult to identify the causes of failure to achieve good water status, and consequently to develop solutions and to implement measures. Coordination in addressing this issue between the two countries is therefore crucial. Thus, the Interreg AKWA project (100694066 – Impacts of climate change on transboundary water bodies on the CZ-SN border) aims for Czech-German cooperation focused on identifying sources of pollution in six transboundary streams (Rožanský and Jiříkovský Creeks, Spréva, Mandava, Lužnička and Polava Rivers), and to propose appropriate measures to minimise their impacts on both the Czech and Saxon sides. The lead partner of the project is the T. G. Masaryk Water Research Institute, p. r. i., and the cooperation partner is the Saxon State Office for Environment, Agriculture and Geology. Cooperation with the Ohře River Basin, state enterprise, and the regional authorities on the Czech side and the State Reservoir Administration of Saxony and the district authorities on the Saxon side is also involved in the project. Thanks to this all-round cooperation, appropriate transboundary measures can be proposed to eliminate the identified causes and improve the condition of the rivers. Another aim of the project is to raise awareness of water management issues among the general public, with a focus on children, through Czech-Saxon cross-border project days.

2. Solution progress

At the beginning of the project, a joint Czech-German database with all information on the selected watercourses was created. Based on the historical results and all available datasets on potential pollution sources in the catchment, a monitoring programme was designed for each studied stream (Rožanský and Jiříkovský Creeks, Spréva, Mandava, Lužnička and Polava Rivers) in order to identify pollution sources (Figure 1–3). The monitoring will be carried out until the end of 2025. Furthermore, we focused on transboundary cooperation between water authorities on the Czech and German side. In 2024, we organized two workshops where we presented the aims of the AKWA project to Czech and German representatives of these water authorities, the Ohře River Basin, state enterprise, and the State Reservoir Administration of Saxony, and we addressed and discussed with them the most pressing problems they face. Concerning the environmental education in the field of water protection, we have prepared 14 Czech-Saxon cross-border project days for Czech and German primary schools so far. At four stations (river morphology, water chemistry, micro- and macro-world in water), we presented to Czech and German children what we can find and explore in water.

3. Conclusion

Transboundary measures to improve water status cannot be achieved by national initiatives alone. Harmonisation of German and Czech analytical methods will contribute to better comparability of measurement results and simplify future assessments. The project can create the basis for long-term transboundary cooperation between the responsible water authorities, which is essential for coping with the tasks imposed on them in the border waters. The intensified transboundary cooperation of schools planned in the project and the work with the public will strengthen cooperation based on trust and awareness of common responsibility for our waters, especially in times of climate change.

4. Acknowledgements

This contribution was supported by the European Union through the Interreg Czech – Saxony 2021-2027 programme, project 100694066 – AKWA – Impacts of climate change on transboundary water bodies on the CZ-SN border.

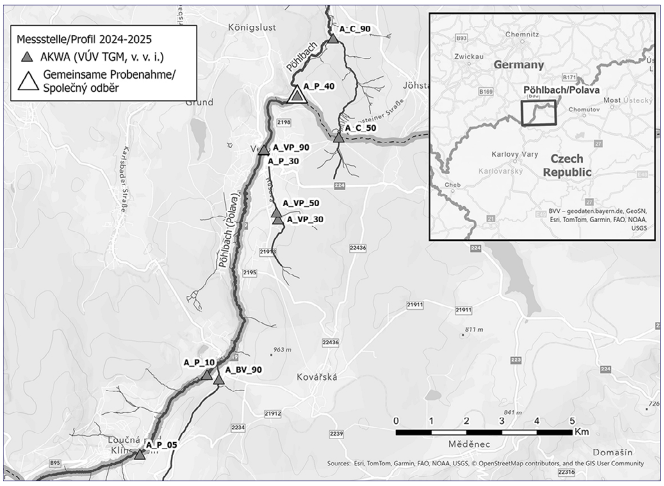

Fig. 1: *Monitoring sites on the Polava River*

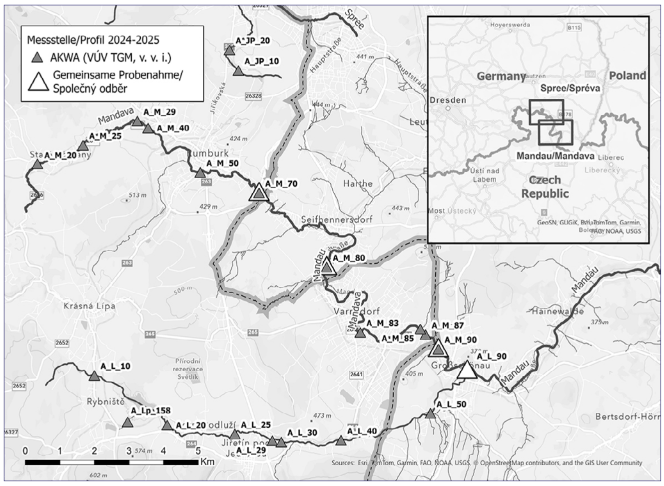

Fig. 2: *Monitoring sites on the Mandava and Lužnička Rivers*

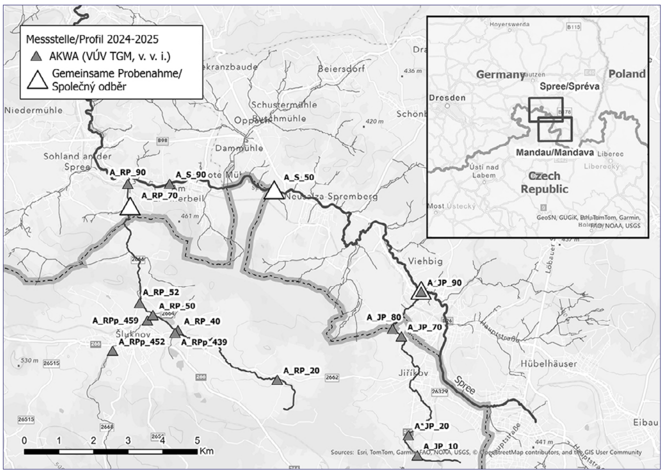

Fig. 3: *Monitoring sites on the Jiříkovský and Rožanský Creeks and the Spréva River*

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Mobility of emergent micropollutants in soils in the Czech Republic, an important factor for assessment of specific groundwater vulnerability

Vít Kodeš, Radka Kodešová, Alina Sadchenko, Martin Kočárek, Miroslav Fér, Helena Švecová, Aleš Klement, Antonín Nikodem, Roman Grabic, Hedvika Roztočilová

1. Introduction

Soil and groundwater can be contaminated with various micropollutants if treated wastewater or surface water that has been contaminated with these substances is used for irrigation. Another source of contamination can be sewage sludge from wastewater treatment plants, which is often used for soil enrichment [1]. These contaminants can migrate through the soil environment and subsequently contaminate groundwater [2, 3]. The occurrence of substances in the soil or their leaching from the soil and migration into groundwater depends on climatic conditions, the properties of the vadose zone environment and the behaviour of a specific substance, i.e. its sorption on soils and sediments and stability in the environment. The aim of this work was to evaluate the sorption of selected organic micropollutants in agricultural soils of the Czech Republic and subsequently their potential to contaminate soils and groundwater.

2. Materials and methods

The substances were selected based on the results of our screening in 2023 aimed at mapping the occurrence of micropollutants in surface and groundwater and soils in intensively irrigated agricultural areas. The main criteria for selecting substances were: 1) Frequent occurrence in the analysed water and soil samples; 2) Different source of contamination of substances; 3) Different characteristics of substances determining their behaviour in the soil environment, and thus different potential for accumulation of substances in soil, or conversely, contamination of groundwater. Six compounds were identified (1,3-diphenylguanidine, triethyl citrate, 4-acetamidoantipyrine, naphthalene-2-sulfonic acid, benzo(d)thiazole-2-sulfonic acid and 6:2 fluorinated telomer sulfonate).

Given that these compounds are found in the environment, they are relatively stable compounds. To determine their mobility in various soil environments, the methodology previously described by [4] and [5] was used. Standard sorption experiments were performed for each substance and 16 representative soils of the Czech Republic. The sorption isotherm points describing the relationship between the equilibrium concentrations of the substance dissolved in water and sorbed onto soil particles were evaluated at 5 initial concentrations of the applied substance and 2 repetitions for each concentration. Subsequently, Freundlich sorption isotherms were calculated. Multiple linear regressions in the general form were used to derive equations for predicting the Freundlich sorption coefficient (KF) using the properties of the tested soils, i.e. organic carbon content, soil pH and clay content. The resulting equations included only those soil properties whose influence was statistically significant. These equations and soil property maps [6] were used to predict the distribution of KF values in agricultural soil and subsequently to define the mobility classes of the studied compounds in the soil. The mobility classes were defined as follows: $KF < 2.5$ – very high mobility, $2.5 \le KF \le 5$ – high mobility, $5 < KF \le 10$ – medium mobility, $10 < KF \le 20$ – low mobility, $20 < KF \le 40$ – very low mobility, $40 < KF$ – immobile.

3. Results

For illustration, 2 examples are given here for 1,3-diphenylguanidine (accelerator and activator for other rubber vulcanization accelerators, HPV (high production volume) chemical, i.e. a substance produced in quantities greater than 1000 tonnes/year in at least one OECD country) and 6:2 fluorinated telomer sulfonate (a substance from the group of PFAS (perfluoroalkylated and polyfluoroalkylated substances), which replaced the previously used PFOS and PFOA, especially in the production of fluoropolymers, in chromium plating of metals, in fire-fighting foams). The corresponding maps of predicted KF coefficients and maps of mobility classes are shown in Fig. 1.

While DIP is mainly moderately sorbed in the soil environment and is therefore moderately mobile in the soil/vadose zone, FTS is very poorly sorbed in soils and can therefore move easily in both soil and rock environments. This

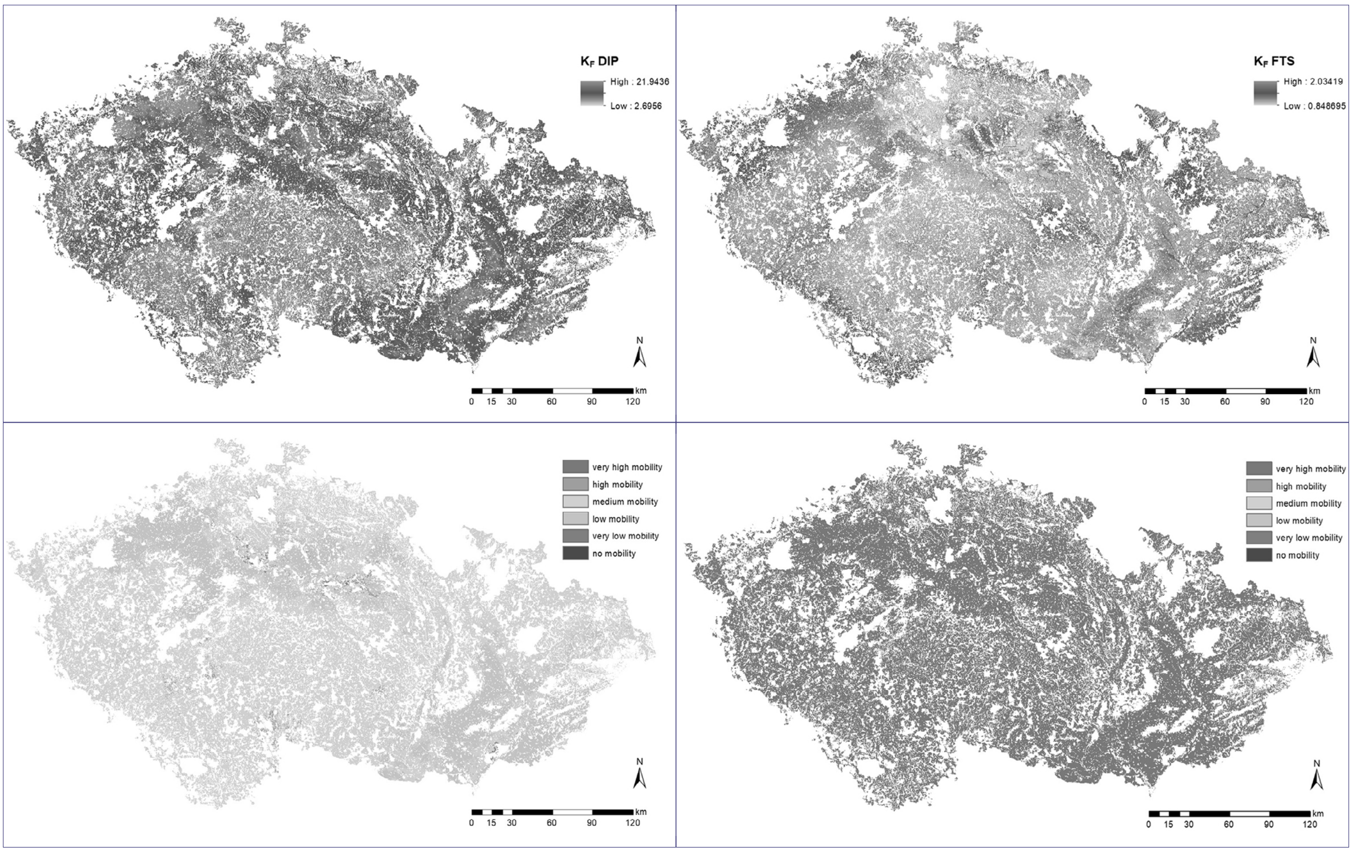

Fig. 1: *Maps of KF coefficients and mobility classes (1,3-diphenylguanidine left, 6:2 fluorinated telomer sulfonate right)*

means that while DIP shows an increased potential for accumulation in soils and only in some areas an increased potential to contaminate groundwater, FTS shows a very high potential to contaminate groundwater throughout the area.

4. Conclusions

Maps of mobility classes of the studied substances in agricultural soils of the Czech Republic were created. For substances that showed a wide spectrum of sorption behavior in different soils, mobility class maps showed significant spatial variability depending on the distribution of soil properties. For substances that sorbed very little in soils, spatial variability of substance mobility classes was minimal. The behavior of micropollutants in the soil environment is one of the key elements determining the potential of foreign substances to contaminate groundwater and water resources used to supply the population with drinking water through their leaching from soil and thus eventually increase specific groundwater vulnerability.

The work was supported by the Ministry of Agriculture of the Czech Republic, project No. QK23020018.

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Emerging Topics in the Monitoring of Organic Micropollutants in Surface Waters

Milan Koželuh, Lenka Sikorová, Lumír Kule

Driven by recent discoveries regarding the environmental impact of widespread organic chemicals, the EU has introduced new regulations for municipal wastewater treatment (UWWTD, 2024) and drinking water production (Directive (EU) 2020/2184). In response, the team at water management laboratories in Pilsen has developed analytical methods for determining emerging organic micropollutants, suitable for routine analysis of various water types. Our presentation highlights four key issues affecting water quality.

1. Pharmaceuticals and personal care products (PPCPs) in the UWWTD

The Urban Wastewater Treatment Directive (UWWTD) (EU) 2024/3019 of 27 November 2024, establishes rules for the collection, treatment, and discharge of urban wastewater. It mandates that large wastewater treatment plants (WWTPs serving ≥ 150,000 people) implement advanced quaternary treatment before discharge. Additionally, these WWTPs must monitor 12 specific micropollutants, as listed in Annex I, Part C of the Directive (Table 1), with sampling frequency determined by WWTP size using a 48-hour composite sample. A minimum 80 % reduction of these micropollutants relative to the inlet load is required.

Tab. 1: *Substances affecting water quality at trace levels – micropollutants (According to the Directive (EU) 2024/3019)*

Category 1 (substances that can be very easily treated)		**Category 2** (substances that can be easily disposed of)
Amisulpride	Diclofenac	Benzotriazole
Carbamazepine	Hydrochlorothiazide	Candesartan
Citalopram	Metoprolol	Irbesartan
Clarithromycin	Venlafaxine	4(5)-Methylbenzotriazole

At a selected WWTP without quaternary treatment, we assessed the removal efficiency of analytes using a multicomponent LC-MS/MS method. This WWTP discharges into a drinking water source river, with raw water abstraction occurring 40 km downstream. For a mass balance analysis, annual input and output for 2024 (including treated effluent and untreated overflows) were converted into total mass (kg) for each substance. Table 2 presents both the calculated removal efficiency by the WWTP's existing technology and its load at the raw water intake. Our findings show that the treatment efficiency is significantly lower than UWWTD requirements. Furthermore, the considerable agreement between the combined load from the WWTP (effluent and overflows) and the load in the receiving water body suggests this WWTP is the primary source of pharmaceuticals and personal care products (PPCPs) in the water system.

Tab. 2: *Mass balance analysis of selected PPCPs (2024)*

	Analyte	WWTP					Recipient
		Effluent (kg)	Influent (kg)	Removal Efficiency (%)	Owerflow (kg)	Effluent & Overflow (kg)	Annual Load (kg)
Cat. 2	Benzotriazole	30.72	6.35	79	1.91	8.26	9.89
	4(5)-Methyl-benzotriazole	4.18	2.49	41	0.29	2.78	2.20
Cat. 1	Clarithromycin	4.77	1.32	72	0.30	1.62	4.29
	Diclofenac	6.30	4.68	26	0.42	5.09	6.10
	Metoprolol	1.77	0.87	51	0.13	1.00	1.16
	Venlafaxine	1.19	1.00	16	0.08	1.08	1.75

2. 1,2,4-Triazole: an ubiquitous metabolite

1,2,4-Triazole is a persistent organic compound, often found in the environment as a degradation product of agricultural triazole fungicides. It's also a key component in many pharmaceuticals, such as antifungal, antiviral, and antibacterial drugs. Monitoring of 1,2,4-triazole has been ongoing since early 2024. Repeated detections have been observed in surface waters impacted by agricultural activity and in waters impacted by municipal wastewater discharge.

3. Trifluoroacetic acid (TFA): a challenge for water management

TFA is a persistent, highly mobile pollutant, showing increasing concentrations in water sources like groundwater, rainwater, rivers, and oceans due to its high solubility. It is a product of historically used refrigerants, presumed to enter the Earth's surface through atmospheric deposition, and is also a breakdown product of many long-chain PFAS. In the Vltava River Basin in 2024, TFA was detected in over 90 % of samples at concentrations of 1000–4000 ng/L. Smaller catchments showed low variability, suggesting consistent, long-term loading. The highest concentrations were found in the Švihov Reservoir catchment (five-month average in 2025: 3374 ng/L). TFA contamination poses a significant challenge for future research due to its widespread distribution, persistence, and the difficulty of its removal.

4. Chlorothalonil: a persistent threat in waters

Chlorothalonil R471811 is a metabolite of a widely used broad-spectrum fungicide chlorothalonil, which has been banned in the EU since May 2020 due to its carcinogenicity and the presence of potentially toxic transformation products in groundwater. The total consumption of chlorothalonil in the Czech Republic between 1997 and 2020 was approximately 500 tons (Source: ÚKZUZ). Initial findings demonstrate its persistent, year-round presence in surface waters from agricultural regions at concentrations of several hundred ng/L (Figure 1). Notably, Chlorothalonil metabolites are difficult to remove through conventional water treatment methods during drinking water production.

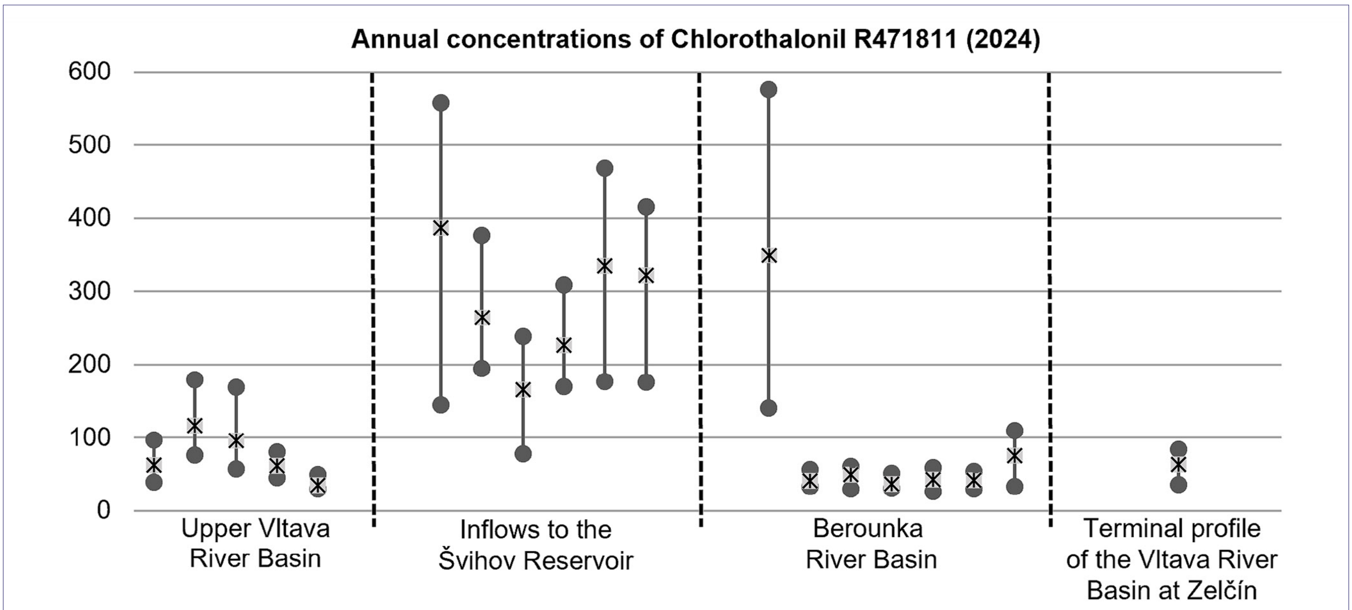

Fig. 1: *Annual concentrations of Chlorothalonil R471811 in selected sampling points in 2024 (ng/L).*

Conclusions

New analytical methods enable the determination of selected micropollutants at trace concentrations. Initial monitoring confirms their high frequency of occurrence, particularly in agricultural areas (like the Švihov Reservoir catchment) and downstream of municipal WWTPs, indicating a significant environmental concern.

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Experiences with High-Frequency Monitoring of Episodic Concentration Waves

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Based on long-term monitoring of surface waters, it is increasingly evident that episodic pollution waves are a key factor influencing the achievement of good ecological status and the nutrient load, especially phosphorus, in surface waters. Addressing these challenges will likely require significant reductions in emissions from combined sewer overflows (CSOs), which recent evaluations show contribute substantially to total pollution.

At the same time, the implementation of the revised EU Urban Waste Water Treatment Directive is under discussion, setting a maximum limit of 2% of the incoming pollution load that may be discharged through CSOs. Reliable and representative data are crucial for planning effective measures. However, monitoring CSOs is challenging due to the episodic, rapid nature of pollutant loads, comparable to runoff of erosion material or pesticides.

Since 2023, we have focused on detailed monitoring of CSOs from the city of Klatovy (22,000 inhabitants) discharging into the Úhlava River, the sole source of drinking water for around 220,000 people in the Pilsen area. Our results show that overflows occur even with rainfall of only 1–2 mm, with 93 days in 2024 exceeding this threshold. Despite of our intensive efforts, only four events were sampled in 2023 and one in 2024, which is insufficient for reliable annual estimates. This highlights the need for improved and efficient monitoring approaches to gather enough robust data.

Monitoring Methods Used

Three monitoring methods with different technical and logistical demands were tested:

Combination of Manual Sampling and Automatic Samplers (AS)

This approach combines AS deployed at stable profiles (upstream of the city, WWTP outlet, and WWTP CSO outlet) with manual samples where rapid changes occur. Typically, 2–3 AS units, at least two operators, and lab capacity for 20–40 samples per event are needed. This method allows accredited sampling and flexible timing but is very demanding, dependent on uncertainty of rain events, and yields too few samples for robust annual estimates [1].

Mobile monitoring unit

This mobile solution uses AS powered by solar panels, equipped with sensors and remote data transfer. Sampling starts automatically when sensors (typically pressure) reach set thresholds. Collected samples are then transported to the lab. The system is power-independent and reduces staffing needs but faces risks like vandalism and less flexible sampling intervals. Successfully deployed in 2024 in Volary near the Lipno Reservoir and currently in Dolní Dvořiště, this method has proven efficient for targeted sampling during events while optimizing lab workload [2].

Advanced Multiparameter Probes

Continuous monitoring was tested in 2025 using a Proteus probe (Proteus Instruments Ltd.), equipped with sensors for temperature, pH, conductivity, dissolved oxygen, turbidity, ISE sensors for NO_3-N and NH_4-N, and fluorescence sensors for tryptophan and CDOM. Algorithms allow estimation of BOD_5, COD, TOC, DOC, and faecal coliforms. Real-time BOD_5 and COD estimation is particularly promising. Precise site-specific calibration is essential, as relationships between primary and derived parameters vary. The probe is best suited for continuous or semi-continuous monitoring at a single location with tailored calibration, capturing most of events, reducing manual sampling, and easing lab loads, but it requires higher investment, careful handling, more power, and faces risks of damage or theft. Using a lockable trailer can be an advantage.

Results

At the time of writing this text, we were still testing various methods of onsite calibration to optimize the accuracy and reliability of the Proteus probe measurements under real-world conditions. The preliminary results are promising and indicate that the relationship between laboratory reference measurements and the real-time data obtained from the Proteus probe shows a relatively strong correlation: BOD_5 – $R^2 = 0.81$, COD – $R^2 = 0.94$, and TOC – $R^2 = 0.96$. However, it is crucial to emphasize that these relationships must always be validated by collecting multiple parallel samples for laboratory analysis to verify and adjust the slope and intercept of the regression line for each specific site and monitoring period.

One of the most frequently raised concerns about the use of multiparameter probes is the question of measurement precision and the comparability of probe-generated data with results from standard accredited laboratory methods. While this concern is valid, it is important to keep it in perspective. For example, the expanded measurement uncertainty for BOD determination is typically around 30% for concentrations above 5 mg/L and around 20% for concentrations below this threshold. Similarly, the uncertainty for COD is generally around 15%. Given these levels of inherent uncertainty in conventional laboratory analysis, we believe the benefits of multiparameter probes are evident – especially for providing continuous, high-frequency data that deliver a detailed and realistic picture of how sources of episodic pollution behave over extended timeframes, which would be impossible to capture using manual sampling alone.

Conclusion

Multiparameter probes would represent a significant step forward in monitoring episodic pollution. Thanks to their high-frequency and relatively accurate measurements, they would allow for a better understanding of pollution source behaviour, especially in conditions where traditional manual sampling often fails. At the same time, they help reduce personnel and material demands and limit the need for repeated field visits, thus lowering the monitoring carbon footprint. Ultimately, this approach does not aim to fully replace accredited laboratory measurements, but would complement them, providing operators and decision-makers with timely and actionable information for better water quality management and pollution control. In the future, multiparameter probes could play a key role in managing emissions from combined sewer overflows, meeting European legislative requirements, and supporting the principles of sustainable water management.

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Monitoring of Perfluorinated Compounds (PFAS) in Waters of the Vltava River Basin

Lumír Kule, Lenka Sikorová, Milan Koželuh

1. Introduction

PFAS (Per- and polyfluoroalkyl substances) are a group of man-made chemicals (nearly 15 000, over 4700 with CAS numbers) characterized by carbon chains with attached fluorine atoms. They are documented as environmentally persistent compounds due to their highly resistant carbon-fluorine bond, which is responsible for PFAS resistance to chemical, biological, and thermal degradation. PFAS possess unique properties (water and oil resistance, temperature stability, and surfactant capabilities) making them useful for various applications and consumer products, including food and beverage packaging, clothing, cookware, cosmetics, paints and coatings, lubricants, and firefighting foams. PFAS are continuously released into the environment and accumulate in the tissues of living organisms. Human intake of PFAS mainly occurs through water and food. They have demonstrable negative effects on human health. Certain PFAS are suspected carcinogens and reproductive toxicants. Recent toxicological studies have led to a significant reduction in the acceptable daily intake levels for certain PFAS in human consumption. Consequently, both European and Czech legislation are being updated to reflect these new scientific findings.

2. Methods

A direct injection method on an Agilent Technologies LC-MS/MS system (LC 1290 with PFAS free kit and MS/MS 6495b) was developed and validated for 20 PFAS (Table 1), with quantification limits ranging from 0.5 to 6 ng/L. During sample pre-treatment and analysis, it was essential to maintain a 1:1 water-to-methanol volume ratio for adequate recovery of all analytes. A lower methanol content led to significant losses, especially of long-chains analytes. A parallel off-line SPE method using a LCTech XANA and D-EVA system was developed, optimized, and validated to achieve significantly lower detection limits (0.1 – 0.2 ng/L) required by European directives.

Tab. 1: *Overview of analyzed PFAS (LOQ – Limit of Quantification)*

Analyte	LOQ (ng/L)		CAS#	Analyte	LOQ (ng/L)		CAS#
	Direct Injection	Off-line SPE XANA			Direct Injection	Off-line SPE XANA	
PFBA	6	0.2	375-22-4	**PFBS**	1	0.1	375-73-5
PFPeA	2	0.2	2706-90-3	**PFPeS**	1	0.1	2706-91-4
PFHxA	2	0.2	307-24-4	**PFHxS**	0.5	0.1	355-46-4
PFHpA	2	0.2	375-85-9	**PFHpS**	1	0.1	375-92-8
PFOA	2	0.1	335-67-1	**PFOS**	0.5	0.1	1763-23-1
PFNA	1	0.1	375-95-1	**PFNS**	1	0.2	68259-12-1
PFDA	1	0.1	335-76-2	**PFDS**	1	0.1	335-77-3
PFUnDA	1	0.1	2058-94-8	**PFUnDS**	1	0.2	749786-16-1
PFDoDA	1	0.1	307-55-1	**PFDoDS**	1	0.2	79780-39-5
PFTrDA	1	0.1	72629-94-8	**PFTrDS**	2	0.2	791563-89-8

3. Results and discussion

The water management laboratories of the Vltava River Basin in Pilsen have been monitoring selected PFAS in surface water and wastewater since 2023. The frequency of PFAS occurrence exceeding 10 % in waters of the Vltava River basin in 2024 is shown in Figure 1. The results indicated that PFHxA, PFBS, PFPeA, PFOA, PFOS, PFBA, PFHpA, and PFHxS were the most frequently detected. Some PFAS (primarily long-chain) have not yet been detected, including: PFNS, PFDoDA, PFDoDS, PFTrDS, PFUnDA, and PFUnDS. The highest frequency of occurrence was observed for perfluorohexanoic acid (PFHxA). PFHxA was predominantly detected in the effluents from wastewater treatment plants (Figure 2). The highest concentration of PFHxA was detected in the effluent from the Rokycany WWTP on November 5, 2024. PFHxA is an impurity, degradant, and metabolite from short-chain fluorotelomer-based products. Although its direct use is being limited, PFHxA was previously also used (together with PFHxS) as an alternative to other more toxic PFAS [1]. There have been several studies demonstrating the occurrence of PFHxA in surface water, lakes, and rivers around the globe. Available data suggests PFHxA is unlikely to be carcinogenic, a selective reproductive or developmental toxicant, or an endocrine disruptor. In summary, effects caused by PFHxA exposure are largely limited to potential kidney effects, are mild and/or reversible, and occur at much higher doses than observed for PFOA [1]. However, most of the information regarding PFHxA toxicity originates from animal studies. Human data is still more limited. Moreover, PFHxA has been demonstrated to have the potential for toxicity, as well as bioaccumulation in aquatic organisms, specifically fish [2].

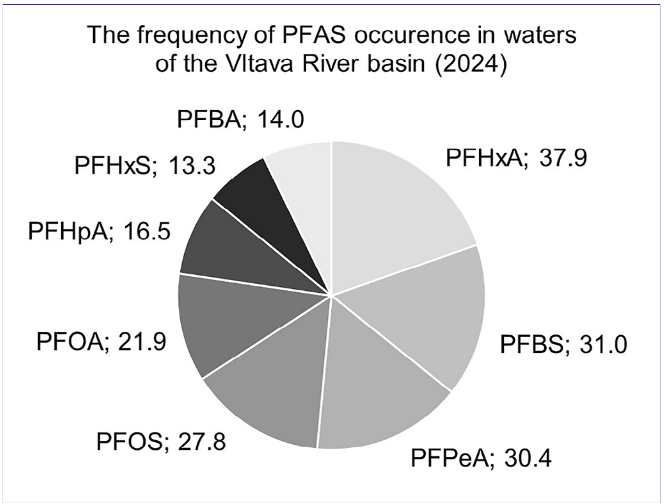

***Fig. 1:** The frequency of PFAS occurrence in waters of the Vltava River basin in 2024 (%).*

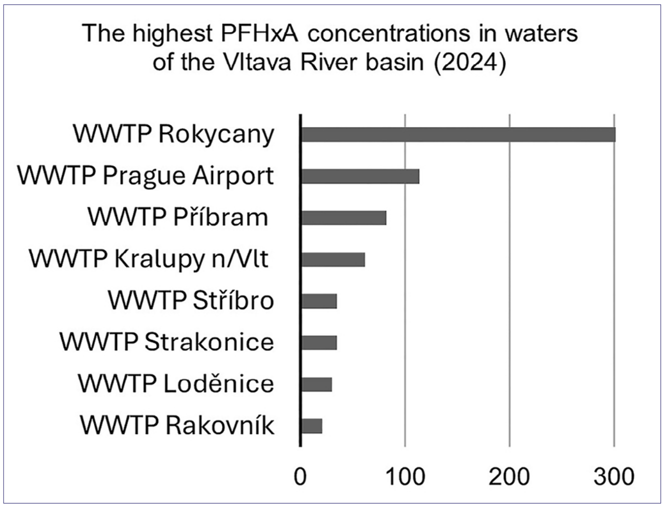

***Fig. 2:** The highest PFHxA concentrations in waters of the Vltava River basin in 2024 (ng/L).*

4. Conclusions

PFAS are recognized as a significant group of environmental contaminants. Given their negative effects on human health, it is crucial to monitor their presence in various environmental compartments. PFAS were predominantly found in wastewater treatment plant effluents, where perfluorohexanoic acid (PFHxA) exhibited the highest concentration. Moving forward, we will expand our monitoring of surface water and wastewater to include a broader range of PFAS substances, utilizing both analytical methods (the direct injection method and the off-line SPE method). This ongoing expansion of our analytical capabilities will provide a more complete picture of PFAS contamination, crucial for understanding potential ecological and human health risks in the region.

Literature:

[1] Luz, A. L. (2019) Perfluorohexanoic acid toxicity, part 1: Development of a chronic human health toxicity value for use in risk assessment. Regulatory Toxicology and Pharmacology 103, 41–55.

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Evaluation of the quality of river sediments on measurement profiles under the management of the company Povodí Labe, státní podnik

Jiří Medek, Pavel Hájek

River sediments are an important component of the hydrosphere and monitoring their quality is therefore an integral part of monitoring programmes. As part of the monitoring of the river basin administrator, the quality of river sediments has been monitored in a selected network of measurement profiles since 1999. The network of measuring profiles comprises a total of 62 profiles, of which 13 are located directly on the Elbe, 15 profiles on the final profiles of the Elbe tributaries and 34 are located in other locations to cover the entire area under our management.

To evaluate the historical data for the period 1999 to 2024, we used the methodology recommended by the International Commission for the Protection of the Elbe River (ICPER) in the form of sediment quality indices (SQI) [1]. This procedure has already been used for 13 profiles on the Elbe and for 15 final profiles on the tributaries of the Elbe as part of the study 'Mapping of sediment quality and quantity in the Czech Elbe reservoirs ("MaSEL")' [2] and provided interesting and valuable results. Therefore, we used the same procedure to evaluate all the historical data available for the whole basin in our administration. The evaluation was further updated with the results from 2024. The aim was to obtain an illustrative source of information on the sediment load of relevant pollutants in the area under the management of our company. The list of these pollutants being based on the ICPER recommendations [1]. In this way, we have obtained a clear overview of the spatial and temporal occurrence of these substances, including the evolution of pollution over the last 25 years. The results will be further used to optimise river sediment quality monitoring in the coming years, where the frequency of monitoring can be reduced for profiles with low and time-invariant contamination levels, resulting in financial and capacity savings. Conversely, increased attention can be focused to profiles with elevated or time-varying contamination rates, which may be of anthropogenic or geogenic origin.

The use of the ICPER methodology for the evaluation of historical sediment quality data has proven to be appropriate and beneficial, as this procedure can convert large amounts of numerical data into a clear and graphical representation that facilitates the handling of these data and is a valuable source of information.

Literature:

[1] The Sediment Management Concept of the ICPER – Recommendations for a good sediment management practice in the Elbe River basin to achieve supra-regional operational objectives (2014) ICPER Magdeburg

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Funding programmes and scientific foundations to support living floodplains along the Elbe River

Ina Quick, Timo Riecker

1. Introduction

Floodplains in their near natural and natural conditions are the most species-rich habitats in the world. Such living floodplains are of crucial relevance to counteract the loss of biodiversity, climate change and its consequences and negative effects of human impacts, e. g. from draine landscapes. Their ecosystem functions are legally prescribed and required, next to others, in the Nature Restoration Law (NRL), Fauna-Flora-Habitat (FFH) and Water Framework Directive (WFD). Today, floodplains are among the most threatened ecosystems. In order to improve the situation of the highly endangered type-specific habitats and species of floodplains, their protection and restoration must be implemented nationwide much more. This also applies to the Elbe River, that has been subject to basic hydromorphological alterations due to navigation, hydropower, and so on. Inundation areas of the former floodplains of the Elbe River have been dramatically reduced. Furthermore, an intensive depth erosion of the river bed negatively effects the floodplains. Therefore, protection of nature as well as funding and supporting floodplain restoration is of outstanding importance.

2. Funding programmes for living floodplains

The Federal Agency for Nature Conservation (BfN) is a higher federal authority that provide professional, scientific and administrative expertise in nature conservation and landscape management. BfN funded several projects for floodplain restoration along the Elbe River in the present and the past. Some examples of such funding programmes, financed by the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN), are large-scale nature conservation projects in the „chance.natur“ federal funding programme for nature conservation, model projects for floodplain restorations of the Federal Action Plan on nature based solutions for Climate and Biodiversity and the "Floodplain restoration programme" under Germany’s Blue Belt Programme. The Blue Belt is a joint initiative of BMUKN and the Federal Ministry of Transport (BMV) for navigable surface waters. In order to restore the floodplains of the Federal Waterways, BMUKN had set up the "Floodplain Funding Programme". Local authorities and municipalities, associations, NGOs and others can apply for funding from BfN to realise restoration projects. BfN is responsible for the scientific and administrative accompanying of the funding recipients. Main goals are the establishment of an ecological biotope network of national importance and to improve the floodplain status. Within this, a new restoration project along the Middle Elbe as well as a preliminary examination of the Elbe River in Brandenburg have recently launched, for instance. Fig. 1 gives an overview about all restoration projects and their spatial distribution in and along the Elbe River, funded by BfN and their temporal distribution (timeline).

3. Scientific foundations for living floodplains

Furthermore, BfN develop and give order to work out many scientific foundations for living floodplains. For example, the maximum of CO2-saving potential was analysed, based on rewetting of organically shaped soils in the floodplain areas of the "Floodplain restoration programme" of the Blue Belt. The results show up to around 4 million tonnes of CO_2 per year, as potential contribution to natural climate protection [1]. Further important instruments developed and made available by BfN are the German Floodplain Status, recent and former floodplain expansions and the loss of flood areas [2], reconnection and restoration potentials [3] etc.

4. Conclusions

Restored connectivities of rivers and floodplains improve their status and landscape water balance. Living floodplains serve as effective natural climate protection due to greenhouse gas retention, they increase and protect biodiversity and are essential for achieving goals of NRL, FFH, WFD etc. The work mentioned supports sponge landscapes for the reduction of floods and compensation of low water levels. As well within the Elbe catchment area, the resilience of living floodplains is of outstanding importance, e. g. due to negative climate change implications, critical depth erosions of the river bed and numerous highly protected areas.

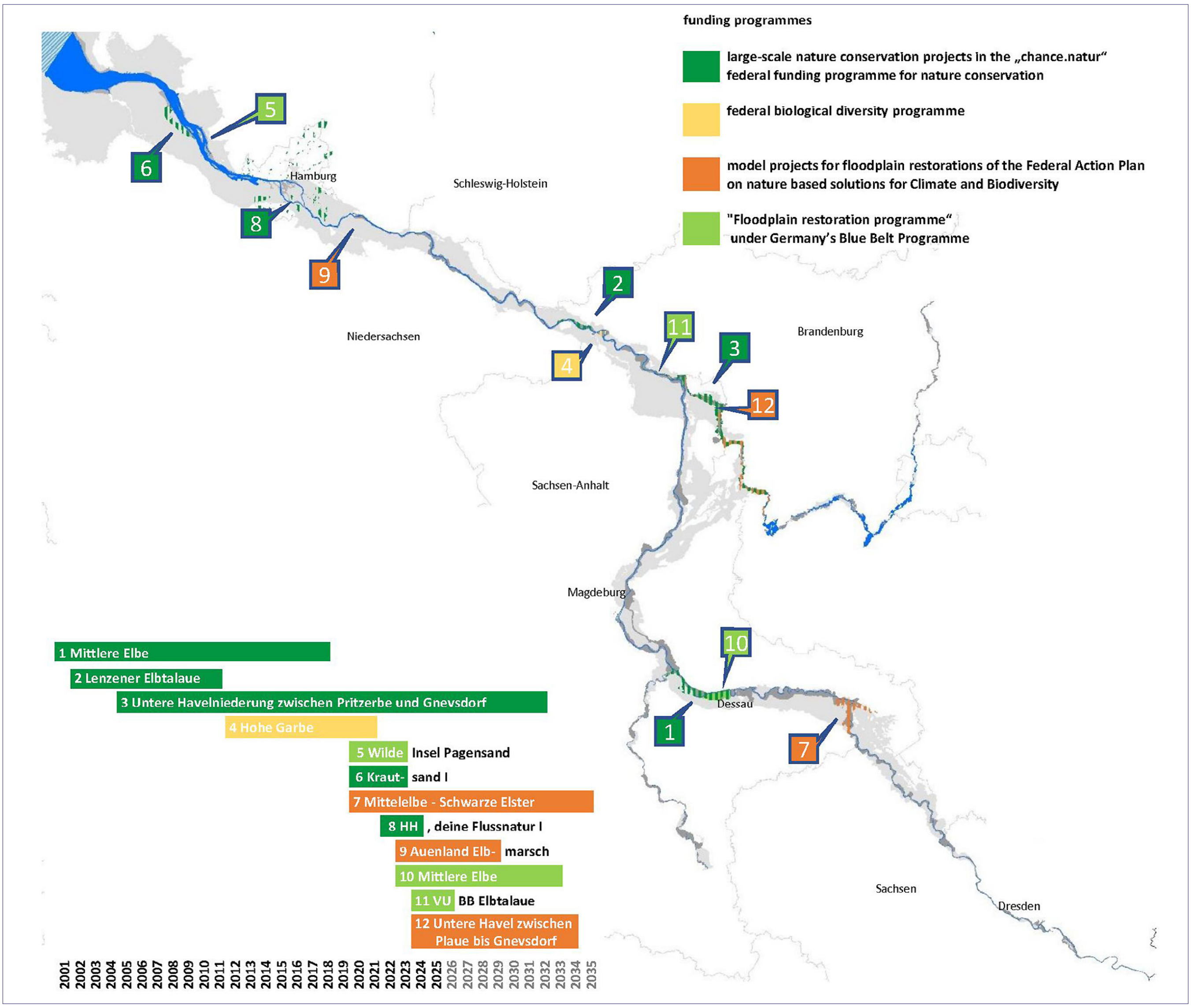

Fig. 1: *Map of floodplain restoration projects in and along the Elbe River, funded by BfN and temporal distribution (timeline) of these funding projects during the last 25 years.*

Literature:

[1] Quick, I.; Riecker, T.; Hausmann, B. (2024) Die Bedeutung der Erschließung bundesweiter Potenziale zur naturnahen Auenentwicklung. Wasser und Abfall 06/2024, 42-46

[2] BMU/BfN (2021) Auenzustandsbericht 2021. Flussauen in Deutschland

[3] Harms et al. (2018) Potenziale zur naturnahen Auenentwicklung. Bundesweiter Überblick und methodische Empfehlungen für die Herleitung von Entwicklungszielen. BfN-Schrift 489

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Disappeared wetlands in the Elbe lowland around Lysá nad Labem town

Pavel Richter

1. Introduction

The main goal of the research presented in this article is the analysis and evaluation of long-term changes in wetland habitats at the landscape level. The cadastral districts in the middle part of the Elbe River basin, intensively used for agriculture, were selected as pilot research areas. In the future, we are planning to map other locations in the Elbe River basin in a similar way [1].

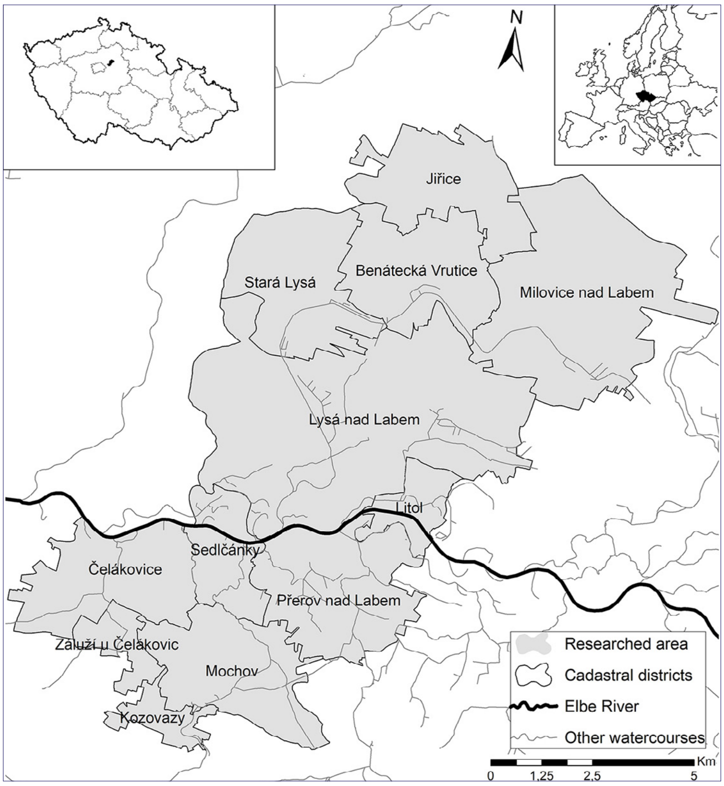

Fig. 1: *Location of the researched area within the current borders of the cadastral districts and within the Czech Republic and Europe.*

2. Delimitation of the area

The area was delimited using the borders of the current cadastral districts. A total of 12 cadastral districts with a total area of 117,899 km^2 were selected (Fig. 1). The delimited area lies almost entirely in the Elbe River basin from the Výrovka River to the River (third-order basin 1-04-07); a small part is located in the Jizera River basin up to its confluence with the Klenice River (third-order basin 1-05-03) [2]. The area is located in the agriculturally intensively used landscape of the Elbe Lowland. In the northern part it is a slightly undulating, partially wooded landscape, where part of the cadastral district of Milovice nad Labem lies in the former military area of Mladá [1].

3. A brief summary of the methodology

Archival maps of the Stable Cadastre (Franziszeischer Kataster) and the current orthophoto map of the Czech Republic were used as the main sources. Archival maps of the Stable Cadastre were georeferenced and then vectorized. Spatial changes were detected using analysis in a GIS environment using the Symmetrical Difference and Intersection tools. The result is a categorization of wetlands into continuous, disappeared, and new segments [1].

4. Results

The historical wetlands are formed by the sum of areas of disappeared and continuous wetlands. In the first half of the 19th century, the area of wetlands in the researched area was 1,125.68 ha, which represents 9.55 % of the researched area. On the other hand, current wetlands occupy only 51.04 ha, i.e., only 0.43 % of the researched area (Fig. 1). The total wetland area has therefore decreased by a factor of almost exactly twenty-two, i.e. the area of current wetlands corresponds to 4.53 % of the area of historical wetlands. A substantial part of historical wetlands in the researched area was wet meadows, namely 1093.26 ha, followed by swamps and marshes with an area of 26.69 ha. The remaining area of historical wetlands, 43.67 ha, was wet meadows with woody vegetation. Current wetlands are formed by the sum of areas of new and continuous wetlands. Currently, swamps and marshes occupy the largest area among wetland types. They cover 43.67 ha. The rest of the area of the current wetlands is wet meadows and wet meadows with woody vegetation. They cover 2.87 ha and 4.50 ha, respectively (Tab. 1) [1].

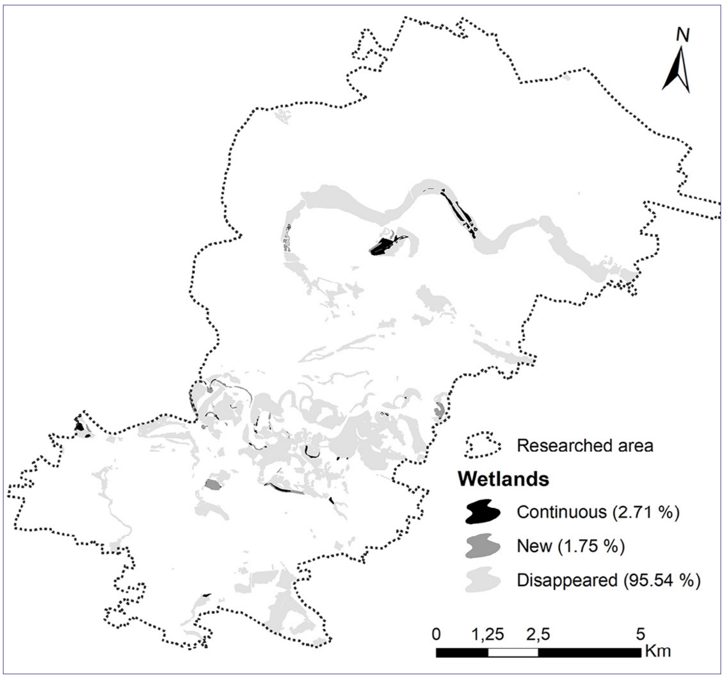

Fig. 2: *Spatio-temporal changes of wetlands in the researched area*

Tab. 1: *Change in area of wetlands in the researched area.*

Land use/cover	Area [ha]		Area [%]		Situation against 1841/42 [%]
	1841/42	2022/23	1841/42	2022/23	
Wet meadows	1,093.26	2.87	97.12	5.62	0.26
Wet meadows with woody vegetation	5.73	4.50	0.51	8.82	78.50
Swamps and marshes	26.69	43.67	2.37	85.56	163.63
Σ	1,125.68	51.04	100	100	4.53

5. Conclusion

The results presented in this article should form a practical, usable basis for the restoration of disappeared wetlands and, simultaneously, for the management of current wetlands, or in proposing measures to improve the ecological status of surface water bodies.. These landscape elements are a part of solutions for adapting to the issues caused by climate change. A varied landscape with a sufficient representation of wetland habitats contributes significantly to retaining water in the landscape and maintaining a stable climate [1].

6. Acknowledgements

This contribution was supported by the TGM WRI internal grants No.3600.54 .03 "Water in the landscape as an indicator of changes in the Elbe Lowland" and No. 3600. 23/2025 "Research Support – Institutional Support, Department 230".

Literature:

[1] Richter, P. (2023). The Trajectory of Wetland Development in the Middle Part of the Elbe River Basin in the Past 180 Years. Polish Journal of Environmental Studies, 32(4), 3755-3767. https://doi.org/10.15244/pjoes/163156

[2] Hydroekologický informační systém (HEIS VÚV). Mapa Vodní hospodářství a ochrana vod [on-line]. [Accessed 08/05/2025]. Available at: https://heis.vuv.cz/data/webmap/ isapi.dll?map=mp_heis_voda

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Development of pond locations in the Polabí lowland since the mid-19th century

Pavel Richter, Václava Maťašovská

1. Introduction

This post focuses on mapping the development of the lowland landscape from the mid-19th century to the present, related to pressures to use lowland areas for economic purposes, including the transformation of wetland habitats (specifically ponds) into arable land. The Polabí lowland was chosen as the study area because it is currently affected by a lack of water. As part of the evaluation of historical pond representation in Polabí, the part between Pardubice and Poděbrady was chosen as the one where their representation was the highest (Fig. 1).

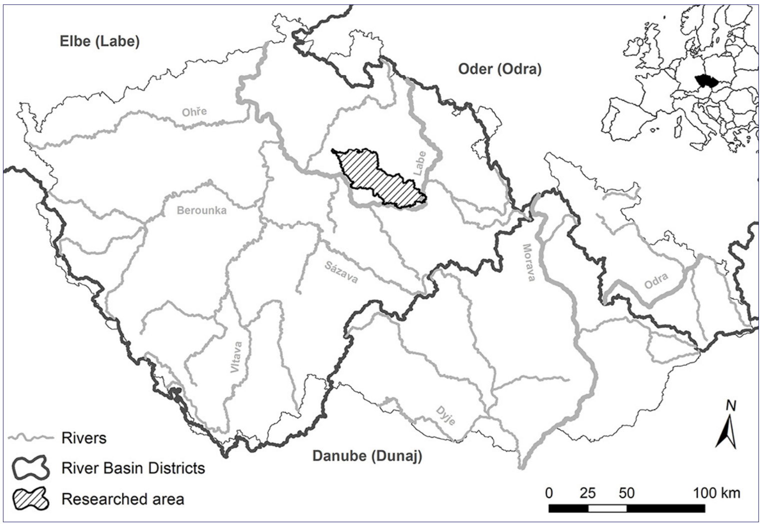

Fig. 1: *Location of the researched area in a hydrological context and within the Czech Republic and Europe.*

2. Methodology

The first step was the selection and subsequent comparison of the current and historical state of new, continuous, and disappeared ponds in Polabí based on map interpretation.

The map of Second Military Mapping was selected for the primary detection of the occurrence of ponds. The current Basic Topographic Map of the Czech Republic 1:10,000 (BTM 10) and the current orthophoto map of the Czech Republic were primarily used to show the current state of ponds and other water bodies.

The next step was a field survey of sites with the largest proportion of historical and current ponds to verify their current condition, or the state of the sites of disappeared ponds [1, 2].

3. Results

The area of all types of ponds according to stability makes up 7.34 % of the researched area. Disappeared ponds are the most represented, 56.01 % of the area of all ponds according to stability. Continuous ponds follow with 27.13 %, and new ponds occupy the smallest area with16.86 % (Fig. 2, Tab. 1). The average area of disappeared ponds is 13.12 ha, continuous ponds 6.48 ha, and new ponds only 2.06 ha. The minimum size of the new and continuous pond area is identical to the minimum size that was considered during the data analysis. For the maximum size of the area, the largest were historical ponds (disappeared and continuous), while the new ponds are the smallest (Tab. 1) [1, 2].

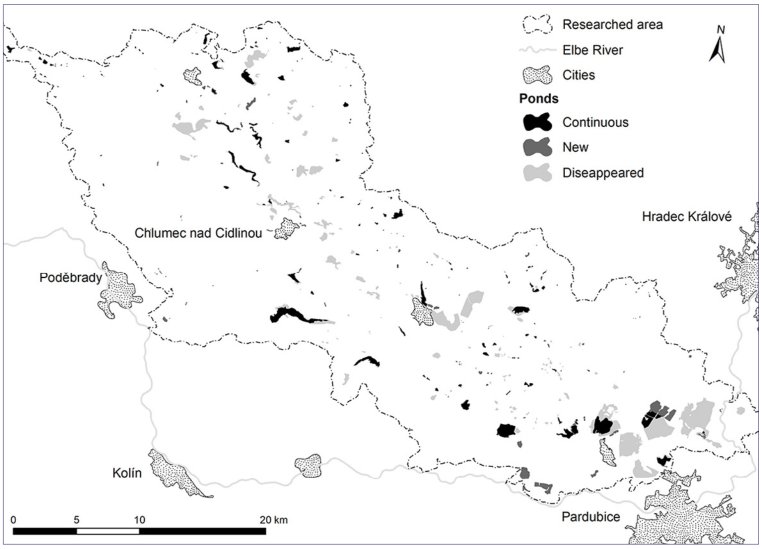

Fig. 2: *Pond location development in the researched area*

Tab. 1: *Landscape-ecological characteristics of pond development according to stability in the researched area*

Polabí – researched area (99 073.4 ha)			
Ponds 1836/52–2022/23	**dissapeared**	**continuous**	**new**
Area [ha]	4068.03	1970.76	1224.48
Number of plots [pcs]	310	304	594
Minimum plot size [ha]	0.1	0.01	0.01
Maximum plot size [ha]	520.45	185.87	63.84
Average plot size [ha]	13,12	6,48	2,06
Share of the total area of ponds in the researched area [%]	56.01	27.13	16.86
Ratio to the total area of the researched area [%]	4.11	1,99	1,24

4. Conclusion

Analyses show that five-eighths of the disappeared ponds have been replaced by arable land, i.e, in the past, there have been major changes in the use of the landscape in this area, mainly caused by intensive agricultural activity and the associated modifications of the landscape.

Therefore, there is significant scope for designing landscape changes in the catchment area to retain water in the landscape. One of the possibilities offered is the restoration of ponds, i.e., one of the types of wetland habitats as one of several ways of combating drought.

5. Acknowledgements

This contribution was supported by the TGM WRI internal grants No.3600.54 .03 "Water in the landscape as an indicator of changes in the Elbe Lowland" and No. 3600. 23/2025 "Research Support – Institutional Support, Department 230" and by the Technology Agency of the Czech Republic grant SS02030018 "Centre for Landscape and Biodiversity "

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[1] Richter, P. (2023) Vývoj lokalizace rybníků v Polabské nížině od poloviny 19. století – 1. část – Pardubicko. Vodohospodářské technicko-ekonomické informace, 65(3), 32–38. ISSN 0322-8916.

[2] Richter, P. (2023) Vývoj lokalizace rybníků v Polabské nížině od poloviny 19. století – 2. část – Poděbradsko. Vodohospodářské technicko-ekonomické informace, 65(4), 32–38. ISSN 0322-8916.

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Long-term monitoring of dioxins in fish and sediments from the Elbe River basin

Hedvika Roztočilová, Libuše Barešová, Vít Kodeš

1. Background

Dioxins are persistent organic pollutants characterized by their high toxicity, hydrophobicity and ability to accumulate in biotic and abiotic environmental compartments, as well as in food chains. These compounds can be generated unintentionally during incomplete combustion processes in the presence of chlorine. After formation they tend to bind to small particles, which enables their long-range atmospheric transport. Once reached the aquatic ecosystem dioxins accumulate in lipid tissues of organisms and in sediments where they sorb to organic carbon. This study summarizes dioxin monitoring data in sediment and fish samples collected from the Elbe River and its major tributaries across the Czech Republic over the period 2015 to 2024. Results indicate different distribution patterns between matrices. In all fish samples the consistently predominant congener was PCB 126, while concentrations of individual compounds in sediments were more site-specific. Another difference is also in spatial trend, which was observed in fish, where dioxin levels increase along the downstream course of the Elbe River, whereas in sediments there is no clear dependence. Dioxin concentrations in sediments reached their long-term maximum at the Bílina River, with levels approximately an order of magnitude higher than those at other sites. In contrast, fish samples showed smaller concentration variability.

2. Dioxins in fish and sediments in the river Elbe and its tributaries in the Czech Republic

The occurrence of 29 dioxin compounds, including polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF) and dioxin-like polychlorinated biphenyls (DL-PCB), was evaluated in the common chub (Squalius cephalus) and sediments. Each matrix was sampled once per year based on individual profile during the monitoring period 2015–2024 (fish: 2 profile sets rotating every 3 years). Concentrations were normalized to lipid content in fish and to organic carbon (OC) content in sediments. Following the recommendations of the World Health Organization [1], all concentrations are expressed in toxic equivalents (TEQ).

Results are summarized in Table 1 and Figure 1. Compared to the other monitoring profiles, Ohře – Terezín was the only one where significant amounts of 12378PeCDD were detected in both fish and sediment samples. An exception was also observed in fish from Labe – Obříství, where 2378-TCDD was present in higher proportions compared to other locations. Throughout the monitoring period, DL-PCB in fish were above the limit of quantification (LOQ) in 100 % of the samples, whereas their occurrence above LOQ in sediments were generally lower. Conversely, dioxins and furans were more frequently detected above the LOQ in sediment samples than in fish.

Tab. 1: *Summary for each group of dioxin compounds over the monitoring period 2015 – 2024 at all monitoring profiles. Maximum concentrations (cmax) for fish are in ng TEQ/kg fat and for sediments in ng TEQ/kg OC.*

Group:	ΣPCDD		ΣPCDF		ΣDL-PCB	
Matrix:	Fish	Sediment	Fish	Sediment	Fish	Sediment
The most abundant compound	**2378TCDD**		**2378TCDF**	**23478PeCDF**	**PCB 126**	
c_{max}	0,14	147	0,04	232	0,9	550
Profile with c_{max}	Labe – Obříství	Labe – Děčín	Labe – Litoměřice	Bílina – Ústí n. L.	Vltava – Zelčín	Bílina – Ústí n. L.
% of the total sum ΣPCDD/F + DL-PCB	0 – 16	0 – 27	3 – 10	0 – 50	61 – 82	0 – 50

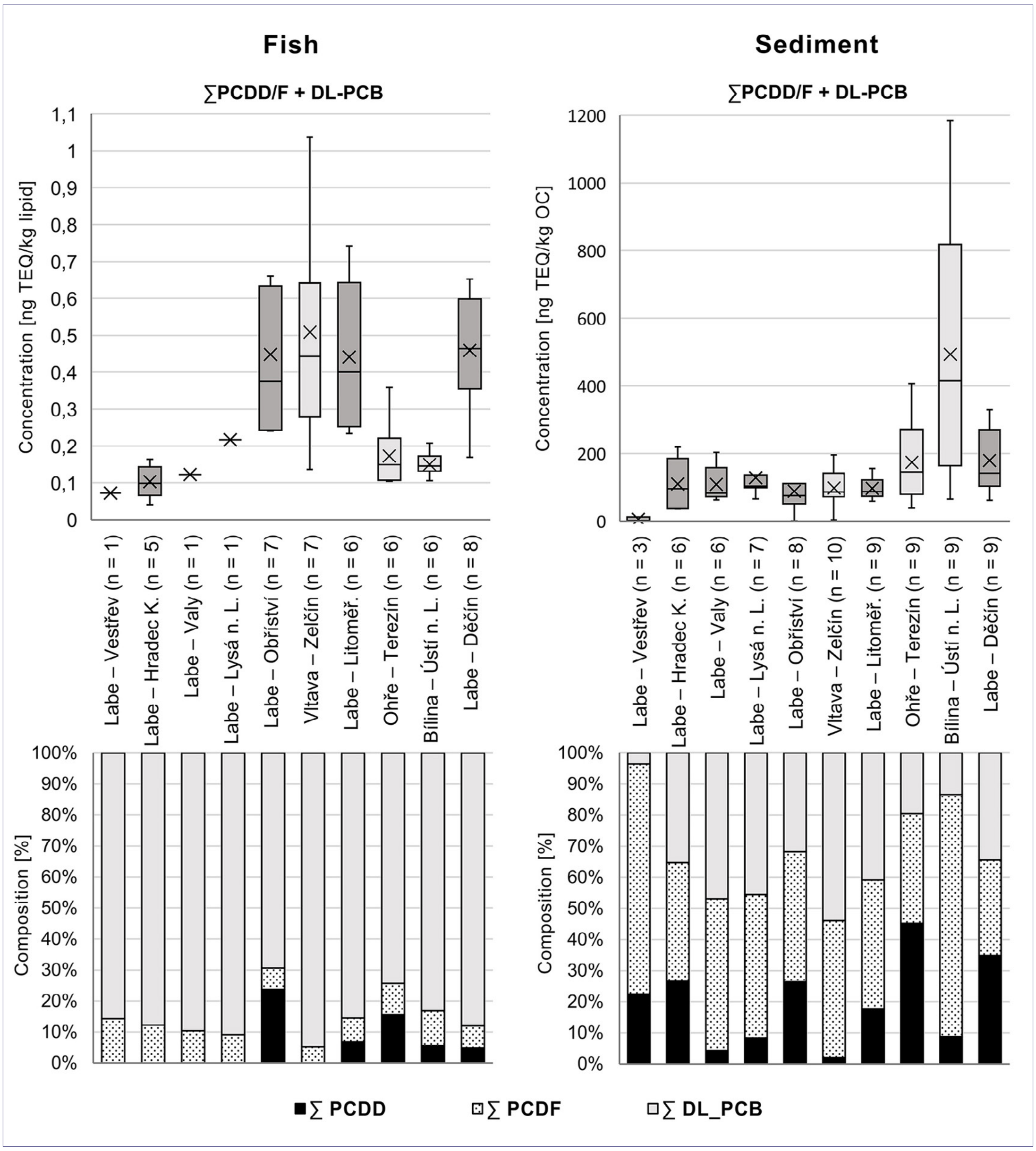

Fig. 1: *Long-term accumulation of ΣPCDD/F + DL-PCB (upper graphs) and composition of compound group (dioxins, furans, dioxin-like PCB) in lower graphs, for fish and sediments at Elbe river profiles and selected tributaries over the monitoring period 2015–2024. Profiles are ordered according to the river flow direction and tributaries are indicated in a lighter colour of boxplots.*

Literature:

[1] M. Van den Berg et al., "The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds," 2006. doi: 10.1093/toxsci/kfl055.

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Qualitative monitoring of bank filtration of the Elbe in the north of Saxony – Learning from yesterday for tomorrow

Sven Schirrmeister

Every water supplier wants to produce drinking water reliably and profitably. These goals can be achieved with natural treatment steps. The national water strategy of Germany aims to preserve natural forms of treatment. However, the preservation of natural treatment processes has become increasingly difficult. Many anthropogenic substances are classified as persistent, mobile and toxic (pmt). These trace substances can only be removed to a limited extent by natural treatment processes in waterworks. There is a risk that drinking water will be contaminated. Monitoring is essential to assess the risk to drinking water. At the same time, an evident recording of raw water quality can justify the avoidance of cost-intensive and high-tech drinking water treatment techniques under certain circumstances. Monitoring raw water quality is a challenging task that has become increasingly complex in recent years. A steady increase in the number of parameters to be examined, combined with a reduction in the limit values for permissible concentrations of various substance groups and individual substances in drinking water, places high demands on monitoring. At the same time, efficient monitoring must be created in a dynamic environment under real economic conditions.

The Fernwasserversorgung Elbaue-Ostharz GmbH (FEO) company collects bank filtrate with an annual production of approx. 35 million m³ in the Elbe catchment area in the north of Saxony. A retrospective of the monitoring strategies of the past 30 years was carried out. The knowledge gained about trace substances and their behaviour in bank filtration is considered. Based on the experience gained, an attempt is made to identify difficulties in monitoring new parameters. The aim is to establish an efficient approach to the investigation of new parameters in addition to the DVGW 108 and 254 recommendations for action.

Monitoring has always been subject to change, but the past decades can be divided into three sections. Three periods of investigation were defined: I (1992–2007), II (2007–2020) and III (2020–ongoing). The first period is referred to as 'development of the catchment area', the second as 'behaviour of river-specific trace substances in bank filtrate' and the third as 'establishing orientation values'. Each investigation period has different monitoring requirements for FEO GmbH. A numerical assessment of the monitoring strategies I and II was not consistently possible. Nevertheless, fundamental indications of efficient monitoring of trace substances could be found.

1. Do not prioritise high local resolution of the analyses. Only carry out detailed analyses after an evident determination of the concentration and an impending impairment of drinking water quality.

2. The examination of the retention and degradation capacity through the bank filtration passage and the substance transport behaviour in the catchment area should be carried out in cooperation with other partners
   a. Participation in research topics
   b. Awarding of research work in cooperation with colleges and universities

3. Take into account official coordination and use synergies through official measuring points or measuring networks

4. Synchronise sampling tours with existing plans

5. Step up committee work
   a. Motto: It's better to act than to react
   b. Obtain information before there is a limit value through regulation

The implementation of the guidelines is discussed in terms of the challenge in the third investigation period. It is considered possible to generalise the approach to other catchment areas.

Early water temperature measurements in the River Elbe in the 18th and 19th century

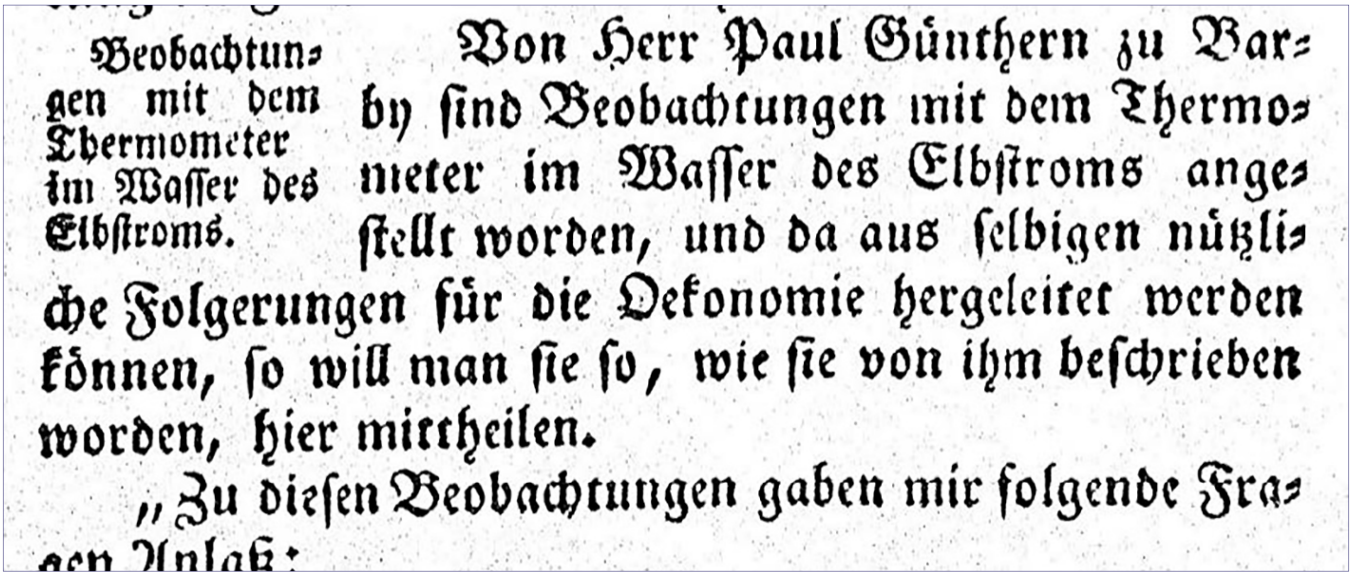
Daniel Schwandt, Gerd Hübner

1. Introduction

Already in the 18th century, series of water temperature measurements have been made for the River Elbe and other European Rivers by interested individuals. The renaissance of swimming and bathing in rivers in the late 18th and early 19th century lead to the establishment of river baths in the 1830s/1840s in large cities like Dresden, Prague, Magdeburg, Leipzig and Hamburg. Water temperature measurements from those river baths have been published in local newspapers during summer. Scientific interest fueled year-round daily measurements of water temperatures e.g. in Prague (Vltava, 1840–1844), Dresden (Elbe, 1864–1866) and Lobositz/Lovosice (Elbe, 1866–1867).

2. Examples of water temperature measurements in the 18th and 19th century

In 1779, Paul Günther (1740–1792) started periodic water temperature measurements of the Elbe at Barby (approx. 30 km upstream of Magdeburg) which continued for a decade. He worked as an assistant/mechanic for the teachers of the seminary of the Moravian Church in Barby. Günther measured the water level, observed the ice on the Rivers Elbe and Saale and started in February 1779 daily measurements of the water temperature. In 1779, the highest water temperatures occurred on August 6/7 with 76 °F (24.4 °C). He observed the first ice on the Elbe at a water temperature of 33 °F (0.6 °C) on December 19. Unfortunately, only few of the water temperature measurements have been published.


Beobachtungen mit dem Thermometer im Wasser des Elbstroms.

Von Herr Paul Günthern zu Barby sind Beobachtungen mit dem Thermometer im Wasser des Elbstroms angestellt worden, und da aus selbigen nützliche Folgerungen für die Oekonomie hergeleitet werden können, so will man sie so, wie sie von ihm beschrieben worden, hier mittheilen.

„Zu diesen Beobachtungen gaben mir folgende Fragen Anlaß:

Fig. 1: *Cutout of the first publication by Günther (1780) about water temperature measurements in the River Elbe [1].*

Karl Fritsch (1812–1879) worked as an assistant at the royal observatory in Prague. He measured the water level and the water temperature and observed the ice of the River Vltava from 1840 to 1844 at the Brückenmühle (bridge mill) in Prague. Reports of the measurements in [2] contain only monthly extremes and means.

Tab. 1: *Minima and maxima of the water temperature of the River Vltava at Prague for the years 1840 until 1843 [2].*

Year	Minimum (date)	Maximum (date)
1840 (July – Dec.)	0.1 °R = 0.1 °C (December 15)	18.3 °R = 22.9 °C (July 22)
1841	0.0 °R = 0.0 °C (December 31)	20.8 °R = 26.0 °C (June 27)
1842	0.0 °R = 0,0 °C (January 4)	18.9 °R = 23.6 °C (August 7)
1843	0.1 °R = 0.1 °C (January 21/22)	19.0 °R = 23.8 °C (June 4)

Dr. phil. Emil Kahl (1827–1893) was a teacher for physics and chemistry at the Royal Saxon Military College in Dresden. He was a meteorological observer from 1863 to 1869 and conducted daily measurements of the water temperature of the Elbe from June 1864 to April 1866 at the military swimming bath in Dresden-Neustadt. His results were published in [3].

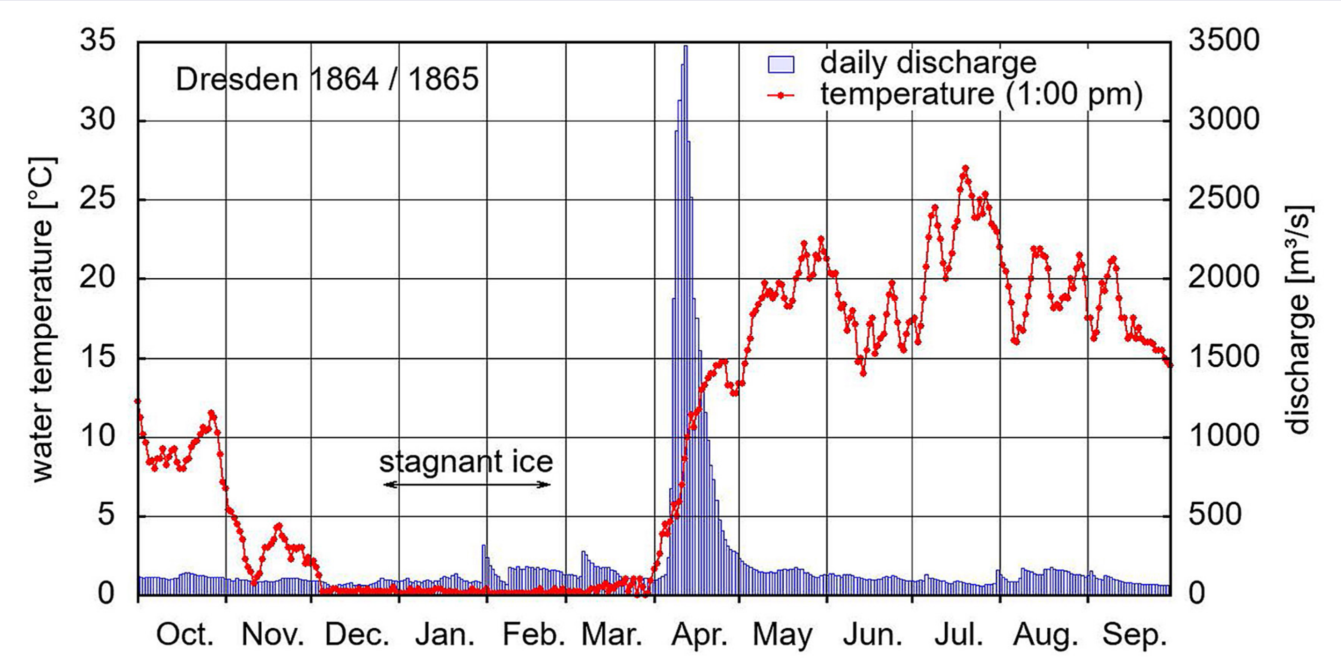


Fig. 2: *Water temperature and discharge of the River Elbe in Dresden from Oct. 1864 – Sep. 1865. Data [3,4,5]*

3. Conclusion

Cold winters with long ice cover were frequent phenomena in the 18th and 19th century, but on the other hand during heatwaves the water temperature approached and surpassed the 25 °C mark. The curiosity for the development of ice on the river and the economic importance of this phenomenon often sparked the interest in the measurement of water temperature. The search for early water temperature data will hopefully lead to long-term data series at several places along the Elbe that can be used for instance to quantify changes between the pre- or early industrial period and the present time. Early measurements are part of the monitoring history and should be preserved by using them.

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Sources of water pollution of PAHs as a key factor for designing and evaluating measures and monitoring

Silvie Semerádová

1. Introduction

When evaluating the chemical status of surface waters in the Czech Republic, one of the parameters most often causing the failure to achieve good status are substances from the group of polycyclic aromatic hydrocarbons (PAHs), [6] (Vyskoč, 2024). PAHs are most commonly introduced into the aquatic environment from the air through atmospheric deposition [1] (EEA report, 2024). In Europe, areas with high concentrations of PAHs in air and high deposition are located in the southern part of Poland and the northern and north-eastern part of the Czech Republic [2] (Gusev et al., 2022). However, there has been a significant improvement in the last twenty years [2] (Gusev et al., 2022). To a lesser extent, concentrations in surface waters are also decreasing [3](Prchalová, 2023), yet the proportion of non-compliant water bodies remains high and environmental quality standards are achieved in rather isolated cases. Moreover, in many cases monitoring is incomplete because PAH determination is costly.

2. Projects

In 2020–2022, the Water Research Institute developed a project on monitoring atmospheric deposition and determining its risk to the aquatic environment. It also involved the determination of PAHs in various environmental matrices at two natural sites with no direct anthropogenic sources. At the same time, a dry deposition model of benzo[a]pyrene for the whole Czech Republic was developed and converted to relative potential maximum inputs for each water body. In 2021, two-year monitoring was initiated in the framework of the Water Centre project, which built on the previous results. In the catchment area of Výrovka – leftside tributary of Elbe river several matrices were sampled and compared. The observed matrices were monthly sampled precipitation, moss (an indicator of deposition over 1–3 years), humus (an indicator of deposition over a longer period) and watercourse, including floating sediment. In a sample settlement the sources were monitored – in particular the potential pollution input from the built-up area (in the form of surface runoff, run-off from WWTPs and relief chambers) and major roads. A single rainfall-runoff event was sampled during heavy rain when the stream contained a significant surface runoff input, including an erosion event.
Tables 1 and 2 provide an overview of selected results in solid matrices and in water. A more detailed description of the methodology and evaluation of the results is presented in the research summary report [4] (Semerádová et al., 2024).

Tab. 1: *Table 1 – summary of measured values for different matrices (μg.kg-1)*

matrice	Measured value
Moss	180 (2021), 307 (2022, after the forest fire in NW Czechia) average 243
Moss 5 m from a busy road	442–743
humus	1345–1969
humus 5 m from a busy road	2992–3137
Floating sediment	1308–2749

Tab. 2: *Table 2 – summary of measured values in water (μg.l-1)*

matrice	Measured value
precipitation	0,053–0,087
Surface runoff	0,521–0,884
Storm overflow	0,167–0,508
Sewage treatment plant discharge	0,05
Výrovka stream in Plaňany	0,058
Výrovka stream in Plaňany by high flow rate	0,485

3. Conclusion

It has been confirmed that atmospheric deposition can be a significant pollutant of surface waters. However, the measured values also show the ability of PAHs to bind to various matrices and remain there until they are released into the watercourse through surface runoff, erosion or sewer overflows.

From these findings, possible measures can be suggested. In addition to measures aimed at improving air quality in general, measures to reduce erosion rates, reduce surface runoff and manage contaminated material (e.g. sewage sludge) may also be recommended.

Monitoring then makes sense to target the potentially higher risk sites (with higher air pollution) and where measures are to be or have been implemented. From a reference – less polluted sites can be considered those with lower air pollution and intact soil horizons and cover.

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Long-term changes in the aquatic invertebrate community of the upper section of the Zdobnice River

Jan Špaček, Pavel Hájek

Introduction

Since the middle of the 20th century there have been plans for the construction of a waterworks reservoir in the area of the confluence of the rivers Zdobnice and Říčka in the Orlicke Mountains. In the 1970s and 1980s, the area suffered from severe acidification. Like most of the Sudeten Mountains in the Czech Republic [5]. This had a significant impact on the communities of organisms, including aquatic organisms. However, monitoring of aquatic organism communities in the 20th century was very sporadic in this area and comprehensive chemical and biological data are virtually non-existent or unavailable. The first systematic survey took place only at the beginning of the 21st century [1]. In 2015, plans for the construction of a dam were renewed. Its main purpose was to retain water for treatment into drinking water. Monitoring of chemical and biological indicators of the Zdobnice River and some tributaries in the area of the planned reservoir was initiated. This was mainly exploratory monitoring. Chemical and biological data from this area were very sporadic.

Methodology

10 sampling profiles were established on the Zdobnice stream and tributaries. Three profiles could also be compared with data from 2004 and 2005 [1] [3] [4]. The source of the other data is the laboratory of Povodí Labe, státní podnik. The data on aquatic invertebrates come from autumn sampling. Therefore, autumn data from other years were also used for comparison. Other older data exist from 2012 and 2015 on the Zdobnice – Pěčín profile used for the WFD ecological status assessment. This profile is also the only one with regularly measured data. For all macrozoobenthos sampling, the Methodology for the collection and processing of macrozoobenthos samples of flowing waters using the Perla method [2] was used. The same methodology was used for the 2005 sampling, which was not yet officially approved at that time. However, this makes the results comparable. The compared pH values are from field measurements.

Results and conclusion

Oxygen ratios on the monitored profiles are good. Rarely does the oxygen saturation drop below 80 % and the dissolved oxygen below 8.5 mg/l. Only in the winter months is there an occasional drop in dissolved oxygen below 8.5 mg/l. The pH values are usually stabilised between 6 and 7,5. In some locations, however, pH decreases occur sporadically. Zdobnice – below the confluence with Říčka in 2017 pH 4.00, Zdobnice – above Čertovodolský brook pH 4.2. The most frequent decreases and the greatest fluctuations in pH values occur on the profiles Zdobnice – above Čertovodolský brook and Čertovodolský brook. On the Zdobnice – Pěčín profile, the average pH values have been between 7.2 and 7.8 since 2012. On the profile Zdobnice – above Čertovodolský brook, the average pH values range from 5.8 (in 2004) to 7.7. On the Čertovodolský brook profile, the average pH values range from 6.1 (in 2004) to 7.8.

On the Zdobnice – Pěčín profile, values of other indicators are available from 2009, 2012 and 2015–2004. The mean values of total nitrogen in 2009 are 2.2 mg/l, the maximum value is 3.1 mg/l. Since 2012, the mean values range from 0.9 to 1.2 mg/l, with maximum values reaching 1.6 mg/l. Mean nitrate nitrogen values range from 0.7–1.2 mg/l over the entire period, with a maximum value of 1.3 mg/l. Mean values for total phosphorus range from 0.01–0.05 (in 2009) mg/l. The maximum values are 0,08 mg/l. Mean values of orthophosphate phosphorus vary between 0,01 and 0,02 (in 2009) mg/l. The maximum values are 0,04 mg/l. The composition of the macrozoobenthos communities in 2005 showed lower diversity and the species composition was typical of a declining acidification. Diversity has gradually increased since 2012. The fluctuations were caused by low flows.

The area of the Zdobnice river basin in the area planned for the construction of the dam is rehabilitated from the period of acidification. Episodic pH drops occur on some profiles. Nutrient conditions are good for the envisaged storage for treatment for drinking water. Aquatic communities are rehabilitated and show good diversity and the presence of rare and sensitive species.

Zdobnice – Pecin												
	$N\text{-}NO_3$		N total		$P\text{-}PO_4$		Ptotal		Zn		Al	
	median	max	median	max	median	max	median	max	median	max	median	max
2009	1,0	1,1	2,2	3,1	0,02	0,02	0,05	0,07	9,0	13,0	99,0	104,0
2012	1,0	1,3	1,0	1,4	0,02	0,04	0,03	0,05				
2015	1,2	1,3	1,1	1,5	0,02	0,02	0,02	0,03	0,1	0,1	25,0	73,0
2016	0,9	1,3	1,1	1,5	0,02	0,04	0,03	0,07	0,1	0,1	85,0	275,0
2017	1,2	1,3	1,1	1,4	0,01	0,04	0,03	0,06	5,0	3,4	92,0	586,0
2018	0,9	1,2	1,0	1,4	0,01	0,03	0,02	0,05	0,1	0,1	36,0	185,0
2019	0,8	1,3	0,9	1,6	0,02	0,02	0,02	0,03	5,0	16,7	107,0	509,0
2020	0,8	1,2	1,1	1,4	0,01	0,02	0,01	0,04	3,8	9,3	63,0	429,0
2021	0,9	1,2	1,2	1,4	0,01	0,01	0,02	0,03	2,5	17,7	53,0	240,0
2022	0,9	1,2	1,1	1,6	0,02	0,03	0,02	0,06	2,5	12,3	58,0	200,0
2023	0,9	1,2	1,1	1,5	0,01	0,02	0,02	0,08	2,5	9,7	25,0	254,0
2024	0,7	1,1	0,9	1,1	0,02	0,02	0,02	0,04	4,5	10,8	85,0	486,0

***Tab. 1:** Selected chemical data from profile Zdobnice – Pěčín*

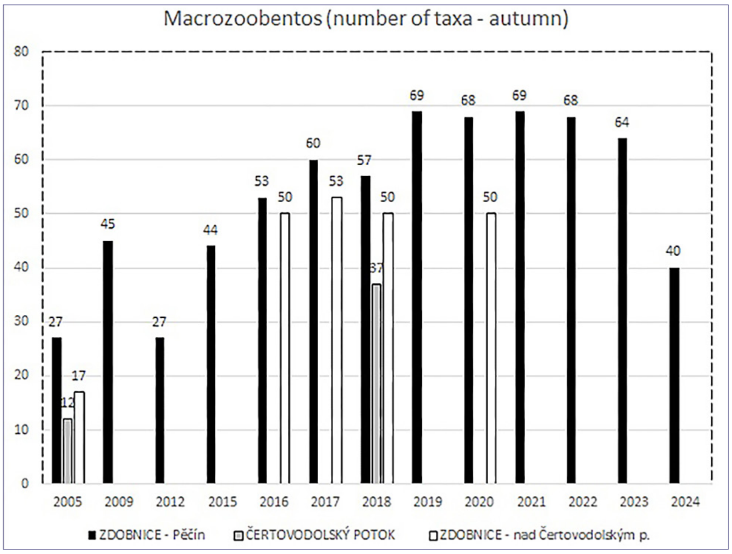

***Fig. 1:** Number of macrozoobenthos taxa in the compared profiles*

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Talsperrenbetrieb Sachsen-Anhalt (TSB) – Committed to People and Nature

Topographically, Saxony-Anhalt is not typically considered a "reservoir region." Nevertheless, the state is home to numerous dams and reservoirs of varying sizes and storage capacities. Responsibility for the operation and maintenance of these structures has rested with the Saxony-Anhalt Reservoir Authority (Talsperrenbetrieb Sachsen-Anhalt, TSB) since its establishment as a public-law institution in 1999.

In line with its statutory mandate, the TSB ensures:
- the provision of raw water for drinking water treatment,
- flood protection,
- and low-water flow augmentation.

Some facilities also serve recreational purposes — for example, the Rappbode Dam, the Wendefurth Dam, the Kelbra Reservoir, and the Muldestausee.

Prior to the TSB's founding, these responsibilities were spread across various administrative structures. Their consolidation into a single, independent institution ensures that tasks are fulfilled efficiently, with high quality, and in line with current standards of cost-effectiveness.

Most of the state's reservoirs are located in the Harz Mountains. However, there are also flood retention basins in former mining areas near Merseburg and Bitterfeld, as well as the Schrote retention basin, which helps protect the Magdeburg region from flooding.

As part of the flood protection strategy developed in response to the major flood events of 1994, 1998, and 2002, a new retention basin is currently under construction on the Selke River.

In total, the TSB manages 36 classified reservoirs with a combined storage volume of approximately 320 million cubic metres. This infrastructure plays a key role in supplying over one million people in central Germany with drinking water and mitigating flood risks on rivers such as the Bode, Helme, Unstrut, and Selke.

Talsperren-Wasserkraft Sachsen-Anhalt GmbH (TSW)

Founded in 2006, *Talsperren-Wasserkraft Sachsen-Anhalt GmbH (TSW)* is a wholly owned subsidiary of the Saxony-Anhalt Reservoir Authority. Its purpose is to plan, build, and operate hydropower plants that harness the energy potential of the TSB's reservoir systems.

TSW currently operates facilities at the Königshütte, Wendefurth, and Wippra dams, as well as at the Muldestausee and the Kalte Bode flood retention basin. Another plant is currently being planned at the Rappbode Dam.

Assessing groundwater discharge and its impact on riverine eutrophication – the Elbe case study

Julia Zill, Christian Siebert, Markus Weitere, Ulf Mallast

1. Dimensioning groundwater discharge

Excessive nutrient inputs and the resulting eutrophication represent a significant challenge to the quality of surface water bodies. As groundwater is the most important diffuse nutrient source, its contribution must be quantifiable and qualifiable over time. One of the most significant ecological effects of increased nutrient concentrations is eutrophication. The consequences are manifold and include unstable oxygen conditions, an increased risk of toxic algal blooms and ultimately a decrease in biodiversity. Accordingly, this project quantifies the spatial, temporal and past dynamics of diffuse groundwater discharge using the eutrophic river Elbe as a case study, wherein the impact of groundwater-borne nutrients on benthic and planktonic eutrophication was systematically analysed.

Groundwater discharge to the river was spatially and temporally localised using hydraulic head gradients along a 450 km free-flowing stretch of the German Elbe. Volumetric estimation was determined by a multi-method approach based on a flux balance, an inverse geochemical and tritium modelling and a Darcy approach [1]. Along the river, groundwater discharge occurred with high variability, while effluent conditions are detectable between early summer and autumn and inverse gradients (influent) during spring and winter (Fig. 1A). The highest likelihood of groundwater discharge was found in the mountainous upland areas, regardless of season or condition, and decreased in the lowland downstream parts (Fig. 1B). Unexpected but significant contributions from cropland drainage channels were detected in the lowland parts, while groundwater contributed with a higher total volume of about 40 m³/s under low flow conditions.

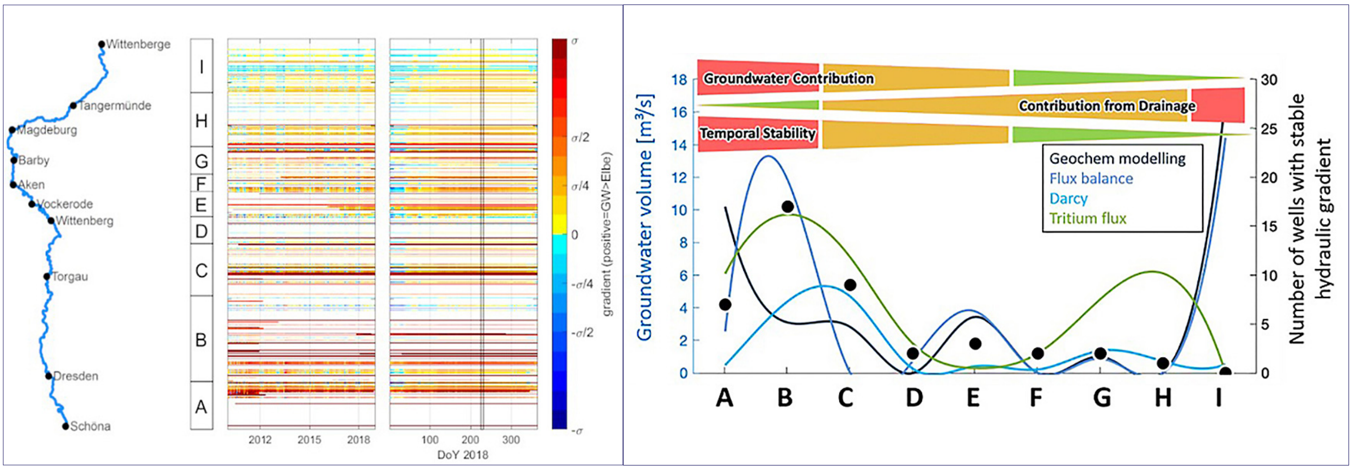

Fig. 1: A) shows investigated reach of the Elbe River with gauging stations; central panel: hydraulic gradients for long-time period (2010–2018) and for the year 2018 (DoY=days of the year), including indication of field campaigns (two black vertical lines). The colour of the bands indicates either effluent (reddish) or influent (blueish) conditions, where sigma represents the variance of all gradients). B) Combined results of qualitative and quantitative approaches and its interpretation regarding groundwater contributions, temporal stability and the deduced contribution from field drainages. Note that the left blue ordinate axis refers to all line elements while the right black ordinate axis refers to point elements in the figure.

In order to place these detected groundwater fluxes and the nutrients within a chronological stamp, the time scales of groundwater flow of adjacent aquifers were obtained in a lump parameter model. The multi-environmental tracer inputs of $^{3}H/^{3}He$, SF_6, CFCs and ^{14}C resulted in an age distribution of 0–41 years [2]. This young groundwater system is partly denitrified and shows little to moderate mixing with older water. It can therefore be concluded that groundwater-borne nutrient concentrations flowing into the Elbe River will decrease in the future, as the fertiliser peak from the GDR period (1945-1989) has already passed. This prediction is highly relevant for a sustainable river basin management to mitigate the consequences of eutrophication due to nutrient surplus.

2. Groundwater affected eutrophication

Nutrient transport from the groundwater can stimulate the local benthic as they have direct access to the nutrient. However, once it reached the water column, it can also enhance the total algae biomass in the lower parts of the Elbe River, as it can be limited particularly by the availability of phosphorus (P). Here we test the effect of groundwater on benthic algae in field experiments and model the effect of the groundwater-borne P on the surplus of planktonic algae in the lower parts of the Elbe.

The ecological effects of groundwater-borne nutrients on the eutrophication in the Elbe River were determined by using local (biofilms) and regional (phytoplankton) ecological parameters, which are key factors in eutrophication [3]. Biofilms were recorded seasonally on artificial substrates in selected river reaches along gradients of nutrient input through groundwater. Effects of the limiting nutrient P on plankton under low flow conditions were estimated using a stoichiometric approach based on river-conform data of algae and nutrients. As a result, biofilm proxies show distinct effects of seasonality as a primary factor and the interaction of aquifer type and groundwater flux. The impact of groundwater is generally highest in autumn in loose rock aquifer reaches with high groundwater influence and in summer, regardless of aquifer type. Major environmental impact factors affecting biofilms are temperature, electrical conductivity, turbidity and nutrients in the water column. With regard to phytoplankton, diffuse groundwater-borne P contributes 1.5 t/d under low flow conditions for the investigated 450 km stretch. This corresponds to an additional planktonic load of 46 t/d particular organic carbon under nutrient-limiting conditions, which has a significant impact on eutrophication potential. Thus, our study shows that groundwater not only contributes to the nutrient load of the Elbe River, but also enhances the overall eutrophication within the plankton significantly. Furthermore, it seems to alter the benthic eutrophication, however, in a non-consistent way over location and season.

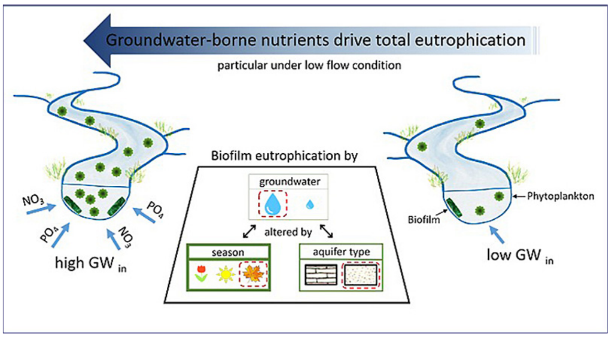

Fig. 2: *Combined results for the effects of (i) groundwater-borne P on planktonic algae during low flow and (ii) groundwater on benthic algae for different seasons and aquifer types.*

Literature:

[1] Zill, Julia, et al. "A way to determine groundwater contributions to large river systems: The Elbe River during drought conditions." Journal of Hydrology: Regional Studies 50 (2023): 101595.

[2] Zill, Julia, et al. "Will groundwater-borne nutrients affect river eutrophication in the future? A multi-tracer study provides evidence." EGUsphere 2025 (2025): 1-23.

[3] Zill, Julia, et al. "Contribution of groundwater-borne nutrients to eutrophication potential and the share of benthic algae in a large lowland river." Science of The Total Environment 951 (2024): 175617. Under review

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Assessing groundwater discharge and its impact on riverine eutrophication – the Elbe case study

Julia Zill, Christian Siebert, Ulf Mallast, Markus Weitere

Motivation

- **Diffuse nutrient** inputs via groundwater and the associated eutrophication represent a serious **water quality problem**
- **Research questions**:
  A) Where are diffuse groundwater inputs along the river?
  B) How much groundwater is discharged into the river?
  C) What is the mean residence time in the aquifers?
  D) How do groundwater-borne nutrients affect benthic and planktonic eutrophication?

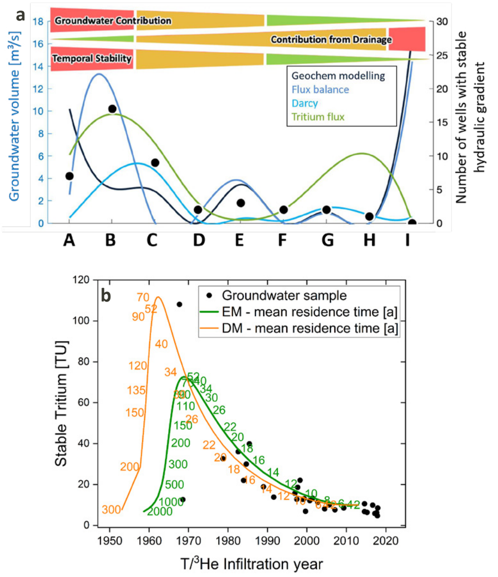

Fig. 2 (a) Groundwater contribution in m³/s to the river according to the different methods. (b) Synoptic plot of stable Tritium versus T/He infiltration age using an exponential model (green) and a dispersion model (orange).

Results

- Groundwater inflow between early summer and autumn (effluent), reverse gradients during winter and spring (influent)
- Highest likelihood of groundwater discharge in upland areas, regardless of season and conditions

- Significant contribution from lowland cropland drainages
- Total groundwater discharge about 40 m³/s

- Mean residence time distribution is about 2 - 41 years
- Groundwater-borne nutrient concentrations flowing into the Elbe will decrease in the future

- Biofilm parameters show effects of seasonality as primary factor and the interaction of aquifer type x groundwater
- Diffuse groundwater input of 1.5 t/d P under low flow

Key publications
Zill et al. (2023). A way to determine groundwater contributions to large river systems: The Elbe River during drought conditions. *Journal of Hydrology: Regional Studies*, *50*, 101595.
Zill et al. (2024). Contribution of groundwater-borne nutrients to eutrophication potential and the share of benthic algae in a large lowland river. *Science of The Total Environment*, *951*, 175617.
Zill et al. (2025). Will groundwater-borne nutrients affect river eutrophication in the future? A multi-tracer study provides evidence. *EGUsphere 2025 (2025): 1-23. under review*

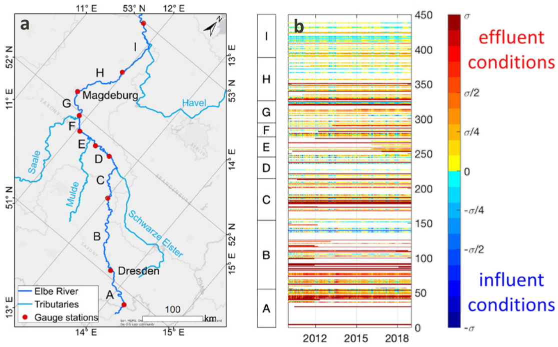

Fig. 1 (a) Studied 480 km section of the German Elbe River. (b) Hydraulic gradients between the Elbe and the groundwater table: warm colours indicate effluent conditions (GW discharging into the river), while cold colours indicate influent conditions (aquifer loses water to the river).

Methodology

A) Analysis of daily time series of **hydraulic gradients**

B) **Multi-method approach** to quantify groundwater volumes

C) Lumped parameter modelling using multiple **environmental and anthropogenic tracers**

D1) **Quantitative analysis** of seasonal biofilms from artificial substrates

D2) **Groundwater-P modelling** with respect to C:P stoichiometry of planktonic algae (regional eutrophication)

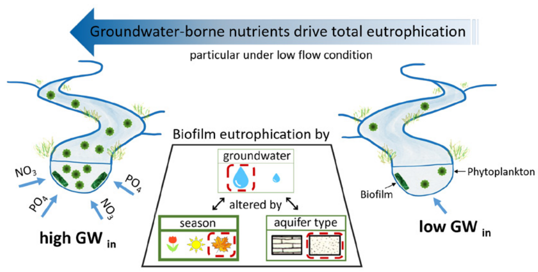

Fig. 3 Combined results for the effects of (i) groundwater-borne P on planktonic algae during low flow and (ii) groundwater on benthic algae for different seasons and aquifer types.

River Elbe at Torgau — Blank exposted substratum — Biofilm grown on substratum

Conclusions

- **total groundwater discharge of 40 m³/s during low flow**
- **Groundwater residence time of 2 – 41 years**
- **Groundwater-borne nutrients affect local eutrophication mainly in autumn and where unconsolidated aquifers prevail**
- **Groundwater-borne P contributes significantly to regional eutrophication during droughts**

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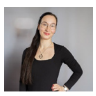


Hospodaření s vodou v povodí Labe včera, dnes a zítra

Internationale Kommission zum Schutz der Elbe 1990 – 2025

Mezinárodní komise pro ochranu Labe 1990–2025

Mit Unterzeichnung der Vereinbarung über die Internationale Kommission zum Schutz der Elbe (IKSE) am 8. Oktober 1990 in Magdeburg begann die grenzübergreifende Zusammenarbeit im Einzugsgebiet der Elbe – bis heute eine Erfolgsgeschichte.

Podepsáním Dohody o Mezinárodní komisi pro ochranu Labe (MKOL) 8. října 1990 začala přeshraniční spolupráce v povodí Labe a dodnes úspěšně pokračuje.

♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦ Labe ♦ Elbe ♦

In den ersten Jahren zielten die Schwerpunkte der Arbeit der IKSE auf die Senkung der Gewässerbelastung durch kommunales und industrielles Abwasser, den Bau von kommunalen Kläranlagen, die Verbesserung der Gewässergüte und der ökologischen Verhältnisse, später kam auch der Hochwasserschutz dazu. Mit der Umsetzung der europäischen Richtlinien (Wasserrahmenrichtlinie seit 2000 und Hochwasserrisikomanagement-Richtlinie seit 2007) wurde das Spektrum der Themen erweitert und bildet die Grundlage der Arbeit der IKSE.

> Nachdem die Elbe Ende der 1980er Jahre zu den am stärksten belasteten Flüssen Europas gehörte, war der gesellschaftliche Umbruch in Osteuropa für die Elbe Rettung in letzter Minute.

V prvních letech byla práce MKOL zaměřena hlavně na snižování znečištění způsobeného komunálními a průmyslovými odpadními vodami, na výstavbu komunálních čistíren odpadních vod, na zlepšení jakosti vody a ekologických poměrů, později přibyla i oblast ochrany před povodněmi.

> Labe patřilo koncem 80. let 20. století k nejvíce znečištěným řekám v Evropě, společenské změny ve východní Evropě proto pro Labe představovaly záchranu na poslední chvíli.

Implementací evropských směrnic (Rámcové směrnice o vodách od roku 2000 a Povodňové směrnice od roku 2007) se spektrum témat rozšířilo a tvoří základ práce MKOL.

▶ Umsetzung der europäischen Richtlinien

Ziel ist die Erreichung eines guten und möglichst naturnahen Zustands aller Gewässer und die Verringerung des Hochwasserrisikos.

▶ Implementace evropských směrnic

Cílem je dosažení dobrého a pokud možno přírodě blízkého stavu všech vod a omezení povodňových rizik.

▶ Hochwasserschutz

Hochwasser gehören im Einzugsgebiet der Elbe zu den Naturgefahren, die die größten Schäden verursachen. Der Klimawandel bringt neue Herausforderungen und Unsicherheiten mit sich. Wichtig ist eine enge Zusammenarbeit und Koordination vor allem bei der Hochwasservorhersage und bei Hochwasserschutzmaßnahmen.

▶ Ochrana před povodněmi

Povodně patří v povodí Labe k přírodním nebezpečím způsobujícím největší škody. Změna klimatu přináší nové výzvy a nejistoty. Důležitá je úzká spolupráce a koordinace především při předpovědi povodní a při protipovodňových opatřeních.

▶ Sedimentmanagement

Sedimente erfüllen grundlegende Funktionen als Gewässerbett, aquatischer Lebensraum und in Stoffkreisläufen der Gewässer. Entsprechende Maßnahmen zur Verbesserung des Sedimentstatus gehen vom Sedimentmanagementkonzept der IKSE aus.

▶ Nakládání se sedimenty

Sedimenty plní základní funkce při utváření koryt vodních toků, jako vodní stanoviště a v koloběhu látek vodních toků. Příslušná opatření ke zlepšení stavu sedimentů vycházejí z Koncepce MKOL pro nakládání se sedimenty.

▶ Reduzierung der Nährstoffeinträge

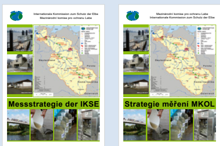
Die Stickstoff- und Phosphoreinträge wirken sich nicht nur negativ auf die Elbe und ihre Nebenflüsse, sondern auch auf die Nordsee aus.

▶ Snížení vnosu živin

Vnosy dusíku a fosforu ovlivňují negativně nejen Labe a jeho přítoky, ale také Severní moře.

▶ Internationales Messnetz und Messprogramm

Das Messprogramm wird bereits seit 1992 jährlich gemeinsam erstellt und abgestimmt. Die Proben werden sowohl in Deutschland als auch in Tschechien zu einheitlichen Terminen an den Messstellen entnommen und anschließend ausgewertet.



▶ Mezinárodní měřicí síť a program měření

Již od roku 1992 je každoročně společně sestavován a odsouhlasován program měření. Vzorky jsou odebírány v České republice i Německu ve stejných termínech na měrných profilech a následně vyhodnocovány.

▶ Warn- und Alarmsystem

Dem Internationalen Warn- und Alarmplan Elbe und dem Alarmmodell Elbe kommt eine außerordentliche Bedeutung insbesondere bei grenzüberschreitenden unfallbedingten Gewässerbelastungen zu.

▶ Varovný a poplachový systém

Mezinárodní varovný a poplachový plán Labe a Poplachový model Labe mají mimořádný význam zejména v případě havarijních znečištění vod přesahujících státní hranice.

▶ Niedrigwasser

Die Elbe gehört in Mitteleuropa zu den großen Fließgewässern mit dem geringsten verfügbaren Wasserdargebot pro Einwohner des Einzugsgebiets. Die Niedrigwasserperiode in den letzten Jahren hat die Bedeutung des Niedrigwasser- und Wasserknappheitsmanagements hervorgehoben.

▶ Sucho

Ve srovnání s velkými toky ve střední Evropě patří povodí Labe k oblastem s nejmenšími dostupnými vodními zdroji na jednoho obyvatele. Suché období v posledních letech zdůraznilo důležitost zvládání sucha a nedostatku vody.

Hieran arbeiten wir gemeinsam – einige Beispiele:

♦ Internationale Pläne ♦ Messprogramm ♦ Sondermessprogramm für hydrologische Extremereignisse ♦ Gemeinsame Probenahmen ♦ Zusammenarbeit der Hochwasservorhersagezentralen ♦ Hydrologische Auswertungen von Hochwasser- und Niedrigwasserereignissen ♦ Hydrologische Zahlentafeln ♦ Warn- und Alarmplan – Tests, Übersichten und Auswertungen der Meldungen ♦ Havarieübungen ♦ Alarmmodell für die Elbe, Moldau, Saale und Bílina ♦ Internationale Elbeforen ♦ Magdeburger Gewässerschutzseminare ♦ Fachgespräche ♦ Workshops ♦ Vermittlung von Fachkontakten ♦ Auswertung von Stellungnahmen der Öffentlichkeit ♦ Berichte ♦ Informationsblätter ♦ Flyer ♦

Danke für euer Vertrauen und die gute Zusammenarbeit.

Na tomto pracujeme společně – několik příkladů:

♦ mezinárodní plány ♦ program měření ♦ mimořádný program měření za extrémních hydrologických situací ♦ společné odběry vzorků ♦ spolupráce předpovědních povodňových centrál ♦ hydrologická vyhodnocení povodní a sucha ♦ hydrologické tabulky ♦ varovný a poplachový plán – testování, přehledy a vyhodnocení hlášení ♦ havarijní cvičení ♦ poplachový model pro Labe, Vltavu, Sálu a Bílinu ♦ mezinárodní labská fóra ♦ Magdeburské semináře o ochraně vod ♦ odborné konzultace ♦ workshopy ♦ zprostředkování odborných kontaktů ♦ vyhodnocení připomínek veřejnosti ♦ zprávy ♦ informační listy ♦ letáky ♦

Děkujeme za Vaši důvěru a dobrou spolupráci.

Internationale Kommission zum Schutz der Elbe
Oktober 2025

www.ikse-mkol.org

Mezinárodní komise pro ochranu Labe
říjen 2025

Hospodaření s vodou v povodí Labe včera, dnes a zítra

Analyse der Niedrigwasserperiode 2014 – 2023 im Einzugsgebiet der Elbe
► Oberflächengewässer

Analýza málovodného období 2014–2023 v povodí Labe
► Povrchové vody

Im Zeitraum 2014 – 2023 war das Einzugsgebiet der Elbe durch unterdurchschnittliche Niederschläge und überdurchschnittliche Lufttemperaturen geprägt. Das hatte zur Folge, dass sich im tschechischen und im deutschen Teil des Elbeeinzugsgebietes wiederholt sehr lange Niedrigwassersituationen mit jeweils unterschiedlichem räumlichen Ausmaß und unterschiedlicher Intensität einstellten.

V období 2014–2023 v povodí Labe převažovala období s podnormálními srážkami a nadnormální teplotou vzduchu. To mělo za následek, že se v české i německé části povodí Labe opakovaně vyskytovaly i velmi dlouhé periody s minimálními průtoky s rozdílným prostorovým rozsahem a různou intenzitou.

Die Expertengruppe „Hydrologie" der Internationalen Kommission zum Schutz der Elbe (IKSE) erstellte eine gemeinsame Analyse dieses zehnjährigen Niedrigwasserzeitraumes [1], www.ikse-mkol.org. Diese erweitert die Analyse des siebenjährigen Zeitraums 2014 – 2020 [2] und ergänzt die Untersuchungen der Niedrigwassersituation der Elbe im Jahre 2015 [3] und im Jahr 2018 [4], in denen auch der Einfluss von Talsperren auf die Aufhöhung von Niedrigwasserabflüssen ausführlich beschrieben ist.

Skupina expertů Hydrologie Mezinárodní komise pro ochranu Labe (MKOL) vypracovala společnou analýzu tohoto desetiletého suchého období [1], www.ikse-mkol.org. Analýza rozšiřuje analýzu desetiletí 2014–2020 [2] a doplňuje vyhodnocení sucha v povodí Labe v letech 2015 [3] a 2018 [4], ve kterých je také podrobněji popsán vliv vodních děl na zvětšování minimálních průtoků.

Für die Analyse wurden 11 maßgebliche Pegel aus dem Einzugsgebiet der Elbe (*siehe Tab.*) ausgewählt. Betrachtet wurden Kenngrößen der Lufttemperatur, des Niederschlages und des Abflusses, die mit der Bezugsperiode 1981 – 2010 verglichen wurden. Bewertet wurden die Wasserhaushaltsjahre jeweils von April bis März des Folgejahres. Der Bewertungszeitraum reicht vom 1. April 2014 bis zum 31. März 2024.

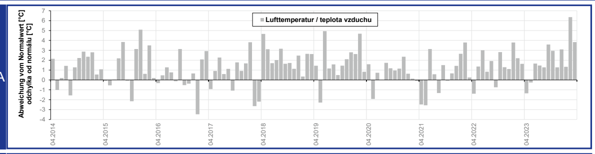
Nummer Číslo	Gewässer Tok	Pegel Vodoměrná stanice	Einzugsgebiet Plocha povodí [km²]
1	**Labe / Elbe**	**Kostelec nad Labem**	**13 183**
2	Otava	Písek	2 914
3	Sázava	Zruč nad Sázavou	1 421
4	Berounka	Beroun	8 286
5	**Labe / Elbe**	**Děčín**	**51 120**
6	Freiberger Mulde	Nossen 1	586
7	Vereinigte Mulde	Bad Düben 1	6 171
8	Saale / Sála	Calbe-Grizehne	23 719
9	**Elbe / Labe**	**Magdeburg-Strombrücke**	**94 942**
10	Sude	Garlitz	735
11	**Elbe / Labe**	**Neu Darchau**	**131 950**

Pro analýzu bylo vybráno 11 vodoměrných profilů v povodí Labe (*viz tab.*). Analyzovány byly charakteristiky teploty vzduchu, srážek a průtoku, které byly porovnány s referenčním obdobím 1981–2010. Hodnoceny byly vodohospodářské roky vždy od dubna do března následujícího roku. Hodnocené období je od 1. dubna 2014 do 31. března 2024.

Ein Beispiel der Ergebnisse für den Pegel Magdeburg-Strombrücke an der Elbe ~ Vybrané výstupy na příkladu vodoměrné stanice Magdeburk-Strombrücke na Labi

Abb. 1A:
Abweichungen der mittleren Monatstemperaturen in °C von den Werten der mehrjährigen Monatsmittel
93 Monate lagen über den Normalwerten und nur 27 unter den Normalwerten. Die größte positive Abweichung beträgt 6,4 °C (02/2024), die größte negative Abweichung -3,5 °C (01/2017).

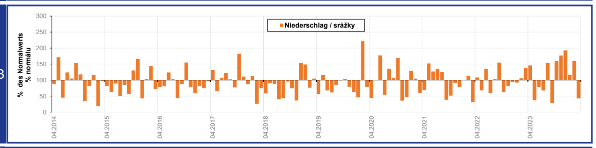
1A



Obr. 1A:
Odchylky průměrných měsíčních teplot v °C od hodnot dlouhodobých měsíčních průměrů
93 měsíců bylo nadnormálních a pouze 27 podnormálních. Největší kladná odchylka činí 6,4 °C (02/2024), největší záporná odchylka -3,5 °C (01/2017).

Abb. 1B:
Mittlere Monatsniederschläge in Prozent der Werte der mehrjährigen Monatsmittel
69 Monate lagen unter den Normalwerten und 51 über den Normalwerten. Die größte positive Abweichung vom Normalwert beträgt 121 % (02/2020), die größte negative Abweichung -81 % (02/2015).

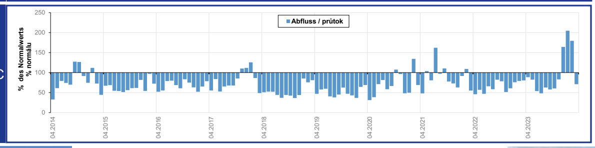
1B



Obr. 1B:
Průměrné měsíční srážkové úhrny vyjádřené v procentech hodnot dlouhodobých měsíčních normálů
69 měsíců bylo podnormálních a 51 nadnormálních. Největší kladná odchylka od normálu činí 121 % (02/2020), největší záporná odchylka -81 % (02/2015).

Abb. 1C:
Mittlere Monatsabflüsse in Prozent der Werte der mehrjährigen Monatsmittel
105 Monate lagen unter den Mittelwerten und nur 15 über den Mittelwerten. Die größte positive Abweichung beträgt 105 % (01/2024), die größte negative Abweichung -69 % (04/2020).

1C

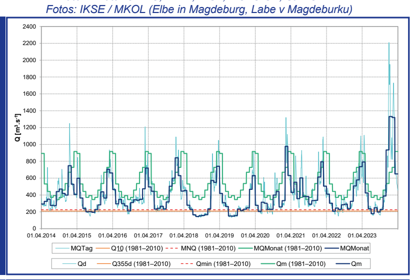


Obr. 1C:
Průměrné měsíční průtoky vyjádřené v procentech hodnot dlouhodobých měsíčních průměrů
105 měsíců bylo podnormálních a pouze 15 nadnormálních. Největší kladná odchylka činí 105 % (01/2024), největší záporná odchylka -69 % (04/2020).

Quelle / Zdroj: IKSE / MKOL
Daten / Data: ČHMÚ, DWD, WSV, LfULG SN, StALU WM
Fotos: IKSE / MKOL (Elbe in Magdeburg, Labe v Magdeburku)

Abb. 2:
Entwicklung der hydrologischen Situation im Zeitraum 2014 – 2023
■ Q_{10} – mittlerer Tagesabfluss, der im Jahr im Mittel an 10 Tagen unterschritten wird
■ MNQ – arithmetisches Mittel der niedrigsten mittleren Tagesabflüsse der Einzeljahre
Zum Beispiel bewegten sich im Zeitraum 07/2018 – 11/2018, also über eine Zeit von 5 Monaten, die mittleren Monatsabflüsse deutlich unter Q_{10} und MNQ.

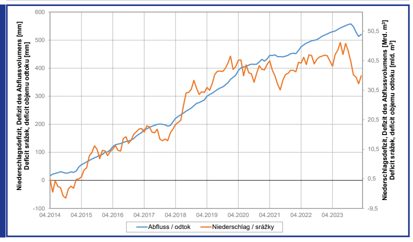
2



Obr. 2:
Vývoj hydrologické situace v období 2014–2023
■ Q_{355d} – průměrný denní průtok, který je dosažen nebo překročen průměrně 355 dní v roce
■ Q_{min} – aritmetický průměr nejmenších průměrných denních průtoků z jednotlivých roků
Například v období 07/2018–11/2018, tedy po dobu 5 měsíců, se průměrné měsíční průtoky pohybovaly výrazně pod úrovní Q_{355d} a Q_{min}.

Abb. 3:
Anstieg des Defizits des Abfluss- und des Niederschlagvolumens in Bezug auf die mehrjährigen Werte für den Zeitraum 1981 – 2010
Im zehnjährigen Zeitraum 04/2014 – 03/2024 wuchs das Abflussdefizit auf mehr als 49 Mrd. m³ (520 mm Abflusshöhe), was bedeutet, dass in diesem Zeitraum der Abfluss um 28 % niedriger als die mehrjährigen Mittelwerte war. Das Niederschlagsdefizit stieg ab Januar 2020 nicht weiter an, während sich das Abflussdefizit in Folge der überdurchschnittlichen Temperaturen und der hohen Verdunstung weiter verstärkte.

3



Obr. 3:
Nárůst deficitu objemu odtoku a srážek ve vztahu k dlouhodobým hodnotám za období 1981–2010
V desetiletém období 04/2014–03/2024 došlo k nárůstu deficitu odtoku na více než 49 mld. m³ (520 mm odtokové výšky), což znamená, že v tomto období byl odtok o 28 % menší než dlouhodobé hodnoty. Deficit srážek od ledna 2020 dále nenarůstal, zatímco deficit odtoku se v důsledku nadprůměrných teplot a vysokého výparu nadále prohluboval.

Für die Pegel an der Elbe in Děčín (ab 1851) und in Magdeburg (ab 1727) wurde für die statistische Einordnung dieses Niedrigwasserzeitraumes auf lange Beobachtungsreihen zurückgegriffen. Die diesbezüglichen Auswertungen zeigen, dass der zehnjährige Zeitraum 2014 – 2023 zu den abflussärmsten seit Beobachtungsbeginn dieser Pegel gehört.

Pro vodoměrné profily na Labi v Děčíně (od roku 1851) a Magdeburku (od roku 1727) bylo pro statistické zhodnocení tohoto suchého období využito jejich dlouhých řad pozorování. Na základě tohoto hodnocení lze konstatovat, že desetileté období 2014–2023 patří k nejméně vodným za období pozorování těchto stanic.

Literatur:
[1] IKSE (2025): Analyse der Niedrigwasserperiode 2014 – 2023 im Einzugsgebiet der Elbe
[2] IKSE (2023): Analyse der Niedrigwasserperiode 2014 – 2020 im Einzugsgebiet der Elbe
[3] IKSE (2017): Hydrologische Auswertung der Niedrigwassersituation 2015 im Einzugsgebiet der Elbe
[4] IKSE (2022): Hydrologische Auswertung der Niedrigwassersituation 2018 im Einzugsgebiet der Elbe

Literatura:
[1] MKOL (2025): Analýza málovodného období 2014–2023 v povodí Labe
[2] MKOL (2023): Analýza málovodného období 2014–2020 v povodí Labe
[3] MKOL (2017): Hydrologické vyhodnocení sucha v povodí Labe v roce 2015
[4] MKOL (2022): Hydrologické vyhodnocení sucha v povodí Labe v roce 2018

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Oktober 2025

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říjen 2025

Wasserbewirtschaftung im Einzugsgebiet der Elbe gestern, heute und morgen

Analyse der Niedrigwasserperiode 2014 – 2023 im Einzugsgebiet der Elbe ► Grundwasser

Analýza málovodného období 2014–2023 v povodí Labe ► Podzemní vody

Im Jahr 2014 begann im Einzugsgebiet der Elbe eine Periode mit überwiegend unterdurchschnittlichen Niederschlägen und überdurchschnittlichen Lufttemperaturen. Nach den hydrologischen Auswertungen der Niedrigwassersituation im Einzugsgebiet der Elbe im Jahr 2015 [1] und im Jahr 2018 [2] wurde die Auswertung der gesamten Niedrigwasserperiode 2014 – 2020 erarbeitet [3], die die Bewertung der Oberflächengewässer sowie des Grundwassers enthält und 2025 auf den zehnjährigen Zeitraum 2014 – 2023 erweitert wurde [4].

Počínaje rokem 2014 nastalo v povodí Labe období s převážně podnormálními srážkami a nadnormální teplotou vzduchu. Po hydrologických vyhodnoceních sucha v povodí Labe v roce 2015 [1] a v roce 2018 [2] bylo v roce 2023 zpracováno vyhodnocení suchého období v letech 2014–2020 [3], které obsahuje hodnocení povrchových i podzemních vod a bylo v roce 2025 rozšířeno na desetiletí 2014–2023 [4].

■ **Bewertete Grundwassermessstellen:**
Flachbohrungen – 186 Messstellen im tschechischen und 86 im deutschen Teil des Einzugsgebiets der Elbe (*Abb. 1)*
Tiefbohrungen – nur im tschechischen Teil des Einzugsgebiets der Elbe, 22 Messstellen in den ausgewählten wasserwirtschaftlich bedeutenden hydrogeologischen Gebieten (*Abb. 1)*

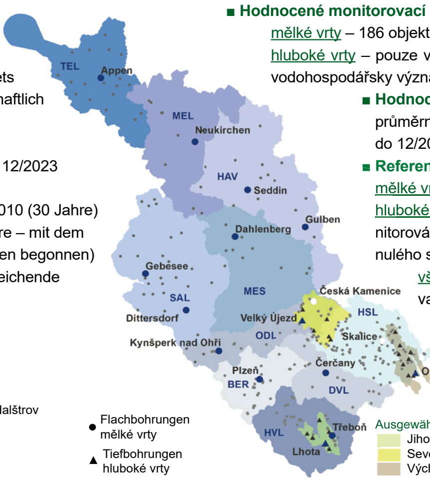
■ **Bewerteter Zeitraum und Werte:**
Monatsmittelwerte des Grundwasserstands von 01/2014 bis 12/2023

■ **Referenzzeiträume:**
Flachbohrungen (Tschechien, Deutschland): 01/1981 – 12/2010 (30 Jahre)
Tiefbohrungen (nur Tschechien): 01/1991 – 12/2010 (20 Jahre – mit dem Monitoring der Tiefbohrungen wurde erst in den 1990er Jahren begonnen)
alle Bohrungen 01/1991 – 12/2020 (30 Jahre) – für die vergleichende Auswertung in den Jahren 2021 – 2023

■ **Hodnocené monitorovací objekty podzemní vody:**
mělké vrty – 186 objektů v české a 86 v německé části povodí Labe (*obr. 1)*
hluboké vrty – pouze v české části povodí Labe, 22 objektů ve vybraných vodohospodářsky významných hydrogeologických oblastech (*obr. 1)*

■ **Hodnocené období a hodnoty:**
průměrné měsíční hodnoty stavu podzemní vody od 01/2014 do 12/2023

■ **Referenční období:**
mělké vrty (Česko, Německo): 01/1981–12/2010 (30 let)
hluboké vrty (pouze Česko): 01/1991–12/2010 (20 let – monitorování hlubokých vrtů bylo zahájeno až v 90. letech minulého století)
všechny vrty: 01/1991–12/2020 (30 let) – pro srovnávací vyhodnocení v letech 2021–2023



Legende / Legenda

Koordinierungsräume / Koordinační oblasti
- HSL – Horní a střední Labe / Obere und mittlere Elbe
- HVL – Horní Vltava / Obere Moldau
- BER – Berounka
- DVL – Dolní Vltava / Untere Moldau
- ODL – Ohře a dolní Labe / Eger und untere Elbe
- MES – Mulde-Elbe-Schwarze Elster / Mulde-Labe-Černý Halštrov
- SAL – Saale / Sála
- HAV – Havel / Havola
- MEL – Mittlere Elbe/Elde / Střední Labe/Elde
- TEL – Tideelbe / Slapový úsek Labe

● Flachbohrungen / mělké vrty
▲ Tiefbohrungen / hluboké vrty

Ausgewählte hydrogeologische Gebiete / Vybrané hydrogeologické oblasti
- Jihočeské pánve / Südböhmische Becken
- Severočeská křída / Nordböhmische Kreide
- Východočeská křída / Ostböhmische Kreide

1 *Internationale Flussgebietseinheit Elbe und ihre Koordinierungsräume (Quelle: ČHMÚ) / Mezinárodní oblast povodí Labe a její koordinační oblasti (zdroj: ČHMÚ)*

Sowohl bei den Flachbohrungen als auch bei den Tiefbohrungen (nur in Tschechien) wurde die Entwicklung des Grundwasserstands in den gegebenen Gebieten *(Abb. 1)* verbal bewertet und durch Diagramme mit Ganglinien des Grundwasserstands in ausgewählten Messstellen ergänzt – siehe Beispiel in *Abb. 2* (Gulben – Flachbohrung).

Darüber hinaus gibt es bei den Flachbohrungen für jeden Koordinierungsraum Tabellen mit dem prozentualen Anteil der Messstellen, in denen in den einzelnen Monaten des bewerteten Zeitraums starkes oder extremes Niedrigwasser erreicht wurde *(Beispiel in Tab. A)*. Bei den Tiefbohrungen in Tschechien unterstützen Tabellen mit der Gesamtklassifizierung des Grundwasserstands anhand der Perzentilwerte die verbale Bewertung der drei ausgewählten wasserwirtschaftlich bedeutenden hydrogeologischen Gebiete *(Abb. 1)* – siehe Beispiel in *Tab. B*.

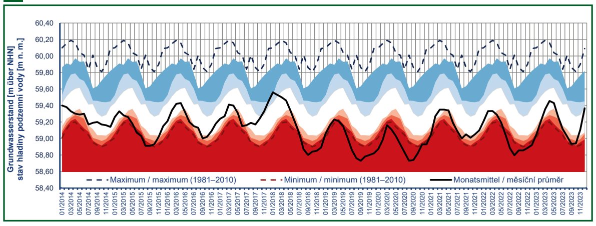
Zum Vergleich wurde eine Auswertung der Daten der Jahre 2021 – 2023 anhand des neueren Referenzzeitraums 1991 – 2020 durchgeführt, bei dem es erwartungsgemäß bei den Kategorien des Niedrigwassers zu deren Minderung kam – siehe Publikation [4].

Jak u mělkých vrtů, tak i u hlubokých vrtů (pouze v Česku) byl vývoj stavu hladiny podzemní vody v daných oblastech (viz *obr. 1*) hodnocen verbálně a doplněn grafy s průběhem hladiny podzemní vody ve vybraných monitorovacích objektech – viz příklad na *obr. 2* (Gulben – mělký vrt).

Kromě toho byly u mělkých vrtů pro každou koordinační oblast zpracovány tabulky s procentuálním podílem monitorovacích objektů, ve kterých bylo v jednotlivých měsících hodnoceného období dosaženo výrazně nízkého nebo mimořádně nízkého stavu hladiny podzemní vody – viz příklad *tab A*. U hlubokých vrtů v Česku podporují verbální hodnocení tří vybraných vodohospodářsky významných hydrogeologických oblastí *(obr. 1)* tabulky s celkovou klasifikací stavu hladiny podzemní vody pomocí hodnot percentilů – viz příklad *tab. B*.

Pro srovnání bylo provedeno hodnocení dat za období 2021–2023 pomocí novějšího referenčního období 1991–2020. Podle očekávání se ukázalo, že přitom dochází u kategorií nízkého stavu k jejich zmírnění – viz publikace [4].

2 *Gulben (BB_42517005) – Ganglinie des Grundwasserstands im Zeitraum 01/2014 – 12/2023*
Průběh hladiny podzemní vody v období 01/2014–12/2023
(im Vergleich zum Referenzzeitraum 1981 – 2010 / ve srovnání s referenčním obdobím 1981–2010)



B *Perzentilwerte im Gebiet Südböhmische Becken – Anzahl der Messstellen: 6*
Hodnoty percentilů v oblasti Jihočeské pánve – Počet monitorovacích objektů: 6

Jahr / Rok	Monate / Měsíce												Jahr / Rok
	1	2	3	4	5	6	7	8	9	10	11	12	
2014	94	93	85	80	84	77	60	63	84	86	76	55	81
2015	63	56	47	51	53	44	23	9	2	5	12	24	19
2016	32	33	29	23	21	23	27	35	14	15	22	20	20
2017	27	20	22	18	42	19	8	9	10	4	17	21	14
2018	30	31	26	9	11	21	14	1	<0,5	<0,5	1	4	7
2019	19	22	18	4	6	2	2	<0,5	<0,5	<0,5	<0,5	<0,5	2
2020	1	1	1	<0,5	<0,5	1	4	1	<0,5	<0,5	2	4	1
2021	5	10	11	3	6	4	6	6	1	<0,5	1	3	5
2022	5	5	2	<0,5	<0,5	<0,5	2	<0,5	<0,5	<0,5	1	7	1
2023	17	23	16	22	41	26	6	1	<0,5	1	7	27	12

Für die einzelnen Messstellen wurden aus den Monatsmittelwerten des Referenzzeitraums monatliche statistische Merkmale unter Einbeziehung der Werte Minimum, Maximum und Perzentilwerte *(siehe Legende)* festgelegt. Diesen Merkmalen wurden die Monatsmittelwerte aus dem bewerteten Zeitraum 01/2014 – 12/2023 zugeordnet und in sieben Kategorien eingestuft.

A *Prozentualer Anteil der Messstellen im Koordinierungsraum Havel mit starkem (hellrot) bzw. extremem (dunkelrot) Niedrigwasser – Anzahl der Messstellen: 16*
Procentuální podíl monitorovacích objektů v koordinační oblasti Havola s výrazně nízkou (světle červeně) a mimořádně nízkou (tmavě červeně) hladinou – Počet monitorovacích objektů: 16

Jahr / Rok	Monate / Měsíce											
	1	2	3	4	5	6	7	8	9	10	11	12
2014	0	0	6	6	6	0	0	0	6	6	6	0
	0	0	0	0	0	0	0	0	0	0	0	6
2015	0	6	13	19	19	6	13	25	0	13	0	0
	6	0	0	6	6	19	19	13	19	13	6	6
2016	0	0	0	0	0	6	6	13	13	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
2017	13	19	13	6	13	19	13	6	6	0	6	0
	6	6	6	13	13	13	6	0	0	6	0	0
2018	0	0	0	0	0	6	13	13	19	13	13	13
	0	0	0	0	0	0	6	6	13	25	25	25
2019	6	13	19	19	13	6	0	6	0	0	6	13
	31	25	25	44	50	63	63	63	63	63	50	44
2020	19	25	19	25	13	19	13	31	13	6	6	19
	50	44	38	44	50	50	50	50	63	63	56	50
2021	6	13	13	6	6	13	6	6	0	0	0	0
	63	44	38	50	44	44	44	44	44	44	38	38
2022	0	0	0	19	31	13	13	19	6	0	0	0
	38	38	38	38	38	63	63	63	69	69	69	69
2023	6	13	13	0	0	0	6	6	0	13	0	0
	69	50	38	38	38	38	38	38	50	38	38	38

Legende / Legenda

> 95 %	extremes Hochwasser / mimořádně vysoký stav hladiny
> 85 und / a ≤ 95 %	starkes Hochwasser / výrazně vysoký stav hladiny
> 75 und / a ≤ 85 %	Hochwasser / vysoký stav hladiny
> 25 und / a ≤ 75 %	normale Werte / normální hodnoty
> 15 und / a ≤ 25 %	Niedrigwasser / nízký stav hladiny
> 5 und / a ≤ 15 %	starkes Niedrigwasser / výrazně nízký stav hladiny
≤ 5 %	extremes Niedrigwasser / mimořádně nízký stav hladiny

Pro jednotlivé monitorovací objekty byly z měsíčních průměrů referenčního období stanoveny měsíční statistické charakteristiky zahrnující minimum, maximum a hodnoty percentilů *(viz legenda)*. K těmto charakteristikám byly následně vztaženy hodnoty měsíčních průměrů v hodnoceném období 01/2014–12/2023 a byly rozděleny do sedmi kategorií.

Literatur:
[1] IKSE (2017): Hydrologische Auswertung der Niedrigwassersituation 2015 im Einzugsgebiet der Elbe
[2] IKSE (2022): Hydrologische Auswertung der Niedrigwassersituation 2018 im Einzugsgebiet der Elbe
[3] IKSE (2023): Analyse der Niedrigwasserperiode 2014 – 2020 im Einzugsgebiet der Elbe
[4] IKSE (2025): Analyse der Niedrigwasserperiode 2014 – 2023 im Einzugsgebiet der Elbe

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Literatura:
[1] MKOL (2017): Hydrologické vyhodnocení sucha v povodí Labe v roce 2015
[2] MKOL (2022): Hydrologické vyhodnocení sucha v povodí Labe v roce 2018
[3] MKOL (2023): Analýza málovodného období 2014–2020 v povodí Labe
[4] MKOL (2025): Analýza málovodného období 2014–2023 v povodí Labe

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Internationales Messprogramm Elbe
Aufbereitung und Darstellung der Messdaten

Mezinárodní program měření Labe
zpracování a prezentace naměřených dat

Das internationale Messprogramm Elbe wird bereits seit 1992 jährlich gemeinsam erstellt und abgestimmt. Die Proben werden sowohl in Deutschland als auch in Tschechien zu einheitlichen Terminen an den jeweiligen Stellen entnommen und anschließend ausgewertet.

Již od roku 1992 je každoročně společně sestavován a odsouhlasován Mezinárodní program měření Labe (MPML). Vzorky jsou odebírány v České republice i Německu ve stejných termínech na příslušných místech a následně vyhodnocovány.

Das Internationale Messprogramm Elbe (IMPE) umfasst:

- 15 Messstellen: 10 an der Elbe, 5 an den Nebenflüssen der Elbe
- 4 Teilmessprogramme (*insgesamt ca. 375 Parameter*): Wasser *(ca. 260 Parameter)*, schwebstoffbürtige Sedimente *(ca. 70 Parameter)*, Biota *(ca. 35 Parameter)*, Biologie *(ca. 10 Parameter)*
- Das IMPE wird seit 2019 nach den Grundsätzen der Messstrategie der IKSE aufgestellt.

- An den Messstellen, die mit Messstationen ausgestattet sind, werden einige Parameter, z. B. Wassertemperatur, pH-Wert, elektrische Leitfähigkeit, gelöster Sauerstoff und Durchfluss, kontinuierlich gemessen.
- Für die Bestimmung der anderen Parameter und an Messstellen ohne Messstationen werden die Proben entweder automatisch oder manuell zu einem abgestimmten und einheitlichen Termin entnommen. Im Anschluss werden die Proben in den nationalen Laboren, die auf dem neuesten Stand der Technik sind, analysiert.
- Die Ergebnisse der IMPE-Analysen werden in den nationalen Datenbanken gespeichert. Seit 2025 ist es neu möglich, auch die aggregierten tschechischen Daten jederzeit und ohne Anmeldung über einen herkömmlichen Webbrowser abzurufen und herunterzuladen. In **Deutschland** erfolgt der Zugriff über das Datenportal der Flussgebietsgemeinschaft Elbe (FGG Elbe) https://www.elbe-datenportal.de. Die Daten können in den Formaten CSV, XLS, PNG, PDF und SVG abgerufen werden. In der **Tschechischen Republik** ist der Abruf über die Datenbank des Tschechischen Hydrometeorologischen Instituts (Český hydrometeorologický ústav) https://mkol.chmi.cz in den Dateiformaten CSV, PNG und SVG möglich.

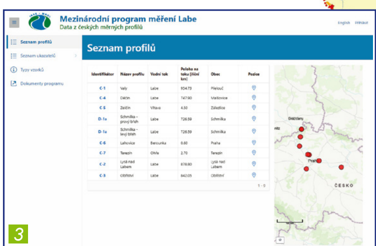
So ist die Verarbeitung großer Datenmengen möglich. Die neuen Daten sollen bis zum Ende des folgenden Kalenderjahres in der Datenbank verfügbar sein.

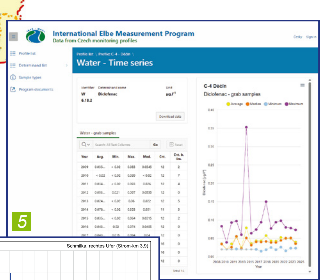
Mezinárodní program měření (MPML) zahrnuje:

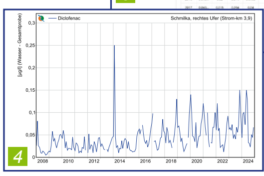
- 15 měrných profilů: 10 na Labi, 5 na přítocích Labe
- 4 dílčí programy *(celkem cca. 375 ukazatelů)*: vodná fáze *(cca. 260 ukazatelů)*, sedimentovatelné plaveniny *(cca. 70 ukazatelů)*, biota *(cca. 35 ukazatelů)*, biologie *(cca. 10 ukazatelů)*
- MPML je počínaje rokem 2019 sestavován podle zásad Strategie měření MKOL.
- Na měrných profilech, které jsou vybaveny měřicími stanicemi, se některé ukazatele, např. teplota vody, pH, konduktivita, rozpuštěný kyslík a průtok, měří kontinuálně.

- Pro stanovení ostatních ukazatelů a na měrných profilech bez měřicích stanic probíhá automatický nebo manuální odběr vzorků v dohodnutém a jednotném termínu. Tyto vzorky se poté analyzují v příslušných národních laboratořích, které jsou vybaveny nejmodernější technikou.
- Výsledky analýz vzorků MPML jsou ukládány v národních databázích. Od roku 2025 je nově možné také znázornit a stáhnout agregovaná česká data, a to za pomoci běžného prohlížeče bez nutnosti přihlášení. V **České republice** se jedná o databázi Českého hydrometeorologického ústavu https://mkol.chmi.cz a data lze stahovat ve formátu CSV, PNG a SVG. V **Německu** je to databáze FGG Elbe (Společenství oblasti povodí Labe) https://www.elbe-datenportal.de a data lze stahovat ve formátu CSV, XLS, PNG, PDF a SVG.

Tímto je umožněno hromadné zpracování dat, přičemž nová data lze očekávat v databázi do konce následujícího kalendářního roku.







Na obrázcích 1, 2 a 3 jsou snímky obrazovky databáze FGG Elbe a databáze Českého hydrometeorologického ústavu, pro kterou existuje také anglická verze. Jako příklad vývoje koncentrací v Labi byl vybrán lék Diklofenak v měrném profilu Hřensko/Schmilka (4) a Děčín (5).

Die Abbildungen 1, 2 und 3 zeigen Screenshots des Datenportals der FGG Elbe sowie der Datenbank des Tschechischen Hydrometeorologischen Instituts, für die es auch eine englische Version gibt. Als Beispiel für die Darstellung der Entwicklung der Konzentrationen in der Elbe wurde das Medikament Diclofenac für die Messstellen Schmilka (4) und Děčín (5) ausgewählt.

- Die Daten werden von der Expertengruppe SW der IKSE in regelmäßigen Sechsjahreszyklen ausgewertet. Der Schwerpunkt liegt dabei auf spezifischen Parametern, die für die Elbe entlang ihres gesamten Längsprofils von Interesse sind.
- Zur Unterstützung des IMPE wird für die Elbelabore jedes Jahr eine gemeinsame internationale Probenahme im Gelände und die anschließende Auswertung der Ergebnisse organisiert.

- Tato data jsou vyhodnocována skupinou expertů SW MKOL v pravidelných šestiletých cyklech, přičemž těžištěm jsou specifické ukazatele zajímavé pro Labe v celém jeho podélném profilu.
- Na podporu MPML je pro labské laboratoře každoročně organizován mezinárodní společný terénní odběr vzorků s následným vyhodnocením výsledků.

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