MAGDEBURSKÝ SEMINÁŘ O OCHRANĚ VOD 2018

MAGDEBURGER GEWÄSSERSCHUTZSEMINAR 2018

SBORNÍK
TAGUNGSBAND

PRAHA 18. – 19. ŘÍJNA 2018
PRAG 18. - 19. OKTOBER 2018

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Vážení účastníci Magdeburského semináře o ochraně vod, vážení čtenáři,

tématem letošního, již osmnáctého, Magdeburského semináře o ochraně vod je „Sucho a požadavky na užívání vod v povodí Labe“. Když v loňském roce Programový výbor Magdeburského semináře o ochraně vod diskutoval, jaké bude hlavní téma semináře, málo kdo z jeho členů tušil, že téma sucha bude i po více než roce až tak moc aktuální. Jsem rád, že letošní seminář může zástupcům vědy, praxe a orgánů státní správy nabídnout nejnovější poznatky a zkušenosti z této oblasti. To platí samozřejmě i pro další témata semináře, kterými jsou například jakost vod nebo problematika sedimentů.

Voda nezná administrativně správních hranic. Odborná debata je tedy vždy důležitá, zejména pak v rámci celého hydrologického povodí, v našem případě mezinárodního povodí Labe. Extrémní hydrologické jevy v jeho horní části, ať se jedná o povodně či o sucho, mají logicky mnohdy negativní dopady i níže v povodí. Považuji za důležité, aby určité názory, postupy a metody byly v maximální možné míře „sladěny“ v rámci celého mezinárodního povodí. Z probíhajících diskuzí je zřejmé, že jak v české části, tak v německé části povodí řešíme obdobné problémy, a proto je důležité si zkušenosti vyměňovat a využít nových poznatků k řešení obdobných problémů na obou stranách.

Cíl máme společný, a to je kvalitní péče o vodu v přírodním prostředí, včetně všech souvisejících aktivit s odpovědností vůči našim dětem, abychom realizovali taková opatření, aby i budoucím generacím byl umožněn život ve vodním blahobytu, kterého si dopřáváme my nyní. Přeji nám všem, aby se podařilo šířit výstupy semináře nejen mezi odbornou a laickou veřejnost, ale i mezi politiky, protože bez jejich podpory se budou mnohá nezbytná opatření realizovat jen těžko!

Přál bych si, aby i letošní seminář přispěl k těsnější spolupráci a koordinaci činností mezi všemi dotčenými subjekty v mezinárodním povodí Labe. Mysleme na budoucí generace, mysleme hlavou a srdcem...bez vody to totiž nepůjde...

Vítejte v Praze ☺

Sehr geehrte Teilnehmerinnen und Teilnehmer des Magdeburger Gewässerschutzseminars, liebe Leserinnen und Leser,

das Thema des diesjährigen, bereits achtzehnten, Magdeburger Gewässerschutzseminars ist „Niedrigwasser und Ansprüche an Wassernutzungen im Einzugsgebiet der Elbe“. Als im Vorjahr im Programmkomitee des Magdeburger Gewässerschutzseminars das Hauptthema für das nächste Seminar diskutiert wurde, ahnten nur wenige seiner Mitglieder, dass Niedrigwasser auch nach mehr als einem Jahr immer noch hochaktuell bleibt. Ich bin froh, dass das in diesem Jahr stattfindende Seminar den Vertretern aus der Wissenschaft, der Praxis und den Behörden die neuesten Erkenntnisse und Erfahrungen auf diesem Gebiet vermitteln kann. Dies gilt natürlich auch für andere Themen des Seminars wie z. B. für die Gewässergüte oder Sedimente.

Verwaltungstechnisch gesehen kennt das Wasser keine Grenzen. Eine Fachdiskussion ist daher stets von Bedeutung, besonders im Kontext des gesamten hydrologischen Einzugsgebiets, in unserem Fall des internationalen Einzugsgebiets der Elbe. Oft wirken sich hydrologische Extremereignisse im oberen Teil des Gewässers, sei es nun Hochwasser oder Niedrigwasser, logischerweise negativ ebenfalls auf die jeweiligen Unterlieger im Einzugsgebiet aus. Ich halte es für wichtig, bestimmte Ansichten, Vorgänge und Verfahren im Rahmen des gesamten internationalen Einzugsgebiets in höchstmöglichem Maße in Einklang zu bringen. Aus den stattfindenden Diskussionen ist ersichtlich, dass wir sowohl im deutschen als auch im tschechischen Teil des Einzugsgebiets ähnliche Probleme lösen. Aus diesem Grund ist es wichtig, Erfahrungen auszutauschen und neue Erkenntnisse zur Lösung von ähnlichen Problemen auf beiden Seiten zu nutzen.

Wir haben ein gemeinsames Ziel, und zwar einen guten, umweltgerechten Umgang mit Wasser, einschließlich aller Aktivitäten, die mit der Verantwortung unseren Kindern und zukünftigen Generationen gegenüber zusammenhängen. Dementsprechend sollten wir solche Maßnahmen ergreifen, die es auch kommenden Generationen ermöglichen, ein Leben im Wasserwohlstand, wie wir es jetzt genießen, zu führen. Ich wünsche uns allen, dass es uns gelingt, Ergebnisse des Seminars nicht nur in der Fachwelt und breiten Öffentlichkeit, sondern auch in der Politik zu verbreiten, denn ohne ihre Unterstützung wäre manch eine notwendige Maßnahme nur mühsam umsetzbar!

Ich würde mir wünschen, dass auch diesjähriges Seminar zu einer engeren Zusammenarbeit und Koordination der Tätigkeiten unter allen betreffenden Subjekten im internationalen Einzugsgebiet der Elbe beiträgt. Denken wir auf künftige Generationen, denken wir mit dem Kopf und mit dem Herzen...denn ohne Wasser läuft nichts...

Herzlich willkommen in Prag ☺

RNDr. Petr Kubala

prezident MKOL
a generální ředitel
státního podniku Povodí Vltavy

Präsident der IKSE
und Generaldirektor
des staatlichen Wasserwirtschaftsbetriebs für die Moldau

OBSAH / INHALT

PROBLEMATIKA SUCHA
Wassermanagement in Trockenperioden

Content

Overall strategy for the Elbe – achievements to date and next steps

Thomas Gabriel
Generaldirektion Wasserstraßen und Schifffahrt

1. Introduction

In order to account for the different interests with regard to the use of the Elbe (shipping, nature conservation, waterway management, flood defence, ports management, etc.), the Federal Ministry of Transport and Digital Infrastructure (BMVI) and the Federal Ministry for the Environment (BMU) agreed to draw up an overall strategy for the Elbe in 2010.

First of all, a paper with key issues had to be developed together with the riparian federal states of the Elbe. This paper summarizes the most important aspects and objectives of the future overall strategy. Since the middle of 2013, the key issues have been defined. Based on these issues, it was now possible to draw up the overall strategy for the Elbe (GKE).

Representatives of the Federal Government and the federal states have developed the overall strategy for the Elbe in a process that lasted several years. Environmental and industry associations as well as citizens' action groups were also actively involved in the process [1]. The final draft was presented at the end of 2016.

The priority areas of the overall strategy for the Elbe are divided into four work packages: water management, nature conservation, stream control and transport.
On 17 January 2017, the overall strategy for the Elbe was adopted by the resolution body of the Federal Government and the federal states [2]. With the decree of 6 February 2017, the overall strategy for the Elbe was introduced as a mandatory framework for action for the Waterways and Shipping Administration (WSV).

On 27 March 2017, approximately 200 interested guests came together in the Cathedral of Magdeburg at the invitation of the Federal Government and the federal states involved to discuss this overall strategy as a basis for future action related to the Elbe as a living environment and transport route.

Fig. 1*: Course of the Elbe near Griebo (km 226.5) (Source: A. Hilger)*

Water management (WP 1)	
a.	Reduce material loads (nutrients, harmful substances) in the water as well as in the sediments of the Elbe and its floodplains (water quality and sediment quality management)
b.	Improve continuity and dynamics with regard to sediments
c.	Improve hydromorphology (dynamics of discharge, water bodies' structure, habitats)
d.	Expand flood retention in catchment areas (flood retention spaces – e.g. relocating dykes, bypass retention basins; adaptations of use)
e.	Improve flood defences (technical flood protection; safeguard efficiency of flood water outflow cross-sections, e.g. ice floods)
Nature conservation (WP 2)	
a.	Create favourable conservation statuses for habitat types and species in the river bed and banks (N2000 conservation objectives, aqua-ecological functions), improve waterbodies' structures, stimulate morphodynamics, reduce solid bank fixation)
b.	Improve horizontal (lateral) links of floodplain waters and affluents to strengthen the ecological impact of river and floodplain connections (N2000 coherence, ecological functions of floodplains)
c.	Stop further vertical separation as a result of river bed erosion to restore functional river-wetland couplings (N2000 conservation objectives and coherence, ecological functions of floodplains), near-natural water level dynamics
d.	Expand inundated areas in former floodplains, relocate dykes
e.	Protect species and habitats (N2000 conservation objectives) by avoiding disturbances, reducing material and other loads and adapting use with regard to rivers and floodplains
Stream control and river bed stabilization (WP 3)	
a.	Optimize stream control system for low water range averages (reliability)
b.	Stabilize beds by widening cross-section scopes (incl. forelands, following the river bed stabilization strategy) and optimize stream control system for mean water ranges to reduce erosion followed by stabilization of water levels and to achieve steady sediment transport
c.	Stabilize river beds by reducing bedload deficits
d.	Optimize river regulation structures in ecological terms to maintain/improve their control function
Transport (WP 4)	
a.	Maintain and optimize transport function upstream of Magdeburg
b.	Maintain and optimize transport function downstream of Magdeburg
c.	Extend time period for low water ranges when fairway is guaranteed to be sufficiently deep
d.	Improve usability, for example by means of digital route information, traffic rules and traffic information
e.	Prioritize sections with transport problems (remove bottlenecks)

Tab. 1: *Objectives for the overall strategy for the Elbe*

The overall strategy for the Elbe enjoys support at the highest political level. Following the recommendation made by the Committee on Transport and Digital Infrastructure, the German Bundestag took note of the overall strategy for the Elbe on 22 June 2017 and adopted a corresponding resolution. With the resolution, the Bundestag called upon the Federal Government to draw-up and implement corresponding measures for the overall strategy for the Elbe aimed at developing the German non-tidal Elbe in a timely manner and within the available budget.

2. The overall strategy for the Elbe

Based on the paper with key issues, the overall strategy for the Elbe specifies a total of 19 objectives for the four above-mentioned work packages (Tab. 1).

Objectives are compared and potential interactions are analysed: are there synergies, are there conflicts or are there no interactions?

As result of the further analysis, five separate fields plus the field Z (objectives that cannot be achieved in the short term and are beyond the framework of the key issues paper; they will be dealt with in the follow-up process) are identified. (Tab. 2)

These six fields form the guideline and, as such, represent the framework for action of the overall strategy for the Elbe. The fields are to be treated equally, and measures undertaken to implement the objectives of individual fields must not compromise the objectives of other fields.

From the guideline, 55 proposals for specific measures will be developed that are to make a contribution to nature conservation, waterway management and shipping in the future. The overall strategy contains profiles (Fig. 2) with options for measures that will subsequently be attributed to the individual sections along the Elbe.

Fields		Tasks and objectives
E	Erosion control and bedload balance	Bed and water level stabilization
W	Improvement of flood defences, water retention and water balance	Improvement of flood defences, water retention and water balance
G	Reduction of input of substances	Reduction of material loads
S	Improvement of navigation conditions	Optimization for low water ranges
		Improvement of route information
		Optimization of river regulation structures in ecological terms
		Strengthening of the Elbe/Mittelland Canal/Elbe Lateral Canal federal waterways system
N	Preservation and restoration of habitats and living environment types in water bodies, on banks and in floodplains	Improvement of the structure of bodies of water and banks
Z	Future considerations	Perspectives for the future and requirements that are beyond the framework of the key issues and the rules of procedure of the overall concept in terms of spatial scale, content and time

Tab. 2: *Field (overarching objectives) of the guideline for the overall strategy for the Elbe*

Themenfeld	**Erosionsbekämpfung und Geschiebehaushalt (E)**
	Bezug zu Themenfeld N
Aufgabe	Stabilisierung der Sohle und des Wasserspiegels
Bezeichnung der Maßnahme	**Geschiebezugabe** *N: Vernetzung von Fluss und Aue*
Maßnahmennummer	**E.07**

Maßnahmentyp/Erläuterung	**Bemerkung/ Kommentar**
Flächenhaftes Einbringen von flusstypischem Geschiebe, z.B. mit Hilfe von Klappschuten. Zusätzlich können Depotschüttungen vorgesehen werden.	weitere Optimierung der Geschiebezugabe erfolgt laufend über AG Sohlstabilisierung
Einsatzmöglichkeiten In der gesamten Erosionsstrecke vornehmlich in Bereichen, an denen eine strömungsbegünstigte, zügige Mobilisierung gewährleistet ist.	
Wirkung **Strombau/Verkehr:** Sohlstabilisierung, auf diese Weise erfolgt Geschiebedurchtransport ohne, dass aus der Sohle zusätzlich Material ausgetragen wird. Durch die Art der Zugabe erfolgt keine Behinderung für die Schifffahrt. **Naturschutz/ Wasserwirtschaft:** Verringerung der weiteren Entkopplung Fluss- Aue	Wechselwirkung zur WRRL: grundsätzlich Synergie (Wechselwirkung zu Maßnahme N2.03) NATURA 2000: Synergie

Fig. 2: *Gravel augmentation profile as an example of options for measures of the overall strategy for the Elbe*

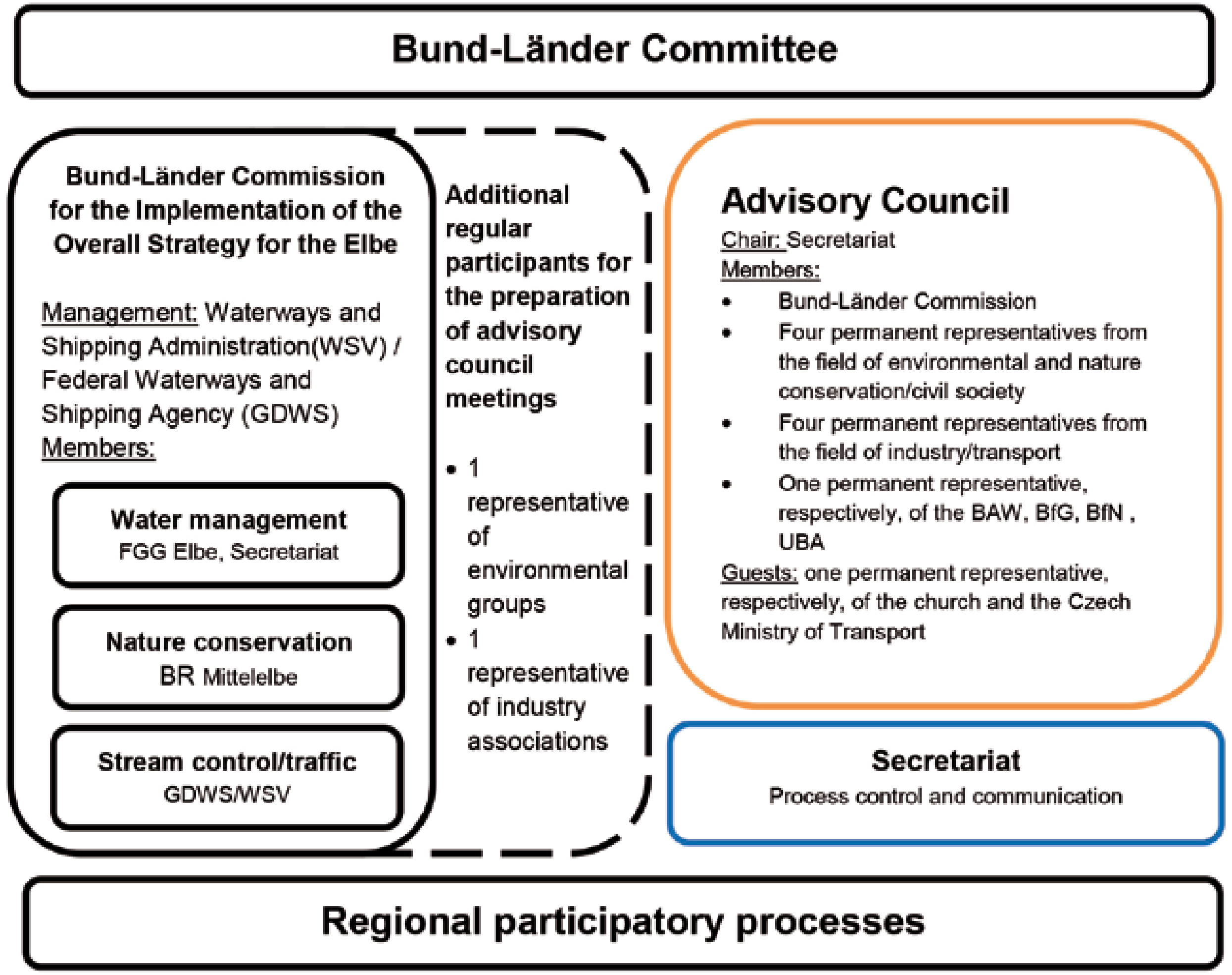

Fig. 3*: Overall strategy for the Elbe – Organizational structure for the follow-up process*

3. Next steps

It is intended to implement the overall strategy for the Elbe within a period of 20-30 years. The follow-up process depends upon the overall strategy for the Elbe.

The bodies intended to implement the overall strategy for the Elbe are currently being set-up. Apart from the Bund-Länder Commission – where representatives of the German authorities and the Länder discuss the measures that are defined in the overall strategy for the Elbe – an advisory council is established. The advisory council will be composed of representatives of environmental groups, industry and shipping who will play an active role in the process. Moreover, the executive agencies of the Federal Ministry of Transport and Digital Infrastructure (BMVI) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) will be represented in the body. As in the past, decisions will be taken by a Bund-Länder Committee. This commission is composed of representatives of the Federal Government and federal state ministries responsible for the implementation of the overall strategy for the Elbe (Fig. 3).

Further information in German on the state of planning and implementation can be found online at www.gesamtkonzept-elbe.bund.de

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Identification of low water discharge for ungauged locations in Thuringia

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1. Introduction

Natural low-water situations represent periods in which the water biocenosis can be exposed to increased physiological stress. If these natural low-water situations are additionally exacerbated by anthropogenic influences, the ecological functionality of the waters can be severely impaired.

In order to be able to make statements and not to aggravate low water situations, it is necessary to know the natural low water flows in rivers. However, as this information is strictly only known for observed gauges, methods must be used to transfer these low flow values to other areas.

The term „regionalization“ summarizes a few methods, which transfer point information (e.g. gauge information) to other not observed locations.

In recent years, regionalization of flow parameters has been carried out in almost all federal states in Germany. Because of many years of experience, the DHI WASY GmbH was commissioned by the Thuringian State Institute for the Environment and Geology (TLUG) to regionalize mean low flow discharges for Thuringia. The applied method combines multiple linear regression between discharge and different catchment area parameters. Besides a regional analysis and compensation of the residuals of multiple linear regression with top kriging shall be applied.

Major milestones in the processing are the identification of catchment area parameters, determination of quasi-homogeneous runoff regions, the application of the regionalization procedures and the plausibility check of the results.

As a result, average low water discharges for the hydrological year (MNq_{Year}), the summer period (MNq_{Summer}) and winter period (MNq_{Winter}) are available for defined river profiles, for selected weir sites and hydraulic structures on largely uninfluenced waters.

2. Data base

Gauge data are required for the application of the regionalization procedure. For this purpose, the TLUG has already prepared 173 gauges for average low flow discharge for MNq_{Year}, MNq_{Summer} and MNq_{Winter}. After assessing the gauge data, 160 gauges were selected for further use (Fig. 1). In addition to the 121 gauges from Thuringia, a total of 39 gauges from neighboring states were used.

The regionalization method multiple linear regression requires gauge data and parameters derived therefrom for spatial units, so-called area parameters. These area characteristics need to be available for the entire study area.

For this purpose, it was possible to use data from regionalization of flood water in Thuringia. It was further investigated to use additional area parameters. For the low water discharge the groundwater enrichment is one of the most important parameters. For the determination of the parameter, the client provided a grid data set of the average long-term groundwater enrichment for the state area of Thuringia. For the neighboring federal states (except Saxony), data in raster data format were also transferred. In Saxony, the data were available as shape files based on the partial catchment area classification of Saxony, whereby an average groundwater enrichment value could be derived for each subarea. These data sets

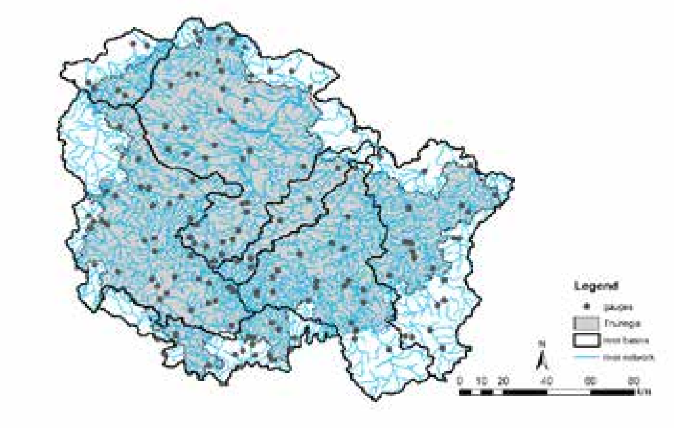

***Fig. 1**: Used gauges for regionalization*

were merged for the study area. If the different data sets are overlapping, the Thuringian data set was used with top priority. In case of gaps, especially between Saxony, Bavaria and Thuringia, the missing values were determined by interpolation. Figure 2 shows the results of the groundwater enrichment. A total of 17 area characteristics were available for further investigations.

3. Application of regionalization procedures

For the regionalization of average low flow discharge in Thuringia, a combination of multiple linear regression and top kriging was applied.
In the case of multiple linear regression, average low flow discharge of gauges and area characteristics of the ri-

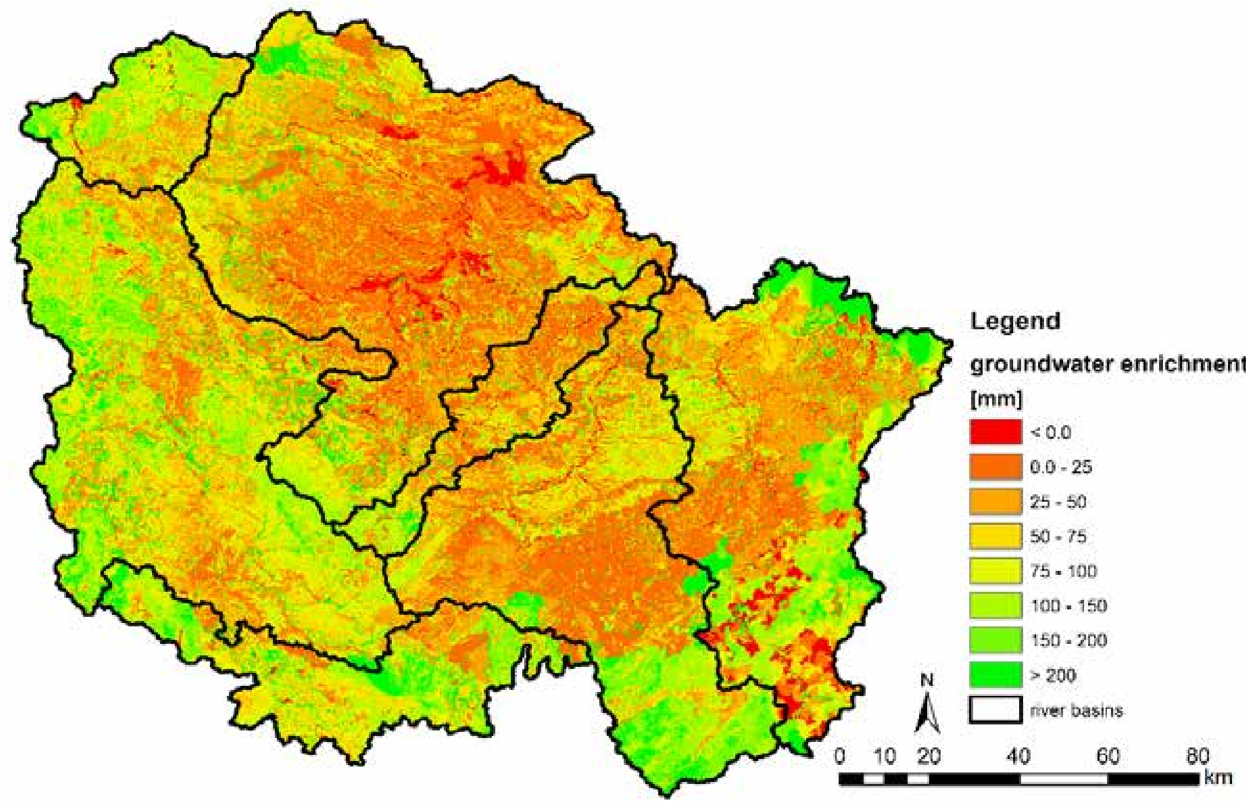

***Fig. 2**: Groundwater enrichment in study areafollow-up process*

ver basins are linked by regression models. It is assumed that average low flow discharges can be determined with the established models even for unobserved rivers whose area characteristics are known.

Multiple Linear Regression has been successfully used several times in flood regionalization over the past two decades, for example in [1], [2] and [3]. But also in the regionalization of low flow parameters, multiple linear regression is the most commonly used method [4] and was also applied in Saxony [5].

Top Kriging belongs to the group of geostatistical methods, which assume that neighboring areas show a similar flow behavior, as the climate and area properties change only gradually in space. Geostatistical methods are used for the spatial interpolation of many hydrological variables such as groundwater levels, precipitation or soil moisture and have also been successfully applied in other regions for the regionalization of flood water (e.g. [6]) and low flow discharge [7].

For the current investigations, this method did not determine the low flow discharge, but instead transferred the residuals to unobserved areas. The residuals are generated from the difference between the calculated and observed MNq values. Figure 3 shows the residuals for the MNq_{Year}. The color scheme shows that the residuals of the gauges were topologically correctly transferred to the catchment areas. Decisive for the unobserved headwaters of the river are the residuals of the nearest gauge on the same river.

The regionalized residuals can now be summed up to the MNq determined by multiple linear regression. As a result, this means that the gauge basins areas reflect the observed MNq values. Furthermore, the deviations between observed and calculated MNq are transferred to similar areas in the respective neighborhood (similar size and distance from the observed level catchment area). Thus, possible over- or underestimates of MNq can be offset to some extent by the regression models in the unobserved areas.

Subsequently, a series of analysis were carried out to make the calculated low flow discharges plausible. Implausible small and large low flow discharges have been identified, the local consistency of the results was checked ($MNq_{Year} \leq MNq_{Summer} \leq MNq_{Winter}$) and the plausibility in longitudinal section was examined.

In Figure 4 the preliminary results are shown. Visualized are the low flow discharge for the study area, where the plausibility in longitudinal section has not yet been performed.
The MNq data for the full year, the summer period and the winter period for Thuringia will be available for the planning of hydraulic engineering facilities, by the time the project is completed in fall of 2018.

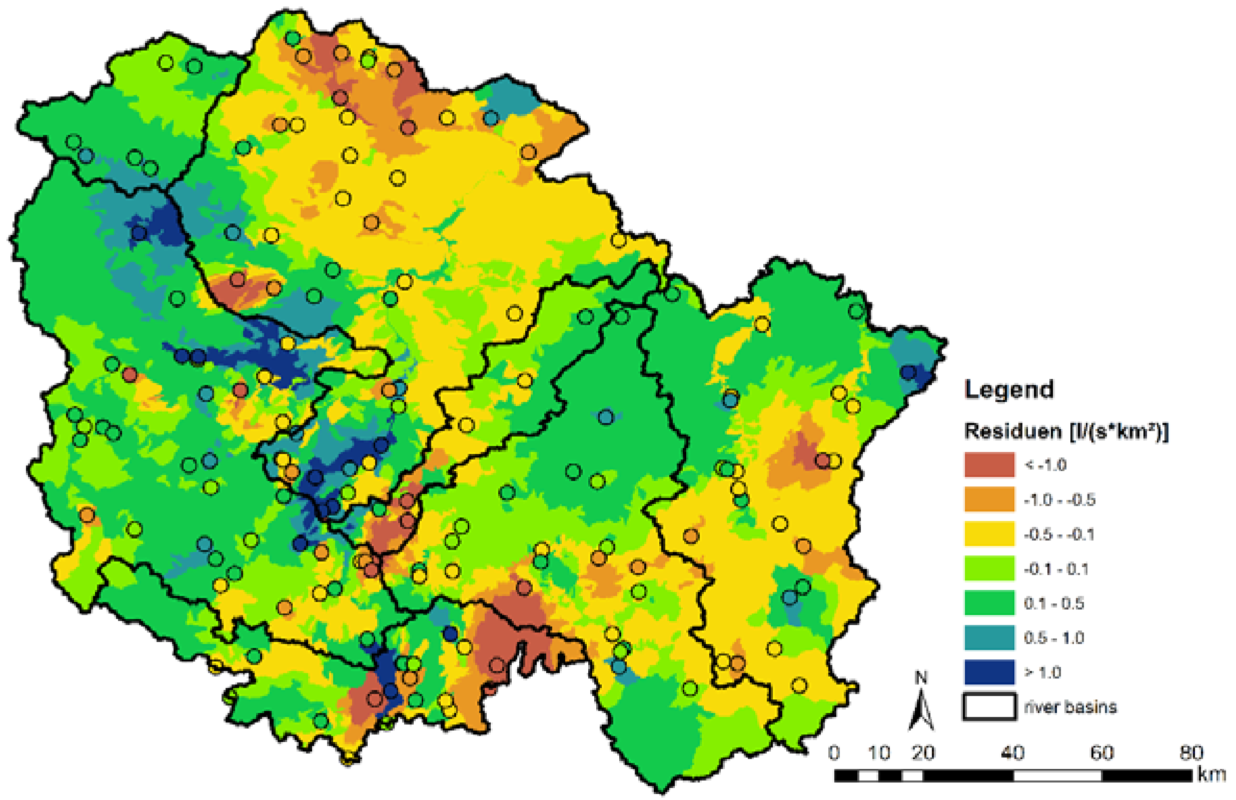

***Fig. 3**: Residuals transmitted by top kriging for the MNq of the whole year (points show the residuals at the gauges)*

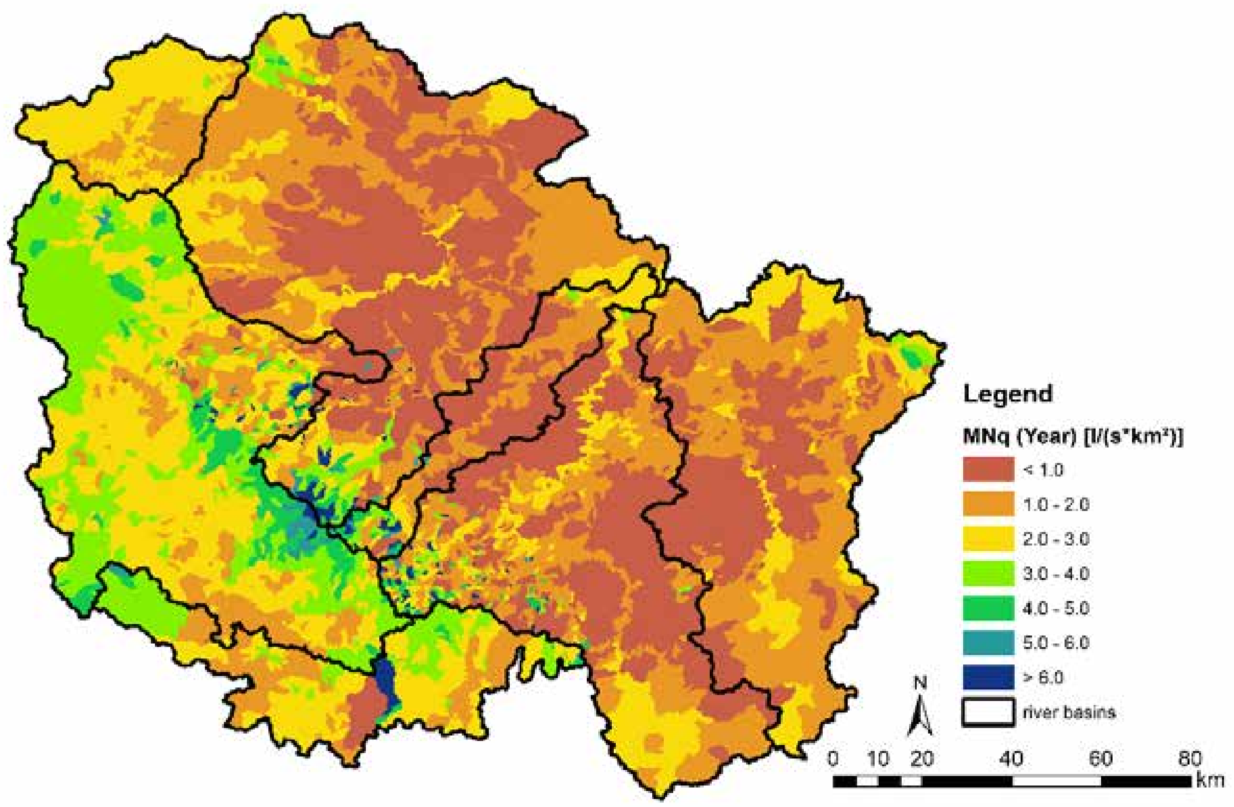

***Fig. 4**: Low flow discharge MNq of the whole year*

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Hydrological drought in headwater areas of Šumava Mt. (Bohemian Forest) and Krušné hory Mt. (Ore Mt.)

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1. Introduction

Recently, the issue of global climate change and its impact on physical-geographic as well as socio-economic processes has gained popularity. From the viewpoint of hydrological research, these issues are of crucial importance, since it is beyond doubt that changes are occurring in the hydrological cycle, and that water resources in individual regions are showing redistribution. This issue is perhaps most importance in places where the hydrologic extremes are deepening. The presented study is an attempt to evaluate trends in runoff regime and hydrologic drought in headwater areas of the Elbe and Danube Rivers catchments; focused on the Šumava (Bohemian Forest) and Krušné hory Mt. (Ore Mt.) regions.

2. Study areas

The model basins (gauging station) used were Vydra (Modrava), upper Otava (Rejštejn), Otava (Sušice), Schwarzer Regen (Teisnach), Großer Regen (Zwiesel), Ilz (Kalteneck), Regen (Chamerau) in the Bohemian Forest and the upper Rolava River (Chaloupky) and Slatinný Brook (KH), upper Svatava River (Klingenthal), Načetínský Brook (Rothenthal) which drain the western part of the Ore Mountains Fig. 1.

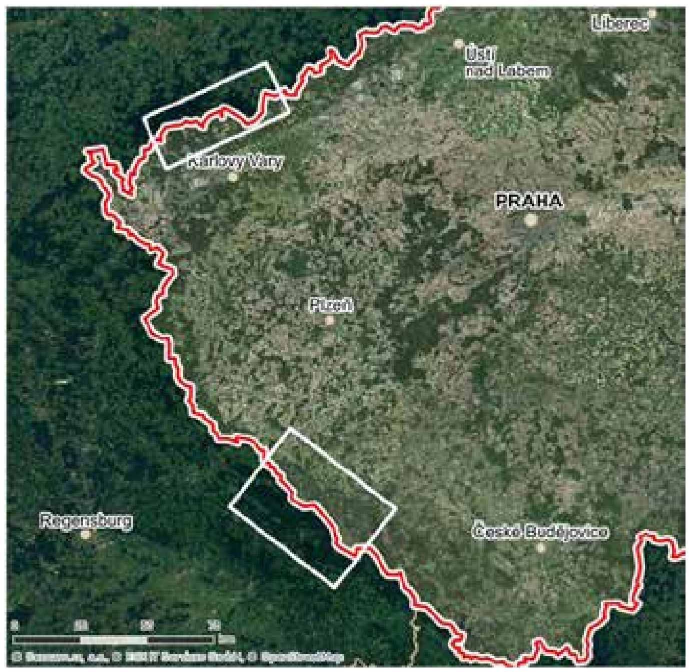

Fig. 1: *Location of model study areas*

3. Data sources and applied methods

Studied period covers the period 1930/71–2014/2017; when the input data were available. Values of Qd (mean daily discharge), Qm (mean monthly discharge), minimum QMin – the lowest mean daily discharge and Q355 – discharges which were reached or exceeded 355 days in the year were used. Input data were provided by the CHMI, DWD, Bavarian Institute for Environment and gauging station of the Department of Physical Geography and Geoecology, Faculty of Science, Charles University.

For the assessment of hydrological droughts more methods were used, e.g. the threshold value method of Q355 and Gumbel 63, this defines hydrological drought like minimal discharge of every hydrological year. Detection of trends in hydrological parameters was determined using non-parametric statistical Mann-Kendall test (MK-test) [5]. For trends detection were used two modifications of MK-test: the first is the basic wide-used form; by this test were tested time series of Qm and monthly sums of drought days according to the threshold concept. The second form of this test is MK-test with Zhang method, which uses vector calculation.

A tool for calculating the characteristics of hydrologic regimes is the Indicators of Hydrological Alteration (IHA) and IHA 7.1 statistics software, which was used to calculate basic hydrological characteristics and also base flow index, 1, 3 and 7-day minimums. As next parameter of low discharges were calculated the Low-flow index (LFI) (Qmin/Qa) [4] and Streamflow drought index (SDI) [2, 3].

4. Results

In case of the trends in Šumava Mt. evaluating, the results are, that in study period occurrence of drought days decreases very significantly on all the studied stations with one exception. On the most of the stations there is defined trend on 5% confidence level. The exception is profile Chamerau, but there isn´t trend defined only by one testing (Tab. 1). In hydrological drought trends occurrence there weren´t found out any strong or conclusively remarkable differences between windward and lee side of the mountains, however, on the other hand, noteworthy finding is strongest of the trends of hydrological drought decreasing across whole the Šumava region. Drought seasonality evaluation results seem to be more interesting. There were found out very significant differences between windward and lee side of the mountains (Fig. 2). The main difference is in that on the windward

Mann-Kendall trend test results for deficit volume time series							
Profile	Modrava	Rejštejn	Sušice	Zwiesel	Teisnach	Chamerau	Kalteneck
p-value	0,00000	0,000003	0,000002	0,011259	0,000001	0,598408	0,000021
Mann-Kendall trend test results for monthly sums of drought days time series							
p-value	0,00000	0,00000	0,000048	0,000207	0,000006	0,000000	0,000006

Tab. 1 : *Mann-Kendall trend test results for Šumava Mt. catchments*

side profiles drought episodes are concentrated to late summer and mainly autumn and on the lee side profiles is drought concentrated mainly in winter. One exception represents profile Teisnach that is on the windward side but, its drought episodes seasonality is pretty the same, like on the profiles of the lee side. Remarkable is also effect of different elevation on the lee side: by higher elevation (Modrava) there is more droughts in October than in August and, by lower elevation (Sušice) there is more drought in August than in October.

Decreasing trends of Qm were identified in the Krušné hory Mt. in the upper Svatava and in the Načetínský Brook in the period 1971-2017. Typical is a significant decrease of Qm from April until July. The similar decreasing trend of Qm was detected also in the longer period 1929-1971 in April and May and an increasing trend of Qm in December and March in the Načetínský Brook catchment. Another development using Mann-Kendall test were found in the upper stream of the Rolava catchment, where the Qm increases presents in November, December, February, March, September and October. As for seasons, a water level increase was detected in the upper Rolava River basin in the autumn and winter, which was also manifested in evaluating the entire cold period. Dry period were recognized in the Rolava River basin 1968-1971, 1975-1979, 2008-2014. Especially dry years were 1975, 1969 and 2012. Linear increasing trend of 7-days minimums is typical for the profile Rolava-Chaloupky (Fig.3). Results of basic hydrological drought indexes for Rolava and Slatinný Brook presents also Table 2. Decreases of 1, 3, and 7- days minimum values and base flow index are typical for the upper Svatava and Načetínský Brook compering the periods 1969-1992 and 1992-2017.

5. Conclusion

In brief, it can be summarized that an essential increase in runoff in winter months has been seen in the upper Rolava basin since the end of the 80's and especially in

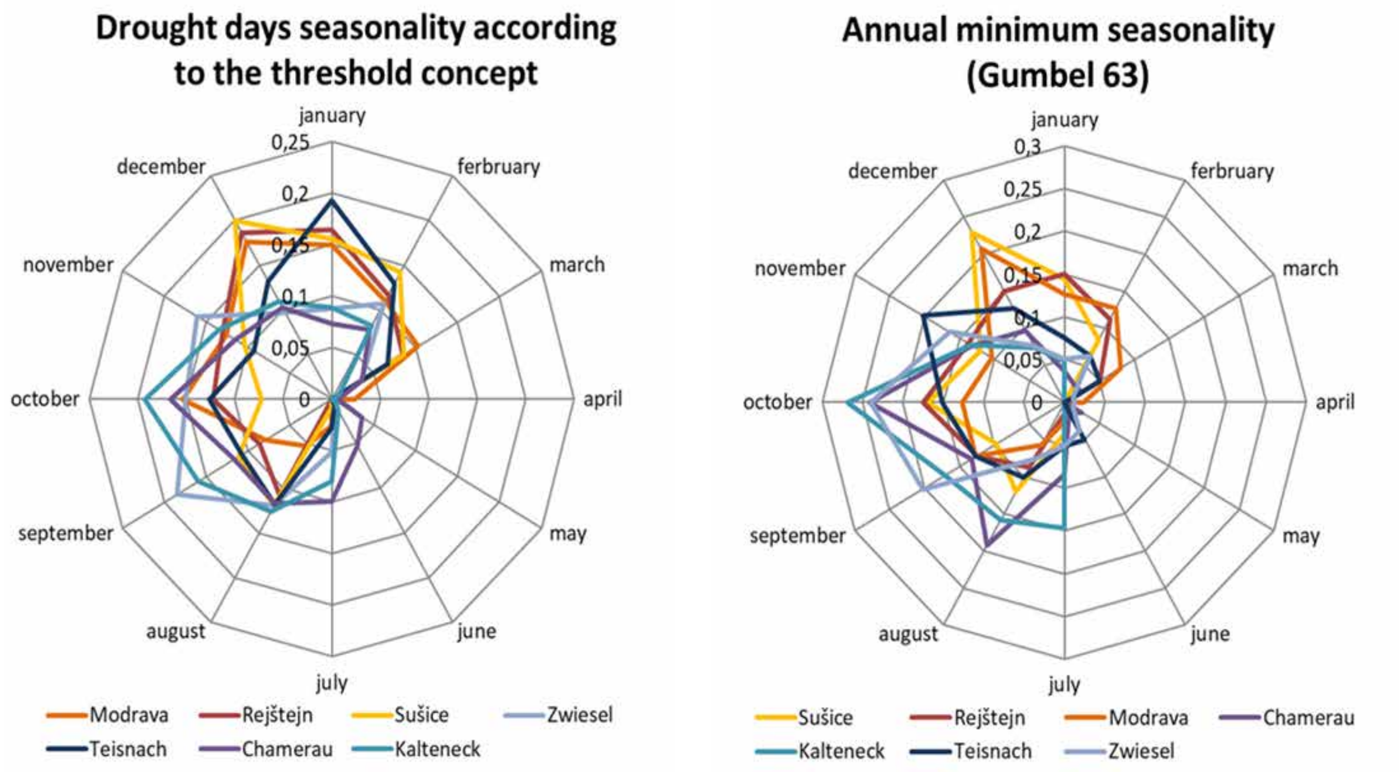

Fig. 2: *Seasonality of drought in the Šumava Mt. catchments*

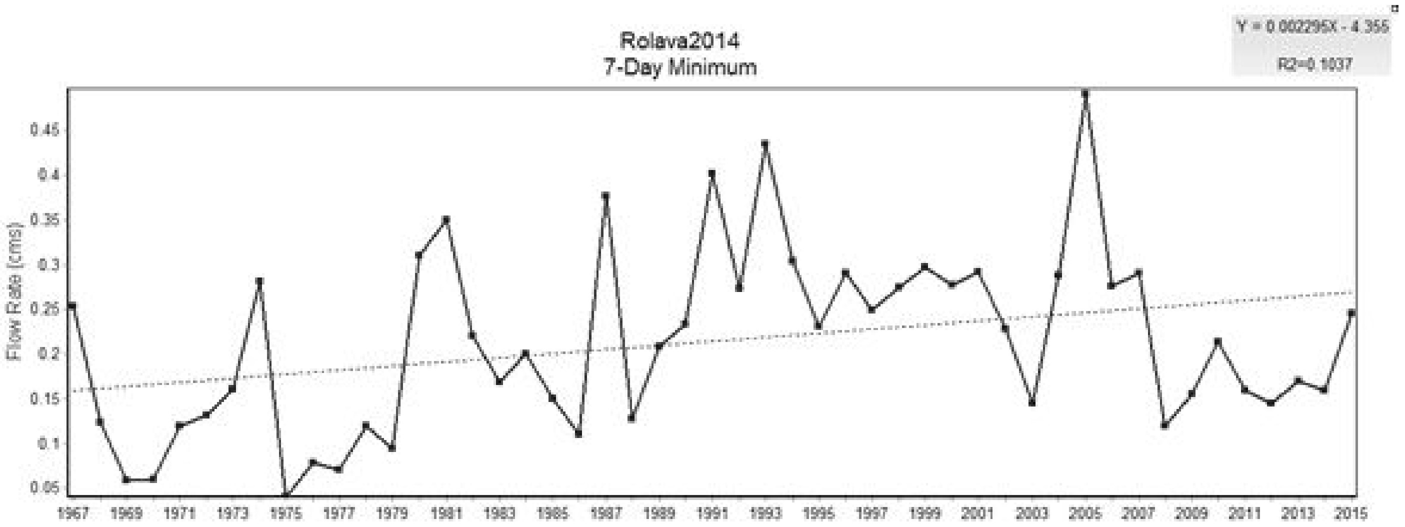

Fig. 3 *Trend of 7-day minimum values for the gauging station Chaloupky in the Rolava catchment, Ore Mt.*

	Rolava			Slatinný Brook		
year	**Q_{355} (m³/s)**	***LOWFLOW***	***SDI***	**Q_{355} (m³/s)**	***LOWFLOW***	***SDI***
1969	0,105	0,070	0,124	-	-	-
1975	0,070	0,056	0,160	-	-	-
2009	0,163	0,213	0,130	0,104	0,130	0,098
2010	0,213	0,270	0,140	0,117	0,121	0,116
2011	0,202	0,121	0,143	0,149	0,141	0,123
2012	0,145	0,193	0,115	0,446	0,482	0,172
2013	0,167	0,225	0,132	0,033	0,015	0,107
2014	0,166	0,206	0,095	0,903	0,864	0,197

Source: CHMI and Faculty of Science, Charles University Prague

Tab. 2: *Hydrological drought indexes for the Rolava and Slatinný Brook catchments*

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A small guide through water management risks due to lack of water in north-eastern Bohemia

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1. Introduction

It seems that the turn of the millennium has brought higher temperatures to Europe. The rise in temperature altogether convincingly shows the results of long-term air temperature measurements under the Copernicus program. The results of the daily water temperature measurement at the water surface of the reservoirs in Central and Eastern Bohemia also manifested a similar trend. Several of these reservoirs have digitized data from over forty years. The rise in temperature on the reservoirs appears to have a striking consistency with the results of the European Space Program Copernicus (Fig.1). Changing the thermal conditions are not only associated with the impact in the luminous flux, but also assumed a relatively close influence at hydrological regime. Typical are summer torrential rains in Central Europe and the increasingly frequent periods of lack of rainfall. The range of these episodes are already leading in some areas the discussion on how the industrial society is going to cope with this development without crisis impacts. The goal of this paper is to highlight some adverse situations caused by water shortages in the past that the Elbe river basin management was forced to deal with. Outstanding episodes of drought were recorded in 1904, 1921 and mainly 1947 in the last century. Longer seasons with lack of rainfall appeared in 1983 and 1992. In the course of the third millennium, three dry periods have already occurred – 2003, 2015, 2016. In addition, the spring of 2018 has indicated a dry season too. What did these dry times bring?

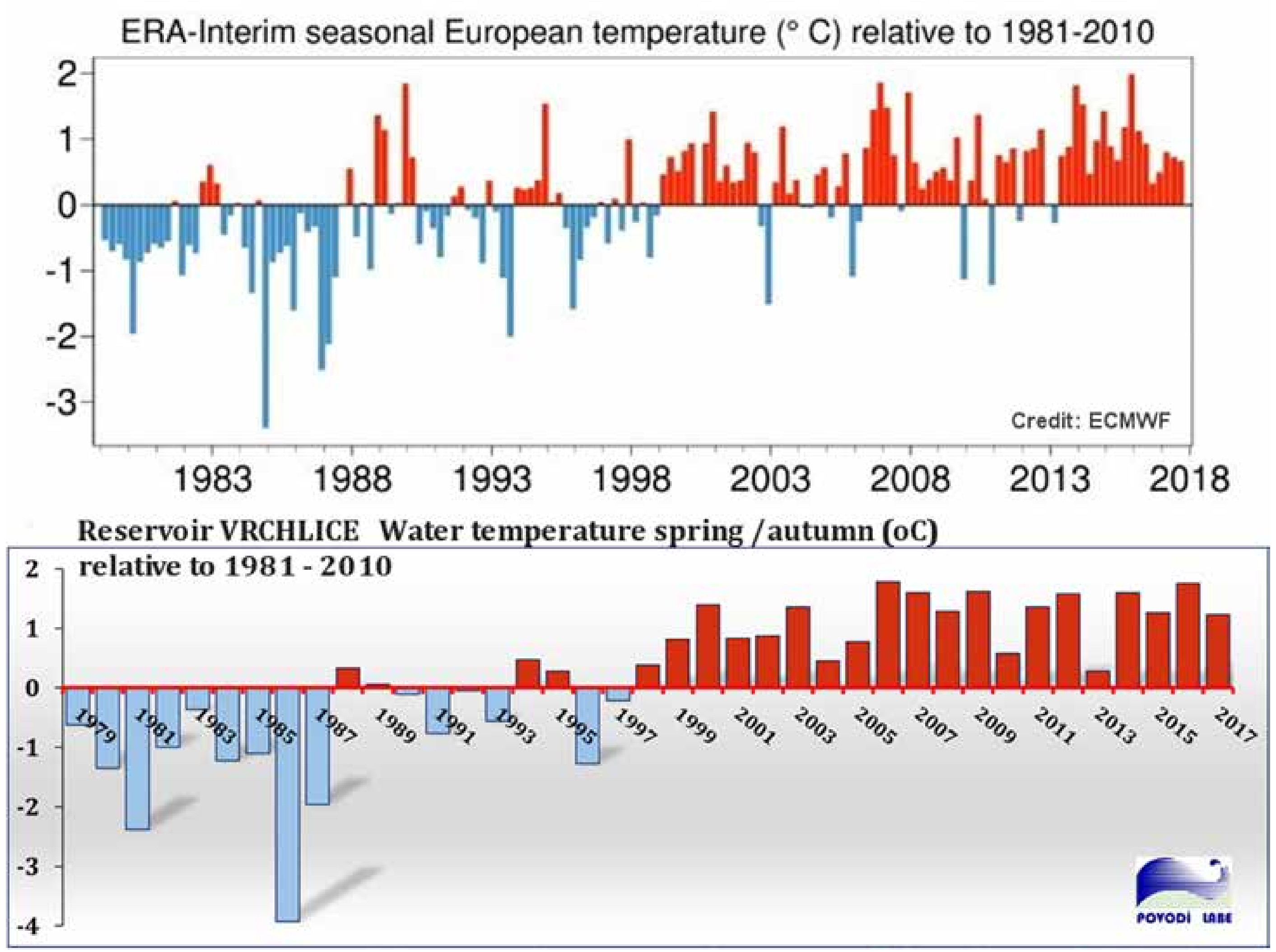

Fig. 1: *Rising air temperature (Copernicus) and rising water temperature (River Elbe Board)*

Fig. 2: *The Water supply reservoir Hamry on the Czech-Moravian Highlands*

2. Drinking water supply

In course of every long dry periods, the experts are concerned about drinking water sources primarily. Several dry periods have occurred in the North-East region of Bohemia in the past, but the drinking water supply was not affected so far. A big advantage for the entire area are several large water supply systems. Although in the past occurred in some local sources minor disturbances, large water supply systems have proven themselves in the worst situations. Water supply systems have diversified resources. The use of underground water sources is predominant in the area. Nevertheless, it also provides a very important role for the five water supply reservoirs. In addition, several important water withdrawals on rivers were installed here (for example river Orlice near city Hradec Králové).

Several recent dry years have caused a drop in groundwater resources. This decline is still falling. In spite of, that it is assumed that there are large reserves of groun dwater resources that are not yet in use.

The great advantage of water reservoirs is the technical management of their operation. In this way, it is possible to predict crises successfully and to take effective measures to avoid them. Even in the dry seasons, no crisis operations had yet to be carried out on both water reservoirs in the Jizera Mountains. In the small Hamry reservoir in the Bohemian-Moravian Highlands (Fig.2), the decreasing level stopped about one meter above the inactive storage in the autumn of 1983. Therefore, in order to avoid a repeat of similar developments during the 1992 drought, the guaranteed minimum flow from the reservoir was reduced in time. Throughout this operation, the oxygen concentrations of the whole river were measured in detail under the dam. The long period of drought from the year 1991 to 1992 was also associated with a large drop of the level in the Vrchlice reservoir of about six meters. Also, in this case, the water supply was reduced preventively and the situation was solved without any major damage and uncontrollable problems.

It is generally possible to summarize that so far recorded drought periods lasting several months on the drinking water withdrawal, did not form serious crises. On the contrary, water quality due to lower load is often better. We know from experience, that the retention of a water supply reservoir in the water supply system is very advantageous. That is why we would welcome the construction of at least one other water supply reservoir in eastern Bohemia. At the beginning of 2018, the construction of the water reservoir Pěčín was being prepared. Now the preparations of this water work with the decision of the Czech Government has been stopped.

Fig. 3: *Drought of Elbe near the Ustí nad Labem city.*

3. Industry and Energy water supply

Lack of water could endanger the operation of four large power plants and the production of the chemical industry concentrated in Pardubice, Kolín and Ústí nad Labem (Fig.3). To meet the needs of the chemical industry so far no problems have occurred. For the individual plant level to ensure water economy depends partly on its location in the Elbe river basin. The Mělník power plant is very secure because it is located near the river Elbe below the confluence with the river Vltava. A cascade of large dams is built on the Vltava River. The Chvaletice power plant is built upstream of the Elbe River. Also its water needs are well secured by taking off from the navigable part of Elbe and above the withdrawal there are six smaller dams.The Opatovice power plant is built high upstream of the Elbe. Water supply to this power plant by the Elbe alone would not be enough in the dry season. That is why the energy complex is also protected by the large water reservoir Rozkoš on the river Úpa. In 2015, there was a large drop in the Rozkoš reservoir, and some emergency measures were also under preparation, but production was not limited. The most troubles in dry conditions are formed at the Poříčí power plant on the river Úpa in the Giant Mountains. One reason for this is probably the lack of local technical possibilities for water retention in the period of its sufficiency. It was during the summer months of 2015 and 2016, due to the prolonged drought accompanied by low discharges in the Úpa river, the water supply was reduced and thus the power of the Poříčí power plant was significantly reduced. These episodes (but also economic reasons - the rising cost of surface water) have led the Opatovice power plant and the Poříčí power plant to look for a technical solution that would ensure a significant and sustained reduction in the amount of water from the river in the future.

Periodic threat of water scarcity is also a big risk for Škoda Auto – Kvasiny plant. This constantly developing factory is only dependent on the water withdrawal from the small river Bělá in the Orlické Mountains.

4. Agriculture irrigation systems

A significant proportion of the result of harvest of crops depends on existence of irrigations. The role of these systems is growing at an extraordinary degree in course of drought. In these situations, it is actually very important in whether there are sufficient available water resources. Fortunately, in the area of north-eastern Bohemia, most of the crops consuming lots of water are concentrated in a relatively narrow corridor along the great river Elbe. We can see them nearby Hradec Kralové and Pardubice cities, in the section from town Nymburk to Neratovice and the lowest downstream spot is an area round Litoměřice. Great irrigation systems are situated downstream of the river Jizera also. Even in the seasons when the level of watercourses decreased, there were no problems with supply of water for plant growing.

Now, however, we have recorded more companies interested in establishing new orchards. The most important criteria for the choice of areas to establish new orchards is a favourable habitat for growing fruit. Often, however, it is forgotten about sufficient water security, especially in the period of its shortage. In this way, difficult situations are arising in some locations near Žehuň, Mladá Boleslav and elsewhere. Even though newly set up kits are in most cases equipped with modern irrigation systems (drip irrigation). In this context, it is increasingly used to refer to the effective use of underground water or rainfall (retention in specific irrigation tanks) or the use of alternative sources of irrigation, especially the purified waste water.

5. Other impacts and conclusion

Due to the future lack of water in the countryside, it is necessary to prepare the entire area of the river basin, which is under the administration of the River Elbe Board. Symptoms of possible future crises in the long-term lack of water are already observed in the area around the Cidlina and Mrlina rivers, in central Bohemia around the the town of Kutná Hora. But, also in the higher positions below the Orlicke Mountains and the Bohemian-Moravian Highlands the shortage of water is measured. On one hand, the drop in river discharges reduces the transport of undesirable substances. On the other hand, the decrease of the dilution ratio under the wastewater plants results in significant decreases in oxygen and the increase in ammonia.

We have a considerable negative experience with the consequences of this process on the Elbe river in the area below Kolin, where often fish deaths occur.

Our goal is to mitigate the adverse effects of dry periods to the minimum. Therefore, besides minor measures, we also organize large projects such are verifications of water and substances load under press of the long term drought. An important role we have in the support of forming of river basin management plans and we manage the ongoing monitoring of qualitative and quantitative water indicators.

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The influence of dam reservoirs operated by Povodí Labe, state enterprise on the river discharges in episodes of drought

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1. Introduction

Czechia faced several floods with high return period in the last two decades. During and after these flood events the public discussion about the function of dam reservoirs in the system of flood protection took place. The general public came to know about the purpose of flood storages in the dam reservoirs. The opposite hydrological extreme, drought, appeared quite rarely in the last two decades. We experienced the periods of drought in 2003, 2015 and 2016. The long-lasting drought in 2015 triggered a need of the drought mitigation measures and quantification or categorisation of drought. The general public mentioned the drought at the time, when some water management authorities came to restrict or prohibit the general right to use water (watering gardens, filling pools etc.). The dam reservoirs operated by Povodí Labe, state enterprise were fulfilling their purpose for weeks or months at that time and were using their active storage to cover needs of water in lower sections of watercourses without notice of mass media or public. This article aims to explain and quantify the significance of the dam reservoirs to the mitigation of hydrological drought consequences.

2. Hydrometeorological situation 1. 1. – 31. 10. 2015 and operational issues on reservoirs

In 2015 Czechia faced one of the strongest drought of last few decades. Mainly the absence of usual air pressure formations in summer caused high temperatures, lack of precipitations and high transpiration. These meteorological conditions affected hydrological conditions. From May to October the most of water gauges on watercourses went and stayed under the limit for drought. The total precipitation from January to October 2015 was 438 mm which is 152 mm less than average. Lower precipitation was observed only in 2003 (429 mm).

Active storages of dam reservoirs operated by Povodí Labe, state enterprise slightly emptied from May till October. Several issues complicated operational water management on dam reservoirs. Reservoir Les Království emptied to 36 % of volume and unexpected amount of sediment appeared. There was a concern about sediment to move and block bottom outlets. Quite heavy rainfall ameliorated this situation in the last moment. Reservoir Rozkoš added more than 2 m^3/s to discharge in river Metuje and further in Elbe for 68 days emptying its active storage to 36 %. Water level in reservoir Pařížov declined to inactive storage twice, in the half of August and in the beginning of September.

3. Quantification of volume from dam reservoirs and hypothetical discharge in river Elbe

The episode of drought in Czechia in 2015 was due to its duration and its scale an extreme situation that verified the storage function of water reservoirs. Some water management authorities came to restrict or prohibit the right to use water from watercourses without dam reservoirs for industrial purposes in the administrative area of Povodí Labe, state enterprise. The discharges in watercourses with dam reservoirs were also low, but there was no need to restrict the water usage. Dam reservoirs ensured minimum discharge in watercourses with water from their active storages. One exception appeared in river Doubrava where the water level in reservoir Pařížov went down to inactive storage. This low water level was reached twice – in August and in September. Water usage from Doubrava river was practically thwarted during this period. The volumes of water in water-supply reservoirs during the period of drought were sufficient to cover the water-supply needs. Dam reservoirs with one exception (Pařížov) fulfilled their purposes in the strongest phase of drought.

The public began perceiving the significance of flood storage in reservoirs after flood episodes in Czechia in late 1990s. Water falling down through the spillway is an interesting background for journalists and it shows that the dam works as expected. When dam reservoir works as expected in dry period, it´s barely visible. Water level in reservoir goes slightly down and reaching the inactive storage does not mean there is no water in the reservoir. The drought is not as dynamic phenomenon as flood. Flood lasts few hours or days, the drought lasts few weeks or months. This is the reason why we find the quantification of the dam reservoir significance in dry periods necessary. The time period from May to November 2015 was chosen as a reference period for the quantification.

The first part of our quantification focuses on dams operated by Povodí Labe, state enterprise. The inputs for the calculation of used volume were time series of daily inflow, outflow and intake for each dam. Contribution of

5/2015 - 11/2015	Reservoir	Labská	Les Království	Rozkoš	Pastviny	Hamry	Seč	Křižanovice	Pařížov	Vrchlice	Josefův Důl	Souš	Mšeno	Harcov	Bedřichov	Fojtka	Mlýnice
Active storage	mil. m^3	0.756	1.422	45.948	6.236	1.206	14.017	1.62	0.262	7.89	19.133	4.585	1.897	0.35	1.754	0.124	0.092
Intake	Ø m^3/s	-	-	-	-	0.014	0.010	0.137	-	0.107	0.153	0.147	-	-	-	-	-
Intake volume	mil. m^3	-	-	-	-	0.268	0.185	2.540	-	1.980	2.829	2.725	-	-	-	-	-
Percentage of active storage usage	%	**-**	**-**	**-**	**-**	**22**	**1**	**157**	**-**	**25**	**15**	**59**	**-**	**-**	**-**	**-**	**-**
Minumum residual discharge	m^3/s	0.8	1.9	0.08	0.8	0.08	0.9	0.9	0.245	0.03	0.12	0.085	0.06	0.046	0.02	0.025	0.012
Volume of discharge contribution	mil. m^3	1.270	2.602	35.241	3.894	0.236	3.115	0.269	0.592	0.191	0.740	0.099	0.875	0.220	0.000	0.050	0.000
Percentage of active storage usage	%	**168**	**183**	**77**	**62**	**20**	**22**	**17**	**226**	**2**	**4**	**2**	**46**	**63**	**0**	**40**	**0**
Amelioration up to average discharge	Q_a m^3/s	2.83	8.89	6.79	3.91	0.635	2.27	2.62	1.76	0.396	0.683	0.505	0.09	0.206	0.126	0.141	0.1
Volume of discharge contribution	mil. m^3	2.540	6.056	35.241	6.865	0.509	8.551	0.656	0.813	0.216	1.266	0.216	0.875	0.232	0.381	0.124	0.048
Percentage of active storage usage	%	**336**	**426**	**77**	**110**	**42**	**61**	**41**	**310**	**3**	**7**	**5**	**46**	**66**	**22**	**100**	**52**

Fig. 1: *Usage of active storages in May – November 2015 (volume, percentage)*

water from active storage in total discharge is basically a difference between outflow and inflow. The calculation is made only in days with outflow higher than inflow. This situation may happen also during flood when outflow higher than inflow is set before flood wave comes or after flood culminates to decrease water level back to active storage. Inflow in calculation was separated into two categories to remove these situations from output data. Total used volume is computed for each reservoir in both categories – contribution to ensure minimum residual flow (by law) and contribution to ameliorate discharges lower than average (Qa). The percentage of the active storage used to enlarge discharge is computed for both categories. This quantity (what part of reservoir or how many reservoirs) is more comprehensible to public. This article focuses on drought, therefore the category with volume used to ensure minimum residual flow is most interesting quantity. In a simplified way, this volume would be absent in watercourse in dry period, if there was no dam.

Fig. 1 shows volumes of water used for water supply, to ensure minimum residual flow and contribution to enlarge discharges lower than average. It may be said that reservoirs with higher values of water exchange coefficient used more than 100 % of active storage to ensure minimum residual discharge. Conversely, water-supply reservoirs were mostly used to ensure water supply, volume used to ensure minimum residual flow is lower than 20 %. Rozkoš reservoir´s most important purpose is to supply water to node Opatovice to cover needs of coal power plant. In 2015 three quarters of its volume were used to this purpose. In total 69,4 mil. m^3 of water was the volume of reservoir contribution to ensure optimal discharge condition in watercourses in upper Elbe and Lusatian Neisse basin, it is 46 % of all active storages. The total volume used to ensure minimum residual discharge and to cover needs in node Opatovice is 49,4 mil. m^3 of water (46 % of all active storages). Active storage in water-supply reservoirs is mostly used to ensure water supply. Numbers above doesn´t contain volume used for this purpose, but the volume is not negligible in total evaluation.

The next step to picture the significance of dam reservoirs is removing their effect from observed discharges. The presumption "How much water would be in rivers, if there were no reservoirs" is comprehensible to public to imagine the difference. Our arrangement of computation counts with assumption that hypothetical outflow at dam water gauge would be equal to inflow. The difference between inflow and outflow propagates itself down the watercourse and to basin´s backbone watercourse. It may be said that without dam reservoirs there were no intakes for water supply from reservoirs. This could make hypothetical situation a little bit better. An usual discharge progress time is also taken into our calculation. Two water gauges on river Elbe were chosen to visualize discharge difference. Observed and hypothetical discharge is projected to water gauges Kostelec nad Labem (closing profile of Czech middle Elbe) and Ústí nad Labem (primary profile for river navigation on Czech lower Elbe near closing profile).

With regard to complexity of water management structures in the catchment area of tributaries Ohře and Vltava the computation includes absence of the largest reservoirs Nechranice (Ohře) and Orlík (Vltava) only. The effect of reservoirs missing in the calculation makes approximate difference in lower Elbe in the strongest period of drought about 2 – 5 m^3/s. This quite large difference is the effect of other reservoirs, mainly Skalka and Jesenice (Ohře), Lipno a Slapy (Vltava) and other reservoirs in the catchment area of rivers Berounka and Sázava.

Hypothetical discharge at water gauge Kostelec nad Labem in the beginning and in the end of reference period practically copied observed values. The difference raised from the beginning of July, contribution of water from active storages of reservoirs ranged from 20 to 45 % of discharge in middle Elbe from the second half of July till the half of September. In the strongest period of drought in the half and in the end of August was the contribution from 50 to 68 %. On the contrary, the consequences of precipitations in summer were reduced by reservoirs and the oscillation of observed discharge was not as strong as of hypothetical discharge. More noticeable effect of dam reservoir contribution to discharges came out in Ústí nad Labem. Till the end of June the observed and hypothetical discharge did not differ. The contribution of discharge from reservoirs ranged between 20 and 55 % from the beginning of July till the beginning of October with a short term interruption in the half of October. The hypothetical discharge at Ústí nad Labem water gauge would be lower than 40 m^3/s for 8 days in a row. Although observed discharges limited the possibility to navigate on the regulated section of lower Elbe, the hypothetical situation without reservoirs would be much worse including probability of damaged vessels.

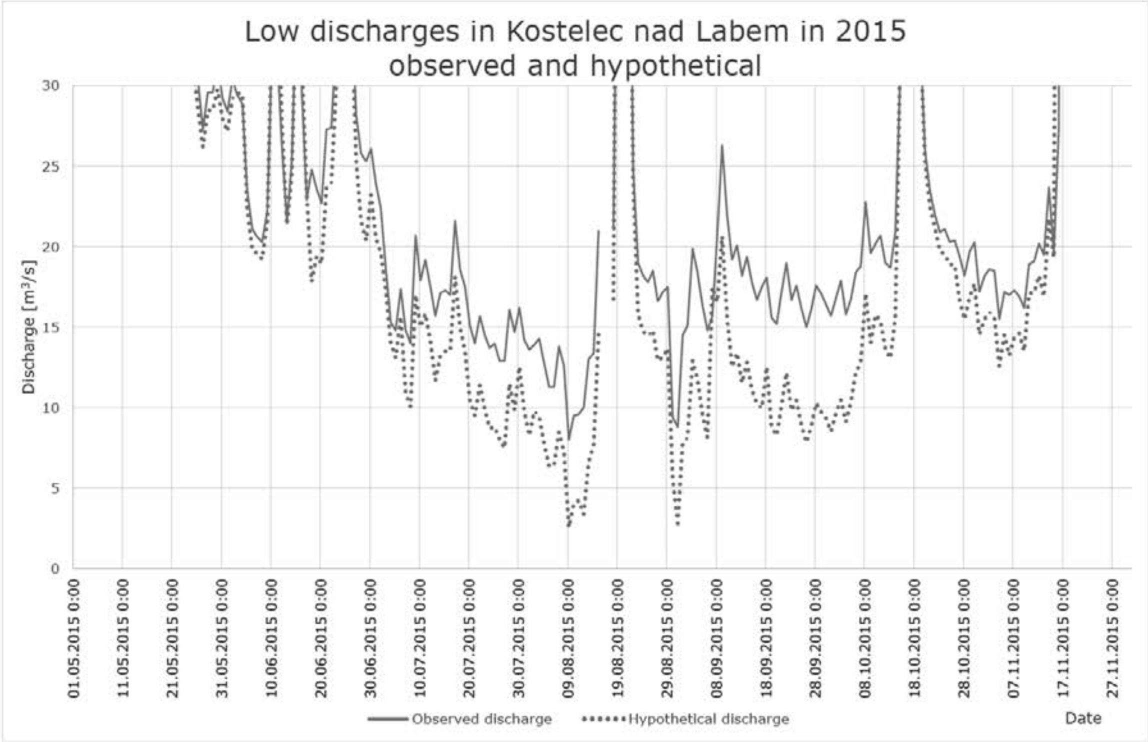

***Fig. 2:** Observed and hypothetical discharges in river Elbe at water gauge Kostelec nad Labem*

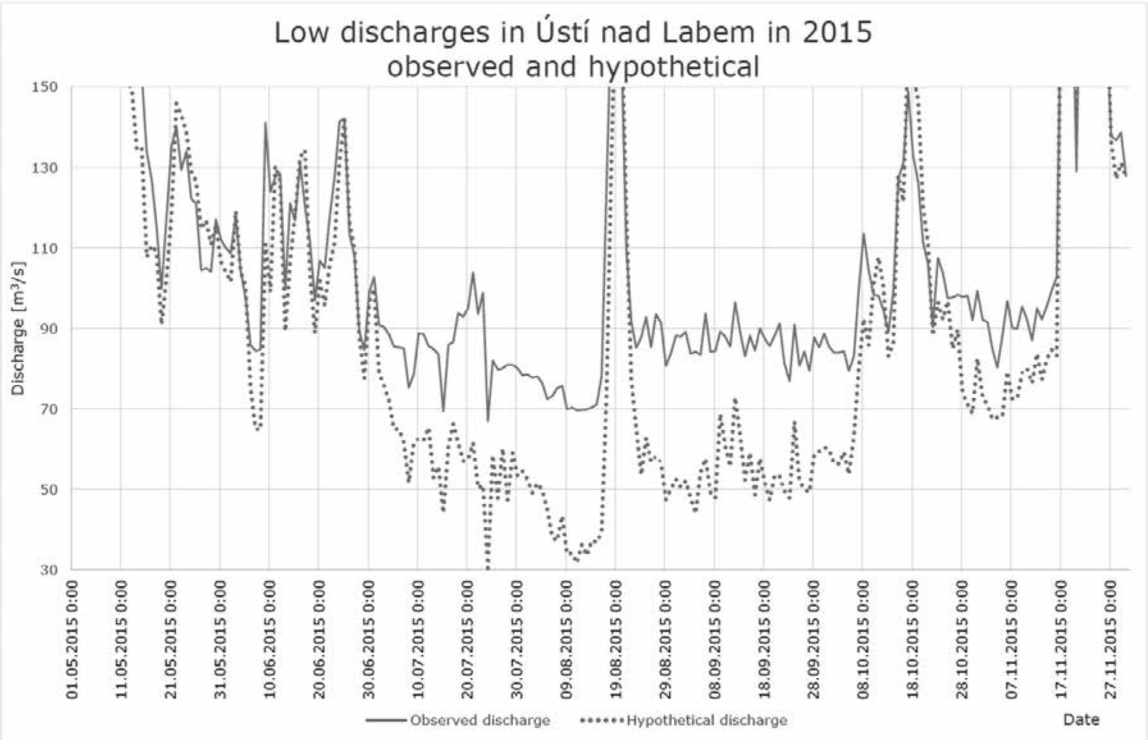

***Fig. 3:** Observed and hypothetical discharges in river Elbe at water gauge Ústí nad Labem*

4. Comparison of dry periods in 2003, 2015 and 2016

The chosen period in 2015 is comparable to course of discharge in 2003. The duration of low discharges period was analogous to 2015, but the values of discharge in summer 2015 were lower than 2003. In 2016 there were several precipitation events increasing discharge for a short term periods. But it´s still noticeable that precipitation deficit from 2015 affected discharge conditions in 2016. When viewed from the volume aspect the volume of outflow from Elbe catchment area was lowest of these three years. This is why 2015 was chosen as a reference period for quantification.

water from reservoirs to total discharge in river Elbe exceeded 50 % in the strongest period of drought in 2015. Primarily the fact that dam reservoirs are effective way to mitigate the consequences of hydrological drought is confirmed. Water management analysis counts with these extreme situations. All purposes of active storages were fulfilled even during the strongest phase of drought (except Pařížov). Hydrological conditions without influence of the dam reservoirs would not satisfy needs for water supply (mainly for industry and energy production) and navigation on the lower Elbe. Also the quantification of emission production from coal power plants in hypothetical hydrology conditions should be made without the influence of operative water management supporting

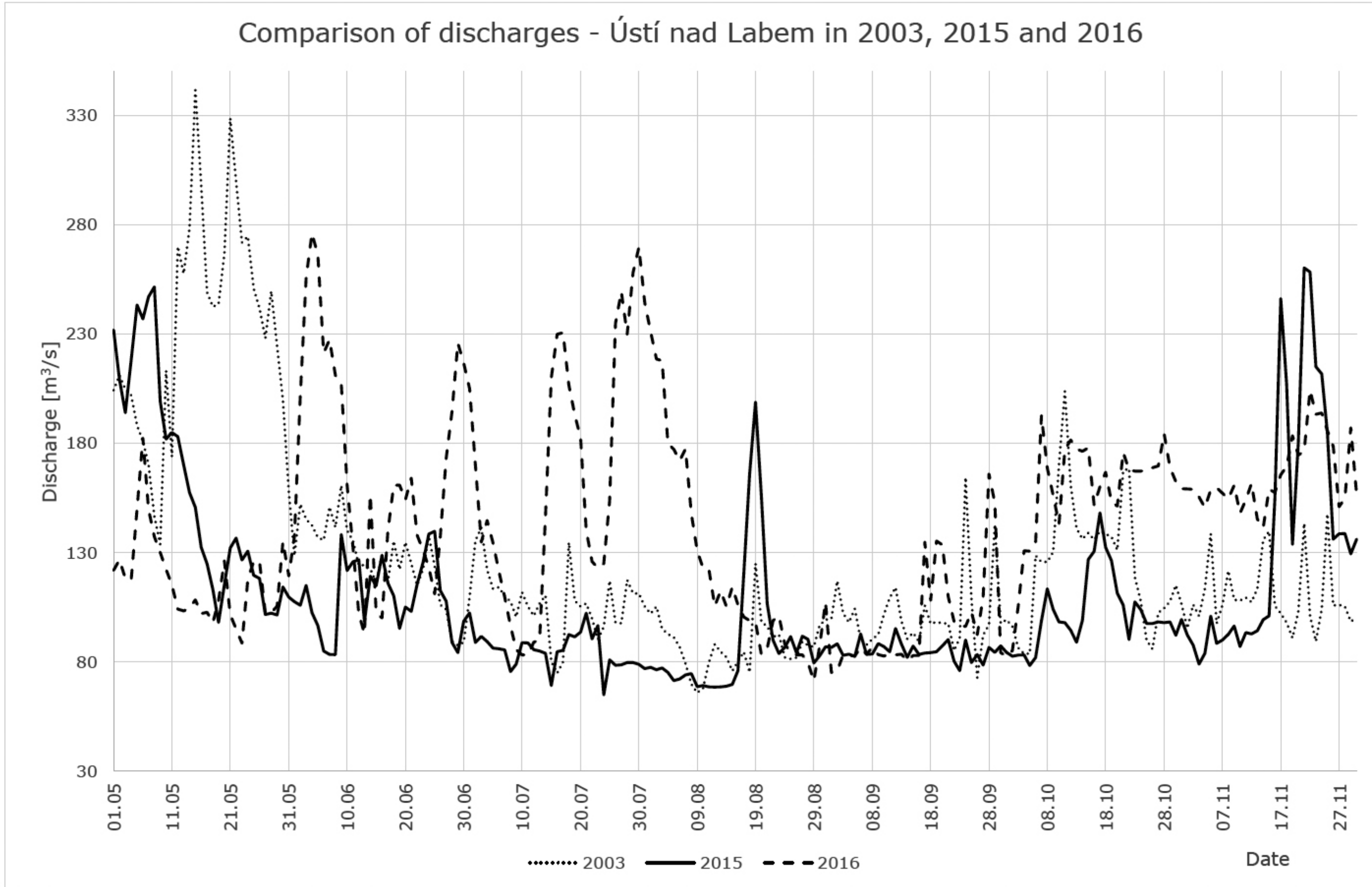

***Fig. 4:** Observed discharges at water gauge Ústí nad Labem in 2003, 2015 and 2016*

5. Conclusion

This article quantified volumes in reservoirs used to ensure minimum residual discharge in watercourses in the administrative area of Povodí Labe, state enterprise in the first part. Next part aimed to construct hypothetical time series of discharge without the influence of reservoirs in two selected water gauges on the Czech middle and lower Elbe. Previous chapters show the positive effect of waterworks in extremely dry periods. The contribution of hydro power plants with necessary discharge from dam reservoirs. We are expecting the same quantification of contribution in the appropriate scale for the near natural measures promoted nowadays to mitigate the consequences of hydrological drought.

Evolution of drought issue and water shortage in the region of Rakovník

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Povodí Vltavy, státní podnik

1. Abstract

Region of Rakovník is one of the driest areas within the Vltava/Moldau River Basin from the time immemorial. Total annual rate of precipitation between 484 and 584 mm has ranked this region amongst the areas with the lowest precipitation amount within the Czech land. The long time decrease of annual precipitation amount has been very low, it's been true, but its annual distribution has shifted in time and in view of intensity. High precipitations occurrence has decreased substantially within entire catchment area and also the spring precipitation amount has decreased between March and June. Air temperature has distinctly increased since 1960. Total increase was 1,4° C by 2009. Hydrological situation within Rakovnický Brook catchment area has been recorded in Rakovník gauge since 1960. The analysis of reconstructed sequence of flow rates has confirmed enormous decrease gradient between 40% and 60% during the last forty years. The detailed analysis of meteorological and hydrological observations has proved the main reasons of substantial change of outflows from this catchment area – warming up of the whole area, increase of evaporation, decrease of high precipitations frequency and decrease of spring precipitations. There is also the distinct downward trend of ground water tables. This trend was not interrupted even in the early nineties due to the substantial decrease of drinking water intakes and has achieved approximately 23% during last forty years.

T. G. Masaryk Water Research Institute together with Czech Agriculture University in Prague performed a systematic hydrological survey of Rakovník Region since 2009 to 2011. All results of this survey were included into so called Pilot project "Possibilities of current climate change impacts mitigation through improvement of retention and accumulation capacity within the Rakovnický Brook catchment area". This Pilot project proposed the set of possible adaptation measures in two basic branches. The first one consisted of "traditional" water management measures – construction of accumulation water reservoirs in substitution or combination with water transfer from neighbour Ohře/Eger River Basin. The second one consisted in measures within landscape especially in organizational, agrotechnological and biotechnical measures.

2. Small water reservoirs (SWR)

Povodí Vltavy, State Enterprise has gradually prepared adaptation measures proposed in Pilot project and placed the set of specialized feasibility studies. Initially was drawn up "Feasibility study of water reservoirs within catchment area of Rakovnický Brook". There were screened eight localities in Tab. 1.

	Water course (brook)	Location	Catch. area [km^2]	Q_a 88–08 [l/s]	Volume max. [mil. m^3]	Water table [ha]	Dam height [m]	Dam length [m]
1	Rakovnický B.	nad Oráčovem	18,0	20	0,234	5,9	10	140
2	Rakovnický B.	nad Pšovlky	35,3	37	0,371	17,3	6	240
3	Petrovický B.	pod Petrovicemi	14,0	22	1,613	40,16	11	340
4	Řeřišský B	nad Šanovem	9,6	25	1,525	36,4	12,5	310
5	Rakovnický B.	nad Šanovem	50,5	54	0,544	22,2	5,2	450
6	Kolešovický B.	pod Kolešovicemi	39,5	28	0,602	53,8	3	280
7	Lišanský B.	býv. rybník Chobot	49,3	49	0,488	37,5	4	430
8	Kolešovický B.	u Senomat	51,0	32	0,675	24,6	6,2	280

Tab. 1: *Basic parameters of initially proposed SWR*

This feasibility study has proved, that four above mentioned SWR were unfeasible due to fundamental territorial conflicts. Proposed SWR "pod Kolešovicemi" was situated in place reserved for WWTP Kolešovice construction by spatial plan. SWR "bývalý rybník Chobot/former pond Chobot" was in conflict with corridor of proposed highway D6. Across proposed SWR "nad Pšovlky" and "nad Šanovem" were lead crude oil and high pressure gas pipelines. Following two SWR have proved to be too low effective. SWR "nad Oráčovem" due to small storage volume and SWR "pod Petrovicemi" due to small catchment area. Remaining two SWR have been the most promising. Therefore SWR "u Senomat" and SWR "nad Šanovem" were recommended to construction as the most effective localities with rather low rate of conflicts.

During the year 2016 were drawn up specialised feasibility studies for these two SWR. The main aim of these studies was to prove detailed technical conditions for construction of SWR Senomaty on Kolešovicky Brook and SWR Šanov on Rakovnický Brook including creation of water management design and evaluation of their dis charge outputs for water balance improvement in particular water courses.

This year following steps for preparation of both SWR construction are running. The design documentation for land use permission has been currently under preparation. Simultaneously the detailed surface water monitoring is running with the aim to improve the water quality in both SWR.

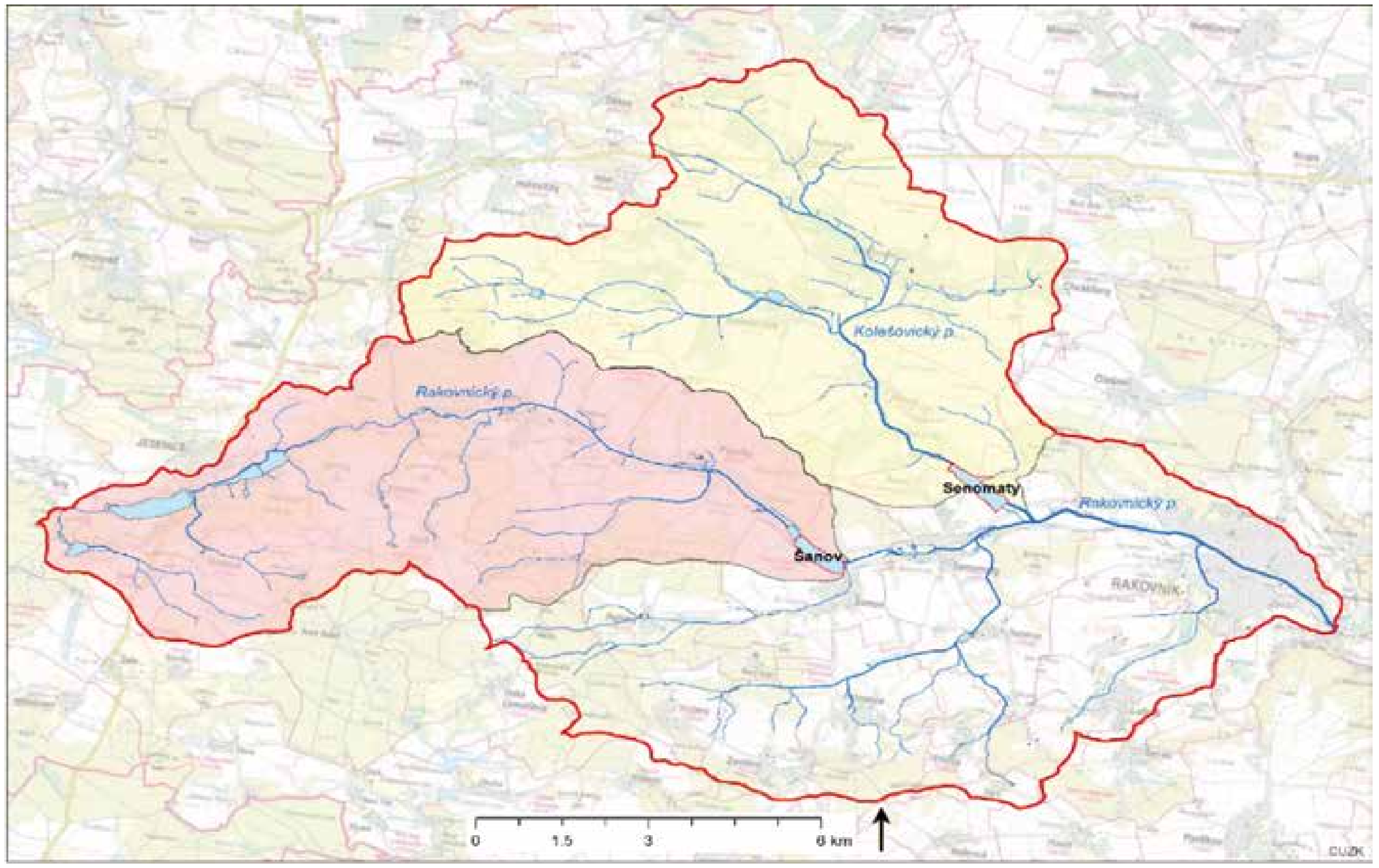

Fig. 1 : *Locations and catchment areas of proposed SWR Senomaty and SWR Šanov*

Basic parameters	SWR Šanov	SWR Senomaty
Maximal dam height (m)	7,8	7,6
Dam length in crest (m)	330	335
Dam width in crest (m)	4,0	4,0
Maximal dam altitude (m a. s. l.)	350,50	337,70
Altitude of spillways (m a. s. l.)	349,00	336,20
Altitude of water table in Q_{100} (m a. s. l.)	349,58	336,76
Altitude of water table in Q_{1000} (m a .s. l.)	349,90	337,10
Dead storage volume (th. m^3)	3,7	6,5
Available storage volume (th. m^3)	586,10	639,20
Flood storage volume (th. m^3)	296,60	229,30
Total storage volume (th. m^3)	886,50	774,90

Tab. 2: *Selected parameters of proposed SWR Senomaty and SWR Šanoví*

3. Water transfer from Ohře/Eger River Basin

There is a chance how to fundamentally improve the water balance not only within Rakovník Region but also within neighbour right bank tributaries of Ohře/Eger River consisting in water transfer from Ohře/Eger River Basin. Therefore State Enterprises Povodí Vltavy and Povodí Ohře placed in mutual collaboration common study "Water transfer from Ohře/Eger River to the Blšanka River and Rakovnický Brook river subbasins". Various possibilities of interconnection individual Berounka and Ohře/Eger water management framework systems were evaluated in this study. The main aim of this study was to select the most suitable variant of this connection and to elaborate particular investment intents. The purpose of this connection was to improve the capacity of surface water sources within the Liboc River, Blšanka River and Rakovnický Brook subbasins so that there were covered the current water uses during dry periods and created sufficient reserves for potential future uses especially for hop gardens irrigation. This connection might also have a positive feedback in improving flow rates as an important condition of good surface water body ecological status. This study was placed and finalised during the year 2016.

There were defined three investment intents as a result of this study. The first one was whole situated within Ohře/Eger River Basin and consisted in water pumping from existing pumping station Stranná on the left bank of Ohře/Eger River to the existing SWR Vidhostice. The length of pipeline would be 31 km.

The remaining two investment intents propose the water transfer across water divide into Berounka River Basin in two branches. The first branch leads from SWR Vidhostice to the Great Jesenice Pond on Rakovnický Brook with the length of 15 km and cooperates with scheduled SWR Šanov. The second branch leads also from SWR Vidhostice but to the Kolešovický Brook subbasin with the length of 16 km and cooperates with scheduled SWR Senomaty. There is a possibility to construct either only one selected branch or both of them.

4. Nature friendly and other measures

During the year 2017 was drawn up the study "Nature friendly measures within the catchment areas of Rakovnický and Kolešovický Brooks (Waterworks Senomaty and Šanov)". Povodí Vltavy, State Enterprise received this task on the basis of the Czech Government Resolution from 24th August 2016 No. 727 "Concerning preparation of water reservoir constructions within the regions affected by dry periods and with the risk of water lack as a part of measure set in affected subbasins". The main purpose of this study was to carry out detailed analyses of both catchment areas and to propose effective measures focused especially on river network and connecting meadows renaturation and revitalisation, on decreasing of water erosion and substance flushing from surface and ground of resolved catchment areas and on decreasing of pollution from urban sources.

Afterwards the set of proposed measures was overall evaluated from the point of view of their contribution to water retention and retardation of the outflow from intended Senomaty and Šanov waterworks catchment areas as well as to water quality protection in these reservoirs.

5. Further possible steps

There is another chance how to improve the water balance of Rakovník Region without necessity of surface water pumping from Ohře/Eger River consisting in construction of Kryry Dam in close neighbourhood of this region within the Ohře/Eger River Basin and transfer of water from this dam.

By the end of 2017 all above mentioned measures were proposed and evaluated individually without necessary interactions. Therefore the complex project was established at the end of 2017, which shall assess and evaluate all measures in one complex – integrated water management schedule system. This complex project is addressed by the Czech Technical University in Prague.

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Drought: Measures under preparation in the Blšanka basin

Tomáš Pail
Povodí Ohře, státní podnik

1. Introduction

The catchment area of the Blšanka River lies in northwest Bohemia and belongs to the Ohře River basin. The Blšanka River originates in the military area Hradiště at an altitude of 680 m above sea level (a.s.l.). The length of the watercourse is 51 km, the catchment area is 482.8 km^2 and the Blšanka River flows into the Ohře River from the right side below the town of Žatec at river km (RK) 81.5.
The river basin district of the Blšanka River and neighbouring river basins of the right tributaries of the Ohře River are typical of long-term low precipitation sums – the average annual precipitation in the area is only 450–500 mm. Decreasing water flow rates and long-term problems of water scarcity, especially for irrigation, are also reflected in the catchment areas of the Blšanka and Liboc rivers and from this perspective are some of the most endangered in the Czech Republic.

2. Drought assessment and measures under preparation

The topic of drought and water scarcity in the Blšanka River basin has been elaborated in several studies in recent years. First it is worth mentioning the 2009 work [1] which assessed water demands and possibilities of measures in the catchment areas of the Blšanka and Liboc rivers. Another important piece of background was the 2010 study [2] which evaluated water demands in the climatic outlook not only for the Blšanka River basin but for the entire territory of the Ohře River Basin Authority. According to this assessment, the Blšanka River basin along the Teplá River, Liboc River, and upper Ploučnice River basins, is the most vulnerable in the whole administrative area of the Ohře River Basin Authority, where the mean flows will drop by 20% and even minimum residual discharges (MRD) will not be assured. Necessary measures to mitigate the impacts of climate change are proposed to increase the accumulation potential of the river basin.

Especially in connection with Government Resolution No. 620 of July 2015, preparation of several measures against drought and water scarcity were started in the Blšanka River basin. Based on the tasks arising from this resolution, several studies have been commissioned for the most vulnerable river basins. These studies have not only assessed the hydrological conditions and water demands, but also proposed specific measures in the form of feasibility studies. Three measures are presented for the Blšanka River Basin in this paper: the Mukoděly water reservoir, water transfer from the Ohře River, and the Kryry water reservoir.

3. Mukoděly reservoir

In 2014, the Ohře River Basin Authority, a state enterprise, commissioned a feasibility study of a reservoir on the watercourse of the Blšanka River [3]. The intention is to build a multipurpose reservoir to increase flood protection especially for the town of Kryry, including the possibility of creating a storage volume of water designed to improve flow in the Blšanka River and increase the available water for agricultural irrigation. The intention is one of the type A measures in the Plan of the river sub-basin [7].

The considered profile of the Mukoděly dam was identified by the 2009 study [1] as the most suitable among 33 localities. It is located on the Blšanka River downstrem of the village of Mukoděly and upstream of the confluence with the Mlýnecký Stream at RK 31.0; the river basin area to the profile is 65.6 km^2.

The study examined hydrological, natural, geological, and soil conditions including abrasions, landslide areas, and sediment flow regime. An important part of the study is the identification of property rights. A precipitation-runoff model is a part of the water management solution. The economic evaluation included an estimate of investment and operating costs.

The reservoir capacity is 0.920 million m^3 with a maximum water level of 321.27 m a.s.l. and a reservoir area of 24.6 ha. Two variants of the distribution of the storage capacity and controllable flood protection capacity were compared; option 2 is proposed with a storage capacity level of 315.50 m a.s.l., with a storage capacity of 0.404 million m^3 and with a controllable flood protection capacity of 0.338 million m^3. The water management solution was performed on a number of mean monthly flows; MRD downstream of the water reservoir was taken into account in two variants – according to the current methodology from 1998 (40 l/sec) and also the newly prepared methodology (105 l/s). A harmless discharge of 8.9 m^3/s, i.e. approximately Q_2, was specified for the outflow from the water reservoir (WR).

The dam is an embankment type of rockfill, homogeneous; the height of the dam is 11.5 m, the length is 180 m; the dam crest is 323.50 m a.s.l. A combined structure with bottom outlets (2 × DN 1000 + DN 250) and a 24 m long spillway with the capacity of 34.8 m^3/s is proposed. It is envisaged to include WR in category III according to dam safety supervision. The design includes a sedimentation basin in the form of a submerged barrage at the end of the reservoir backwater.
Coordination is envisaged with handling of the existing

Route I: ČS Stranná – Vidhostice WR (the Blšanka River basin); DN 900, 0.531 m^3/s max.,
Route II: Vidhostice WR – the Great Jesenice Pond (the Rakovnický Stream basin); DN 450, 0.127 m^3/s,
Route III: Vidhostice WR – the Kolešovický Stream (the Rakovnický Stream basin); DN 600, 0.254 m^3/s.

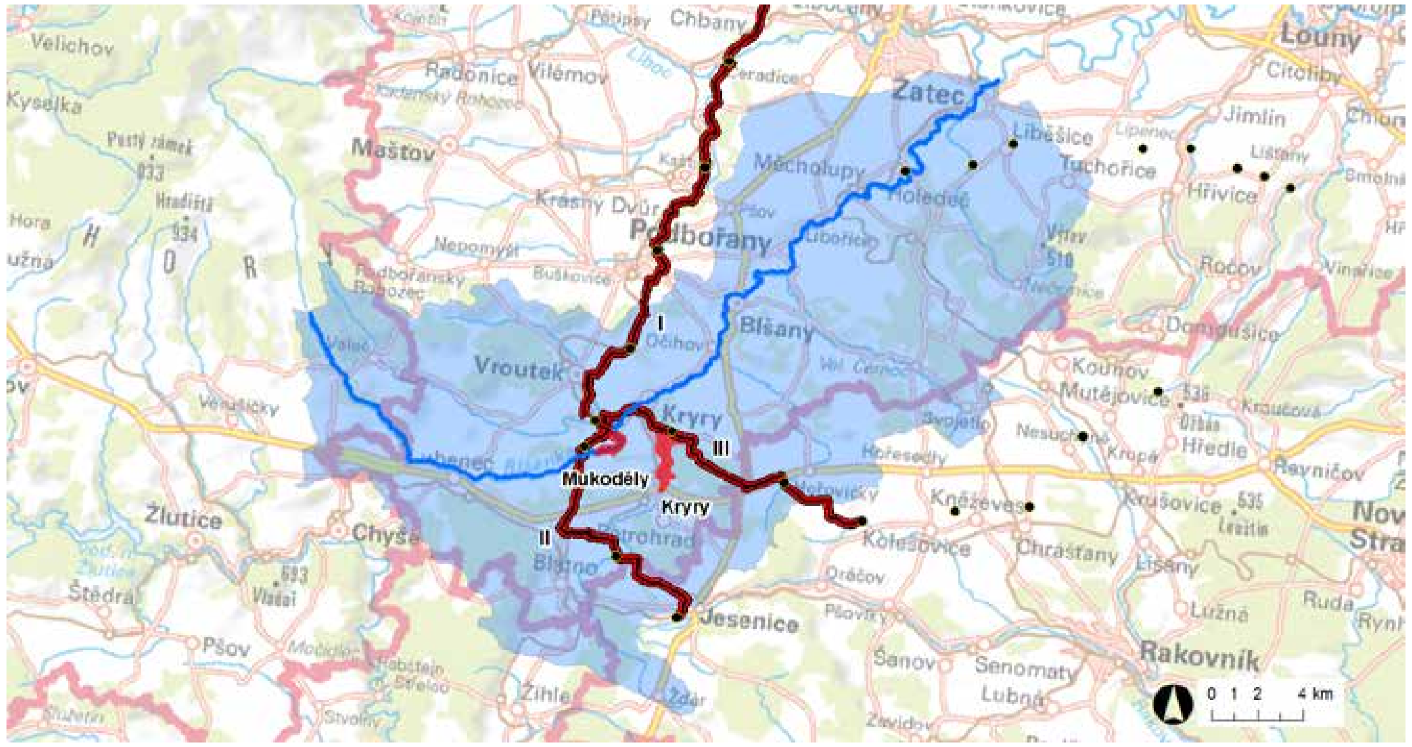

Fig. 1: The Blšanka River basin with the proposed measures

Vidhostice WR on the Mlýnecký Stream at RK 1.10 and a reservoir capacity of 1.075 million m^3. Investment costs are estimated at CZK 123 million and operating costs at CZK 180 thousand per year.

The plan was evaluated as feasible, but disagreement by several key land owners has to be resolved. The problem is also the continued use of high-quality land. The plan was positively discussed with local authorities; negotiations with land owners are ongoing.

4. Water transfer Ohře – Blšanka – Rakovnický

In 2016, the Vltava River Basin Authority and the Ohře River Basin Authority, state enterprises, commissioned a feasibility study on water transfer from the Ohře River basin to the Blšanka River basin and the Rakovnický Stream basin [4]. The idea of this plan is to balance the long-term hydrologically unfavourable situation in the catchments of the Liboc River, the Blšanka River, and Rakovnický Stream, including supply of sufficient water for agricultural irrigation, in the Žatec and Rakovník areas, especially for irrigation of hops.

The proposal is partly based on the use of the existing technology of the Ohře River Basin Authority, i.e. ČS Stranná (Stranná Pumping Station) and part of the Industrial Water Mains Nechranice (IWMN), taking water from the Ohře River about 4 km downstream of the Nechranice WR. The water from IWMN would be gravitationally transferred by a new pipeline; the design takes into account various diameters of steel pipes in three routes. The pipeline routes together with other measures (Mukoděly, Kryry) are shown in Figure 1.

In the proposal of the pipeline and water demands, climate change has been taken into account. It follows from the previous studies that, even from a long-term point of view, the Ohře River and the Nechranice WR are sufficient sources of water.

A key element in the water transfer system is the existing Vidhostice WR on the Mlýnecký Stream in the Blšanka River basin, with a storage capacity of 861 thousand m^3. The reservoir would serve as a compensating reservoir, from which the water would be pumped either to the upper part of the Rakovnický Stream, the Velký Jesenický Pond or to the Kolešovický Stream, the left-side tributary of the Rakovnický Stream, despite the considered Kryry reservoir. The intention is to lead the pipeline route as far as possible through land owned by the state. Investment costs are currently estimated at CZK 1.142 billion for the route to the Blšanka River basin (Vidhostice WR) and for the route to the Rakovnický Stream basin it is another CZK 363 million. Operating costs were estimated in several variants, up to CZK 63.2 million per year.

The plan faces a number of obstacles. In addition to the collision with the land and the current infrastructure in

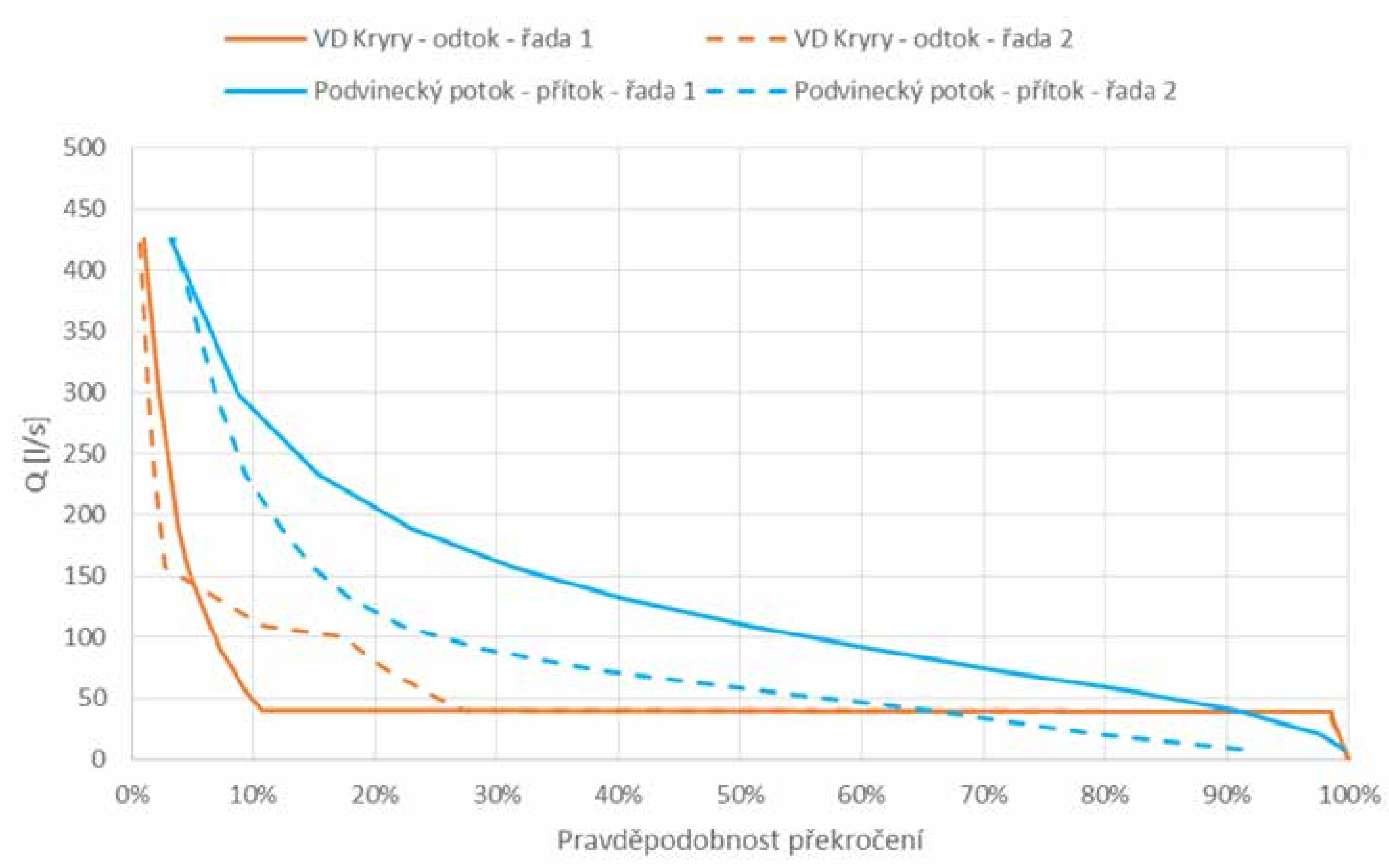

Fig. 2: *Lines of exceedance of monthly flows for the Kryry site – var. A (SHDP+VRV 2017 [5])*

the transfer route, there are considerable investment costs. At the same time, there are high operating costs that stand out especially due to the considerable uncertainties of the project and problematic sustainability and economic effectiveness of the measure: water quality in pipelines and possible quality impacts in target water bodies, uncertain water receipts in conjunction with uncertain water demands for irrigation.

5. Kryry reservoir

In 2017, the Ohře River Basin Authority, a state enterprise, commissioned a feasibility study of the Kryry water reservoir on the Podvinecký Stream in the Blšanka River basin [5]. The Kryry site is included in category B in the General Plan [6]. The intention is to build a high-capacity water source to improve flow in watercourses and agricultural irrigation. At the same time, the proposed reservoir should serve for flood protection of the town of Kryry and other municipalities on the Blšanka River.

The profile of the dam is considered above the town of Kryry at RK 1.50, the catchment area to the dam profile is 84.1 km^2. The long-term mean flow is 185 l/s. Three variants of the dam were considered – each with different reservoir capacity and reservoir area. For each of the variants a water management solution of the reservoir was carried out and the storage and protective effect was tested. Within the solution, MRD downstream of the WR was considered in two variants – both according to the current methodology from 1998 and according to the newly prepared methodology. According to both of them, MRD in this profile is 39 l/s. In addition to ensuring MRD downstream of the WR, flow enhancement of the minimum flow in the profile Stránky on the Blšanka River basin and water abstraction for irrigation (all for 95% and 98.5% water supply reliability).

The solution was made based on a synthetic 500-year series of mean monthly flows. In addition to current hydrological conditions, the impact of climate change in the long-term was also taken into account in the term 2071–2100. Multi-year flow management of the output from the reservoir has been proven in two large variants. In Figure 2 you can see for the max. variant A the lines of exceedance of monthly flows at the input and output from the Kryry WR compared for the existing (series [řada] 1) and the future (series [řada] 2) state. A harmless discharge at the output from WR was specified to 13 m^3/s, which corresponds approximately to Q_2 on the Blšanka River in the town of Kryry. The reservoir in the recommended maximum A variant, with a storage capacity level of 323.80 m a.s.l. and the maximum water level of 325.40 m a.s.l., has a reservoir capacity of 7.988 million m^3 (storage capacity of 6.234 million m^3 and controllable flood protection capacity 0.698 mil m^3) and the reservoir area of 110 ha.
The dam is designed as embankment with a loamy core, with grouting gallery and grout curtain; the height of the dam is 19.4 m, the length is 360 m; the dam crest 327.20 m a.s.l. A multi-level water intake tower structure and bottom outlets (2 × DN 1400 + DN 300) is proposed. A side spillway with a length of 36 m has a design capacity of 61.3 m^3/s. It is envisaged to include WR in category II according to dam safety supervision.

In addition to ownership, hydrological, and geological conditions, water quality issues were also tested in the study [5]. Attention was paid to the verification of the land stability, the reservoir hillside slope, the geotechnical measures, and the influence of the future reservoir on the state of groundwater in the area. The environmental aspects of the plan, including the solution of migration permeability and construction of, for example, a fish chamber and elevator were assessed as well. The proposal also includes the construction of a pumping station for eventual use of the Kryry WR for the transfer of water to the Kolešovický Stream and the Rakovnický Stream basin. For protection against sediments it is planned to build several sedimentation pre-basins in the catchment area.
As with any similar large construction, the project comes into conflict with the land and the existing infrastructure in the territory (engineering networks, pipelines, roads, railways, D6). The total cost of the measure is estimated at CZK 1.571 billion.

6. Conclusion

Currently (June 2018), individual measures, together with others and their combinations, are reviewed within the project Comprehensive water management solution to new impounding reservoirs in the Rakovnický stream and Blšanka catchment areas and other measures to reduce the water deficit in this area.

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Comprehensive water management solution to new water storage reservoirs in the Rakovnický and Blšanky stream catchment areas and other measures to reduce the water deficit in this area

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1. Abstract

The catchment areas of the Blšanka and Rakovnický streams are amongst areas most impacted by droughts along the Czech reaches of the Elbe river. Therefore, the issue of drought in this area is paid great attention to in the Czech Republic. Over the past decade, a number of partial measures have been proposed in the catchment areas of the Rakovnický stream and the Blšanky in order to mitigate the consequences of drought. Considering the fact that based on latest knowledge the drought continues worsening and partial measures taken to mitigate the drought in this area are not sufficient, all measures need to be assessed as a new (just emerging) water management system. This assessment required a comprehensive water management solution for the entire area, especially with regard to the discussions over the proposed measures with water users and the public. The results of the water management solution will be presented both for expert evaluation of the system and they will also be presented to all participants.

The aim of the study was to offer a comprehensive water management solution in the form of a set of proposed measures in the catchment areas of the Rakovnický and Blšanka streams, which will be considered as a water management system. For this purpose, a water management system has been defined to enable evaluation of the reliability of ensuring water management functions not only in the profiles downstream the dams of the individual newly designed reservoirs but also in the key defined balance profiles. The main benefit of the proposed system is the possibility of evaluating its reliability based on formulating variants of the individual measures in the form of new or existing water storage reservoirs and water transfers with optional parameters (size of the storage volume, transfer capacity, etc.).

2. Introduction

The catchment area of the Blšanka and Rakovnický streams is one of the driest areas in the Czech Republic with actual lack of water for its use. The need for water is related to agriculture, industries and the common use of water to meet the needs of people living in this area. Several conceptual studies were developed between 2009 and 2017 aimed at boosting water resources in this catchment area. These studies are related to the implementation of new water reservoirs, transfer of water from the Ohře basin and implementation of nature-friendly measures. These individual studies considered the proposed measures without including their interactions. The improvement effects of the reservoirs were generally assessed starting from the profile downstream the individual reservoirs without assessing their impact on profiles downstream the streams and for various variants of their actual deployment and co-operation in the water management system. There was also a new requirement to assess the possibility of transferring water from the Berounka river to the dry river basins.

3. Hydrological data for the entire water management system

Hydrological input data forms a necessary and crucial basis for a comprehensive water management solution for the entire set of measures in this area. The quality of the input data clearly determines the quality and informative value of the results of the entire solution. Hence, the preparation of hydrological data was paid considerable attention to in the study. A decision was made that with regard to the character of the reservoir discharge control, which includes elements of compensation control and water transfer between the river basins, the water management solution would be provided in daily time steps. This timing of flow-rate series in a much more suitable manner allowed for the interpretation of the results and effectiveness of the proposed measures by changing the daily flow-rate exceeding lines in the basic profiles of the whole system.

For the comprehensive water management system solution, the hydrological data for the representative period of 1981-2017 was used, which reliably represent the current hydrological conditions and the hydrological conditions in the nearest future.

In order to consider the impact of the expected climate change, the climate change scenarios were used according to the parallel project titled „Ensuring the availability of water resources in selected areas of the Karlovy Vary Region", which is developed under the programme titled „Comprehensive Sustainable Systems in Agriculture" (KUS) administered by the Ministry of Agriculture. The control period was considered as the period of 1981-2010, the scenarios were derived for the periods of 2021-2040, 2041-2060 and 2081-2100. These periods were mainly selected in order to ensure consistency with the scenarios currently in use. For the purpose of assessing the impacts of climate changes on the comprehensive water management solution in the Rakovnický and Blšany catchment areas, one probable scenario was selected based on the terms of reference.

4. Optional measures, results of the water management solution

The assessed options were developed for the separate subsystem of the Rakovnický and Blšanky catchment areas and the solution was expanded by the possibility of transferring water from the Ohře (Blšanky) stream into the Rakovnický stream. In each separate subsystem, a variant describing the current status was developed to assess the effects of the proposed measures and to ensure better interpretation of the results. In total, 12 basic options were identified and sub-options were considered for some of them. The objective was to cover the full range of possible outcomes.

For all options, uniform sets of results were developed, including: water demand and water transfer, minimum residual flow-rates, storage reservoir level fluctuations, exceeded daily flow-rate lines in water courses profiles, etc. The following figures show the results for the P3 option, which is an option that assumes implementation of storage reservoirs, Mukoděly, Kryry, Senomaty and Šanov together with the transfer of water from the Blšanka and Rakovnický streams.

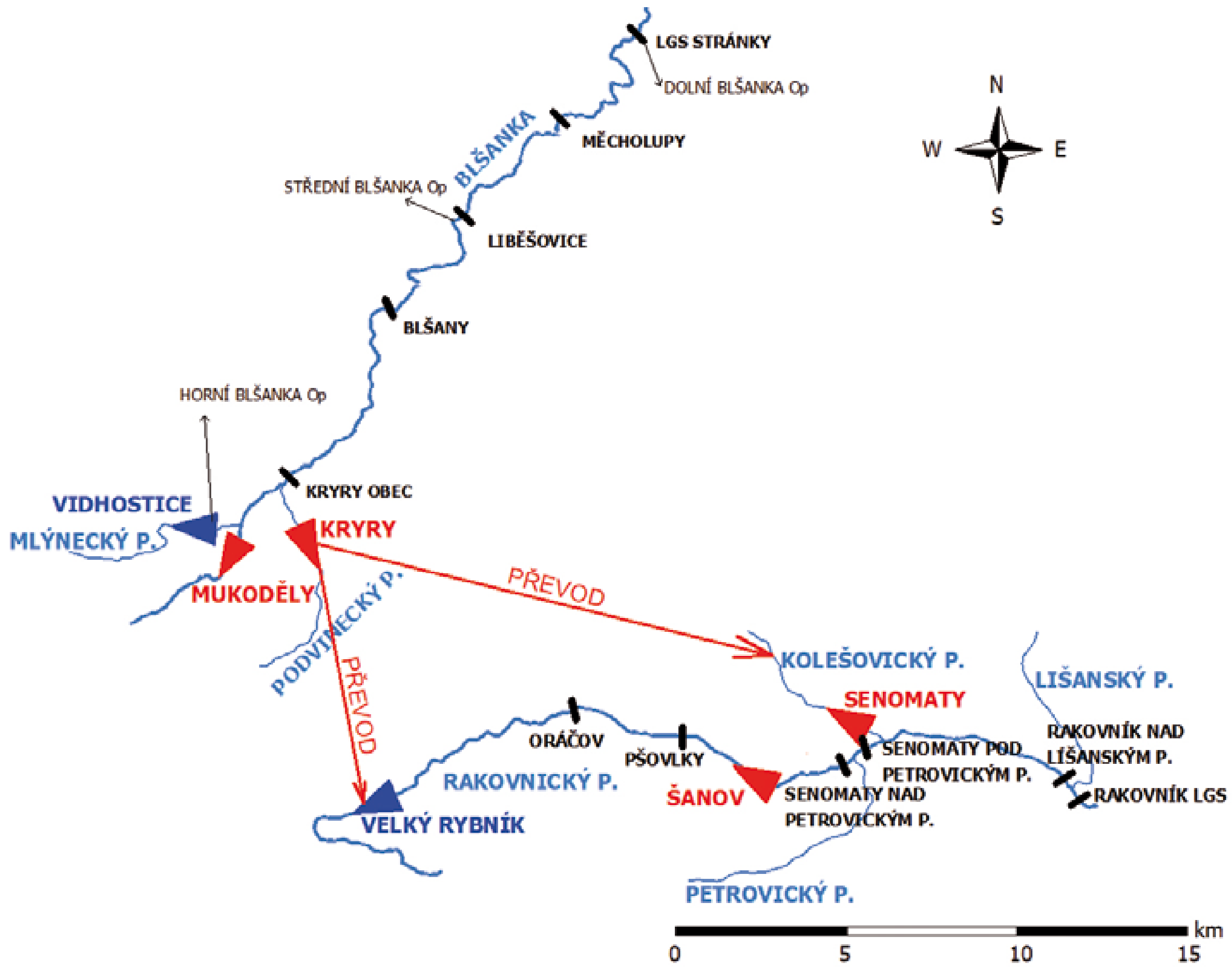

Fig. 1: *Scheme of P3 option- Transfer from the Kryry reservoir to the Kolešovický stream and the Rakovnický stream*

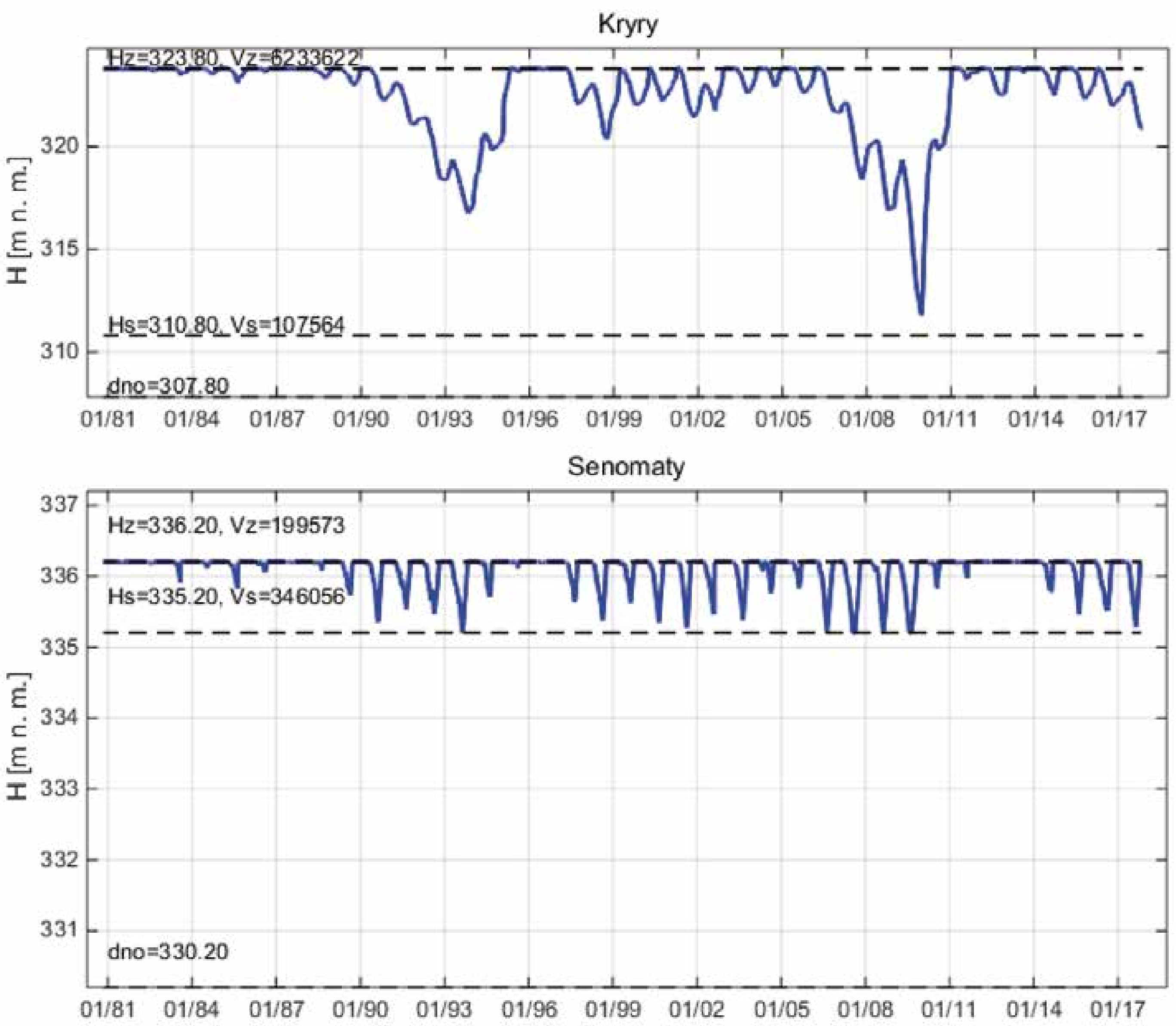

Fig. 2: *Level fluctuations in the Kryry and Senomaty reservoirs in the P3 option*

5. Assessing the impacts of nature-friendly measures

In the past, an extensive study of the entire set of nature-friendly measures in the catchment area of Rakovnický stream was drawn up. Therefore, their possible impact on the quantity of water as well as on its quality was assessed.

The beneficial effect of grassing or forestation of the river basin is demonstrated during heavy rains. Compared to arable land, there is lower surface run-off in these localities and more water is infiltrated into the soil. The infiltrated water is then divided into water which increases water supply in the soil (i), water which runs through preferred paths as hypodermic outflow (ii), and water that penetrates into the groundwater zone (iii), this is primarily about the ability of soil to absorb this water. According to the estimate made by TGM Water Management Research Institute (2012), the effect of the measures under assessment given realistically estimated options of changing the land use is low and they will not resolve water scarcity in this area.

A great influence of nature-friendly measures can be seen in their impact on the quality of water in the catchment area where they are highly desirable. As an erosion protection, they significantly reduce the transport of sediments including nutrients to the existing and newly proposed water reservoirs. This will limit their fouling and also development of eutrophication in these bodies of water.

6. Conclusion

The considered water management solution encompassed a number of options combining elements proposed to reduce the drought deficit in the area. The impact of these measures has been quantified in order to enable a responsible decision to be made in the future about their possible implementation. Great attention has been paid to the collection of hydrological data that clearly determine the quality of the study results. Presentation of the results and their informative value already reflect the future discussion abuot the implementation of the measures with the professional as well as general public.

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SUCHO A JEHO VLIV NA JAKOST A UŽÍVÁNÍ VOD

Trockenperioden und ihr Einfluss auf Gewässergüte und –nutzungen

Content

Qualitative Water Shortage in the North of Lower Saxony: Solutions for the Antifreeze Irrigation

Heinrich Reincke - *Unterhaltungsverband Kehdingen*
Petra Schneider - *Hochschule Magdeburg-Stendal*

1. Introduction

Elbe water has always been used for agricultural purposes in the Northern Lower Saxony river maintenance associations. According to the State Statistical Office, in 2015 in Lower Saxony 18,279 hectares of vegetables were cultivated in the field. In the Weser-Ems region 42% of all Lower Saxony vegetables are produced, as well as nearly 72% of the cabbage production are concentrated in this region. The antifreeze irrigation serves the protection of plants from freeze to death during the flowering period. It is a common practice in the north of Lower Saxony, Germany, to avoid future crop failures. The area in the focus of the investigation is called Altes Land, where the required irrigation water volume of up to 1000m³ per night and hectare is currently fed into the various marshes in the area via the dikes of the Elbe River. The respective fresh water must have a quality of no more than 0.2 to 0.3 ‰ salt content. Due to the increasing Elbe depression, several rivers in the Elbe catchment of Altes Land do not contain any longer proper fresh water, and reached already a salt content of >1 ‰. As the brackish water zone of the Elbe River is shifting downstream, a qualitative water scarcity results and therefore the need for an alternative fresh water supply. Further, the need for irrigation water has steadily increased due to recent climatic changes. The scope of the study was to deter-mine alternative fresh water supply options. To reach this scope, the current and future water demand was determined, as well as the current water availability, and conducted a deficit analysis. In principle, there are several generally feasible solutions for an alternative water supply, as a) taking water from tributaries or adjacent connected sub-catchments, b) the increase of the storage volume through reservoirs, and c) taking water from the existing drinking water network or well.

2. Case Study

The investigation area for the pilot feasibility study was the area of the Water Operation Association Kehdingen, in which the water for the frost protection of the fruit plantations has so far been taken from the Freiburger Schleusenfleth. In case of announced night frosts, the antifreeze irrigation is carried out at the same time on all orchards in the entire Kehdingen area, resulting in the need of a large quantity of water. The association area is located between the rivers Oste, Schwinge and Elbe, parallel to the Elbe with a width of 4 to 7 km in a low-lying terrain (marsh, moor). The association cover a land area of 27,628 ha, out of which 24,761 ha are farmed and drained by a network of 254 km of heavily modified water bodies and 60 km of artificial water bodies. The river network density is 0,92 km/km², regulated by 180 regulating buildings. There are no natural rivers. The antifreeze irrigation serves to protect plants from frost breaks during the flowering period from April to May and thus to avoid future crop failures [1]. Here, crops in fruit, wine and vegetable cultivation are sprayed with very fine water droplets. This causes a protective ice pack around the flowers and protect them from direct frost. Usage claims exist on the one hand for the cattle drinkers and on the other hand for antifreeze irrigation as well as the irrigation of fruit plantations. At the same time, the water volumes required for the antifreeze irrigation exceed the requirements of other types of use. With an irrigation water volume of up to 1000m³ per night and hectare, the protection against frost is the case with the largest hydraulic load case. The proportion of Elbe water in the irrigation water is currently more than 50%. The areas for fruit cultivation are mostly located within the marsh and are therefore usually directly connected to comprehensive drainage systems. The competing usage claims lead to a water shortage in the area, which can be defined as "water risk" according to the definitions of UN-Water definition (2006), and the related definitions by the World Resources Institute [2,3]. While "Water scarcity" refers to the volumetric abundance of water supply, and "Water stress" to the ability to meet human and ecological demand for water, "Water risk" refers to the probability of an entity experiencing a deleterious water-related event [3].

In this case, the fresh water used must have a quality of no more than 0.2 to 0.3 ‰ with respect to the salt content, and has so far been taken from the Freiburger Schleusenfleth. Due to the increasing Elbe depression, the Freiburger Schleusenfleth has now no longer suitable fresh water, and a salt content > 1 ‰. Usually, the available usable water volume in the marshes is sufficient for some irrigation hours. However, if there is a need for several days of irrigation, the water present in the system is consumed. For this reason, additional Elbe water is fed to the inland waters. The brackish water zone is expected to shift further upstream in the lower regions and further intensify the local saltwater problem. Due to the planned water way extension, the farmers in Kehdingen are worried about their fruit growing areas. For them, it is also important in the future that sufficient fresh water is available for the irrigation of the plantations. Also with the background that the need for irrigation water

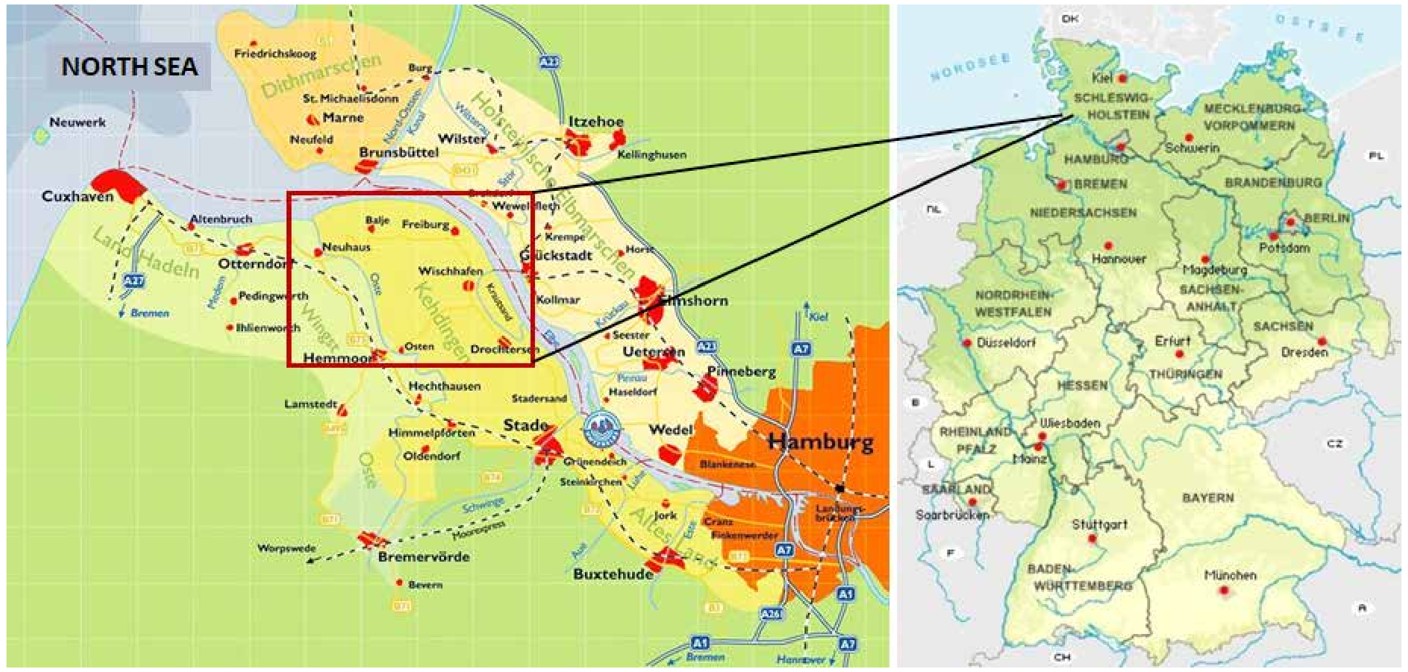

Fig. 1: Location of the study area

has steadily increased because of the climatic changes in recent decades. The scope of the study was to determine the possibilities for alternative fresh water supply outside the Elbe River, especially for the Freiburg-Schleusenfleth water system. A connection to the Oste River was examined as a preferred variant. The location of the study area is shown in Figure 1.

For this purpose, the water demand was determined, and inventoried in terms of the current water availability, further was conducted a deficit analysis of the current water supply and the development of various concepts for alternatives. In principle, there are several approaches that might be considered for an alternative water supply:

• Water provision through gravity flow or by pumping from tributaries and / or adjacent areas,
• Increasing the storage volume by creating new irrigation ponds or reservoirs and / or river widening,
• Injection from the existing drinking water network or wells.

Feasible and realistic options were analysed and described in terms of planning criteria. The terrain level is usually very shallow, the surface gradient is barely present and the adjacent marsh ground is barely able to absorb water. Nowadays, the area is partially below sea level and is largely diked. All these circumstances indicate that this area is in principle rather unsuitable for economic land management. However, over decades, a complex irrigation and drainage system with canals, ditches, pipelines and drainage allows for land management as it is today. Through a large number of pumping stations, the drainage of the marshes is ensured and the water level in the artificial water systems is kept at a low level. In contrast to natural streams, the hydraulic flow processes of artificial waters are largely determined by hydraulic regulation systems. In the frame of the study, the demands of those fruit cultivation companies have been summarized that collect their irrigation water together from a joint body of water. Three different variants were examined in terms of their feasibility and expected construction costs. Table 1 presents the considered options and the characterization of the variants including the required construction activities and the respective cost are given in table 1.

3. Results and Discussion

The results can be summarized as follows:
Concept 1 is considered a feasible variant, if the depression of the Elbe does not cause a significant change to the expected salt content in the Elbe river at Wischhafen.
Concept 2 is considered the most cost-effective variant and an optimal solution with regard to the resolution of saltwater intrusion problems in the Lower Elbe at Freiburg and Wischhafen, and there-fore preferable.
Concept 3 is considered to not be economically feasible compared to the preferred variant from the current point of view, therefore an implementation is not recommended.
Concept 4 is also not considered to be economically feasible compared to the preferred variant from the current point of view, therefore an implementation is not recommended. The option might become relevant for an upstream shifting of the brackish water zone in the Oste river.

As a result of this study, the connection of the Freiburg Schleusenfleth to the Neuensee Schleusenfleth via Krummendeich (variant 2) is considered a preferred variant. With this concept, it is possible to effectively prevent wa-

Variants	General location
1	Length: approx. 6 km Course of the route: 1) Wischhafener Schleusenfleth (expansion) 2) Hollerdeicher Wettern (expansion) 3) Connecting channel (new construction) 4) Allwördener Fleth (expansion) Construction costs (estimated): approx. € 1.37 million (trench solution) Construction costs (estimated): approx. € 2.87 million (tube solution)
2	Length: approx. 9.5 km Course of the route: 1) Neusenseer Schleusenfleth (expansion) 2) Connecting channel 1 (new construction) 3) Krummendeicher Wettern (removal) 4) Connecting channel 2 (new construction) Construction costs (estimated): approx. € 2.4 million (trench solution) Construction costs (estimated): approx. € 4.5 million (tube solution)
2.1	Length of the supply route: 20.6 km Course of the route: 1) Neusenseer Schleusenfleth (expansion) 2) Connecting channel 1 (new construction) 3) Krummendeicher Wettern (removal) 4) Connecting channel 2 (new construction) 5) Connecting channel 3 (new construction) Construction costs (estimated): approx. € 3.2 million (trench solution) Construction costs (estimated): approx. € 5.26 million (tube solution)
3	Length: approx. 20,6 km Course of the route: 1) Neusenseer Schleusenfleth (expansion) 2) Connecting channel 1 (new construction) 3) Wischhafener Schleusenfleth (expansion) 4) Hollerdeicher Wettern (expansion) 5) Connecting channel 2 (new construction) 6) Allwördener Fleth (expansion) Construction costs (estimated): approx. € 3.55 million (trench solution) Construction costs (estimated): approx. € 6.15 million (tube solution)
4	Length: approx. 20.4 km Course of the route: 1) Herrenfleth (expansion) 2) Connecting channel 1 (new building) 3) Wischhafener Moorkanal (expansion) 4) Wischhafener Schleusenfleth (expansion) 5) Hollerdeicher Wettern (expansion) 6) Connecting channel 2 (new building) 7) Allwördener Fleth (expansion) Construction costs (estimated): approx. € 4.48 million (trench solution) Construction costs (estimated): approx. € 8.86 million (tube solution)

Tab. 1 : *Considered options*

ter shortage during frost protection in Freiburger Schleusenfleth. In addition, the fruit farms along the extension, which are located outside of the Freiburger Schleusenfleth, can also profit from the irrigation. Compared to variants 2 and 3, the project has a construction cost of approx. 2,4 Mio € also one of the cheapest variants. Compared to the Freiburger Schleusenfleth, the salt water problem for the fruit farms at the Wischhafener Schleusenfleth so far represents no serious problem. The permissible limits for the antifreeze irrigation are rarely exceeded at the Wischhafen barrier and allow a dehydration from the Elbe at present. In this respect, the supply of the Freiburg Schleusenfleth from Wischhafen is also a noteworthy alternative.

4. Conclusions and Acknowledgements

In all variants it was demonstrated that a transfer of salt-free water from the Oste river to the Freiburger Schleusenfleth is possible and can replace the Elbe water. In principle, the saltwater problem on the Elbe river needs regularly to be monitored carefully in order to observe the evolvement over the next few years to develop strategic action plans for water provision. There are still study needs, as for instance the impact of the planned navigation channel adaptation on the brackish water zone of the Lower Elbe. The development of salt-tolerant crops as discussed in [4] is not a relevant option for the Lower Saxony region in Germany. Beside the problem of the deepening the Elbe waterway, the salt water problem will be significantly worsened in the future by climatic changes. In such a case, the implementation of variant 2 is a feasible and cost efficient option. By means of this concept, both the antifreeze irrigation in the area of Wischhafen and Freiburg could be protected by irrigation water from the Oste river. With approx. € 3.5 million construction costs, this concept is about € 1.1 million more expensive. The project was financially sustained by the Unterhaltungsverband Kehdingen, and mainly prepared through the support of students works. We particularly acknowledge the preparatory input of M.Eng. Jens Machemehl of the University of Applied Sciences Magdeburg-Stendal [5].

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A water quality model for the Czech part of the river Labe/Elbe: Application for recent state and scenarios of climate change

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1. Introduction

Water quality is an enduring problem in water management and has global importance due to the increasing use of water. Especially in view of the expected climate change, the availability of water of acceptable quality will increasingly be a "hot" topic. The aim of this study is to simulate and analyse the recent state (2010-2015) of the water quality of the river Czech part of the Labe/Elbe and predict and quantify the possible effects of climate change on the water quality parameters such as water temperature, oxygen and chlorophyll-α. For modelling the water quality QSim an instrument for the simulation and prognosis of the oxygen, nutrient and plankton dynamics in running waters [2] is used. This model was developed by the Federal Institute of Hydrology (BfG – Koblenz, Germany).

2. Study area

This study deals with the part of the Elbe River located in the Czech Republic (see Figure 1). The upper boundary of the model is located below the Srnojedy weir (km 960.8) near the city of Pardubice (Figure 1, thick grey line). The lower boundary is delineated by the Czech-German border (km 726.6) near Schmilka/Hřensko. The total distance of the model section is 234 km. The model application also includes the 9 largest tributaries of the Elbe river area as lateral boundaries. The model area comprises 23 navigation dams, which cause an increase of water level for shipping purposes. The position of each weir, tributary and measuring station is shown in Figure 1.

3. Methods, data source and model validation

Model QSim

QSim is a one-dimensional model which means that all variables are uniformly distributed across the profile. It uses simulated data of the hydraulic model (HYDRAX) e.g. water levels, discharges, and other morphological and hydraulic parameters as mean water depths or flow velocities as driving forces. In the model, the most important biological processes of the oxygen and nutrient budget as well as the development of phyto- and zooplankton and the processes at the river bottom are calculated. Model results are presented as daily and seasonal cycles of the physical, chemical and biological state parameters along the river [6].

Input data

Data regarding river morphology, discharge, water level, water quality and meteorology (air temperature and global radiation) are required to define the boundary conditions of the model. The selected discharge and water quality monitoring stations and the list of available water quality parameters for the reference period (2010 – 2015) are presented in Table 1. These data were provided by the Elbe River Basin Authority (SOE), the Ohře River Basin Authority (SOE), the Vltava River Basin Authority (SOE) and the Czech Hydrometeorological Institute (PVL, POH, PLA and CHMI).

For the modelled part of the Elbe River, some biological parameters are not available, which became apparent to be indispensable for the proper functioning of the model. The first results of the model showed markedly overestimated values of chlorophyll-α concentration in the summer months. The grazing effect of the active benthic filter feeders (in particular mussels), which was not taken into account for the first model runs, was taken as a possible cause for this overestimation. Therefore, a scenario was created which uses data derived from the macrozoobenthic monitoring program of the Elbe River form Elbe Data Information System and from another studies about quite similar rivers (e.g. Danube [7]) to estimate the abundance of Dreissena polymorpha (DP) at the initialisation of the model. For the whole model area, the same density of mussels was chosen at the initialisation. The assumed density of Dreissena is 270 lnd/m^2 [4]. All these data mentioned above, including the DP scenario, were also used to model the effects of climate change on the water quality.

Model validation

The simulated values of flow and water temperature were very similar to the measured values. Likewise, nutrient concentrations, especially N and Si, show great consistency with the measured data. The deviations between measured and model values of P are bigger, but overall the model results can be considered as sufficient.

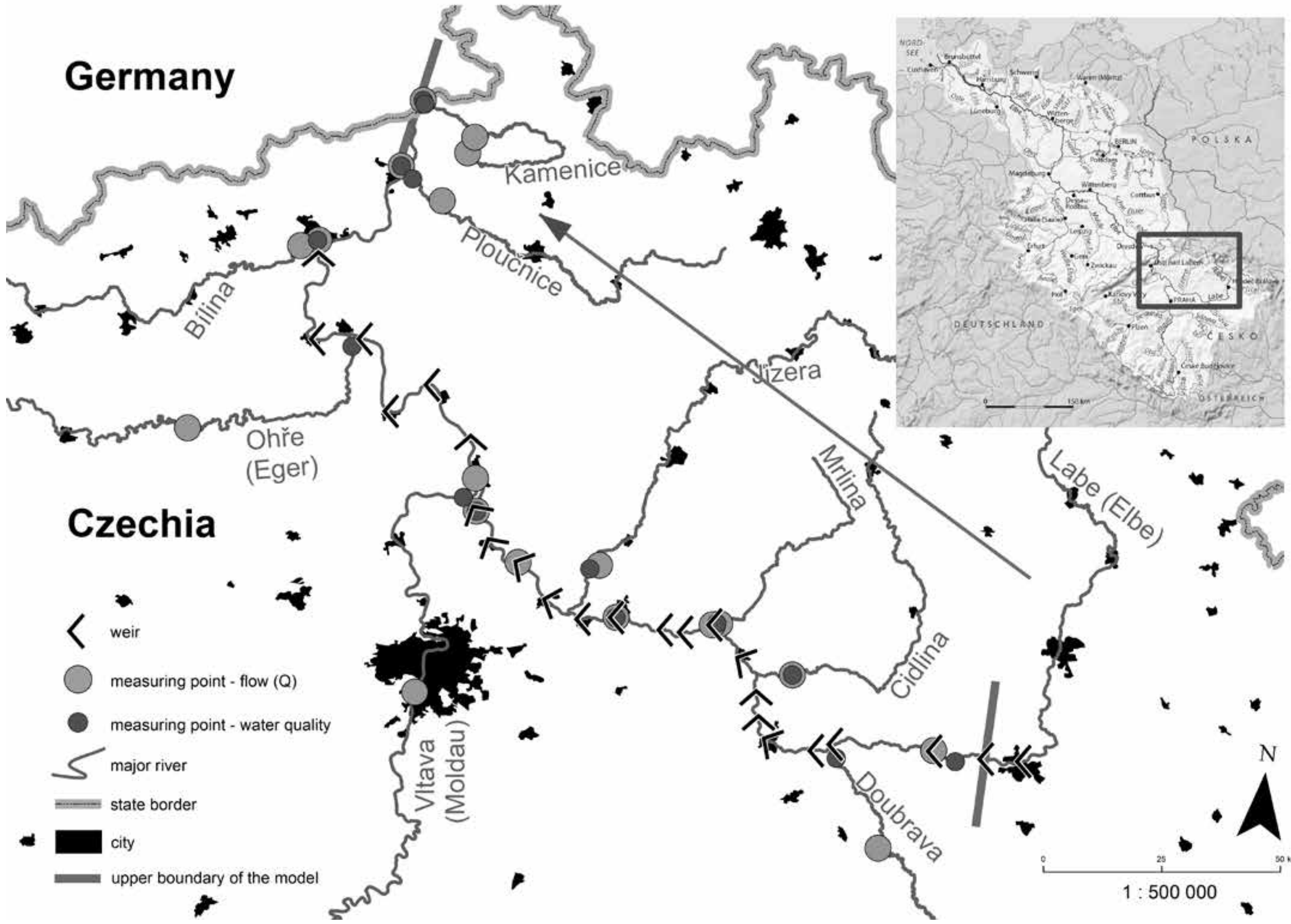

Fig. 1 : *Model area - Czech part of the Elbe (from Srnojedy to Schmilka/Hřensko)*

Discharge profiles						Water quality profiles					Water quality parameters	
river	station	mouth - km	river - km	average Q [m^3.s^{-1}]	data source	river	station	mouth - km	river - km	data source	parameter	unit
Elbe	Přelouč		951,18	52,89	PLA	Elbe	Valy		954,73	PLA	water temperature	[°C]
Elbe	Lysá nL		878,07	60,00	PLA	Elbe	Lysá nL		878,07	PLA	dissolved oxygen (mg O_2/l)	[mg/l]
Elbe	Obříství		843,50	87,22	PLA	Elbe	Obříství		843,50	PLA	COD	[mg/l]
Elbe	Děčín		740,52	289,54	PLA	Elbe	Děčín		740,52	PLA	amonium nitrogen (NH_4-N)	[mg/l]
Elbe	Schmilka/Hřensko		726,59	294,14	PLA	Elbe	Schmilka/Hřensko		726,59	PLA	nitrite-Nitrogen (NO_2-N)	[mg/l]
Doubrava	Žleby	931,30	23,71	2,49	PLA	Vltava/Moldau	Zelčín	837,20	4,50	PVL	nitrate nitrogen (NO_3-N)	[mg/l]
Cidlina	Sány	907,90	6,79	4,25	PLA	Ohře/Eger	Terezín	792,50	2,70	POH	total nitrogen (TN)	[mg/l]
Mrlina	Nymburk	896,49	0,75	1,35	PLA	Cidlina	Sány	907,90	6,79	PLA	total Phospor (TP)	[mg/l]
Jizera	Předměřice nJ	869,20	11,50	23,00	PLA	Mrlina	Nymburk	896,49	0,75	PLA	orthophosphospores (PO_4-P)	[mg/l]
Vltava/Moldau	Praha	837,20	25,10	168,38	DPGG	Jizera	Tuřice	869,20	11,20	PLA	silicate (SiO_2)	[mg/l]
Ohře/Eger	Louny	792,50	53,40	32,50	POH	Bilina	Ústí nL	766,00	0,20	POH	pH value	
Bilina	Trmice	766,00	3,76	6,39	POH	Ploučnice	Březiny	741,10	3,70	POH	alkalinity (m-value)	[mmol/l]
Ploučnice	Benešov nPl	741,10	10,90	9,65	POH	Kamenice	Hřensko	728,10	0,50	POH	suspended matter	[mg/l]
Kamenice	Srbská K. + Chřibská Kamenice	728,10	14,5 + 1,4	1,75	POH	Doubrava	Záboří	931,30	1,40	PLA	calcium (Ca)	[mg/l]
Elbe	Kostelec nL		856,92	91,31	DPGG						conductivity	[µS/cm]
Elbe	Mělník		836,65	240,99	DPGG						BOD_5	[mg/l]
											chlorophyll - α	[µg/l]

Tab. 1 *List of discharge and water quality monitoring stations and list of available water quality parameters*

Chlorophyll-α and oxygen concentrations differ clearly from the measured data. Therefore, the DP scenario is created to improve the model performance. After this improvement, the chlorophyll-α and oxygen values can be considered as acceptable. A performed statistical validation of the model results shows a level comparable to the results of other river models. For example for chlorophyll the mean value of R^2 is 0,581, a study on the Danube has an average of 0.585 [7] and a study on the Rhine 0.665 [3]. In another paper, the authors compared the results of 153 water quality models with an average value of R^2=0.48 [1]. The average NSE of the Elbe model is 0.343. In the German part of the Elbe, the average result for the period 1999 - 2003 is 0.493 [4] and in the case of the Danube it is 0.350.

Climate change scenarios

The data representing the possible change of climate conditions are obtained from the project "Support for long-term planning and proposal for adaptation in the field of water management in the context of climate change" by the TG Masaryk Water Research Institute in cooperation with the CHMI. In contrary to the reference period, the data for the climate change are presented as monthly averages. The reference period is compared to the „near future" 2021-2050 (NF - 2035) and the „far future" 2071-2100 (FF - 2085). A total of six different climate change scenarios based on three climate model chains were used. It is the ALA_ARP (CHMI) that represents the strongest impacts, CLM_Q0 (ETHZ), which roughly represents the average of all model chains, and REMO_EH5 (MPI), which predicts only slightly negative or even positive changes in hydrology compared to the presence [5]. The modelling of the future water quality is only driven by the changes of the climatic parameter air temperature and hydrological parameter runoff. Based on air temperature data, for all tributaries and the model start the input data of the future water temperature. Data were calculated by using a simplified QSim model [3].

4. Water quality of the recent state (2010-2015)

The average flow time for the whole model area in the period 2010-2015 ranged from 5 to 12 days, depending on the season. The flow time influences the water quality. The average flow velocity increases along the longitudinal profile and the average velocity for the reference period throughout the whole river stretch was 0.417 $m{*}s^{-1}$. The highest water temperatures in the Elbe River were measured at the Děčín station, where 26°C were reached. The warmest tributary is Cidlina (max 25.9°C) and the coldest is Kamenice (max 17.9°C). In downstream direction of the Elbe/Labe, the average measured water temperature increases. The phytoplankton was evaluated from the chlorophyll-α content. The simulation results show, that the predation pressure has a major influence on the phytoplankton biomass of the Elbe River. Due to the lack of data, the influence of benthic filters is estimated as a scenario based on Dreissena polymorpha (DP scenario). Figure 2 shows the development of the algal growth rate (light grey) with the QSim model at the Schmilka/Hřensko station. The strong influence of Dreissena on the algae biomass is evident. Especially in late summer, the clams show a high filtration rate in the flow and thus control the late summer algae production. In the entire model area of the Elbe River, the oxygen concentrations range between 9 and 11.5 mg/l (data not shown). Of course, during the summer months, oxygen levels are lower at high water temperatures and lower flow rates.

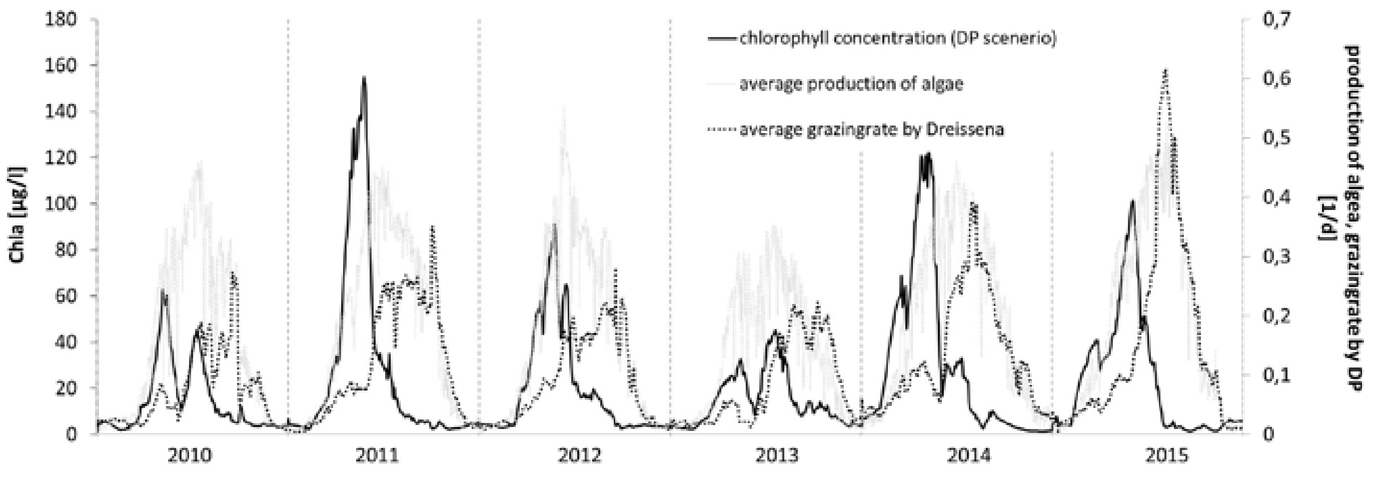

Fig. 2 Model results of the daily averaged chlorophyll-a concentration, loss rate per day due to elimination of Dreissena polymorpha and production of algae per day at Schmilka/Hřensko station (km 726) for 2010-2015.

5. Possible impact of the climate change

Frequent low water situations predicted for future scenarios can strongly affect the average flow time. Figure 3a describes the flow time for the near future. The black line represents the flow time from the start of the model (km 960) to the final point (km 726) for the reference period, the three grey lines for different runs of the future scenario. The average monthly values are represented here. For example, in November, the flow time for the CLM_Q0_NF scenario will be more than 10 days greater than in the reference period. In the case of the water temperature, there is an increase in all scenarios in the near and far future, too. As a result, the number of days where the water temperature exceeds 25°C is expected to increase significantly. At the moment, this number is quite low. For example, on river km 878, 25°C is exceeded only on 2 days per year. In contrast, with the REMO EH5 FF scenario, 25°C will be exceeded on more than 20 days per year. Another example is the chlorophyll-α concentration. The chart included in figure 3b shows changes at the Schmilka/Hřensko station for each scenario compared with the reference period. The graph shows a significant difference between individual scenarios. In the case of the NF, there is a noticeable increase in April and May, but on contrary a decrease of the chlorophyll-α values in July and August. For the REMO scenario, the increase comprises up to 10%. In the FF, however, there will be a more significant decrease of the chlorophyll-α values in summer month's concentrations for the CLM and ALA_ARP scenarios.

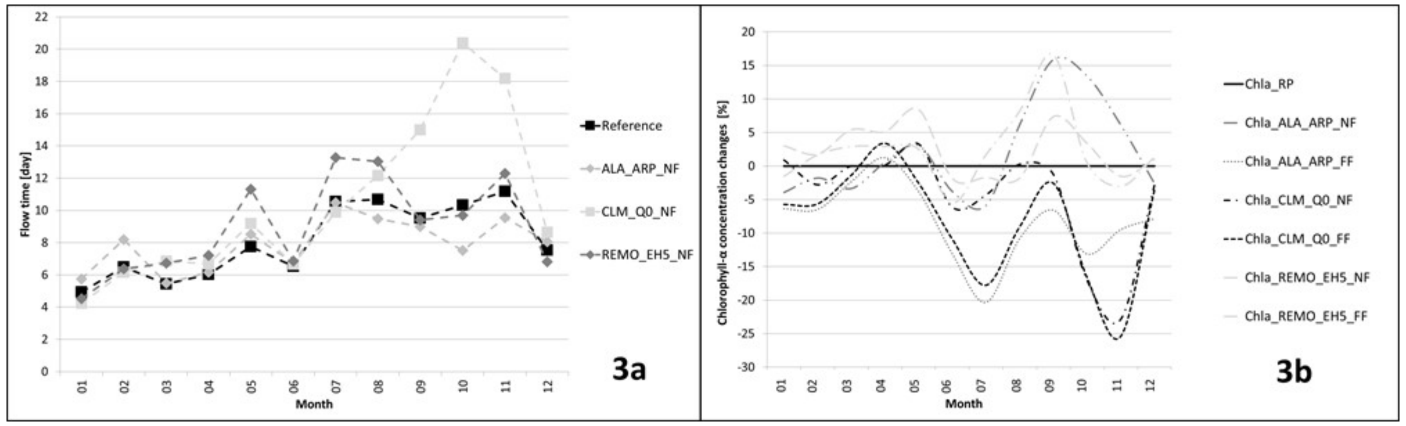

Fig.3a: The average monthly flow time for the model area up to the station Schmilka/Hřensko (km 726) for climate change scenarios in the near future compared with the reference period.

Fig.3b: Projected chlorophyll-a concentration change at the station Schmilka/Hřensko (monthly average)

6. Conclusion

A main question is the reliability of the model results. This model achieves better results by including the predation pressure of Dreissena on the phytoplankton, but it is still only an assumed scenario based on estimated values of the mussel density. We propose an extended measurement campaign to better understand the influence of benthic filter feeders on the phytoplankton development along the Elbe. If only climate scenarios without the other hydrological parameters are used to predict the development of water quality, a large inaccuracy can arise. The socio-economic developments (wastewater from sewage treatment plants and industrial plants, land use) can significantly influence the future quality of river water. Due to these uncertainties, the present results may be interpreted only as possible scenarios for estimating the future evolution of surface water quality.

Acknowledgment

This study was created during the Luboš Mrkva internship at the Federal Institute of Hydrology (BfG). We thank the German Federal Environmental Foundation (DBU) for financing the stay in Koblenz. Input data for model validation and scenario simulations were provided by River Basin Authority in the Czech Republic (PVL, PLA, POH) and Czech Hydrometeorological Institute.

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Water quality and contaminant loads during the extreme low flow of the River Elbe in 2015

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1. Introduction

Extreme low flow events of the River Elbe occurred in the current century in the years 2003 and 2015. During the low flow period in summer and autumn 2015, the "Monitoring Programme for Hydrological Extreme Events of the River Elbe" (MPE) of the River Basin Community Elbe (FGG Elbe) was conducted, coordinated by the Federal Institute of Hydrology (BfG). This programme initiates and compiles more frequent water quality measurements from the co-operating German federal states at several sites of the Elbe and the tributaries Saale, Mulde, and Havel, close to their mouth. A description of the MPE and a compilation of the measured data are available from the information system Undine [1]. Evaluations of the measurements give an overview of water quality and pollutant loads during the 2015 low flow [2]. Pollutant (salt and heavy metals) inputs and loads in the Elbe for the low flow period were compared to measurements during the MPE to investigate the substance-specific importance of tributaries and point sources and to evaluate the monitoring strategy [3]. Here, we present main findings of both studies.

2. Methods

Water quality in the Elbe basin during the 2015 low flow was measured by the MPE (biweekly grab samples from 20. Jul. to 5. Oct.; sampling sites: see Tab. 1) and compared to the reference year 2012 (no noticeable flood or low flow) and to the low flow in 2003 (data from FGG Elbe 2016/17).

In addition to the MPE data, the following data sources were used to calculate the pollutant input and load of the Elbe: • regular water quality monitoring in the Elbe basin from the competent authorities in Saxony, Saxony-Anhalt, Brandenburg and Lower Saxony / • daily mean discharge at gauges of the Federal Waterways and Shipping Administration and from authorities of the federal states /• effluent quality of the wastewater treatment plants at Dresden, Dessau and Magdeburg and of the Zielitz potash plant / • the Pollutant Release and Transfer Register (UBA 2017), disaggregated to daily emissions / • weekly composite water samples of the Elbe at Schmilka, Wittenberg and Schnackenburg (after FGG Elbe 2016/17).

The mean daily load during low flow (MDL_{LF}; period: 20. Jul.-5. Oct.) of the Elbe was calculated on the basis of the daily mean discharge using three different approaches: a) the MDL_{LF} of tributaries and discharges into the Elbe was consecutively added to the MDL_{LF} at Schmilka (calculated after c) and labelled "Accumulated load"; b) calculation of MDL_{LF} of the Elbe on the basis of grab samples (MPE) and c) of weekly composite samples.

3. Water quality

The low flow of 2015 was characterized by high water temperatures, temporarily low oxygen concentrations (above critical level) and elevated values of electrical conductivity. Elevated concentrations of salt-ions (e.g., chloride, Fig. 1), orthophosphate and arsenic (Fig. 2) were measured. In some places, especially in the Elbe at Schnackenburg, also higher concentrations of heavy metals (e.g., copper, Fig. 2) were observed. The supplemental water from Czech reservoirs had a positive impact on the water

River	Sampling site	River-km	Riverside	Reference gauge	Federal State
Elbe	Schmilka (SM)	3,9	right	Schöna	Saxony
Elbe	Wittenberg (WB)	213,8	middle	Wittenberg	Saxony-Anhalt
Elbe	Magdeburg (MD)	318,1	left	MD-Strombrücke	Saxony-Anhalt
Elbe	Cumlosen (CU)	470,0	right	Wittenberge	Brandenburg
Elbe	Schnackenburg (SN)	474,5	left	Wittenberge	Lower Saxony
Mulde	Dessau (DE)	7,6	left	Priorau	Saxony-Anhalt
Saale	Rosenburg (RO)	4,5	right	Calbe-Grizehne	Saxony-Anhalt
Havel	Havelberg (HV)	144,9	right	Havelberg-Stadt	Brandenburg

Tab. 1 *Sampling sites and reference gauges of the MPE*

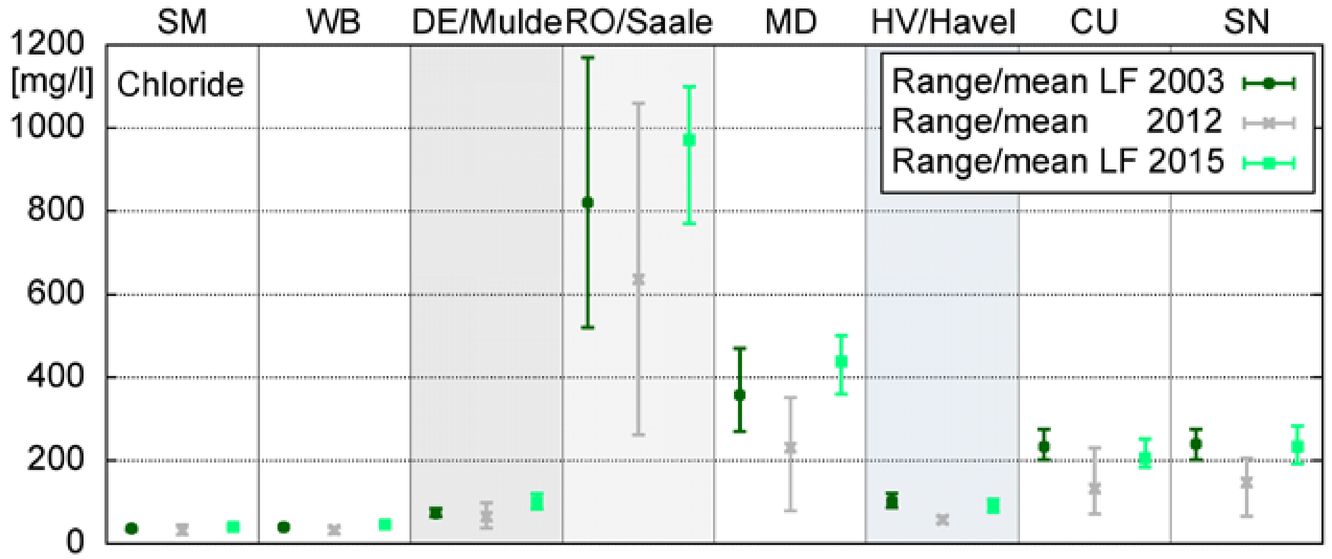

Fig. 1: *Concentrations of chloride in the Rivers Elbe, Mulde, Saale and Havel during the low flow (LF) in 2015, the year 2012, and the low flow in 2003*

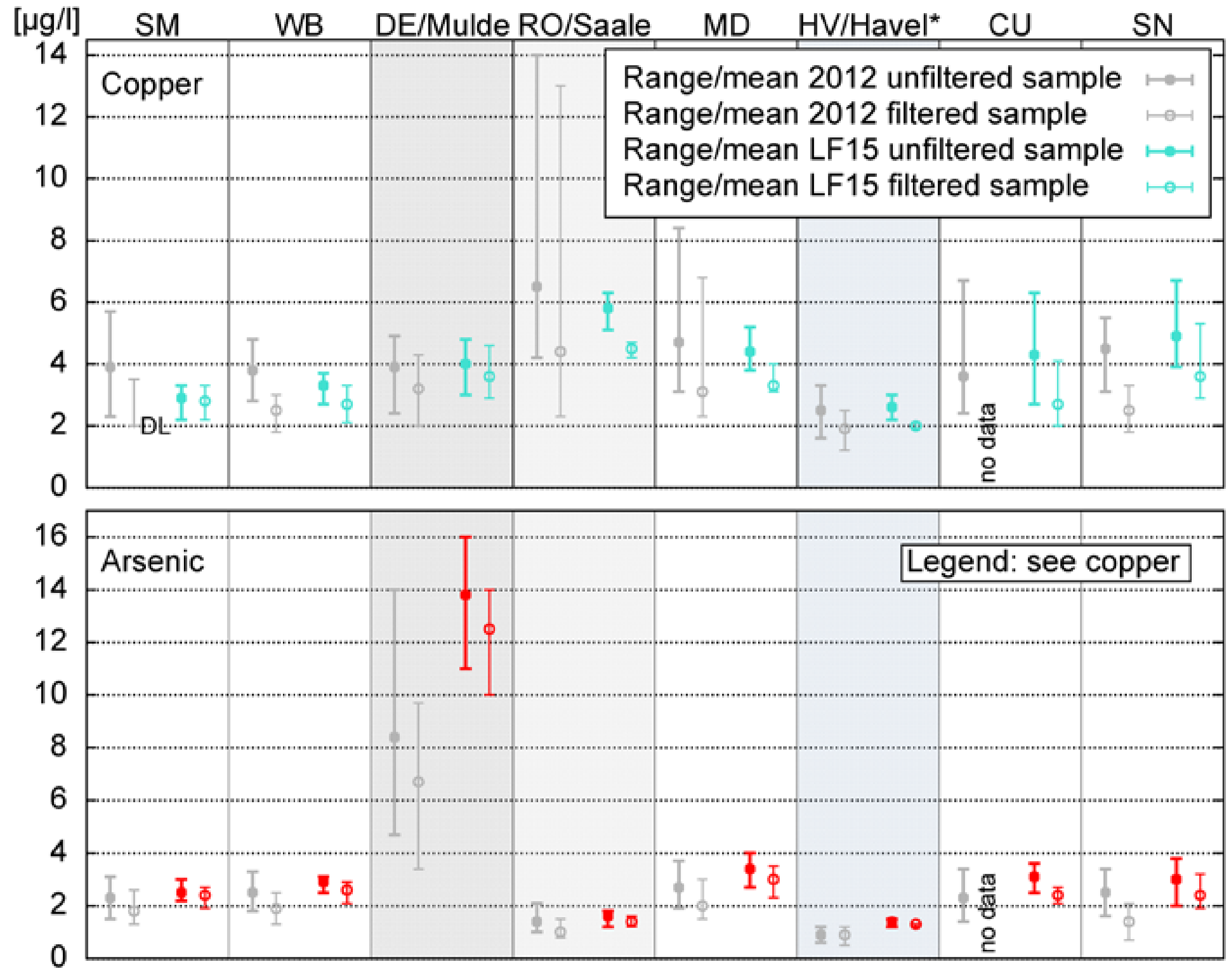

Fig. 2: *Concentrations of copper and arsenic in the Rivers Elbe, Mulde, Saale and Havel during the low flow in 2015 (LF15) and in the year 2012; DL: detection limit; *measuring site 2012: Toppel / Havel*

quality of the Elbe, most notably at the measuring site at Schmilka.

Compared with the low flow in 2003, concentrations of suspended solids were lower in 2015 and corresponding, the concentration of heavy metals and arsenic as a rule was also lower, while the pollution with chloride (Fig. 1) was quite similar.

4. Contaminant loads

There were no large differences between the results of the three differently calculated loads for the measuring sites at Schmilka and Wittenberg (Fig. 3). Depending on the substance, the "Accumulated load" was more (chloride, nickel) or less (copper) similar to the load calculated from weekly composite samples and grab samples at Cumlosen and Schnackenburg. Due to the high sampling frequency it can be expected that the load calculated from composite samples is closer to reality. Therefore, the results suggest that in case of chloride and nickel – in contradiction to the case of arsenic and especially copper – all important sources / inputs have been included in the "Accumulated load".

Loads at Cumlosen and Schnackenburg calculated from the grab samples (MPE) were often lower than the other load calculations (Fig. 3). In particular, small loads at Cumlosen (chloride, copper, and nickel) are probably affected by the tributary Havel, which joins the River Elbe 32 km upstream at the same riverside and discharges only relatively small loads of chloride and heavy metals. Generally, the load calculations highlight the importance of the Saale for the pollution of the Elbe by chloride and heavy metals. Arsenic originated primarily from the Mulde.

5. Conclusion

The MPE yielded useful data for the description and assessment of the 2015 low flow event in the Elbe basin. The approach for load balance calculation during low flow considering point sources and tributaries proved viable. However, for some elements additional information on sources / inputs are needed. To advance the calculation and assessment of the clearly increased loads after the Mulde and Saale confluences and to account for their delayed mixing into the Elbe, MPE needs additional sampling sites at Magdeburg (right side of the river) or Tangermünde. A coordinated Czech – German special monitoring programme for extreme low flows and floods in the Elbe basin would have the potential for even deeper insights into water quality and contaminant transport along the Elbe.

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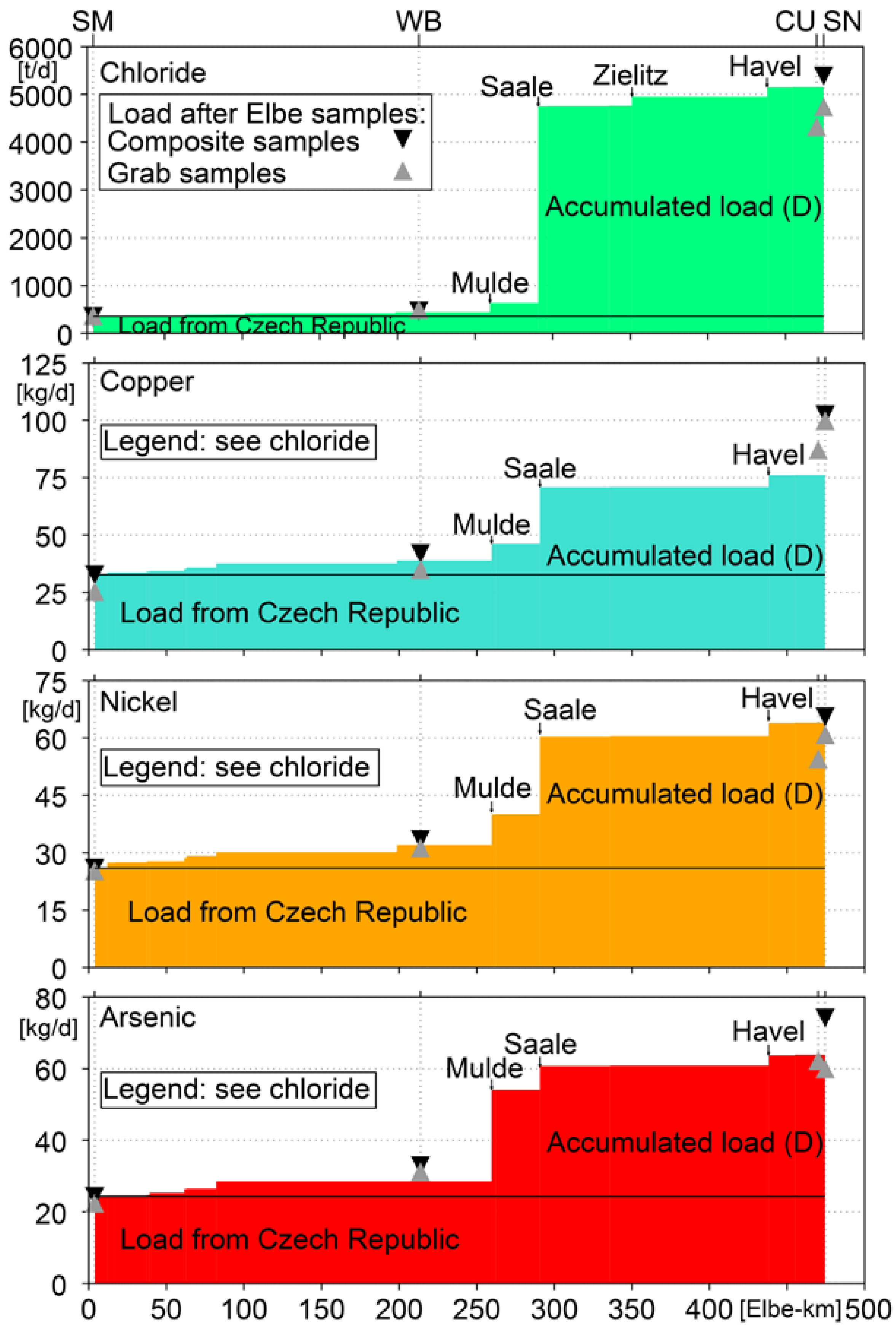

Fig. 3: Mean daily loads of chloride, copper, nickel, and arsenic in the River Elbe during low flow: "Accumulated load" versus load after weekly composite samples and grab samples (MPE) from the Elbe on top of the load from the Czech Republic

Influence of low flows on diversity and recovery of macrozoobenthos communities as one of the components of ecological status assessment according to the Framework Directive

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Povodi Labe, statni podnik

1. Introduction

At the Magdeburg Seminar in 2010 we presented the problem of drying of small and medium streams focused on ecological status assessment. This was mainly the development and recovery of communities after the stressful episodes in streams with the different levels of hydromorphological adjustment.

In years 2014-2016 we met extremely low flow rates even at the large rivers. That is why we are now focusing on several locations on the Elbe River. Again with emphasis on different types of hydromorphological treatments. And also with different proportions of non-native species in the macrozoobenthos community. Here we evaluated the structure of macrozoobenthos community in the minimum summer flowrate period.

Low flow rates produce a number of negative effects on biological components. These influences it usually acts as a complex. It does, however, differ taking into account which stressors predominate. These factors can be divided into three groups and given the most significant.

Physico - chemical factors
Temperature increase
pH and conductivity changes
Oxygen régime changes
Increasing nutrient and pollutant concentrations
Precipitation of metals on the surface of the substrate and organisms
The objective reduction of living space
Reduced number of microhabitats
Reduction of flow velocity
Siltation

Escape reactions of organisms
Direct die-off organisms
Predation increasing
Greater parasite development and easier transmission of diseases

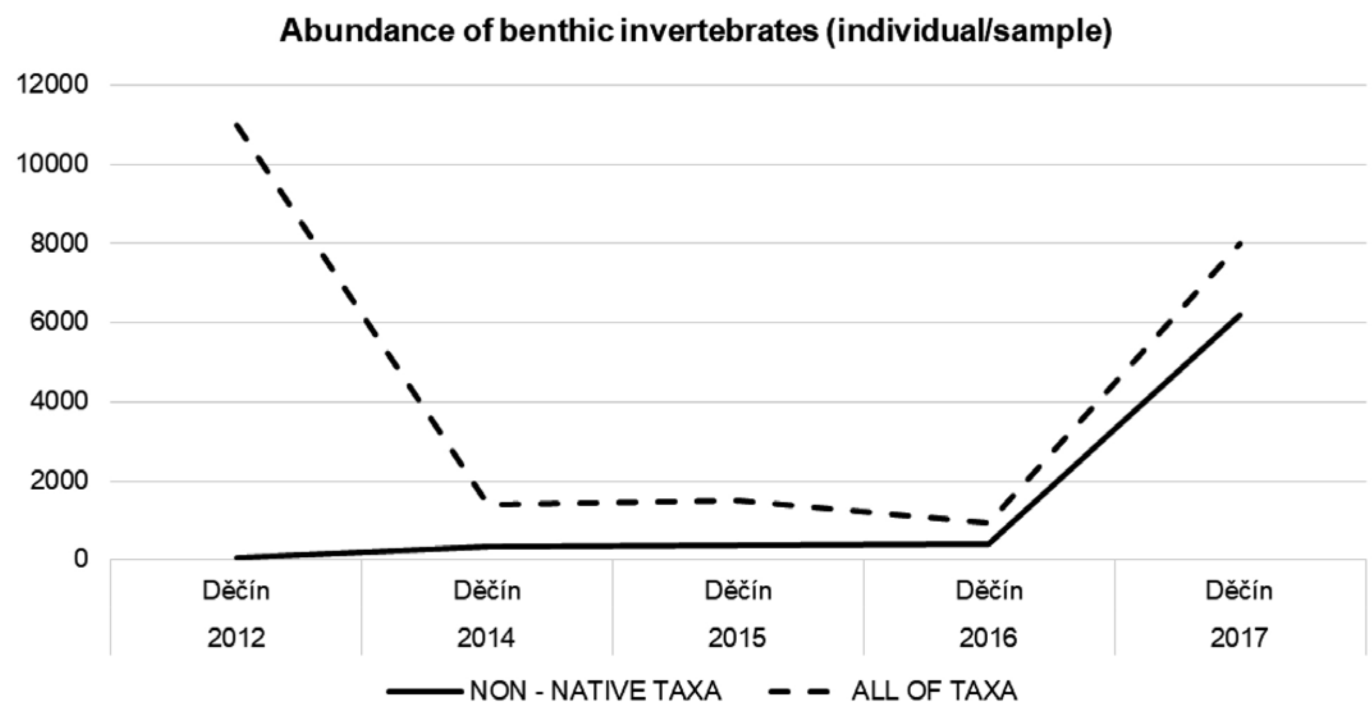

Fig. 1: *Abundance of benthic invertebrates on Elbe River – Decin in summer samples.*

Hydromorphological factors
Flow size
Geological subsoil
Extent, scope and type of anthropic adaptations
Landscape type

2. Metodology and locations

Sampling was carried out at the operational monitoring sites for ecological status assessment. Methodology of sampling and processing of macrozoobenthos samples of large unbearable rivers was used [1]. This methodology was tested in 2012 and has been standardly used since 2014. There was no sampling in 2013, so the data is missing.

Elbe River - Decin and Elbe River - Valy sites were used as examples. These sites differ primarily in the hydromorphological status and the degree of artificial treatment. The Elbe River in Decin is partly natural watercourse with stone and gravel benches. The width of the flow is about 100 m at normal flow rates. The flow width is reduced to about 70 m at low flow rates. The fluctuations in flow rates are high. The Elbe River in the Valy is fortified by a stone throwing and influenced by the drainage of the weir in Prelouc. The flow width is about 60 m, the flow fluctuations are minimal.

Data on the occurrence of invasive round goby Neogobius melanostomus come from visual observation and capture in a sample of macrozoobenthos from the Elbe River - Schmilka, Decin and Lovosice localities.

3. Results

At the time of testing the methodology in 2012, the flows in the Elbe River were normal. Therefore, the number of species and their abundance can be taken as a starting point for comparison. Non-native taxa were found to be only 2 of a total of 38 taxa. Non-native taxa accounted for only 0.6% of total abundance. Since 2014, summer flows have fallen sharply. There has been a decrease in the number of taxa and a strong decline in total abundance at locality Decin. This situation lasted until 2016. In 2017 there is a significant increase in total abundance a number of taxa. There are a total of 51 taxa, which 13 are non-native taxa. Non-native taxa already account for 77.5% of total abundance Fig.1, 2.

There are no significant fluctuations in the Valy site, and the community is not significantly affected. From 2012 to 2016, the community is stable. In this period, the abundance of non-original taxa accounts for a maximum of 22.5% of total abundance. In 2017 there is an increase in abundance, the total number of taxa and the number of non-native taxa. The abundance of non-native species is 51% of total abundance Fig.3, 4.

Population dynamics of the round goby Neogobius melanostomus is interesting. This species was found in the Czech Republic for the first time in 2015 near Usti nad Labem [3]. In our samples, one individual in Lovosice collected in 2016. In 2017 a total of 5 individuals were found in Lovosice and Děčín. In 2018 this species is already common in the localities of Schmilka, Děčín and Lovosice (more than 200 individuals on the sampling sites).

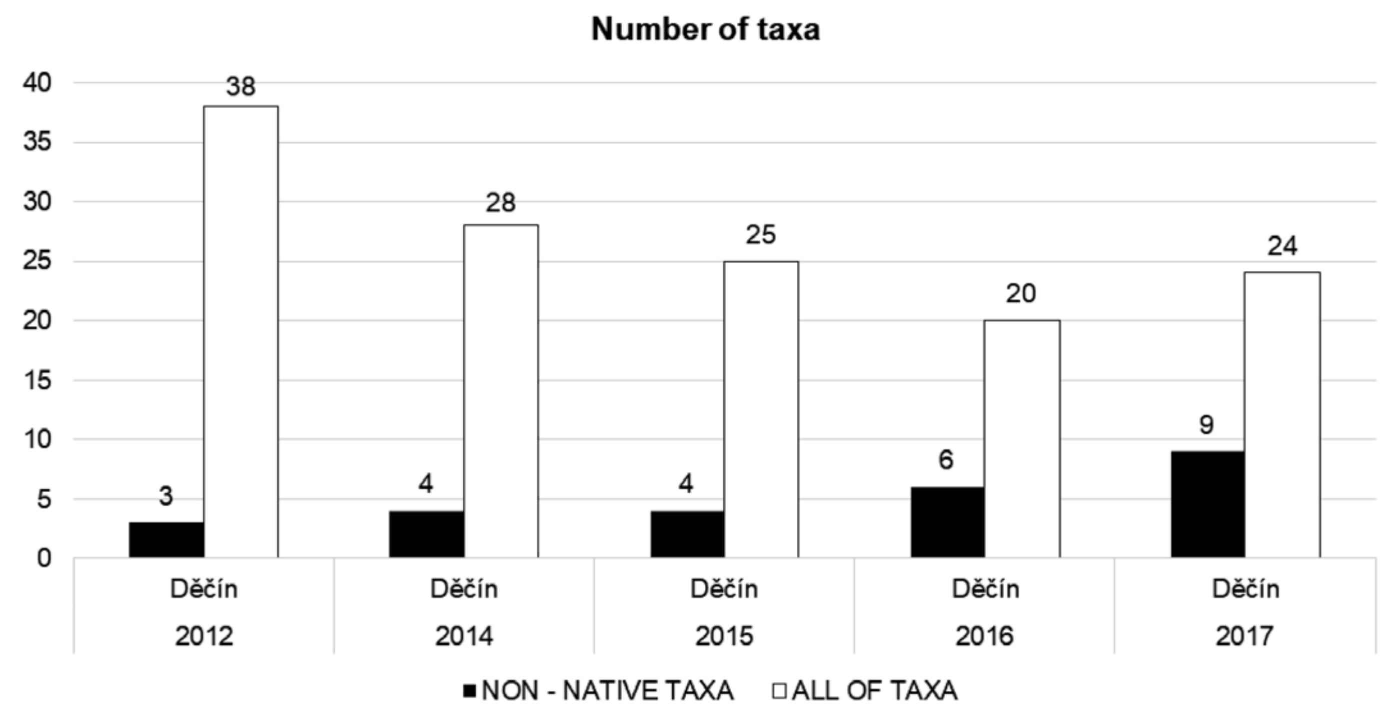

Fig. 2: *Number of benthic invertebrates taxa on Elbe River – Decin in summer sample.*

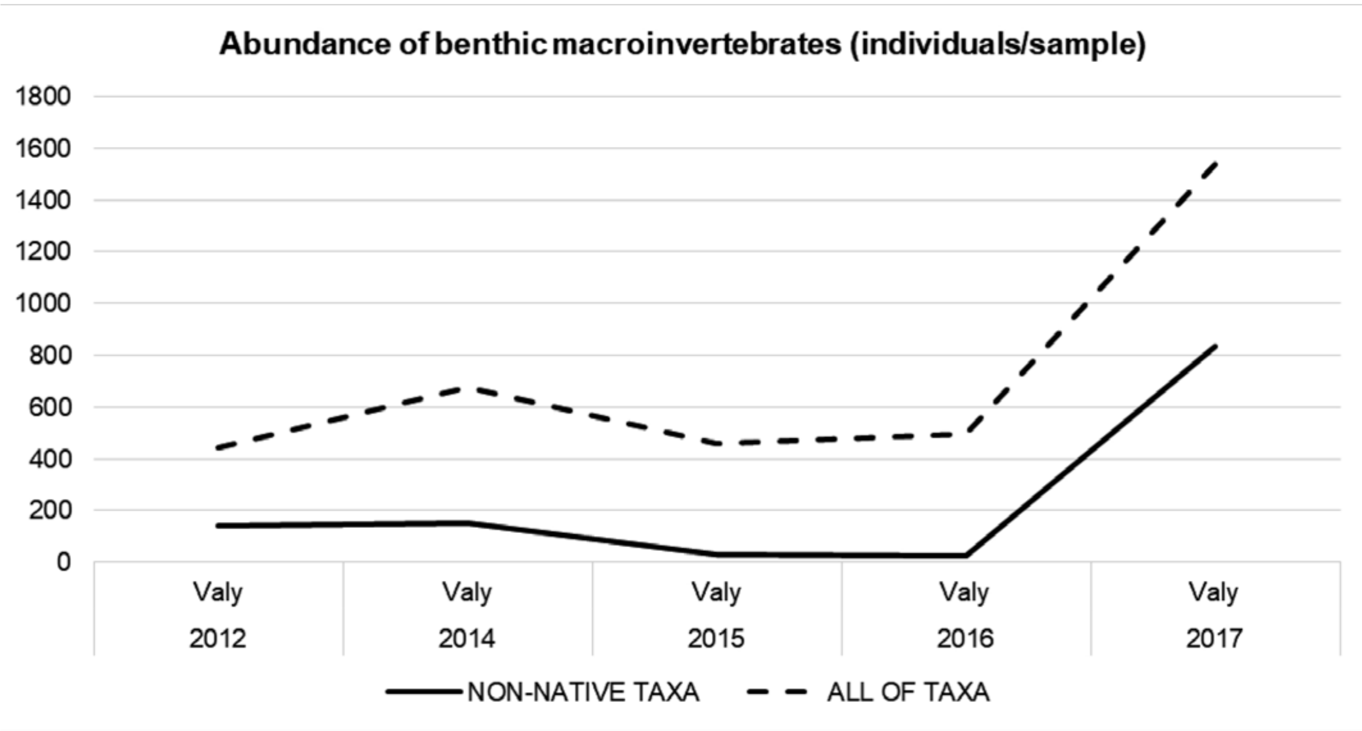

Fig. 3: *Abundance of benthic invertebrates on Elbe River – Valy in summer samples.*

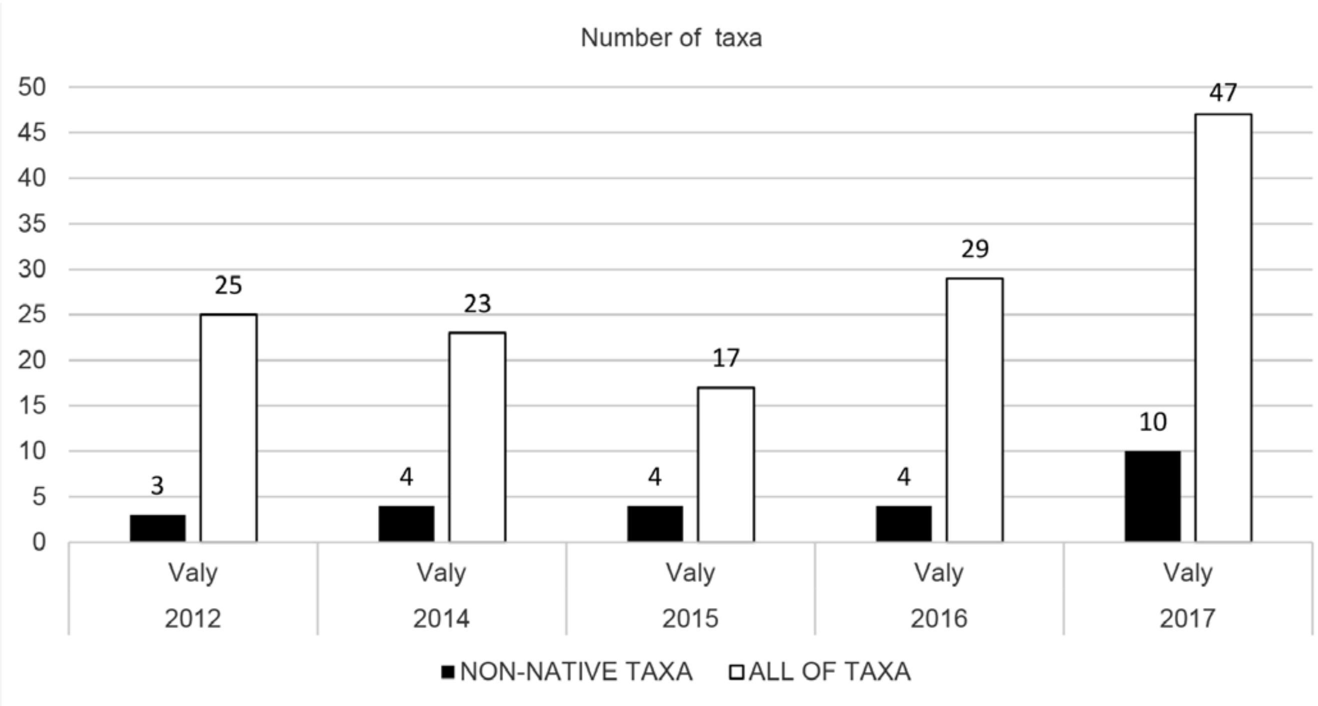

Fig. 4: *Number of benthic invertebrates taxa on Elbe River – Valy in summer samples.*

4. Summary

Low flow rates on large streams have a negative impact on aquatic organisms. However, this impact differs with regard to technical adjustments to flows, intensity of level fluctuations and the presence of non-native species. After periods of low flow rates, the number and abundance of non-native species will increase so that they will largely or completely change the original community. This will negatively affect of the ecological status assessment.

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Requirements for mine flooding / water treatment at low water discharge - Case Study of mine Schlema-Alberoda / Wismut GmbH

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Wismut GmbH

1. Introduction

In the early 1990s the Mulde river was already recognized as a polluted tributary of the Elbe river. Until now, it has been remaining an important nationwide source of surface water contamination, especially for heavy metals and arsenic. Main causes for the pollution are geogenic contributions from the catchment area together with extensive, centuries-old contributions from ore mining and processing activities. After the termination of most of the mining activities in 1990, the Wismut GmbH started mine closure and remediation of dumps and processing sites. The work continues to date and some of the activities are long-term tasks, e.g. the water treatment.

2. Remediation site Schlema-Alberoda

Within the catchment area of the Mulde the mining and remediation site Schlema-Alberoda with the correspondent uranium mine is one of seven remediation sites of the Wismut GmbH (Fig. 1). The mine Schlema-Alberoda has been, with a meanwhile flooded underground cavity of 35 million m³, the largest mine in the Erzgebirge. Between 1946 and 1991 about 80,000 tons uranium from depths up to 1,800 m were mined. In total, 80 shafts, 62 levels, 4,200 km mine galleries [1], large-scale complex dumps and one tailing pond arose over an area of about 10 km².

3. Mine flooding

After decommissioning the mine was flooded in a controlled manner between 1991 and 2007. Due to increased concentrations of uranium, radium, arsenic and iron, the flooding water can´t be discharged directly into the receiving water (Fig. 2). The flooding water level, maintained at a level below the hydraulic overflow into the river Zwickauer Mulde, depends on the natural, meteorologically influenced water inflow to the mine area. It is controlled by the management of the mine internal working and buffer storage system (volume 0.5 million m³) considering of the hydrological and the procedural requirements of the water treatment plant (WTP) Schlema-Alberoda.

4. Water treatment

The flooding water passes through the largest WTP of Wismut GmbH, with a maximum capacity of 1,200 m³/h, built in 1998 (unit 1) and extended in 2002 (unit 2). Since 2005, the treatment technology is based on modified lime precipitation. The output of the WTP is regulated by a water permit. While the limit values of the WTP emissions for pH, uranium, radium, iron, manganese, sulfate and chloride are independent of river flow rate, the residual arsenic concentration or load depends on the respective discharge rate of the river Zwickauer Mulde (Table 1, 2). The mean residual emissions of WTP Schlema-Alberoda amount to 0.13 mg/l for uranium and 64 µg/l for arsenic (2017).

For management of the residual contaminated water flows mean and primarily low river discharges are significant. Below the long-term mean discharge of the Zwickauer Mulde (12.6 m³/s) increased attention is required to avoid unfavourable mixing ratios between river and treated water. In dependence of the river discharge, the flow rate of treated water and its residual arsenic content must be adapted. In case of a mean low water discharge below 4 m³/s, only the arsenic load is to be adhered.

Fig. 1: Positions of remediation sites and treatment plants of Wismut GmbH in relation to water bodies of the Elbe catchment area

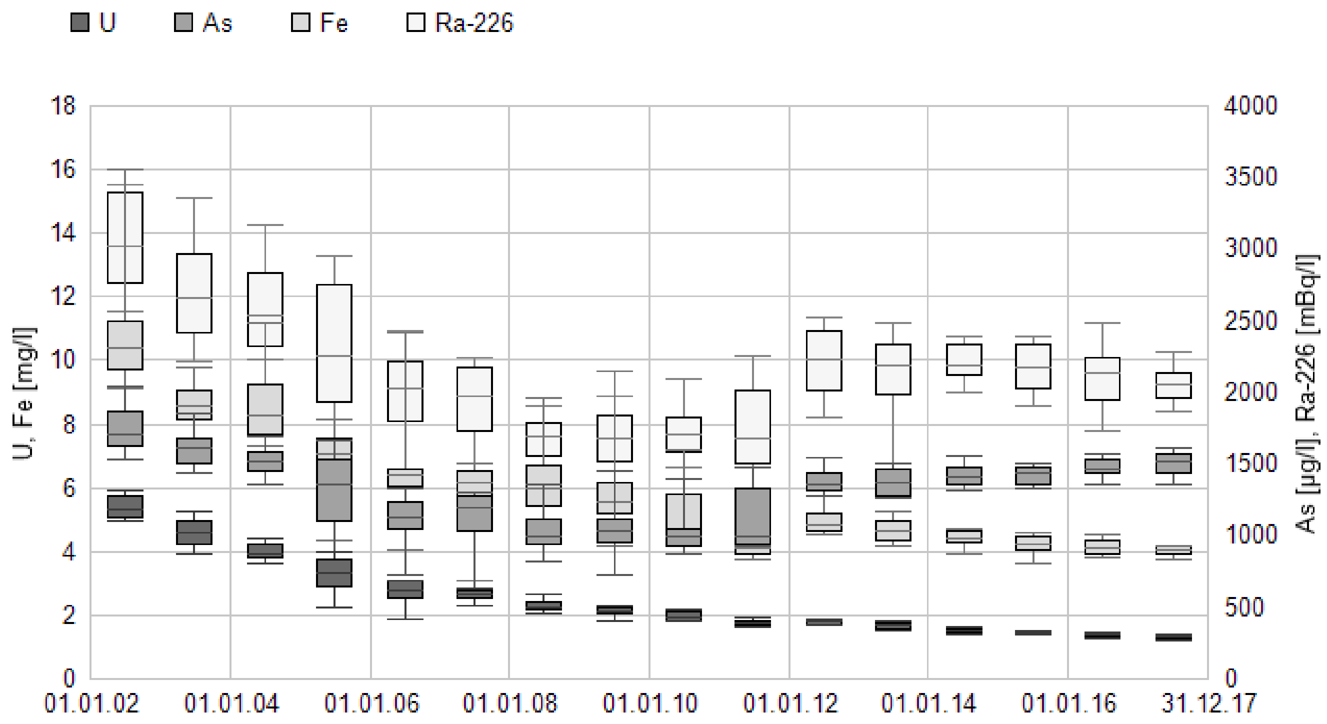

Fig. 2: Concentrations of mining related parameters in flooding water at site Schlema-Alberoda since implementation of the 2nd plant unit

pH	Filterable solids [mg/l]	Fe [mg/l]	Mn [mg/l]	SO_4 [mg/l]	Cl [mg/l]	U [mg/l]	^{226}Ra [mBq/l]
6.5 … 8.5	20	2	3	2,500	1,000	0.5	400

Table 1: Flow rate-independent limits for WTP Schlema-Alberoda

Gauge Niederschlema / Zwickauer Mulde [m³/s]	Discharge of WTP Schlema-Alberoda [m³/h]	Arsenic concentration of WTP [mg/l]	Arsenic load of WTP [g/h]
> 10	1,200	0,3	-
7 … 10	1,200 / 750	0,2 / 0,3	-
4 … 7	1,200 / 750 / 500	0,1 / 0,2 / 0,3	-
3 … 4	1,200	-	84
< 3	800…1,200	-	56

Table 2: Flow rate-dependent limits for arsenic for WTP Schlema-Alberoda

5. Influence on the Zwickauer Mulde River

The long-term average annual flow is undercut especially in the summer months. In spite of slightly above-average annual precipitation, less than 10 m^3/s was discharged on approx. 200 days and less than 7 m^3/s on approx. 100 days in 2017. At 18 days, less than 4 m^3/s was recorded (Fig. 3).

The volume of flooded water pumped and treated in WTP Schlema-Alberoda varies mainly between 500 and 800 m^3/h. Its proportion of the Zwickauer Mulde discharge is in the range of 1:50 to 1:150, but may increase to 1:20 in the summer months (Fig. 4).

In addition to the outflow of the WTP, further substance emissions from rehabilitated dumps, the separate mine Schneeberg (pronounced arsenic point source) and historical mining and ore processing contribute to the water quality of the receiving waters [2]. For the substantial contaminants arsenic and uranium, this influence on the Zwickauer Mulde depends on the flow rate, partially already in the upper reaches (Fig. 5).

On days with discharge below 4 m^3/s, the arsenic load remains below the required limit, because the arsenic effluent values are significantly below 0.1 mg/l. Measured by the load difference before/after the remediated area in low-discharge periods, the arsenic content from the water treatment remains largely constant.

In the suspended matter the combined influence of historical mining objects, former ore processing sites and remaining influences of remediated objects and water treatment are detectable as well. Increased concentrations of arsenic and non-ferrous metals such as copper and nickel are already present in the upper reaches of the Zwickauer Mulde. During the passage of the described river section, the element uranium passes into the phase of particulate matter [2].

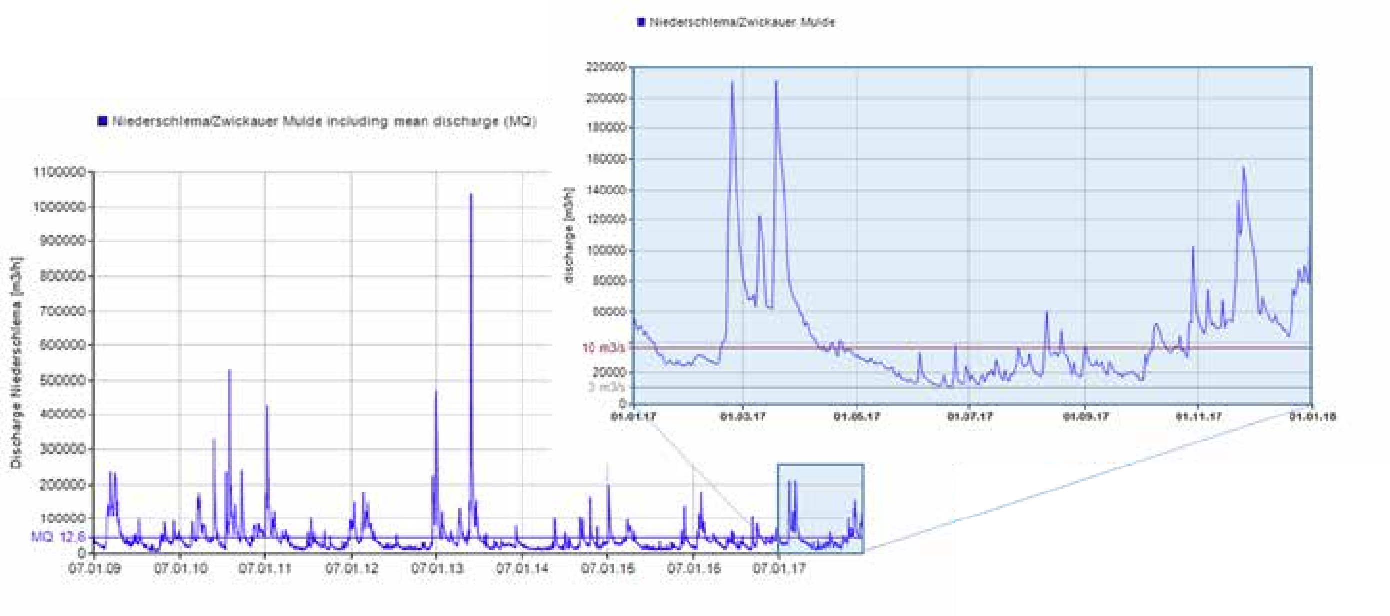

Fig. 3: Discharge of Zwickauer Mulde at gauge Niederschlema, with year 2017 in detail

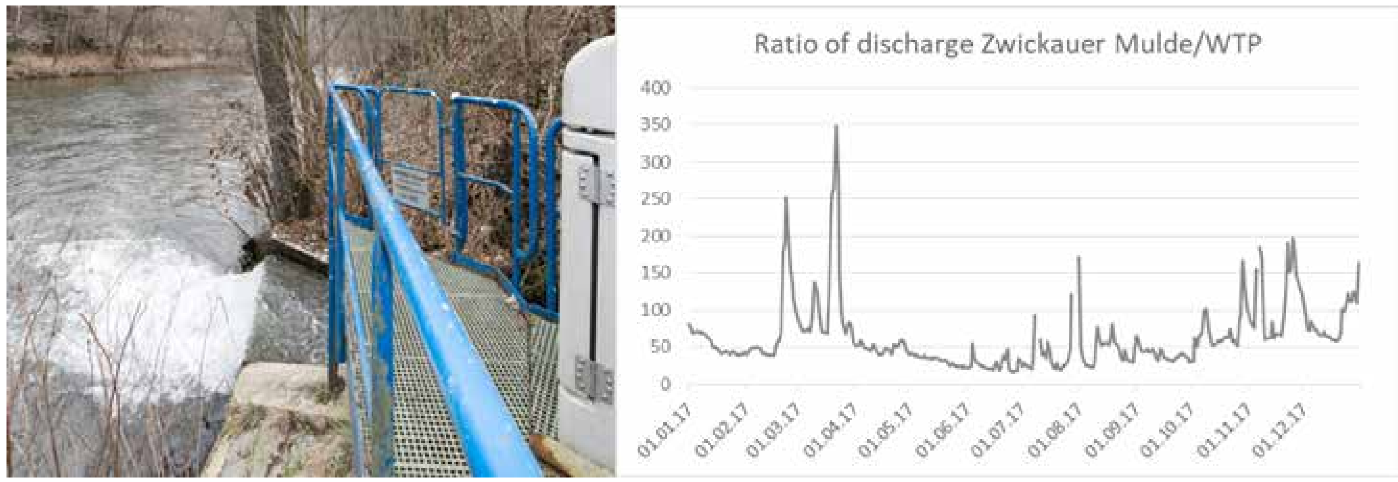

Fig. 4: Discharge of treated water into the Zwickauer Mulde (left, picture from 17.03.2017, outflow of WTP appr. 900 m3/h) and the relation of Zwickauer Mulde and WTP Schlema-Alberoda discharge in 2017 (right; ratio appr. 1:70 at 17.03.2017)

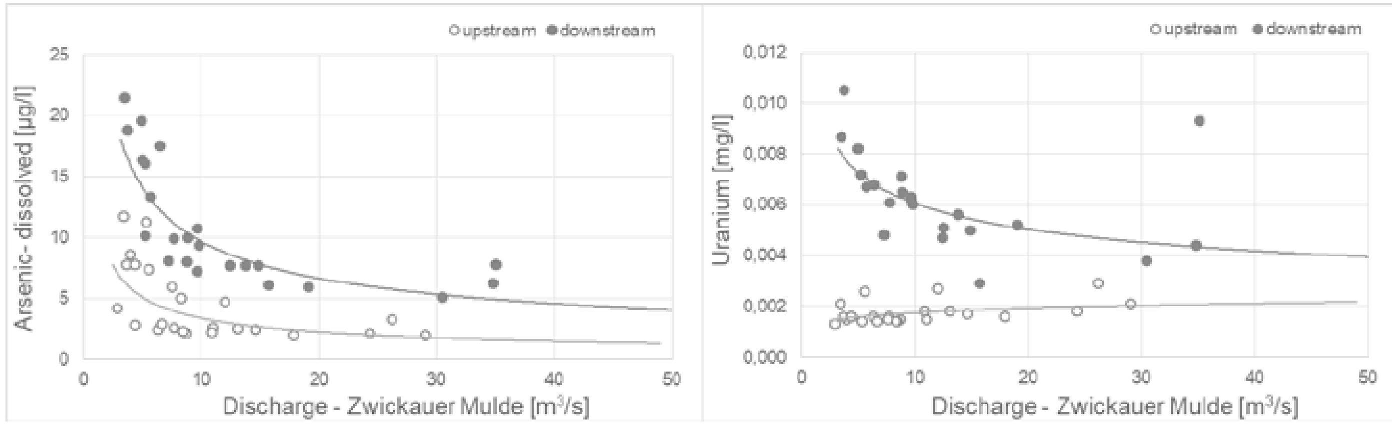

Fig. 5: Relation between As-/U-concentrations and discharge of the Zwickauer Mulde upstream and downstream of the Wismut remediation site Schlema-Alberoda (2017)

6. Summary

The water treatment plant Schlema-Alberoda removes uranium from the system in the dimension of about 7 t/a and arsenic of about 8.5 t/a (2017). Directly at the pollutant source this treatment measure represents a significant and indispensable contribution to the pollutant reduction in the Elbe river system. The residual emissions from the water treatment inevitably lead to an increase of uranium and arsenic concentrations within the receiving water. However, the water quality can be influenced positively due to limited arsenic loads during periods of low water level.

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Drought and its influence on water quality in water reservoirs

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Povodí Vltavy, státní podnik

1. Inflows

Each reservoir forms an integral part of its drainage basin. Therefore, when considering the impacts of dry weather on reservoirs, it is necessary to pay attention to processes in the streams in their watershed. What was detected during dry years [1]?

Much lower content of humic substances i.e. much better conditions for drinking water reservoirs. Water treatment became less difficult and drinking water was of better quality (esp. Římov Reservoir, Fig. 1, Lučina Reservoir).

Decreased concentrations of nitrates i.e. much lower input of nitrates into the reservoir. This seemingly positive phenomenon in the case of the most of the reservoirs in the Czech Republic means also a lack of very important buffer of redox conditions esp. on the water/sediment interface. Phosphorus compounds are more susceptible to be released from sediments into the water column during anoxic period. Such internal loads could be of great importance (1) in the most eutrophied shallow upper layers of the reservoirs and (2) near the dam from where the water discharged – i.e. phosphorus is carried downstream.

Considerably worse water quality downstream point pollution sources as wastewater was less diluted. This applies to phosphorus, too, but it could be compensated by the self-purification processes in the streams. The role of biota in self-purification was largely enhanced by slower flows and higher ratio of inhabited bottom surfaces and water volume over the bottom. Naturally, good hydromorphology and rich hyporheic habitat could potentially intensify P retention. We confirmed that in drainage basins where P sources were located in upper parts (far above the reservoir) P concentrations in the inlet were lower compared with other years. And vice versa: when a P point source was near the reservoir, the P content in the inflowing water was higher.

2. Reservoirs

Behaviour of water reservoirs is always a complex answer to various factors. Therefore, the following influences could be manifested differently by different reservoirs.
Much lower loads of phosphorus, the key nutrient. Reduced P supply in the inlets provides a generally good chance for reaching better eutrophic conditions in a reservoir. This usually applies to the lower parts of (esp. canyon-shaped) the reservoirs (reservoirs Želivka, Orlík, Hracholusky), but the upper parts are regularly in a worse condition with more intense water bloom in dry years.

Dry years are also characterised – along with longer theoretical water residence time - by **more stable thermal stratification** as a consequence of sunny warm weather during the summer. Stable stratification causes stronger oxygen deficits (Fig. 2) and, therefore, higher risk of internal P loading esp. when there is lack of nitrates. Moreover, this phenomenon is more pronounced in dry years due to longer duration of the stratification (autumnal mixing takes place later). This internal loading could (1) enhance late summer cyanobacterial blooms (*Woronichinia naegeliana* is more and more common) and/or (2) enhance phytoplankton generally - particularly in shallower upper parts which are closer to the water surface due to the drop in the water level and (3) considerably worsen eutrophication (cyanobacterial blooms) in the case of shallow reservoirs with sediments rich in P (e.g. the České údolí reservoir, fishponds).

3. Conclusions

In majority of reservoirs, dry years increased susceptibility to phosphorus inputs. Therefore, measures aimed on to considerably reduce phosphorus emissions (in the CR these are predominantly point sources) are urgently needed along with measures supporting phosphorus retention in natural ecosystems (esp. improved hydromorphology of streams).

Dry years may often induce less efficient phosphorus retention in reservoirs (and in thousands of fishponds, too). More intensive transport of phosphorus through drainage basins may have possible negative consequences for the general level of eutrophication of not only inland, but also brackish and coastal water.

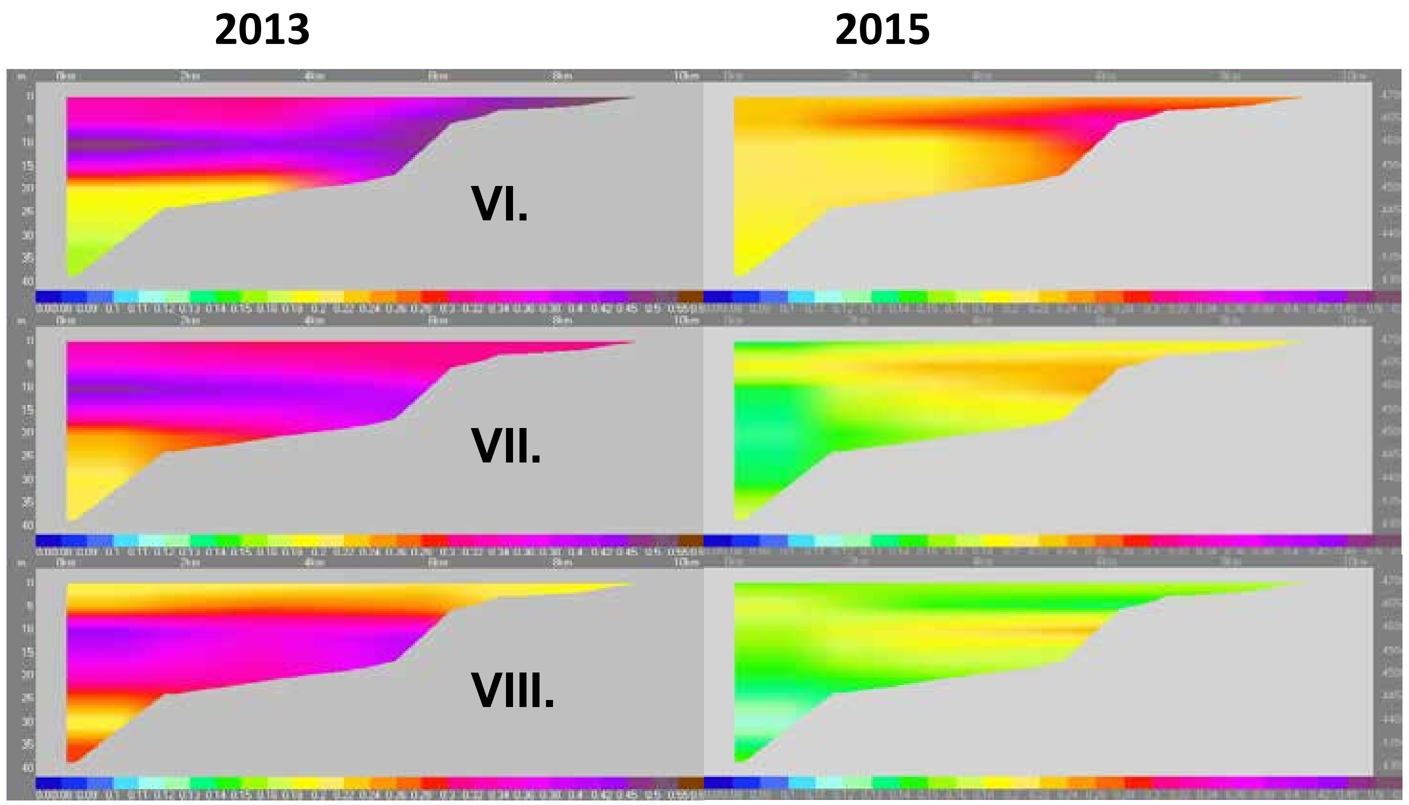

Fig. 1: *Difference between water rich (2013) and dry (2015) year in concentrations of humic substances. Římov Reservoir, absorbancy 254 nm*

Literature:
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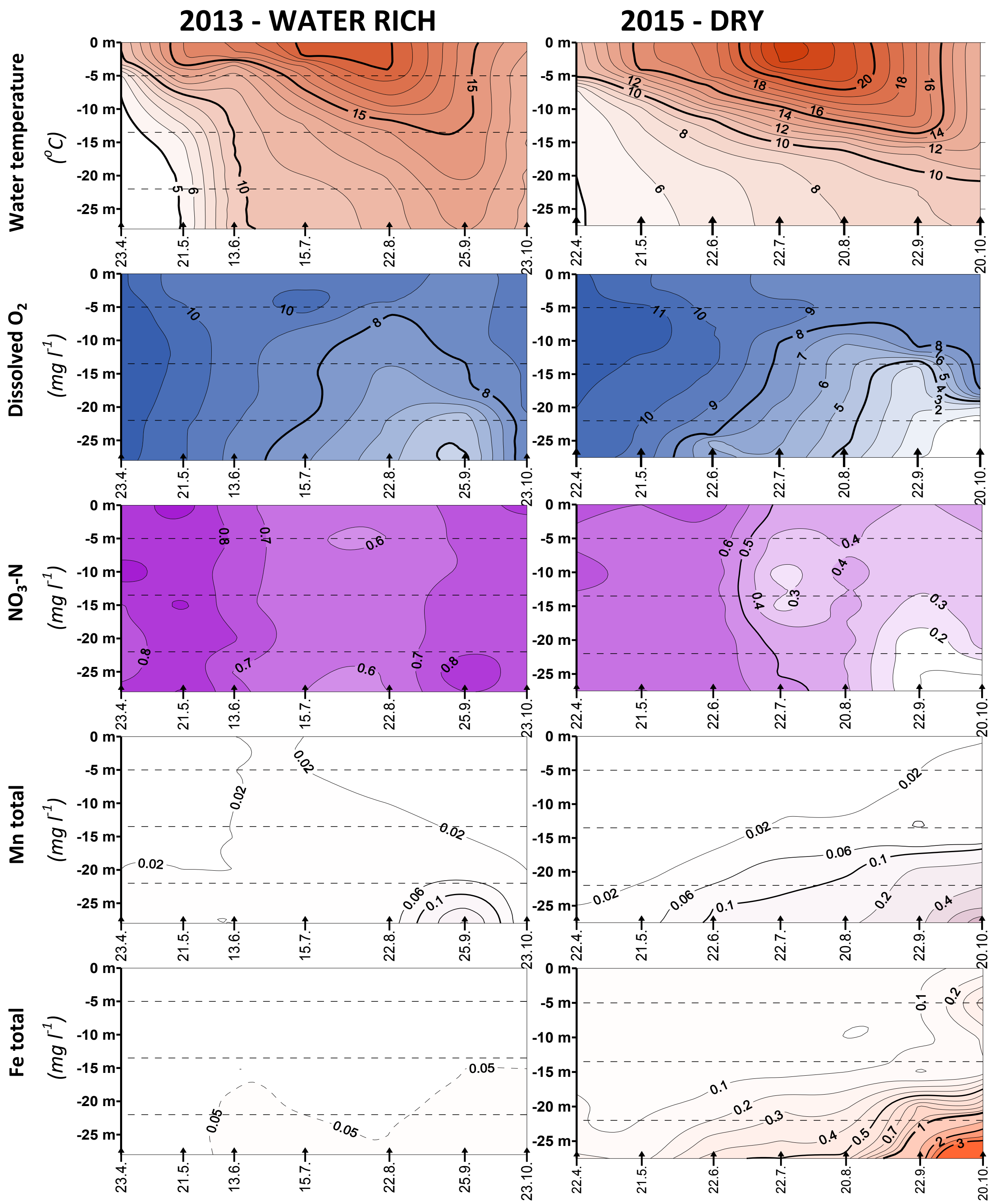

Fig. 2: *Difference of thermal stratification and stratification of some important parameters during water rich (2013) and dry (2015) year. Drinking water Nýrsko Reservoir. Apparent tendency to oxygen and nitrate depletion appeared in the end of Summer with consequent release of Mn and especially Fe from sediments. Thid phenomenon is risky not only for the reservoir itself, but for outflowing water, too.*

Small water reservoirs in a dry landscape - what benefits can they provide?

Luboš Zelený, Jindřich Duras, Michal Marcel
Povodí Vltavy, státní podnik

1. Introduction

In relation to our drying landscape, the importance of constructing water reservoirs that will contribute to water retention is often discussed. An interesting view is provided when dealing with the water quality. With respect to this, we are faced with the fact that if a water reservoir is to be constructed in a degraded area where municipalities have not resolved the issue of wastewater treatment, where the watercourses are straight and deepened and where agricultural land is cultivated to the very banks of the local streams, the benefits of the reservoirs can be expected to be limited and their full potential will not be fully utilised. The water reservoirs should then be optimally viewed as part of the overall land reclamation. The authors of this paper intent to illustrate this situation using the example of the Rakovnický and Kolešovický river basins.

The Rakovnický river basin is an area which is increasingly affected by hydrological drought. According to Matoušková [1], the total rainfall does not change but its distribution during the year changes, which leads to continuous temperature rise and flow-rate reduction. This is probably due to major changes in the land caused by human activities over the past 200 years, and at the same time due to the present climate changes. One of the many method of improving the whole situation is to efficiently retain water in the land, i.e. along the entire river basin. It is also necessary to make fundamental changes, especially directly in the watercourses and in their floodplains.

In the past, a number of studies and projects were carried out in the Rakovnický river basin which concerned drought and its impacts on the landscape, water management or human relationship to the relevant area. What is worth mentioning is, for example, the study by Matoušková [2], which showed than half of the Rakovnický river is strongly affected by human activities (hydro-melioration, river bed straightening or deepening). Between 2009-2011, the project titled "Possibilities to mitigate the current effects of climate change by improving the storage capacities in the catchment area of the Rakovnický river" was implemented within the Agrarian Sector Research Programme. The pilot project [3] was implemented by T. G. Masaryk Water Research Institute, public research institution, and the Czech University of Agriculture in Prague. The main objective of the project was the develop a methodology for proposing measures that will increase the amount of usable water in the river basin, thus reducing the current and future impacts of climate change on the landscape. The above study indicates that the most effective measures to improve water storage in the river basin include the construction of storage reservoirs, the main purpose of which is to improve the flowrates in the watercourses downstream, in particular the Rakovnický river in the Rakovník region.

Povodí Vltavy, state enterprise, followed up on the T. G. Masaryk Water Research Institute's pilot project by commissioning a Feasibility Study related to the water reservoirs in the Rakovnický river basin, which was developed between 2013-2014. The study was developed by Vodohospodářský rozvoj a výstavba, a.s. The study was drawn up in two stages. The first stage focused on assessing the feasibility of water reservoir construction in the relevant area from the point of view of ownership relationships, land-use planning documentation, limits of the relevant area and technical infrastructure networks. The first stage resulted in the identification of such localities that meet the conditions for the implementation of the proposed water reservoirs (WR). A total of eight potentially suitable localities were selected, out of which the preparatory work continues in two of them. On the basis of Decree No. 171 of the Government of the Czech Republic dated 29th February 2016, Povodí Vltavy subsequently developed an investment plan for the preparation and implementation of two water reservoirs, Šanov and Senomaty, in the Rakovník region.
The latest study [8] is focused on the proposal for nature-friendly measures in the Rakovnický and Kolešovický river basins, namely in the catchment areas of the newly proposed water reservoirs Šanov and Senomaty. This paper concerns these storage reservoirs.

2. Exploratory monitoring in the Rakovnický and Kolešovický river basins

Exploratory monitoring in the Rakovnický and Kolešovický river basin was focused on water quality. The monitoring was proposed and implemented by Vodohospodářská laboratoř Plzeň, Povodí Vltavy, state enterprise. It included 5 samplings during 2016 (from August to December) and twelve samplings during 2017, in regular monthly intervals. The sampling profiles were chosen so that the influences of the various stretches of the river basin could be well specified. Based on the experience from 2016, the network of monitoring profiles was modified for 2017. The exploratory monitoring continues in 2018 but the data is not included in the provisional results.

profile number	stream	Profile	year of monitoring
1	Rakovnický river	Velký rybník lake downstream	2016, 2017
2	unnamed tributary	Dolní Fikač lake, water level	2016
3	Kosobodský river	Kosovna stop	2016, 2017
4	Leština	Oráčov	2017
5	Rakovnický river	Hopfův mlýn mill	2016
6	Rakovnický river	Pšovlky upsteamn	2016
7	Rakovnický river	Pšovlky downstream	2017

Tab. 1: *Sampling profiles in the Rakovnický river basin (Šanov WR)*

The monitored water quality parameters were selected so that water quality forecasts in the proposed water reservoirs could be made while, at the same time, specifying the sources of pollution and subsequently proposing improvement measures. Measurements of pH, water temperature, conductivity, dissolved oxygen and oxygen saturation were measured in the field. Laboratory analyses focused on biochemical oxygen demand (BOD), chemical oxygen demand by dichromate (COD_{Cr}), suspended solids at 105 °C (SS-105), suspended solids at 550 °C (SS-550), total phosphorus (P_{total}), phosphor phosphates ($P\ PO_4$), ammoniacal nitrogen ($N\text{-}NH_4$, nitrite nitrogen ($N\text{-}NO_2$), nitrate nitrogen ($N\text{-}NO_3$), total nitrogen (N_{total}), thermo-tolerant coliform bacteria (FKOLI). In 2017, flow measurement using Flow Tracker was made in parallel with sample taking where enabled by the condition of the river bed and character of the watercourse.

3. Results (the Rakovnický river basin - future Šanov WR)

At the beginning of the project, the network of sampling profiles was very dense but based on later findings the number of sampling profiles was significantly reduced to just 3 regular sampled profiles (Tab. 1. The result must be assessed by taking into account that the year 2016 (and part of 2017) were very dry and also preceded by two very dry years (2014 and 2015). Dry years generally mean a greater impact of point sources of pollution and, at the same time, low flow-rates result in more intensive self-cleaning processes and therefore the effects of point sources upstream the river basin usually weakens [4].

Average concentrations of organic matter in the inlet profile of the planned water reservoir were detected to be low (BOD 1.9 mg l^{-1} and COD_{Cr} 16 mg l^{-1}) and NH_4N concentrations were also relatively low (0.12 mg^{-1}). This means that there will be no direct risk to the oxygen regime in the intended reservoir. The average concentrations of phosphorus compounds in the Pšovlky profile are relatively low and correspond to more or less unpolluted river basins: P_{total} at 0.056 mg l^{-1} and $P\text{-}PO_4$ at 0.02 mg 1^{-1} (Figure 4). The value of 0.05 mg l^{-1} P_{total} is considered under Czech law (Government Decree No. 401/2015 Sb.) as the maximum permissible level in inflows to recreational lakes used for bathing.

From the point of view of risk assessment related to the evolution of eutrophication effects in stagnant water, it is important to consider not only the average concentrations of $P\text{-}PO_4$ and P_{total} (Figure 4), but mainly the so-called "specific phosphorus intake", i.e. P inflow from the river basin per year/ 1 m^{-2} of the storage reservoir surface This is the procedure according to Vollenweider [5]. According to the obtained data (Q = 0.069 m.s^{-1} and average concentration of P_{total} = 0.056 mg l^{-1}) the total phosphorus input is ~ 122 kg per year, i.e. only 0.5 gm^{-2}year^{-1}. This is a relatively low value, which guarantees a quite good water quality during long retention times (at Q in 2017 => ~ 95 days).- a weak eutrophicity, probably without cyanobacteria, water flowers, or with a low intensity of their growth Taking into account the higher water yield of the Rakovnický river in a year with a higher rainfall (Q = 0.1 m^{3}s^{-1}) and the higher

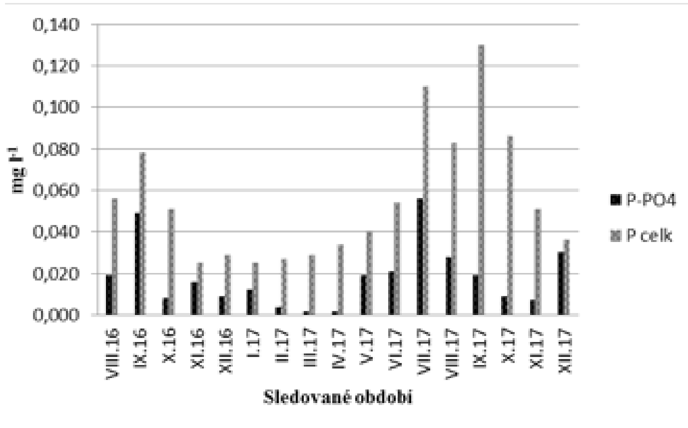

Fig. 1: *Šanov water reservoir - seasonal concentrations of P-PO4 and Ptotal over the monitored period in the closing profile*

content of phosphorus (P_{total} = 0.1 mg l^{-1}), it would total 315 kg P, i.e. ~ 1.4 g m^{-2}.year^{-1}conveyed to the Šanov water reservoir. Even this value can still be viewed as acceptable, the water in the reservoir would correspond to a standard eutrophic lake.

4. Results (the Kolešovický river basin- future Senomaty WR)

After evaluating the results obtained from the monitoring conducted in 2016, when a high degree of pollution of all surface water was detected, the monitoring was much denser in 2017 (Tab. 2) because it was necessary to determine the proportion of pollution coming from the individual sources.

The drought, typical of the evaluated years, could not be reflected in strong effects of self-cleaning processes on the water quality [4] in the Kolešovický river basin with

profile number	stream	Profile	year of monitoring
1	Kolešovický potok	Prison Oráčov downstream	2017
2	unnamed tributary	Čížkov lake downstream	2017
3	Kolešovický potok	Zderaz downstream	2017
4	unnamed tributary	Kolešovice upstream	2017
5	Kolešovický potok	Kolešovice upstream	2016, 2017
6	Kolešovický potok	Kolešovice downstream	2016, 2017
7	unnamed tributary	Chrášťany	2017
8	unnamed tributary	Kněževes upstream	2016, 2017
9	unnamed tributary	Kněževes upstream WWTP	2016, 2017
10	unnamed tributary	Kněževes downstream	2016, 2017
11	unnamed tributary	Hořesedly	2017
12	Hájevský potok	Hořesedly downstream	2017
13	Hájevský potok	Kněževes	2016, 2017
14	Kolešovický potok	Přílepy upstream	2016
15	Kolešovický potok	Přílepy downstream	2016, 2017

***Tab. 2:** Sampling profiles in the Kolešovický river basin (Senomaty WR)*

a high volume of pollution emissions from point sources, moreover near the closing profile [4]. Furthermore, the hydromorphological condition along most of the watercourse length is very poor and therefore, no self-cleaning support mineralisation of organic pollution and retention of nutrients- could be expected.

The quality of surface water in the Kolešovický river was very poor during the evaluated period. The only sites where relatively good water quality was detected were small watercourses upstream the settlements (profile No. 2) and profiles 5 and 11, where very high concentrations of NO_3N were detected. In the other monitored profiles, municipal wastewater pollution was prevalent -> high values of BOD, COD_{Cr}, N-NH_4, N $_{total}$, bacterial contamination. Agriculture contributed with high N values-NO_3. The following text will not describe the detailed situation in the individual monitoring points, but we will focus on evaluating the closing profile.

In the closing profile Kolešovický river Přílepy downstream (the inflow profile to the proposed Senomaty WR), relatively low average concentrations of direct organic pollutant indicators (BOD 2.2 mg l^{-1} and COD_{Cr} 15.6 mg $l^{-1)}$ were detected during the survey and the average concentration of NH_4 N (0.34 mg^{-1}) was not to high, with maximum values in the winter months. Therefore, there is probably no high risk to the oxygen regime in the proposed water reservoir. However, the question of water quality during rain water has not been addressed (currently there is no data), when combined system overflows are in operation and it will therefore be necessary to anticipate shock inflows of easily degradable organic matter.

From the point of view of the risk assessment related to eutrophication in the proposed water reservoir [5] the concentration of phosphorus compounds at the inlet into the water reservoir (profile No. 15) is crucial. The average P_{total} concentration (0.73 mg.l^{-1}) and P-PO_4 concentration (0.60 mg.l^{-1}) is extremely high. What is also important is water retention in the reservoir. The retention time is very long in the case of the Senomaty WR. If the measured flow-rate values are used in the calculation, i.e. ~ 0.03 $m^{-3}s^{-1}$, it would be ~ 260 days. This is a very long period of water replacement indicating higher resistance of the reservoir to eutrophication. However, phosphorus inflow in the inlet would be very high: at Q and P content P at the level of 2017, it would be about 665 kg, i.e. 2.6 g m^{-2} $year^{-1}$. The situation would not be improved by a regular increase in phosphorus compound concentrations during the summer period (VI-IX: 1.1-1.4 mg l^{-1} P_{total} and 0.81-1.3 mg l^{-1} PO_4 P!), i.e. at the time of maximum phytoplankton growth. With higher flow-rates during years with higher water yield, the phosphorus input would increase: at Q = 0.1 it would be about 2.2 t of phosphorus, i.e. 8.5 gm^{-2} $year^{-1}$. Other risk factors include level lowering (i.e. the area and volume reduction associated with lower resistance to phosphorus oversupply, shallow depth and high probability of phosphorus load reactivation in sediments), as well as highly probable episodic pollution inputs during rainfall-runoff events; especially with municipal wastewater overflows.

The described situation indicates a strongly eutrophic condition (hypertrophy) in the proposed Senomaty WR with a massive phytoplankton growth, including cyanobacteria. Such a condition also entails oxygen deficits at the bottom with increased NH_4N content and with an uncertain forecast of phosphorus concentrations: nitrate ions (as an oxidation-reduction buffer) are currently suffi-

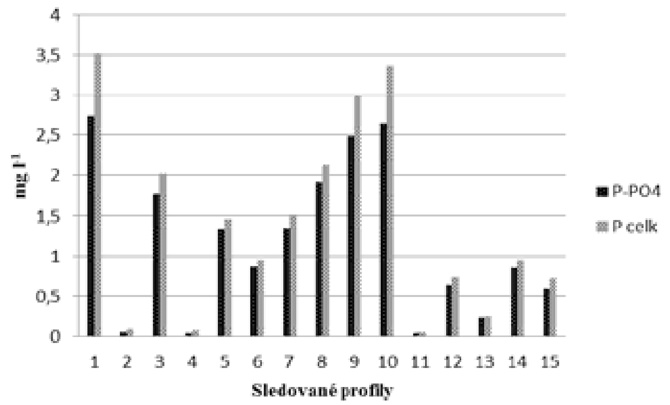

***Fig. 2:** Senomaty WR - with seasonal concentration of P-PO 4 and P total over the monitored period in the closing profile*

cient but under intensive anoxic ratios there will probably be intensive denitrification occurring at the bottom with potential subsequent increase in P compound release from sediments at the bottom. A favourable concentration of P_{total} at the inflow into the Senomaty WR can be considered as ~ 0.1-0.2 mg/l, with about 100-200 kg P inflow a year, i.e. <1 g m^{-2} $year^{-1}$.

5. Discussion

The results of the detailed survey of water quality in the Rakovnický and Kolešovický river basins showed that it would be a mistake to consider the volume of water retained in the newly constructed water reservoirs in the relevant studies separately from the overall condition and use of land in the relevant catchment areas. Water reservoirs are a functional integral part of their entire catchment areas. When considering the location of the new water reservoir in a basin severely degraded by human activities (especially the Kolešovický river basin, Senomaty WR), it is necessary to take into account accelerated fouling caused by erosion material and strong eutrophication phenomena, which will certainly degrade the stored water and thus the water intended to improve the flow-rate in the watercourse downstream the reservoir, or water extraction for irrigation purposes. The discharged water will be anoxic if discharged at the bottom, with increased concentrations of N-H_4N, Fe, P and an increased content of reduced organic matter. In the case of water discharges from the euphoric layer, the permanently high plankton biomass will be removed from the reservoir, including potentially toxic cyanobacteria. It is obvious that without significant and systematic measures taken in the catchment areas of the reservoirs, the expected benefits cannot materialise.

The results of operational monitoring of the water quality have therefore shown the need to address the possibilities of corrective measures in both monitored river basins in detail. In 2017, a study focusing on near natural measures [8] was completed (commissioned by Povodí Vltavy, state enterprise). The status analysis was reflected in the proposed measures that focus on all areas. Measures reducing erosion should be included into comprehensive land reclamation projects. Other measures (organisational and agricultural) are being developed in other specialised studies. Discussions with the agricultural sector has shown that farmers are mainly in demand of water from the Ohře river basin (Nechranice WR) and despite their partial willingness to change the farming method, they are not willing yet to take care of the implemented projects (erosion, reclamation ...) and demand compensation for potential damage caused by such measures. Obviously, intensive communication must follow in this respect as without the active participation of farmers, successful implementation of the proposed measures in the intensively agriculturally cultivated river basins is hopeless.
The study also proposes measures in the field of revitalization and re-naturisation of watercourses, including the addition of green vegetation, which will also boost the self-cleaning potential of flowing water. Wetlands and the restoration of a number of small water reservoirs are also proposed, which should be incorporated into rainwater management in municipalities. The issue of finding a fundamental solution to point pollution sources by constructing corresponding WWTPs is addressed separately.

From the point of view of biodiversity, it is interesting that the proposed water reservoirs Šanov and Senomaty generally aim to increase the water storage in the river basins with their main purpose being the improvement of flow-rates in the watercourses downstream. Such use means significant fluctuation in the reservoir water level with the expected significant drop in the water level at the end of the dry summer season. These reservoirs will support fish life and other water-bound organisms in a limited manner, taking into account their possibilities.

6. Discussion

The submitted paper compares the possibility of constructing two water reservoirs tanks in the same climate area but in two completely different types of river basins. The river basin of the upper stretches of the Rakovnický river is relatively healthy and therefore the water flowing out of it is of a relatively good quality. From the point of view of water quality, the proposed water reservoir in Šanov could therefore perform its function well. On the other hand, the river basin of the Kolešovický river can be considered as severely degraded, as mentioned above, with all kinds of degradation mechanisms that accelerate water runoff from the land and result in its long-term drying out (and further overheating). The quality of stored surface water in the new reservoir (Senomaty) will not be of acceptable quality given the present condition of the river basin. Surface water quality will certainly improve if near natural measures and other measures such as wastewater treatment get implemented. In view of the above, Povodí Vltavy pays attention to addressing this issue before the construction of these two water reservoirs takes place.

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JAKOST VOD A SEDIMENTY
Gewässergüte und Sedimentmanagement

Content

Examples of modelling assessment of point and non-point measures impact to water balance and water quality

Pavel Tachecí, Marek Maťa, Markéta Součková
DHI, a.s.

1. Introduction

The basic pre-requisites for proposal of efficient measures of surface water quality improvement are:

1. thorough analysis and assessment of current pollution sources
2. correct calculation of input flow, concentrations and matter fluxes in river network and water reservoirs
3. quantification of expected impact of individual measures to runoff, discharge and concentrations. Its result should reach sufficient level of accuracy for reasonable decision making process.

Afterwards, expected impact of combined measures can be calculated and future water quality improvement evaluated at some target (representative) river cross section. Mathematical modelling techniques are very suitable for these purposes. These models are assumed to simulate future conditions (flow and concentrations) at reasonable manner, considering spatial and time scale as well as spatial variability of conditions and appropriate resolution level of processes description. This contribution focuses on two model categories:

a) Water balance models for river basin scale (MIKE BASIN).
b) Complex integrated hydrological simulation system, suitable for detailed simulations (MIKE SHE)
   Examples from two modelling studies located in Vltava river basin (Czech Republic), are given below, illustrating both approaches.

2. River basin scale approach

This modelling approach was developed in 2009 for water balance and water quality simulations in frame of planning process (part of WFD implementation in Czech Republic). The aim was to establish a tool for assessing impacts of measures on water quality in scale of individual surface water bodies. A simple GIS-based water balance and water quality model in MIKE BASIN 2009 (DHI) software was used as a core of simple decision support system (PLANOP). Model set-up includes several main element categories: river reaches, catchments and water users connected to rivers. Time series and parameters are assigned to these elements. Water balance is established using 12 monthly median discharge values in gauging stations and measured data of water users. Simple 1st order decay equation is used for approximation of concentration changes along river reaches. Total phosphorus, BOD, COD, $N\text{-}NO_3$ and $N\text{-}NH_4$ were used for modelling in frame of WFD implementation. Based on matter flux / discharge relationship, 12 characteristic values of concentrations were calculated in water quality sampling points. Subsequently, load from non-point sources was back-calculated. Consecutively slightly modified approach was later on used in several local case studies, mostly in more detailed scale. For instance, model of Hracholusky water reservoir catchment area is presented below.

A high amount of phosphorus load to Hracholusky reservoir (river Mže, CZ), causes eutrophic conditions in water volume and, consequently, limits recreation activities. Plzeň region authority established project for finding main source of the phosphorus in catchment area upstream of the reservoir. This study was conducted by consortia of companies VRV a.s. and DHI a.s. Model (about 1579 km^2) was built with aim of calculating water balance and concentration changes along streams and rivers (phosphorus, nitrogen). Consecutively, model is intended as a tool for assessment of impact of measures proposed. This model in MIKE BASIN software consists of 300 model catchments (average area 5.27 km^2), 452 individual water users and about 1021 km of river branches. Model scheme is at Fig.1. Calculations of water balance as well as Total phosphorus, $P\text{-}PO_4$, Total Nitrogen and $N\text{-}NO_3$ were conducted across the whole catchment.

3. Detail integrated hydrological modelling approach

Certain types of measures (namely aiming to non-point pollution sources) might be outside of the basin-wide models resolution. Also, their impact might be rather complex and dynamic. In such cases, modelling tools suitable for detail simulations should be used.

Complex integrated hydrological modelling system MIKE SHE [1], can be used for detail hydrologic processes modelling. MIKE SHE uses physically based description of surface and subsurface runoff, groundwater movement, channel flow as well as a pollution transport description. The main advantage is integrated description of surface and subsurface flow in spatially distributed manner. It offers several options for description of hydrological processes, and takes advantage of physically-based parameters.

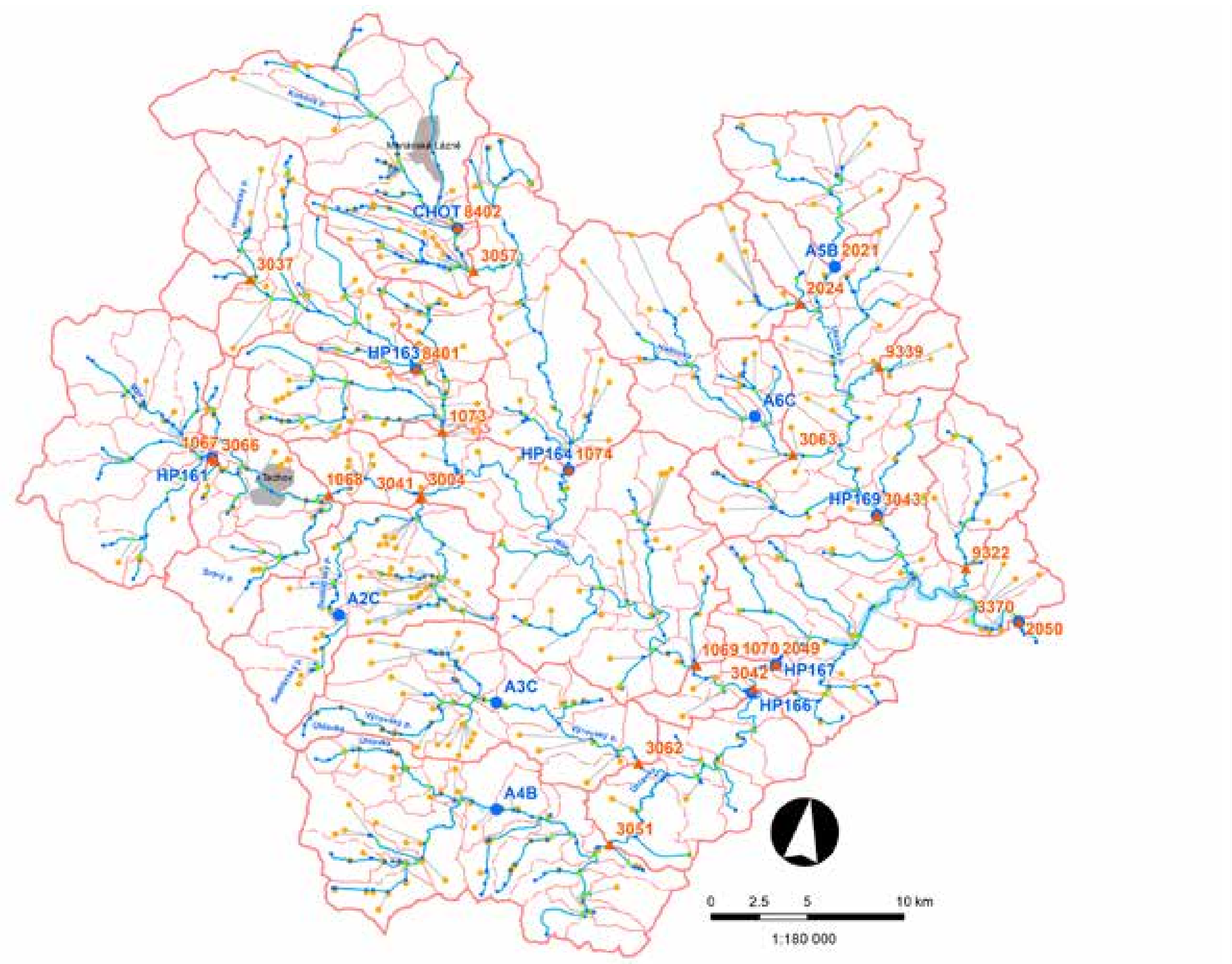

***Fig. 1 :** MIKE BASIN model scheme upstream of the Hracholusky reservoir. Triangles denote sampling points, circles denote discharge gauges, squares denote connected water users. Subcatchments are marked as solid and dashed lines. Simple lines symbolise river reaches; dots symbolise computational nodes.*

This modelling system is flexible in term of spatial and time scales and it is suitable and frequently used for simulation of future man-made and climate changes impacts of on hydrologic cycle. Several research studies focusing on land use changes (agricultural management changes, measures on artificial drainage systems, and conversion of crop area to grassland) and their impact were led by Soil Research institute in Prague (VÚMOP, v.v.i.) at Kopaninský potok catchment and its micro-catchments [2], [3]. Other modelling results focusing on simulation of artificial drainage and agricultural management impact to soil water content at experimental microcatchment P6 (part of experimental catchment Kopaninský potok, operated by VÚMOP, v.v.i.) are presented further on.

Microcatchment P6 (15.7 ha) is formed mostly by arable area (96 %, Fig. 2), covered mainly by dystric cambisol and drained by tile drainage (61% of the area). Hydrologic and soil water variables and parameters were available from long-term observation and measurement. Change between previous land use (1953) and current state (2010) can be recognised at Fig.2. A complex hydrological model was established, including surface runoff, unsaturated zone flow (1D Richards equation), shallow groundwater flow, drainage and stream flow, evapotranspiration and snow melt. Computational grid size was 10 x 10m, time step 10 minutes. Model was calibrated for 2004-2012 period, using observed discharge (drainage outflow), shallow ground water level and calculated soil water content. Then, model set-up and parameters were modified according to the conditions expected for 1953. Comparing selected results (overall water balance, discharge, spatially distributed depth of ground water level and soil water content in several soil horizons), it is possible to outline basic conclusions for microcatchment P6:

After tile drainage installation, main rainfall-runoff mechanism changed from surface and hypodermic flow to nearly 100% drainage runoff. Rain water infiltrates through 90 cm of soil matrix and preferential pathways and then reaching tile drainage system in current conditions. Shallow groundwater level depleted and wet areas were drained out. Long-term outflow is higher for current conditions (about 8%), but volume of fast runoff in high-intensity events decreased. Water, taking part in drainage outflow (in current conditions), was in 1953 used by crop for evapotranspiration, and partly formed surface and hypodermic runoff. Tile drainage has major impact on water balance and runoff, but changes in crop

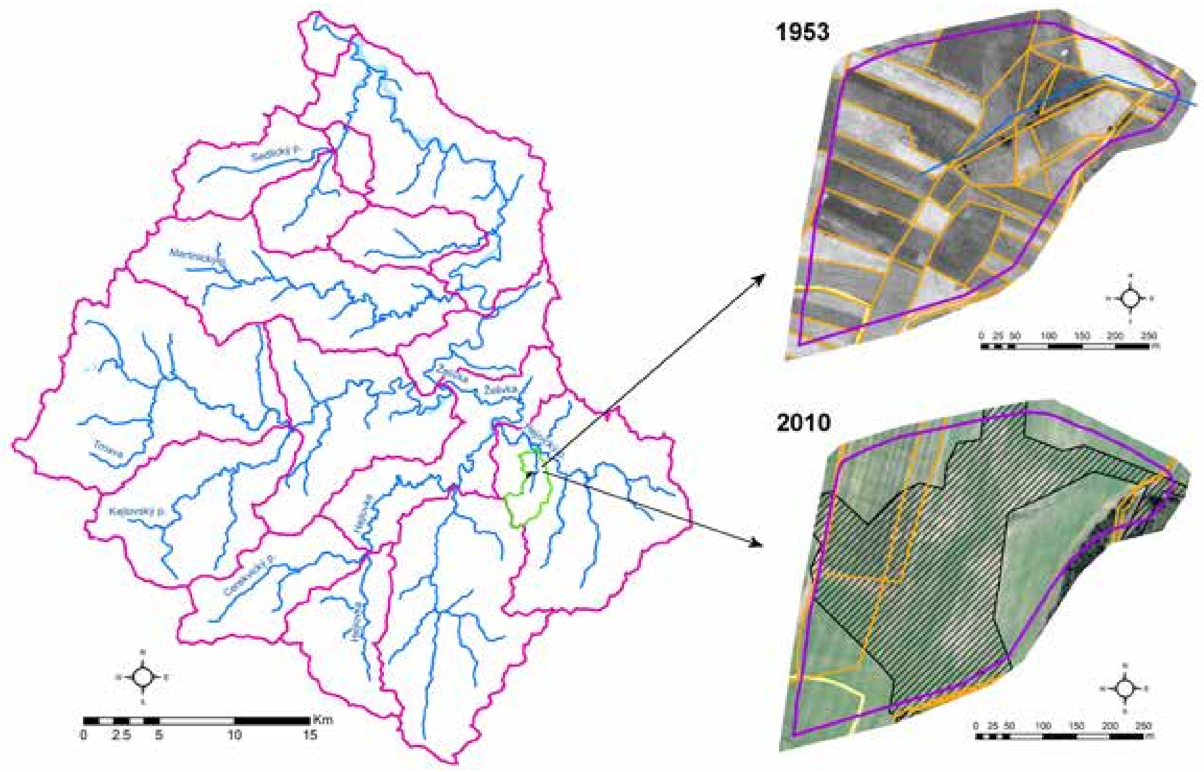

Fig. 2: A left hand side: Želivka catchment (1057 km²), surface water bodies (violet border), selected subcatchment (Kopaninský potok, 8.7 km², green line denotes surface divide) and microcatchment P6 (black colour, 15.7 ha). A right hand side: detail of land use distribution in 1953 (upper) and in 2010 (lower) at P6 microcatchment. Violet line denotes surface divide, orange line field units, black line drained area and blue line stream. Aerial photo source: cenia.cz.

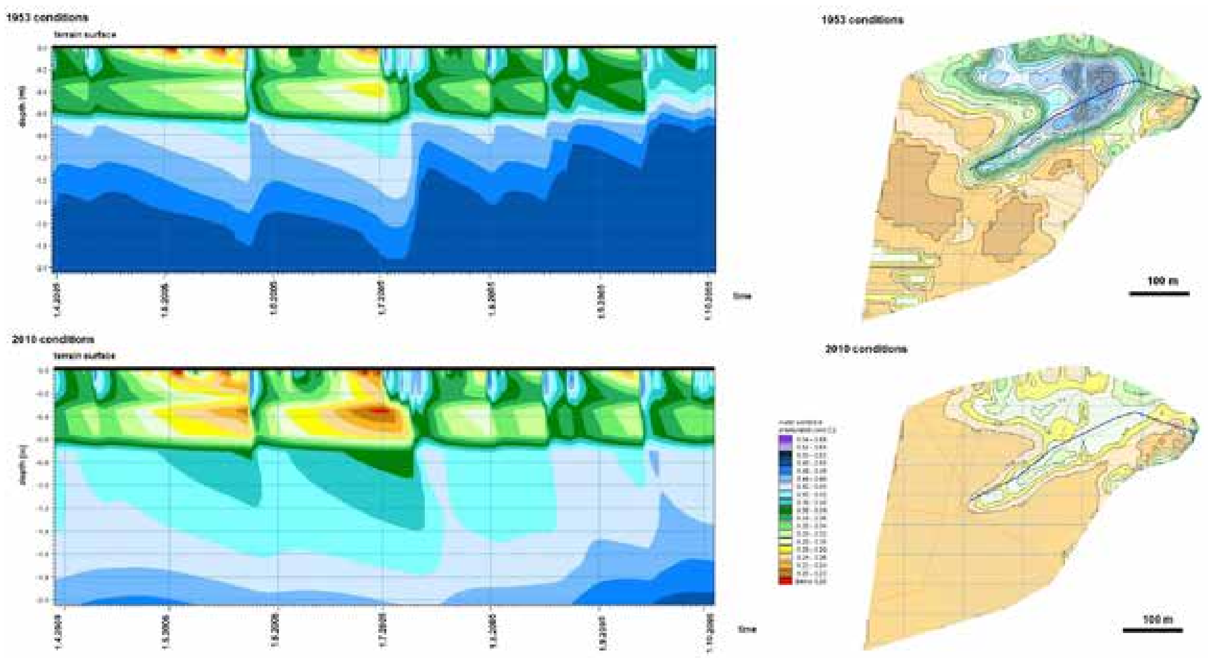

Fig. 2: Example of detailed MIKE SHE model results: soil water content at microcatchment P6 for 1953 conditions (upper part) and current conditions (lower part). Time series of soil water content changes in vertical soil profile (0 – 2 m depth) on left and maps of soil water content distribution in depth 15 cm for selected day during dry period (22nd May) on right.

distribution cannot be neglected. They influence soil water content between precipitation events and hydraulic conditions of soils markedly.

4. Summary

Both model approaches are suitable for simulation of dynamic changes (discharge, concentrations) along river branches or across river catchments. Detailed physically-based simulations allow more complex assessment of impacts of small-scale measures distributed across river basin area. Simplified, basin-wide approach allows easy-to-understand, effective and brisk simulations over large areas and complex river networks. Basin-wide models can be supplied by results of detailed local simulations. Combination of both, modelling techniques benefits the user by selection of the most appropriate approach for optimal proposal of different types of measures and its spatial distribution. It also provide basis for efficiency evaluation of measures and their combinations, aiming to good state of water bodies or to nutrient balance improvements (e.g. for water reservoirs management or transboundary issues).

Acknowledgement:
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PARAFAC modelling and FT-ICR-MS data from Muldenberg reservoir samples for better description of the DOM composition for drinking water treatment

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1. Introduction

An increase of dissolved organic carbon (DOC) is recorded in many surface waters of the northern hemisphere in the last two decades. If the DOC concentrations are too high, the building of haloform compounds is possible during the chlorination in drinking water treatment. These compounds may have a negative effect on the human health. It is necessary to use raw water with little of dissolved organic matter (DOM). The 2D fluorescence spectroscopy is an innovative and low-cost possibility for measuring the changes in the DOM composition in a very short time. Excitation and emission spectra can be recorded synchronously. Each spectrum has important areas of humic-like and protein-like substances to characterize the DOM.

In the project, funded by the German Federal Environmental Foundation (DBU) (2015-2017, AZ: 20014/357), different water samples from the catchment area of the Muldenberg dam in a bi-weekly gap were taken, in close cooperation with the State Reservoir Administration (LTV) in Plauen. The water samples were measured with the 2D fluorescence spectrometer Aqualog of Horiba and the excitation emission matrices (EEM) were evaluated. For the judge-and assessment a PARAFAC model was calculated, with the data of the different depths of the Muldenberg dam and its catchment area. For the summer time of the year 2016, a three component model could be validated. For the winter month only a two component model was calculated.

In addition FT-ICR-MS measurements were done to characterize the different elemental formula components or biogeochemical groups in the water samples best as possible. For this the lowest layer (low: 694 m a.s.l.), the chosen depth for the drinking water treatment (ce: 698/702 m a.s.l.) and the surface water (up: 708 m a.s.l.) were used.

2. Study site

In the catchment area of the Muldenberg dam, at the German-Czech border about 60 km southwest of Chemnitz, exists a number of moor. This moorland was artificially drained with grave systems and used for forestry

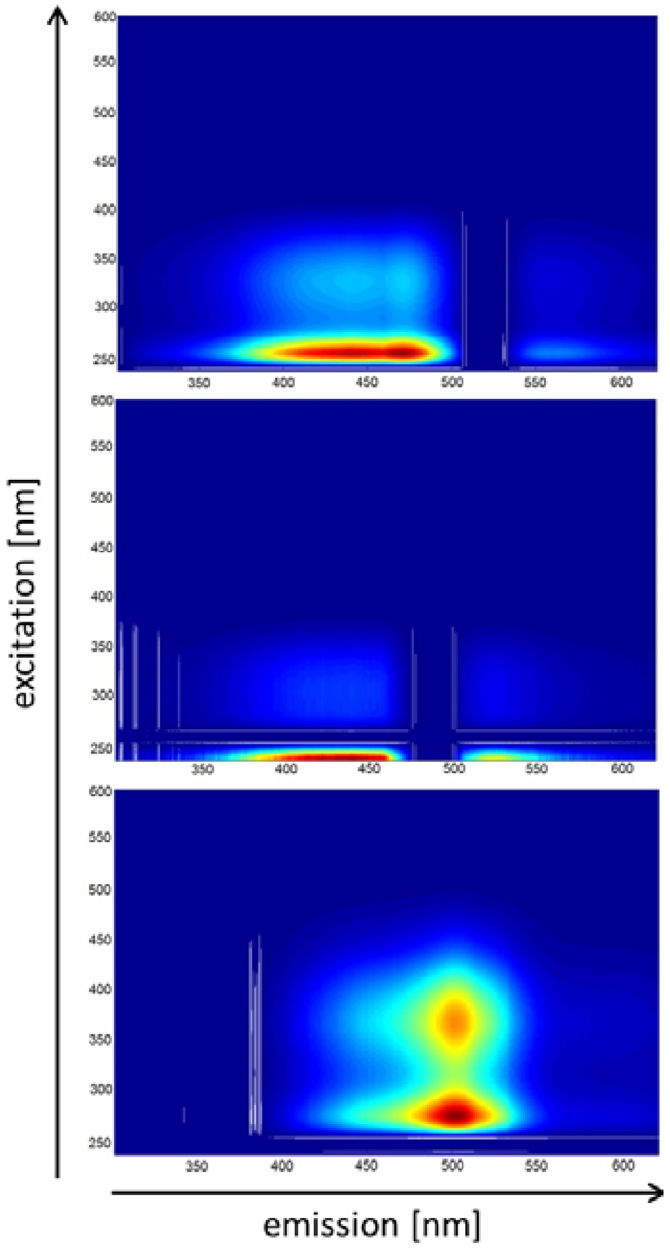

Fig. 1: Three calculated PARAFAC components of all depths of the Muldenberg dam from October to February 2015 to 2017

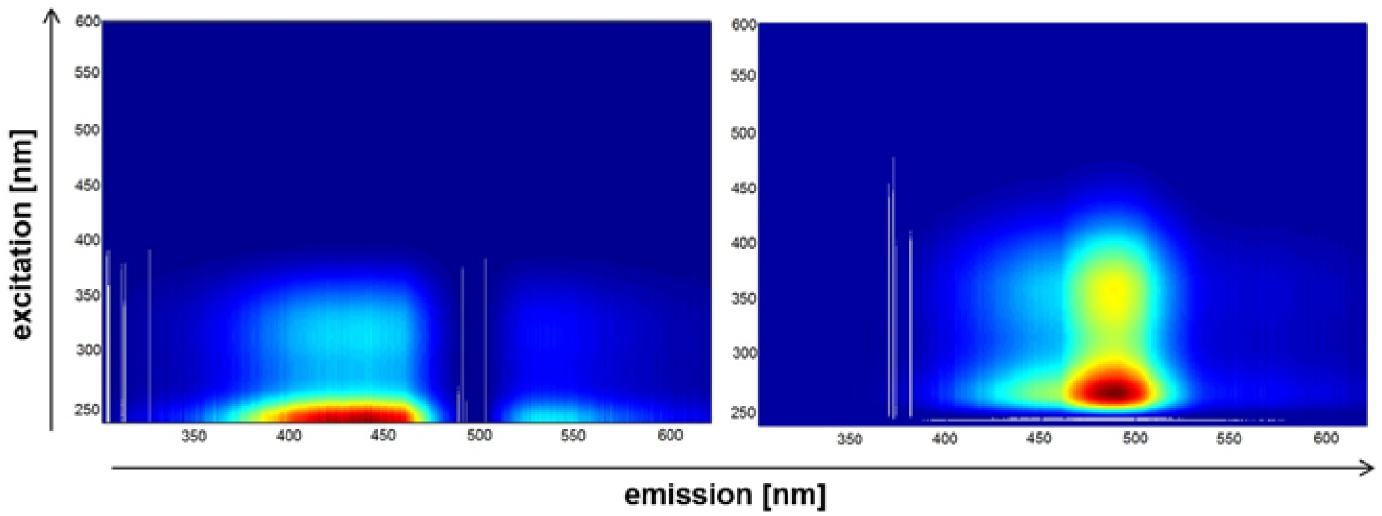

Fig. 2: Two component PARAFAC model of the catchment area of the Muldenberg dam in year 2016

with "Norway spruce" for decades. Currently these grave systems were maintained no longer. So it comes to rewetting. [1,2] In the degenerating moor were inhibited oxygen-dependent enzymes that are responsible for the degradation of phenolic components such as lignin and humane, by water accumulation. In that case will be encouraged an enrichment of organic matter and the formation of peat. [3]

3. Material and methods

All filtered water samples were measured with the 2D fluorescence spectrometer Aqualog® by the HORIBA Company. The following PARAFAC decomposition was performed with Solo+MIA and has about six modeling steps, the correction of the fluorescence data, the outlier test, the exploratory data analysis, the split half validation, the validation by random initialization and the export of the model. Correction of the fluorescence data includes the Raman and Rayleigh plus the inner filter effect correction. The following step includes different mathematical tests of the detection of outliers in the data set. Outliers should be removed from the data set before the PARAFAC modelling starts.

In addition Fourier-transform ion cyclotron resonance mass spectrometry (FT-ICR-MS) measurements were performed after solid phase extraction (SPE) at the UFZ in Leipzig. Both SPE and FT-ICR-MS measurements are described by Raeke et al. [4].

4. Results and discussion

In general, a three component model during the winter time was found. For this model we used all depths of the Muldenberg dam from October to February. The three components, which were calculated with the Solo+Mia software, are shown in Fig. 1. The first and second component is humic like. The third component is fulvic like. During the summer time just a two component model could be calculated (Fig. 2). The second component of the three component model is more pronounced in the two component model. This component represents DOM, which is microbially modified, that can be one reason, why it is pronounced in the summer PARAFAC model. The last fulvic like component is found during the whole year. Events like the spring thaw (March 2015) can be the reason for the immission of new organic fulvic like material in large amounts into reservoirs.

In addition to the PARAFAC modeling we measured some samples with (FT-ICR-MS). Like by the PARAFAC model differences between summer and winter months were found in FT-ICR-MS elemental formula data sets. In general, the differences for the major part of all 5962 detected components were not significant. A minor part of components was found to show differences with high significance. Of those two elemental formula components were selected in Fig. 3 and 4.

As shown in Fig. 3, the component $C_{20}H_{42}O_4N_2$ was most present in winter 2015 / 2016 from November to March but not in February / March 2015 and during spring / summer months except for May 2016. The component $C_{17}H_{26}O_4$ (Fig. 4) showed completely different annual presence behavior compared to $C_{20}H_{42}O_4N_2$ (Fig. 3). $C_{17}H_{26}O_4$ showed significant differences in the three sampled depths at several sampling dates.

$C_{17}H_{26}O_4$ showed larger maximum relative intensities compared to $C_{20}H_{42}O_4N_2$ due to higher concentration or higher ionisation efficiency or higher recovery rate in the SPE process.

5. Conclusion

i) During the year 2016 a two component model resulted and during the winter month we have a three component model. ii) The first and second component are humic like. We assume that the second component represents DOM, which was modified microbially during the warmer

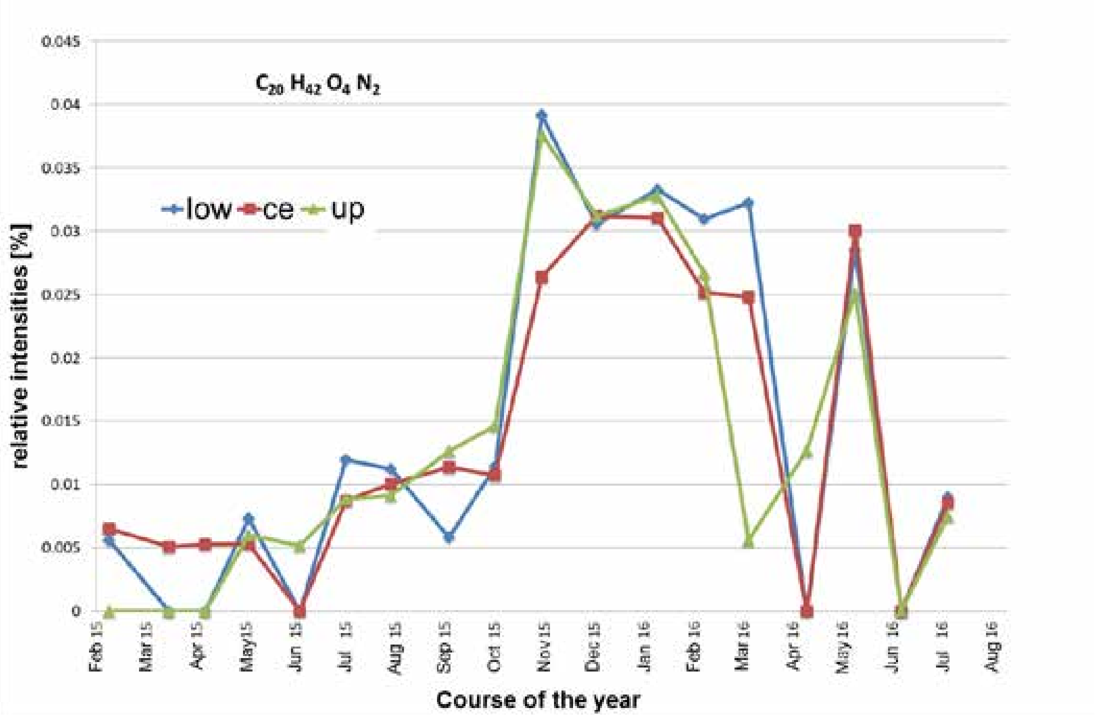

Fig. 3: *Annual distribution of the component $C_{20}H_{42}O_4N_2$ from the water samples of the surface water (up – 708 m a.s.l.), the chosen depth for the drinking water treatment (ce – 698/702 m a.s.l.) and the lowest depth (694 m a.s.l.) from February 2015 to August 2016*

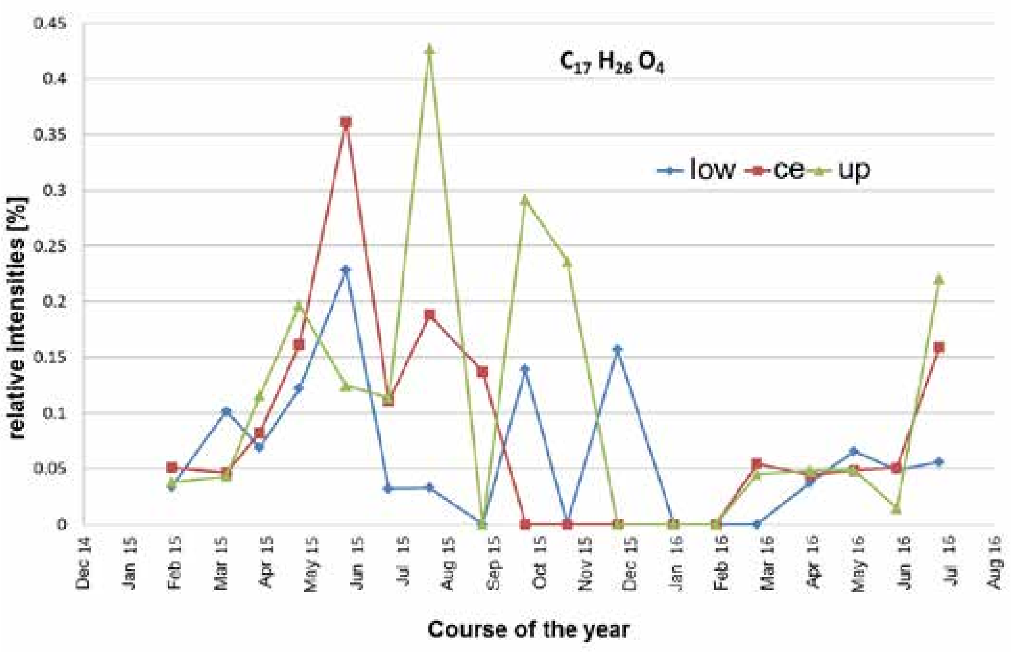

Fig. 4: *Annual distribution of the component $C_{17}H_{26}O_4$ from the water samples of the surface water (up – 708 m a.s.l.), the chosen depth for the drinking water treatment (ce – 698/702 m a.s.l.) and the lowest depth (694 m a.s.l.) from December 2014 to August 2016*

months. The third component is fulvic like. iii) The second microbial modified component is more pronounced in the summer months. iv) The distribution of the elemental formula components can be different inside the dam. The isomer mixture with the formula $C_{20}H_{42}O_4N_2$ shows mainly the same level of presence in all depths whereas that with the formula $C_{17}H_{26}O_4$ shows at several sampling dates significant different levels of presence.

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Long-term sediment contamination in the Elbe River floodplain, and an example of a limnological study

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1. Introduction

Floodplains with their fluvial lakes are one of the major ecosystems contributing to biodiversity and landscape stability. Their function is significant in flood protection and retention potential of the landscape. The research of fluvial sediments can provide information not only about significant hydrological events, but also about the development of pollution, as a number of pollutants (heavy metals, specific organic substances, etc.) bound to fine grained particles drifted by the river settle down under low flow rates. Although these substances may be present in a stable form in sediments, under certain conditions (change of redox potential, pH, presence of certain chemicals, etc.), their remobilization and reactivation may occur, which poses a risk to the aquatic ecosystem.

As for the whole Elbe river basin, the problem of contaminated sediments was investigated, for example, by Förstner [4] or Prange et al. [11,12]. In Czechia, the attention has turned to suspended matter and sediments since 1990. The sediment contamination of the Czech Elbe was investigated e.g. during the National Project Elbe. Pollutant dynamics and sedimentation processes were studied, for example, by Rudiš [13], Borovec [2]. As only surface river bed fresh sediment layers are sampled within the systematic monitoring, the information about older floodplain pollution was missing. For that reason, the presented research has been focused on the deeper layers of oxbow lakes subaquatic sediments.

After 2000, a number of complex limnological studies on water quality of old meanders including detailed research of subaquatic sediments to describe and explain the spatial extent of the old anthropogenic pollution of the Czech middle course of Elbe River were carried out [1, 5, 7, 8, 10, 14,15]. The above mentioned researchers also collaborated on the ELSA project (Remediation of Contaminated Elbe Sediments) - SedLa (Bedeutung der Altsedimente der Elbe und ihrer Seitenstrukturen im Abschnitt von Pardubice/Pradubitz bis Moldaumündung für das Sedimentmanagement im Einzugsgebiet der Elbe), so the results are discussed in the contribution too [9].

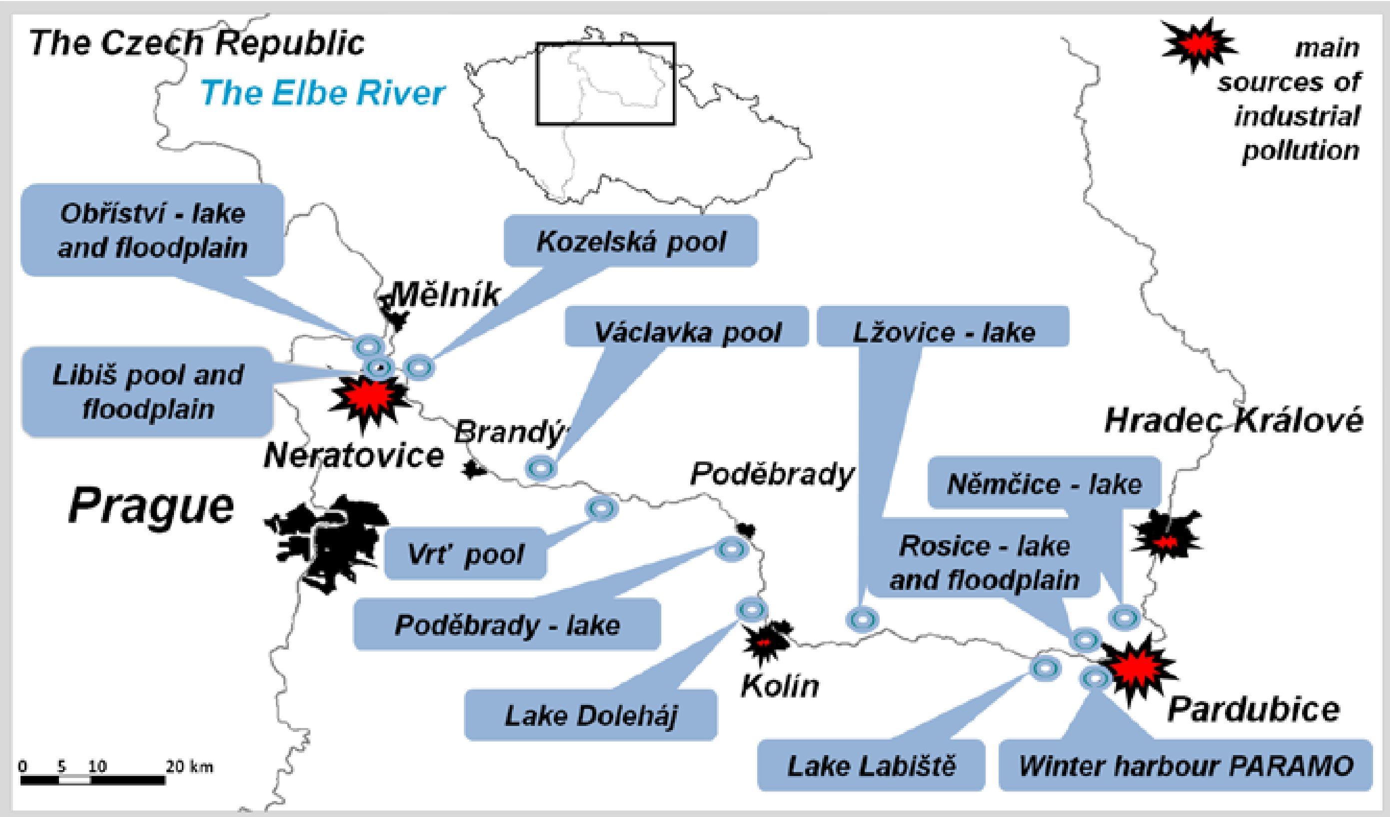

Fig. 1: Study areas in the middle course of the Elbe River in the Czech Republic

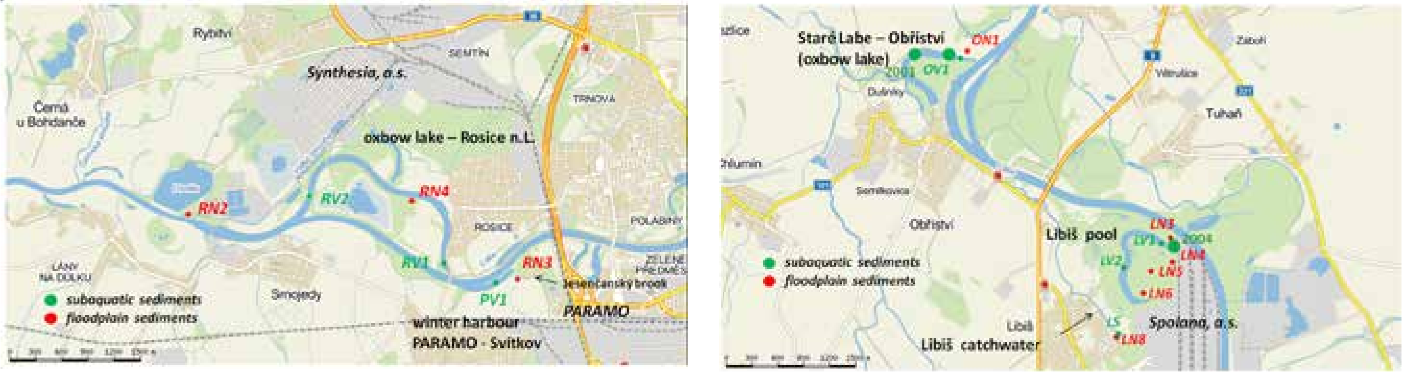

Fig. 2: Sampling points near Pardubice and Neratovice

2. Study site

The investigated oxbow lakes are located between Hradec Králové and the confluence with the Vltava River. All of them are old Elbe meanders that were artificially separated from the river especially during flood protection and canalization works in the 19th and 20th century. However, they differ by the time of their cut off from the main river bed, the intensity of hydrological communication with the river, the distance from the industrial source of pollution, and the land use in the surroundings to find the principles of contamination spread in the Elbe River floodplain. The particular investigated oxbow lakes are depicted in Figure 1. Within the SedLa project, the sediment cores were taken also from the floodplain (Figure 2).

Among the oxbow lakes with the most restricted communication with the river, and an early separation from the main river bed usually in the 19th century, belong Václavka pool and Doleháj Lake. On the other hand, the oxbow lakes still connected to the Elbe with one ending are represented by Winter Harbour Paramo, oxbow lakes at Rosice, Lžovice and Vrť pool. The other lakes are usually connected with the river by a water gate, a pipeline or a catchwater.

The main sources of industrial pollution in the investigated area have been located in Pardubice and Neratovice (refinery Paramo, chemical plant Synthesia in Pardubice; Spolana chemical plant in Neratovice), other industrial contamination could come from Hradec Králové (photographic industry), Opatovice and Chvaletice (power plants), Kolín (chemical plants and a refinery), Čelákovice and Nymburk (metalworking industry), or Medieval silver mining in Kutná Hora.

3. Methods

Sediment sampling was carried out between 2001 and 2018. Subaquatic cores were taken from boats with Eijkelkamp piston sampler to the maximum possible depth. The floodplain cores were extracted with the use of RDBS-1 mobile hydraulic drilling machine. Grain fraction of 20 µm was used for chemical analyses..

Samples of sediments from 2001, 2002, 2007, 2015 and 2018 were determined in the laboratories of the Faculty of Science, Charles University with the use of FAAS / ICP MS in aqua regia leaches according to ISO 11466. The analyzes from 2004, 2013 and 2014 were completed in the laboratories of Elbe River Basin Authority in Hradec Králové according to DIN 38406 - E22, ČSN EN ISO 15586 and ČSN 57440. Concentrations of Hg were measured in solid samples using AMA 254. Contamination assessment was elaborated according to the ICPER (International Commission for the Protection of the Elbe River) methods [3,6].

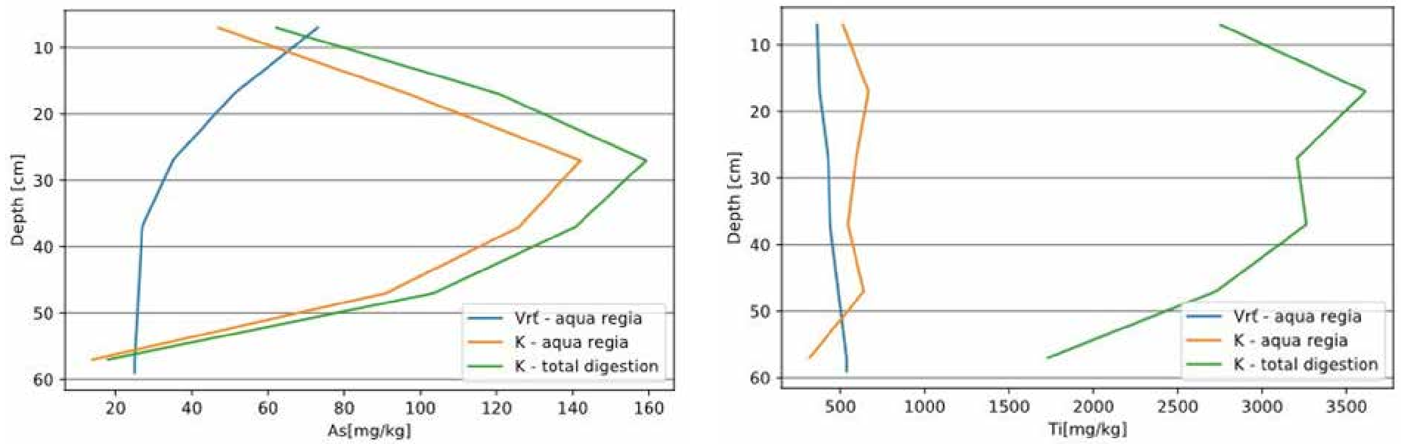

Fig. 3:
Concentration of As and Ti after aqua regia leaching and total digestion

4. Case study - limnological research of Kozelská and Vrť pools

The research included bathymetric measurements, hydrological regime observations, determination of chemical and physical parameters of water (12/ 2016 - 11/2017), microscopic analyses of phytoplankton and zooplankton, grain analysis of sediments and metals and arsenic determination using aqua regia leaching as well as total digestion.

A big difference was identified after using of both digestion methods in Lake Kozelská (Figure 3). The content of Ti after leaching with aqua regia was quite similar to the concentrations of Ti measured in Vrť. On the contrary, the concentration of Ti after total digestion was much higher. In the case of As, the difference was not so significant. These facts corresponded to the differences in sediments, contamination and character of the element.

5. Results and conclusion

The average concentrations of measured elements in each sediment core are given in Table 1. Generally, the most problematic metals were Pb, Hg and Cd.
The upper threshold values were exceeded in the cases of 6 determined elements in Winter harbour Paramo near Pardubice. The oxbow lake is very close to the refinery and its tributary - the Jesenčanský brook - flows through the refinery area. The concentrations of 5 determined elements exceeded their upper threshold values in the sediment cores from Kozelská pool and Libiš A in 2004, four elements exceeded the limit again in Libiš pool and catchwater in 2013 and in Obříství in 2001 due to the proximity of Spolana chemical factory. As Kozelská pool is situated upstrem Spolana, it has been probably affected during large floods on the Vltava River when the flood has come from the confluence even against the Elbe current as it was in 2002.

Sampling point	Year	Depth (cm)	Concentration (mg/kg)								
			Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Oxbow lake at Němčice	2007	67	2,3	20	0,8	121	61	0,44	31	76	478
Winter harbour Paramo - PV	2013	113		20	2,9	96	*215*	2,65	*55*	*272*	*1528*
Oxbow lake at Rosice - RV1	2013	96		14	2,1	161	65	0,48	39	72	422
Oxbow lake at Rosice - RV2	2013	115		10	1,6	211	90	0,90	42	123	648
Floodplain at Rosice - RN2	2013	150		37	0,5	79	21	0,68	*45*	47	243
Floodplain at Rosice - RN3	2013	150		38	0,3	75	24	0,30	39	69	221
Floodplain at Rosice - RN4	2013	150		40	0,3	60	10	0,20	36	44	148
Labiště beneath Opočínek	2001	50	*15,6*		4,0	*255*	87	1,78	*45*	114	*1022*
Labiště beneath Opočínek	2002	50	*14,6*		3,4	214	101	1,50	*51*	117	768
Oxbow lake at Lžovice - A	2007	151	11,2	20	*4,6*	*232*	*209*	3,99	38	89	563
Oxbow lake at Lžovice - B	2007	103	8,5	20	2,2	137	97	2,66	33	84	557
Doleháj	2001	30	*13,0*		2,3	94	34	0,41	33	72	168
Doleháj - A	2002	30	10,9		1,0	101	37	0,41	36	100	206
Doleháj - B	2002	30	3,3		1,3	85	42	0,16	41	108	239
Oxbow lake at Poděbrady	2007	204	2,5	37	1,8	113	85	1,80	34	96	483
Oxbow lake at Poděbrady - A	2015	87	3,9	*90*	2,9	144	110	2,67	32	114	474
Oxbow lake at Poděbrady - B	2015	77	1,2	*91*	1,6	119	63	0,81	28	128	347
Vrť pool	2018	59	6,7	40	2,2		48	0,41	35	68	226
Václavka pool	2007	67	0,4	20	0,2	22	58	1,17	30	50	310
Kozelská pool	2018	57	9,9	*86*	*6,1*		125	3,58	42	166	808
Libiš pool A	2004	60		43	3,3	119	90	2,80	42	109	869
Libiš pool - LV1	2013	115		18	2,9	130	118	*6,05*	44	146	*1037*
Libiš pool - LV2	2013	56		11	0,6	59	39	0,93	35	72	258
Libiš catchwater - LS	2014	50		65	1,5	75	*179*	*8,60*	*51*	117	582
Floodplain at Libiš - LN3	2013	140		35	0,5	73	38	0,55	42	66	246
Floodplain at Libiš - LN4	2013	150		30	0,2	68	16	0,42	41	55	179
Floodplain at Libiš - LN6	2013	150		25	0,3	62	13	0,55	38	46	172
Floodplain at Libiš - LN8	2013	150		19	0,2	60	28	0,46	39	53	145
Oxbow lake at Obříství	2001	60			4,3	*241*	133	*5,80*	*45*	*184*	943
Oxbow lake at Obříství	2002	60	8,4		*6,4*	210	115	3,58	35	*376*	777
Oxbow lake at Obříství - A	2007	163	5,8	25	3,1	125	121	1,36*	43	124	594
Oxbow lake at Obříství - B	2007	187	1,6	22	1,6	46	79	3,41	29	79	629
Oxbow lake at Obříství - OV1	2013	83		10	2,8	121	137	3,40	36	107	427
Floodplain at Obříství - ON1	2013	150		47	1,4	108	71	1,88	*45*	116	398
concentrations below the lower threshold value		concentrations between lower and upper threshod value				concentrations exceeding upper threshold value					

Table. 1: *Average concentrations of measured elements in sediment cores and contamination assessment [3,6] (3 highest concentrations marked in italics; contamination level distinguished by the intensity of the gray colour)*

Four measured elements exceeded their upper threshold values also in Opočínek in 2001, and A sampling point in the lake at Lžovice as a result of a large contamination coming from the industrial zone in Pardubice (Synthesia chemical plant). 4 upper threshold values were also exceeded in A core from the lake near Poděbrady. On the other hand, the lowest pollution was found in the sediments taken from the floodplain and from Václavka pool and Doleháj due to their restricted hydrological communication with the Elbe River.
To summarize, the level of contamination depends on the distance from the source of pollution, but also corresponds to the hydrological communication between the oxbow lake and the river. The oxbow lakes broadly connected with the river show usually higher sediment contamination especially near lake mouth.

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Water quality measurements at hydrological extremes in the lower Mulde River as a supportive decision making aid for the implementation of restoration measures.

Baborowski M., Junge F.W., von Tümpling W., Schulz-Zunkel C.

1. Introduction

In its lower part, the Mulde River can be described as a near-natural river. This is mainly due to partly non fixed riverbanks, resulting in dynamic flow conditions and complex patterns of diversity over a large range of temporal and spatial scales within the adjacent floodplains.

However, because of a Mulde barrage upstream [1], the lower part of the river is subject to vertical erosion. Thus, in December 2015 the collaborative project 'Wilde Mulde' [2] has started with the aim to restore a fixed riverbank, to connect a side arm channel, to increase structural diversity in the river and to initiate new hardwood forests (Fig. 1). The project will gather a deeper knowledge regarding the processes that possibly have favoring effects of the maintenance and recovery of ecosystem functions and services in river-floodplain ecosystems across several habitats.

Though, floodplains and sediments along the Mulde River are distinctly polluted by several contaminants [3]. Thus, results presented in this paper will focus on the investigation of transport dynamics concerning re-mobilization as well retention of particulate matter during hydrological extremes. By using the BACI (before-after-control-impact) design we aim to measure the effects of the restoration measures on water quality. For that reason investigations were carried out at flood and low water events in 2017 to assess the recent water quality status before the implementation of the planned measures. We hypothesize that sediment as well pollutant transport during flood and low water events can be quantified and effects of the planned restoration measure on the transported amounts can be monitored and calculated.

2. Material and methods

Flood investigations (eight sampling campaigns; campaign numbers 1 to 8, cf. Figures 2 to 4) were performed during a small flood (bankfull discharge) in February 2017. To compare the results with low water conditions, a similar sampling campaign was carried out in August 2017 during a low water event (eight sampling campaigns; campaign numbers 9 to 16, cf. Figures 2 to 4). The sampling sites were located from upstream the project area to a downstream located site, close to the mouth of the Mulde River into the River Elbe (Fig. 1). Primarily, suspended matter concentrations (SPM), trace metals (total content) and nutrient concentrations were analyzed in water samples at the sites (1) Jessnitz/ Spittelwasser, (2) Jessnitz/Mulde, (3) Törten/Mulde, (4) Dessau/Mulde and (5) mouth area/Mulde.

At the beginning of the flood investigations samples were taken twice a day, in the morning (campaigns number 1 and 3) and in the evening (campaigns number 2 and 4) to detect both, sediment and soil erosion processes. After that, samples were taken only once a day (campaigns number 5 to 8). Low water samples were taken only in the morning (campaigns number 9 to 16).
More detailed information on analytical methods is given in [4].

3. Results and discussion

An overview of minimum, maximum and median values of selected parameters is given in Table 1. When comparing results of flood and low water investigations, it becomes obviously that concentrations of SPM and most metals (transported in particulate form) reach their maximum value during the flood event. It is caused by erosion of soils and sediments. The maximum values of conductivity, boron (B, indicator of sewage influences) and uranium (U, mainly transported in dissolved form) were higher at low water conditions, due to dilution effects during the flood. Also maximum values of particulate phosphorus (PP), particulate organic carbon (POC) and particulate nitrogen (PN) appeared during the low water campaign, because of biologic turnover processes.

Results presented in Figures 2 to 4 underline the above-mentioned discussion. In the figures, the course of concentrations along the investigated river profile is displayed. Erosion and dilution are main dominating processes during flood, and sedimentation at low water conditions Conductivity shown in Figure 2 can be used as proxy for the course of the flood wave. Thereby, site 1 dominates its pattern. Conductivity decreased with increasing discharge (data not shown), remained on a stable level (numbers 3 to 6), increased at the end of the flood and remained more or less stable over the low water period (numbers 9 to 16). The pattern of Figure 3 is also dominated by concentrations measured at site 1. With increasing discharge high values of SPM (numbers 3 and 4) were measured. Aluminum (Al), iron (Fe), mercury (Hg), manganese (Mn) and zinc (Zn) showed a similar behavior, indicating a re-suspension of soils and sediments in the sub-catchment of site 1. Maximum values of metals decreased rapidly after one day and were lowest at low water (numbers 9 to 16), due to sedimentation along the river course. Increased concentrations at number 16 were due to phytoplankton development.

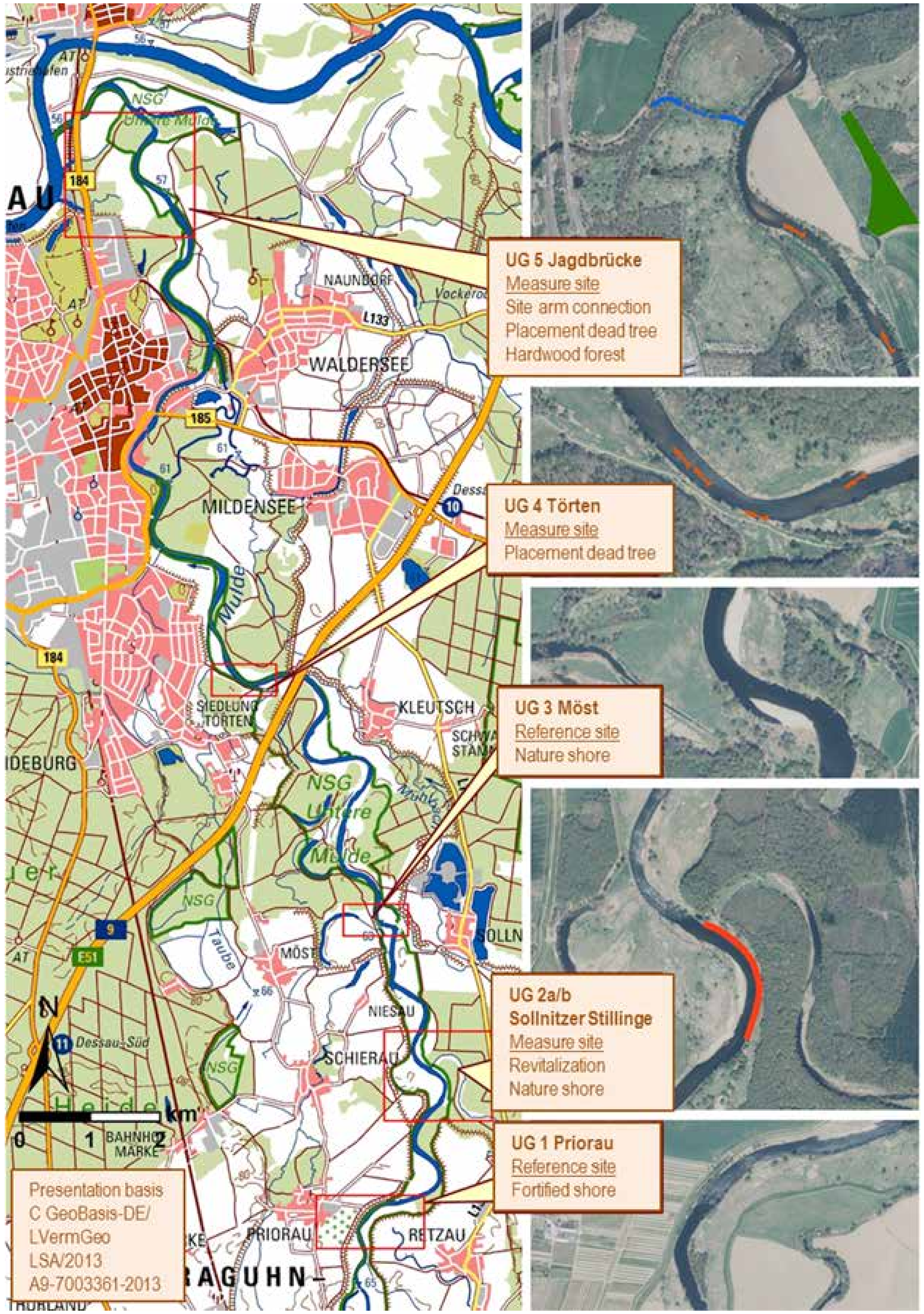

Fig. 1: Study area of the project (cf. [2]) with position of reference sub-sites, (UG 1, UG 3 and UG 5) as well as measure sites (UG 2a/b, UG 4 and UG 5)

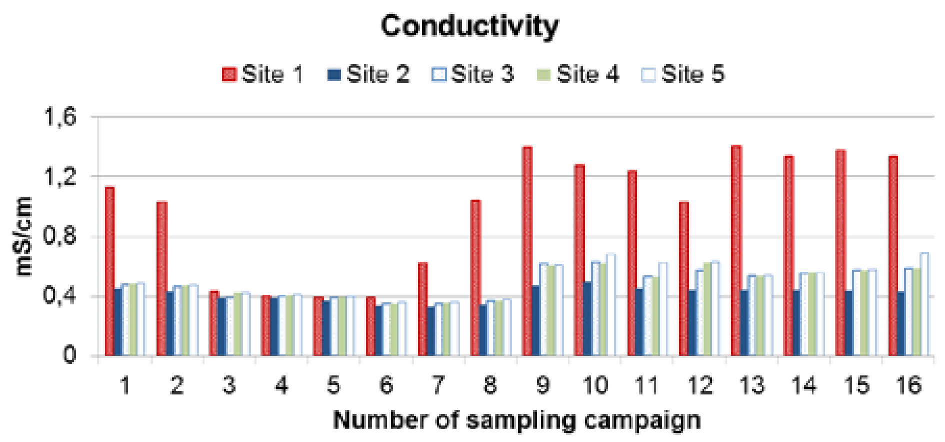

Fig. 2: *Trend of conductivity values during flood (numbers 1 to 8) and low water (numbers 9 to 16)*

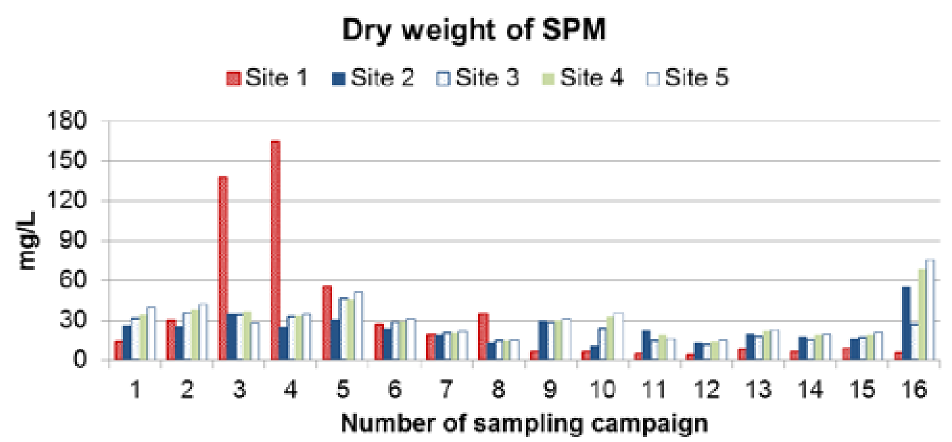

Fig. 3: *Trend of SPM concentrations during flood (numbers 1 to 8) and low water (numbers 9 to 16)*

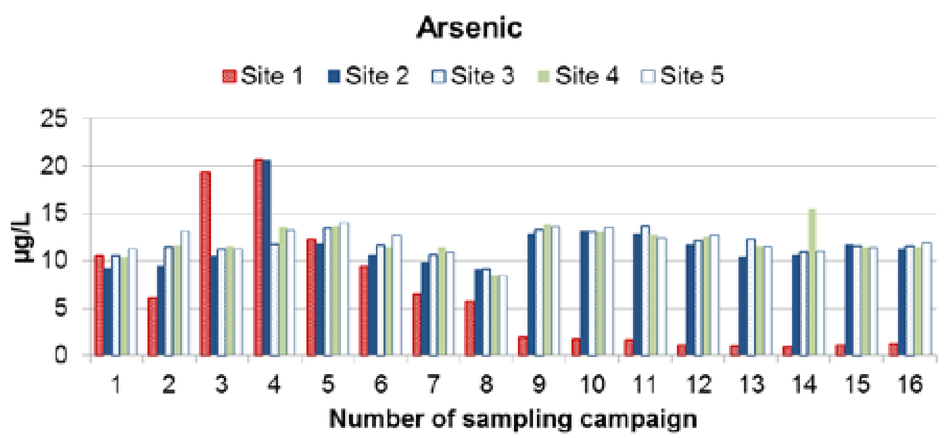

Fig. 4: *Trend of arsenic concentrations during flood (numbers 1 to 8) and low water (numbers 9 to 16)*

Parameter	Unit	Flood			Low water		
		Minimum	Maximum	Median	Minimum	Maximum	Median
Al	µg/L	190	**6950**	1260	60	380	175
As	µg/L	5.7	**20.7**	11.3	0.9	15.5	12.1
B	µg/L	17	141	21.5	72	**391**	92
Cd	µg/L	0.3	**1.0**	0.7	0.1	0.3	0.2
Cu	µg/L	0.6	**17.3**	6.9	1.2	11.0	4.2
Fe	µg/L	670	**10600**	1360	60	510	240
Mn	µg/L	80	**390**	150	15	140	60
Hg	µg/L	0.005	**0.188**	0.027	0.004	0.020	0.012
Ni	µg/L	5.2	**15.3**	6.8	2.1	8.1	3.4
Pb	µg/L	1.2	**25.8**	13	0.3	4.8	2.0
U	µg/L	1.1	2.5	1.7	0.2	**3.4**	2.6
Zn	µg/L	46	**140**	95	10	45	25
SPM	mg/L	13.2	**165**	31.2	4.0	76.0	18.5
PP	mg/L	0.05	0.21	0.09	0.02	**0.24**	0.07
POC	mg/L	0.1	10.3	2.0	0.4	**26.4**	4.8
PN	mg/L	0.2	1.1	0.3	0.1	**4.7**	0.9
Conductivity	mS/cm	0.330	1.130	0.400	0.430	**1.410**	0.580

Tab. 1: *Concentration range of selected parameters, measured at site 1 to 5 during a flood and a low water event in 2017 (bold: the highest value of each parameter)*

In Figure 4, additional to site 1, inputs from upper Mulde stretches are shown (site 2, number 4). Besides arsenic (As), this also applies to chromium (Cr), copper (Cu), nickel (Ni) and lead (Pb). Analogous to the results of flood investigations discussed for site 1, concentrations at site 2 (number 4) decreased after a maximum value was reached. During low water levels, in contrast to site 1, concentrations of As in samples of sites 2 to 5 were higher in comparison to the investigated flood event. This is due to the high geogenic background of As in the Mulde catchment.
It is of importance to point out, that for all measured elements the flood event had no effect on the concentration levels at site 5, located close to the mouth of the River Mulde into the River Elbe.

4. Conclusions

Results of the investigated low water period can be used to evaluate the results of the flood investigations. From the assessment of both investigations, no restrictions regarding the planned restoration measures can be derived.

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Pesticide path from fields to rivers

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1. Introduction

Pesticides occurring in our water courses are mainly related to the present-day agricultural activities where they are used in significant quantities to grow rape, maize, sugar beet, potatoes, cereals and other crops. Surface, drainage and ground water of the Vltava river basin contain mainly triazine type pesticides, uric acid derivatives, chloroacetanilide pesticides, glyphosate and metabolites of most of these groups of substances. At present, there is a number of new pesticides present in the water which gradually replace substances previously used or substances that are now banned, such as pethoxamid, isoxaflutole, thiencarbazone-methyl, cyprosulfamide, bentazone and other newly registered and introduced substances. The watermanagement laboratories of Povodí Vltavy, state enterprise, have been monitoring the presence and quantity of pesticides in surface water for over a decade. Starting in 2014, in cooperation with the Research Institute for Soil and Water Conservation, v.v.i., a study of the occurrence of these substances in drainage water was conducted to assess their kinetics in the system: soil - drainage water - surface water. Another objective was to evaluate the effect of drainage water on the surface water quality. This monitoring was carried out within the project TA04021527 „Study of the Causes and Dynamics of Small Waters Courses affected by Plant Protection Products“, supported by the TAČR between 2014-2017.

2. Material and methods

As part of standard surface water monitoring, a total of 545 water quality profiles are monitored in the Vltava river basin network; however, pesticides are only analysed in a smaller number of them and samples are usually taken at monthly intervals. Nevertheless, this monitoring does not take into account accidental, sometimes extreme, rainfall--runoff events (RREs) when large volumes of these substances can be washed away from the river basin areas. To monitor RRE in surface water, the so-called “automatic sampling station” which can take samples of water during the RRE or continuous integrated samples over a longer period of time, is used. This station is „semi-mobile“ and has been installed for several years in the agriculturally utilised Čechtický river basin in the Švihov impounding reservoir on the Želivka river, hydrometric profile Čechtický potok - Leský mlýn (Fig.1). To monitor RRE in drainage water, automatic samplers fitted in monitoring profiles of the studied micro river experimental basins are used - „drainage groups“ Černičí, Dehtáře and Vepříkov (see Figure 2). REE reflected in both surface and drainage water samples is very important for both quantitative and qualitative analyses, especially because some substances can only occur in water during the rainfall-runoff events and also provided that they were applied on agricultural land just before a rainfall event. Understanding the transformation of parent substances to other products of decomposition is crucial for assessing the impact of the use of plant protection products and the mass balance. What is also important is the knowledge of the relevant river basin and the overview of the application of these substances to crops in the river basin.

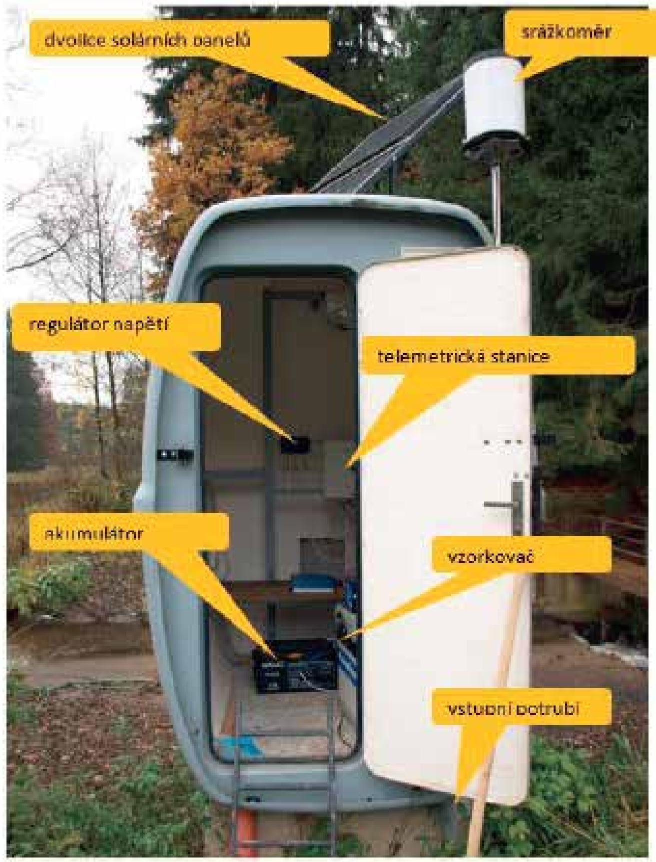

Fig. 1: Automatic sampling station installed on the Čechtický potok, Leský mlýn, profile

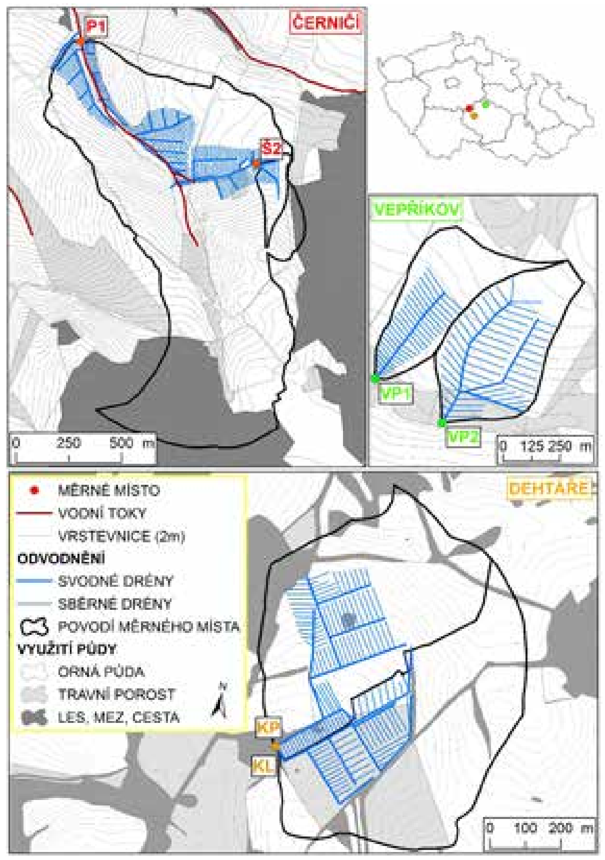

Fig. 2: Schematic maps of experimental drainage systems (Zajíček et al., 2017).

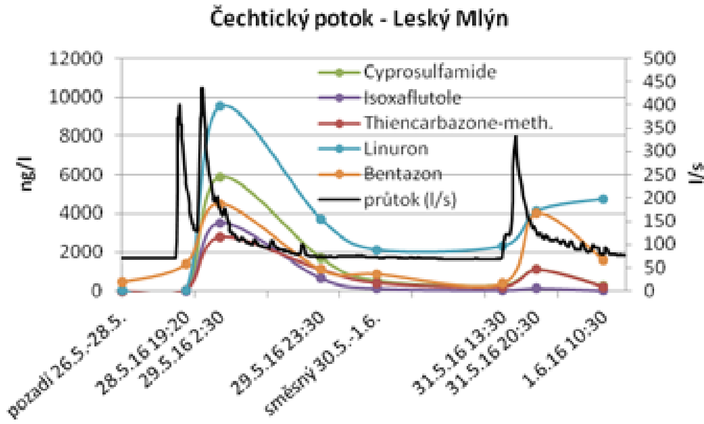

Fig. 3: Development in concentrations of selected pesticides and metabolites during a rainfall event (28th May - 1st June.2016),

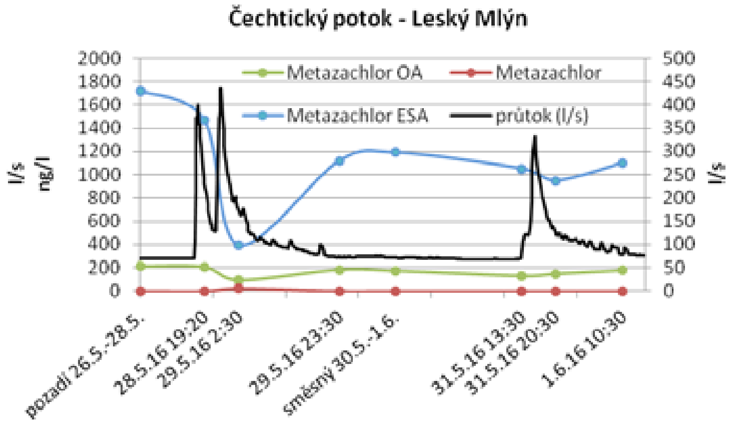

Fig. 4.: Development in concentrations of metazachlorine and its metabolites during a rainfall event (28th May - 1st June.2016)

The sampling scheme differed according to the current hydrological situation. In the periods of the prevailing basic and slow slope runoff, samples were taken manually in regular 2-week intervals. During the rainfall-runoff events, the samples were taken using automatic samplers in 20-minute intervals in the summer and 1-hour intervals in the winter (Zajíček et al., 2017).

Pesticides and their metabolites were determined using liquid chromatograpyh with a triple quadrupole mass detector with positive and negative ionisation (Ultra High-Performance Liquid Chromatograph (UHPLC) and Triple Quad Mass Spectrophotometer MS/MS.

3. Results

The most important outputs of the study of pesticide movement dynamics include the quantification of pesticide transport from agriculturally cultivated micro basins. Hydrological events have a very significant impact on the overall pesticide transport from the river basins, in the course of which there is often a multiplied displacement of pesticides compared to the standard hydrological conditions, which applies to surface water as well as to subsurface and drainage water. The influence of RREs on the concentration of pesticides in the streams is documented in Figure 3, which describes concentrations of „parent“ pesticide substances: linuron, bentazone, cyprosulfamide, isoxaflutole. Different concentrations trends were measured during a rainfall with respect to a number of chloroacetanilide pesticide metabolites (Fig. 4). In the period of increased flow rates in the in Čechtický river, the concentrations and dilutions of all detected metabolites of metazachlorine, alachlorine, acetochlorine and metolachlorine were reduced. These metabolites are highly persistent and have been detected throughout the year in composite samples and therefore they are likely to be „diluted“ at higher flow rates in surface water in proportion to the rainfall.
Thiencarbazone-methyl during a May rainfall (Dobiáš et al. 2017).

Detailed monitoring of the volume and composition of drainage runoff and the concentration of pesticides (in experimental drainage systems of the Černičí, Dehtáře and Vepříkov micro basins) has shown that drainage systems represent a potentially highly significant path of pesticide leaching into surface water. Presence of these substances in the runoff is, in addition to the application period, mainly dependent on the current hydrological situation in the river basin area.

Pesticide metabolites are typically present permanently in drainage water, often in high concentrations. Their leaching is mainly related to the basic and slope runoff. The presence of metabolites of substances that have been applied long before sampling is related both to the high persistence of these metabolites and to the relatively long residence time of slow components of drainage runoffs. During precipitation-runoff events, their concentrations drop unless water from the causal rainfall reaches the drainage water and „dilutes“ their concentrations (Fig. 5), or if the drainage runoff during the rainfall is mainly formed by old water, i.e. rapidly mobilised shallow subsurface runoff. On the contrary, the parent substance leaching is linked almost exclusively to the rainfall-runoff events. A prerequ-

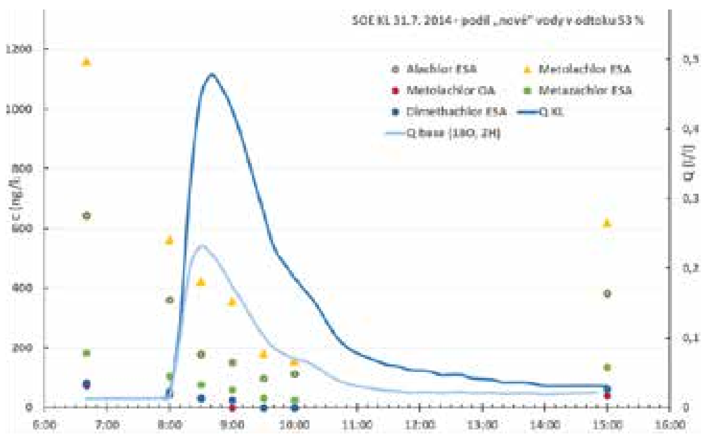

***Fig. 5:** Development in the concentrations of pesticides metabolites during RREs water from causal rainfall (Dehtáře KL)*

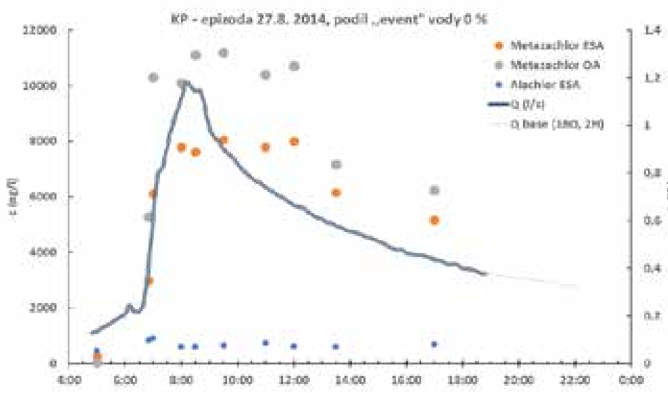

***Fig. 6:** Fig. 6. Development in the concentrations of pesticides metabolites during RREs „old water displaced" (Dehtáře KL)*

isite for the parent substance leaching is that the rainfall--runoff event occurs shortly after their application and, most likely, also the presence of „new" water in the runoff. If these situations occur at the same time, the concentrations of pesticides in drainage water are quite high and the displacement of pesticides can even reach grams per rainfall event. An example of a massive pesticide transport through drainage water during rainfall-runoff event is shown in Fig. 7- experimental drainage system VP2 Vepříkov. The rainfall registered in drainage group of VP 2, Vepříkov site (graph 8), occurred 26 days after the application of terbuthylazine and metolachlorine.

This event represented 20 mm precipitation. Drainage flow rate increased from 0.25 l/s to the peak flow of 9.0 l/s in just 90 minutes. During this PPE, significant concentrations of parent substances and metabolites of pesticides, which were applied approximately 24 days before its beginning, were registered. The summary concentrations of parent substances ranged from 14 ng/l at the outset of the PPE to 434135 ng/l reached just before the peak flow rate. Following the peak flow, the concentrations of parent substances in drainage water sharply dropped and at the end of the rainfall the total concentration was 13 225 ng/l. As regards the parent substance composition, the substances applied just before the rainfall clearly prevailed, the highest concentrations were reached by metolachlorine with a maximum of 120 000 ng/l; in the case of terbuthylazine, the highest value totalled 92 033 ng/l. As regards other substances, there was a significant proportion of chloroacetanilide metabolites, predominantly metolachlorine in the form of ESA and OA, probably from the last application. There were also very high concentrations of several forms of terbuthylazine metabolites. The transport of pesticides over this 24-hour period was calculated to total 33 grams, of which 14.6 grams were parent substances and 18.4 grams were represented by their metabolites.

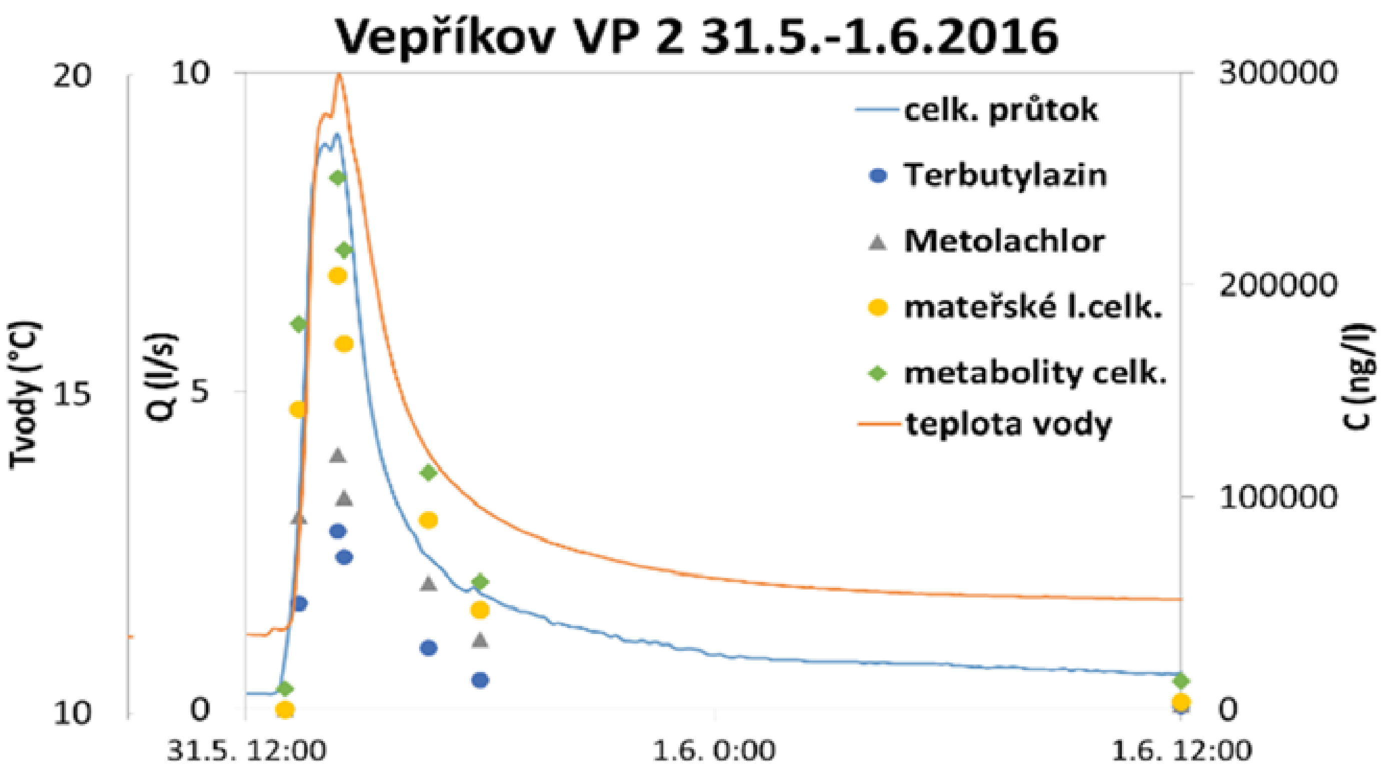

***Fig. 7:** Massive increase in the concentrations of terbuthylazine and metolachlorine in drainage water during RRE, approx.24 days after Gardoprim Gold application. Vepříkov VP 2 site*

4. Conclusions

The results clearly show that well-functioning drainage systems draining intensively cultivated agricultural land (with the application of plant protection products, „PPP") are point sources of pesticides in surface water. The highest concentrations of pesticides in surface water are carried off from the drainage systems during the so-called rainfall-runoff evens after the previous application of PPP.

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Comparison of satellite-derived chlorophyll-a and turbidity measurements with probe data at Lake Rummelsburg, Berlin

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1. Introduction

The conservation of water quality is of high importance in today's society. The recreational potential of waterbodies is subject to a strict monitoring of dissolved inorganic matter, chlorophyll and turbidity. The implementation of the European Water Framework Directive has led to an intensification of monitoring efforts. The dynamic development of algae blooms comes along with a deterioration of water quality so that safe bathing cannot be guaranteed anymore due to their potential harm to the human body. The operative systems of public authorities are not sufficient enough to adequately monitor this dynamic phenomenon [3]. Hence, there is a demand for appropriate monitoring techniques.

One approach is the use of water remote sensing techniques [1]. It can fulfil the spatial and temporal highly dynamic requirements of water quality monitoring. In this context, this research is dedicated to the issue of a comparison of satellite-based and in situ measured data of different water quality parameters. The aim is to clarify to which extend the satellite-based data of EOMAP are comparable with in-situ monitoring data of the RuBuS-project [xx1] of the Freie Universität Berlin. It is mainly focused on the comparability of the data. This comes along with an analysis of the daily persistence of chlorophyll-a and turbidity data. Furthermore, the spatial distribution of these matters is a major component of this work. The area under investigation is the Lake Rummelsburg (river Spree), located close to the centre of Berlin.

2. Methods

By comparing the two datasets, certain factors have to be considered. This includes, among others, the type of satellite data that is processed, the type of multi-parameter probe used and the methodological framework. In figure 1, the experimental set-up is displayed. The two datasets had to be merged before comparing. The bluish colour indicates the concentration of the turbidity in TUR/NTU which was processed by the company EOMAP [2]. The red dots show the sampling sites of the probes which were taken in 2015 by the research group Applied Geography - Environmental Hydrology and Resource Management of the Freie Universität Berlin. In addition data of a stationary probe-chain (marked with a yellow flag and located at the centre of the lake) were used for the analysis.

For the statistical comparison of the two datasets a regression analysis was operated. Therefore, only the in-situ probe measurements were compared with the satellite derived data. The recording dates were at maximum two days apart from each other.

To determine whether the difference between the two recording dates was too large or not, the daily persistence of the concentrations chlorophyll-a and turbidity was analysed. The persistence was processed with an autocorrelation function in RStudio. The measuring interval of the probe-chain was 10 minutes, so that changes in concentrations could be observed continuously.

Other important factors that had to be considered are environmental influences on the validation results. One possible influence on the validation results is the bathymetry of Lake Rummelsburg [4]. The bathymetry was correlated with the concentration of the two different water quality parameters. Regarding the depth of the lake it was assumed that shallow parts of the lake have higher concentrations in chlorophyll because the reflexion of the subsurface is much higher than in deeper parts. To answer this question a developed flow-chart-diagram was applied.

3. Results

In table 2 the results of the regression analysis are displayed. The two water quality parameters are listed for the two different comparison dates (14.02.2015 and 10.04.2015). The data row "Datenreihe" specifies the five different measuring depths of the probe.

The statistical tests of the regression analysis and the tests of mean differences show no evidence for a similarity of the two datasets. Nevertheless, the results show a certain similarity between the deepest measurements of the probe and the satellite-based data.

An explanation for the dissimilarity results of the statistical test could be the large time difference between the two recording dates of the measurements. The diagram in figure 2 visualised the results of the autocorrelation function of the probe-chain. The y-axis shows the achieved correlation. On the x-axis the lags (days) between the recording time of the satellite-derived measurement (0) and the different concentration measurements of the probe-chain are plo-

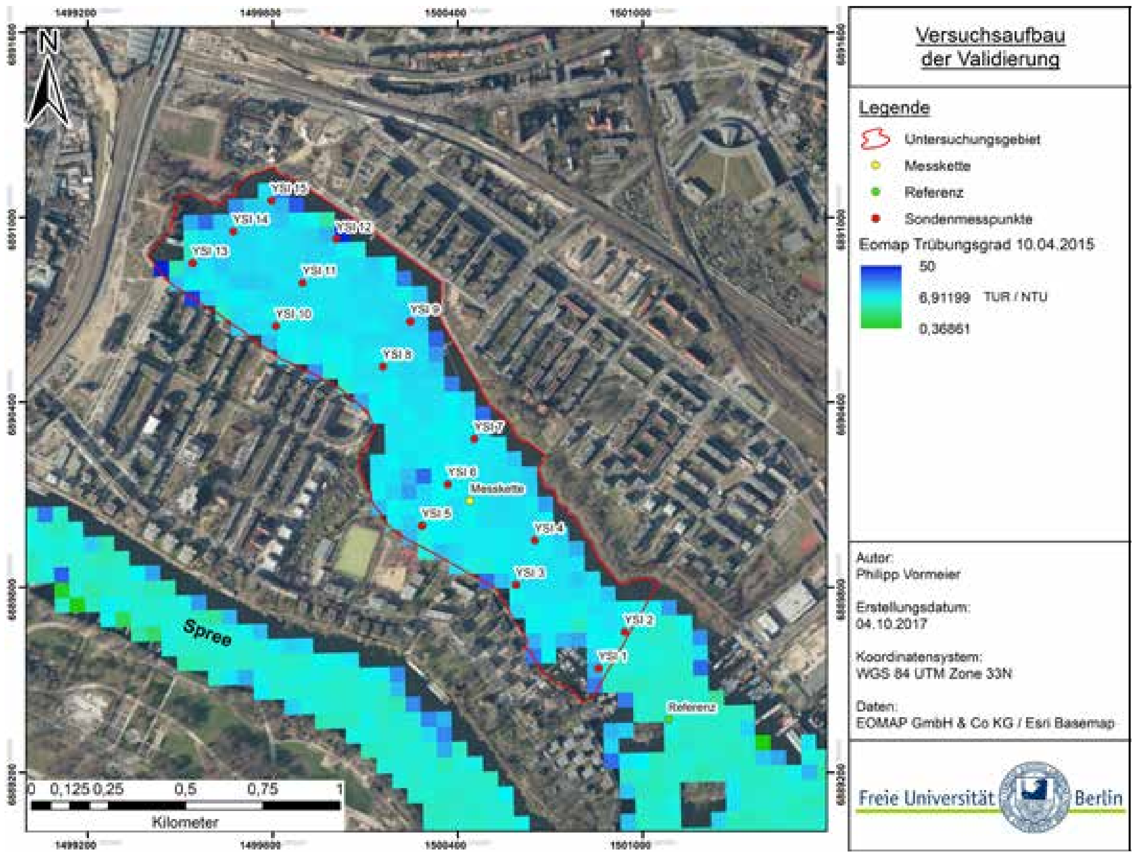

Fig. 1: *Experimental set-up of the comparison*

Art	Datum	Datenreihe	R² mit Ausreißern	Ausreißern	R² ohne Ausreißer	r ohne Ausreißer	p-Wert ohne Ausreißer
Chlorophyll	14.02.2015	RuBuS 20cm	0,016	12	0,14	-0,37	0,17
RFU		RuBuS 50cm	0,074	12, 14	0,12	-0,35	0,23
		RuBuS 100cm	0,24	12, 16	0,046	-0,21	0,46
		RuBuS 150cm	0,44	12	0,4	-0,63	0,011
		RuBuS 200cm	0,38	11, 12	0,65	-0,81	0,0005
	10.04.2015	RuBuS 20cm	0,041	12	0,027	0,16	0,56
		RuBuS 50cm	0,027	16	0,0034	0,06	0,84
		RuBuS 100cm	0,054	12, 16	0,008	0,09	0,76
		RuBuS 150cm	0,082	16	0,11	0,33	0,22
		RuBuS 200cm	0,0004	12, 16	0,000001	0,00	0,99
Trübung	14.02.2015	RuBuS 20cm	0,1	13	0,19	0,44	0,1
NTU		RuBuS 50cm	0,12	13	0,24	0,49	0,063
		RuBuS 100cm	0,054	13	0,17	0,41	0,12
		RuBuS 150cm	0,16	13	0,35	0,59	0,019
		RuBuS 200cm	0,2	13	0,44	0,66	0,0068
	10.04.2015	RuBuS 20cm	0,0072	16	0,31	-0,56	0,031
		RuBuS 50cm	0,058	16	0,29	-0,54	0,039
		RuBuS 100cm	0,0092	16	0,25	-0,50	0,058
		RuBuS 150cm	0,0014	16	0,21	-0,46	0,088
		RuBuS 200cm	0,15	16	0,34	-0,58	0,024

Tab. 2: *Comparison of the multivariate statistics results*

tted. The daily persistence analysis indicates that considering the great time difference between the two recordings the difference is too large to overcome the uncertainty factor. This analysis was conducted for the entire observation period (10 months) and for the satellite recording time which includes observations 10 days before and after the recording

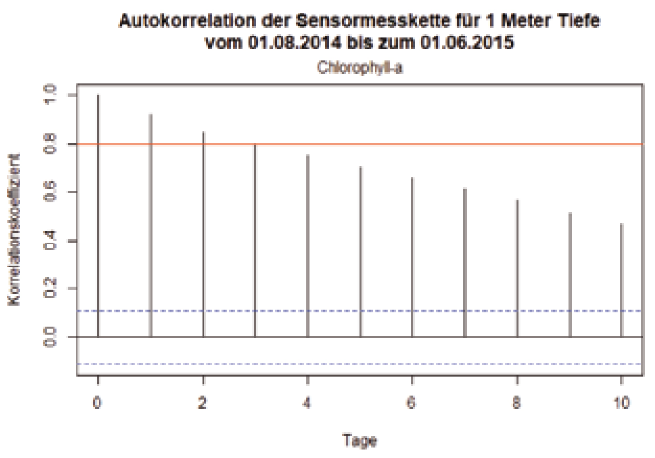

Fig. 2: *Daily persistence of Chlorophyll-a for the depth of 1 meter in the measuring period 01. 08. 2014 - 01. 06. 2015*

date. The results were similar to the results shown in figure 2. The first step to identify whether the raster datasets of the satellite derived data has a spatial distribution is to determine a clustered condition of the values. All comparable datasets were clustered. In the next step correlation analysis between the bathymetry and the satellite-raster-data were conducted. The correlation matrix in figure 3 shows that there is no correlation between the two different datasets. Therefore, the analysis of the spatial distribution of chlorophyll and turbidity indicates that there is no large difference between the two measuring methods. Only the satellite raster data at one recording date show a significant correlation. Therefore, the reflexion of the lake bottom cannot be a crucial parameter regarding the distribution of concentration. Accordingly, the chlorophyll and turbidity concentration is independent of the depth.

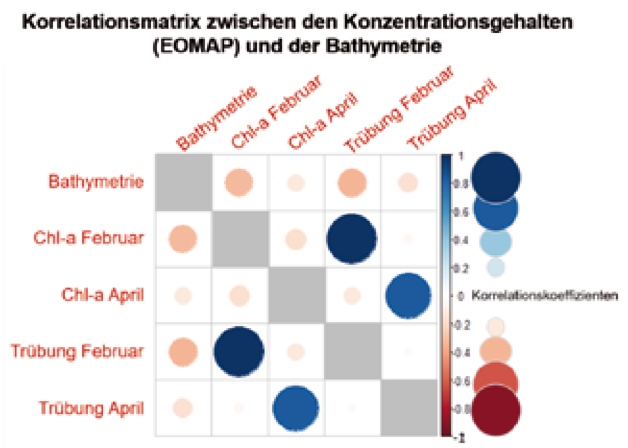

Fig. 3: *Correlation matrix between the satellite-derived raster for chlorophyll and the bathymetry of Lake Rummelsburg*

4. Discussion

The results of the comparison between the two datasets are different to other studies that were conducted on this topic [5]. The coefficient of determination was much lower than expected. A reason for this could be the consistence in the statistical tests. The comparison included five datasets of one measuring method and compared it with one dataset of a different measuring method. Therefore, this method could be overrated by the test. Nevertheless, similarities between the two datasets could be asserted in deeper depths (150 cm and 200 cm). Possible reasons for this dissimilarity could be the coarse spatial resolution of the satellite data (30 x 30 m). Another important factor seems to be the recording time.

The results of the daily persistence analysis indicate that a difference more than one day between the recording dates is too large to validate the datasets properly. To verify these results it would be useful to repeat this experimental set up with waters that differ much stronger in concentrations of chlorophyll-a and turbidity.

One factor that can be excluded of the failure assessment for the regression results is the depth of the water. The correlation results show that there is no relationship between the concentrations and the depth. To confirm these results a repeat measurement at a much deeper lake with higher concentration fluctuations is needed.

The scientific findings of this work contribute to a better understanding of water remote sensing and an implementation in the scientific discipline of applied environmental hydrology. Water remote sensing has a fundamental potential to achieve an improved water quality monitoring. In this context more comparison with conventional measurements are necessary. Nevertheless, water remote sensing offers the only option of complex water quality monitoring regarding the short-term spatial-temporal dynamics of water bodies.

Acknowledgements: The in-situ data used in this study had been collected before in the monitoring programme of the RuBuS-Project [xx1], which was co-financed by the Berlin State Government in the framework of the “Umweltentlastungsprogramm” (UEP II) and the European Funds for Social and Regional Development (EFRE); Project-Number 11429 UEPII/2.

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HYDROLOGICKÉ EXTRÉMY
Hydrologische Extreme

Content

Economic aspects of nature based flood protection measures in landscape

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1. Introduction

In recent years, nature based solutions are discussed and implemented in Europe more and more frequently. These are measures that provide number of other benefits besides solving a particular problem. However, implementation of nature based flood protection measures in the Czech Republic faces numerous challenges. First of all, there is a low level of awareness about the significance of such measures, which is reflected in their low chance of being promoted, financed and eventually implemented. Secondary, benefits of nature based measures are difficult to grasp. Although nature based measures in alluvial plains and entire catchment areas are frequently built as flood-prevention measures, they often have numerous additional benefits, such as reduced erosion, reduced run-off of phosphorus into watercourses, etc. Economic assessment of the measures can be used as a basic argument for implementation of the measures and for raising the awareness. Standard method of financial assessment applied in water management in the Czech Republic don´t result in formulation of an appropriate economic argument about the importance of the measure.

The objective of the paper is to present possible method of economic assessment which can lead to raising awareness about the nature based measures and their importance. The paper is tightly linked to measures contained in the catalogue presented in form of poster by our colleagues from the Czech Technical University in Prague (CTU). Each of the measures is subjected to an economic assessment. The economic assessment includes costs and benefits. The purpose of this paper is to show the wide range of benefits provided by measures, including those that are not normally included in assessment. We demonstrate the capabilities of economic assessment on the example of the catalogue of measures produced in cooperation with the CTU as part of the cross border project STRIMA II.

2. Economic assessment of measures

Economic thinking is gradually expanding into a number of fields that were previously closely associated with other professional disciplines (such as science, technology, or legal subjects). One of these areas is water management, where economics is increasingly being promoted since the turn of the century. The demand for complex approaches has grown in recent years. An essential role was played primarily by the Water Framework Directive. Economics primarily addresses the allocation of scarce resources

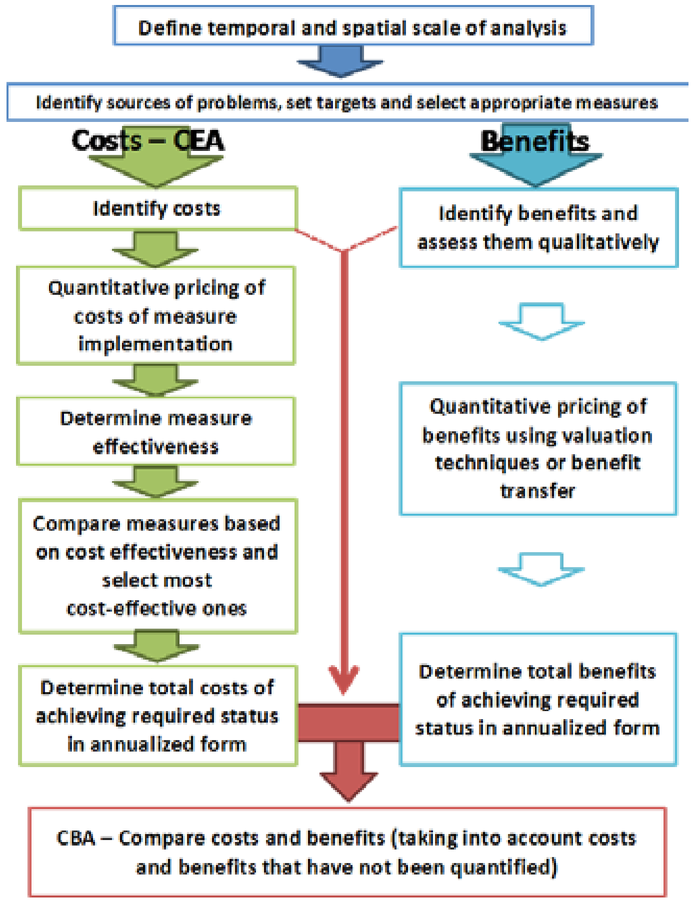

Fig. 1: *Process of measures assessment using cost-benefit analysis (based on: [2])*

between competitive uses. Economics offers a wide range of possible approaches used for assessment. Based on the [1] three basic approaches are currently applied in water management: (i) monetary cost-benefits analysis; (ii) criterial cost-benefit analysis; and (iii) methods based on affordability and social acceptability.

Based on literature review (e.g., [2], [3]), economic assessment of nature based measures can be made using a cost-benefit analysis (CBA) and the ecosystem services concept. CBA is an analogical method to a financial analysis in an enterprise where, in addition to the private financial benefits and costs of the company, social costs and benefits are also taken into account. The social costs and benefits are often not of a direct financial nature, but they have a noticeable influence in the basin. Therefore both on the benefits side and on the cost side, we encounter a number of non-market goods/services that need to be dealt with in the assessment. The concept of ecosystem services can be used to identify and categorize the costs and benefits. Assessment of costs and benefits and their comparison is burdened with a number of complications. The most important of these challenges is time and cost distribution.

Costs, with the exception of routine regular maintenance, are often one-off. On the other hand, benefits are achieved over the lifetime of the measure. Even the distribution of the costs themselves differs between investment measures (e.g., water reservoirs or wetlands) or operational measures (e.g., change in crop rotation etc.). For this reason, it is appropriate to use the cost and benefit annualisation method used by e.g. [4], [5].

The process of economic assessment using annualisation is depicted in Figure 1. The cost and benefit valuation is carried out in parallel. In the first step, it is necessary to identify all the costs / benefits based on the concept of ecosystem services. The quantification of costs / benefits and their expression in monetary units follows. Within valuation, both costs and benefits are divided into a number of categories for which annualisation is done separately based on the lifetime. Once the total value of costs and benefits has been determined, total annual costs and benefits can be compared. Because of uncertainties and risks, sensitivity analysis is performed. It is usually done in the form of scenarios where the impact of the discount rate is at least tested. According to results of cost-benefit comparison and sensitivity analysis, conclusions are set.

3. Results

In order to make the assessment more accessible and simpler and thus to support implementation of measures, catalogue of nature based flood protection measures is currently being developed in cooperation with CTU. Actual 15 types of measures are involved in the catalogue. For each measure costs and benefits were identified. The following Table 1 contains an example overview of costs for 5 selected measures. The investment and operating costs are identified based on existing measures in the Czech Republic. In additional, cost of opportunity were set based mostly on loss of profits.

Measure	Investment costs		Operating costs (OC)		Opportunity costs	
Wetland	all investments costs excluding the purchase of land and administrative costs.	1,370,000 CZK/ha or	OC 1: Sediment and mud removal.	390 CZK/m^3	Loss of agricultural land - loss of profits from agricultural.	7,380 CZK/ha
		85 CZK/m^3	OC 2: Technical Supervision (if relevant)	170 CZK/hour		
Infiltration – Retention ditch	all investments costs (especially earthworks and reinforcement of ditch) excluding the purchase of land and administrative costs.	795 CZK/ 1 metre	OC 1: Ditch maintenance - Grass moving	27 CZK/ 1 metre	In respect of area it is not necessary to include opportunity costs.	x
			OC 2: Other cleaning	12 CZK/ 1 metre		
Grassing	all investments costs (especially earthworks and planting grass) excluding the purchase of land and administrative costs.	Slope of the terrain from 0° to 3°: 7,600 CZK/ha	Grass moving (2-3 times per year)	Slope of the terrain from 0° to 3°: 2,170 CZK/ha	Loss of agricultural land - loss of profits from agricultural.	3,162 CZK/ha
		Slope of the terrain from 3° to 7°: 8,350 CZK/ha		Slope of the terrain from 3° to 7°: 2,400 CZK/ha		
		Slope of the terrain above 7°: 9,870 CZK/ha		Slope of the terrain above 7°: 2,825 CZK/ha		
Agricultural measures - crop growing in strips and its rotation	Either no investment costs or low investment costs associated with the necessity of buying new machines (seed drills).	x	Higher operating costs considering planting crops (sowing and harvesting must be done separately for each strip).	265 CZK/ha	Loss of profits caused by changes of crop growing in strips (the effectivity of agricultural production decreased).	735 CZK/ha

Tab. 1: *Example of cost valuation for selected measures*

In addition, we compiled an overview of benefits based on ecosystem services provided (Table 2). They cover both the primary function of each measure and its secondary benefits. The rate of provision of each service was determined on a scale 0-3. Zero means that the service is not provided by the measure, three means full provision. Cost and benefit annualisation can then be used for expressing the annual costs and benefits, and their subtraction yields the net social benefit.

4. Discussion and Conclusion

Although the nature based measures bring multiple social and environmental co-benefits, their real-world implementation often comes up against numerous obstacles that are frequently related to low awareness about the society-wide benefits provided by such measures. This article presents a procedure for the economic assessment of nature based flood protection measures. It is appropriate to assess the measures in relation to local conditions. This means that the importance of measure can be translated from hydrological/biological aspects into monetary value, which is understandable for whole stakeholders (not only for experts in water management or biologists). The CBA results can be used as a strong argument for support of the implementation of measures.

Ecosystem services	Wetland	Infiltration-retention ditch	Grassing	Crop growing in strips
Increase of water retention	3	3	3	1
Flood protection function	2	2	1	1
Improving of water quality	2	2	2	1
+ health impact				
Soil protection against erosion	0	3	2	2
Regulation of air quality	0	1	2	1
Carbon sequestration	0	1	2	1
Production of biomass	0	2	3	2
Increase of aesthetic value	2	2	3	2
Recreational benefits	2	1	0	1
Increase of biodiversity	3	2	1	2

Tab. 2: *Rate of provision of individual ecosystem services for each measure*

The necessary step to gain support is to make the public aware of the CBA results. The monetary results (comparison of costs and benefits) can be combined with qualitative assessment for those who are more familiar with water management and detailed aspects.

The lack of primary data necessary for benefit valuation is the main complications in economic assessment. Thus it is advisable to create a database of values that can be used for valuation and would be open for everybody. In the light of the Water Framework Directive, this is a similar procedure to be followed in justification of exemption by (not)achieving the "good status" due disproportionate costs. The database can be used for different purposes.

Acknowledgement
The paper is based on the outcomes of the project Saxon-Czech Flood Risk Management II (STRIMA II, project reg. no. 100282105), supported under the Cooperation Programme Free State of Saxony – Czech Republic 2014-2020.

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20 Years of Stormwater Management in Dresden - Objectives and Knowledge Learned

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1. Introduction

Urbanization and ongoing growth of big cities will significantly increase surface sealing causing a variety of secondary ecological problems. This growth also has a considerable effect on water balance. In comparison to open landscape areas, in urban areas the natural water cycle is affected. Precipitation can seep away only to a limited extent, and is drawn away from the surface directly into surface waters or into in the sewer system. Evaporation on sealed surfaces is likewise severely reduced. Both factors lead to a massive increase in as well as acceleration of runoffs.

Historically grown sewer networks and urban waters have often not grown along with the increased volumes of water, which can lead to swamping, high water/flash floods and discharges from the sewer system. In addition, the biocenoses of urban waters, which need to be brought into good environmental condition as stipulated by the EU Water Framework Directive, cannot cope with impact loads of this nature. This low evaporation is also causing the inner-city climate to deteriorate.

By as early as the early 1990s, Dresden already began to develop strategies to counteract these negative environmental effects and introduced the concept of stormwater management in 1997.

2. Objectives and Guidelines

Our guiding principle for stormwater management is the maintenance and/or restoration of a water balance that is as natural as possible, i.e. to negatively impact the water balance as possible. It should be obvious to anyone that in an urban environment, this objective is possible only with certain limitations.

Another key requirement concerns bodies of water which, according to the Water Framework Directive, must be brought to good environmental and chemical condition. As a result, these bodies of water may be subjected to only low levels of contamination and hydraulic loading. In general, unthrottled discharges into surface water cannot be authorised. Contaminated stormwater must be treated (purified) before being discharged into surface waters.

At the same time, the local authority district must ensure that traditional requirements of urban drainage (up-to-date drainage conveniences and hygienic conditions) are fulfilled, and that flood protection is guaranteed.

3. Content and Methods

The guiding principle of a natural regional water supply requires knowledge on the water supply balance, under exclusion of the current urban impact. By 1996, Dresden already worked out and classified typical values of natural water balance . Finally five types were determined on the basis of hydrological modelling and a map showing possibilities for natural seepage (Tschirner & Fuhrmann 1996). The five water balance region types are marked with the average characteristic values of evaporation, direct runoff and subsurface runoff (Fig. 1). Stormwater is to be managed primarily at the location where it accumulates, in accordance with the water balance for that region. Surface runoffs are minimized and discharges into bodies of water are tolerated only up to the degree typical of the region.

Natural runoff rates for typical reference rainfalls of different annualities were determined over the course of determining characteristic hydraulic values for bodies of water in Dresden. These rates represent an key basis for determining the maximum throttled runoff for discharges of stormwater into running water. Throttled runoffs must be restricted in such a way that the natural runoff rate for the reference rainfall is not exceeded, and that an increase in the risk of floods does not result. The guide value for this is the natural runoff for the region, for a maximum 10-year (generally more frequent) rainfall event.

Dresden's rapid growth as well as the challenges arising due to climatic change require a comprehensive approach of suitable measures for stormwater management:

- First, the negative impacts of ground sealing on the water balance must be limited by min-imising the sealing itself.
- Given a suitable subsurface, stormwater must be seeped away by passing it through a grassy, biotic soil zone (in order to purify it and keep back harmful substances).
- Evaporation must be encouraged as much as possible by means of green roofs, lush green-ery on open ground and open drainage systems.
- The use of stormwater is encouraged through fee waiving (split sewage fees).
- Surplus stormwater is generally held back and discharged only in a throttled manner.

Rigorous observance of minimum qualitative and quantitative standards for stormwater drainage must be maintained. The relevant technical regulations (e.g. DWA-M 153, BWK-M 3, RAS-Ew) apply when discharging stormwater into bodies of water and into ground water. Adequate flood protection in accordance with DIN-EN 752 and DIN 1986-100 must be ensured.

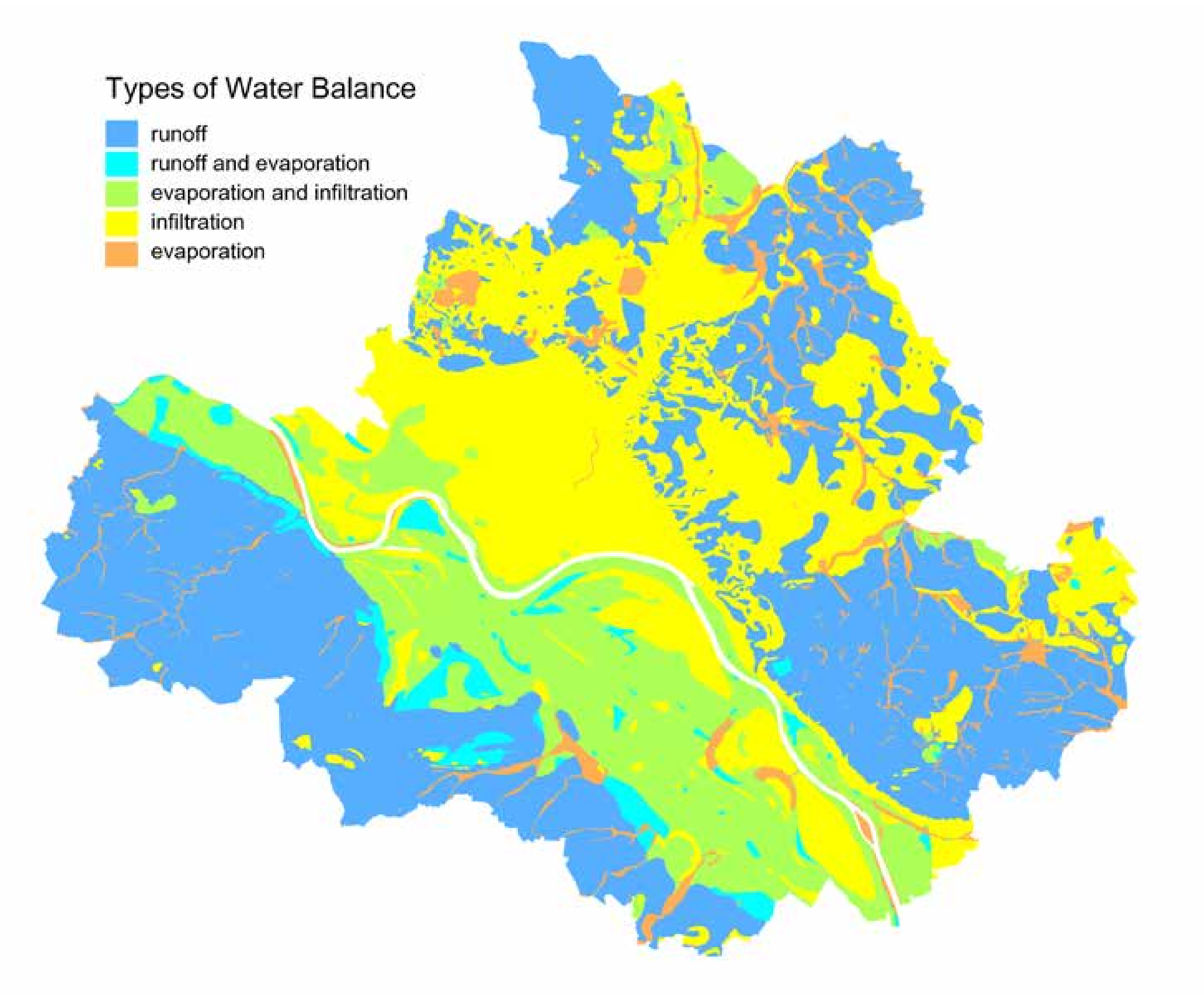

***Fig. 1:** Types of regions with natural water balance*

The practical implementation of this concept is based on three pillars:

- possibilities for waiving stormwater fees
- establishment of measures in urban development planning
- keeping building owners and land owners comprehensively informed

The practical guide „Budgeting Stormwater" („Mit Regenwasser wirtschaften", published by the state capital of Dresden in 2004) contains recommendations of measures which are coordinated to each region type. This information for managing stormwater, dimensioning private facilities, waiving stormwater fees, etc. is available to anyone and is accessible over the Internet (http://www.dresden.de/de/rathaus/dienstleistungen/c_357.php).

4. Integration within Urban Planning

Natural stormwater management is implemented as part of binding urban development planning. The basis for this is the German Federal Building Code (Baugesetzbuch/BauGB 1987). A development plan enters into force through municipal by-laws.

Region-specific requirements and solution variants are proposed by the environmental agency. In addition, it is sometimes necessary for compromises to be reached, since development sometimes occurs on sites which are not optimal. In this case, the key points and solutions which are arranged are recorded in the drainage concept. Planners, architects and developers must be informed of the given environmental requirements before each individual planning phase.

The secured development (stormwater disposal in this case) must be proven when the development plan is ready to be implemented as a by-law. Details are governed in the plan's development concept. Key hydraulic requirements are often also included in the by-law directly. By-laws on binding urban development planning are available to anyone, and are accessible over the Internet at http://stadtplan2.dresden.de.

In contrast to already developed areas, the possibility generally exists for implementing natural stormwater management in new plans for undeveloped areas. Environmental problems in already developed areas can be solved by means of decoupling. Existing hydraulic loading on water bodies and canals can be reduced and water balance improved through decentralised seepage and also through measures to reduce the accumulation of water (e.g. green roofs, use and retention). Seepage generally does not require a permit if done on one's own property.

Despite the increase of sealing due to developed areas in the past few years, the area in Dresden for which stormwater fees are collected (fee-effective area) has expanded only marginally. That area was largely balanced out though measures for decentralized stormwater management.

5. Examples and Concrete Solutions

Simple drainage solutions are the exception in building, industrial and commercial locations. They come in useful mainly on subsurfaces which are capable of seepage. However, there is an increasing need in Dresden for development to be carried out in locations with unfavourable conditions as well. Stormwater retention, evaporation, seepage and drainage are often combined in these areas. The avoidance of runoffs is a high priority especially when no drainage capability exists or such capability is already overloaded. As a result, measures such as green roofs and a stormwater management system which does not include runoffs for the most part are prescribed for large building projects. One example of this is the Globus Baumarkt DIY superstore in the north of Dresden (roof greening, water-permeable parking spaces, evaporation ponds).

Stormwater runoffs cannot be avoided. If only low runoff volumes are permissible, solutions must be found for retention, as well as for grey water utilization if necessary. The already-existing „Kräutersiedlung" in Dresden-Gorbitz was redesigned, by means of measures for retention, evaporation and seepage, to gain a significantly reduceed drainage in Gorbitzbach.

Because of the waiving of stormwater fees and the permit-free seepage of uncontaminated precipitation, the private sector primary uses the following stormwater systems:

- cisterns (for garden watering, service water use)
- water-permeable fortifications (joint plaster, porous concrete, checker bricks)
- grassy percolation troughs, surface infiltration
- trough-trench systems and pure trench systems
- roof greening on outbuildings is often already required in the development plan.

6. Limits of Stormwater Management

The contribution of stormwater management to decreasing the risk of floods decreases with the statistical likelihood of rainfall and flooding. Systems with a significant impact in this area are primarily those with a large specific storage volume and no drainage system (e.g. percolation troughs, non-networked trough-trench systems, green roofs, stormwater cisterns, etc.). Such systems can even surpass the effectiveness of natural areas. When added to decentralized measures, stormwater retention systems are suitable for realising the necessary absorption of peak runoffs. Through throttled runoffs, these systems help to reduce and delimit the damage potential of floods. A number of these basins have appeared on the outskirts of areas of new development (residential and commercial areas) within the last 20 years. In the event of failure, methods are provided to draw off masses of water so they don't cause damage.

The Stetzsch and Johannstadt pumping station, which takes the load off the canal system during floods and heavy precipitation, was built in order to prevent overflooding from sewerage systems. The overflow from the sewer system which remains as a residual risk in case of extreme events was extensively modelled, and is to be minimised through an intelligent canal management system.

Due to climatic change we must assume that not only heavy rain and unconfined water, flooding and periodically exposed bodies of water and heat stress in the inner city, but also general water balance deficits which also have an effect on the groundwater balance, will accompany us in the future.

Increased thermal loading during high-pressure weather systems over the summer is a problem in the inner city. Stormwater management and city planning are required in this area in order to create significantly more evaporation surfaces and green spaces. As a result, Dresden is currently taking part in the „HeatResilientCity" BMBF joint project („Hitzeresiliente Stadt- und Quartierentwicklung in Großstädten am Beispiel von Dresden und Erfurt") for heat-resilient urban development and regeneration in major cities, based on the example of Dresden and Erfurt.

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MOSES – Modular Observation Solutions for Earth Systems: A flexible and mobile monitoring systems investigating short-term dynamic events

Dietrich Borchardt, Peter Dietrich, Claudia Schütze, Ute Weber

1. Introduction

We have to consider that climate change may lead to an increase in global average temperature of at least 2°C in the near future. There is substantial evidence that this climate change will be associated with an increase in the frequency, intensity or a shift in timing of extreme events such as rainfall extremes and dryness, elevated flooding and extended low water periods, all with as yet unforeseeable environmental and socioeconomic consequences and feedbacks. Such meteorological and hydrological events are restricted in time and spatially distinct, but their ultimate impact may be significant for much larger regions (e. g. downstream catchment areas flooded from run-off generation in upstream headwaters) and with delayed effects (e.g. algal blooms in the vegetation periods in coastal zones triggered by legacy nutrient pulses from inland sources). The presentation will exemplarily analyse such event chains with emphasis on hydrological extremes and the processes they trigger: the mobilization of nutrients, carbon and harmful substances, their passage from land based sources into the aquatic environment and how these are transported or retained. We present a new modular and event driven observation concept that captures events from their origin to their fading and which complements existing data and models from long-term monitoring and observatories. This concept systematically combines mobile and high resolution event monitoring with stationary integrative observation and it aims at unravelling the (potentially decisive) role of the increasing frequency and intensity of extreme meteorological and hydrologic events on the status of our tightly coupled hydrologic, ecological and socio-economic environment.

2. General goals and scientific concept

The main goal of MOSES is to improve our capability in observing, comprehending and predicting the insufficiently understood effects of single and repetitive small to synoptic-scale, but temporally and spatially restricted, events that have the potential to trigger complex event chains across different Earth compartments. MOSES aims to provide high quality data and data products for improving our understanding of terrestrial, oceanic and atmospheric processes and fluxes triggered by such events as well as their effect on long-term trends (Figure 1). This knowledge is a prerequisite for improved prediction of the expected environmental, social and economic consequences of events, their feedbacks on climate as well as for the design and implementation of protective measures.

MOSES data will be provided in sufficiently high density and quality to allow enhanced and new strategies and approaches. These strategies and approaches include non-linear event-based Earth system modelling and will foster the epidemiological approach of understanding possible effects of events on long-term Earth dynamics.

The MOSES observation systems must meet the challenging requirements arising in event-driven campaigns. In particular, they must be mobile and modular, cover a broad range of observation scales and provide high resolution data in near real-time across compartments. These demands require the development of novel modular and mobile observation systems linking compartments while superimposed on our existing long-term observatories, which serve as the data backbone for the enhanced MOSES system. MOSES, however, will also support the overall research structure of Helmholtz by developing a demanding and integrative sensor network among the Helmholtz Centres. MOSES will significantly improve the scientific and infrastructural interfaces between the Earth science disciplines by providing a logistic and infrastructure platform for enhanced interchange and development within Helmholtz Earth sciences.

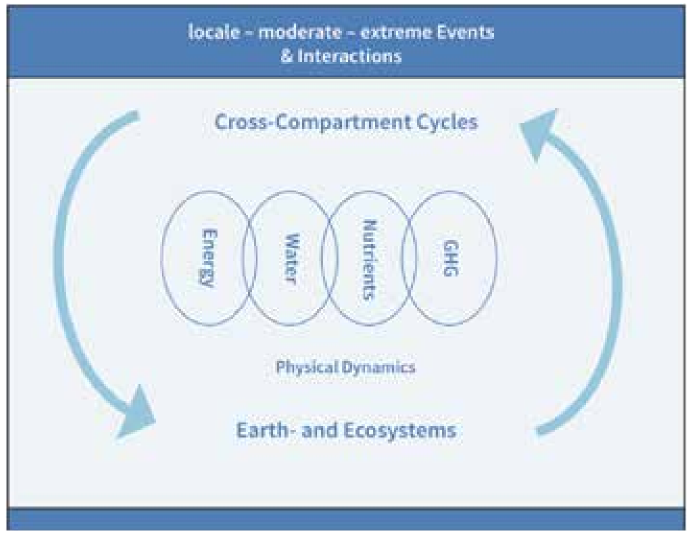

Fig. 1: *Illustration of the MOSES approach, which combines observations in several compartments and disciplines and across a large range of spatial and temporal scales.*

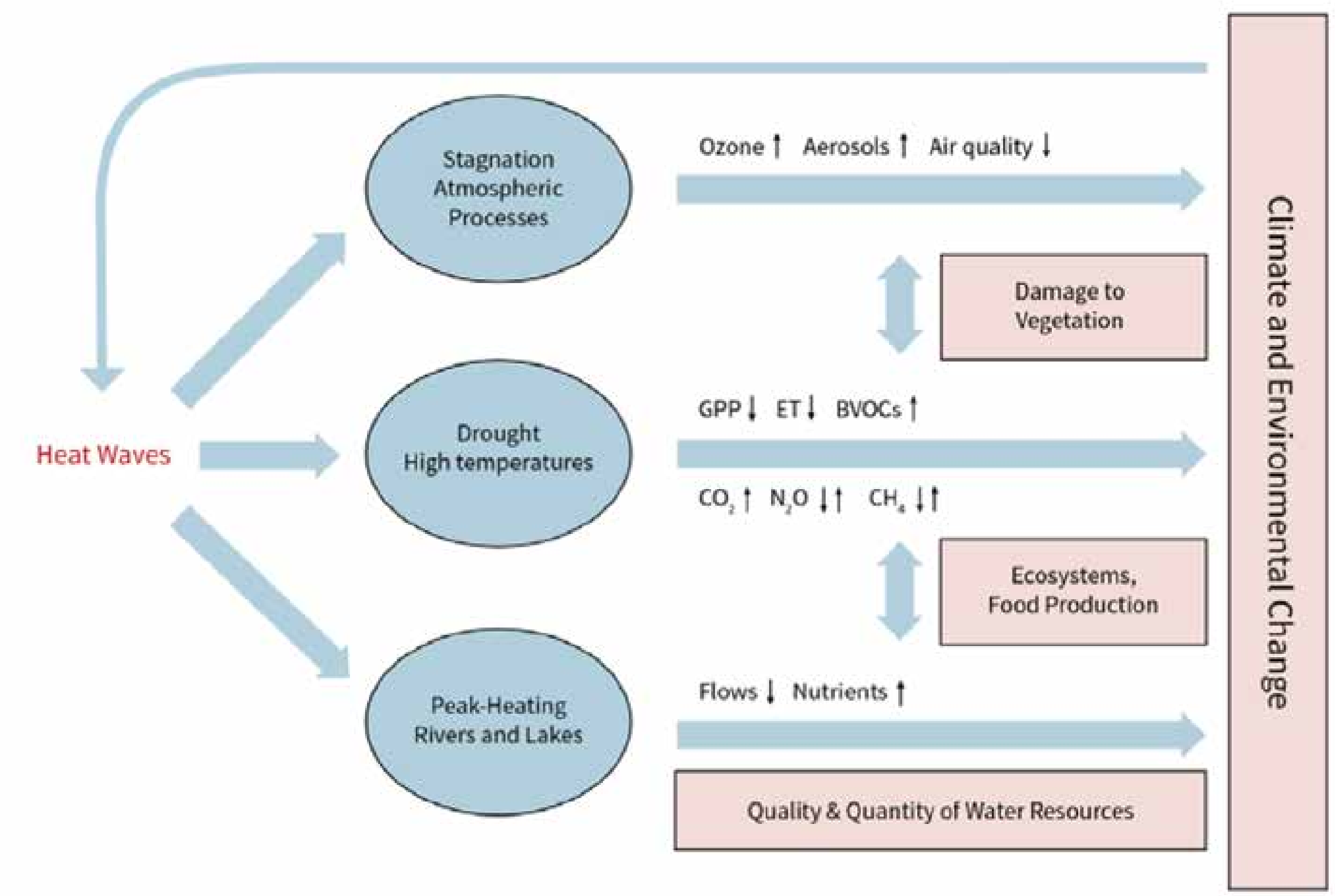

Fig. 2: *Schematic diagram of event chains triggered by heat waves: (1) Peak heating in rivers and lakes lead to decreased flow regimes and increasing concentrations of nutrients impacting negatively water quality; (2) heat waves lead to the occurrence of drought periods affecting ecosystems functioning such as gross primary production (GPP), evapotranspiration (ET) and emissions of biogenic volatile organic compounds and (3) they lead to increased concentrations in ozone and aerosols negatively impacting air quality. The arrows denote either an increase or decrease in magnitude.*

3. The Module Heatwaves

In the last fifteen years five extreme heat waves events have occurred world-wide, four of which were observed in Europe (Coumou and Rahmstorf 2012). These past heat waves have had a devastating impact on the functioning of ecosystems and have led to an increasing vulnerability beyond the duration of heat waves (e.g. degradation and increased erosion, reduced carbon uptake by vegetation, susceptibility of plants to pests and diseases). Such impact also includes loss of agricultural production and the presence of environmental conditions that are being unfavorable for human health and lead to high fatality rates (Robine, Cheung et al. 2008). A better understanding of the causes, the development and the consequences of heat waves is essential for the development and improvement of adaptation and protection measures. One goal of MOSES is to provide high quality data for improving our understanding of hydrologic, biological/biogeochemical and atmospheric processes induced by heat waves. This knowledge is prerequisite for improved prediction of the expected environmental, societal and economic consequences as well as for the design and implementation of protective measures.
We address three main event chains that develop as a consequence of extended heat periods that will be investigated by MOSES infrastructure. The first event chain is due to the occurrence of drought, associated with drastic changes in gross primary productivity, in evapotranspiration (ET) and greenhouse gas (GHG) fluxes. The second event chain is related to the degradation in quantity and quality of groundwater and surface waters (rivers and lakes) and the third event chain addresses the increase of aerosol and ozone formation, leading to a loss of air quality (Figure 2).

4. Hydrological extremes

Recent global projections predict a 10-20 % increase in the frequency and intensity of synoptic scale storm events causing severe precipitation and floods for the Northern Hemisphere until the end of the century (Coumou and Rahmstorf 2012; IPCC 2012). A thorough understanding of the temporal and spatial dynamics of such meteorological and hydrological events in relation to local, intermediate and large-scale climatic trends is crucial for predictions of the long-term effects of such events on the of a heavy precipitation event in combination with long-term measurements of soil moisture can, for example, be used as model input for describing the generation and propagation of the flood wave. The data provided by the different MOSES infrastructure components along the event chain (Figure 3) will improve the understanding of coupled atmospheric, terrestrial, estuarine and coastal systems.

5. Implementatiom

Taking the spatial extent and dynamics of the investigated systems into account, the deployment and operation of the MOSES components will be supported by preceding model analyses and model based optimizations to identify areas of specific interest for the event chain. A model area for testing this approach will be the Elbe river system. For this particular catchment area, a flood model chain has been recently developed, quantifying the runoff generation in the catchment, the propagation of the flood wave, the inundation (also in the instance of dike overtopping) and the socio-economic consequences (Falter, Dung et al. 2014; Falter, Schröter et al. 2015). Feeding this model chain with precipitation forecasts will facilitate forecasting inundation areas and processes. These forecasts can be used to optimize the deployment of the MOSES infrastructure. For this and other possible MOSES target areas, atmospheric and rainfall data are operationally available from the networks of ombrometers, synoptic weather stations and operational rain radars of national weather services (e.g., DWD). Such data are assimilated into 6-hourly model analyses and provide regular 3D fields of the atmosphere at intermediate resolution (3 km grid).

High-resolution hydrographic, biochemical and biota data are available from TERENO and COSYNA and can be used to describe the background state of the terrestrial, limnic and coastal environments. Furthermore, data collected with the equipment described will be used in combination with satellite data (e.g., Sentinel I&II and SMAP) to assess trends. Valuable expertise has been already obtained from near real-time disaster analysis by Helmholtz centres during the Elbe flood in 2013 (Schröter, Kunz et al. 2015) and from satellite based flood monitoring using Synthetic Aperture Radar (Martinis, Kersten et al. 2015). For the implementation and optimization of this approach across Helmholtz centres, the first operations will run under average conditions (no event case) in catchments where the Helmholtz centres already possess broad experience in field investigations. (Mudelsee, Börngen et al. 2004) already showed that the Elbe catchment is influenced by cyclone pathways. The catchment has recently been affected by major floods (return periods > 100 years in 2002, 2007 and 2013) followed by extremely low flows (in 2003). Sivapalan, Blöschl et al. (2005) have shown that the active floodplain plays a key role in flow retention, water quality (Baborowski, Simeonov et al. 2012) and nature conservation (Tockner, Pusch et al. 2010).

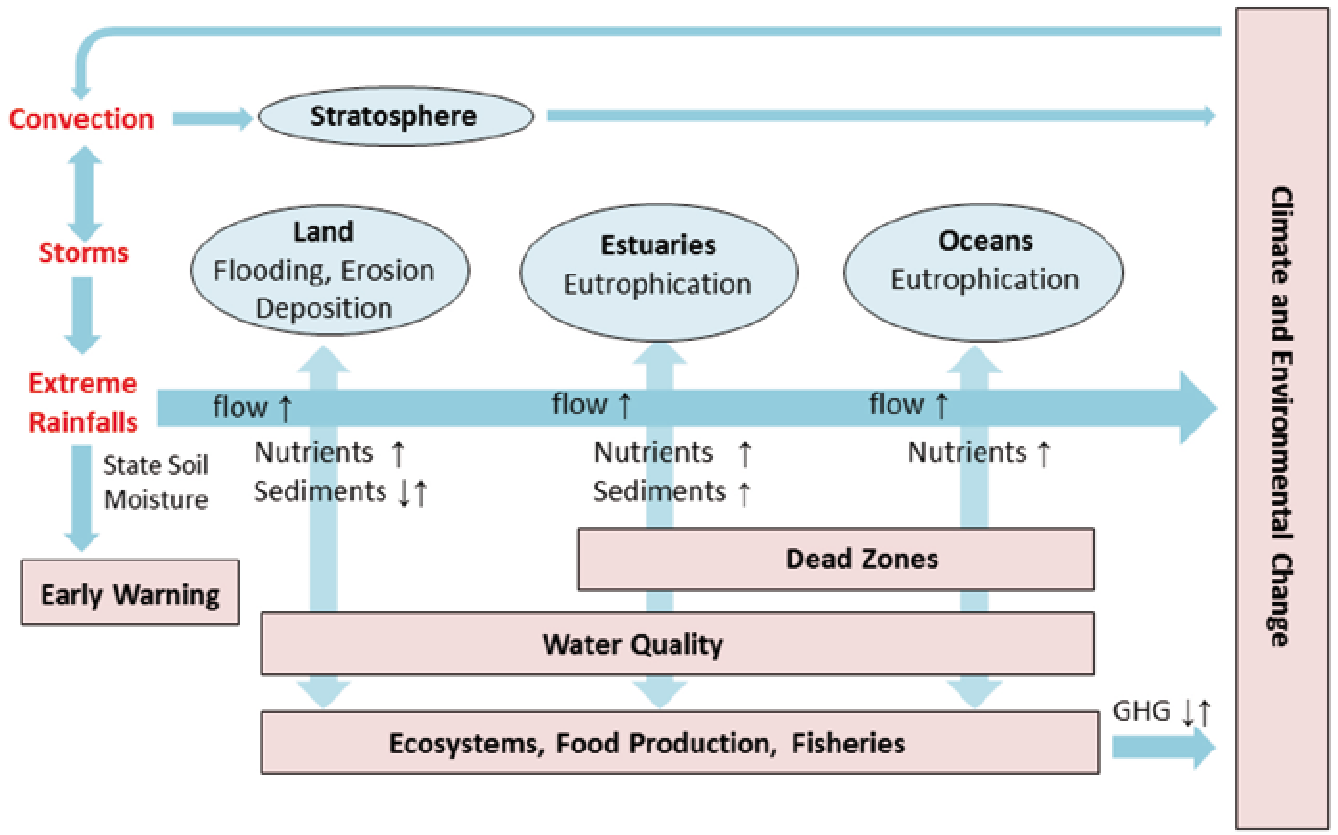

Fig. 3: Schematic diagram of hydrologic event chains triggered by synoptic scale storms: Synoptic scale storm events cause atmospheric convection and extreme precipitation events. The subsequent flood wave affects the terrestrial systems by land erosion and nutrient and matter mobilization. Water constituents are transported with the flow to lower river areas and the aquifers of the catchment area and finally reach the estuary and coastal waters. The event driven surplus import of matter and nutrient cause eutrophication of the coastal waters and affect the environmental health status and the socio-economic value of the related systems with a high potential for complex feedbacks.

Learning from the first runs under average conditions, scenarios for operation during extreme events will be developed and implemented. The experiments under normal conditions will also provide a test bed for cooperation between the different disciplines and institutes involved. While developing the system, other major Central European river catchments will also be considered. Finally, given the knowledge gained from these studies, the operation of MOSES will be extended to other regions relevant to the participating Helmholtz Centres' research activities.

National and international scientists are invited to participate in the implementation phase which started in 2017 within the scope of the numerous research collaborations established by the Helmholtz Observatories and the manifold interlinkages with international earth observation networks. To implement and test operation procedures, small campaigns started already in 2018. These test series must continue until approximately 2021 with increasing complexity until full event chains can be covered. The regular MOSES operation, which comprises planning and performing event-driven campaigns, will start in 2022 (Figure 4).

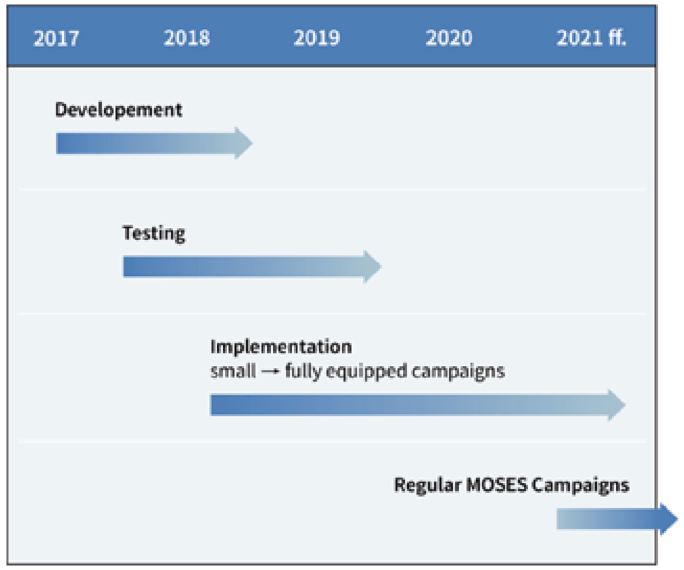

Fig. 4: Timeline of the MOSES development, testing and implementation phases.

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REVITALIZACE A RENATURACE
Revitalisierung und Renaturierung

Content

3-D reconstruction of a montane reservoir using UAV photogrammetry, aerial LiDAR, and field survey: A case study of Rokytka reservoir, Sumava Mts.

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1. Introduction

The small reservoirs in the European montane landscape, which were built in past centuries for various purposes, represent specific cultural and technical heritage but also feature retention potential for mitigating the emerging impacts of climate change, namely, the course of flooding or droughts. However, the frequent lack of technical data on these historical structures, including their storage volume and flooded areas, prevents their consideration in water management planning.

Our research focused on the abandoned montane reservoirs in the mid-mountain environment of the Sumava Mts., Central Europe. In this area of the Sumava Mountains (Bohemian Forest), a network of montane reservoirs was built in the 19th century to enable timber flowing into lowland regions. In the second half of the 20th century, the reservoirs were abandoned, and in most cases, their dikes were destroyed. We used UAV imaging as a source of high-resolution spatial data to enable detailed topographic analysis and bathymetric reconstruction of the selected abandoned reservoir structure. Use of UAV photogrammetry enabled 3-D reconstruction of the reservoir structures with an unparalleled level of detail through on-demand data acquisition.

The goals of this study were: (i) to derive the retention volume of the selected reservoir based on UAV survey; (ii) to compare the results with the historical estimates; and (iii) to compare the results achieved using UAV survey with the 3-D reconstructions based on conventional data sources, namely, aerial LiDAR data and geodetic field survey, and to determine their effect on the calculation of the volumetric properties of the reservoir structure to assess the efficiency and potential of the application of UAV imaging and photogrammetry for the reconstruction of historical landscape structures [1].

2. Material and Methods

Study area
The study site of the Rokytka reservoir (49°00′58.7″N 13°25′02.2″E) is located in the headwater area of the Sumava Mountains, Central Europe (Fig 1a). Historically, this region was covered by virgin forest and peat land, which was replaced in the 18th century by Norway spruce (Picea abies [L.] Karst.) monoculture planted for the extensive timber industry. To enable timber transport to the lowlands, a complex system of channels and reservoirs was built and operated. In the Upper Vydra basin, the system, built in 1799-1801, consisted of 8 reservoirs and a channel connected in a network, facilitating log transportation (Fig 1b). In the 1960s when the Sumava montane range became a military area along the so-called “Iron Curtain”, the reservoirs became unused and their dikes were mostly destroyed.

The study site is represented by the Rokytka reservoir, located in the peatland-dominated area in the headwaters of Rokytka Brook, with a catchment of 2.66 km^2 (Fig 1c). The reservoir was built in 1800, and according to the available historical records, the flooded area reached 1.58 ha with full water storage of 18000 m^3 [2]. Unlike the other reservoirs in the area, which were destroyed in the second half of the 20th century, the Rokytka reservoir still features a preserved dike with a concrete culvert that enables the potential use of the reservoir for water storage and transformation of peak flows. The reservoir thus recently acts as a dry polder, storing and transforming the flood wave, however, without active control (Fig 1d).

Methodology and data sources
The 3-D reconstruction of the reservoir combines various data sources, including (i) official DEM based on aerial LiDAR scanning, (ii) the geodetic field survey of the reservoir and (iii) the unmanned aerial vehicle (UAV) elevation data, derived from the high-resolution overlapping imagery, acquired in the study area.

The official DEM was represented by the models, supplied by the Czech Cadastral Office with different levels of generalization and spatial resolution: the DMR4G model with 5x5 m resolution and launched in 2014 and the DMR5G, featuring 2x2 m resolution per pixel and released in 2016 [3].

The ow geodetic survey, covering the area of the Rokytka reservoir was based on measurements taken by a total station. During a three-day survey campaign, 1118 points were measured using a Leica TCRP1202 R1000 total sta-

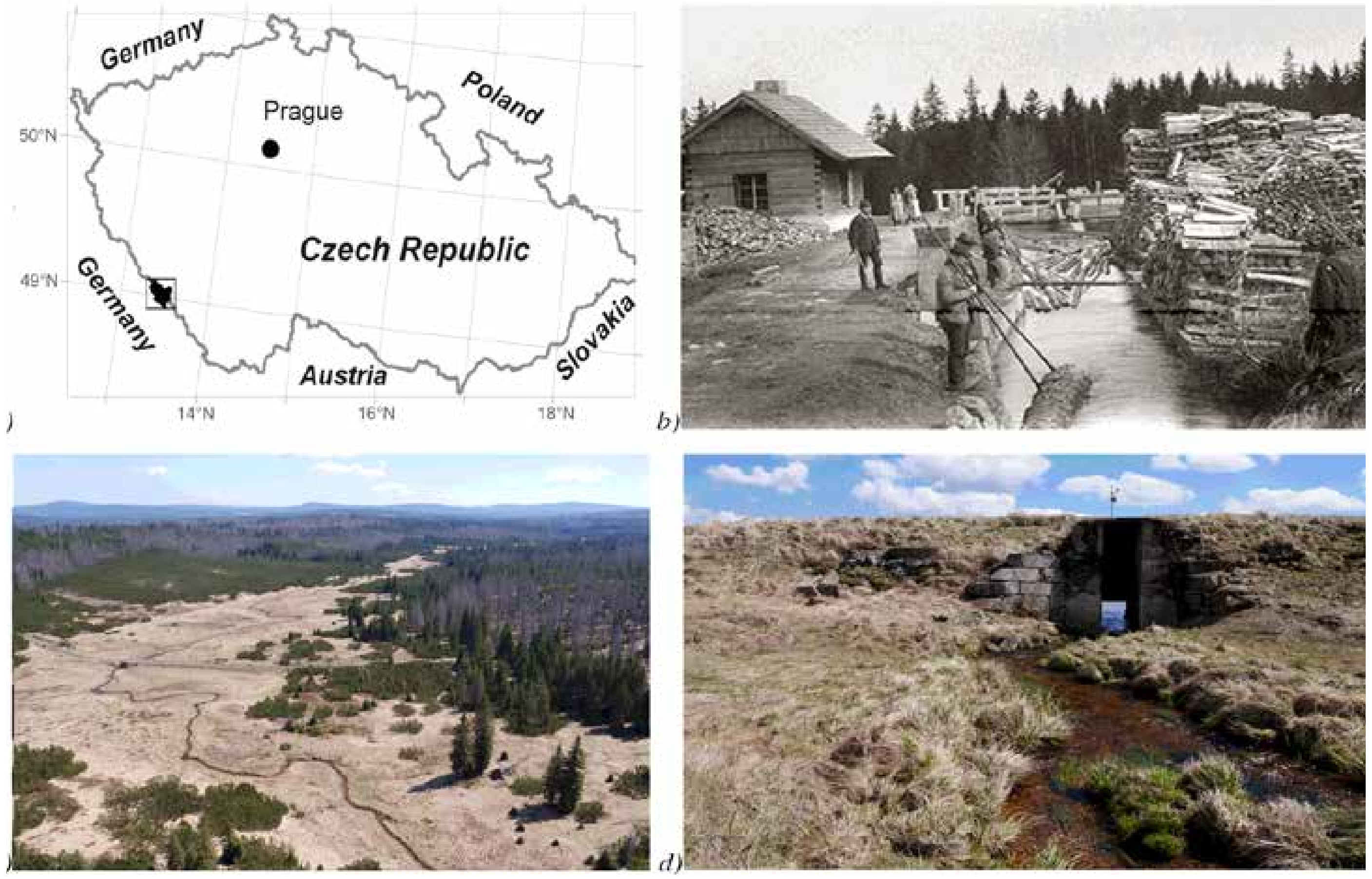

Fig. 1: Rokytka reservoir. a) Location of the study area of upper Vydra River, b) Timber flowing in the study area on a historical postcard, c) Aerial view of the abandoned Rokytka reservoir with a dike crossing the valley, d) Recent status of the reservoir dike with remnants of a culvert.

tion. The reservoir basin was using interpolation by Ordinary Kriging.

The UAV imagery, representing the source of most detailed elevation model in the study was acquired by a DJI Inspire 1 Pro imaging platform with a Zenmuse X5 camera equipped with a 15 mm prime lens (Fig 2a). The imaging campaign resulted in 492 images, taken at an altitude of 91.5 m above ground with 70% front and side overlap. The imaging campaign was completed with the GNSS-measured Ground Control Points (GCPs) used for georeferencing and checkpoints (CPs) used for quality control (Fig 2b).

Modeling of the bathymetric properties and extent of flooded area was performed using the SAGA GIS lake flood module. The algorithm performs flooding of the digital elevation model, starting from the given seed point, and calculates flooding at an absolute water level over the given point [4]. In our study, the absolute water level, related to the known elevation of the reservoir dike, was used to calculate the bathymetric properties at different water levels.

3. Results

The maximum water depth in the reservoir when filled to 1 meter below the dike crown at 1091 m a.s.l. does not exceed 3 meters, while the maximum depth is reached in a limited zone near the reservoir outlet, while the flooded zone of most of the basin is very shallow.

The UAV-based elevation model was sampled to 5 cm per pixel and consisted of 22.836 million grid fields. The lake, flooded at an altitude of 1091 m a.s.l., features a maximum depth of 2.81 m and covers an area of 23,896 m^2 and a volume of 20 163 m^3. The UAV data perform best in the reconstruction of the fine structures of the reservoir bottom due to the very high spatial resolution. The elevation of the lowest parts of the basin (e.g., channels or depressions) in the UAV model mostly matches the values based on the total station survey. On the other hand, in the large flat zones of the basin bottom, the elevation values of the UAV model are more similar to the aerial LiDAR-based models.

The mean water depth for the models based on the aerial LiDAR data is very low: 23 cm for the 2 m grid and 7 cm for the 5 m grid. The spatial generalization due to the grid resolution is not allowing to distinguish the fine inner structure of the basin bottom.

The terrain generalization is translated to the calculations of the flooded volume and area (Table 2). Despite the differences in geometric resolution and level of generalization, the DEMs based on the aerial LiDAR data

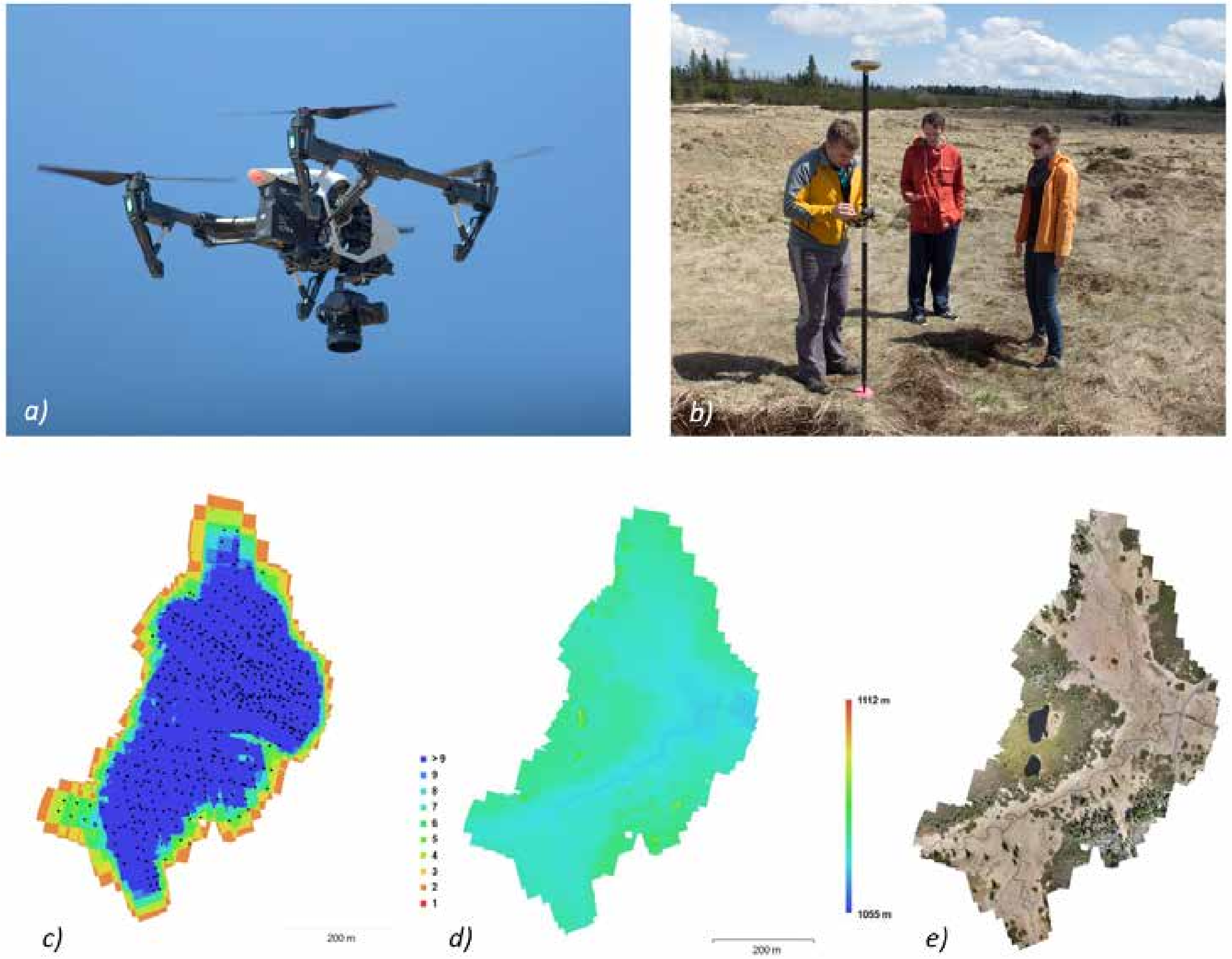

Fig. 2: *UAV imaging campaign and data processing. a) UAV platform DJI Inspire 1 Pro used for image acquisition, b) GNSS positioning of GCPs and CPs, c) Alignment and overlap of the imagery, e) Digital elevation model, f) Orthoimage of the Rokytka reservoir.*

produce nearly identical values of storage volume and flooded area (Table 2). Hence, the volumetric estimates based on such generalized data have the limited reliability, especially in the shallow zone.

The reconstructions based on more detailed data that better describes the inner structure of the reservoir, i.e., the total station and UAV models, produce significantly higher estimates of the storage volume and flooded area (Table 1).

Compared to the results of the models based on aerial LiDAR and UAV data, the bathymetric model based on total station measurements displays substantially higher retention volumes for all water levels. Despite the high accuracy achieved at individual points, the irregular distribution and low density of the points (Table 1) compared to the regular grid of values from the aerial LiDAR or UAV photogrammetry, prevent relatively reliable modeling of the whole space of the reservoir basin.

The differences in the calculations based on the different data sources more significantly affect the volumetric model than the calculation of the flood extent (Table 1). The differences are especially pronounced at low levels of flood spill when a detailed description of the reservoir bottom is crucial to accurately calculate the lake storage volume. At a water level of 1092 m a.s.l., corresponding to full reservoir capacity, the storage volume according to the UAV-derived DEM is 13.8% higher than the results from a 5 m grid. However, at a water level of 1090.5 m a.s.l., corresponding to flooding of just the basin bottom, the difference is 45.3 %.

Data source	*Number of data points*	*Grid size [m]*	*Max depth [m]*	*Flooded area [m²]*	*Volume [m³]*
Historical estimate	N/A	N/A	N/A	26 600	18 000
UAV 5 cm	21 405 266	0.05	2.98	23 896	20 163
LiDAR 2 m	53 112	2	3.00	19 440	15 884
LiDAR 5 m	8 655	5	1.81	19 350	15 812
Total station	1118	10	3.6	27 948	25 686

Tab. 1: *Bathymetric parameters of the reservoir reconstruction based on flooding the basin derived from different data sources at an altitude of 1091 m a.s.l.*

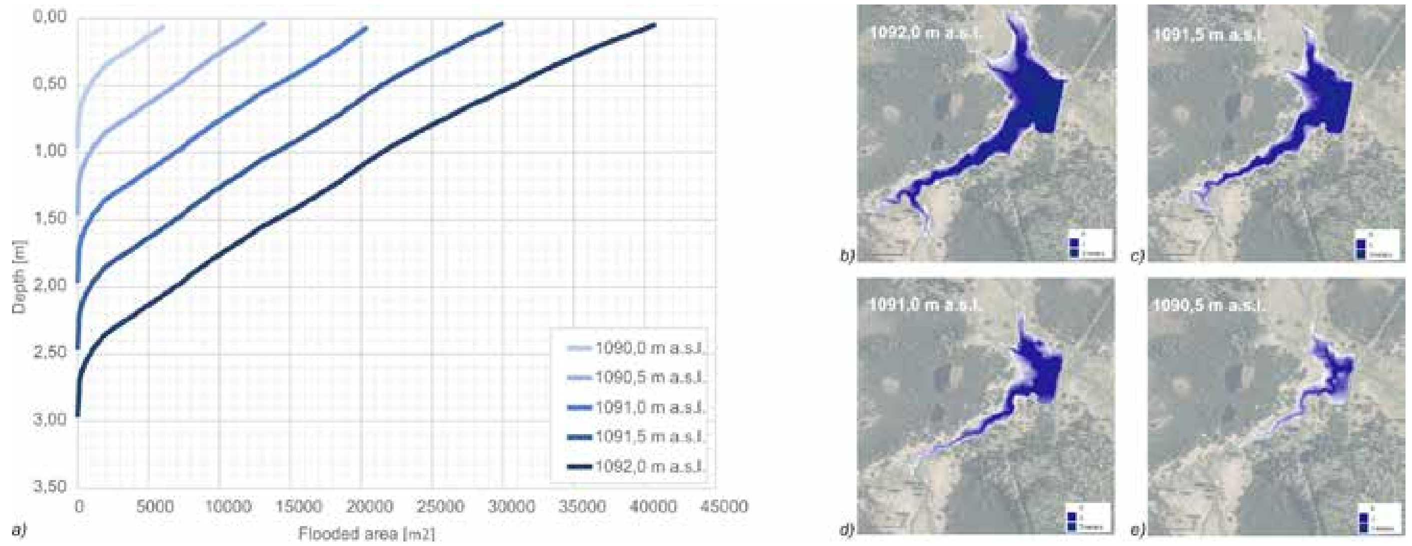

Fig. 3: *Flooded area of the Rokytka reservoir at varying water levels based on the UAV-based model. a) hypsometric curves for given altitudes. Extent of the flooding at different water levels: b) 1092 m a.s.l., c) 1091.5 m a.s.l., d) 1091 m a.s.l., e) 1090.5 m a.s.l.*

4. Conclusions

The bathymetric properties based on UAV photogrammetry enabled construction of a 3-D model that accurately described even the fine structures of the flat bottom of the abandoned reservoir that is formed by a system of narrow and shallow drainage channels. In such conditions, there is an apparent effect of the spatial resolution and generalization, which results in an underestimation of the basin volume for the LiDAR-based DEMs and a lack of ability to describe the fine inner structure of the lowest part of the basin. Despite the effect of generalization, the UAV-based and LiDAR-based models report similar altitudes across all zones of the reservoir basin. However, the DEM based on the total station measurements estimates significantly lower altitude values, especially in the central part of the basin, where the difference reaches almost 0.5 meters in some areas. Such differences are translated into significantly higher estimates of the basin storage capacity.

The differences are significant, especially in the lowest part of the shallow basin, which is characterized by narrow channels. The varying level of generalization of the spatial information in this zone is then a key source of difference in the resulting bathymetric models, where the differences are more significant in the calculation of the volumetric properties than the flood extent.

Despite the differences among the models, a comparison shows a surprisingly good fit of the historical records. The potential storage capacity of the structure is higher than was estimated in the historical sources: the full capacity of the structure is almost triple the retention volume estimated by the historical records. Although the Rokytka reservoir has been without management and control since the middle of the 20th century, it continues to act as a structure to support the effective transformation of flood waves.

This study proved that the use of high-resolution UAV-based data is significant for the assessment of the actual storage potential of historical landscape structures, which is fundamental information for their potential implementation in water management and flood mitigation plans.

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POSTEROVÁ SDĚLENÍ
Posterpräsentationen

Content

Monitoring the quality of surface water in the dry season

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Povodí Vltavy, státní podnik

1. Abstract

The drought phenomenon has been included in the list of major threats in the past few years with a large overlap in society. Drought significantly affects the quality of surface water [1]. Compared to floods, it has different (but not less significant) risks. The Laboratories of the Vltava River Basin, State Enterprise have the internal directive, which regulates the normal operational monitoring. Concentrations of nutrients from point sources significantly increased during droughts. Otherwise, pesticides and others that came from land-based sources, weren´t be washed into the surface water at all or to a limited extent. In this case, they represent the risk during short and intensive hydrological events [2,3]. We got interesting results of the nutrients and special organic substances mass balance analysis associated with average flow rates in drought affected areas.

2. Methodics

The values from long term period as well as values from monitoring of drought are used in the results. The study is focused mainly on the nutrients (phosphorus and nitrate nitrogen) and basic physico-chemical parameters in water, but also some specific organic pollutants, bacteria pollution and concentration of chlorophyll-a are mentioned. For the evaluating the drought period, we also took the long term results into the account.

3. Nutrients

We observed rapid changes in oxygenation conditions in many rivers, one of the main reasons was relatively constant inflow from point sources of pollution (WWTP´s etc.), it was proved by higher concetrations of amonium nitrate and total phosphorus [1] (Fig. 1).

4. Special organic compounds

Concentrations of some special organic compounds during the drought were higher too. It happened especially under the point sources [2,3], where they were diluted in smaller quantity of water (e.g. EDTA compound used like a ingredient of many detergents). Also concentrations of selected drugs were sometimes higher during the drought (e.g. ibuprofen, diclofenac, hydrochlorthiazide and other). Partly positive thinking could bring the pollution of pesticides during the drought. Thanks to the low rain precipitations, pesticides didn´t came out from the agriculturally cultivated land into the sub/surface waters in the amount such usual [3]. See Fig. 2 of total mass balance of pesticides in Čechtický brook.

5. Conclusions

During the drought period (for example in 2015) degradation of quality of the surface water was observed. In some reservoirs (especially with the shorter TRT) stratification conditions during the summer were changed, this was connected with oxygen demand, water temperature and pH changes. This conditions may lead to nutrient release etc.

One of the main advantages of intensive extraordinary drought monitoring is to detect fast changes in concentrations and mass balances of compounds. Than we can have a better idea, what is happening inside the rivers and reservoirs during the extreme hydrological conditions.

We observed positive effect of Vltava cascade on the quality (nutrient retention, oxygen concentrations) and quantity (control of the water volume) of water in the lower part of Vltava River. This fact should be taken into account when we think about the function and use of the Vltava River cascade.

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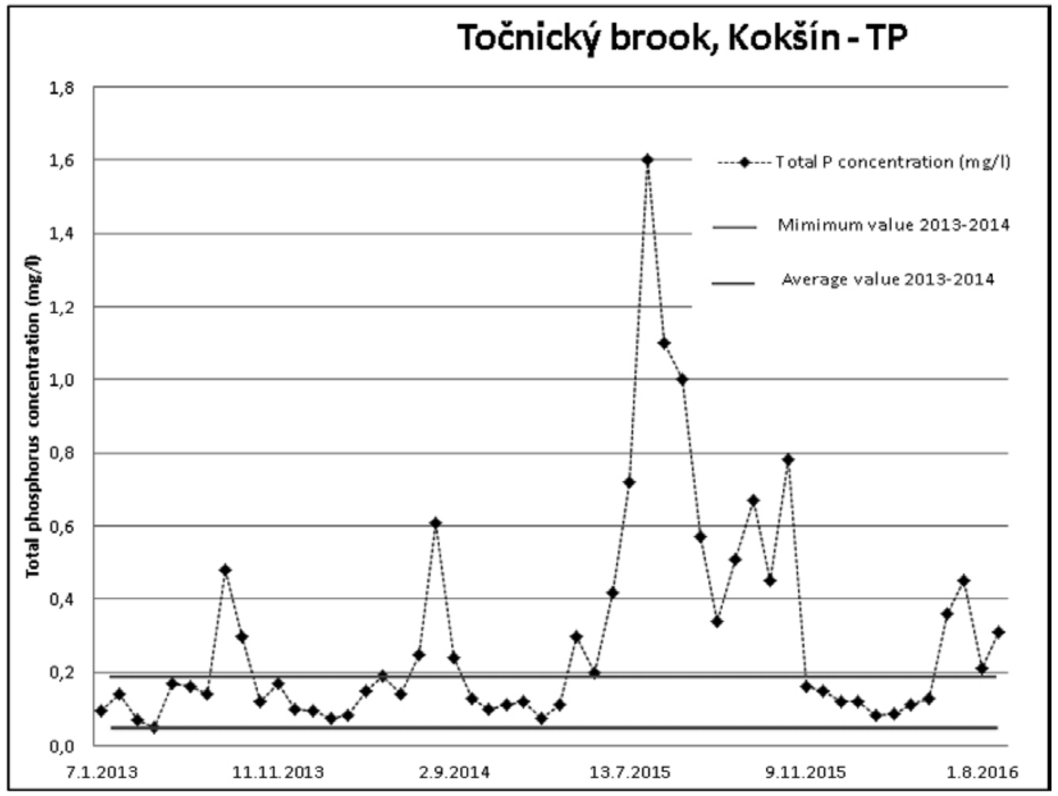

Fig. 1: *Závišínský brook: long term concentration of total phosphorus.*

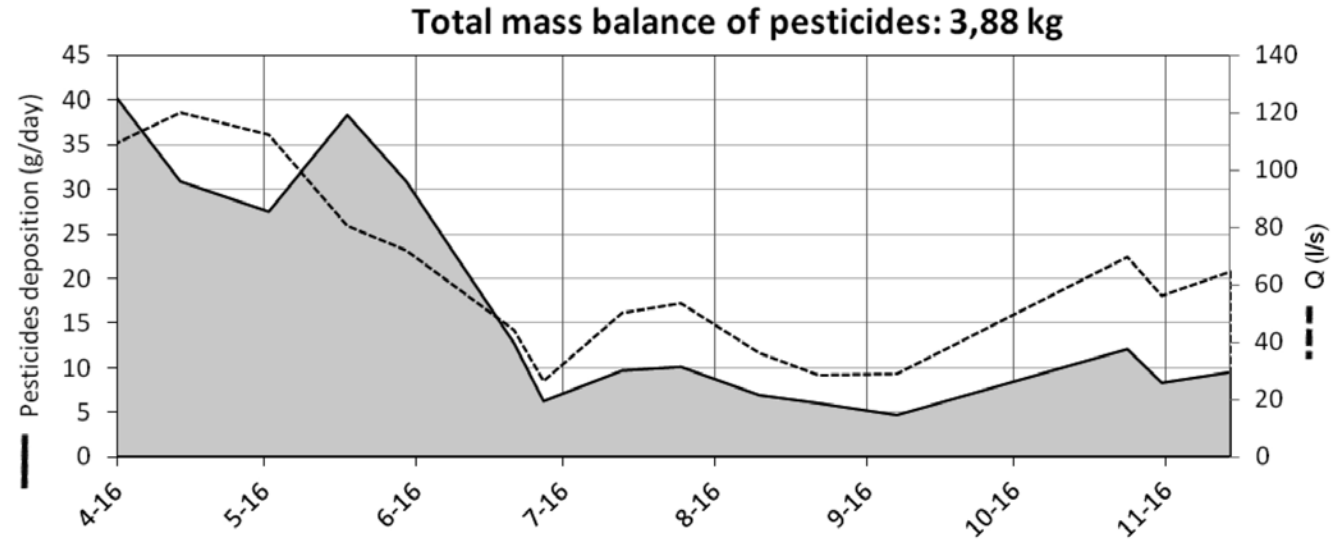

Fig. 2: *Čechtický brook: Total mass balance of pesticides (1. 4. – 30. 11. 2016).*

Nature-close measures in the catchment as complex approach to drought and flood problems

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After three serious flood events during last 16 years (2002, 2010, 2013) Elbe catchment has suffered by opposite extreme feature – drought - in 2015, 2016, 2017. This fluctuation evokes needs of complex control and compensation measures, which could help to eliminate negative effects of both climatic extremes. Good solution seems to be implementation of nature-close multifunctional measures, supporting retention of water within the catchment. They should be complementary alternative measures to commonly designed standard technical retention and flood control ones, but they should not be understood as universal alternative to technical control measures. Nature–close retention measures are expected not only to increase retention capacity of the landscape, but also positively act in water quality and microclimate control or improvements in biodiversity and touristic attractiveness of the landscape. Due to their multifunctionality and therefore attractiveness, great attention of researchers, land and water managers, stakeholders becomes interested in and they are more and more frequently designed and also practically implemented within catchments. They find their application within landscape but also directly within cities as part of their climate change mitigation and adaptation.

The catalogue of nature-close retention measures, suitable for both of river floodplains and free landscape within Elbe catchment is developed within STRIMA II project with specific needs of Elbe catchment and CZ-D transnational applicability. The technical design parameters, effectiveness, applicability and suitability for various conditions will be emphasized. Authors respected specifics of nature-close retention measures which come up from their multifunctionality and application of "soft processes", which hardly can be quantified by standard engineering methods. Therefore standard procedures of design, based of return time of design event often fail. Difficulties in design and operation is also linked to the fact, that processes of flood and drought work opposite directions. Both need retention spaces within the catchment, but while flood control needs empty volumes, drought prevention prefers full retention volumes. Same problems arise in case of effectiveness assessment as well. Therefore, application of non-standard approaches to CBA and economic effectiveness, including ecosystem services assessment has been included within closely linked paper of (Machac J. et al.) within same meeting.

Principally, nature-close retention measures work with two main natural processes
- Water retention within the landscape
- Flood wave transformation by water temporal retention within floodplain, retention spaces, specific structures, etc.

This is principal difference from standard flood control measures, which can be characterized basically as:
- Water retention within technically designed structures (retention ponds, manipulated retention volumes of water reservoirs, ...)
- Improvement of capacity of stream channels to prevent spilling of water to the floodplain and flooding of structures
- Specific flood control structures to protect urbanized areas or infrastructure against flood discharges (levees, specific structures at single buildings, etc.

Technical flood control measures are usually well technically defined, they are assessed by engineering methods and their efficiency can be quantified in respect of flood recurrence period, what is generally accepted in property, health and human life protection. On the other hand, technical measures usually works only "single purpose". It means, no water storage is offered, except of retention reservoirs, which have dedicated retention volume to increase river discharges in case of droughts.

Nature close measures on the other hand operates with "soft" measures and natural processes. They are usually hard to be exactly quantified, as their effectiveness depends strongly on recent state of the catchment (for instance storage capacity of soil depends on recent carbon content and surface layer conditions, on recent crop and its development, ... – what changes over time).

Therefore, nature-close control measures on one hand can hardly be designed as main control measures to protect vulnerable human structures, on the other hand, such measures are much more flexible and multi-purpose. Their great benefit can be found mainly in side effects targeted to drought mitigation, ecological diversity support, aesthetic values improvement and related activities (tourism, ...) support. They act also in water quality improvement and soil conservation process.

To store water in the landscape, mainly soil properties improvement is desirable, modification in agricultural technologies and cropping systems, general land-use changes, improvements of landscape matrix diversity, landscape greening and decentralized technical soil erosion control measures with retention effect and volumes can be applied. To improve transformation effect of floodplains, there is necessary to select wide, flat floodplains, which can be extensively agriculturally used. Stream channels rehabilitation and renaturalization is highly desirable, mainly in the meaning of decreasing of their capacity and therefore stimulation of water spilling into floodplain. Floodplain in such a case is expected to have high surface roughness – i.e. spread bush and trees. In such a cases, high transport of drifted wood during flood event is expected and additional measures to minimize its risky effects on bridges and culverts have to be adopted. The effect of flood wave transformation within the floodplain is anyway expected not higher than 10 – 15 % of peak discharge. Much more significant effect has been documented in time shift of peak discharge occurrence.

Catalogue of nature-close flood control measures, developed within STRIMA II project will list possible measures together with their applicability, effectiveness and process description will be issued by the end of 2018 and will generally be bilingual (CZ-D). It will include and synthetize other applied information sources from both countries (CZ-D) and will emphasize "on-catchment" measures, linked strongly to other field of expertise – mainly effect of agricultural soil and its utilization on water retention.

Acknowledgement:

The paper is based on the outcomes of the project Saxon-Czech Flood Risk Management II (STRIMA II, project reg. no. 100282105), supported under the Cooperation Programme Free State of Saxony – Czech Republic 2014-2020.

Hydrology of the Lower Elbe in the recent years, the current water flow management issues and international waterway's problems caused by drought.

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1. Law water level influence on the navigation

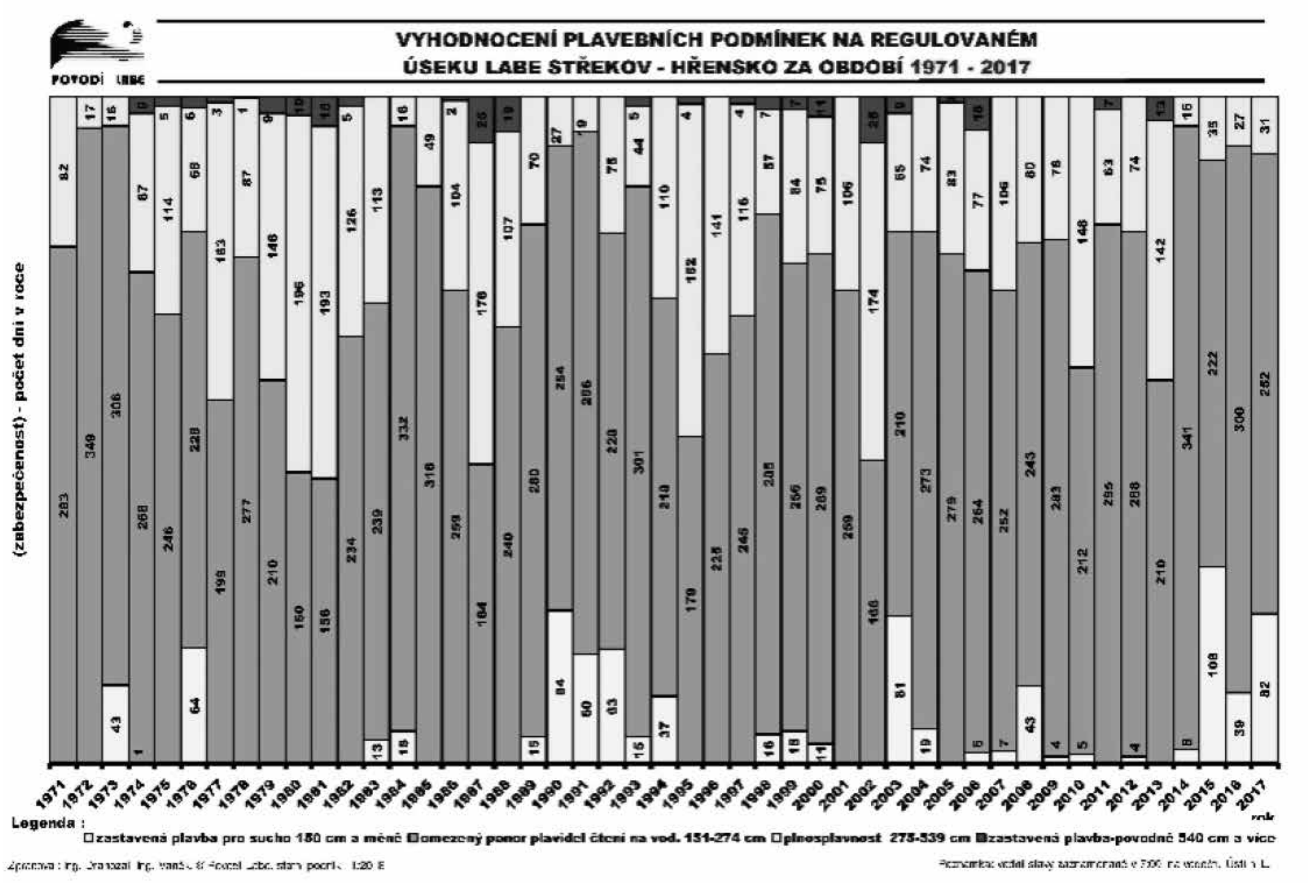
The annual rainfall in the Czech Republic influences directly the navigation conditions especially on the regulated river Elbe section starting by the water building Střekov up to the state border. The allowed boat draught directly depends on the actual water flow and the water gauge in the town of Ústí nad Labem, which is different on the section controlled by weirs. On the enclosed chart we can see the allowed draught on the regulated river section divided in years. The lower columns show the days of stopped navigability caused by the law water level, middle columns show days with limited draught and the upper columns, being the shortest during recent years, show full navigation days, which means navigation on maximum draught.

2. The hungry stone – monitoring the law water levels in the town of Děčín

This stone lays on the left Elbe bank appr. 100 m down from the traffic bridge. The stone name expresses the consequences of the droughts and low water level periods. People rafting the wood on the river were able to read the water level from this stone. In the 19th century a German title appeared: „ Wenn du mich siehst, dann wiene!", which means "When you see me, cry!" Later a Czech advice completed the message: "Girl, do not cry, when it is dry, but splash the field!" The German text is visible with water level of 100 cm, the last time we could read it was in May 2018 with water level of 98 cm and the water flow 88,4 m³/s.

Date	Flow m³/s
28. 1. 1909	34
22. 8. 1911	35
29. 7. 1934	37
11. 7. 1921	38
5. 1. 1875	40
8. 1. 1954	40
4. 9. 1947	40
12. 2. 1904	42
1. 7. 1904	42
6. 12. 1902	43
3. 9. 1935	44
24. 7. 2015	68

Tab. 1: *Historical minimal water flows on the river Elbe in Děčín since 1851*



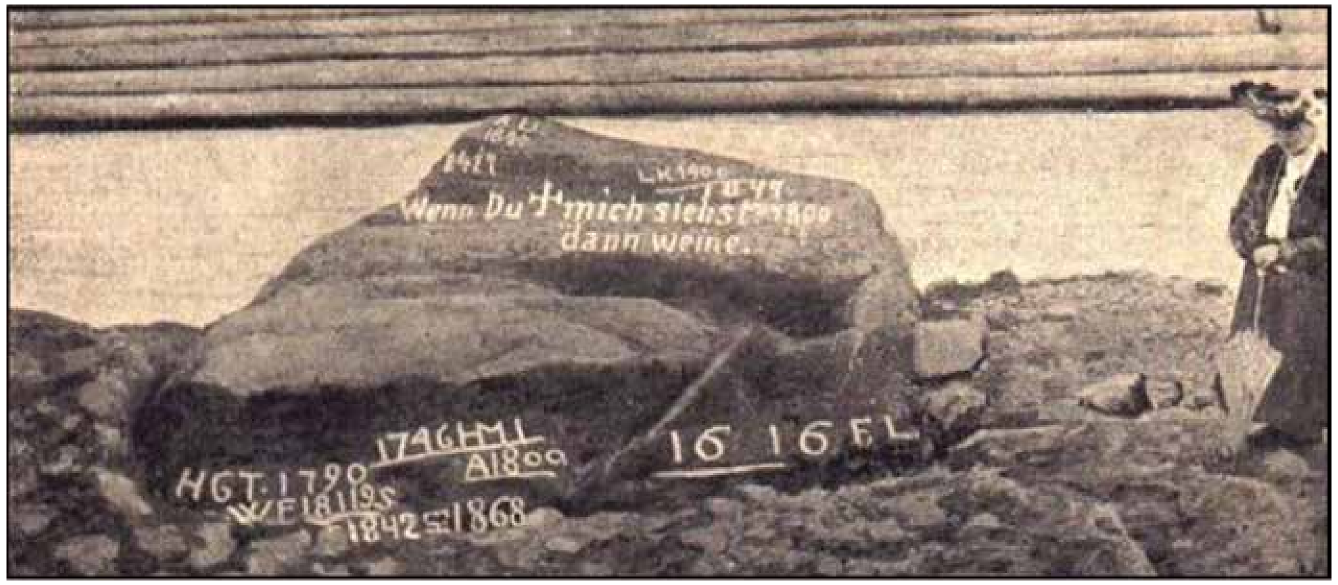


Fig. 2: *The hungry stone*

Source: Lower Elbe, J. Podzimek and coll..

Entry of nutrients through municipal sewerage overflows

Jindřich Duras, Michal Marcel
Povodí Vltavy, státní podnik

1. Introduction

Over the last two decades has been recognized that sewerage overflows considerably contribute to water pollution but only scarce data has been available [1]. The first data collected in Vltava River drainage area shows that surprisingly high amounts of phosphorus enter the stream from the town of Pelhřimov (the main inflow to the Czech largest drinking water reservoir, Švihov) and the town of Blatná (the inflow of the Orlík reservoir). Phosphorus loads during rain events were ~2-6 times higher per year than loads when periods of precipitation were not included [2].

A project related water quality improvement is prepared for the Hracholusky reservoir near the city of Pilsen. The first part is aimed at phosphorus sources in the watershed. Therefore, influence of sewerage overflows is studied and balanced, too.

2. Results

Three precipitation events were monitored in 2017-2018. The study was related to the town of Stříbro which is situated very near the reservoir. The most illustrative are results obtained on 18th May 2018 (Fig. 1): 11.8 mm of rain fell over 8 hours and interrupted a long dry period with low flow rates. The precipitation was local and the reaction of the town was very pronounced and no response came from the drainage basin.

Wastewater effluents from the WWTP was of very good quality with concentrations of Pt of 0.13-0.18 mg l^{-1} during whole the monitoring period. On the other hand, the overflowing water was heavily polluted (Pt = 1.0-5.3 mg l^{-1}). About 5.6 kg of P entered the river during the six hours of monitoring – the contribution of wastewater properly treated at the WWTP was about 4% only.

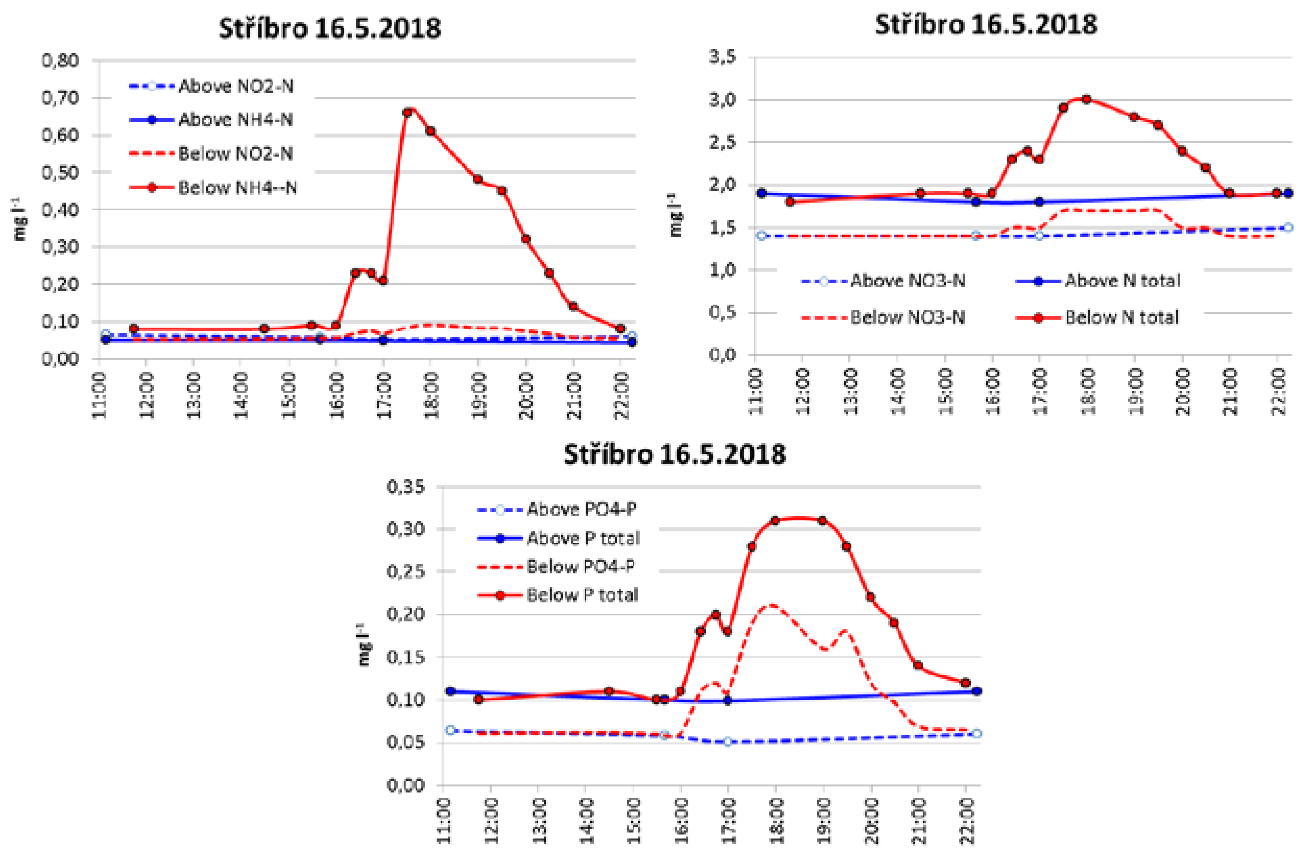


Fig. 1: *Concentrations of P and N compounds in the Mže River upstream and downstream the town of Stříbro during one six-hour rain event.*

Fig. 2: *Overflows completely change the look of a river – and chemical composition, too!*

During other two events, 15 kg of P in 24 hours [3] and 7 kg of P during 4 hours entered the river (24 and 11.6 mm of precipitation). Rough estimates show that the amount of P from overflows was high as P emissions from the WWTP with properly treated wastewater in one relatively dry year.

3. Conclusions

The transport of phosphorus into water ecosystems via sewerage overflows poses a considerable problem with the quality of surface water – 1 kg of P increases P concentration in 100,000 m^3 of water by 0,01 mg l^{-1}. Even this little increment is highly important when cyanobacterial blooms is to be managed. As regards cities provided with well operating WWTPs it seems very reasonable to support smart solutions related to rainwater management in the cities: green roofs, green facades, infiltration, storage and reuse. Such solutions are also very beneficial for vegetation and climate conditions in the city.

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Impact of Droughts on Occurrence of Organic Micropollutants in Surface Waters

Martin Ferenčík, Jiří Medek
Povodí Vltavy, státní podnik

Povodí Labe, state enterprise, carries out operational monitoring based on regular spot sampling with monthly period. Results of this monitoring prove different variability of occurrences of micropollutants in relation to water precipitations and river flows. While majority of pesticides have highest findings in surface waters after the first rain precipitations following the pesticide application, more persistent pesticides like isoproturon and chlorotoluron and persistent metabolites, for example ESA metabolites of chloroacetanilides (acetochlor, alachlor, metolachlor, metazachlor) have high findings throughout the year in dependence on rain falls and snow melting necessary for the leaching of residues adsorbed on soil.

Other pollutants, originating mainly from point sources (pharmaceuticals and personal care products (PPCP's) from municipal waste water treatment plants (WWTP's) and centrally untreated municipal waste water sources are emitted more or less continuously and their concentrations in rivers are during dry periods higher, because of lower dilution effect. This effect is significant in rivers with low flow and high number of equivalent inhabitants. This is the case of the river Lužická Nisa at Hrádek nad Nisou, where median flow was 5.000 l/s in 2017 and the effluent from WWTP Liberec and Hrádek nad Nisou serving more than 150.000 inhabitants was 590 l/s in 2016 [1]. Similar situation is also on the river Orlice and its tributaries. Especially the river Třebovka downstrem of the town Česká Třebová consists significantly of the effluent from WWTP (16-50 %) during a quarter of the year. Other small towns with number of inhabitants between five to fifteen thousands (Žamberk, Letohrad, Choceň, Rychnov nad Kněžnou, Třebechovice, Týniště, Ústí nad Orlicí) contribute by its treated waste water effluents to the quality of the river Orlice. The river Orlice in Hradec Králové is used as a raw drinking water source for advanced drinking water treatment process.

Quality of surface water in urbanized areas depends heavily on the percentage of total municipal waste waters treated in central WWTPs and on the quality of treatment proces. Brooks and rivers with low average annual flow receiving significant volume of effluent from WWTPs are contaminated with pharmaceuticals, sweeteners and other organic contaminants at hundreds to thousands of nanograms per liter [2]. More efficient waste water treatment processes utilizing adsorption of pollutants on activated carbon sorbents would improve unfavorable situation.

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The Importance of Water Quality Measuring Stations during Droughts

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Povodí Labe, state enterprise, has lot of experience with the use of the water quality measuring stations, operated since the early 90's. These measuring stations are located on the Elbe River as a part of the international monitoring network of the International Commission for the Protection of the Elbe (ICPE).

An important role is played by stations not only in regular monitoring, which is a part of the Elbe River international measurement program (ICPE), but also in the water quality monitoring during atypical situations. There are significant risks of deterioration of water quality during droughts, i.e. at low water flows, for example due to low dilution of industrial and communal waste water. Negative effects may be also caused by increased water temperature, changes in oxygen and nutrient regime or changes in the composition of biological communities.

In the dry season, i.e. during droughts is needed detailed water quality monitoring with a higher monitoring frequency than in the normal state. The measuring stations enable continuous or quasi-continuous observation of the basic indicators (temperature, dissolved oxygen, conductivity, pH, turbidity, UV-absorption, etc.). They also allow the sampling of composite water samples and the sampling of solid matrix samples (suspended sediments) for subsequent analysis in the laboratory. In this way it is possible to obtain enough relevant data on the current state of water quality, respectively of quality of the hydrosphere. Favourable is the fact that there are no technical restrictions in terms of operation of the measuring stations and that the stations can be operated without any problems. This is the difference from the use of measuring stations at high water flows and floods.

In conclusion, the water quality measuring stations have an irreplaceable role in water quality monitoring during droughts

Surface water quality in Šlapanka River basin in years 2002 and 2014

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1. Introduction

Development of water quality in the river basin is determined inter alia by the spectrum and the progress of anthropogenic activities. Their reducing or development is immediately reflected in a change in water quality. The method and intensity of agricultural land management, livestock farming, concentration of industry and settlement development are related to the demographic, socioeconomic and political development of society. In the Czech Republic there has been a significant change in water quality in the 20th century. In the Czech Elbe River basin has tackled this issue Langhammer [4]. While at the beginning of the 20th century the quality of the water in the Elbe enabled its versatile use, it was radically deteriorated in the second half of the century. Only after the political and economic changes commenced in 1989 the water quality in the Elbe River had improved again, but not in all parts of catchment area. One of the river basins, where the quality of water is still very low, is the catchment area of the Šlapanka River, the left-side tributary of the Sázava River. The aim of the study was to find out what developments occurred in the surface water quality in basin in 2002 and 2014.

2. Material and methods

The Šlapanka River drainage water from the central part of the Bohemian-Moravian Highlands. The catchment area is 265.28 km^2. The bedrock is formed Moldanubian zone - crystalline shales, gneiss and migmatites [1] that are poor in ions and nutrients [2]. According to the Czech Hydrometeorological Institute (CHMI) average annual rainfall is 689 mm per year. The long-term average flow rate is 1.54 m^3 / s^{-1} (CHMI). The catchment area of is intensively used in agriculture. Arable land is represented at 50 % of the catchment area. The use of agricultural fertilizers limits the Nitrate Directive for fertilizing with nitrogen-containing substances in vulnerable areas. The number of beef cattle and pigs in the catchment recorded an increase between 2002 and 2014 (cattle by 9 %, pigs by 20 %). The population of the river basin increased by almost one thousand to 15 600 between 2002 and 2014. Three new wastewater treatment plants (WWTPs) for 3000 inhabitants were also built in the catchment area.

For monitoring the quality of water in the basin was selected 11 sampling profiles. During the years 2002 and 2014, 24 water samples were taken from each profile and water discharge were measured. The following parameters were determined by standard methods: conductivity, pH, nitrate (NO_3-N), nitrite (NO_2-N) and ammoniacal nitrogen (NH_4-N), phosphate phosphorus (PO_4-P), biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD_{Mn}). For the evaluation was also used long-term monitoring data of profile Mírovka provided by the CHMI and another data in catchment by the Vltava River Basin Authority (SOE).

3. Results

A study from 2002 showed a low water quality on all monitored profiles in the basin. These were classified into the V. class of quality according to ČSN 757221 due to NO_3-N concentrations. More information is provided in the publication Judová and Janský [3]. The results of the study in year 2014 showed that the water quality has improved, the flow came from V. to IV. quality class. The development of individual water quality parameters between 2002 and 2014 differed considerably. The RDA data analysis from the source water catchment (upper sub-basin) showed that the difference in monitored water quality parameters in these sub-basins is statistically significant. The year of sampling explained 43% variability. Variance analysis (ANOVA) for individual water quality parameters showed a statistically significant difference in conductivity values, COD_{Mn} and NO_3-N. Between 2002 and 2014, NO_3-N and NH_4-N decreased in these upper sub-basins and increased COD_{Mn} and conductivity. In the longitudinal profile of the Šlapanka River, the trends are similar. The conductivity values in the longitudinal profile between 2002 and 2014 are very similar. Profiles are included in I. or II. quality classes. Concentrations of NO_3-N in the Mírovka end-profile were slightly fluctuated between 2002 and 2014 and showed no trend. Annual averages ranged from 3.5 to 7 mg/l and the profile was classified in IV quality class. Throughout the longitudinal profile the average NO_3-N concentration in 2014 was lower than in 2002. Depending on the characteristic values, the flow was shifted from V. to III. class. This is probably due to compliance with the Nitrate Directive for fertilizing. According to this directive, nitrogen fertilizers should not be applied to the soil in the winter season, which could reduce the extreme values of nitrates during snow melting. The annual average concentrations of NH_4-N in the Mírovka profile between 2002 and 2014 gradually decreased. The profile moved from II. to the I. class. Also, a significant decrease in concentration was observed in the river basin profiles. In addition to profiles in upper sub-basins, the average concentration in 2014 decreased by more than half compared to 2002. Decrease concentration NH_4-N goes against the trend of increasing the number of livestock. The reason for this is that, as in the case of NO_3-N, the change of the fertilization system and the improvement of the waste water managements. For the evaluation of the long-term development of concentrations of PO_4-P on the profile Mírovka missing some data. During samplings in 2013, the PO_4-P values were the highest for the entire measurement period. The PO_4-P concentration in the longitudinal profile was either the same or higher in 2014 than in 2002. Average COD_{Mn} values in the longitudinal profile show a significant increase between 2002 and 2014. In characteristic values, COD_{Mn} for all profiles belongs to IV. quality classes. The reason for the increase in the organic matter content at the lower stream could be caused by growing industrial production in the river basin (e.g. the production of doors and plastic windows). On the upper stream could be the reason agricultural farming on arable land.

Similar studies of water quality in rivers flowing through the agricultural landscape were processed by Vacková [6] and Mrkva [5]. Both studies have shown that water quality, unlike this study, improved in most parameters.

4. Conclusion

Quality of the water in the Šlapanka River is still low. The development of individual water quality parameters between 2002 and 2014 is different. The concentrations of NO_3-N and NH_4-N significantly decreased. Conductivity values increased slightly. PO_4-P values have increased slightly or concentration are comparable. The COD_{Mn} values increased significantly on all profiles and the flow came to IV. quality classes. Newly are problematic organic substances and PO_4-P, which need to be more in the spotlight in this catchment in following years.

Acknowledgements
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Evaluation of the water transport in the Vltava and Elbe Rivers using tritium as a tracer

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1. Introduction

Tritium (^{3}H), the radioactive hydrogen, is produced in nuclear facilities. Unlike other radionuclides, tritium cannot be removed from the plant liquid waste using available technologies. Thus, the commonly used way to dispose tritiated wastewater is controlled releasing into the hydrosphere.

It is not otherwise at the Temelín nuclear power plant, which releases its wastewater into the Vltava River at Kořensko. Despite the tritium releases meet all the legal requirements (Euratom, 2013), the tritium releases are well measurable and its activity concentration peaks can be markedly distinguished from the background.

Since tritium is a part of water molecule, its migration can be a good indicator of water motion. It can be used to evaluate the migration and retention time of ground water (Kanduc et al., 2014; Ako et al., 2013) or tritium was used as a tracer to study discharge dispersion in see water (Gomes, et al., 2014).

It seems to be also a good tracer to represent the water movement in the river course, which we tried to prove in this study

2. Methods

Water samples for tritium analysis were collected along the Vltava River and following flow of the Elbe River, downstream of the Temelín nuclear power plant in the river reach influenced by its tritiated wastewater releases. The frequency of sampling ranged from once per a month to twice per week. In addition, two reference sites without the nuclear power plant influence were monitored, too.

The tritium concentrations were determined using low-level liquid scintillation counting according to ISO 9698 (2010). The data shown were collected in the period 2012-2015.

3. Results and Discussion

Concentration of tritium, stemming from the Temelín wastewaters, decreases with the distance from the source. The tritium concentrations are summarized in Tab. 1. As implies from the values of their standard deviations, the measured tritium concentrations fluctuate over the time in connection to the Temelín wastewater discharge.

The data on the tritium concentrations were used for evaluation of the hydrodynamics of the river course. Times of contamination travelling in particular river sections were estimated. These travel times are stated in table 1.

4. Conclusions

It was confirmed that tritium discharges, which are released from the nuclear power plant during common operation can be used as a tracer to evaluate river hydrodynamics. This eliminates a need to bring additional chemical substances into hydrosphere for the hydrodynamic studies.

Acknowledgements

This work was prepared with the support of the VG20122015088 sponsored by Ministry of the Interior of the Czech Republic

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	c(^{3}H) [Bq·l^{-1}]		Distance from source [km]
	Average	Std. dev.	
Vltava - Hluboká nad Vltavou *	1,0	0,2	-
Labe - Lysá nad Labem *	1,0	0,3	-
Vltava - Kořensko	46	136	0
Vltava - Solenice	26	11	55,6
Vltava - Štěchovice	22	9	117,7
Vltava - Podolí	15	7	144,2
Vltava - Zelčín	13	6	195,9
Labe - Hřensko	7	4	308,9

* Reference site

Table 1: *Tritium concentrations in monitored sites along the Vltava and Elbe River in the period 2012 - 2015.*

River section	Time t_d [day]
Štěchovice – Podolí	3
Podolí –Zelčín	3
Zelčín- Hřensko	3

Table 1: *Estimated tritium travel times in selected sections of the river course.*

Occurrence of bisphenol A in the Vltava river basin

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1. Introduction

Bisphenol A (BPA) is a monomer used in the production of polycarbonates and epoxy resins used in the production of a wide variety of products such as food and drink package coatings, some types of paper documents and forms, powder paints and optical lenses. In addition to its weakly estrogenic activity, BPA has been proved to show some antiandrogenic activity. The objective of this study was to evaluate the occurrence of BPA in surface water in the Vltava River basin over the past 3 years, and to obtain at least the basic information on the BPA input from a point sources of pollution.

2. Materials and methods

Since 2006, water management laboratories of Vltava River state enterprise have provided the monitoring of BPA in surface water (monthly), and since 2016 they have collected 24-h period samples of wastewater treated in selected large WWTPs (usually quarterly). Two methods for BPA determination were used.

A. GC-MS (Gas chromatography with mass spectrometry)
Samples were taken in 1000 mL glass bottles. Pre-treatment was performed immediately. This analytical method is based on derivatization of BPA with acetic anhydride and subsequent extraction into heptane. A 6890 Gas Chromatograph with 5973 Mass Selective Detector (MSD) of Agilent Technologies was used in the SIM mode. This method is very sensitive and robust. Therefore, it was preferred for the determination in surface water. The limit of quantification was 5 ng.l^{-1}.

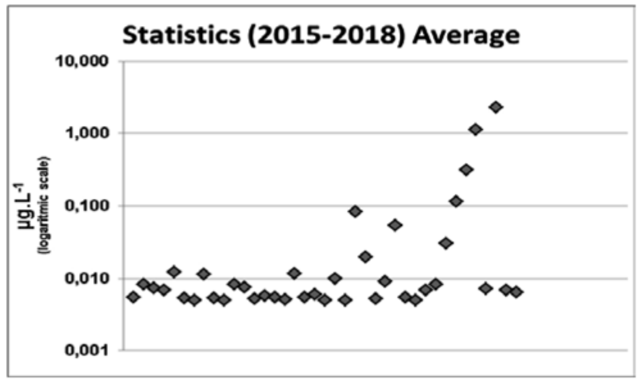
B. LC-MS/MS (Liquid chromatography with tandem mass spectrometry)
Samples were taken in 60 ml amber glass vials and samples were stored in a freezer. On the day of the analysis, the samples were defrosted at max. 30 ° C and the analyses were carried out immediately after de-freezing. The sample was centrifuged in headspace vials for 5 min. at about 3,500 rpm. Then, exactly 1.50 g of the sample was weighed into a 2 ml vial on an analytical balance. After that, 1.5 µL of acetic acid was added into the sample. An isotope dilution was made in the next step and deuterized internal standard of d^{14}-BPA was used. BPA were separated and detected using the LC-MS/MS methods based on a direct injection of samples into the chromatograph. A 1290 Ultra High-Performance Liquid Chromatograph (UHPLC) in tandem with 6495 Triple Quad Mass Spectrophotometer (MS/MS) of Agilent Technologies was used in the ESI-mode. The limit of quantification was 50 ng.l^{-1}. This method is very quick and resistant to the matrix effect. Therefore, it was used for determination in wastewater.

3. Results

The evaluation from 2015 to 2018 was carried out (i) for surface water (Fig. 1; Tab. 1) and (ii) for WWTP effluent (Fig.2; Tab. 2). The case of the Trnava River was selected as an example of a significant and permanent impact of BPA coming from a point source (iii). BPA has been shown to penetrate into wastewater if it is present in paper tickets and receipts that are recycled at the paper mill in Červená Řečice. Trnava is one of the major tributaries of the Švihov drinking water reservoir. The sampling sites were located upstream and downstream the paper mill. Wastewater samples were taken from the WWTP effluent. Fig. 3 shows the concentration profile at the site downstream the paper mill. Here, the max. concentrations of BPA 16 µg.L^{-1} were detected. Upstream the paper mill, these are background values, and the maximum concentration of BPA was 0.011 µg.L^{-1}. The average concentration was 0.007 µg.L^{-1} upstream the paper mill, and 1.122 µg.L^{-1} is the average value downstream the paper mill. Wastewater samples were collected over a 24-hour period. Results for the paper mill WWTP effluent: The average concentration of BPA was 2.993 µg/l, max. 26 µg/l.

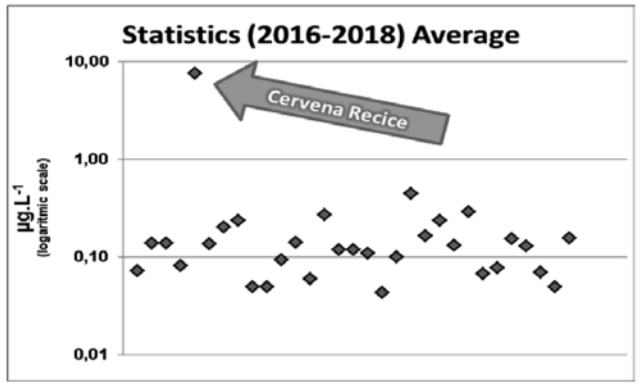
4. Conclusion

BPA is a hazardous contaminant for surface water. It is commonly present in surface water in the Czech Republic in measurable concentrations. BPA contamination is affected by wastewater from municipal and industrial WWTPs. If the BPA source is important, concentrations may exceed several orders of magnitude. The risky areas need to be carefully monitored, especially in the case of water supply areas such as the Trnava River, which is heavily influenced by the paper mill located in Červená Řečice.



Sampling Site	Statistic (2015-2018)		Unit
	Average	Max	
Trnava under paper mill	1,122	16,000	µg.L^{-1}
Trnavka Water Reservoir	0,316	1,800	µg.L^{-1}
Trnava Brtna	0,115	0,420	µg.L^{-1}
Zelivka Porici	0,030	0,130	µg.L^{-1}
Zelivka Svihov Vojslavice	0,020	0,089	µg.L^{-1}
Vltava Libcice	0,012	0,031	µg.L^{-1}
Cerveny stream Velvary	2,306	22,000	µg.L^{-1}
Vltava Zelcin	0,011	0,028	µg.L^{-1}
Berounka Bukovec	0,012	0,110	µg.L^{-1}
Pribramsky stream	0,054	0,160	µg.L^{-1}
Dobrovodsky stream	0,083	1,100	µg.L^{-1}

Fig. 1: *Monitoring of BPA in surface water. Distribution of average BPA concentration (2015-2018) in 39 sampling sites of the Vltava river basin.*
Tab. 1 *shows the selected sampling sites (Trnava river basin; sites downstream industrial cities).*



Municipality WWTP	Statistics (2016-2018)		Unit
	Average	Maximum	
Praha	0,157	0,330	µg.L^{-1}
Plzeň	0,154	0,420	µg.L^{-1}
ČB	0,235	0,800	µg.L^{-1}
Kladno	0,203	0,350	µg.L^{-1}
Písek	0,272	0,770	µg.L^{-1}
Tábor	0,118	0,410	µg.L^{-1}
Klatovy	0,077	0,180	µg.L^{-1}
Pelhřimov R	0,444	0,740	µg.L^{-1}
Havl. Brod	0,292	0,920	µg.L^{-1}
Slaný	0,043	0,068	µg.L^{-1}
Příbram	0,050	0,050	µg.L^{-1}

Fig. 2: *BPA in wastewater. Distribution of average BPA concentration (2016-2018) in 31 outflows from WWTPs of the Vltava River Basin.*
Tab. 2 *shows results of BPA for WWTPs in the largest municipality.*

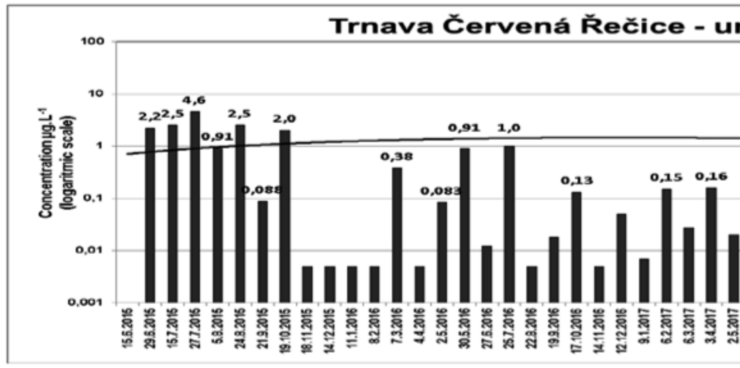


Fig. 3: *Regular monitoring of BPA in the Trnava River, sampling site downstream the paper mill. One of the most significant cases of continuous BPA contamination from an industrial source.*

Hydrologické vyhodnocení sucha v povodí Labe v roce 2015

Petr Kuřík
Mezinárodní komise pro ochranu Labe (MKOL)

V roce 2015 postihlo území západní a střední Evropy, včetně České republiky a Spolkové republiky Německo, významné meteorologické sucho. V povodí českého a německého Labe docházelo během roku k nárůstu deficitu srážek, což se projevilo zejména v letních měsících výrazným nedostatkem vody v krajině a půdě, citelným snížením hladin podzemních vod a malými průtoky ve vodních tocích. Tato skutečnost vedla místy ke vzniku extrémního sucha, jehož vyhodnocením se zabývala skupina expertů Hydrologie v rámci mezinárodní spolupráce pod záštitou Mezinárodní komise pro ochranu Labe (MKOL) a vypracovala společnou zprávu [1], která je k dispozici na internetových stránkách MKOL www.ikse-mkol.org.

Ve zprávě jsou zdokumentovány rámcové meteorologické podmínky, počínaje vývojem sněhových zásob za zimní období 2014 a 2015 přes teploty vzduchu až po průběh srážek v následujících měsících.

Zpráva dále obsahuje popis vlivu období sucha na podzemní vody; zvláštní pozornost je věnována analýze hydrologických dopadů meteorologické situace. Sem patří zdokumentování minimálních průtoků ve vodních tocích v povodí Labe na základě záznamů z reprezentativních vodoměrných stanic, vyhodnocení a zařazení intenzity této epizody, které se provádí statistickým přístupem pomocí výpočtů, analýz a porovnání příslušných charakteristik a indexů.

Pro porozumění procesů ovlivňujících vznik a rozsah této epizody sucha je důležitá znalost vlivů hospodaření s vodou. Hlavní pozornost je zaměřena na manipulace na významných vodních dílech, jejichž vliv byl zkoumán zčásti pomocí metod odhadu, zčásti pomocí hydraulických modelů. Přitom lze prokázat, že jen díky dotování průtoků z vodních děl, zejména z Vltavské kaskády, se podařilo zabránit i na úseku německého Labe ještě extrémnějšímu suchu.

Literatura:
[1]
MKOL (2017) Hydrologické vyhodnocení sucha v povodí Labe v roce 2015. Magdeburk: MKOL

Hydrologische Auswertung der Niedrigwassersituation 2015 im Einzugsgebiet der Elbe

Petr Kuřík
Internationale Kommission zum Schutz der Elbe (IKSE)

Das Gebiet West-und Mitteleuropas einschließlich der Bundesrepublik Deutschland und der Tschechischen Republik wurde im Jahr 2015 von einer ausgeprägten meteorologischen Trockenheit erfasst. Im Einzugsgebiet der tschechischen und der deutschen Elbe nahm das Niederschlagsdefizit im Laufe des Jahres zu, was sich insbesondere in den Sommermonaten in einem deutlichen Wassermangel in der Landschaft und im Boden, einem spürbaren Fallen der Grundwasserstände und in niedrigen Abflüssen in den Gewässern zeigte. Es entwickelte sich eine teils extreme Niedrigwassersituation, mit deren Auswertung sich die Expertengruppe „Hydrologie" im Rahmen der internationalen Zusammenarbeit unter dem Dach der Internationalen Kommission zum Schutz der Elbe (IKSE) befasste und einen gemeinsamen Bericht [1] erstellte. Der Bericht steht auf den Internetseiten der IKSE www.ikse-mkol.org zur Verfügung.

Der Bericht enthält die Dokumentation der meteorologischen Rahmenbedingungen, angefangen von der Entwicklung der Schneerücklagen im Winter 2014/2015 über die Lufttemperaturen bis hin zum Niederschlagsgang in den Folgemonaten.

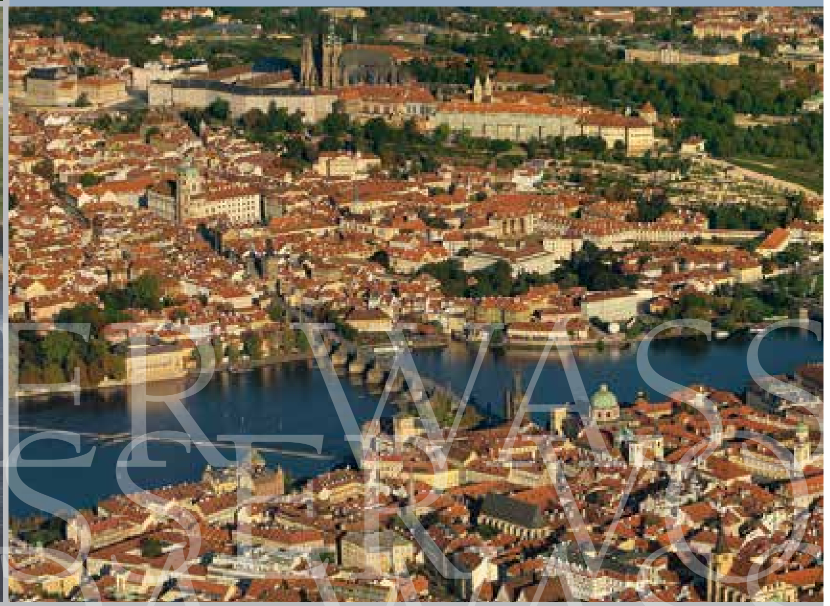
Ferner wird im Bericht der Einfluss der Trockenperiode auf das Grundwasser beschrieben; ein besonderes Augenmerk wird auf die Untersuchung der hydrologischen Folgen des Witterungsgeschehens gelegt. Hierzu gehören die Dokumentation der Niedrigwasserabflüsse in den Gewässern im Einzugsgebiet der Elbe anhand repräsentativer Pegelaufzeichnungen sowie die Bewertung und Einordnung der Ereignisintensität. Letztes geschieht auf statistischem Wege über die Berechnung, die Analyse und den Vergleich einschlägiger Kenngrößen und Indizes.

Wesentlich für das Verständnis der wirksamen Prozesse bei Entstehung und Ausmaß dieses Niedrigwasserereignisses ist die Kenntnis von Bewirtschaftungseinflüssen. Das Hauptaugenmerk wird auf die Steuerung der bedeutenden Talsperren gelegt, deren Einfluss teils über Schätzverfahren, teils über hydraulische Modellierung untersucht wurde. Dabei lässt sich nachweisen, dass es nur dank der Abflussstützung durch Talsperren, insbesondere der Moldaukaskade, bis weit in die deutsche Elbestrecke hinein zu keinem noch extremeren Niedrigwasser gekommen ist.

Literatur:
[1]
IKSE (2017) Hydrologische Auswertung der Niedrigwassersituation 2015 im Einzugsgebiet der Elbe. Magdeburg: IKSE

ODBORNÉ EXKURSE
Fachexkursionen



Content

Úpravna vody Podolí v Praze

Z historie pražského vodárenství

Technická díla, která přiváděla potřebnou vodu do míst, kde jí byl nedostatek, můžeme v pražské aglomeraci sledovat již od 12. století. Šlo o díla samospádová, tedy gravitační, bez čerpací techniky. Přivaděče měly formu otevřených koryt či vodovodních řádů vyrobených z různých materiálů - dřevo , kámen, pálená hlína, olovo. Vodovody pro církevní či panovnické objekty měly povahu ryze soukromou a v prvopočátcích veřejnosti nesloužily. Prvním zařízením určeným výhradně obci byl až Novoměstský vodovod z poloviny 14. století.

Za jeden z nejstarších přivaděčů v Praze je považován románský vodovod ve Strahovském klášteře, který využíval jako zdroj vydatné prameny z petřínského úbočí, dále vodovod na Vyšehradě, kterým již na počátku 12. století přitékala voda ze studánky zvané v pověstech Libušina lázeň. Po roce 1140 nechal český kníže Vladislav II otevřené koryto zatrubnit do dřevěných rour a dal na Vyšehradě postavit kašnu. V roce 1361 nechala vyšehradská kapitula zchátralý dřevěný vodovod zrekonstruovat a položit roury z hlazeného kamene. Další významná pražská lokalita Pražský hrad byl od nepaměti zásobován vodou z místních studní a pramenů, prvním zdrojem bylo povodí potoka Brusnice, který vyvěrá v benediktinském klášteře na Břevnově.

Za počátek zásobování obyvatelstva našeho hlavního města vodou z veřejného vodovodu bývá považována polovina 14. století. Spolu se vznikajícím Novým Městem pražským bylo v roce 1348 položeno dřevěné potrubí na pramenitou vodu pro kašny na Dobytčím a Koňském trhu (dnešní Karlovo a Václavské náměstí).

Doba renesance byla opravdovou obrodou také pro distribuci vody. Vznikaly první vodárny, byl ustálen vodohospodářský systém a stanovena technologie kladení potrubí i způsob odběru pomocí veřejných či soukromých kašen. V pražských městech byly postupně v 15. a 16. století založeny čtyři vltavské vodárny. Staroměstská pro Staré Město pražské, Petržilkovská pro Malou Stranu, Šítkovská a Novomlýnská pro Nové Město pražské. V padesátých letech 19. století doplnila distribuční systém čtyř vltavských vodáren Žofínská vodárna. Vzniklý způsob zásobování vodou sloužil s drobnými odchylkami až téměř do konce 19. století.

Průmyslovou revolucí v 19. století získala Praha drážní spojení do Vídně a také dvojnásobné množství obyvatel. Kolem roku 1900 mělo přímo v Praze trvalé bydliště 120 tisíc a s okolními obcemi přes půl milionu lidí. Kromě továren se rychle stavěly i nájemní domy a veřejné objekty a dosavadní zásobování vodou z Vltavy, potoků a studní dávno nestačilo. Zejména v létě při delším suchu hrozily požáry, mnoho domácností nemělo přístup k vodě a problémy hlásily i výrobní podniky. Situace se stávala neúnosnou a pražští zastupitelé ji museli řešit. Podle průzkumu zřízené komise dodávalo pět pražských vodáren na území Starého a Nového Města a Malé Strany do přibližně 500 odběrových míst asi 10 tisíc m^3 surové vltavské vody, což pro zásobování obyvatel vnitřní Prahy nestačilo. Nakonec bylo rozhodnuto pro postavení vodárny nové, s dostatečnou kapacitou a technologickým zázemím.

V roce 1885 vznikla na pravém břehu Vltavy pod Branickou skálou Pražská vodárna. Fungovala na parní pohon a čerpala spodní vodu smíchanou s vodou říční, která se přirozeně filtrovala ve třech filtračních studních na Schwarzenberském, dnes Veslařském ostrově. Touto úpravnou byla zvýšena dodávka do vnitřní Prahy na přibližně 30 tisíc m^3 vody za den. Pražské domácnosti díky tomu získaly dostatek vody a mohly si začít pořizovat koupelny a splachovací toalety. Potrubím z Pražské vodárny však neproudila pitná voda, pro tu se teprve stavěla vodárna v Káraném, která Prahu začala zásobovat zkušebně od roku 1912, naplno pak od roku 1914. Praha tedy měla konečně kvalitní zdroj pitné vody, což její obyvatelé ocenili především v období 1. světové války. V dobách epidemií, všeobecného nedostatku, kdy civilní obyvatelstvo trpělo nedostatečnou výživou a z fronty přicházely nakažlivé nemoci, má voda z Káraného velký podíl na poměrně příznivém zdravotním stavu obyvatel Prahy v těchto dobách.

Podolská vodárna

Pražská vodárna v Braníku postupně ztrácela svůj smysl, její provoz se zastavil a v roce 1922 byla zbořena. V té době došlo k připojení sousedních obcí a vznikla tzv. Velká Praha se zvýšenými nároky na spotřebu a kvalitu vody. Pitná voda z Káraného už na zásobování takového množství lidí nestačila a její přívod byl drahý. Bylo nutné zřídit nový zdroj pitné vody a město se znovu vrátilo k možnosti využívat na tento účel vltavskou vodu. V letech 1922 – 1929 byla v Podolí na pravém břehu Vltavy vybudována nová vodárna a filtrační stanice. Autorem architektonicko-urbanistického řešení byl Antonín Engel, který zvítězil v soutěži s projektem v duchu monumentálního klasicismu.

Antonín Engel pojal návrh areálu vodárny velkolepě. Navrhl monumentální průmyslovou stavbu se vzezřením veřejné budovy a prvky světelné hry známé z kostelů. Dvě velké filtrační budovy stojící proti sobě doplňovaly symetricky dvě menší stavby, strojovna a administrativní budova. V první etapě byla realizována pouze polovina návrhu, byla postavena budova filtrační stanice, strojovna a administrativní budova. Zakázku získala podnikatelská firma Karel Kress, mající zkušenosti s prováděním vodárenských staveb a železobetonových mostních oblouků. Práce koordinovala projekční kancelář Vodárenského úřadu hl. města Prahy. V roce 1929 šlo o největší železobetonovou stavbu u nás, rozpětí parabolických oblouků v hlavním sále s výškou 16 m činilo 24 m a bylo

Filtrační hala. Hlavní prostor sloužil k úpravě vody a od roku 1929 se jeho podoba nezměnila.

zcela mimořádné. Hala o rozměrech 60 × 24 m působí i přes mohutnost subtilně a zvláštním způsobem křehce, při pohledu vzhůru sloupové oblouky připomínají žebroví velryby. Problém dostatečného osvětlení vyřešil Antonín Engel velkoformátovými okny ve stěnách a pravoúhlými skleněnými výplněmi ve stropě, který kaskádovitě klesá směrem k řece. Do vznikající okolní vilové zástavby jednoduchá obdélníková stavba s vysokými okny a rafinovaným zdobením fasády zapadla a zároveň se díky objemu stala přirozenou dominantou podolského nábřeží.

Technologie čištění vody

Podzemní voda ze Schwarzenberského ostrova byla přivedena shybkou pod ramenem Vltavy na podolský břeh do původní sběrné studny, z níž bylo položeno nové potrubí o profilu 600 mm ke třem novým sběrným studním, z nichž byla čerpána voda samostatným potrubím do filtračního zařízení. Říční voda se jímala v hlavním řečišti rekonstruovaným nátokem bývalé Vinohradské vodárny v Podolí a převedena stávající eliptickou shybkou pod vltavským ramenem k již zmíněným novým sběrným studnám.

Kvůli nevhodnému složení podzemní vody se čerpala říční voda, která se upravovala filtrační soustavou systému Puech-Chabal. Vzhledem k nedostatku místa byla volena dispozice filtračních skupin nad sebou. Hrubocezy a předfiltry jsou tudíž v etáži nejvyšší, filtry jemné v etáži nižší a konečně nádrže na čistou vodu jsou v suterénu budovy. Byly zvoleny, vyprojektovány a postaveny tři hrubocezné stupně. Touto technologií mohlo být denně čerpáno do vodovodní sítě 35 000 m^3 vody.

Problém nedostatečné kapacity řešilo město okamžitě po slavnostním otevření vodárny. Za provozu postupně obměňovalo technologické prvky, až v roce 1946 vodárna dosáhla svého maxima. Bohužel i to přestávalo stačit, a tak bylo rozhodnuto o rozsáhlejší rekonstrukci celé vodárny. Zastavení provozu nebylo možné, a tak se výstavba nového objektu uskutečnila na místě původně projektované jižní haly filtrů. Návrh opět vypracoval Antonín Engel, v té době už pán v penzi. Stavba trvala dlouhých 11 let, během kterých občas docházelo ke kritickému nedostatku vody. V roce 1965, sedm let po úmrtí arch. Antonína Engela, byla dokončena architektonická podoba celého vodárenského areálu. Jižní průčelí nové budovy zdobí jedenáct soch znázorňujících Vltavu a její přítoky.

V roce 1961 se tehdy ještě nedostavěná vodárna stala hlavní výrobnou pitné vody, po dokončení, o pět let později, zásobovala Prahu ze dvou třetin. Nejvíce pitné vody vyrobila Podolská vodárna v roce 1972, téměř 69 milionů m^3. V tomto roce byla uvedena do provozu vodárna na Želivce, která se od té doby stala hlavním zdrojem pitné vody pro

Prahu a okolí. Činnost v Podolské vodárně se začala postupně utlumovat. Pro její rozvoj se neučinilo téměř nic a její osud byl nejistý, dokonce se mluvilo o ukončení činnosti. V roce 1992 bylo konečně započato s rozsáhlou rekonstrukcí. Tato rekonstrukce, která proběhla za provozu vodárny, byla v úplnosti dokončena v roce 2000. Nesledovala zvýšení výkonu, ale zlepšení kvality upravené vody a snížení negativních vlivů na životní prostředí v okolí vodárny. Svoji funkci plnila vodárna jen 2 roky. Po povodních v roce 2002 ukončila aktivní činnost a slouží jen jako záložní zdroj pitné vody. Stroje se rozběhnou čtyřikrát za rok pro ověření funkčnosti.

Výroba vody

Od roku 1929, kdy vodárna vyrobila 4 463 385 m^3, výroba vody až do roku 1972 stoupala, kdy dosáhla historického maxima 68 911 372 m^3. Zprovozněním Úpravny vody Želivka výroba výrazně klesla. Zájem o vodu z Podolí začal stoupat ve druhé polovině sedmdesát let minulého století v souvislosti s výstavbou nových pražských sídlišť. Od roku 1982, kdy vodárna do sítě dodala 64 295 000 m^3, její výkon postupně klesal až na 10 357 000 m^3 v povodňovém roce 2002.

Muzeum pražského vodárenství

Interiér filtrační stanice je od výstavních prostor oddělen skleněnou stěnou a tak se návštěvníkům naskytne neuvěřitelný výhled do Engelovy „katedrály" s filtry. Celá expozice zachovává chronologické členění historického vývoje pražského vodárenství od prvních soukromých vodovodů z 12. století, přes vltavské vodárny renesančního období a vodárenské snahy konce 19. století, až po současné zásobování hl. m. Prahy vodou. Je zde vystaven originál čerpacího stroje klatovské vodárny z roku 1830, vodovodní potrubí z antického období, část hradního vodovodu z doby Rudolfa II. a řada dalších exponátů. Trojrozměrné předměty doplňuje řada kopií unikátního a dosud nevystavovaného archivního materiálu a množství historických fotografií. Velmi cenné jsou sbírky druhů vodovodního potrubí, uzavíracích elementů a další historických přístrojů a nástrojů. Samostatně je prezentována unikátní sbírka vodoměrů.

Zřizovatelem Muzea pražského vodárenství v Praze 4 - Podolí je akciová společnost Pražské vodovody a kanalizace.

Ústřední čistírna odpadních vod v Praze

letecký pohled ÚČOV

Počátky pražské kanalizace

Středověká Praha, stejně jako jiná středoevropská města, byla zahlcena nečistotami pevnými i kapalnými. Odpadní voda z chlévů, žump a různých jímek přetékala do ulic, všude se hromadil hnůj a odpadky. Jediné čištění ulic zajišťoval spíše prudký déšť než soustavná snaha městské správy.

Prvním technickým dílem, které zbavovalo jeden z pražských stavebních objektů nežádoucí vody, byla stoka odvodňující areál Strahovského kláštera premonstrátů. Při budování kláštera v polovině 12. století byla přivedena pitná voda z petřínských štol a zároveň vybudována odvodňovací štola zbavující stavební komplex odpadní vody. Stavba to byla v této době ojedinělá a v níže položeném městě nebyla dlouhá léta napodobena.

V roce 1310 byla postavena stoka, která odvodňovala proboštův dům v dnešní Nerudově ulici. Není ale známo, kam nečistoty odváděla. Výjimkou byla také stavba vzniklá ve druhé polovině 17. století, kdy roku 1673 vybudovali jezuité velkou kamennou stoku, která odváděla splašky ředěné vodou z Klementina do Vltavy.

Jednou ze zásadních modernizačních akcí bylo zahájení stavby podpovrchové pražské kanalizace v roce 1787 podle projektu Leonarda Hergeta. Práce však z počátku vázly, protože majitelé domů museli uhradit část nákladů na stavbu stoky, která vedla podél jejich nemovitosti. Teprve nejvyšší purkrabí Karel hrabě Chotek se energicky postaral o dokončení první pražské veřejné kanalizace. V období let 1816 až 1828 bylo postaveno 44 kilometrů stok. Kanalizace byla vyústěna přímo do Vltavy třiceti pěti výpustmi. Po stránce technické i zdravotní však vybudované stoky vykazovaly z dnešního pohledu řadu závad (ploché dno, obyčejné cihly, místo malty byla použita hlína, nevhodné průřezy a nedostatečné sklony). Čištění stok se provádělo v noci, vytěžený materiál se odvážel.

Budování pražské kanalizační soustavy a čištění odpadních vod v Praze

Během druhé poloviny 19. století se postupně měnila tvář Prahy, která se přetvářela na moderní velkoměsto. Z této proměny vycházela i nutnost změnit její urbanistické, komunikační a hygienické poměry. Rozvojem průmyslové výroby došlo nejen ke zvýšení počtu obyvatel, ale i k velké zátěži životního prostředí. Strojírenství, chemický průmysl a výroba stavebních hmot stále více ohrožovaly životní prostor pražské kotliny. Stav pražské kanalizace byl také průběžně zhoršován častými povodněmi.

Cílevědomý přístup k řešení odvedení odpadních vod z území hlavního města Prahy počíná v roce 1865, kdy byl správou tehdy existující kanalizace pověřen zřízený Hospodářský úřad, samostatný Úřad kanalizační byl pak zřízen v roce 1883. Po dvou neúspěšných pokusech získat projekt pražské kanalizace jako výsledek vypsané soutěže byl o jeho návrh požádán stavební rada Frankfurtu nad Mohanem anglický inženýr William Heerlein Lindley. Ten předal městu svůj projekt v červnu 1893.

Dle jeho návrhu bylo vyústění celé stokové sítě situováno u Císařského ostrova v Bubenči. Součástí projektu byla mechanická čistírna odpadních vod s kapacitou 160 000 m^3 splaškových vod za den. Stavba moderní pražské kanalizační soustavy začala na počátku roku 1898. Projekt čistírny byl dokončen v roce 1890, v září 1901 byla zahájena stavba a zkušební provoz byl zahájen 27. června 1906. Byl úspěšný a za necelého půl roku bylo dosaženo normálního chodu všech zařízení. Lindleyova čistírna sloužila více než šedesát let a dnes představuje ojedinělou technickou památku, která ve své době představovala špičku zdravotně technického inženýrství.

Vytvoření Velké Prahy v roce 1920 znamenalo napojení nových území a vážný zásah do Lindleyovy koncepce. Růst objemu odpadních vod z nových území znamenal nedostatečnou kapacitu čistírny odpadních vod v Bubenči. Generel kanalizace předložený v roce 1925 uvažoval se dvěma novými čistírnami – v prostoru vyústění Botiče do Vltavy a v Řeži. Vybrán byl návrh druhé čistírny v Řeži, ale nikdy nebyl realizován

V roce 1927 proběhla první modernizace bubenečské čistírny. Byla postavena nová česlovna, vznikl trojdílný lapač písku a další čtyři usazovací nádrže. Kaly byly odváženy k dalšímu využití speciálními loděmi.

Mezinárodní situace v třicátých létech, druhá světová válka a hospodářské možnosti bezprostředně po jejím ukončení byly důvodem, proč nebylo možné v tomto období přistoupit k zásadnímu řešení čištění odpadních vod z hlavního města Prahy. A to přes to, že produkce splaškových vod postupně rostla. Lindleyova čistírna byla ještě jednou v roce 1947 modernizována, avšak kapacitně nebyla schopna ani po této modernizaci všechny odpadní vody čistit a část jich bylo nutné vypouštět nečištěné přímo do Vltavy.

Situaci postupně zhoršovala i bytová výstavba po roce 1950 a prudký nárůst počtu obyvatel připojených na stokovou síť. Rozhodnutí o výstavbě nové čistírny odpadních vod hl. m. Prahy (ÚČOV) na Císařském ostrově bylo přijato v roce 1954, v roce 1959 byla zahájena výstavba jejích provozních objektů a nová mechanicko-biologická ÚČOV byla uvedena do provozu v červenci 1966. Zároveň po šedesáti letech ukončila svou činnost Lindleyova čistírna. Narůstající potřeba vedla k další rekonstrukci, v letech 1974 – 1975 dochází ke zvýšení čistícího procesu ÚČOV.

Na konci minulého století se stalo účinné čištění odpadních vod jedním z významných témat ochrany životního prostředí v celé Evropě. Pražská aglomerace byla a je významným producentem odpadních vod a nedostatečnou účinnost ÚČOV bylo nutné řešit. V letech 1994 – 1995 došlo k intenzifikaci, která zvýšila účinnost vodní linky a pomohla zajistit dostatečnou účinnost čistícího procesu pro tehdy platnou legislativu. Jako vícekrát v historii čistírny odpadních vod pro hlavní město Prahu, díky nedostatku finančních prostředků nebyla realizovaná druhá etapa zaměřená na kalové hospodářství, tuto oblast se podařilo postupně intenzifikovat řadou dílčích opatření.

Po roce 1990 byla posouzena celá řada variant umístění čistírny pro hlavní město Prahu mimo Císařský ostrov i na vlastním ostrově. Postupně se ukázalo, že s ohledem na vývoj legislativy a závazky přijaté Českou republikou při vstupu do Evropské unie může odpovídající čištění odpadních vod zajistit jen nová čistírenská kapacita a jediné reálné uzemní řešení je Císařský ostrov, kde se na základě schválené koncepce z roku 2004 v současnosti realizuje výstavba Nové čistírny odpadních vod rozdělené do několika etap.

Stará čistírna odpadních vod V Praze – Bubenči

Stará čistírna odpadních vod je průmyslový objekt, který se ve své kategorii stal architektonickou chloubou. Byla naplněním snu o moderní kanalizaci, která hlavní město Českého království zařadila mezi přední velkoměsta tehdejšího světa.

Výstavba čistírny probíhala v letech 1901–1905. V samotném závěru stavby došlo k zásadní změně. Autoři opustili strohé “frankfurtské” provedení a vsadili také na vnější vzhled budovy. Výsledkem je moderní, krásná a sofistikovaná čistírna.

Sir William Heerlein Lindley, původem Angličan, působil převážně v Německu. Do Prahy přenesl své zkušenosti z výstavby čistírny ve Frankfurtu nad Mohanem. Řešení, jež předložil, znamenala technologický vrchol těchto zařízení. Navíc veškeré „páchnoucí“ provozy umístil do podzemí, takže neobtěžovaly život v blízkém okolí a nezatěžovaly další pozemky. Pečlivě vybíral i kvalitní materiál - „Zvonivky“, cihly z cihelny v Uhříněvsi, jsou dodnes ve stejném stavu jako v roce 1906, kdy byla stavba dokončena.

V roce 1966 ukončila stará čistírna svou činnost , v roce 2010 se stala národní kulturní památkou.

Ústřední čistírna odpadních vod (ÚČOV)

ÚČOV byla uvedena do provozu v roce 1966. Ve své době patřila k největším v Evropě, avšak brzy přestávala stačit zvyšujícím se požadavkům na kvalitu vyčištěné vody.

Z tohoto důvodu byly nejdříve v 80. a pak znovu v 90. letech minulého století na ÚČOV provedeny významné rekonstrukce a dostavby některých nových objektů. Jednalo se především o zvýšení kapacity biologického stupně čištění včetně zavedení procesu nitrifikace odpadní vody. V kalovém hospodářství byly instalovány odstředivky na strojní odvodňování kalu. Pro výrobu tepla a elektrické energie z bioplynu byly instalovány nové kogenerační jednotky. Také byl postupně vybudován rozsáhlý automatický a monitorovací systém řízení technologických procesů čištění vody, zpracování kalů i výroby energií. I v současné době na ÚČOV průběžně dochází k výměně a modernizaci fyzicky nebo morálně zastaralého zařízení, které zajišťují udržení požadované kvality procesu čištění odpadních vod.

Nová čistírna odpadních vod

Celková přestavba a rozšíření ÚČOV Praha má několik etap. Jedná se o vybudování NVL (etapa 0001), rekonstrukci stávající vodní linky (0002), rekonstrukci kalového hospodářství (0003), stavbu dvou nových nátokových labirintů na levém a pravém břehu (0004 a 0005), nové hlavní čerpací stanice a nátoků na ÚČOV (tyto objekty budou společně sloužit oběma vodním linkám, etapa 0007). Posledními dvěma etapami jsou kompenzační opatření (z hlediska PPO, etapa 0008) a stavba nových retenčních nádrží na pravém břehu Vltavy (0004 a 0005). V současné době je realizována etapa 0001 – Nová vodní linka, etapa 0007 – Nátoky na ÚČOV a etapa 0008 – Kompenzační opatření.

Přínos modernizace

Stávající Ústřední čistírna odpadních vod pro hlavní město Prahu (ÚČOV) nesplňuje dlouhodobě požadavky současné národní i evropské legislativy na kvalitu vypouštěných vyčištěných odpadních vod, zejména v ukazateli dusík a fosfor.

Hlavním účelem stavby Nové vodní linky je zvýšení kapacity „ÚČOV“). Výstavba Nové vodní linky umožní čištění odpadních vod z jednotného kanalizačního systému Prahy na úroveň jakosti požadované právními předpisy k vypouštění předčištěných odpadních vod. pro kapacitu 1 427 560 EO.

Cílem modernizace je provést nápravu ve dvou krocích. Prvním je vybudování Nové vodní linky ÚČOV, která už sama o sobě přispěje výrazně ke zlepšení kvality vyčištěných odpadních vod vypouštěných do Vltavy. Ve druhém kroku bude provedena modernizace stávající vodní linky ÚČOV, kterou bude zabezpečeno odstraňování dusíku a fosforu na stanovené hodnoty i při nevyšším zatížení čistírny odpadními vodami.

Nová vodní linka ÚČOV je navržena jako plně zakrytá, s chemickou nebo biologickou dezodorizací procesního

vzduchu vypouštěného z čistírny do ovzduší. Moderní architektonicko-urbanistické řešení areálu, a jeho jednotlivých technologických celků, přispěje ke zlepšení celkového prostředí v Trojské kotlině.

Technické řešení

Splaškové odpadní vody přiváděné stokovou sítí budou rozděleny mezi novou a stávající ČOV. Nová vodní linka je navržena jako kaskádová aktivace s regenerační nádrží vratného kalu. Mechanické předčištění odpadní vody je na lamelových usazovacích nádržích, kde se čistí i část průtoku dešťových vod. Kaskádová aktivace je rozdělena do čtyř samostatných linek s podélnými dosazovacími nádržemi. Odtok z dosazovacích nádrží je zaveden na třetí stupeň čištění, kde probíhá v lamelových usazovacích nádržích chemické odstraňování fosforu. Produkovaný primární, přebytečný aktivovaný kal a kal ze třetího stupně čištění je čerpán do stávajícího kalového hospodářství na ÚČOV, které je společné pro obě linky.
Množství odpadní vody přitékající na NVL a ÚČOV bude řiditelné. Základní rozdělení průtoků je 50:50, ale prakticky bude možné měnit rozdělení až do vyčerpání látkové či hydraulické kapacity více zatížené linky. Určitý minimální průtok odpadní vody NVL i ÚČOV však musí být zachován.

Součástí nové linky je mechanicko-chemické čištění 3 m^3/s srážkových vod. Maximální hydraulická kapacita biologického stupně je 6 m^3/s po dobu maximálně jedné hodiny v průběhu dne. Tato kapacita bude využita při přerušení provozu stávající ÚČOV z důvodu její rekonstrukce.

Protipovodňová ochrana

Samostatnou otázkou v rámci výstavby nové linky čističky bylo řešení protipovodňové ochrany a to jak během stavby, tak po dokončení díla, a samozřejmě i vliv nové stavby na záplavové území a průtokové poměry.
Ochrana stavební jámy při realizaci NVL, je navržena tak, že po celém jejím obvodu je provedena podzemní stěna, která je přisypána obvodovou zemní hrází na úroveň výšky 184,00 m n.m. (Q_{20}). Na horním líci obvodové hráze je provedena zpevněná obslužná komunikace, která umožňuje pojezd těžké techniky. Obvodová hráz je na čtyřech místech snížena na kótu 183,00 m n.m., pro možné zaplavení stavební jámy při průtocích vyšších než Q_{20}.

Nedílnou součástí protipovodňové ochrany stavby NVL byla změna Manipulačního řádu vodního díla Troja – Podbaba, která nově zohledňuje možnost převádění povodňových průtoků přes plavební komory Podbaba a která minimalizuje vliv výstavby nové vodní linky ÚČOV Praha na průběh vod v oblasti Císařského ostrova

Z hlediska protipovodňové ochrany bude dokončená NVL vyřazena z provozu již při dosažení hladiny vody Q_{20} ve vodním toku Vltava, Zároveň budou uzavřeny výpusti vody a vodotěsné dveře u vybraných objektů, tak aby nedocházelo k zaplavení „suchých“ místností, a bude provedeno zahrazení mobilním protipovodňovým hrazením.

Jedno z dalších opatření se týká samotných nádrží NVL, které musí být při povodní naplněné na provozní hladinu, aby vydržely vztlak pro hladinu při Q_{2002}.

Technická data projektu Nové vodní linky

Mechanicko-biologická linka čištění odpadních vod s chemickým srážením

Zvýšení kapacity ÚČOV o 183 560 ekvivalentních obyvatel na celkovou kapacitu 1 611 000 EO (8,2 m^3/s mechanicko-biologicky čištěných odpadních vod)

Další mechanicko-chemické čištění odpadních vod v množství max. 3 m^3/s při srážkových průtocích.

Po dokončení se předpokládá celkové odstranění znečištění v ukazateli BSK5 35 tis. t/rok, CHSK 91 tis. t/rok, nerozpuštěné látky 66 tis. t/rok, dusík celkový 7 tis. t/rok a fosfor celkový 1 tis. t/rok.

Vodní elektrárna a plavební komora Štvanice v Praze

Nejstarší, z dnešního pohledu velmi jednoduchý, návrh na kanalizování Vltavy u ostrova Štvanice pochází z roku 1778 od stavebního ředitele Hergera, který navrhoval rozšíření Rudolfovy štoly na průplavní tunel. V roce 1895 bylo rozhodnuto c. k. ministerstvem vnitra, že se bude kanalizovat Vltava a Labe z Prahy do Ústí nad Labem. Práce na splavnění dolní Vltavy od r. 1896 prováděla komise pro kanalizování řek Vltavy a Labe v Čechách. V rámci těchto prací bylo v letech 1907 až 1913 vybudováno vodní dílo u ostrova Štvanice. Byly postaveny nábřežní zdi, v obou ramenech řeky nové jezy, vorová propust, plavební komory a elektrárna na západním cípu ostrova Štvanice. Stavbu realizovaly firma Miller a Kapsa a firma Lanna. Tento soubor vodohospodářských staveb tvoří vodní dílo dodnes.

U levého břehu Vltavy je situován Helmovský jez s charakteristickým půdorysným tvarem písmene „S.

Helmovský jez

Nový Helmovský jez byl postaven pod původním jezem z roku 1398. Je pevný, betonový, obložený kvádry, v řezu tvaru lichoběžníku. Kóta přelivné hrany je 184,50 m n.m. Půdorys je zakřivený ve tvaru písmene S. Délka přelivné hrany jezu je 164,45 m a spád 4,40 m. Pod jezem je obdélníkový vývar ze žulových kvádrů. V roce 1940 byla při povodni protržena pravá část jezu. U levé nábřežní zdi je situována vorová propust šířky 12,00 m, která se v dolní části rozšiřuje na 17,33 m. Délka propusti od počátku dělicí zdi je 289,70 m. Boční zdi vorové propusti jsou z kamenného kyklopského zdiva. Uzávěr propusti je klapkový. Na břehu je dochovaná dodnes používaná otočná lávka, kterou vyrobila firma Bratří Prášilové a spol. Stavbu jezu a vorové propusti provedla firma Müller & Kapsa v r. 1907 až 1910, přičemž samotný jez byl postaven v celkové době sedmi měsíců. Během stavby zatopila velká voda sedmkrát stavební jímky. Na pravé straně jezu na špičce ostrova Štvanice je umístěna malá vodní elektrárna.

Vodní elektrárna na Štvanici

Stavba elektrárny začala v r. 1908 a probíhala ve dvou etapách. V první etapě byla provedena spodní stavba a v letech 1913 až 1914 bylo osazeno technologické zařízení vodní elektrárny a postavena vlastní budova. Ta byla postavena dle návrhu ing. arch. Aloise Dlabače. Celou stavbu provedla firma Müller & Kapsa. Tři třístupňové Francisovy turbíny každá o hltnosti 3×16 m^3/s, a výkonu 474 kW dodala firma Kolben & Daněk. Roční výroba byla průměrně 5,8 mil. kWh. Není bez zajímavosti, že základy elektrárny postavila kanalizační komise bez povolení, protože rozhodující orgány bránily na kanalizovaných řekách jakémukoli využití vodní energie, s výjimkou plavby.

Elektrárna sloužila bez větších problémů až do prosince 1972. Na základě programu rekonstrukce a obnovy malých vodních elektráren z roku 1981 byla v r. 1984 zahájena její rekonstrukce. Dodavatelem stavební části byla firma Metrostav a technologické části ČKD Blansko. V r. 1988 byla elektrárna předána do provozu. O výrobu elektřiny se starají tři horizontální Kaplanovy turbíny, každá o průtoku 55 m^3/s. Oběžné kolo o průměru 3,5 m, má čtyři lopatky a 107,1 ot/min. Generátory dodala Škoda Plzeň, rotor o průměru 4,2 m má 56 pólů výkon 1,89 MW, napětí 6,3 kV. V roce 1988 výkon elektrárny téměř pokryl spotřebu pražského uličního osvětlení. V současné době je roční průměrná výroba 18 mil. kWh.

Od 1. 8. 2002 se stává majitelem elektrárny Povodí Vltavy státní podnik. Při povodni 14. 8. 2002 byla elektrárna zcela zaplavena a následně proběhla oprava a modernizace zařízení. Pohledově vysoce exponovaná secesní budova elektrárny ve středu řeky na území pražské památkové rezervace je od roku 2002 prohlášena kulturní památkou.

Rekonstrukce elektrárny

V současnosti probíhá v elektrárně rozsáhlá rekonstrukce. V MVE Štvanice jsou instalovány 3 přímoproudé Kaplanovy turbíny o průměru oběžného kola 3 400 mm, hltnosti 3 x 55 m^3/s, výkonu 3 x 1890 kW, průměrná roční výroba 24 000 MWh. Problémem posledních let byla vysoká poruchovost a špatná regulace turbín, která neumožňovala optimální využití průtoků. Cílem prováděné rekonstrukce je zajistit vyšší spolehlivost zařízení, lepší regulaci soustrojí, vyšší účinnost a tím vyšší výrobu elektrické energie. Zabetonovaný vtokový kus, savka, hřídel a generátor zůstávají původní. Bylo instalováno nové těleso turbíny s nově navrženým rozvaděčem (rozváděcím kolem) a nové oběžné kolo. Podle provedeného počítačového modelu byl pro zlepšení proudění vody v savce změněn směr otáčení turbín na levotočivé. Tyto úpravy zlepší regulaci soustrojí a účinnost o cca 10%. Rekonstrukci provádí firma MAVEL a.s. z ČR.

Plavební komory pod Hlávkovým mostem

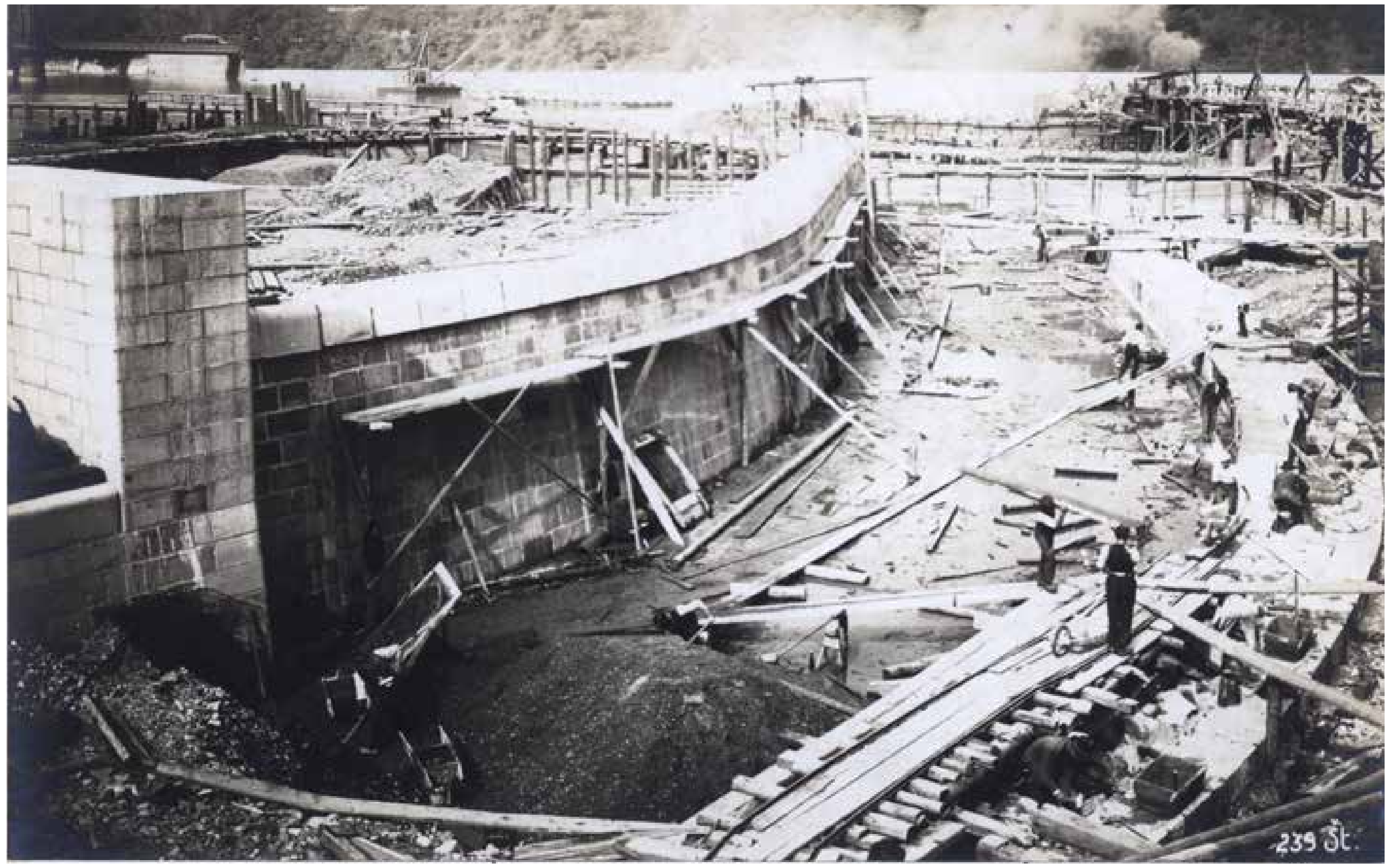
Plavební komory jsou dvě, umístěné vedle sebe. Obě jsou děleny středními vraty na dvě komory. Levá malá komora byla dlouhá 55 m, ale v r. 1980 až 1981 došlo k rekonstrukci a prodloužení na 115 m. Pravá velká komora je dlouhá 175 m. Komory se uzavírají ocelovými vzpěrnými vraty. Všechna vrata jsou ovládána hydraulicky. Komory jsou plněny dlouhými obtoky, uzávěry obtoků tvoří segmenty s hydraulickým pohonem. Doba plnění malé plavební komory je 10 minut a spotřeba vody pro proplavení 5 566 m^3. Čas potřebný k plnění velké komory je 13,5 minuty a spotřeba vody pro proplavení 9 204 m^3.

Pod Hlávkovým mostem vedle plavebních komor byl postaven pevný betonový jez. Jez byl přímý délky 58,28 m se spádem 2,48 m. V roce 1988 byl nahrazen jezem se dvěma pohyblivými ocelovými klapkami, každá délky 27,0 m s hradicí výškou 3,3 m. Pod jezem je betonový vývar hloubky 1,8 m.

Návrh domku pro plavidelníka pochází od prof. arch. Fr. Sandera. Na svou dobu byl velmi moderně vybaven. Do všech místností byl zaveden elektrický proud, do kuchyní a záchodů voda, kancelář a byt plavidelníka byly vybaveny telefonem. Domek byl zkolaudován v březnu 1913.

Stavbu plavebních komor, pevného jezu pod Hlávkovým mostem, domku plavidelníka a okolních nábřeží prováděla v letech 1907 až 1913 firma Lanna.

Hydrologické údaje:	
plocha povodí:	26 966,80 km^2
průměrný dlouhodobý roční průtok:	148,31 m^3/s
N-letý průtok Q_{100}:	3 726 m^3/s
Technické údaje:	
Jezová zdrž:	
celkový objem:	1,675 mil. m^3
délka jezové zdrže:	2,130 km
Jez Helmovský:	
tok:	Vltava ř.km. 51,057
druh jezu:	pevný
konstrukce pevné části jezu:	betonový obložený kamenem
kóta koruny pevné části jezu:	184.50 m.n.m.
spád:	4.4 m
stavební délka jezu:	184.7 m
počet jezových polí:	1
Propust vorová:	
rozměry š x dl.:	12 x 290 (m)
druh uzávěru:	klapka
Propust štěrková odlehčovací:	
rozměry š x dl.:	3.6 x 14,2 m
druh uzávěru:	klapka
Jez Štvanice	
tok:	Vltava ř.km. 50.690
druh jezu:	pohyblivý
konstrukce pevné části jezu:	betonový
kóta vztyčené hradící konstrukce:	185,75 m.n.m.
spád:	3.3 m
stavební délka jezu:	54 m
počet jezových polí:	2
druh uzávěru jezového pole:	klapka
Plavební komora:	
typ plavebních komor:	vlaková
Velká plavební komora	
použitelná plavební š x dl. x hl.:	11 x 160,5 x 2,5 m
typ vrat (horní, střední, dolní):	vzpěrná
Malá plavební komora	
použitelná plavební š x dl. x hl.:	1 x 85 x 2,5 m
typ vrat (horní, střední, dolní):	vzpěrná
Elektrárna:	
typ turbiny:	Kaplan přímoproudá
počet soustrojí:	3
instalovaný výkon:	5 670 kW (3 x 1 890)
max. hltnost:	3 x 65 m^3/s



Výstavba Helmovského jezu

Výstavba plavební komory

Helmovský jez

Plavební komory

Protipovodňová opatření v Praze, projížďka lodí po Vltavě

Po celý svůj vývoj muselo čelit hlavní město České republiky nepravidelně se vyskytujícím povodním. V historii máme záznamy o katastrofálních povodních např. v letech 1342, 1432, 1784, 1872, 1890. Vůbec největší povodeň (do roku 2002) byla zaznamenána 26. února 1784, kdy byl naměřen průtok 4 580 m^3/sec. Největší změřenou letní povodní byla velká voda ze dne 4. září 1890, která dosáhla průtoku 3 975m^3/sec a pobořila Karlův most.

Do vzniku Vltavské kaskády nebyla řeka Vltava regulovaná a průběh povodní se nedal žádným způsobem ovlivnit. Až vybudování přehrad na Vltavě umožnilo vodohospodářům průběh a dopad povodní korigovat. Není v lidských silách ničivou sílu povodní úplně zastavit, jediné, co nám zbývá, je přijmout taková opatření, aby byly následky co nejmenší. Již před rokem 2002 byla v Praze místní protipovodňová opatření. Po ničivé povodni v roce 2002 se začalo budovat koncepční protipovodňové opatření v rámci celé Prahy, které ošetřuje nejen protipovodňovou ochranu města, ale také například metro, které bylo povodní v roce 2002 také zasaženo.

V roce 1997 – 1998 byly zpracovány projekty na ochranu před povodní na průtok Vltavy Prahou QN 3700 m^3/sec s bezpečnostní rezervou 40 – 60 cm. Po povodni v roce 2002 byly projekty přepracovány na průtok QN 5 160 m^3/sec s bezpečnostní rezervou 30 cm.

Stupně povodňové aktivity v Praze

1. SPA Q - 450 m^3/sec
2. SPA Q - 1 000 m^3/sec
3. SPA Q - 1500 - Q 3 440 m^3/sec

Sucho Q 27,9 m^3/sec
Běžný průtok cca 50 m^3/sec

Systém protipovodňových opatření v Praze

Protipovodňová ochrana Prahy patří k jedné z nejmodernějších v Evropě. Hlavní město Praha do výstavby zábran dosud investovalo 3.7 miliardy korun.

Protipovodňová opatření jsou tvořena

1. Liniová opatření
- mobilní protipovodňové bariéry
- stálé protipovodňové zemní hráze
- železobetonové stěny
- na některých úsecích jsou využity železniční náspy

2. Uzávěry na kanalizační a stokové síti
- zpětné klapky
- přečerpávací stanice

Výstavba protipovodňových opatření je rozdělena do etap

ETAPA 0001 Staré Město - Josefov
Délka 909,4 m
Výška hrazení od 0,4 m do 5,2 m
dokončena v roce 2000
Ochrana na Q_{100} + 40 cm

ETAPA 0002 Malá Strana - Kampa
Říční ulice, Čertovka, Kampa, Úřad vlády
Délka 1060,8 m
Výška hrazení od 1,3 m do 3,6 m
realizace od 2002 do 2005
Ochrana na Q_{2002} + 30 cm

Malá Strana a Kampa je chráněna dvojitou hradbou mobilních ochran. První linie se nachází hned u Vltavy, druhá linie je osazena v ulicích, plní ochranou funkci poté, kdy níže položená 1. linie přestane plnit funkci. Kvůli pevnosti musí obsahovat pomocné vzpěry.

Čertovka zkouška

Uzávěr Čertovky
- Je součástí protipovodňového opatření na ochranu hl. m. Prahy od nábřežní zdi pod mostem Legií až po Karlův most.
- V klidové poloze jsou vrata schována za nábřežní zdí směrem ke Karlovu mostu.
- Délka uzávěru je 23,5 m, výška 4,9 m a hmotnost 51 tun.
- Slupice pro osazení mobilních hliníkových prvků jsou vysoké 2,8 m, Celková výška s mobilním hrazením činí 7.87 m, což odpovídá úrovni povodně 2002 + 30 cm.
- Liniová ochrana pokračuje od vrat dále podél celého břehu Kampy.
- Shora je Čertovka chráněna tabulovým uzávěrem ve Smíchovské komoře.
- Vrata musí být uzavřena při průtoku 450 m^3/sec a zadrží cca 1000 m^3 vody.
- Kvůli rybám je nutno zajistit i v době uzavření průtok okysličené vody, hasiči dole odčerpávají spolu s vodou, která se nahromadí průsaky.
- Svému účelu slouží uzávěr od roku 2005.

Libeň

Manipulace na uzávěru Čertovky
- příprava manipulace při průtoku ve Vltavě 350 m^3/s (vyčištění pojezdového prahu pod vodní hladinou, instalace hydraulického navijáku pro vysunutí vrat, instalace mobilních čerpadel k přečerpávání průsaků a uzavření šoupěte na Čertovce u Říční ulice.
- Samotná manipulace (uzavření vrat a zahájení čerpání případných průsaků) se nařizuje při průtoku ve Vltavě 400 m^3/s, uzávěr musí být uzavřen do průtoku ve Vltavě 450 m^3/s, to znamená do doby, kdy nastane I. stupeň povodňové aktivity.
- Osazení mobilního hrazení na uzávěr se nařizuje společně s úsekem PPO HMP Karlův most – Čertovka při dosažení průtoku ve Vltavě 1530 m^3/s, což je při vyhlášení III. stupně povodňové aktivity.

ETAPA 0003 Karlín – Libeň
- realizace 2005 - 2006
- Délka 506,9 m
- Výška hrazení od 0,8 m do 3,8 m

V případě lokality Libně bylo důležité ošetřit oblast, kde přitéká do Vltavy potok Rokytka.

Protipovodňová opatření v oblasti soutoku sestávají ze tří hlavních částí:

- vrata uzavírající ústí Rokytky,
- přečerpávací stanice
- vrata uzavírající vjezd do Libeňského přístavu.

Čerpací stanice je osazena 6 čerpadly, každé o kapacitě 3,35 m^3/sec, celková kapacita čerpání je cca 20 m^3/sec. Vzpěrná vrata mají ocelovou konstrukci a jsou vysoká 8,8 m.

Postup zpohotovení uzávěru Libeňských přístavů

- vyčistí se těsnící prahy pod hladinou u obou vrat
- napustí se vakový jez
- uzavřou se vrata, čímž se zabrání přítoku z Vltavy do Libeňských přístavů
- uzavřou se další vrata, čímž se zabrání vzedmutí

hladiny v Rokytce v důsledku zvýšených průtoků Vltavou
- Rokytka začne přetékat do Libeňských přístavů a její vody se čerpací stanicí přečerpají do Vltavy

ETAPA 0004 – Holešovice – Stromovka
Délka 2538,9 m
Výška hrazení od 0,8m do 5,4m
realizace 2005
Ochrana na Q_{2002} + 30 cm

ETAPA 0005 Výtoň – Podolí - Smíchov
Délka 330 m
Výška hrazení od 0,6m do 3,3m
realizace 2005
Ochrana na Q_{2002} + 30 cm

ETAPA 0006 – Malá a Velká Chuchle, Zbraslav, Radotín
Délka 1063,64 m
Výška hrazení od 0,3 m do 6 m
realizace 2010 a 2013
Ochrana na:
Zbraslav Q_{100} + 40 cm
Radotín, Malá a Velká Chuchle
Q_{2002} + 30 cm

ETAPA 0007 - Troja
Délka 267,4 m
Výška hrazení od 0,33m do 6,27m
realizace 2010
Ochrana na Q_{2002} + 30 cm

ETAPA 0008 Modřany - Komořany

Porovnání povodně 2002 a 2013

Povodeň 2002		Povodeň 2013	
Průtok při kulminaci	5160 m3/s	Průtok při kulminaci	3210 m^3/s
Evakuované osoby	50 000	Evakuované osoby	1279
Celkové škody	27 miliard Kč z toho 7 miliard metro	Celkové škody	cca 2 miliardy





Wasseraufbereitungsanlage in Prag-Podolí

Aus der Geschichte der Prager Trinkwasserwirtschaft

Technische Werke, die das notwendige Wasser in die Standorte brachten, wo Wassermangel bestand, gab es in der Prager Agglomeration schon im 12. Jahrhundert. Das Wasser wurde mittels Schwerkraft weitergeleitet, es gab keine Schöpfpumpen. Als Wasserzubringer dienten unüberdachte Gräber oder Leitungsstränge, die aus unterschiedlichem Material gemacht wurden: Holz, Stein, Backstein, Blei. Wasserleitungen für Gebäude, die der Kirche oder dem Adel gehörten, waren privat und anfangs für die Bürger nicht vorgesehen. Das erste Werk, das ausschließlich der Gemeinde gehörte, war die Wasserleitung in der Prager Neustadt, erbaut in der ersten Hälfte des 14. Jahrhunderts.

Zu den ältesten Wasserzubringern in Prag gehört die romanische Wasserleitung im Strahov-Kloster. Das Kloster nutzte die wasserreichen Quellen am Abhang des Petřín-Hügels und die Wasserleitung auf dem Berg Vyšehrad, durch die schon am Anfang des 12. Jahrhunderts das Wasser aus einem Brunnen floß, der in den Sagen als Bad der Fürstin Libuše genannt wird. Nach 1140 ließ der tschechische Fürst Vladislav II. in den frei angelegten Gräbern Holzröhre verlegen und auf dem Berg Vyšehrad einen Wasserbrunnen errichten. In 1361 ließ das Domkapitel auf Vyšehrad die verkommene Holzwasserleitung beseitigen und Röhre aus Glattstein verlegen.

Die Prager Burg, ein anderer wichtiger Standort, war immer mit Wasser aus lokalen Brunnen und Quellen versorgt. Die erste Wasserquelle für die Burg war der Bach Brusnice, der im Benediktiner Kloster entspringt.

In der ersten Hälfte des 14. Jahrhunderts wurden die Bürger in der Hauptstadt zum ersten Mal mit Wasser aus einer öffentlichen Wasserleitung versorgt. Hand in Hand mit Gründung der Neustadt wurde in 1348 Holzwasserleitung für Quellwasser verlegt, um die Brunnen auf dem Vieh- und Pferdemarkt (heutiger Karlsplatz und Wenzelsplatz) mit Wasser versorgen zu können.

Die Renaissance war für die Wasserversorgung eine richtige Blütezeit. Es entstanden die ersten Wasserwerke, die Wasserversorgung blieb stabil, der Vorgang bei der Rohrverlegung und Schöpfung des Wassers aus öffentlichen und privaten Brunnen wurde geregelt. In Prager Stadtteilen an der Moldau entstanden im 15. und 16. Jahrhundert vier Wasserwerke: Wasserwerk Staroměstská für die Altstadt, Wasserwerk Petržílkovská für die Kleinseite und Wasserwerke Šítkovská und Novomlýnská für die Prager Neustadt. In den 50-er Jahren des 19. Jahrhunderts kam noch das Wasserwerk Žofínská dazu. Dieses System der Wasserversorgung war bis auf kleine Ausnahmen fast bis zum Ausgang des 19. Jahrhunderts in Betrieb.

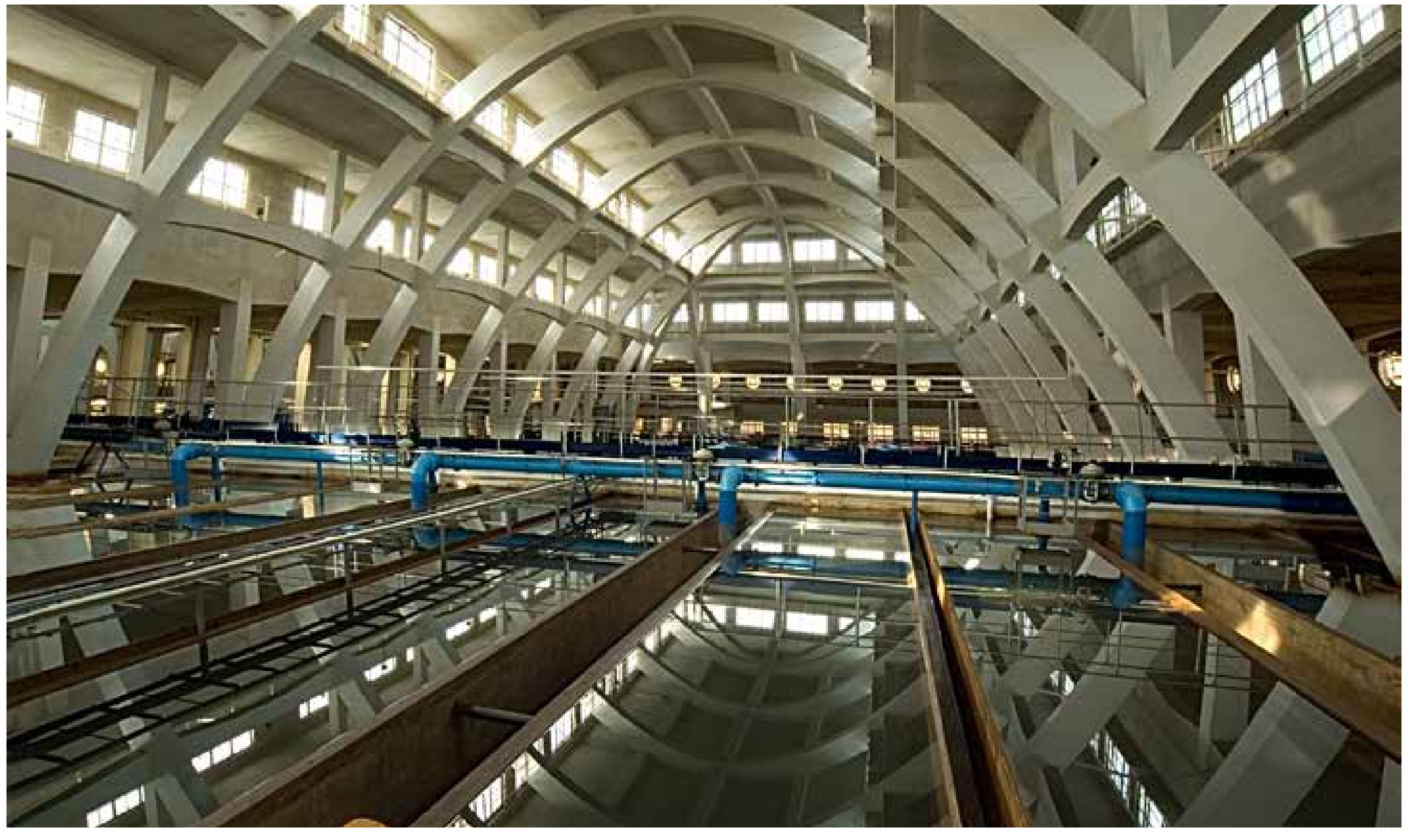
Die Industrierevolution im 19. Jahrhundert zog die Bahnverbindung Prag-Wien und Verdoppelung der Bevölkerungszahl mit sich. Um 1900 hatte Prag 120 000 Einwohner und mit den umliegenden Gemeinden über eine halbe Million. Es wurden neue Betriebe, Miethäuser und Gebäude des öffentlichen Dienstes gebaut. Die bisherige Versorgung mit Wasser aus der Moldau, aus Bächern und Brunnen konnte nicht ausreichen. Insbesondere im Sommer mit langen Trockenzeiten bestand hohe Brandgefahr, viele Haushälte hatten keinen Zugang zum Wasser und auch die Betriebe meldeten Wasserprobleme. Die Prager Stadtvertreter mußten sich mit der unerträglichen Lage auseinandersetzen, es wurde eine Kommission gebildet. Ihre Untersuchung zeigte, daß die fünf Prager Wasserwerke in der Altstadt, der Kleinseite und der Neustadt cca 500 Wasserentnahmestellen mit cca 10 000 m^3 Rohwasser aus der Moldau versorgen. Das war für die Versorgung der Bevölkerung in der Innenstadt ungenügend. Letzlich wurde die Entscheidung getroffen, daß ein neues Wasserwerk zu bauen ist, mit ausreichender Kapazität und entsprechender technischer Ausrüstung.

In 1885 entstand auf dem rechten Modlau-Ufer unter dem Felsenmassiv Branická skála das Prager Wasserwerk. Es wurde mit Dampf betrieben und behandelte Grundwasser, das mit Flußwasser vermischt war. Das Flußwasser wurde in drei Filtrationsbrunnen gefiltert, die sich auf der Schwarzenberg-Insel, heute Ruderinsel, befanden. Mit dieser Wasserbehandlung konnte man die Wasserversorgung für die Innenstadt auf cca 30 000 m^3 Wasser pro Tag erhöhen. Die Prager Haushälte waren nun ausreichend mit Wasser versorgt und konnten mit Badezimmern und Toiletten ausgestattet sein. Durch die Wasserleitung aus dem Prager Wasserwerk floß jedoch kein Trinkwasser. Für das Trinkwasser war das Wasserwerk in Karaný vorgesehen, zu der Zeit jedoch noch im Bau. Der Probelauf startete in 1912, aber erst in 1914 konnte die Stadt definitiv mit Trinkwasser versorgt werden. Prag verfügte endlich über eine hochwertige Trinkwasserquelle, was die Bürger insbesondere im Ersten Weltkrieg schätzen konnten. Für diese Zeit sind Epidemiekrankheiten, allgemeiner Mangel, schlechte Ernährung und aus der Kriegsfront eingeschleppte Infektionskrankheiten typisch. Es war das Wasser aus Karaný, dem der relativ gute Gesundheitszustand der Prager Bevölkerung zugeschrieben werden kann.

Das Wasserwerk in Podolí

Das Prager Wasserwerk in Podolí verlor mit der Zeit an Bedeutung. Es wurde stilgelegt und in 1922 abgerissen. Zu dieser Zeit wurden die benachbarten Gemeinden angeschlossen, der Wasserverbrauch und die Ansprüche an die Wasserqualität stiegen in dem neu entstandenen Groß-Prag enorm. Das Trinkwasser aus Káraný reichte für die große Menschenzahl nicht mehr aus und die Instandhaltung der Wasserleitung war teuer. Es galt eine neue Trinkwasserquelle zu erschließen. Die Stadtverwaltung wendete sich wieder zu der alten Wasserquelle und wollte das Wasser aus der Moldau nutzen. In 1922 – 1929 wurde auf dem rechten Moldau-Ufer im Stadtviertel Podolí ein neues Wasserwerk mit Filtrationsstufe gebaut. Der Planer dieses architektonisch-städtebaulichen Vorhabens war Ingenieur Antonín Engel, der den Wettbewerb gewann. In seinem Projekt macht sich der Geist des Monumentalklassizismus bemerkbar.

Antonín Engel faßte den Komplex des Wasserwerkes großartig auf. Es war ein monumentales Industriegebäude, das wie eine Behörde aussah und mit Lichteffekten ausgestattet wurde, die wir eher in den Kirchen sehen können. Neben den zwei großen, gegenüber stehenden Gebäuden wurden symetrisch zwei kleinere Gebäude erbaut: das Maschinenhaus und das Bürogebäude. In der



ersten Bauetappe wurde nur die Hälfte des Projektes realisiert. Es wurden nur die Filtrationstation, das Maschinenhaus und das Bürohaus gebaut. Mit dem Bau wurde die Firma Karel Kress beauftragt, die mit Wasserbauten und Stahlbetonbrücken Erfahrung hatte. Die Koordinierung der Bauarbeiten übernahm das Projektierungsbüro des Amtes für Wasserwirtschaft in Prag. Das Wasserwerk war in 1929 das größte Bauwerk aus Stahlbeton bei uns. Die Spannweite der parabolischen Bögen in der 16 m hohen Haupthalle betrug 24 m und damit war sie in der Tat absolut einmalig. Die Haupthalle mit ihren Maβen 60 x 24 m wirkt trotz allem subtil und im gewissen Sinne zart. Beim Anblick nach oben erinnern die Säulenbögen an Walfischgerippe. Auch das Problem der Beleuchtung wurde von Antonín Engel exzellent gemeistert. In den Wänden sind groβflächige Fenster eingebaut und in der Decke rechteckige Glasscheiben. Die Decke ist in Kaskaden abgestuft und das Dachgefälle geht in Richtung Moldau. Das einfach gestaltete rechteckige Gebäude mit hohen Fenstern und raffinierter Verzierung paβte sich dem neu entstehenden Villenviertel sehr gut an. Darüber hinaus wurde das Wasserwerk zu einer natürlichen Dominante des Moldau-Ufers in Podolí.

Technologie der Wasserreinigung

Das Grundwasser aus der Schwarzenberg-Insel wurde durch einen Kanal unter der Moldau in den Sammelbrunnen auf dem Moldau-Ufer in Podolí geführt. Aus dem Brunnen wurde eine neue Wasserleitung vom 600 mm Durchmesser hinausgeführt, die zu drei neuen Sammelbrunnen gezogen wurde. Aus diesen Sammelbrunnen wurde durch eine selbstständige Wasserleitung das Wasser in die Filtrationsstation gepumpt. Das Fluβwasser wurde über die Auflaufstelle des alten Wasserwerkes geschöpft und durch die Leitung unter dem Moldaukanal in die schon erwähnten neuen Sammelbrunnen geführt.

Weil die chemische Zusammensetzung des Grundwassers ungünstig war, muβte zusätzlich das Fluβwasser geschöpft werden, das anschlieβend in der Puech-Chabal--Anlage gefiltert wurde. Wegen Raummangel wurden die Filtrationsstufen übereinander aufgestellt. Grobfilter und Vorfilter befanden sich in dem höchsten Stockwerk, die Feinfilter in dem tieferen Stockwerk. Die Behälter für Reinwasser waren im Keller untergebracht. Es wurden drei Stufen mit Grobfiltern projektiert und gebaut. Dank dieser Technologie konnten täglich 35 000 m³ Trinkwasser bereitgestellt werden.

Mit der Frage der nicht ausreichenden Kapazität setzte sich die Stadtverwaltung sofort nach der feierlichen Eröffnung des Wasserwerkes auseinander. Die Lösung war, daβ unter Betriebsbedingungen die technischen Teile ständig gewechselt wurden, bis in 1946 das Wasserwerk sein Mögliches erreichte. Aber auch das war wenig. In der Folge wurde entschieden, daβ das ganze Wasserwerk einer umfangreicher Rekonstruktion unterzogen werden muβ. Die Wasserproduktion konnte man aber nicht unterbrechen. Und so muβte ein neues Wasserwerk auf dem Standort gebaut werden, der ursprünglich für die schon projektierte Filtrationshalle Süden

vorgesehen war. Der Projektentwurf kam wiederum von Antonín Engel, der zu der Zeit schon Rentner war. Der Bau zog sich 11 Jahre, manchmal war es mit dem Wassermangel sehr kritisch. In 1965, sieben Jahre nach dem Tod von Antonín Engel, war der Komplex des Wasserwerkes aus der architektonischen Sicht fertig. Die südliche Vorderseite des neuen Gebäudes ist mit elf Plastiken verziert, die die Moldau und ihre Zuflüsse darstellen sollen.

In 1961, obwohl noch nicht fertiggebaut, wurde das Trinkwasser schwerpunktmäβig in diesem neuen Wasserwerk produziert. Fünf Jahre später, nach der Fertigstellung, konnten zwei Drittel der Stadt mit Wasser versorgt werden. Die Spitzenleistung des Wasserwerkes in Podolí wurde in 1972 erreicht, als fast 69 Millionen m³ bereitgestellt wurden. In diesem Jahr wurde auch das Wasserwerk am Fluβ Želivka gebaut, das heute der wichtigste Hersteller des Trinkwassers für Prag und Umgebung ist. Die Wasserproduktion im Wasserwerk Podolí wurde langsam gedämpft, man sprach sogar von der Stillegung. In 1992 wurde endlich mit einer umfangreichen Rekonstruktion begonnen. Sie erfolgte unter laufendem Betrieb und wurde in 2000 komplett abgeschlossen. Mit der Rekonstruktion verfolgte man nicht das Ziel, die Produktionsleistung zu erhöhen, sondern die Qualität des behandelten Wassers zu verbessern und negative Auswirkung auf die Umwelt in dem Werkumkreis zu mildern. Das Wasserwerk war nur zwei Jahre im Betrieb. Nach dem Hochwasser in 2002 wurde das Werk stilgelegt und heute dient es bei der Trinkwasserbereitung als Reserve. Die Maschinen laufen nur viermal im Jahr, um die Funktionsfähigkeit des Wasserwerkes zu überprüfen.

Wasserproduktion

In 1929 produzierte das Wasserwerk 4 463 385 m³ Wasser. Seitdem stieg das produzierte Wasservolumen andauernd bis 1972. In diesem Jahr wurde das historische Maximum von 68 911 372 m³ erreicht. Nach der Inbetriebnahme der Wasserbehandlungsanlage am Fluβ Želivka sank die Wasserproduktion in dem Wasserwerk bedeutend. Das Interesse für Wasser stieg wiederum im letzten Jahrhundert, in der zweiten Hälfte der 70-er, als neue Prager Wohngebiete entstanden sind. In 1982 konnte das Wasserwerk für das Trinkwassernetz 64 295 000 m³ bereitgestellen. Seitdem sank kontinuierlich die Wasserproduktion bis auf das Volumen von 10 357 000 m³ in dem Hochwasserjahr 2002.

Museum der Prager Trinkwasserwirtschaft

Der Innenraum der Filtrationstation ist von den Ausstellungsräumen durch eine Glaswand getrennt, so daβ die Besucher einen unglaublich schönen Einblick in die Engel´s Kathedrale mit Wasserfiltern genieβen können. Die Ausstellung verfolgt chronologisch die historische Entwicklung der Prager Trinkwasserwirtschaft – von den ersten privaten Wasserleitungen im 12. Jahrhundert über die Wasserwerke an der Moldau in der Renaissance und die Wasserwerkplanung am Ausgang des 19. Jahrhunderts, bis zu der heutigen Wasserversorgung in der Hauptstadt Prag. Es ist hier ein Pumpwerk aus dem Wasserwerk in Klatovy aus dem Jahre 1830 zu sehen, eine Wasserleitung aus der Antike, ein Teil der Burgwasserleitung aus der Zeit von Rudolf II. und andere Gegenstände. Auβer den dreidimensionalen Exponaten gibt es hier auch Kopien von einmaligen und noch nicht ausgestellten Archivalien und viele historische Bilder. Vom hohen Wert sind Sammlungen von unterschiedlichen Typen der Wasserleitung, Abschluβelementen und anderen Geräte und Werkzeugen. Eine einmalige Sammlung von Wasserzählern wird als selbständige Ausstellung präsentiert.

Zentrale Kläranlage in Prag

Anfänge des Prager Kanalisationsnetzes

Das mittelalterliche Prag, ähnlich wie andere mitteleuropäische Städte, war von festen und flüssigen Abfällen verunreinigt. Das Abwasser von Ställen, Senkgruben und sonstigen Fanggruben drang in die Gassen hinein. Mist und Abfälle häuften sich überall an. Für die Gassenreinigung sorgte eher ein heftiges Regen als eine systematische Gassenpflege der Stadtverwaltung.

Das erste technische Bauwerk, das je einen Prager Wohnkomplex vom ungewünschten Schmutzwasser schützte, war ein Abflussgraben, der für Wasserabführung aus dem Premonstratenserkloster in Strahov sorgte. Beim Klosterbau in der ersten Hälfte des 12. Jahrhunderts wurde Trinkwasser aus den Stollen unter dem Petřín-Berg hergeführt. Gleichzeitig wurde ein Entwässerungskanal gebaut, der die Klosteranlage vom Abwasser befreien sollte. Es handelte sich in der damaligen Zeit um ein einmaliges Bauvorhaben, das unter den Städten, die in Tieflage angelegt wurden, jahrelang keinen Nachfolger hatte.

In 1310 wurde ein Abflußgraben gebaut, der aus dem Probsteihaus in der heutigen Neruda-Gasse das Abwasser abführen sollte. Es ist allerdings nicht bekannt, wohin das Abwasser weitergeführt wurde. Auch der große Steinkanal, den in 1673 der Jesuitenorden erbaute, war zu der Zeit eher eine wasserbauliche Ausnahme: das Abwasser, das mit Reinwasser verdünnt war, führte der Steinkanal aus dem Jesuitenkloster (Klementinum) in die Moldau ab.

Eine Modernisierungsmaßnahme von grundsätzlicher Bedeutung war der Bau eines unterirdisch angelegten Kanalnetzes, das in 1787 nach dem Projekt von Leonard Herget in Gang gesetzt wurde. Anfangs kamen die Arbeiten ins Stocken, weil sich die Hausbesitzer an der Finanzierung der Kanalabschnitte, die an ihren Liegenschaften entlangführten, kostenmässig beteiligen mußten. Es war erst der Höchste Burggraf, Karl Graf von Chotek, der sich energisch für die Vollendung der ersten öffentlichen Prager Kanalisation einsetzte. In dem Zeitraum 1816-1828 wurden 44 Kilometer von Abwasserkanälen gebaut. Die Kanalisation mündete auf 35 Auslaßstellen in die Moldau. Die Abwasserkanäle wiesen aus der technischen und hygienischen Sicht mehrere Mängel aus: sie hatten flachen Grundboden, wurden mit üblichen Ziegeln ausgelegt, für Mörtel wurde Erdmasse eingesetzt, der Durchmesser und das Gefälle waren nicht ausreichend dimensioniert. Die Kanalreinigung erfolgte in der Nacht, die aufgesammelten Schmutzstoffe wurden wegtransportiert.

Bau des Prager Kanalisationsnetzes und Abwasserentsorgung in Prag

In der 2. Hälfte des 19. Jahrhunderts änderte sich das Prager Antlitz. Prag wurde zu einer modernen Großstadt. Aus diesem Wechsel ergab sich die Notwendigkeit, auch die Verhältnisse in der Stadt hinsichtlich Städtebau, Erschließung und Gesundheitsschutz zu ändern. Die industrielle Entwicklung führte nicht nur zum Bevölkerungswachstum, sondern auch zur Umweltbelastung. Maschinenbau, chemische Industrie und Herstellung von Baustoffen trugen dazu bei, daß die Lebensqulität im Prager Tal andauernd gefährdet wurde. Der Bauzustand der Prager Kanalisation war durch häufiges Hochwasser beeinträchtigt.

Ein zielbewußter Ansatz für die Abwasserentsorgung in der Hauptstadt Prag kam in 1865. In diesem Jahr wurde das Wirtschaftsamt errichtet und mit Verwaltung der Prager Kanalisation beauftragt. In 1883 entstand ein selbständiges Kanalisationsamt. Nach zwei mißlungenen Versuchen, für die Prager Kanalisation ein Projekt auszuschreiben, wurde um Erarbeitung eines Projektentwurfes der Baurat in Frankfurt am Main gebeten. Es war der Engländer William Heerlein Lindley. Im Juni 1893 stellte er sein Projekt der Stadtverwaltung vor.

Die Kanalisation sollte in der Nähe der Kaiserinsel (Císařský ostrov) im Prager Stadtviertel Bubeneč in die Moldau eingeleitet werden. Bestandteil des Projektes war auch Kläranlage für mechanische Wasserreinigung, mit einem Volumen von 160 000 m³ Abwasser pro Tag. Der Bau eines modernen Kanalisationsnetzes begann Anfang 1898. Das Projekt der Kläranlage wurde 1890 fertiggeschrieben, im September 1901 startete der Bau und am 27. Juni 1906 wurde Probebetrieb angesagt. Der Probelauf war erfolgreich, innerhalb von einem halben Jahr liefen alle Werke im Standardbetrieb. Die Kläranlage von Lindley diente mehr als 60 Jahre, heute ist sie ein einmaliges technisches Denkmal, welches zu seiner Zeit ein Spitzenwerk der hygienisch-technischen Bauplanung darstellte.

Das Entstehen der Agglomeration Groß-Prag in 1920 zog das Anschließen der Randgebiete mit sich, was logischerweise ein ernsthafter Eingriff in das Konzept von Lindley war. Der Anstieg der Abwassermenge aus den eingemeindeten Gebieten führte dazu, daß die Kapazität der Kläranlage in Prag-Bubeneč nicht mehr ausreichend war. Der Generalplan für das Kanalisationsnetz, der in 1925 unterbreitet wurde, rechnete alternativ mit zwei neuen Kläranlagen: an der Mündung des Baches Botič in die Moldau und in der Gemeinde Řež. Man entschied sich für die andere Alternative, sie wurde allerdings nie realisiert.

In 1927 hatte sich die erste Modernisierung der Kläranlage in Prag-Bubeneč vollzogen. Es wurde ein neues Rechenwerk gebaut, ein dreiteiliger Sandfänger und vier zusätzliche Absetzbecken. Der Schlamm wurde mit Spezialschiffen zu nachfolgender Behandlung abtransportiert.

Die internationale Lage in den 30-er, der zweite Weltkrieg und die Wirtschaftsbedingungen unmittelbar nach dem Kriegsende verursachten, daß in den Folgejahren eine grundsätzliche Lösung der Abwasserproblematik in Prag nicht in Sicht war - trotz der Tatsache, daß der Anfall vom Abwasser kontinuierlich stieg. Die Kläranlage von Lindley wurde in 1947 noch einmal modernisiert, volumenmäßig konnte sie aber mit der Stadtentwicklung nicht den Schritt halten. Auch nach weiterer Modernisierung war es nicht möglich, die Gesamtmenge des anfallenden Abwassers zu reinigen. Die Folge war, daß das Abwasser teilweise ungereinigt in die Moldau eingeleitet werden mußte.

Die Lage verschlechterte sich noch durch den Wohnungsbau in 1950 und durch einen dramatischen Anstieg der Zahl der Bürger, die sich neu auf die Kanalisation angeschlossen hatten. In 1954 wurde die Entscheidung getroffen, daß auf der Kaiserinsel (Císařský ostrov) eine neue Kläranlage für die Hauptstadt Prag (ÚČOV) zu bauen ist. In 1959 begann man mit dem Bau der technischen Gebäude und im Juli 1966 wurde eine neue Kläranlage auf mechanisch-biologischer Basis in Betrieb gesetzt. Die Kläranlage von Lindley wurde dagegen nach sechzig Jahren aus dem Betrieb gesetzt. Der steigende Bedarf an Wasserreinigung führt zu einer weiteren Modernisierung der Anlage, in 1974-1975 wird der Reinigungsprozeß intensiviert. Es entsteht gleichzeitig ein Projekt für eine neue Kläranlage in der Gemeinde Hostín bei Mělník. Das Projekt wurde nie realisiert.

Am Ausgang des vorigen Jahrhunderts wurde eine effiziente Abwasserreinigung zu den wichtigsten Umweltschutzthemen in ganz Europa. Die Prager Agglomeration war zu der Zeit (und bleibt) ein großer Produzent vom Abwasser und es war notwendig, sich mit der mangelhaften Wirksamkeit der Kläranlage auseinanderzusetzen. In 1994-1995 wurden für den Reinigungsprozeß Intensivierungsmaßnahmen vorgenommen, mit denen der Wirkungsgrad des Reinigungsverfahrens in Vereinbarkeit mit der damals gültigen Gesetzgebung erhöht werden sollte. Wie es schon so oft in der Geschichte der Prager Kläranlagen war, die zweite Modernisierungsstufe, die auf die Schlammbehandlung ausgerichtet war, konnte aufgrund des Geldmangels nicht durchgeführt werden. Es ist jedoch gelungen, diesen Bereich durch Teilmaßnahmen intensiver zu betreiben.

Nach 1990 wurden mehrere Varianten für den Standort einer neuen Prager Kläranlage diskutiert: auf der Kaiserinsel oder außerhalb der Insel. Die politische Entwicklung zeigte jedoch deutlich, daß infolge der neuen Gesetzgebung und der Verpflichtungen, die die Tschechische Republik nach dem Beitritt zu der EU angenommen hatte, eine gesetzesgerechte Abwasserreinigung nur dann garantiert werden kann, wenn eine neue Kläranlage gebaut wird. Als einziger realistischer Standort für die Kläranlage zeigte sich die Kaiserinsel. Nach dem neuen, in 2004 beschlossenen Konzept, wird hier die Neue Kläranlage angelegt. Der Bau soll in mehreren Baustufen erfolgen.

Die alte Kläranlage im Stadtviertel Bubeneč

Die alte Kläranlage in ist ein industrielles Werk, das in seiner Kategorie zum architektonischen Stolz wurde. Es war ein Traum, der in Erfüllung ging: ein Wasserwerk als Bestandteil einer modernen Kanalisation, mit der die Hauptstadt des Böhmischen Königsreichs zu den führenden Großstädten der damaligen Welt gezählt werden konnte.

Die Bauarbeiten an der Kläranlage liefen in den Jahren 1901–1905. Ganz zum Schluβ der Bauarbeiten kam es jedoch zu einem grundsätzlichen Meinungswechsel. Die Planer verzichteten auf das strenge „Frankfurter" Konzept, es sollte mehr das Gebäudeaussehen unterstrichen werden. Eine moderne, schöne und technisch durchdachte Kläranlage ist das Ergebnis.

Sir William Heerlein Lindley, von der Abstammung her ein Engländer, war vorwiegend in Deutschland tätig. Er brachte seine Erfahrungen aus dem Bau der Kläranlage in Frankfurt / Main mit sich nach Prag. Der von ihm unterbreitete Planentwurf war bei derartigen Bauwerken ein technischer Höhepunkt. Die ganze „stinkende" Technik befand sich unter der Erde. So war die Lebensqualität in den benachbarten Gebieten keineswegs beeinträchtigt und weitere Grundstücke muβten nicht belastet werden. Lindley wählte sorgfältig auch den geeigneten Baustoff aus: die „klingelnden" Ziegel aus dem Ziegelwerk im Stadtviertel Uhřiněves sind bis heute in dem Zustand wie in 1906, als die Kläranlage fertiggebaut wurde.

In 1996 wurde die Kläranlage von Lindley stilgelegt und in 2010 zum Nationalen Kulturdenkmal erklärt.

Zentrale Kläranlage (ÚČOV)

Die Zentrale Kläranlage wurde in 1966 in Betrieb gesetzt. Zu ihrer Zeit gehörte sie zu den gröβten in Europa, bald konnte sie aber den steigenden Anforderungen auf die Qualität des gereinigten Wassers nicht Rechnung tragen. So wurden zuerst in den 80-er und später noch in den 90-er des vorigen Jahrhunderts wesentliche Modernisierungsmaβnahmen durchgeführt und neue Anlagen wurden dazugebaut. Es wurde vor allem das Aufnahmevermögen der biologischen Reinigungsstufe erhöht und der Nitrifikationsprozeβ eingeführt. Im Schlammbehandlungsbereich wurden Trennschleuder für maschinelle Schlammentwässerung eingeführt und für die Wärme- und Stromproduktion aus dem Biogas wurden neue Produktionseinheiten der Strom-Wärme-Kopplung eingebaut. Ein umfassendes automatisches System für Monitoring und Steuerung der Reinigungsprozesse, der Schlammbehandlung und Energieproduktion wurde allmählich ein- und ausgebaut. Veraltete oder überholte Technik der Zentralen Kläranlage, die den notwendigen Standards der Abwasserreinigung nicht mehr entsprechen, werden gegenwärtig ausgewechselt oder modernisiert.

Neue Kläranlage

Der komplexe Um- und Ausbau der Prager Zentralen Kläranlage soll in mehreren Modernisierungsstufen erfolgen: Bau einer neuen Wasserlinie (Etappe 0001), Rekonstruktion der bestehenden Wasserlinie (0002), Rekonstruktion des Schlammbehandlungsbereiches (0003), Bau von zwei Anlaufstellen (Labyrinth) auf dem linken und rechten Moldau-Ufer (0004 und 0005), Bau einer neuen Pumpenhauptstation und neuer Abwasserzubringer (0007 – diese Technik ist für beide Wasserlinien vorgesehen). Die letzten zwei Baustufen sind Kompensationsmaβnahmen (Brandschutz, Etappe 0008) und Bau neuer Rückhaltebecken auf dem rechten Moldau-Ufer (0004 und 0005).

Gegenwärtig sind folgende Etappen in Gang: 0001 – neue Wasserlinie, 0007 – Abwasserzubringer und 0008 – Kompensationsmaβnahmen.

Vorteile der Modernisierung

Die heutige Zentrale Kläranlage für Prag (ÚČOV) kann den Anforderungen der nationalen und europäischen Gesetzgebung an die Qualität des gereinigten Abwassers an der Einleitungsstelle nicht langfristig gerecht werden, insbesondere was die Stickstoff- und Phosphorwerte angeht.

Die Hauptaufgabe der Neuen Wasserlinie ist es, das Volumen der Zentralen Kläranlage auf 1 427 560 EGW auszubauen. Die Neue Wasserlinie soll ermöglichen, das Abwasser aus dem einheitlichen Prager Kanalisationsnetz in der Qualität zu reinigen, die in den Rechtsvorschriften für das Auslassen des vorgereinigten Abwasser festgelegt ist.

Für die Modernisierung sind zwei Schritte vorgesehen. Der erste ist, eine neue Wasserlinie zu bauen. Schon die Maβnahme selbst soll für die bessere Qualität des gereinigten Abwassers, das in die Moldau eingeleitet wird, einen wesentlichen Beitrag leisten. Im zweiten Schritt soll die heutige Wasserlinie modernisiert werden. Damit soll erreicht werden, dass auch bei der Höchstbelastung der Kläranlage die festgeschriebenen Stickstoff- und Phosphorwerte eingehalten werden können.

Die Neue Wasserlinie ist als völlig eingekapselt geplant, mit chemischer und biologischer Nachbehandlung der Prozeβluft, die in die Umwelt ausgelassen wird. Ein modernes architektonisches und städtebauliches Konzept einzelner technischer Stufen und der komplexen Kläranlage soll zur Verbesserung der Lebensqualität in dem Prager Troja-Kessel beitragen.

Technische Lösung

Das durch das Kanalisationsnetz kommende Abwasser wird zu der alten und neuen Kläranlage separat geführt. Die Neue Wasserlinie ist als Aktivierungskaskade mit Belebungsbecken für den Rücklaufschlamm entworfen. Mechanische Abwasserreinigung erfolgt in Absetzbecken mit Lamellen, in denen teilweise auch Regenwasser gereinigt wird. Die Aktivierungskaskade ist in vier selbstständige Straβen mit länglich angebrachten Nachklärbecken geteilt. Das Abwasser aus den Nachklärbecken wird zu der dritten Reinigungsstufe geführt, wo in den Absetzbecken der Phosphor chemisch entfert wird. Der primäre, überschüssige und aktivierte Schlamm wird gemeinsam mit dem Schlamm aus der dritten Reinigungsstufe in den Bereich der Schlammbehandlung gepumpt. Diese Stufe ist für beide Wasserlinien vorgesehen.

Das Abwasservolumen, das der Neuen Wasserlinie und der Zentralen Kläranlage zugeführt wird, ist steuerbar. Die Anteile des Durchfluβvolumens sind generell 50:50, in der Praxis soll es aber möglich sein, bis zur Ausschöpfung des Stoff- oder Wasservolumens der mehr belasteten Wasserlinie die Abwasseranteile anzupassen. Ein gewisser Abwassermindestdurchfluβ für die die Neue Wasserlinie sowie für die Zentrale Kläranlage muβ jedoch erhalten bleiben.

Bestandteil der Neuen Wasserlinie ist auch mechanisch-chemische Reinigung des Regenwassers, mit dem Volumen von 3 m^3/s. Das Höchstvolumen der biologischen Stufe beträgt 6 m^3/s für maximal eine Stunde am Tag. Dieses Volumen soll beim Stillstand der Kläranlage während der Rekonstruktion genutzt werden.

Hochwasserschutz

Ein selbstständiges Thema beim Bau der Neuen Wasserlinie war der Hochwasserschutz während der Bauarbeiten und nach der Baufertigung. Auch die Kenntnisse über die Auswirkung der neuen Anlage bei der Überschwemmung und Auswirkung auf die Durchfluβmengen waren von Bedeutung.

Der Schutz der Baugrube während der Bauarbeiten an der Neuen Wasserlinie ist durch folgende Maβnahmen gesichert: im ganzen Bauumkreis wird eine unterirdische Wand angelegt, die mit einem Erddamm bis zu der Höhe von 184,00 m ü. HN (Q_{20}) zugeschüttet wird. Auf der äuβeren Dammoberkannte wird gefestigte Straβe angelegt, die für die Schwertechnik vorgesehen ist. Die Kreisdammhöhe ist für eine eventuelle Überschwemmung der Baugrube beim Durchfluβ von mehr als Q_{20} auf vier Stellen bis zu der Höhe von 183 m ü. HN herabgesetzt.

Zu begleitenden Hochwasserschutzmaβnahmen beim Bau der Neuen Wasserlinie gehören auch Änderung der Betriebsanweisung für das Wasserwerk Troja-Podbaba, in der die Möglichkeit der Hochwasserumleitung über die Schleusen in Podbaba neu berücksichtigt wird und Auswirkung des Baus der Neuen Wasserlinie auf den Wasserstand in der Nähe der Kaiserinsel minimalisiert wird.

Die Neue Wasserlinie wird beim Hochwasser aus dem Betrieb gesetzt, wenn auf dem Oberlauf der Moldau das Wasserpegel Q_{20} erreicht wird. Bei ausgewählten Werkobjekten werden gleichzeitig Wassereinleitungsstellen und wasserdichte Türen geschlossen, damit die „trockenen" Räume nicht überschwemmt werden. Mobile Hochwassersperren werden eingesetzt.

Eine weitere Maβnahme betrifft die Becken in der Wasserlinie. Sie müssen beim Hochwasser bis zu dem Betriebspegel gefüllt sein, um der Auftriebskraft des Hochwassers bei Q_{2002} standzuhalten.

Technische Daten der Neuen Wasserlinie

Mechanisch-biologische Linie für Abwasserreinigung durch chemischen Fällungsprozeβ.

Erhöhung des Abwasservolumens um 183 560 EGW auf das Gesamtvolumen von 1 611 000 EGW (8,2 m^3/s von mechanisch-biologisch gereinigtem Abwasser).

Eine zusätzliche mechanisch-chemische Abwasserreinigung von max. 3 m^3/s beim Regenwetter.

Man geht davon aus, daβ nach Fertigstellung der Kläranlage folgende Werte erreicht werden können: BSK5 35 000 Tonnen / Jahr, CHSK 91 000 Tonnen / Jahr, Feststoffe 66 000 Tonnen / Jahr, Gesamtstickstoff 7 000 Tonnen / Jahr, Gesamtphosphor 1 000 Tonnen / Jahr.

Wasserkraftwerk und Schiffsschleusen Štvanice in Prag

Der älteste, aus heutiger Sicht sehr einfache Projektentwurf für eine Stauregelung der Moldau nahe der Insel Štvanice stammt aus dem Jahr 1778 vom Baudirektor Herger, der eine Erweiterung des Rudolf-Stollens zu einem Kanaltunnel vorsah. Vom k. k. Ministerium des Innern wurde 1895 entschieden, dass die Moldau und die Elbe von Prag bis Ústí nad Labem staugeregelt werden. Die Arbeiten zur Schiffbarmachung des Unterlaufs der Moldau oblagen ab 1896 der Kommission für die Stauregelung der Moldau und der Elbe in Böhmen. Im Rahmen dieser Arbeiten wurde von 1907 bis 1913 nahe der Insel Štvanice eine wasserwirtschaftliche Anlage errichtet. Gebaut wurden Ufermauern, in beiden Flussarmen neue Wehre, eine Floßgasse, Schleusen und ein Kraftwerk auf dem westlichen Zipfel der Insel Štvanice. Die Bauleistungen erbrachten die Firma Miller & Kapsa und die Firma Lanna. Dieses Ensemble wasserwirtschaftlicher Bauwerke bildet bis heute eine Staustufe.

Am linken Ufer der Moldau befindet sich das Wehr Helmovský jez mit seinem charakteristischen Grundriss in Form des Buchstabens S.

Das Wehr Helmovský jez

Das neue Wehr Helmovský jez wurde unterhalb des ursprünglichen Wehres aus dem Jahr 1398 errichtet. Es handelt sich um ein festes mit Quadern verkleidetes Betonwehr mit trapezförmigem Querschnitt. Die Überlaufkante befindet sich auf einer Höhe von 184,50 m ü. NN. Der Grundriss ist wie ein S gekrümmt. Die Gesamtlänge des Wehres beträgt 164,45 m und die Fallhöhe 4,40 m.

Unterhalb des Wehres befindet sich ein rechteckiges Tosbecken aus Granitquadern. Beim Hochwasser im Jahr 1940 brach der rechte Teil des Wehres. Nahe der linken Ufermauer befindet sich eine 12 m breite Floßgasse, die sich im unteren Teil auf 17,33 m verbreitert. Ihre Länge ab dem Anfang der Trennmauer beträgt 289,70 m. Die Seitenwände der Floßgasse sind aus Zyklopenmauerwerk. Sie verfügt über einen Klappenverschluss. Am Ufer ist der bis heute genutzte Drehsteg erhalten, der von der Firma Bratři Prášilové a spol. hergestellt wurde. Das Wehr und die Floßgasse wurden von 1907 bis 1910 von der Firma Müller & Kapsa gebaut, wobei das Wehr selbst innerhalb von insgesamt sieben Monaten errichtet wurde. Während der Bauarbeiten wurden die Baugruben siebenmal vom Hochwasser geflutet. An der rechten Seite des Wehres auf der Spitze der Insel Štvanice befindet sich das kleine Wasserkraftwerk.

Wasserkraftwerk auf der Insel Štvanice

Der Bau des Kraftwerks begann 1908 und verlief in zwei Etappen. In der ersten Etappe wurde der Unterbau ausgeführt, 1913 und 1914 wurden das Wasserkraftwerk technisch ausgestattet und das eigentliche Gebäude errichtet. Dieses wurde nach einem Projektentwurf von Herrn Ing. Arch. Alois Dlabač gebaut. Das gesamte Bauwerk führte die Firma Müller & Kapsa aus. Die drei dreistufigen Francis-Turbinen, jeweils mit einem Schluckvermögen von 3 × 16 m^3/s und einer Leistung von 474 kW, lieferte die Firma Kolben & Daněk. Im Durchschnitt wurden pro Jahr 5,8 Mio. kWh erzeugt. Interessant ist auch, dass die Kommission für Stauregelungen die Fundamente des Kraftwerks ohne Genehmigung baute, da sich die Entscheidungsbehörden gegen jede andere Nutzungsform der Wasserkraft an staugeregelten Flüssen als die Schifffahrt wehrten.

Das Kraftwerk leistete seinen Dienst ohne größere Probleme bis Dezember 1972. Auf der Grundlage des 1981 aufgelegten Programms zur Rekonstruktion und Erneuerung von kleinen Wasserkraftwerken wurde 1984 mit der Rekonstruktion des Kraftwerks begonnen. Auftragnehmer der Bauleistungen war die Firma Metrostav und die Technik lieferte die Firma ČKD Blansko. In Betrieb genommen wurde das Kraftwerk 1988. Um die Stromerzeugung kümmern sich drei horizontale Kaplan-Turbinen, jede mit einem Durchfluss von 55 m^3/s. Das Laufrad mit einem Durchmesser von 3,5 m hat vier Schaufeln und 107,1 Umdrehungen pro Minute. Die Generatoren hat die Firma Škoda Plzeň geliefert, der Rotor mit einem Durchmesser von 4,2 m hat 56 Pole, eine Leistung von 1,89 MW, die Spannung beträgt 6,3 kV. Die Leistung des Kraftwerks deckte 1988 nahezu den Verbrauch für die Prager Straßenbeleuchtung. Zurzeit werden im Durchschnitt 18 Mio. kWh pro Jahr erzeugt.

Ab dem 01.08.2002 ging das Kraftwerk in den Besitz des staatlichen Wasserwirtschaftsbetriebs für die Moldau (Povodí Vltavy, státní podnik) über. Am 14.08.2002 wurde das Kraftwerk beim Hochwasser komplett geflutet, anschließend wurden seine Anlagen instandgesetzt und modernisiert. Seit 2002 ist das ästhetisch ansprechende von weitem sichtbare Jugendstilgebäude des Kraftwerks in der Mitte des Flusses im unter Denkmalschutz stehenden Teil Prags ein Kulturdenkmal.

Rekonstruktion des Kraftwerks

Zurzeit wird das Kraftwerk umfangreich rekonstruiert. Im kleinen Wasserkraftwerk Štvanice werden drei direkt angeströmte Kaplan-Turbinen mit einem Durchmesser des Laufrads von 3 400 mm, einem Schluckvermögen von 3 x 55 m^3/s, einer Leistung von 3 x 1 890 kW und einer durchschnittlichen Stromerzeugung von 24 000 MWh pro Jahr installiert. In den letzten Jahren waren die hohe Störanfälligkeit und die schlechte Regulierung der Turbinen ein Problem, sodass die Durchflüsse nicht optimal genutzt werden konnten. Das Ziel der jetzt durchgeführten Rekonstruktion besteht in der Gewährleistung einer hohen Zuverlässigkeit der Anlagen, einer besseren Regulierung der Maschinensätze, einem höheren Wirkungsgrad und damit einer höheren Stromerzeugung. Der betonierte Einlaufbereich, das Saugrohr, die Welle und der Generator bleiben in der ursprünglichen Form. Installiert wurden ein neuer Turbinenkörper mit einem neu projektierten Leitwerk (Leitrad) und ein neues Laufrad. Anhand des rechnergestützten Modells wurde zur Verbesserung der Wasserströmung im Saugrohr die Drehrichtung der Turbinen in linksdrehend geändert. Diese Anpassungen werden die Regulierung der Maschinensätze und den Wirkungsgrad um ca. 10 % verbessern. Die Rekonstruktion erfolgt durch die Aktiengesellschaft MAVEL a. s. aus der Tschechischen Republik.

Schleusen unterhalb der Brücke Hlávkův most

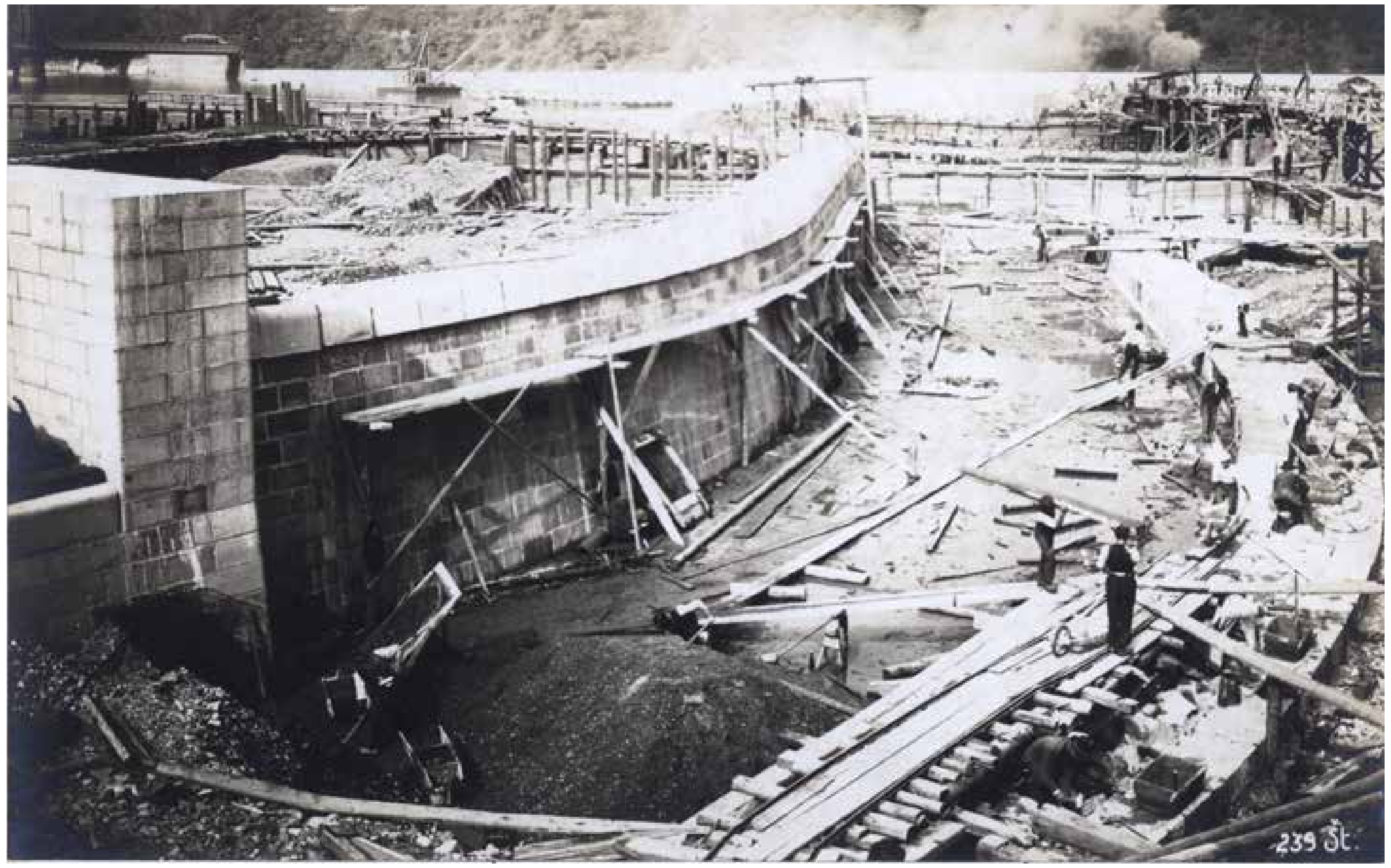
Es gibt zwei nebeneinanderliegende Schleusen. Beide sind durch mittlere Tore in zwei Kammern unterteilt. Die linke kleine Schleuse hatte eine Länge von 55 m, aber 1980 und 1981 erfolgten eine Rekonstruktion und die Verlängerung auf 115 m. Die rechte große Schleuse ist 175 m lang. Die Kammern werden mit Stahlstemmtoren geschlossen. Alle Tore werden hydraulisch gesteuert. Die Schleusen werden mithilfe langer Umläufe gefüllt, ihre Verschlüsse sind hydraulisch angetriebene Segmente. Die Füllzeit für die kleine Schleuse beträgt 10 Minuten und der Wasserverbrauch für die Schleusung 5 566 m^3. Die zum Füllen der großen Schleuse notwendige Zeit beträgt 13,5 Minuten und der Wasserverbrauch für die Schleusung 9 204 m^3.

Unterhalb der Brücke Hlávkův most wurde neben der Schleuse ein festes Betonwehr errichtet. Das Wehr war gerade mit einer Länge von 58,28 m und einer Fallhöhe von 2,48 m. Im Jahr 1988 wurde es durch ein Wehr mit zwei beweglichen Stahlklappen ersetzt, jede mit einer Länge von 27,0 m und einer Stauhöhe von 3,3 m. Unterhalb des Wehres befindet sich ein 1,8 m tiefes Tosbecken aus Beton.

Der Projektentwurf für das kleine Haus des Schleusenwärters stammt von Prof. Arch. Fr. Sander. Für die damalige Zeit war es sehr modern ausgestattet. Alle Räume verfügten über Stromanschlüsse, in den Küchen und Toiletten gab es Wasser, das Büro und die Wohnung des Schleusenwärters waren mit einem Telefon ausgestattet. Im März 1913 erfolgte die Bauabnahme des Häuschens.

Die Bauleistungen für die Schleusen, das feste Wehr unterhalb der Brücke Hlávkův most, das kleine Haus des Schleusenwärters und die umgebenden Ufer erbrachte die Firma Lanna von 1907 bis 1913.

Hydrologische Daten:	
Einzugsgebiet:	26 966,80 km^2
Mittlerer mehrjähriger Jahresabfluss:	148,31 m^3/s
T-jährlicher Abfluss HQ_{100}:	3 726 m^3/s
Technische Daten:	
Stauhaltung des Wehres:	
Gesamtvolumen:	1,675 Mio. m^3
Staulänge:	2,130 km
Wehr Helmovský jez:	
Gewässer:	Moldau-km 51,057
Art des Wehres:	festes Wehr
Konstruktion des festen Wehrteils:	mit Steinen verkleideter Beton
Kronenhöhe des festen Wehrteils:	184,50 m ü. NN
Fallhöhe:	4.4 m
Baulänge des Wehres:	184.7 m
Anzahl der Wehrfelder:	1
Floßgasse:	
Abmessungen B x L:	12 x 290 (m)
Art des Verschlusses:	Klappe
Geschiebedurchlass:	
Abmessungen B x L:	3.6 x 14,2 m
Art des Verschlusses:	Klappe
Wehr Štvanice	
Gewässer:	Moldau-km 50,690
Art des Wehres:	bewegliches Wehr
Konstruktion des festen Wehrteils:	aus Beton
Höhe der aufgerichteten Stauvorrichtung:	185,75 m ü. NN
Fallhöhe:	3.3 m
Baulänge des Wehres:	54 m
Anzahl der Wehrfelder:	2
Art des Verschlusses des Wehrfeldes:	Klappe
Schleuse:	
Art der Schleusen:	für mehrere Schiffe
Große Schleuse	
Nutzbare B x L x T:	11 x 160,5 x 2,5 m
Typ der Tore (oberes, mittleres, unteres):	Stemmtor
Kleine Schleuse	
Nutzbare B x L x T:	1 x 85 x 2,5 m
Typ der Tore (oberes, mittleres, unteres):	Stemmtor
Kraftwerk:	
Turbinentyp:	direkt durchströmte Kaplan-Turbine
Anzahl der Maschinensätze:	3
Installierte Leistung:	5 670 kW (3 x 1 890)
Max. Schluckvermögen:	3 x 65 m^3/s



Hochwasserschutzmaßnahmen in Prag, Bootsfahrt auf der Moldau

Die Hauptstadt der Tschechischen Republik musste im Laufe ihrer Entwicklung immer wieder unregelmäßig auftretenden Hochwassern trotzen. In historischen Quellen gibt es Aufzeichnungen von katastrophalen Hochwassern, so z. B. in den Jahren 1342, 1432, 1784, 1872 und 1890. Das größte Hochwasserereignis überhaupt (bis 2002) wurde am 26. Februar 1784 registriert, als ein Abfluss von 4 580 m^3/s ermittelt wurde. Das größte jemals gemessene Sommerhochwasser vom 4. September 1890 mit einem Abfluss von 3 975 m^3/s brachte die Karlsbrücke teilweise zum Einsturz.

Bevor es durch die Moldaukaskade zu einer Regulierung des Flusses kam, konnte man auf den Hochwasserverlauf keinerlei Einfluss nehmen. Erst mit der Errichtung von Talsperren an der Moldau konnten die Wasserwirtschaftler den Verlauf und die Folgen von Hochwassern verändern. Es liegt nicht in der Macht des Menschen, die destruktive Kraft von Hochwassern vollkommen aufzuheben; das Einzige, was uns bleibt, ist, solche Maßnahmen zu ergreifen, die die Auswirkungen möglichst stark mindern. Bereits vor 2002 gab es in Prag an einigen Stellen Hochwasserschutzmaßnahmen. Nach dem verheerenden Hochwasser 2002 wurde mit dem Bau von systematischen Hochwasserschutzmaßnahmen in ganz Prag begonnen, die nicht nur der Stadt Schutz bieten, sondern auch z. B. der U-Bahn, die 2002 ebenfalls betroffen war.

In den Jahren 1997 – 1998 waren Projekte zum Hochwasserschutz erarbeitet worden, der an der Moldau in Prag für einen Bemessungsabfluss von 3700 m^3 mit einem Freiboard von 40 – 60 cm ausgelegt war. Nach dem Hochwasser 2002 wurden die Projekte für einen Bemessungsabfluss von 5 160 m^3/s mit einem Freiboard von 30 cm überarbeitet.

Hochwasseralarmstufen (HWAS) in Prag

1. HWAS Q - 450 m^3/s
2. HWAS Q - 1 000 m^3/s
3. HWAS Q - 1500 - Q ^{3} 440 m^3/s

Niedrigwasser Q 27,9 m^3/s
Normaler Abfluss ca. 50 m^3/s

Das System von Hochwasserschutzmaßnahmen in Prag

Der Hochwasserschutz von Prag gehört zu den modernsten Europas. Die Hauptstadt Prag investierte in den Bau von Hochwasserschutzwänden bislang 3,7 Milliarden Kronen.

Die Hochwasserschutzmaßnahmen bestehen aus:

1. Linienmaßnahmen
- Mobile Hochwasserschutzwände
- Deiche
- Eisenbetonwände
- an einigen Abschnitten Nutzung von Eisenbahndämmen

2. Verschlüsse am Kanalisationsnetz
- Rückschlagklappen
- Pumpstationen

Der Bau der Hochwasserschutzmaßnahmen wurde in Etappen gegliedert:

ETAPPE 0001 Staré Město (Altstadt) – Josefov (Josefsstadt)
Länge 909,4 m
Stauhöhe von 0,4 m bis 5,2 m
Beendet 2000
Schutz bis zu HQ_{100} + 40 cm

ETAPPE 0002 Malá Strana (Kleinseite) – Kampa
Str. Říční ulice, Čertovka (Teufelsbach),
Kampa, Regierungsamt
Länge 1060,8 m
Stauhöhe von 1,3 m bis 3,6 m
Umgesetzt von 2002 bis 2005
Schutz bis zu HQ_{2002} + 30 cm

Malá Strana (Kleinseite) und Kampa sind durch zwei mobile Hochwasserschutzwandlinien geschützt. Die erste Linie befindet sich gleich an der Moldau, die zweite in den Straßen gesetzte Linie kommt erst dann zum Einsatz, wenn die näher am Fluss gelegene erste Linie ihre Funktion nicht mehr erfüllen kann. Der Festigkeit wegen muss sie Stützen enthalten.

Hochwassertor am Teufelsbach
- ist ein Bestandteil der Hochwasserschutzmaßnahmen für die Hauptstadt Prag von der Ufermauer unterhalb der Brücke der Legionen (most Legií) bis zur Karlsbrücke.

- Im Ruhezustand ist das Tor hinter der Ufermauer in Richtung Karlsbrücke versteckt.
- Die Länge des Hochwassertors beträgt 23,5 m, die Höhe 4,9 m und das Gewicht 51 Tonnen.
- Die Ständer für das Anbringen von beweglichen Aluminiumelementen sind 2,8 m hoch. Die Gesamthöhe einschließlich des mobilen Teils beträgt 7,87 m, was dem Hochwasserstand 2002 + 30 cm entspricht.
- Der Linienschutz setzt sich vom Tor weiter entlang des ganzen Kampaufers fort.
- Von oben wird der Teufelsbach durch eine Tafelsperre in der Smíchov-Schleuse geschützt.
- Bei einem Abfluss von 450 m^3/s muss das Tor geschlossen werden; es kann ca. 1000 m^3 Wasser zurückhalten.
- Der Fische wegen ist es notwendig, den Durchfluss von sauerstoffangereichertem Wasser auch während der Schließung zu gewährleisten; Feuerwehrleute pumpen unten das entstehende Sickerwasser ab.
- Das Hochwassertor dient seinem Zweck seit 2005.

Steuerung am Teufelsbach-Hochwassertor
- Vorbereitung der Steuerung bei einem Abfluss der Moldau von 350 m^3/s (Reinigung der Transportschwelle unterhalb des Wasserspiegels, Aufstellung der hydraulischen Winde zum Hinausschieben des Tors, Aufstellung von mobilen Pumpen zum Umpumpen des Sickerwassers und Schließung des Schiebers am Teufelsbach unweit der Strasse Říční ulice).
- Die eigentliche Steuerung (Schließen des Tors und mit dem Pumpen von eventuellem Sickerwasser anfangen) wird bei einem Abfluss der Moldau von 400 m^3/s angeordnet, das Tor muss bis zu einem Moldauabfluss von 450 m^3/s geschlossen sein, d. h. bis die I. Hochwasseralarmstufe erreicht wird.
- Das Aufsetzen der mobilen Hochwasserschutzwand auf das Tor wird gleichzeitig mit dem Hochwasserschutzabschnitt der Hauptstadt Prag Karlsbrücke – Teufelsbach beim Erreichen eines Moldauabflusses von 1530 m^3/s angeordnet, was bei der Auslösung der III. Hochwasseralarmstufe geschieht.

ETAPPE 0003 Karlín –Libeň
- Umsetzung 2005 - 2006
- Länge 506,9 m
- Stauhöhe von 0,8 m bis 3,8 m

Im Fall des Stadtteils Libeň war es wichtig, das Gebiet zu sichern, wo die Rokytka in die Moldau fließt.

Die Hochwasserschutzmaßnahmen im Mündungsbereich bestehen aus drei Hauptteilen:

- ein die Mündung der Rokytka verschließendes Tor,
- eine Pumpstation,
- ein die Einfahrt in den Hafen von Libeň
- verschließendes Tor.

Die Pumpstation verfügt über 6 Pumpen, jede hat eine Kapazität von 3,35 m^3/s, die Gesamtpumpkapazität beträgt ca. 20 m^3/s. Das Stemmtor hat eine Stahlkonstruktion und ist 8,8 m hoch.

Vorgang bei der Bereitstellung des Tors an den Häfen von Libeň

- An beiden Toren werden die Dichtungsschwellen unterhalb des Wasserspiegels gereinigt.
- Wasser wird in das Schlauchwehr eingelassen.
- Das Tor wird geschlossen, wodurch der Zufluss von Moldauwasser in die Häfen von Libeň verhindert wird.
- Ein weiteres Tor wird geschlossen, wodurch der Anstieg des Wasserspiegels in der Rokytka aufgrund von erhöhten Abflüssen in der Moldau verhindert wird.
- Die Rokytka beginnt nun in die Häfen von Libeň überzulaufen und ihr Wasser wird durch die Pumpstation in die Moldau geleitet.

ETAPPE 0004 – Holešovice – Stromovka
Länge 2538,9 m
Stauhöhe von 0,8 m bis 5,4 m
Umsetzung 2005
Schutz bis zu HQ_{2002} + 30 cm

ETAPPE 0005 Výtoň – Podolí - Smíchov
Länge 330 m
Stauhöhe von 0,6 m bis 3,3 m
Umsetzung 2005
Schutz bis zu HQ_{2002} + 30 cm

ETAPPE 0006 – Malá und Velká Chuchle, Zbraslav, Radotín
Länge 1063,64 m
Stauhöhe von 0,3 m bis 6 m
Umsetzung 2010 und 2013
Schutz bis zu:
Zbraslav HQ_{100} + 40 cm
Radotín, Malá und Velká Chuchle
HQ_{2002} + 30 cm

ETAPPE 0007 - Troja
Länge 267,4 m
Stauhöhe von 0,33 m bis 6,27 m
Umsetzung 2010
Schutz bis zu HQ_{2002} + 30 cm

ETAPPE 0008 Modřany - Komořany

Vergleich der Hochwasser 2002 und 2013

Hochwasser 2002		Hochwasser 2013	
Scheitelabfluss	5160 m3/s	Scheitelabfluss	3210 m³/s
Evakuierte Personen	50 000	Evakuierte Personen	1279
Gesamtschäden	27 Milliarden CZK davon 7 Milliarden für die U-Bahn	Gesamtschäden	ca. 2 Milliarden

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UNIPRESS, SPOL. S R. O.

NÁKLAD / AUFLAGE:

180 KS / 180 STÜCK

VODA