6. und 7. Oktober 2016 in Dresden

6. a 7. října 2016 v Drážďanech

Magdeburger Gewässerschutzseminar 2016

Magdeburský seminář o ochraně vod 2016

Die Elbe und ihre urban beeinflussten Gewässer – Tagungsband

Labe a jeho toky ovlivněné urbanizovaným prostředím – Sborník

Magdeburger Gewässerschutzseminar
MGS
2016
Magdeburský seminář o ochraně vod

Hauptorganisatoren – Hlavní organizátoři:

Mitveranstalter – Spolupořadatelé:

Die Veranstalter bedanken sich beim Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit für die finanzielle Unterstützung zum Satz und Druck dieses Tagungsbandes zum Magdeburger Gewässerschutzseminar 2016.

Organizátoři děkují Spolkovému ministerstvu životního prostředí, ochrany přírody, stavebnictví a bezpečnosti reaktorů SRN za finanční podporu při sazbě a tisku tohoto sborníku Magdeburského semináře o ochraně vod 2016.

Magdeburger Gewässerschutzseminar 2016
Magdeburský seminář o ochraně vod 2016

Das Magdeburger Gewässerschutzseminar 2016 findet unter der Schirmherrschaft der Bundesministerin für Umwelt, Naturschutz, Bau und Reaktorsicherheit Deutschlands und des Ministers für Umwelt der Tschechischen Republik statt. Das Seminar dient auch der Information der Öffentlichkeit im Rahmen der Umsetzung der Wasserrahmenrichtlinie (2000/60/EG) und der Hochwasserrisikomanagementrichtlinie (2007/60/EG) in der internationalen Flussgebietseinheit Elbe.

Magdeburský seminář o ochraně vod 2016 se koná pod záštitou spolkové ministryně životního prostředí, ochrany přírody, stavebnictví a bezpečnosti reaktorů SRN a ministra životního prostředí ČR. Seminář je i součástí informování veřejnosti v rámci implementace Rámcové směrnice o vodách (2000/60/ES) a Směrnice o vyhodnocování a zvládání povodňových rizik (2007/60/ES) v mezinárodní oblasti povodí Labe.

Sehr geehrte Teilnehmerinnen und Teilnehmer des Magdeburger Gewässerschutzseminars 2016,

die Tradition der Magdeburger Gewässerschutzseminare entstand im Jahre 1988. Seither hat sich das Seminar als bedeutende internationale Veranstaltung auf dem Gebiet des Gewässerschutzes im Einzugsgebiet der Elbe etabliert. Es findet alle zwei Jahre abwechselnd in Deutschland und der Tschechischen Republik statt. Die langjährige Kontinuität des Austausches neuester Erkenntnisse ist im Kontext europäischer Flussgebiete einmalig.

Das diesjährige 17. Magdeburger Gewässerschutzseminar hat einige Neuerungen aufzuweisen. Erstmals wird die Thematik Gewässerschutz am Beispiel urbaner Gewässer betrachtet, einschließlich der Themen, die mit der Umsetzung der europäischen Wasserrahmenrichtlinie und der Hochwasserrisikomanagementrichtlinie im Zusammenhang stehen. Die Auswirkungen des Klimawandels, die Belastung von Gewässern mit Mikroschadstoffen und mit Plastikpartikeln sind einige aktuelle Themen in diesem Jahr.

Zum ersten Mal beteiligen sich die Technische Universität Dresden und das Center for Advanced Water Research an der inhaltlichen und organisatorischen Ausgestaltung. Und schließlich ist die Stadt Dresden, auch Elbflorenz genannt, zum ersten Mal Tagungsort des Seminars.

Wir wünschen dem Seminar einen erfolgreichen Verlauf und Ihnen, sehr geehrte Teilnehmerinnen und Teilnehmer, viele interessante Gespräche, Diskussionen, neue Anregungen und gute Kontakte für Ihre weitere Arbeit. Wir freuen uns, dass auch in diesem Jahr auf die Erfahrungen anderer Flussgebiete zurückgegriffen werden kann, da Expertinnen und Experten vom Rhein und der Donau mit ihren Vorträgen zum Gelingen des Seminars beitragen werden. Wir hoffen, dass dadurch das Netzwerk der Fachleute über das Einzugsgebiet der Elbe hinaus gestärkt und erweitert wird.

Vážení účastníci Magdeburského semináře o ochraně vod 2016,

tradice Magdeburských seminářů o ochraně vod vznikla v roce 1988. Od té doby si seminář získal pověst významného mezinárodního fóra v oblasti ochrany vod v povodí Labe. Koná se každé dva roky střídavě v České republice a v Německu. Dlouholetá nepřetržitá výměna nových poznatků je v kontextu povodí evropských řek ojedinělá.

Letošní 17. Magdeburský seminář o ochraně vod přichází s několika novinkami. Poprvé bude posuzována problematika ochrany vod na příkladu toků ovlivněných urbanizovaným prostředím, včetně témat souvisejících s implementací evropské Rámcové směrnice o vodách a Povodňové směrnice. Dalšími aktuálními tématy v letošním roce jsou dopady změny klimatu, zatížení vodních toků mikropolutanty a plastovými částicemi.

Poprvé se na přípravě semináře podílí po obsahové a organizační stránce Technická univerzita Drážďany a výzkumné pracoviště Center for Advanced Water Research. A v neposlední řadě je poprvé místem konání semináře město Drážďany, nazývané také Florencie na Labi.

Semináři přejeme úspěšný průběh a Vám, vážení účastníci, řadu zajímavých rozhovorů, diskusí, nových podnětů a navázání dobrých kontaktů pro Vaši další práci. Těší nás, že také v letošním roce bude možné využít zkušeností z jiných povodí, jelikož ke zdaru semináře svými přednáškami přispějí i odborníci z povodí Rýna a Dunaje. Doufáme, že touto cestou dojde k posílení a rozšíření sítě odborníků nad rámec povodí Labe.

Na tomto místě bychom chtěli srdečně poděkovat za vykonanou práci hlavním pořadatelům semináře, Středisku pro výzkum životního prostředí H. Helmholtze, Technické univerzitě Drážďany, výzkumnému pracovišti

Wir möchten uns an dieser Stelle bei den Hauptorganisatoren des Seminars, dem Helmholtz-Zentrum für Umweltforschung, der Technischen Universität Dresden, dem Center for Advanced Water Research, der Internationalen Kommission zum Schutz der Elbe und ihrem Sekretariat sowie bei allen anderen, die an der Vorbereitung und Durchführung des Seminars mitgewirkt haben, für die geleistete Arbeit herzlich bedanken.

Dr. Barbara Hendricks
Ministerin für Umwelt, Naturschutz, Bau und Reaktorsicherheit
der Bundesrepublik Deutschland

Mgr. Richard Brabec
Minister für Umwelt der Tschechischen Republik

Center for Advanced Water Research, Mezinárodní komisi pro ochranu Labe a jejímu sekretariátu, ale také všem dalším institucím, které se podílely na přípravě a realizaci semináře.

Mgr. Richard Brabec
ministr životního prostředí České republiky

Dr. Barbara Hendricks
ministryně životního prostředí, ochrany přírody, stavebnictví a bezpečnosti reaktorů
Spolkové republiky Německo

INHALT / OBSAH

Fachbeiträge

Odborné příspěvky

Magdeburger Gewässerschutzseminar 2016

Magdeburský seminář o ochraně vod 2016

Nutzungsansprüche

Požadavky na využívání toků

Overall Elbe strategy – current developments

Hans Bärthel

1. Introduction

The Binnenelbe or Inner Elbe has been a waterway for many centuries. As a waterway system between the German-Czech border and Hamburg, the Elbe creates, with the entering navigable watercourses, a connection between the industrial centres of the Czech Republic, Saxony, Saxony-Anhalt, Lower Saxony, Brandenburg and Berlin and the port of Hamburg.

In the past, the various use requirements for the Elbe, i.e. shipping, nature conservation, water resource management with flood control, tourism, ports sector, etc. have led to controversial disputes among stakeholders. The aim of an overall Elbe strategy is to strike a fair balance between the conflicting demands, to make the use of the Elbe as a waterway reliable and to further develop and improve the basic ecosystem principles. The development of an overall strategy and its implementation does not fall exclusively under the responsibility of the Federal Government, or more precisely the two relevant ministries (the Federal Ministry of Transport and Digital infrastructure (BMVI) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMUB)). Some essential parts, i.e. flood control as part of water resource management, nature conservation, tourism and the ports sector are within the competence of the federal states.

With its catchment area, the Elbe is tangent to 10 of the 16 federal states. The regulatory environment has changed over the past years.

The European Water Framework Directive (WFD) assigned a challenging task to the federal states, namely to establish a good ecological status for the Elbe within a few years. This means that the Federal Government's Waterways and Shipping Administration (WSV) is obliged to comply with the 'no deterioration' rule of the WFD regarding any measures related to the Elbe. With the technical means available and its expertise in improving the structure of watercourses, the WSV can already support the federal states in achieving the objectives of the WFD. For a few years now, the WSV has also been able to act in the field of water management maintenance, fulfilling its ownership responsibilities for the federal waterways.

2. Process initiation

Given the various use requirements with the related legal obligations and the assigned responsibilities, BMVI and BMUB agreed on a benchmark paper for the Elbe strategy at the federal level in 2010. The first draft of this paper represents the Federal Government's priorities for the development of an overall strategy. To accommodate all the use requirements, also against the background of the legal responsibilities when developing an overall strategy, every federal state in the Elbe catchment area is given the possibility to get actively involved in the process. In January 2012, the Federal Government and the federal states of Saxony, Saxony Anhalt, Brandenburg, Thuringia, Lower Saxony, Mecklenburg Western Pomerania, Berlin and Hamburg met for the first time to discuss an overall strategy for the Elbe. They constituted the **decision-making body** for coordination purposes. Control over this body is equally divided between BMVI and BMUB. The Federal Waterways and Shipping Agency (GDWS) manages the office.

In a first step, a Federal Government-federal states working group and the WSV adapted the benchmarks to fit the needs of the federal states. The draft results were presented at the "Elbe River Conference" hosted by the WSV in Magdeburg in March 2013. The motto of this event was "Shaping a river together". The benchmarks established by the Federal Government and the federal states were completed in the middle of 2013. They represent the joint tasks for an overall strategy.

3. Content

The Federal Government and the federal states agreed on the following work packages as priorities of an overall strategy:

Fig. 1: *Water resource management*

Fig. 2: *Nature conservation*

Fig. 3: *River control*

Fig. 4: *Transport*

The overall strategy is further developed in two steps:

- Stock-taking (actual state of the 4 work packages) by representatives of the Federal Government and federal states administrations

- Development of a target concept for the work packages with consolidation of the priority areas for the overall Elbe strategy, supported by representatives of associations and churches

To process the work packages, 4 working parties were established as the working level through points of contact at the Federal Government and federal state administrations. The first step was an inventory for the work packages which was approved in July 2015 by the decision-making body with the involvement of representatives of associations and churches.

The inventory displays the weaknesses or deficits of the 4 work packages.

For the second step, the target concept, involvement at the working level is going to be extended. A wide social acceptance is necessary for the success of the overall strategy. This is why, in addition to the close cooperation between the Federal Government and the federal states, at the working level environmental associations, citizens' action groups, trade associations and churches will help to shape this process. In July 2015, an advisory body was established at the working level. This body is headed by an external facilitator. Since then, advisory body meetings have been taking place every 6 to 8 weeks.

4. Outlook

The plan is to present a target concept to the decision-making body (Federal Government-federal state body) by the end of the year so that the **overall Elbe strategy** can be concluded **by the end of 2016**.

The LAWA-BLANO Catalogue of Measures – an innovative tool for the Water Sector

Martin Socher, Kristina Rieth

1. Introduction

The Water Framework Directive (WFD) requires for all European Water Basins the establishment of River Basin Management Plans and Programmes of Measures (PoM) in order to keep all water bodies in a good state or potential or to improve their state. The logic behind these plans and programmes is the Drivers-Pressures-State-Impacts-Responses (DPSIR) concept. In order to transform this concept into a transferable system, the Federal Working Association Water (LAWA) and the Federal Committee for the North Sea and the Baltic Sea (BLANO) jointly developed a catalogue of measures, meeting all European requirements for planning and reporting. Furthermore, the catalogue also describes all measures for the programmes of the Floods Directive (FD) and the Marine Strategy Framework Directive (MSFD) and combining their internal relationships with the WFD through a categorizing system.

2. Principles an structure

The LAWA-BLANO Catalogue of Measures [1] is a table of standardized types of measures, pressure types under WFD Annex II, EU types under FD or environmental objectives by MSFD and other assignments to have a common basis for the preparation of PoM and the reporting in WISE (Water information system Europe) to the EU Commission.

Basically, a targeted planning of measures to improve water status has to ensure that in the selection of measures, the cause is known for the deficits in the water bodies and the measures are best aligned to remedy these deficiencies. The catalogue considers in accordance with the WFD Reporting Guidance 2016 the DPSIR concept (Table 1). Since this reporting is only possible via standardized codes, simplifications and summaries of pressures, impacts and responses (measures) are necessary to ensure a uniform and evaluable data compilation. As part of the planning of measures, the types of measures, that are capable of achieving an improvement in terms of the existing pressures and the observed water status, will be selected accurately for each waterbody.

Tab. 1: *DPSIR chain (Drivers-Pressures-State-Impacts-Responses) [2]*

	Term	Definition
D	Driver	an anthropogenic activity that may have an environmental effect (e.g. agriculture, industry)
P	Pressure	the direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry)
S	State	the condition of the water body resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics)
I	Impact	the environmental effect of the pressure (e.g. fish killed, ecosystem modified)
R	Response	the measures taken to improve the state of the water body (e.g. restricting abstraction, limiting point source discharges, developing best practice Guidance for agriculture)

The catalogue includes four groups of measures (Table 2) and can be extended if necessary to integrate new requirements of the implementation process of guidelines or requirements of new national laws and regulations or European directives.

Tab. 2: *Groups of measures*

No.	Group of measures
1 – 102	Measures of the WFD
301 – 329	Measures HWRMRL
401 – 431	Measures of the MSFD
501 – 510	Strategically-conceptual measures

All measures of the catalogue are described in detail with explanatory texts and examples which specify the content of the measures. That allows an unambiguous assignment of measures to the pressure types under WFD Annex II, EU types under FD or environmental objectives by MSFD. The MSFD programme of measures includes proposals for measures on various environmental objectives, which are displayed in the catalogue. Environmental objectives, which are also valid in the regime of the WFD in the area of coastal waters, are addressed, particularly with regard to nutrients and pollutants. So the catalogue establishes a close link between the objectives of the WFD and the MFSD. Numerous WFD measures also serve to marine protection; also some MFSD measures support the objectives of the WFD in coastal waters. This is marked in the catalogue. A relevance is assigned to each measure describing the effectiveness of a measure related to the management objectives of the WFD, the objectives of FD or MSFD: M1 measures support the objectives of the other policy, M2 measures may lead to a conflict of objectives and an individual assessment must be taken, M3 measures are not relevant to the objectives of the other policy.

The strategic-conceptual measures of the WFD, FD and MSFD were examined to assess whether they can be regarded as so-called conceptual measures and can be merged in a separate group of measures to avoid overlapping and to show the inherent connection between the measures.

The reporting from the German platform "WasserBLIcK" to the WISE platform at European level has to work smoothly taking the previously reported type of measures into account.

3. Key Type Measures

The reporting requirements of WFD and MSFD demand the assignment of the measures to so called Key Type Measures (KTM, Table 3 and 4). For the WFD are 25 KTM available that are included in the catalogue. Therefore the measures can be submitted differentiated to the EU Commission. Each measure of the WFD was associated with a single KTM. Since the measures M 96, M 99 and M 505 cannot relate to the set by the EU KTM, a new KTM „Measures to prevent or control the adverse impacts of other human activities“ (KTM new 40) was established.

Tab. 3: *List of Key Type Measures for the WFD reporting [3]*

No.	Description
1	Construction or upgrades of wastewater treatment plants.
2	Reduce nutrient pollution from agriculture.
3	Reduce pesticides pollution from agriculture.
4	Remediation of contaminated sites (historical pollution including sediments, groundwater, soil).
5	Improving longitudinal continuity (e.g. establishing fish passes, demolishing old dams).
6	Improving hydromorphological conditions of water bodies other than longitudinal continuity (e.g. river restoration, improvement of riparian areas, removal of hard embankments, reconnecting rivers to floodplains, improvement of hydromorphological condition of transitional waters, etc).
7	Improvements in flow regime and/or establishment of ecological flows.
8	Water efficiency, technical measures for irrigation, industry, energy and households.
9	Water pricing policy measures for the implementation of the recovery of cost of water services from households.
10	Water pricing policy measures for the implementation of the recovery of cost of water services from industry.
11	Water pricing policy measures for the implementation of the recovery of cost of water services from agriculture.
12	Advisory services for agriculture.
13	Drinking water protection measures (e.g. establishment of safeguard zones, buffer zones etc).
14	Research, improvement of knowledge base reducing uncertainty.
15	Measures for the phasing-out of emissions, discharges and losses of Priority Hazardous Substances or for the reduction of emissions, discharges and losses of Priority Substances.
16	Upgrades or improvements of industrial wastewater treatment plants (including farms).
17	Measures to reduce sediment from soil erosion and surface run-off.

No.	Description
18	Measures to prevent or control the adverse impacts of invasive alien species and introduced diseases.
19	Measures to prevent or control the adverse impacts of recreation including angling.
20	Measures to prevent or control the adverse impacts of fishing and other exploitation/removal of animal and plants.
21	Measures to prevent or control the input of pollution from urban areas, transport and built infrastructure.
22	Measures to prevent or control the input of pollution from forestry.
23	Natural water retention measures.
24	Adaptation to climate change.
25	Measures to counteract acidification.
Additional „new“ KTMs for WFD reporting in Germany	
new 40	Measures to prevent or control the adverse impacts of other human activities

Tab. 4: List of Key Type Measures for the MSFD reporting [3]

No.	Description
26	Measures to reduce physical loss of seabed habitats in marine waters (and not reported under KTM 6 in relation to WFD Coastal Waters)
27	Measures to reduce physical damage in marine waters (and not reported under KTM 6 in relation to WFD Coastal Waters)
28	Measures to reduce inputs of energy, including underwater noise, to the marine environment
29	Measures to reduce litter in the marine environment
30	Measures to reduce interferences with hydrological processes in the marine environment (and not reported under KTM 6 in relation to WFD Coastal Waters)
31	Measures to reduce contamination by hazardous substances (synthetic substances, non-synthetic substances, radio-nuclides) and the systematic and/or intentional release of substances in the marine environment from sea-based or air-based sources
32	Measures to reduce sea-based accidental pollution
33	Measures to reduce nutrient and organic matter inputs to the marine environment from sea-based or air-based sources
34	Measures to reduce the introduction and spread of non-indigenous species in the marine environment and for their control
35	Measures to reduce biological disturbances in the marine environment from the extraction of species, including incidental non-target catches
36	Measures to reduce other types of biological disturbance, including death, injury, disturbance, translocation of native marine species, the introduction of microbial pathogens and the introduction of genetically-modified individuals of marine species (e.g. from aquaculture)
37	Measures to restore and conserve marine ecosystems, including habitats and species
38	Measures related to Spatial Protection Measures for the marine environment (not reported under another KTM)
39	Other measures

4. Summary

The LAWA-BLANO Catalogue of Measures is an innovative and important tool for the Water Sector. The catalogue closely links the objectives of the WFD, the FD and the MFSD. In principle, standardization at the level of PoM and flood risk management plans (FRMP) on the national part of the international river basins is provided. Federal plans of internal measures don't require a uniform national standardization. The allocation of the national internal types of measures to the standardized catalogue of measures is the responsibility of the respective federal state. The applied DPSIR concept considers the requirements of the reporting to the EU Commission and allows a comprehensive approach of planning, but due to the possibility of multiple pressures additional effort is needed for the planning of individual single measures.

Literature:

[1] LAWA-BLANO Maßnahmenkatalog (WRRL, HWRMRL, MSRL): Bund/Länder-Arbeitsgemeinschaft Wasser (2015)

[2] Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance Document No 3. Analysis of Pressures and Impacts: Office for Official Publications of the European Communities (2003)

[3] Common Implementation Strategy for the Marine Strategy Framework Directive (MSFD). MSFD Guidance Document No 10. Programmes of measures under the Marine Strategy Framework Directive. Recommendations for implementation and reporting: Marine Strategy Coordination Group (2014)

Challenges of water protection in urban areas – Implementing the Water Framework Directive in Berlin

Matthias Rehfeld-Klein

Achieving the environmental objectives of the European Water Framework Directive in Berlin's water bodies is a major challenge for the city, which is the largest metropolitan area in the Elbe river basin. Urban water bodies are exposed to a multitude of different water uses and pressures, such as urban development, water supply and wastewater disposal, industrial water abstractions (e.g. cooling water) and discharges, navigation, fisheries or recreational use.

While other European cities usually obtain their drinking water from the surrounding areas, water supply in Berlin exclusively relies on the city's own water resources. About 70% of Berlin's drinking water is abstracted by bank filtration (60%) and artificial groundwater recharge (10%), about 30% is abstracted from groundwater.

To fulfil the objectives of the Water Framework Directive and ensure a safe supply of drinking water, numerous measures to improve water status are being planned and implemented: To improve hydromorphology of Berlin's surface waters, water development concepts were elaborated in collaboration with the public. Moreover, a programme to increase the storage capacity of Berlin's combined sewer system was established. To reduce the number of combined sewer overflows during major rain events, a total of 300.000 m³ storage space will be provided by 2020. Furthermore, by applying measures of urban stormwater management at different spatial scales, hydraulic stress as well as nutrient and pollutant loads of surface waters can be reduced significantly. However, financing of an appropriate programme in Berlin is still pending.

To further reduce nutrient loads in the rivers Dahme, Spree and Havel, the federal states of Berlin and Brandenburg established a common nutrient reduction concept ([1], [2], [3]). Besides measures to reduce diffuse pollution from agriculture, the concept provides for the implementation of tertiary treatment systems to improve phosphorus removal in all large wastewater treatment plants in the Spree-Havel river basin by 2027. Additionally, the integration of trace organic removal into concepts for tertiary treatment is considered.

To comprehensively analyse the multiple pressures and impacts affecting urban waters and to develop new solutions, Berlin closely collaborates with universities and research institutes and participates in numerous research projects (e.g. the projects "OXERAM" [4] "IST4R" [5], „OgRe" [6]).

Literature:

[1] SenGUV / MUGV (2011) – Senatsverwaltung für Gesundheit, Umwelt und Verbraucherschutz / Ministerium für Umwelt, Gesundheit und Verbraucherschutz: Reduzierung der Nährstoffbelastungen von Dahme, Spree und Havel in Berlin sowie der Unteren Havel in Brandenburg. Gemeinsames Handlungskonzept der Wasserwirtschaftsverwaltungen der Bundesländer Berlin und Brandenburg. Teil 1: Ableitung der länder-übergreifenden Bewirtschaftungsziele. Berlin/Potsdam.

[2] SenStadtUm / MUGV (2012) – Senatsverwaltung für Stadtentwicklung und Umwelt / Ministerium für Umwelt, Gesundheit und Verbraucherschutz: Nährstoffreduzierungskonzept Teil 2: Quantifizierung und Dokumentation der pfadspezifischen Eintragsquellen. Berlin/Potsdam.

[3] SenStadtUm / MLUL (2015) – Senatsverwaltung für Stadtentwicklung und Umwelt / Ministerium für Ländliche Entwicklung, Umwelt und Landwirtschaft: Nährstoffreduzierungskonzept Teil 3: Maßnahmen und Strategien zur Reduzierung der Nährstoffbelastung. Berlin/Potsdam.

[4] Miehe, U., Stüber, J., Remy, C., Langer, M., Godehardt, M. & M. Boulestreau (2013): Optimierung der Flockung für nachgeschaltete Filtrationsprozesse und Evaluierung der Nachhaltigkeit der weitergehenden Abwasserreinigung. Abschlussbericht zum Projekt „OXERAM 2". Kompetenzzentrum Wasser Berlin. Berlin.

[5] Jekel, M., Altmann, J., Ruhl, A. S., Sperlich, A., Schaller, J., Gnirß, R., Miehe, U., Stapf, M., Remy, C. & D. Mutz (2015): Vergleich verschiedener Verfahrensvarianten der weitergehenden Abwasserreinigung zur Entlastung der Berliner Gewässer – Integration der Spurenstoffentfernung in Technologieansätze der 4. Reinigungsstufe bei Klärwerken. Abschlussbericht zum Projekt „IST4R". Technische Universität Berlin, Fachgebiet Wasserreinhaltung. Berlin.

[6] Wicke, D., Matzinger, A. & P. Rouault (2015): Relevanz organischer Spurenstoffe im Regenwasserabfluss Berlins. Abschlussbericht zum Projekt „OgRe“. Kompetenzzentrum Wasser Berlin. Berlin

Assessing disproportionate costs according to the EU Water Framework Directive: Application of the "new Leipzig approach" in the Czech Republic

Jan Macháč, Katja Sigel, Jan Brabec, Bernd Klauer, Lenka Slavíková

Abstract

The growing demand for clean water has led to the adoption of the EU Water Framework Directive (Directive 2000/60 EC; WFD). The new legislation has had a major impact on water management and national economies and instituted numerous requirements, including "good status" of all water bodies by 2015. However, achieving "good status" is associated with large investments, often beyond the capabilities of those who have to bear the costs. In justified cases, member states may request an extension of the deadline or less stringent objectives based on disproportionality of the costs. WFD does not provide a clear explanation how the cost proportionality should be assessed. Within the EU, it is possible to meet a number of different approaches. These approaches are mostly based on cost-benefit analysis (which is also the case of the Czech official methodology). One of the alternative approaches is the German methodology, the "new Leipzig approach", which was the subject of a pilot study in Germany (a river catchment in Rhineland-Palatinate) and in the Czech Republic (Stanovice reservoir – sub-catchment of the Elbe). Also, the Czech official approach is currently being applied to the Stanovice case.

The paper presents the application of the "new Leipzig approach" in the Czech Republic. Based on the results in the catchment of the Stanovice reservoir, the application of the measures seems to be cost proportionate and thus the exemption should be refused.

1. Introduction

With the constantly increasing requirements on water quality, demand for "good status" of water bodies also grows. This year it is 16 years since the adoption of the Water Framework Directive (WFD); it was created in response to the growing demand for clean water and to create an integrated approach to water body management across the EU member states. The primary environmental goals of the directive include the provision of protection, improvement of status and renewal of all water bodies, aiming at achieving their "good status" by 2015 or alternatively using some exemptions by 2021 and finally by 2027. According to the [1], in the Czech Republic only 17 % of surface water bodies currently meet the good ecological status and about 70 % of surface water bodies the good chemical status. However, the Czech Republic does not belong among the countries with the worst situation, but the rate of improvement is very slow in the Czech Republic for many reasons (for example, financial reasons, natural conditions, unknown sources of pollution).

The existence of the Directive and its implementation have a major impact on the economic policy of all EU member states. The binding targets of the Directive are very ambitious in relation to a large portion of water bodies. Thus, achieving their "good status", may significantly increase member states' monetary requirements of authorities in charge for the implementation of required water management measures, including potential social impacts on the populations, e.g., due to increased sewage or water charges. Under certain conditions, however, the Directive sets exemptions that may be applied to justify non-achievement of a "good status" in water body. These exemptions can be both short-term and long-term and they must always be based on at least one possible argument for disproportionality given by the WFD.

Measures adopted to achieve "good status" of water bodies require costs (mostly large investments), which may be disproportionate in many cases in contrast to the expected benefits. In these specific cases, member states may apply for a temporary exemption and extension of the deadline for achieving "good status" for reasons of disproportionate costs. Nevertheless, the Water Framework Directive grants a relatively high level of discretion relating to the definition of the cost proportionality threshold (e.g. [2] or [3]). At the practical and also theoretical level, there are two different fundamental attitudes to evaluating cost proportionality. The most commonly used approach is based on cost-benefit analysis (CBA), which is currently also preferred in the Czech Republic (Czech official certified methodology; [4]). In Germany there was created a unique approach based on comparing the costs of possible measures with the costs of the past and taking into account the benefits from achieving "good status". This approach is known as the "new Leipzig approach" ([5], [6]). Little time needed and low effort is considered as the main advantages of this procedure in comparison to CBA.

The purpose of the paper is to present the application of the "new Leipzig approach" within the Czech Republic and to discuss transfer of the procedure abroad, especially possible usage in the Czech Republic. The paper consists of three chapters. The first chapter summarizes the basic steps of the German methodology. The second chapter presents application of "new Leipzig approach" in case of Stanovice. The further appropriateness of "new Leipzig approach" application is discussed in the conclusion.

2. Methods

Main idea of the „new Leipzig Approach“ is to compare real costs of measures with a cost threshold, which is determined by average past public expenditures and an effort factor. The process of assessment consists of 2 preliminary steps on level of state: (i) Identification of water bodies to be checked for disproportionality of costs; (ii) Calculation of nationwide past average state expenditures on water protection, and 3 main steps on level of water bodies: (i) Estimation of water-body specific costs to reach good status/potential; (ii) Calculation of water-body related cost thresholds for disproportionality; (iii) Comparison of costs and threshold.

In the Czech Republic, we identify the catchment of the Stanovice Reservoir as a pilot area for application of the "new Leipzig Approach" (this area is introduced below). Past public expenditures is calculated for the Czech Republic as an average of water related "Environmental Protection Investment" from Czech Statistical Office [7], particularly the one related to Wastewater Management and the other one to Soil, Groundwater and Surface Water Protection and Remediation. To be consistent with the German methodology, we count only expenditures between years 1994 and 2009, because in 2009 the first planning cycle of the WFD started. The average annual past public expenditures is CZK 181 802 per squared kilometre, which means CZK 16 725 784 in total for Stanovice.

In the next step, costs of achieving the "good status" are estimated. These costs are partly based on investments costs realized from the beginning of the first planning cycle (2009) and partly from the economic analysis of necessary measures to achieve the "good status". The estimation of future costs for measures should be based according the EU on a cost effectiveness analysis (CEA), which is used to minimalize the costs. Multiplying the average past public expenditures by the effort factor, we get a maximum cost proportionate increase in yearly spending on water management. Effort factor consists of "objective distance" and "additional benefits". This factor can be calculated using formula:

$$effort\ factor = \frac{2}{18} * objective\ distance + \frac{1}{18} * additional\ benefits$$

"Objective distance" is determined by several indicators (Macrophytes/Phytobenthos; Macroinvertebrates; Phytoplankton; Fish; and Environmental quality standards). Each of these indicators are ranked from 0 to 3 (0 means, that this indicator meets "good status", 3 means, that the current status is insufficient). These indicators are based on data from monitoring. The second factor in determining the effort factor is "additional benefits". These benefits include Ecology and nature protection; Freshwater provision and treatment; Flood protection and Soil protection; Tourism, recreation, cultural heritage, landscape. According to the estimation of increase in benefits, each category is ranked from 0 to 3 (0 means, that there is no additional benefits). In the last step, the estimated costs together with previous investments are compared with the costs threshold.

3. Characteristics of the catchment area of the Stanovice reservoir

Stanovice reservoir is situated near Karlovy Vary in Western Bohemia in the Czech Republic. There are two inflows-brooks into the reservoir (Lomnický potok and Dražovský potok) that have an impact on water quality. Including these brooks, the area covers 92 km^2. According to information from the T. G. Masaryk Water Research Institute, achievement of "good status" requires a reduction of phosphorus inflow into the reservoir by 60 – 200 kg a year compared to the present status. This paper calculated with a reduction of 200 kg of phosphorus annually at the inflow to the reservoir. The contribution of phosphorus is distributed evenly between point (municipal wastewater) and diffuse sources (agricultural activities). Measures relating to construction and renovation of wastewater treatment plants, sewer systems, dead-end and accumulation cesspits, retention wetlands, biological reservoirs and domestic wastewater treatment plants, and measures relating to intensification of the treatment process at wastewater treatment plants were proposed for the point sources. Agricultural phosphorus inflow measures involved in the case of the Stanovice reservoir include 5 types of measures (building of a broad-base terrace, grassing of sloping areas, changes of crop rotation, leaving crop residue, and introduction of no-tillage methods).

4. Results

According to the cost effectiveness analysis, the total annual costs of all the measures are CZK 1.15 million (EUR 44,231). Measures focused on point sources also contribute according to the result of CEA most significantly to the total reduction of phosphorus (123.75 kg), followed by the grassing of the sloping areas (26.45 kg) and introduction of no-tillage methods (26.36 kg).

To successfully assess the cost proportionality of suggested measure we need to determine objective distance. However, we encounter a major issue in the process, because most of the indicator values, which are used in the "new Leipzig approach", were not measured, analysed or published for the Stanovice reservoir and its inflows. Based on the available values of these indicators from T. G. Masaryk Water Research Institute, objective distance for Stanovice and its inflows is 0.2.

Based on the German methodology, additional benefits ware evaluated for each group's importance on a scale from 0 to 3 (3 = highest additional benefits). The most added benefits are connected with Freshwater provision and treatment and Soil protection. Conversely, with regard to the purpose of the water reservoir is a significant increase in benefits associated with Tourism and recreation is not expected. Results are presented in Table 1. The value of average additional benefits is 1.4.

Tab. 1: Total additional benefits of whole catchment of the Stanovice Reservoir

Ecology and nature protection	Freshwater provision and treatment	Flood protection	Soil protection	Tourism and recreation	Total additional benefit (average)
1	2	1	2	1	1.4

Based on the previously collected data, "effort factor" can be computed, which gives us information that costs of measures are proportionate if they are not higher than 10% of the past public expenditures. Given the methodology it is cost proportionate to spend additional CZK 30,106,404 (EUR 1,114,639) for the application of measures over 18 years to improve water quality in Stanovice. The implementation of measures is expected in the period 2016–2027. Therefore, the costs are cumulated for 12 years. Multiplying by 12 we get the total costs of such measures at CZK 13,774,128. The comparison of costs shows that total costs of CZK 13.8 million do not exceed the cost threshold of CZK 30.1 million given by the methodology. It is possible to conclude that suggested measures are cost proportionate.

5. Discussion and Conclusion

In this paper pilot application of the new German methodology the "new Leipzig approach" in the catchment of the Stanovice reservoir was described. According to the "new Leipzig approach" the result leads to a refusal of exemption for the cost disproportionality in the catchment of the Stanovice reservoir. Based on the pilot assessment this approach is definitely less time consuming and not as expensive as other possible methods such as the performance of cost-benefit analysis.

The application was associated with some problems. Most of them are connected with data availability. It proved to be difficult to collect a sufficient amount of indicator values by which "good status" is determined and objective distance and the level of effort factors are calculated. In this field it would be necessary to perform an analysis of input data availability. If an indicator isn't evaluated frequently it would make sense to replace it with another one.

The question is whether the problem of data limitations is faced by all water bodies or it's a unique case of a small pilot catchment in West Bohemia. The other problem is assigning values to additional benefits. Based on our experience with the pilot study, this assignment is very subjective and can easily affect the outcome of proportionality assessment.

Literature:

[1] European Commission. (2015) The fourth implementation report – assessment of the Water Framework Directive Programmes of Measures and the Flood Directive. Retrieved from: http://ec.europa.eu/environment/water/water-framework/impl_reports.htm#fourth

[2] Jensen, C. L.; Jacobsen, B. H.; Olsen, S. B.; Dubgaard, A.; & Hasler, B. (2013) A practical CBA-based screening procedure for identification of river basins where the costs of fulfilling the WFD requirements may be disproportionate – applied to the case of Denmark. Journal of Environmental Economics and Policy 2(2), 164 – 200

[3] Klauer, B.; Sigel, K.; Schiller, J.; Hagemann, N.; & Kern, K. (2015). Unverhältnismäßige Kosten nach EG-Wasserrahmenrichtlinie – Ein Verfahren zur Begründung weniger strenger Umweltziele. UFZ-Bericht 01/2015, Leipzig.

[4] Slavíková, L.; Vojáček, O.; Macháč, J.; Hekrle, M.; & Ansorge, L. (2015). Metodika k aplikaci výjimek z důvodu nákladové nepřiměřenosti opatření k dosahování dobrého stavu vodních útvarů. VÚV TGM.

[5] Klauer, B.; Sigel, K.; Schiller, J. (2016). Disproportionate costs in the EU Water Framework Directive – How to justify less stringent environmental objectives. Environmental Science & Policy 59, 10 – 17.

[6] Sigel, K.; Klauer, B.; Schiller, J. (2015). Begründung "weniger strenger Umweltziele" nach EG-Wasserrahmenrichtlinie mit unverhältnismäßigen Kosten – ein Verfahrensvorschlag. KW – Korrespondenz Wasserwirtschaft, Heft Nr. 12, 268 – 774.

[7] Czech Statistical Office (2015) Investment on environmental protection 1986 – 2014. Retrieved from: https://www.czso.cz/documents/10180/20543863/2800221501.xls/89e85479-0e28-4f4b-91ee-015254ddc013?version=1.0

The development of methodological, planning and monitoring measures for solution of the fragmentation of the river systems in the Czech Republic

Milan Hladík, Svatopluk Škuta, Tomáš Borůvka, Aleš Zbořil, Jiří Musil, Miroslav Barankiewicz

1. Introduction

The morphological modifications of rivers were found to be one of the most important anthropological pressure affecting the ecological status of rivers in the Czech Republic. More than 8 000 migration barriers cause fragmentation of rivers with significant negative effects on the fish populations as well as on other aquatic biota. The building of fish-passes was required within the "Water-management plans" and supported by the Operational Programme – Environment (OPE) 2009 – 2015, but the realisation of new fish-passes unfortunately remained behind all expectations and financial funds were not sufficiently and effectively drawn. The presented project, co-financed by the Technology Agency of the Czech Republic, was processed in the years 2014 – 2016. The main goal of the project was to enhance building of fish passes and thereby to improve the ecological status of rivers in the Czech Republic. The project was aimed at four significant results.

2. Central database of migration barriers in rivers

One central database was built (http://voda.gov.cz/portal/cz) collecting all relevant data which had not been uniformly operated (e.g. localisation and technical data of migration barriers, hydroelectric plants and already operating fish-passes). This database can be divided, in terms of its content, into four basic parts. The first two parts of the database are accessible to „ordinary" public users using web forms with a map frame.

The first part contains data about rivers and all objects built on a river. This data originates from the public database of water flows (HEIS) and from databases of river authorities and is regularly synchronised.

The second part contains data on "migration barriers". The abstract concept "migration barrier" was introduced as in many cases two or more objects create one obstacle to fish migration (e.g. weir, hydroelectric plant, lock chamber) and the problem must be solved as a whole. This part also contains information about already built fish-passes and about all projects of fish-passes in different stages (proposal, feasibility study, and project).

The third part (non-public) is used to define the properties of objects and define reference tables.

The system includes the following forms:

- Form of descriptive data about a migration barrier
- Form data about objects on a river belonging to the migration barrier
- Form of hydrological data pertaining to the migration barrier
- Data sheet on plots with regard to the proposed solutions
- Data sheet on the proposed migration solution throughput
- Data sheet with photos of migration barriers.

The fourth part enables presentation of all collected data and creating of outputs in a table-format, .pdf-format and also in a map-format. The database will enable the effective usage and evaluation of data for a wide range of professional, scientific and public subjects.

3. Feasibility studies for building of fish passes for all migration barriers in the "National priority migration corridors"

According to experience from previous projects, the "feasibility study" was found to be the first and most important step in realization of a fish-pass. This study evaluates all important factors (hydrology, composition of fish stock, morphology, technical parameters of migration barrier) and defines the technical parameters of the future fish-pass (very often in variants) as well as all possible problems during realisation of the fish-pass (private ownership, technical problems, present rights for usage of water in hydroelectric plants). The Ministry of the Environment of the Czech Republic defined in our river network the "priority migration corridors" and the main aim of the project was focused on these river corridors. All already finished studies and proposals (about 450 profiles) were collected and revised and there were also processed new studies for all remaining migration barriers (about 850 profiles). The result provides the important background for river authorities for future planning and realisation of fish passes.

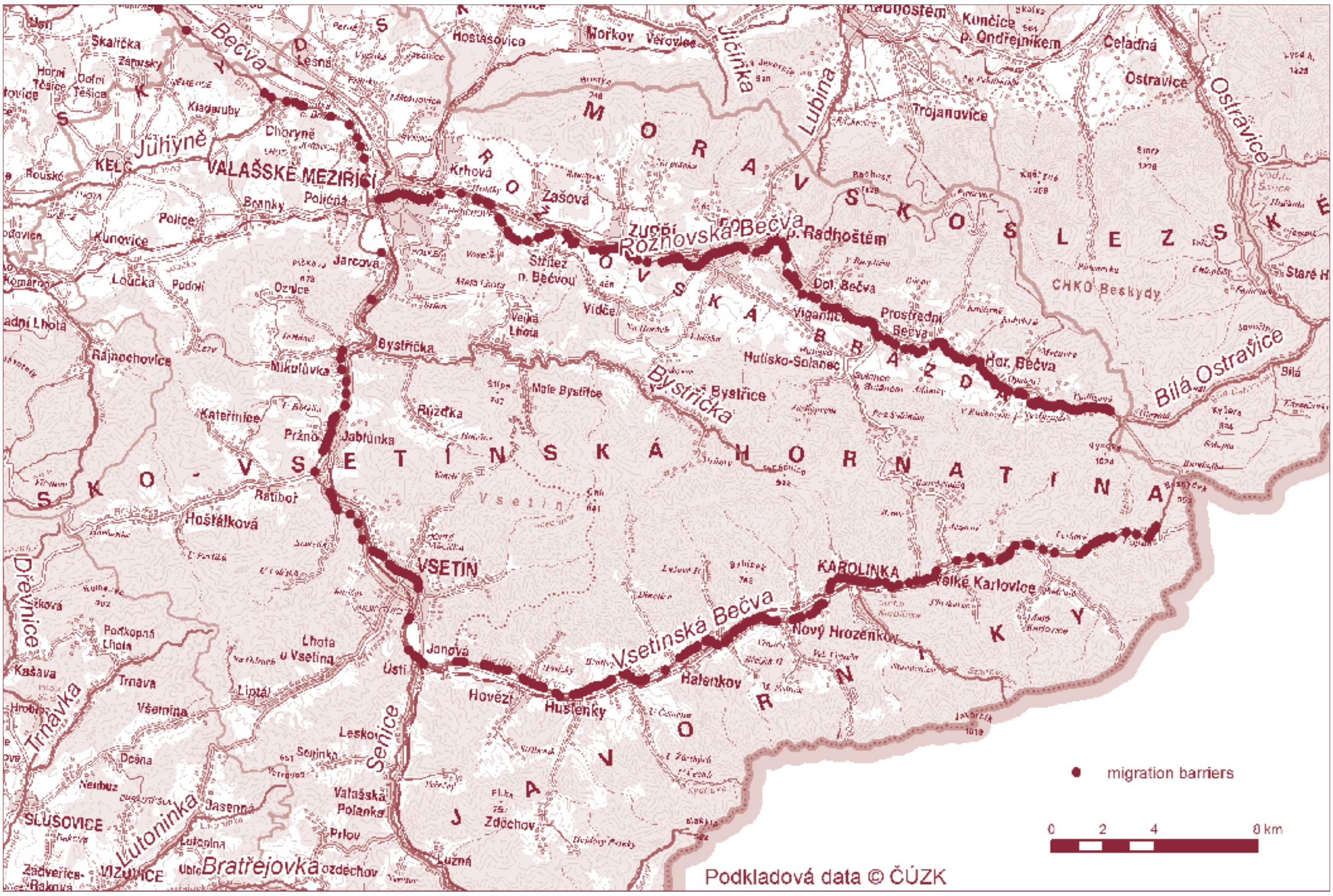

Fig. 1: *Example of the most fragmented rivers – Rožnovská Bečva and Vsetínská Bečva*

Fig. 2: *Relatively low structures with not appropriate construction can create a migration barrier, mainly during low flow conditions.*

4. System of one-off evaluation of the functionality of fish passes and central system of long term on-line monitoring of the functionality of the FP

Building of fish-passes is required by Czech law and it is supported by the State Environmental Fund of the Czech Republic. However, a standardized monitoring approach that would allow robust, non-subjective and site-specific evaluation of effectiveness and right functionality is still lacking and urgently needed.

The aim of the project was to develop a methodological guideline for standardized fish passes evaluation based on selection criteria that include river size vs methods responsiveness (fish diversity, size selectivity, migration success), monitoring duration and rational feasibility costs. During two seasons, there were monitored already functioning fish-passes of different size and different construction by different scientific methods and results were compared. Once a fish pass is considered as functional, a long-term monitoring of its operation is of particular importance. Hence, another project goal was to develop an easy on-line hydrological monitoring system that would allow indication of any disturbances in fish pass functionality at an acceptable cost.

5. Retrieval of the relevant legislation and methodology and proposed necessary improvements

During the project there was processed a review of the Czech and also foreign methodological and legislative documents aimed at the passability of the migration barriers in rivers. Also prepared were proposals for the improvement of legislation focused mainly on the enforcement of the building of fish-passes and on the monitoring of effectiveness and right operation of fish passes.

Representatives of The Ministry of Agriculture of the Czech Republic, Ministry of the Environment of the Czech Republic and of all state river authorities cooperated on the project and final results, which were presented during seminary, will be used in water management already in the near future.

Fachbeiträge Odborné příspěvky

Magdeburger Gewässerschutzseminar 2016
Magdeburský seminář o ochraně vod 2016

Erheblich veränderte und künstliche Gewässer
Silně ovlivněné a umělé vodní toky

MGS
Magdeburger Gewässerschutzseminar
2016
Magdeburský seminář o ochraně vod

Physical river habitat of streams in urban areas in context of hydrological extremes

Milada Matoušková, Kateřina Kujanová, Kateřina Maroušková, Michal Pergl, Vojtěch Tichý

1. Introduction

Many European river basins and waters have been altered by human activities, such as land drainage, dredging, flood protection, water abstraction and inter-basin water transfer, building of dams to create reservoirs and the digging of new canals for navigation purposes. The Water Framework Directive (WFD) recognises in some cases that the benefits of such uses need to be retained. If a series of criteria are fulfilled, it allows designation of the surface water body (SWB) as "artificial" (AWB) or "heavily modified" (HMWB), e.g. reservoirs, canals or canalised rivers (European Commission, 2000). The main objective of this study was to assess the hydromorphological quality of selected river reaches in urban and suburban areas within a context of hydrological extremes.

2. Study areas

A large part of the Czech river network has been affected by anthropogenic modification of various kinds. More than a third of the total length of major rivers has been modified (Němec, Hladný, 2006). The physical river habitat changed fundamentally in central Bohemia since the 20th century especially in urban and suburban areas. Its character was significantly transformed by human activities particularly by buildings of flood protection measures and urbanisation of flood plain areas. Our study represents modified water bodies in the Central Bohemia within a context of hydrological extremes: floods and draughts. Selected case study areas are: lower course of the Berounka River R. km 0.0 – 13.7, louwer course of the Botič Brook (R. km 0.0 – 13.3), which were affected by the flood 2013 and middle and lower course of the Rakovnik Brook (R. km 0.0 – 24), affected by the draught in summer 2015.

3. Applied methods and data sources

The Hydroecological monitoring – HEM (Langhammer and Hartvich, 2014) methodology was applied to assess the status of hydromorphological elements. This methodology was accepted as the national methodology for the assessment of hydromorphological elements of ecological status for rivers in the Czech Republic. HEM methodology is based on the field survey of a river and its floodplain. The river under evaluation is divided in reaches of heterogeneous lengths and homogeneous nature based on the following indicators: typology of rivers, planform, land cover of the riparian zone and floodplain, and channel modifications. The assessment uses a 5 point scale where 1 means the best score. HEM methodology considers 17 parameters in 3 mapped zones. A different weight is set for each parameter in 8 river types. The overall hydromorphological quality value is calculated for individual reach of the river by using the weighted average of score of individual parameters (Langhammer and Hartvich, 2014). The hydromorphological quality value range is from 1.0 to 5.0. The hydromorphological status classification is based on classification of calculated value of hydromorphological quality for each reach on the 5-level hydromorphological status (HS) – HS1: very good, HS2: good, HS3: moderate, HS4: poor, HS5: destroyed. HS of a river corresponds to reference conditions if the hydromorphological quality value is close to 1 with maximum 1.7.

All results were interpreted over the digital layers ZABAGED 1:10,000 (The fundamental base od geographic data of the Czech Republic) with use of GIS and aerial images were used for background presentation. The basic source of input outflow values was the CHMI database.

4. Results

4.1 Hydromorphological condition and impact of the flood 2013 in the Botič catchment

Botič Brook is typical example of modified watercourse in urban area of the Prague city. The watercourse has a typical symptoms of *"the urban stream syndrome"* e.g: channel and riparian belt modification, increased concentration of pollutants or reduced diversity of biota. The entire mapped segment (R. km 0,0 to 13,3) has been modified in the past. The channel is straightened and continuously reinforced by concrete or stone tiles. The mapped part of the Botič Brook can be divided into two segments. The first segment (r. km 0,00 to 8,70) is classified as poor (HS4) and destroyed (HS5). The rate of alterations is very high; channel is continuously reinforced and deepened. The variability of bed structures and the flow diversity is minimal. The second segment (R. km 8.70 to 13.30) is moderately modified (HS3). The channel has mostly no recent signs of reinforcement and the channel course is meandering. The Botič Brook flows through the nature sanctuary Meandry Botiče which is very valuable in the Prague urban area. The second mapped segment is suitable to protect against possible human degradation.

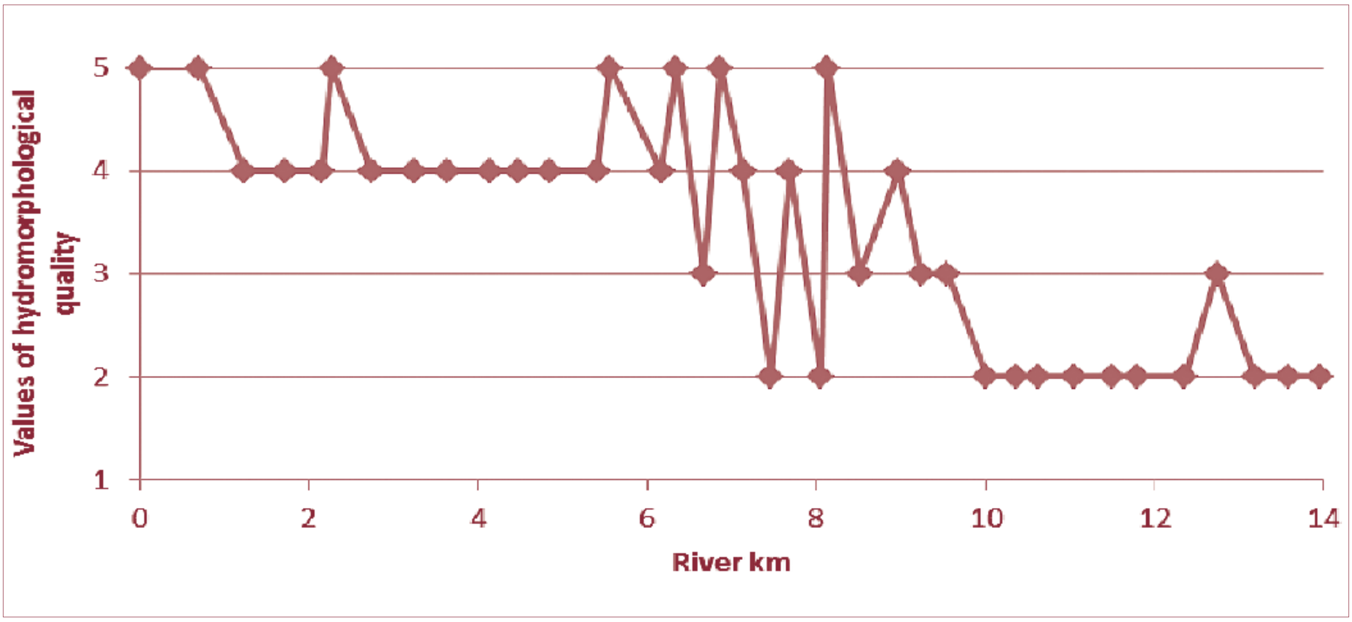

Fig. 1: *Hydromorphological status in the longitudinal profile of the Botič Brook using the HEM method*

Intensive rainfall in upper part of Botič catchment on June 1st and 2nd caused rapid increase of discharges. Extreme level of the flood protection activity was reached in a very short time. The discharges culmination reached 68.5 m^3s^{-1} with the water level of 319 cm on June 2nd in 19:00 at the gauging station Prague-Nusle. The flow peaks reached the level between 50 and 100-years flood. Mostly over flooded parts of the surveyed Botič segment were in Záběhlice, Hostivař and Michle. Numerous of fluvial accumulations were created in the channel and floodplain. High discharges caused damages in channel and riparian zone in several reaches, e.g. channel fortification and roads in the flooded area. Restored reaches near the Folimanka were destroyed as well during the flood.

4.2. Hydromorphological status and modification of the flood plain of the lower course of the Berounka River

Lower course of the Berounka River (0 – 13,7 km) is located in the urban and suburban area of the Prague city. Overall hydromorphological status, according the HEM method is classified as moderate (HS3). Mapped area can be divided into four specific segments. For the first segment (reaches BER001 – BER005) are typical technical flood protection measures. The channel was straightened and deepened; these modifications had complex influence on the floodplain (HS4 poor). In the second segment (reaches BER006 – BER009) the channel course is meandering, but partially regulated. Hydromorfological status of the channel is in moderate quality (HS3), but riparian zones and inundation area are below the average quality. The third segment (BER009 – BER013) is located in the Černošice urban area. Inundation and riparian zone are affected by build-up areas (HS4 poor). The fourth segment (BER014 – BER017) achieves the HS2 and HS3 quality (good and moderate status), even though most of the left bank is located in the urban area. The right side of the floodplain by Radotin is a retention area. But the flood in June 2013 over flooded also the left bank of the Černošice and Radotín urban area. The discharges culmination reached 960 $m^3.s^{-1}$ with the water level of 578 cm on June 3rd in 2013 at the gauging station Berounka-Beroun. Dynamic fluvial-morphologic processes, e.g. bank scours and landslides occurred in mapped reaches during and after flood event.

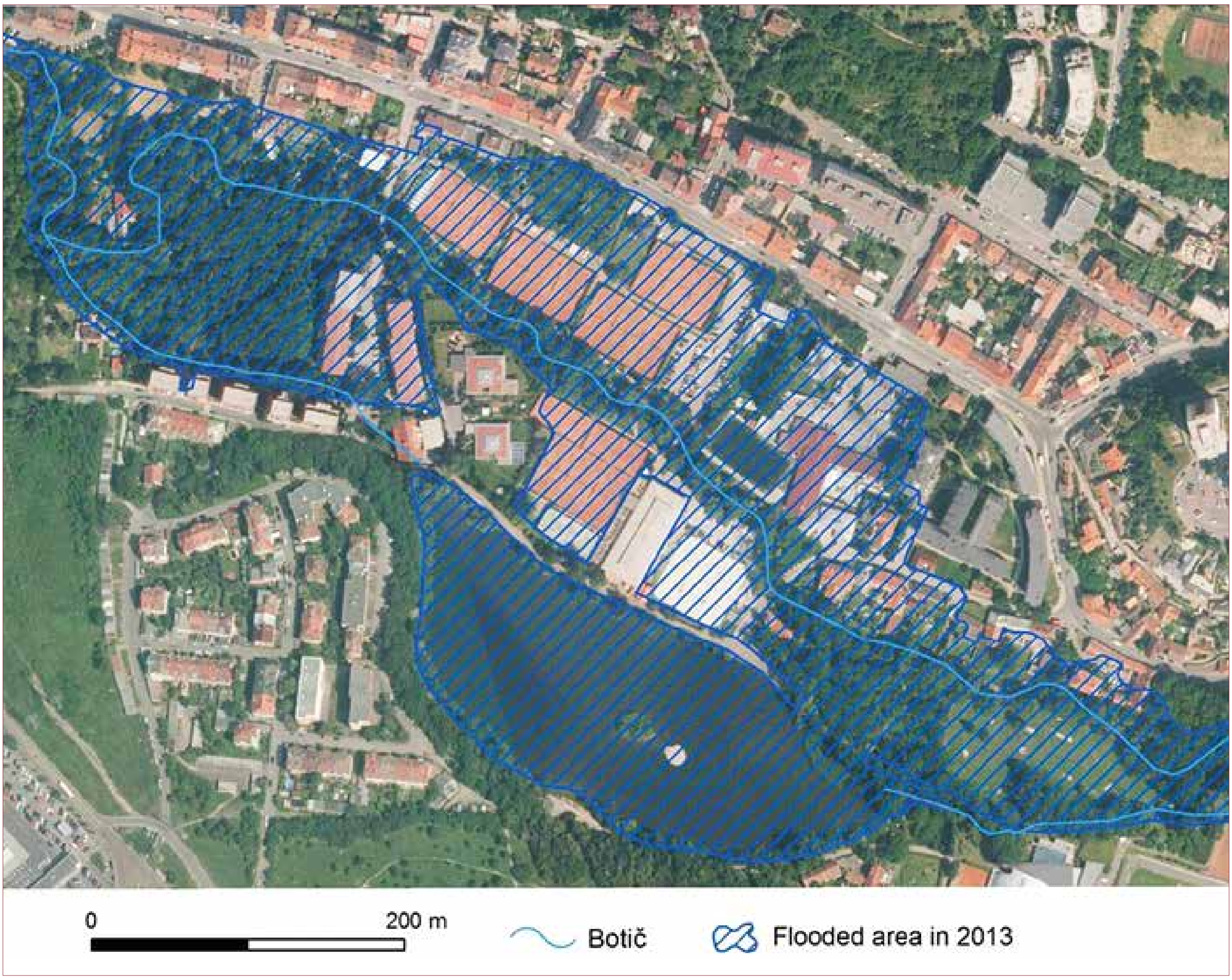

***Fig. 2:** Flooded area of the lower course of the Botič stream in Záběhlice*

4.3. Hydromorphological status and impact of draught 2015 in the Rakovnik Brook catchment

Rakovnik Brook is located in the Central Bohemian region; it is a tributary of the Berounka River. Its upper and middle course flows through intensively used agricultural and urban area, its lower part, on the other hand, crosses a landscape protected area. During the last century almost the entire length of the stream was modified or regulated. Two thirds of the catchment area has been drained and Rakovnik Brook together with its main tributaries has been straightened, deepened and banks have been stabilized. Based on the results of hydromorphological survey reaches with HS4 (poor) were recognized in the Rakovnik city urban area. The uniformity of the channel causes a faster runoff during extreme events such as floods or drought. Increased urbanization and an inappropriate land use in the floodplain area cause an insufficient water retention capacity of soils and thus water deficiency during drought periods. Drought in the summer 2015 had a huge economic and even social impact. Water deficit caused limited water consumption, water quality deterioration and higher risk of forest fires. Riparian zones and floodplain utilization are the primary areas where mitigation measures should be implemented to coping with drought successfully.

5. Conclusion

The Central European population is concentrated in urban areas. The landscape modification has a number of documented effects on stream physical habitat quality. The most consistent impact is an increase in impervious surface cover within urban catchments, which alters the hydrology and fluvial morphology and hydromorphology of streams. Urban streams represent many opportunities for studying river ecosystem disturbances and contributing to more effective water management.

Fig. 3: *Narrowed and deepened channel of the Rakovnik Brook in the city of Rakovnik during the drought in summer 2015. Low discharges below Q355 and poor water quality was recognized. Photo: Matoušková (August 2015)*

Literature

Water Framework Directive (2000). Directive 2000/60/EC of the European parliament and of the Council of 23st October 2000 establishing a framework for Community action in the field of water policy. Official Journal of the European Communities, I., 327/1, Luxemburg.

Langhammer, J. and Hartvich, F. (2014). HEM 2014 Metodika typově specifického hodnocení hydromorfologických ukazatelů ekologické kvality vodních toků. Prague, Ministry of Environment,59 p.

Němec, J. and Hladný, J. (2006): Voda v České republice. Ministry of Agriculture, Consult, 252 p.

Spatio-temporal pattern of sediment contamination and dynamics at the Spree River

Jens Bölscher, Achim Schulte, Konstantin Terytze, Michaela Dumm, René Suthfeldt, Judith Bölscher, Benjamin Vogt

1. Introduction

The plan view of „Rummelsburger See“ (Lake Rummelsburg) is given in Figure 1. It is a former anabranch of the Spree River located in the centre of Berlin, covering an area of more than 45 ha [13, 14]. For almost a century, untreated industrial and municipal wastewater was discharged into the water body. Consequently, the quality of both the water and the sediments decreased dramatically over that period [2, 14]. Previous studies have demonstrated that the sediments still show exceptionally high levels of contamination by heavy metals and organic pollutants, and show a very low level of biodiversity [3, 11, 12, 13, 14]. Based on that, improved knowledge is needed about the spatio-temporal pattern of sediment contamination and dynamics to inform any risk assessment. In order to address these problems the project “RuBuS” was established for the period between Nov. 2013 – Nov. 2015.

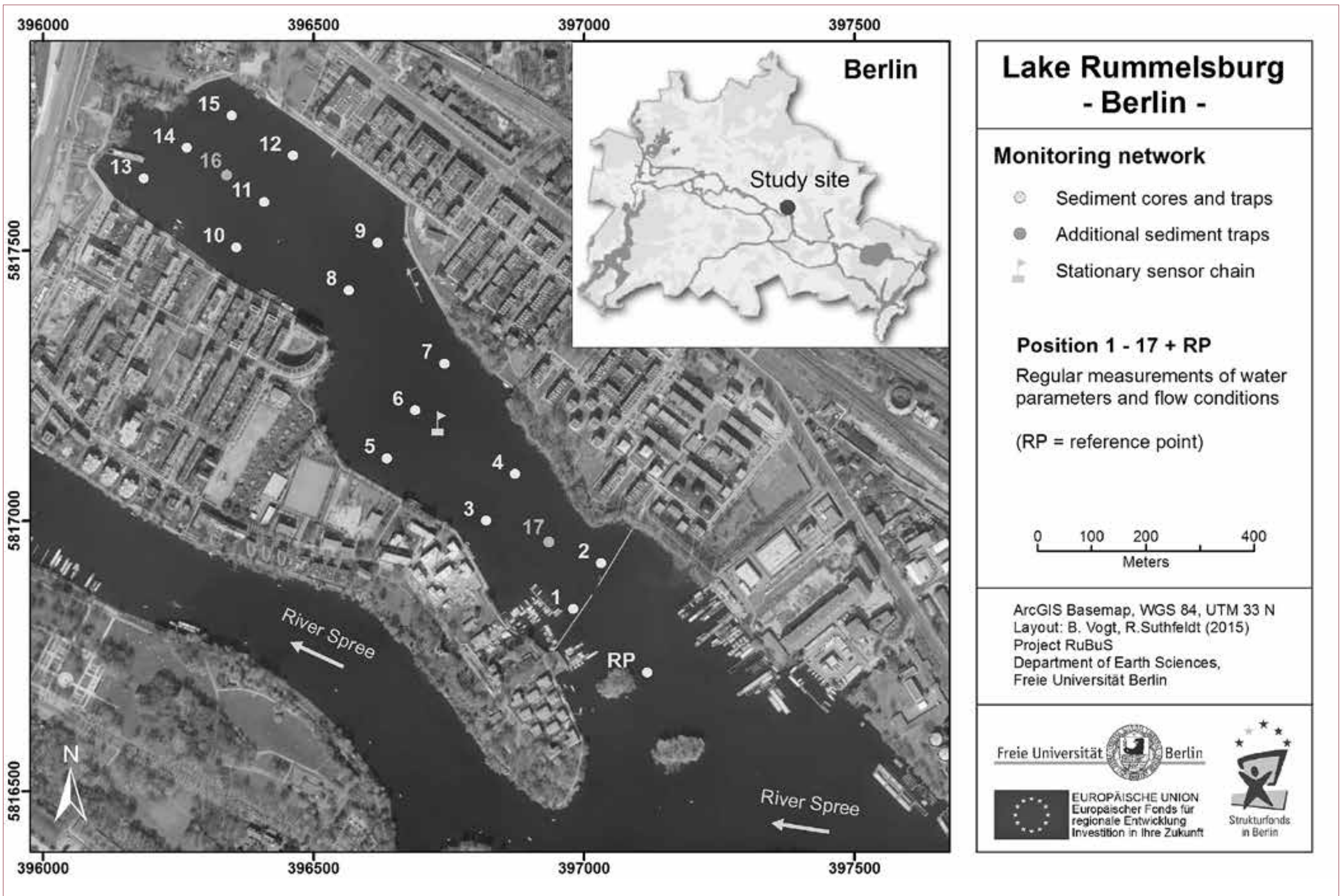

Fig. 1: *A plan view of Lake Rummelsburg (Berlin) and its monitoring locations*

2. Material and Methods

To detect the spatial distribution of pollutants in the sediment, over 200 sediment samples were collected via drill cores at 16 locations: 15 of the 16 sampling locations were distributed across the lake while the final sampling site was located outside the lake to provide a benchmark (see location RP in Figure 1). The upper 15 cm of each drill core was systematically divided into 5 layers (each of 3 cm) for separate examination. The investigation of sediment deposition and remobilisation rates was accomplished by installing 18 sediment traps which collected deposits over more than a year. The presence of selected heavy metals and organic pollutants in the sediments was determined for every sampling location and layer of the drill cores, as well as for all sediment traps. Changes in boundary conditions which influence the spatial and temporal distribution of deposition and resuspension was monitored by placing devices within the lake and taking different mobile measurements (3-D flow conditions, oxygen, turbidity, chlorophyll-a, temperature). To estimate the influence of motorboat manoeuvres on sediment flux within the lake, a special monitoring programme was installed in July 2015. The analysis of sediment and suspended matter included the determination of the total content of inorganic (Hg, Cd, Cr, Pb, Ni, Cu, Zn) and organic compounds (polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH), selected nitro-compounds, selected organotin compounds and polychlorinated biphenyls (PCB, AOX and EOX) in the sediment and suspended matter. The relevant particle size for the investigation of samples for heavy metals was < 63 µm, and for the organic components < 2 mm. The physico-chemical conditions of the samples were examined as well (e.g. grain size distribution). The release of soluble components upon contact with water is considered to be one of the main mechanisms leading to a potential hazard to the environment. The research into soluble and mobilizable sediment-bounded pollutants is based upon a 24 hour batch test [6]. Certain toxic effects of the sediments were determined by different ecotoxicological test methods [4]. In addition, the thresholds of the sediment quality guidelines published by de Deckere et al. [5] were used in this research project to assess the solid contents. The so-called consensus 1 and consensus 2 values were each calculated as an average of an ecological, as well as an ecotoxicological, Sediment Effect Concentration (SEC). The consensus 2 value can be described as the value above which only 5 % or less of the benthic taxa is able to survive and toxic effects are expected. Because of the high concentrations of the pollutants, the consensus 2 values are used as thresholds in this study [5].

3. Results and Discussion

The research provided a detailed insight into this water body and into changes in boundary conditions affecting the spatial and temporal distribution of deposition and resuspension of sediments. Table 1 shows the development of the turbidity as an indicator for sediment motion at 120 cm above bed level (height of sediment traps) from May to December 2014. The table shows that the highest value (16 Nephelometric Turbidity Units [NTU]) was reached at Buoy 16 in August 2014. In general, the north-western part of the lake experienced higher values (Buoys 10 – 16) during that time. The chlorophyll-a concentration showed similar pattern. Thus the increase of phytoplankton was identified as one important factor for the sediment dynamics and deposition during that period. Statistical analyses of additional data sets also evaluated the influence of other processes, such as rainfall or wind speed and direction on turbidity and resuspension of sediments.

Tab. 1: *Values of measured turbidity [NTU] at each position of the monitoring network (shown in Figure 1) for selected dates. The data were captured 120 cm above the sediment*

Date/Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
27.05.2014	3	3	4	6	3	3	7	6	5	6	6	6	6	5	6	3	4
26.06.2014	6	6	8	6	7	7	5	11	8	9	9	9	6	7	6	6	6
31.07.2014	9	8	8	8	8	6	7	8	8	8	8	8	9	8	8	7	8
27.08.2014	10	9	10	9	9	10	8	9	10	9	16	12	9	14	15	12	13
26.09.2014	5	5	6	6	6	7	6	7	6	7	7	7	7	6	7	9	6
30.10.2014	3	2	4	4	3	3	4	3	3	4	4	3	3	3	3	3	3
12.11.2014	4	3	4	4	4	4	4	3	4	3	3	4	3	3	3	3	3
09.12.2014	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The results of the weekly velocity measurements (ADCP) have shown that a slow but constant current moves in the lake. Most surveys indicate that the current in the upper water body travels in a north-westerly direction with velocities of up to 15 cm/s. In general, the speeds vary between 2 and 8 cm/s. In comparison, the current 30 cm above the sediment reached flow velocities of up to 5 cm/s, with an average speed of about 1.5 cm/s. According to Bengtsson & Hellström [1], the shear velocity for particles of 0.1 mm diameter is about 1 cm/s. Even the flow angles show a different picture, with currents going in nearly every direction, sometimes against the currents at the surface level. The pattern of the current was quite stable across the measurements, and was notably independent of the wind direction. The sediment captured in the sediment traps consisted of 60 – 70 % silt, up to 35 % clay and a small amount of fine sand (<10 %). Between 70 – 80 % of the deposited materials were of mineral origin, with grain sizes mainly smaller than 63 µm. Observations showed that between May and November 2014 up to 11 cm of sediment was deposited in the sediment traps, which represents an average sedimentation rate of 27 kg/m² (dry matter) over the period. In total, this adds up to an extraordinarily high relocation and deposition rate of more than 10,000 tonnes of dry matter over the lake area in six months. The results also show that more than 70% was deposited between August and November. Sources include dead algae after strong summer algal blooms and sediments, which were remobilized in particular by wind directions from SE and especially during landing manoeuvres of motorized tour boats. The propeller slipstream, the anchors and the creation of waves into the shore area cause remobilization by boats [9, 10].

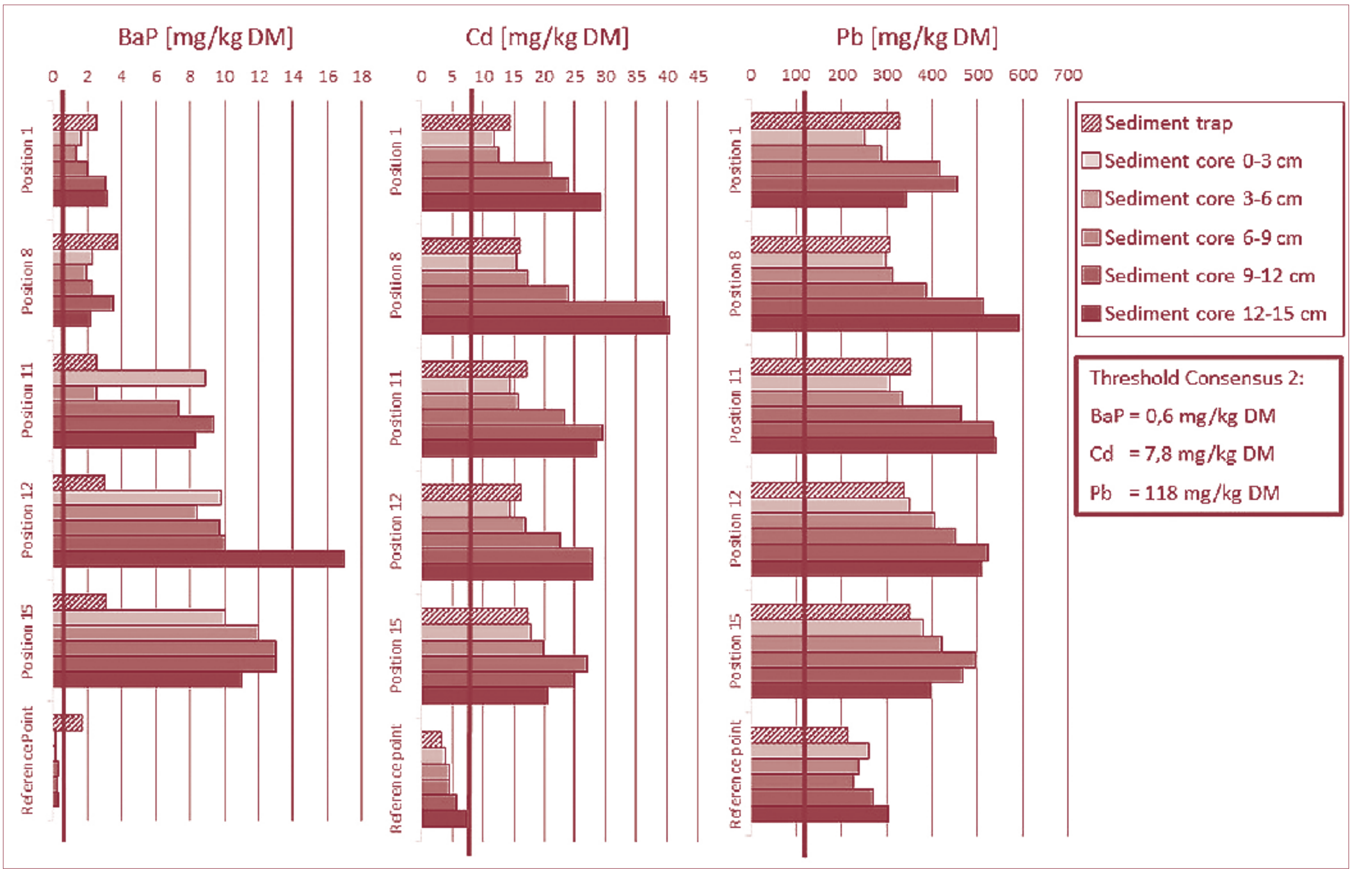

Fig. 2: *Total amounts of Benzo(a)pyrene, Cadmium and Lead at selected sampling sites*

The analysis of the results shows that the concentration of organic and inorganic pollutants in the sediments remains very high. The total contents of the PAHs and all heavy metals investigated exceed the effect-based threshold values according to de Deckere et al. [5]. The results were compared to the "consensus 2" thresholds to identify the measured concentrations, which exceeded the limits and giving rise to concerns regarding toxicity. The only exception among the heavy metals was mercury. Figure 2 shows an example of the total amount of Benzo(a)pyrene (BaP), cadmium and lead measured in the sediment traps, as well as at different depths of the sediment cores of 5 of the sampling points and the reference point. The vertical black line shows the consensus 2 level. With respect to organic pollution, the reference point in the Spree River, which is not very far away from the sheet pile wall, showed concentrations below the threshold. In contrast, the reference point disclosed pollution by heavy metals except for cadmium and mercury concentrations, which were below the threshold. However, the load of heavy metals at the reference point is lower than the one found in the lake. A different spatial distribution of the organic contamination was observed in the lake. In terms of contamination with PAHs, Cd and Pb, areas with different loads can be defined, and this is statistically proven with a significant difference greater than 99%. The less contaminated area is situated between the sheet pile wall and the middle of the lake. Higher loads (sampling sites 10 – 15) were found from the middle of the lake to the north-western shore. However, the sediments in the traps show a homogeneous distribution of the measured pollutants. It was also found generally that the level of contamination increased with sediment depth (refer Figure 2) except at the sampling sites in the middle of the lake which revealed no clear tendency to increase or

decrease depending on the depth. With regard to the level of the European environmental quality standards (EQS), the results of the 24 hour batch test indicates a low mobility of the heavy metals and Benzo(a)pyrene. However, in several eluate samples other PAH compounds exceed the annual average maximum concentration permitted by the EQS [7, 8]. The results of the Luminescent bacteria test showed for the eluates of sediment cores that all samples are not or harmless polluted (non or low toxic effect). However, for the eluates of suspended particles all samples but two are critical polluted, they showed a moderate or increased toxic effect.
The results provide important details on the spatial and temporal distribution of sedimentation and contamination. All sediments of the analysed cores and traps remain highly contaminated with heavy metals and organic compounds. The results indicate the resuspension, transport and accumulation of these sediments and show at least that toxic effects for the benthic taxa are expected. This kind of approach is necessary to create a basis for a remediation programme for, and a risk assessment of, polluted water bodies like Lake Rummelsburg.

4. Acknowledgment

We would like to thank all members of the project group for their support, the Berlin's Senate Department for Urban Development and the Environment and the European Union for their financial support within the framework of the Berlin Environmental Relief Programme II (ERP II) – RuBuS 11429UEPII/2.

Literature:

[1] Bengtsson, L. and Hellström, T. (1991). Wind-induced resuspension in a small shallow lake. Hydrobiologia 241, 163 – 172.
[2] Berliner Senat (2001). Hilfe für den Rummelsburger See. Report of Senate Department for Urban Development and the Environment, Berlin, Germany.
[3] Bundesanstalt für Gewässerkunde (2015): Bestandsaufnahme des Ist-Zustandes der Rummelsburger See Sedimente zur Ableitung von Verbesserungsmaßnahmen für die ökologische Situation. BfG-1836. Koblenz. 92 S.
[4] Calmano, W. [ed.] (2001) Untersuchung und Bewertung von Sedimenten. Ökotoxikologische und chemische Testmethoden. Springer, Berlin – Heidelberg – New York.
[5] de Deckere, E., De Cooman, W., Leloup, V., Meire, P., Schmitt, C., & Peter, C. (2011). Development of sediment quality guidelines for freshwater ecosystems. Journal of soils and sediments, 11(3), 504 – 517.
[6] DIN EN 12457-4:2003-1: Characterisation of waste – Leaching – Compliance test for leaching of granular waste materials and sludges – Part 4.
[7] Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council.
[8] Directive 2013/39/EU of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy.
[9] Gesing, C. (2010) Hydraulische Belastungen am Ufer aus Schifffahrt und Abfluss. Kolloquium Alternative technisch-biologische Ufersicherungen an Binnenwasserstraßen. Wirkungsweise, Belastbarkeit, Anwendungsmöglichkeiten. BAW, Karlsruhe, Germany, 7 – 14.
[10] Kondziella, B., Böder, V., Prokoph, A. & Sauer, A. (2013) Forschung und Entwicklung zum schiffserzeugten Sedimentransport (SeST) im NOK und in der Elbe. Veranstaltungen 5/2013, BfG, Germany, 41 – 49.
[11] Schwarz, S. (2000) Zinnorganische Verbindungen und deren umweltrelevantes Verhalten in den Sedimenten der Berliner und Brandenburger Gewässer. PhD Thesis, Freie Universität Berlin, Germany.
[12] Varlemann R. & Pachur H.-J. (2000) Die Seen der Havel und Spree. In: Die Belastung der Elbe – Teil 2., Hintergrundbelastungen der deutschen Nebenflüsse. ed. Forschungszentrum Karlsruhe GmbH, 147 – 151.
[13] Werner L. (2011) Sedimentkartierung Rummelsburger See 10 – 11/2011. Schlussbericht. Gesellschaft für Umweltanalytik, Boden- und Gewässerschutz. Berlin, Germany
[14] Wolter K.D., Ripl W. 1998 Konzeption von Restaurierungs- und Sanierungsmaßnahmen für den Rummelsburger See, Berlin. Schlussbericht. FR Limnologie, Technische Universität Berlin, Germany.

Revitalisation of the Bílina River at the Ervěnice corridor near Most

Martin Motlík

1. Introduction – a bit of history

In connection with the complex approach to the revitalisation of the area affected by brown coal open-pit mining and building on the continuing consolidation of the dumps after the stoppage of mining, the water management issues in the given area of the Ervěnice Corridor on the route of the Chomutov – Most Road are also being solved.

One of the most significant water elements in the given area of concern is the Bílina River, whose river channel runs in the location of the Ervěnice Corridor via a surface pipeline cpmprising 4 x DN 1200 steel pipes. This, not very suitable ecological solution, which was built at the beginning of the 1980s made it possible to run the watercourse of the Bílina River along the Ervěnice Corridor to compensate the disparity caused by the drop during the consolidation of the mine dump. Currently, practically after completion of the consolidation of the dump, the restoration of the river channel to its initial state is possible, i.e. its relocation from the pipeline to an open channel. One of the pair of pipelines (2 x DN 1200 mm) is presently used as the water supply for the existing small hydro power plant in the Ervěnice Corridor (hereinafter referred to as SHPP EC), and SHPP EC shall in future continue to serve its purpose because of its significance. [2]

The target state of these water management actions is to achieve full restoration of the initial natural character of the landscape taking into consideration the actual needs of this water management system. Within the framework of coal-mining in the coal deposit area of the Most Region, there was substantial interference with the water flows and water management systems.

In the area concerning the Bílina River, this primarily concerns:

a) the cancellation of the Dřínov Reservoir and its replacement with the VD Újezd Reservoir on the Bílina watercourse (built in 1981);
b) the relocation of the Bílina watercourse to the Ervěnice Corridor and its channelling via 4 pipes of 1200 mm diameter and 3.11 km in length (in 1981 – 82);
c) the construction of the feeder in the Ore Mountains Lowlands, which ensures the 100-year protection of the ČSA Open Pit Mine as well as the required water supply.

The Ervěnice Corridor was built using mining engineering techniques in the period from 1978 – 1982 on the inner side of the mine dump (i.e. the mines J. Šverma and Čs. armády) of maximum height 140 m. The main purpose was the protection of the mine against floods and the supply of water to the industry. [3] Apart from the relocation of the road, railway line and other engineering networks between the towns of Most and Chomutov, the Bílina River was also relocated to the Ervěnice Corridor, as one of the most significant water elements in the given area.

The decision to return the Bílina to its open river channel is based on the project ordered by the Ministry of the Environment titled “Water management solution of the recultivation and revitalisation of the coal deposit area of the Ore Mountains Lowlands”.

2. Technical solution of the revitalisation design solution

The actual water channel of the Bílina is suggested for revitalisation in two structurally separate sections. In the first section of a total 109 m length, a boulder chute is suggested that will allow the migration of ichthyofauna. The chute shall consist of boulders of size 0.5 m fixed with concrete in the lower section with a V-shaped cross-section profile. The banks shall be reinforced with hand-packed rock-fill of 50 cm thickness on a sand base. The main section of the water channel of a total 3,045 m length is designed as a trapezoidal profile. This profile is on the basis of a engineering-geological survey locally insulated with mattress padding of geo-composite type (bentonite and two layers of polypropylene geotextiles).

Fig. 1: *View of Bílina in the Ervěnice Corridor in the direction of the town of Most – construction of the EC in 1981*

The insulation was chosen on the basis of IGP recommendations in order to eliminate the risks related to the consolidation of the embankment after filling the open channel with water at exposed points.

The cunette is designed as a variable, **semi-circular-shaped**, with riprap of 30 cm thickness on sand bedding. To facilitate the siting of the revitalised river channel, it is necessary to relocate the existing DN1220 dual pipe feeder used to supply water to SHPP EC. The new feeders shall run parallel to the Most – Chomutov Road outside the area of the new river channel.

Within the framework of other ensuing technical solution modifications of the revitalisation, the new design of the inlet object for the piping and construction of the fish ladder is also solved. The inlet object shall be fitted with a controlled lid – steel weir flap-gate for improved handling of the level in the object. The flap-gate shall operate in automatic mode.

The object shall be supplemented with a new fish ladder structure (hereinafter referred to as the FL) in dual structural design. The first part is of baffle design and made of a trapezoidal profile of 1.2 m width. The bottom and slopes are reinforced with riprap of 20 cm thickness on gravel-sand bedding and the overall length of this part of the FL is 69 m, the remainder of the FL of 55 m length is of a slotted design. The slotted FL is designed as a concrete semi-frame with a total clearance width of 1.2 m. The slots are made of oak partitions of 4 cm thickness set in U-profiles. The total length of the fish ladder is 124 m.

3. Integral parts of the modifications of the surroundings

An integral part of the modifications of the surroundings of the revitalised river channel is the design of modifications of the inflow and outflow object as well as supplementation of the overall area of concern in the corridor with cycling routes and accompanying vegetation. Another object is the construction of a cycling route for pedestrian and cycling traffic, which links the new revitalised river channel to the surrounding roads and parking areas. The new cycling route has a tar surface finish and a standard width of 2.5 m with a paved shoulder on both sides. The total length of the proposed cycling route is 755.5 m.

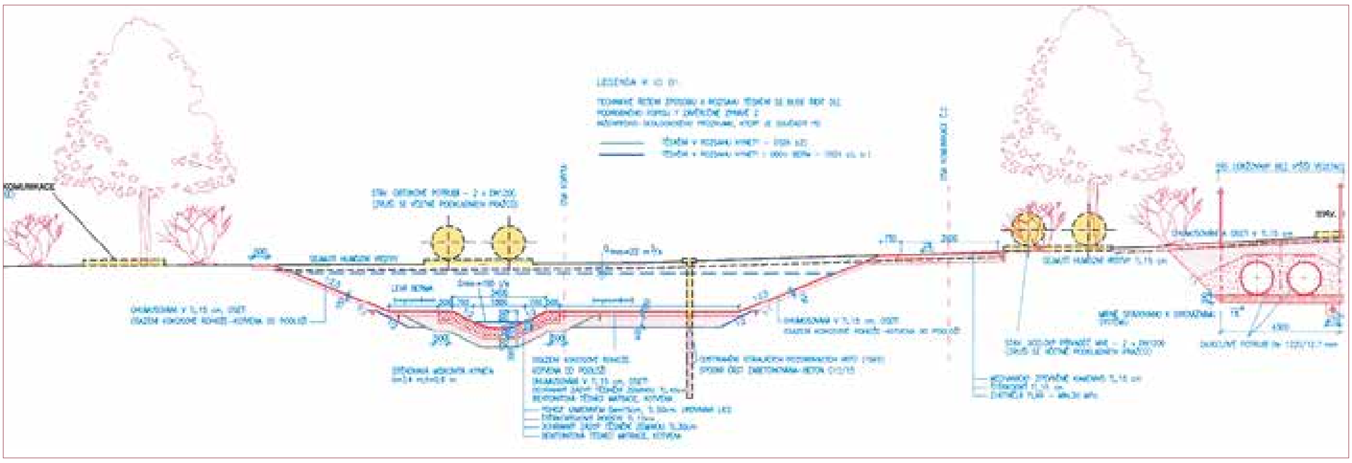

***Fig. 2:** Design profile of the revitalisation of the channel – characteristic profile of the water channel [1]*

The objective of livening up the area of concern is establishment of vegetation elements that link-up to the open channel, newly established during revitalisation, which functionally and optically complete the surrounding landscape. The vegetation elements shall complete the channel on the right bank of the newly designed revitalisation and the left bank shall be left to natural succession. The plants are arranged as a combination of open grassed areas and vegetation. On the open grassed areas, loamy and rocky bumps of approximately 1 m height shall be created, which by their different micro-climatic conditions shall increase the variety of the life space for flora and fauna. The open grassed areas, which are intended for succession, shall comprise 20% of the total area earmarked for vegetative modifications. The structure of the accompanying plants is selected with regard to the type of surrounding landscape.

***Fig. 3:** Revitalisation of the Bílina River – current condition of the inflow object – aerial view – 2015 [4]*

Within the scope of the design, two woody species groups are recommended – preparatory (to be removed after approximately 20 to 30 years) and target woody species. From the preparatory woody species, the following were selected: white birch *(Bettulla alba)*, mountain-ash *(Sorbus aucuparia)*, wild cherry *(Prunus avium)* and common alder *(Alnus glutinosa)*. The target woody species suggested for the area are: pedunculate oak *(Quercus robur)*, Norway maple *(Acer platanoides)*, sycamore *(Acer pseudoplatanus)*, field maple *(Acer campestre)* and Scots pine *(Pinus sylvestris)*. The groups of trees are suitably supplemented with a shrubbery layer.

4. Financing issues

Due to the character of the project, the uniqueness of the solution and extensiveness of the modifications, this is a very expensive revitalisation. According to the expert estimate, the budgeted building costs of this project are about CZK 260 million.

Currently, the possibility to finance the project from a suitable grant title is being verified. Within the framework of previous successful collaboration with the Ústí Region, we assume utilisation of the financial resources which are provided for these projects in relation to the remedy of damage from previous intensive mining operations under the programme titled “Solution of ecological damage arising prior to the privatisation of the brown coal mining companies in the Ústí and Karlovy Vary regions”. The Ústí region in 2014 significantly participated in the funding of the preparation of the project documentation for building construction documentation.

Also under consideration is the grant title – Operational Programme Environment, within which it is possible to also finance some revitalisation modifications related to landscape restoration. Unfortunately, it is not possible according to the current rules to include all the projected building structures in the ensemble of eligible costs according to the applicable rules within this specific project.

However, due to the uniqueness and diversity of the proposed technical solution for this project, we still believe that the financial resources for its realisation shall be found.

Literature:

[1] Revitalisation of the Bílina River in the Ervěnice Corridor – construction documentation (04/2014) – issued by VH-TRES spol.s.r.o.
[2] Significant waterworks Ohře Watershed (1976) Povodí Ohře
[3] Significant waterworks Ohře Watershed (1986) Povodí Ohře
[4] Photo archive of Povodí Ohře státní podnik Chomutov

The story of a purple river

Ibra Ibrahimovič

When my mother, who worked as a checkout clerk at a grocery store, would get free tickets from the ROH (Revolutionary Trade Union Movement) for a children's theatre performance, I would ride the bus with her from the town of Meziboří (until the end of WWII Schönbach) in the Ore Mountains where we lived, to the Theatre of the Workers in the district town of Most.

I would board the bus by the Town Hall, and liked sitting either at the very back or as close as possible to the driver, near the fare box, right by the rounded, hot, red cowling of the motor.

In Litvínov, we would transfer at the stop on the main square behind the church, beside a large concrete parking lot on the site of recently demolished Art Nouveau buildings (to this day it is occupied by the angular Elko shopping centre and prefab “panelák” apartment buildings).

While my mother waited in line at the conductor’s counter on the tram, I would save her a seat on the long leatherette-upholstered bench. During the trip, I would lean against her gently. The trip to Most was slightly oppressive and simultaneously thrilling – whether it would all turn out OK, as about midway through the trip we had to pass near the chemical plant, which I was afraid of.

Already in Litvínov, passengers smelling of chemicals, smoke, and sweat would board the leatherette-scented tram. A cold fog roiled outside the tram window, pierced by silhouettes of chimneys and tall flames from gas flares; everything near the track was sullied with black soot, and the dominant colour was grey. Near the Stalin Plant, there was always a terrible stench. I ruminated whether it could actually blow up, or if we’d be lucky once again. As we would pass the freight yard with its countless cisterns, the stench would begin to recede, and I would feel much safer and would feel happy that we had once again passed it safely!

In Most we would first pass under the viaduct by the spa, and then would get off at the stop a little ways past it. The tracks criss-crossed here, and there were lots of metal railings that I wasn’t allowed to climb through, as well as two ridiculous little ticket huts. Here, we would transfer from tram no. 4 to tram no. 2, which went to the theatre.

I could tell that we were near the centre of Most by the horrible, acrid gasoline smell. It emanated from a footbridge near the traffic island, under which a completely black, oily river flowed. To me, its name seemed absolutely unbecoming of what I saw and tried not to smell. I would plug my nose with all my might, and breathing as little as possible would watch what in my eyes was the greatest attraction in Most, until a clinking sound indicated it was time to board our tram.

The Bělá [White] River flowed lazily and slowly, was dark brown to black, and elicited in me a lazy, even asphalt-like impression. Occasionally something dead would float by, sometimes it had a rainbow sheen, and its vicinity, including the footbridge on which I would stand, was dusty, dark, and grey. I was unable to understand how it was possible and where so much stinky grime could come from. If it was really from the chemical plant, the conditions for those working inside it must be truly horrible...

Robert, Hedvika, Eliška, Gröhmann, Jupiter, Kvido, Julius, Humboldt, Anna, Matylda Evžen, Richard, Jan, Přemysl, Berta, Amálie, Anna and Berta, Emerán, Rudiay, Ludvík, Lotty Marie, Max, and Svornost [Unity]: after World War II, these were the names of the mines in the Most lignite basin that the river passed. It was also polluted by the thermal power plant in Ledvice, by the sugar refinery and distillery in Most, and by the local steel plant. However, the greatest role in its abasement was played by the Litvínov chemical plant, which starting in 1942 produced synthetic aviation fuel from coal as the STW AG (Sudetenländische Treibstoff Werke AG) chemical plant, and later as the Stalin Plant produced various petroleum products.

It arrived from Záluží in Most not as a river, but as a poisoned brownish-black open sewer with purple oily spots, which people remember smelling of phenol. During the 1960s, the river smelled so bad that the residents of Most demanded it be covered. From the spa to the theatre, especially near residential buildings, it was covered in several places with concrete panels.

The river was poisoned along the remainder of its course, through the town of Bílina until Ústí nad Labem, where it merges into the Elbe. In Řehlovice it also received effluent from the Libar cosmetics factory, and in Trmice paint waste from the Ústí chemical plant. As locals recall, the Elbe was light grey, and along its left bank the Bělá River would mix with it like the tail of a black (occasionally rainbow-coloured) comet that could still be seen in Březno.

Starting in 1962, the City of Most was promised a high-capacity wastewater treatment plant, including for the nearby chemical plant. After numerous delays it was finally commissioned in 1973. According to Svět motorů [Motor World] magazine, in the beginning its effect on the cleanliness of the river was negligible.

That year I celebrated by 6th birthday. At that time, the tormented royal city of Most, decrepit due to a long-standing ban on construction work, began to be demolished to make way for extraction of the lignite that lay beneath its surface. The only part of this beautiful city that the Communists decided to save was the Church of the Assumption of the Virgin Mary, which was moved a few hundred metres away on transport trucks along special rails. I used to go watch this unique attraction with my grandfather. I also remember that later I would go with my friends on secret trips to the demolished city.

In 1974, the distillery at the chemical plant exploded. Grandpa picked me up at kindergarten, we climbed the hill above the gardens on the outskirts of Meziboří, and watched the flames lighting up the destroyed plant. In the fall I began attending school.

Starting in 1982, I commuted from our village to Most to vocational high school, by tram, naturally. On the trip between Litvínov and Most I would watch the sun rise from behind the Church of the Assumption of the Virgin Mary, and the fog that lingered above the hole of the Most strip mine. On the site of the former city, conveyor belts transporting coal to the Herkules processing plant ran alongside the road. In a concrete channel right beside the conveyors flowed the Bělá River, looking almost clean to the naked eye. That year during the summer holidays, the first “Washtub Race” took place in nearby Želenice, featuring various decorated amateur vessels. The people stopped being afraid of the Bělá River, even though it was still very toxic.

After the Communist regime was toppled in 1989, I began doing photography, and since 1991 I have been working on a project on northern Bohemia and the local environment. I take pictures of the landscape and document the stories of local people.

With the financial help of the Czech Ministry of the Environment and the T. G. Masaryk Water Research Institute, since last year I have been working on a photo series on the Bílina River. I use mainly 6x12 cm format black and white film, and am in this way attempting to follow up on the photographic legacy of Josef Sudek and Josef Koudelka, who recorded the local landscape in a similar manner in the 1970s and the 1990s. I look for places that have something to say about the relationship between the locals and the river, and those that illustrate its troubled history...

When I was little, people called the Bílina the Bělá [White] River. This is why I use this inaccurate name in my text describing my childhood experiences.

Challenges in Floodplain and River Restoration in the Elbe Catchment – Case Study "Lebendige Luppe" – Revitalization Project in Leipzig's Urban Floodplain Forest

Mathias Scholz, Rolf Engelmann, Carolin Seele, Anna Herkelrath, Annett Krüger, Timo Hartmann, Jürgen Heinrich, Christian Wirth, Jens Riedel, Hans Dieter Kasperidus

Summary

In the Elbe catchment already many projects for floodplain and river restoration have started, but only a few have been finished. One of the larger projects in Central Germany is the revitalisation project "Lebendige Luppe" started in 2012. The objective is the revitalization of more than 16 km of a former river course in Leipzig's northern floodplain ecosystems, with one of the largest urban floodplain forests in Germany. One of the main objectives is to improve floodplain dynamics to increase the quality of the habitats for plants and animals, and to maintain and increase its ecosystem functions and services for people. Unexpected events like the flooding events in January 2011 and in June 2013 inundated the study area and showed the potential of the former river dynamics in the project area.

The presentation will give a short overview of floodplain restoration projects in the German Elbe catchment and presenting more in detail the project "Lebendige Luppe" with its planning challenges in a strongly modified hydrological river and floodplain network in an urban context.

To measure the effects of the river and floodplain restoration a scientific monitoring design was established and indicators for restoration success were identified. First results of the field campaigns for hydrology, soil and biodiversity in 2013 to 2015 will be presented, which are describing the current status of the main ecological features of the area.

1. Introduction and background

The floodplains of the rivers White Elster (Weiße Elster), Pleiße and Parthe are crossing the city of Leipzig as a „green backbone". Because of its widespread hardwood forests this area is classified as a significant Central European floodplain ecosystem [1, 2]. The most natural areas are part of the European Natura 2000 network. Large parts of this floodplain forest are mixed stands with large structural diversity and a high diversity of flora and fauna. Its uniqueness lies in the comparatively large natural area, which has been preserved despite intensive anthropogenic interventions in the river and floodplain system and the immediate proximity to the city. The area of the project is concentrating on the northwest floodplain of Leipzig, which has been formed by the White Elster and its several side arms. The most important ones are the river sections of the Old and New Luppe.

Interventions such as river regulation measures, extensive diking and the drainage of agricultural and pasture fields have had significant impacts on the floodplain. Several impacts have been the result of the creation of the river section New Luppe (Neue Luppe) to serve flood protection in the 1930s and completed in the 1950s. Former river sections were cut off and could not provide the floodplain forest with water anymore. As a result, the formerly water-rich floodplain landscape suffers from massive decline of the groundwater table and is drying out. Today the area consists of many dry river beds without connectivity and a decrease of dynamic floodplain ponds and oxbow lakes [3, 4]. This is a threat among others also to the biodiversity of the floodplain forest and related ecosystem services. Because of the impacted hydrological system only extreme hydrological flood events can reach the floodplain forest and lead to a degradation of the remaining floodplain ecosystem.

In the same time, the floodplain of Leipzig has an important function as recreational area and significantly contributes to life quality of the city residents. The floodplain is appreciated and intensively used by the Leipzig inhabitants especially for cycling, sports and walking.

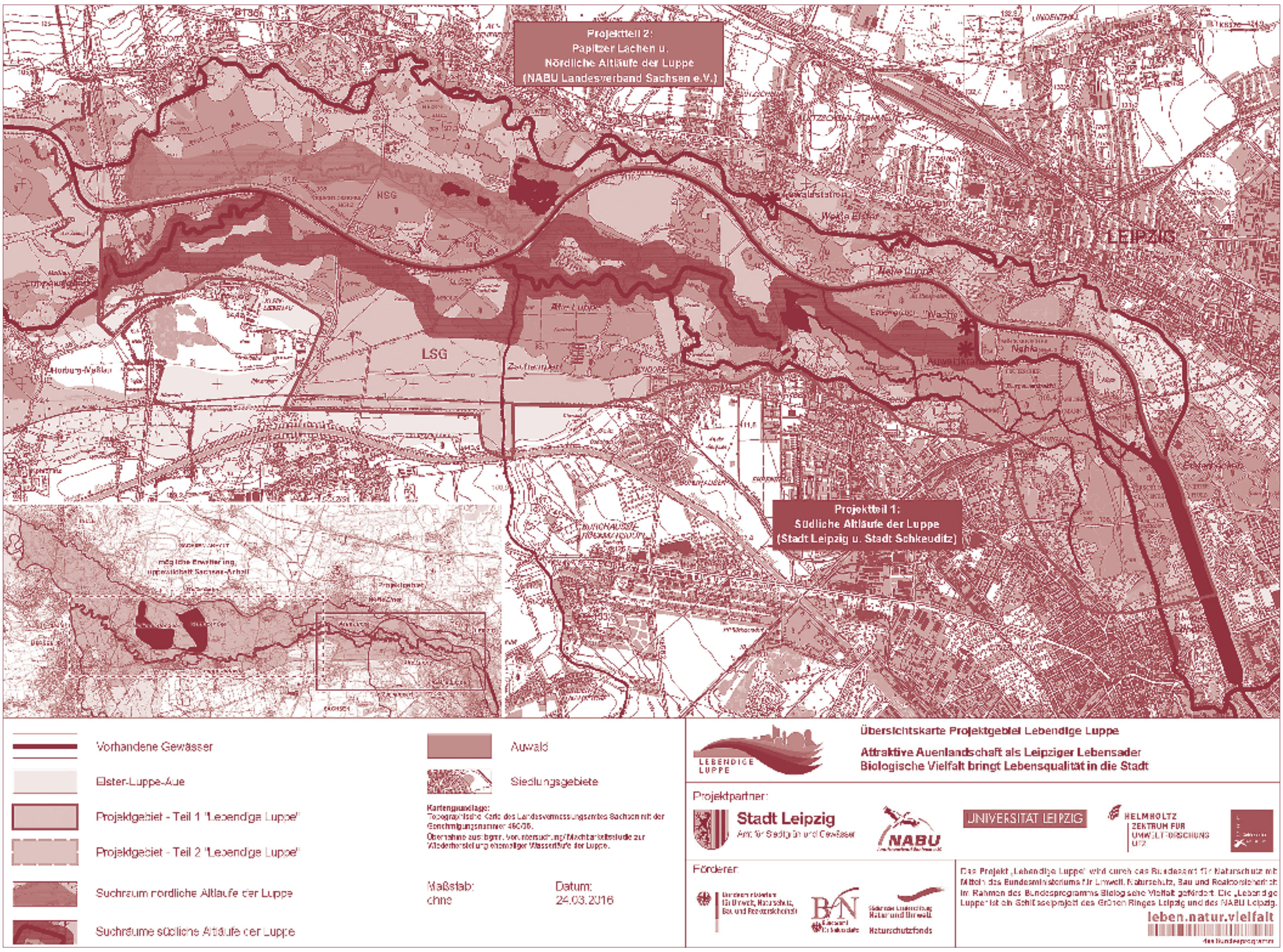

Fig. 1: The planned new water course of the "vibrant Luppe". (Source: BGMR, Project Lebendige Luppe, www.lebendige-luppe.de)

2. The project "Lebendige Luppe"

The restoration project "Lebendige Luppe" (Vibrant Luppe) is one of the largest projects on floodplain and river restoration in Central Germany and started in 2012 (– 2019). The objective is the revitalization of more than 16 km of a former river course in Leipzig's floodplain ecosystems. In the northwest floodplain of Leipzig, dried-up river arms of the former water-rich floodplain, especially of the river Luppe, are to be filled and reconnected again with water and create a continuous water landscape [3, 4]. This activity, combined with the still existing Wildbett Luppe in Saxony-Anhalt, will lead to increased ecological continuity up to the River Saale further upstream. Additionally the project aims to increase the inundation by allowing significant floods to reach large areas of the floodplain via the new river course. It is planned to achieve inundation of at least 30 % of the floodplain area via the new river, mainly floodplain forest. The groundwater table should be stabilised and raised by about 1 meter in most parts of the project area. The revitalisation of stretches of the Luppe should help to counteract the present situation of water shortage in the floodplain and enhance again the diversity of floodplain species and habitats and related ecosystem services, like nutrient retention.

The project also places emphasis on communicating the importance of the floodplain ecosystem for people and nature. The ecosystem services provided by an intact floodplain, such as oxygen supply, sequestration of carbon dioxide and the provision of space for recreation increase the life quality of city inhabitants.

The project is to be considered as a part of a mosaic of different actions to be taken to achieve a more extended revitalisation of the Leipzig floodplain in the future and is planned as a no-regret measure [4].

Major flood events in January 2011 and in June 2013 inundated most of the project area and showed as an important precondition for the project Lebendige Luppe, that the floodplain is still functioning when sufficient inundation is provided. As the project is still in development, the scientific monitoring has to demonstrate the concrete effects on floodplain species and biodiversity. In a first part of the project, which has already been realised, it has been achieved to restore the water supply of a former dredging area and to increase the floodplain typical water supply in the most important Amphibian habitats in the area. The creation of the new river itself is in a planning stage, first construction works are planned to be started in 2018.

3. Scientific monitoring

The project is supported by a scientific long-term monitoring to measure the effects of restoration measures on groundwater dynamics, water and nutrient balance in the soil, of flora and fauna biodiversity and carbon storage. By comparing the ecological situation before and after the measure an indication system for ecological changes in riparian forests will be developed, which allows to measure the effects after restoration.

For this purpose, the selection of 60 permanent plots using a stratified random design were selected in the floodplain forest and additionally on most of the plots groundwater monitoring wells for interdisciplinary observation were installed.. The study design is following a BACI-design [5], means the plots should cover the ecological situation before (B) and after (A) the realisation of the measure in time, and covers control (C) and impact (I) plots (non-effected areas as reference areas) in space. The chosen strata are representing plots with wet, medium and dry hydrological side conditions and are separated in plots which will be affected by the restoration measure or no influence will be probable.

Results of this field surveys are underlying the non-favourable situation in terms of a real floodplain forest. The mean groundwater level is far away from its natural situation; inundation takes place only during extreme events directly or via seepage water. The project area is dominated by alluvial soils (mainly Vega and Vega-Gley), and therefore rich in organic carbon. Together with the above surface situated biomass of the alluvial forest this ecosystem has an important role as carbon storage for greenhouse gas emissions. Especially the remaining wet areas are showing the highest carbon storage rates. Although the herbaceous layer is well describing a hydrological gradient, which is characteristic for floodplain forests, the tree compositions display a large proportion of non-flood tolerant tree species.

4. Outlook

There are still considerable planning challenges on the way to a full revitalisation of the Leipzig floodplain as the interests of other water users and owners must be taken into account. The river and floodplain network especially inside the city of Leipzig has been strongly modified in the past for technical flood protection. In addition, the water supply of the existing or new river arms especially during low or medium water discharge has to cope with small hydropower stations along the Weiße Elster, the dilution of the sewage treatment plant water, the minimum environmental instream flow of all water courses and the requirements of urban sanitary environmental engineering. Also the scientific monitoring has to cope with these changes and still has to meet these new developments.

It should be noted that a full floodplain dynamic cannot be achieved only via the actions which are taken by the project Lebendige Luppe. Wider processes, for example of sedimentation and sediment redistribution, are dependent on frequent large-scale inundations by spring flooding and the unregulated flow of sufficient water quantities of floodplain rivers. The overarching framework conditions set for flood protection and sanitary environmental engineering are decisive for the regulation of flow in and close to the urban area and cannot be influenced to a large extent yet by the actors of the project Lebendige Luppe.

More information: www.lebendige-luppe.de

Literature:

[1] Kasperidus H.D., Scholz, M. (2012) Auen und Auenwälder in urbanen Räumen. In: Chr. Wirth, A. Reiher, U. Zäumer, H.D. Kasperidus (Hrsg.) Der Leipziger Auwald – ein dynamischer Lebensraum. Tagungsband zum 5. Leipziger Auensymposium am 16.April 2011. UFZ-Bericht 06/2011, 26 – 30.

[2] Scholz, M,. Mehl, D., Schulz-Zunkel, C., Kasperdius, H.D., Born, W., Henle, K. (2012) Ökosystemfunktionen in Flussauen. Analyse und Bewertung von Hochwasserretention, Nährstoffrückhalt, Treibhausgas-Senken-/Quellenfunktion und Habitatfunktion. Schriftenr. Naturschutz und biologische Vielfalt 124, 258 p.

[3] Putkunz J. (2012) Lebendige Luppe – attraktive Auenlandschaft: Wiederherstellung ehemaliger Wasserläufe der Luppe im nördlichen Leipziger Auwald. In: Chr. Wirth, A. Reiher, U. Zäumer, Kasperidus, H.D. (Hrsg.) Der Leipziger Auwald – ein dynamischer Lebensraum. Tagungsband zum 5. Leipziger Auensymposium am 16.April 2011. UFZ-Bericht 06/2011, 31 – 37.

[4] Riedel, J., M. Vitzthum (2014) Lebendige Luppe – Attraktive Auenlandschaft als Leipziger Lebensader – Biologische Vielfalt bringt Lebensqualität in die Stadt. DWA Rundbrief Landesverband Sachsen/Thüringen 44, 11 – 12.

[5] Smith, E.P. (2002) BACI design. In: El-Shaarawi A.H., W.W. Piegorsch (Eds.): Encyclopedia of environmetrics. Vol. 1. Wiley, Chichester, U.K: 141 – 148.

Acknowledgement

The city of Leipzig is responsible for the coordination and the implementation for the technical measures together with the neighbouring city of Schkeuditz and the NGO NABU Saxony. Scientific monitoring to evaluate the ecological effects is undertaken by the Centre for Environmental Research – UFZ together with the University of Leipzig, Intitule for Biology and Institute for Geography. Public relation and environmental education tasks are carried out by the NABU accompanied by the University of Leipzig, Institute for Sociology.

The project „Lebendige Luppe" is supported by the Federal Agency for Nature Conservation with funds of the Federal Program for the Biological Diversity from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. In addition, funds from the Conservation Fund of the Saxon Foundation for Nature and Environment are used. It is a key project of the Green Ring Leipzig.

Application of UAV imaging technologies for monitoring of changes in streams and floodplains

Jakub Langhammer

1. Introduction

The paper discusses the potential of Unmanned Aerial Vehicles (UAVs or drones) for applications in water management with a focus on rapid mapping of stream properties and monitoring of stream channel changes.

Current progress in hydrology and fluvial geomorphology is largely based on new field survey and analysis techniques, which employ advanced technologies to monitor the stream channels and runoff process. Application of these techniques provides researchers and river managers with information at a significantly higher qualitative level than using traditional methods of field surveys and measurements either in terms of spatial accuracy and resolution, the frequency of sampling or qualitative characteristics of the acquired data.

In particular, the rapidly evolving technologies of UAV, covering a wide range technologies are opening new possibilities for detection of stream properties and monitoring of their status and changes at the high level of accuracy [1, 3]. Customizable flight routes at low-level altitudes in combination with new algorithms photogrammetric analysis provide spatial data products of ultra-high spatial resolution, suitable for qualitative and quantitative analysis of natural and artificial structures of streams and floodplains and their changes by the natural processes (i.e. floods) or anthropogenic modifications.

2. Material and methods

Aerial platforms

The rapid development of the drone-based imaging technologies resulted in a variety of applicable platforms, suitable for image acquisition. We can distinguish two basic branches of UAV platforms, applicable in water management, each of different parameters and also limitations and suitable applications – the unmanned aircrafts and multirotor platforms. Unmanned aircrafts with a form-factor of miniaturized planes allow a fully automatic operation over the study areas, based on a pre-programmed flight track. These are applied mainly in compact undisturbed areas with no forest vegetation or settlement – typically for precision farming, mining or engineering. Multirotor platforms, most frequently applied in research, forestry or natural hazard monitoring, allow both automatic and manual operation and have excellent maneuvering capabilities at different flight speeds and altitudes. They feature high versatility for application with different sensors and operation in complicated terrain conditions.

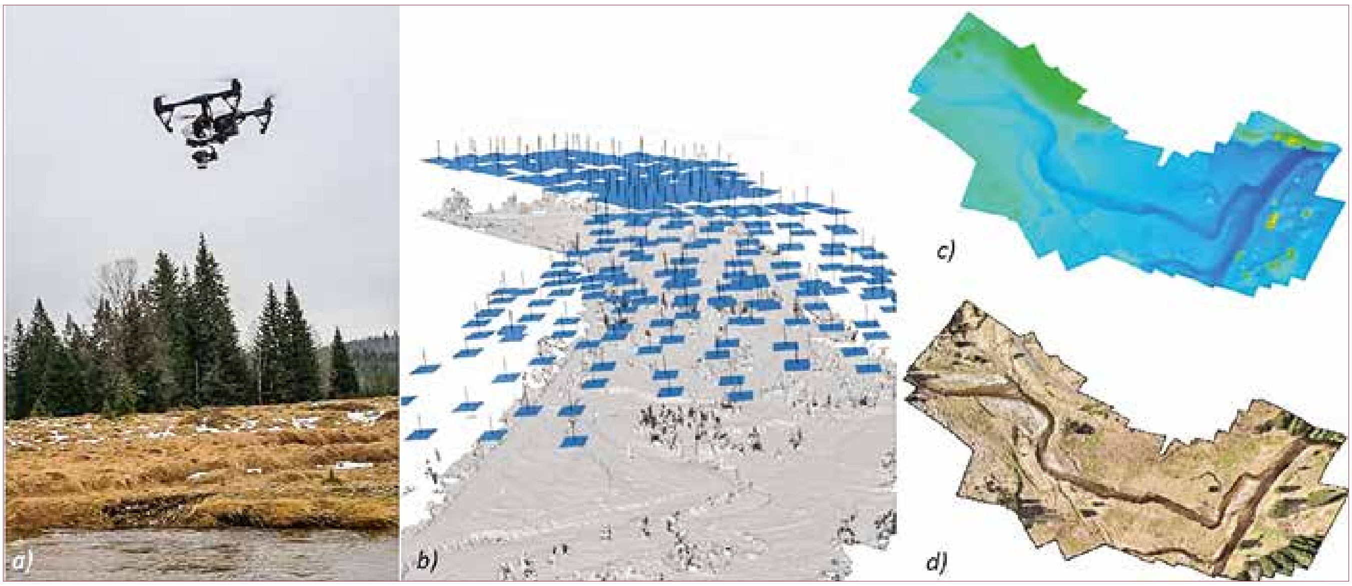

Fig. 1: *Principle of drone-based 3D reconstruction of channel and floodplain. a) imaging using the multirotor UAV platform Inspire 1 Pro, b) creating dense point cloud from aligned imagery using the Structure from Motion algorithm, c) Digital elevation model (DEM), derived from the dense point cloud, d) orthophoto map.*

Photogrammetric treatment of data

The UAV platforms are used to acquire the digital imagery, taken perpendicular to the Earth surface, which is further used for 3D reconstruction of the terrain by means of photogrammetric analysis, based on the geometric-mathematical reconstruction of the direction of the photographic rays in the image [3]. This reconstruction – the aerotriangulation – stems on the information on the elements of the external and internal orientation of the camera – the y, y, z coordinates of the camera and the three camera tilt angles (ω, φ, κ), all relative to the ground coordinate system. The new generation of photogrammetric algorithms, in particular the Structure from Motion (SfM) or Semi-global matching (SGM) provide an automatic calculation of such parameters and the reconstruction of the 3D topography from the imagery taken from different viewpoints [2]. Application of these methods eliminated the key constraints of conventional photogrammetric approaches and enabled wide-range applications of UAV for manifold applications in geosciences [3].

The key steps of photogrammetric analysis based on the SfM approach consist of the acquisition of the imagery featuring overlaps (Fig 1a), detection of pairs of points for aero triangulation, image alignment and generation of dense point cloud (Fig 1b), from which are derived two key deliverables – the Digital elevation model (DEM, Fig 1c) and orthoimage (Fig 1d).

Applied methods and technology

For our study, we have used the multirotor platform DJI Inspire 1 Pro, equipped with 16 Mpx camera with interchangeable lenses. For general reconnaissance and rapid mapping the UAV was operating at the altitude of 70 – 90 m, for detailed analysis of selected features, requiring a higher level of spatial detailed the flight altitude was 40 – 50 m. Photogrammetric treatment was done using the Agisoft Photoscan Pro software.

The paper is presenting results from two types of environments with a different level of human impact.

First study area is Hostavicky brook in Prague, demonstrating a stream in an intensively urbanized area, recently undergoing revitalization. The UAV technology is here applied used for mapping of stream properties and for monitoring of the progress of revitalization. The second case study is the Javori brook in Sumava mts. as an example of a montane stream with high intensity of fluvial activity in response to repeated flooding. Here, the UAV is employed to analyze the changes to the stream channel, including the quantitative analysis of spatial and volumetric changes to the stream.

3. Results

Mapping and identification of stream properties

For the case study of Hostavický brook, the bi-monthly monitoring of stream channel changes has been launched to track the stream changes after restoration in 2015. The repeated imaging campaigns by the multirotor platform provided 2D and 3D data of ultr-high resolution, enabling detailed analysis (Tab. 1).

Tab. 1: *Parameters of photogrammetric reconstruction of Hostavický brook for imaging campaign 2016-04-30.*

Number of images	299	Ground resolution	1,27 cm/pix
Flying altidude	54,6 m	DEM resolution	5,07 cm/pix
Coverage area	8870 sq m	Point density	389 492 points per sq m
Dense point cloud	35 486 019 points	Reprojection error	0.97 pix

Both of the two key data products from the UAV photogrammetric analysis – the digital elevation model and the orthoimage proved to be suitable resources for hydrological analysis. The complex segment of stream in a length of 1 km is covered by a multitemporal set of seamless orthoimagery with resolution of 1,5 cm per pixel. Such resolution allows identification of stream properties, relevant for applications in fluvial geomorphology and stream management. It applies to the identification and documentation of the artificial structures (Fig 2a) and modifications to the stream as well as to the stream hydromorphological features, as is shown in the example of the stream channel, jammed by the wood after a rain storm (Fig 2c). Multi-band imagery allowed distinguishing the qualitative properties of the fluvial structures, i.e. the detection of eutrophication in the ponds, created in the framework of stream restoration project (Fig 2b).

***Fig. 2:** Example of the potential of UAV orthoimage data for identification of stream properties and structures in the Hostavicky brook, Prague. a) stream restoration works on the channel, b) identification of eutrophication at artificial ponds, created during the stream restoration, c) identification of the in-stream obstacle, resulting from wood debris after a spring storm. Data: Charles University in Prague, 2016.*

3D reconstruction of channels and floodplains

The high-resolution 3D model resulting from UAV photogrammetry allows deriving information about stream channels and floodplains with accuracy superior to the conventional data sources. The point density of the UAV-based 3D models is significantly higher even compared to the most recent topographic models, based on the aerial LiDAR scanning. The average density of recent common aerial LiDAR scanning data products (e.g. DEM DMR5G) is typically ranging from 1 to 6 points per sq meter according to the data quality, terrain characteristics and data source [4]. The point coverage density achieved from UAV photogrammetry is several orders higher – on the example of Hostavicky brook, it was 389 492 points per sq m. Although such ultra-high density of 3D terrain reconstruction, achieved by means of UAV photogrammetry cannot be acquired for extensive large areas, it enables to cover complex segments of streams and floodplains, where the high-resolution topography is of key importance for river management. The multitemporal analysis of the Javori brook in montane area of Sumava mts. allowed an accurate calculation of areal and volumetric changes in streams of floodplains in research of fluvial dynamics of montane streams in response to elevated frequency of flooding in relation to climate change [3, 5]. The reseach proved that the acquisition of highly accurate, reliable and rapid information on changes of streams or floodplains is applicable e.g. in mapping of the effects of natural hazards – e.g. the consequences of floods or landslides, for engineering in water management, as well as for different purposes, i.e. detailed tracking of stream restoration or preparing topographic networks for detailed flood protection models (Fig 4).

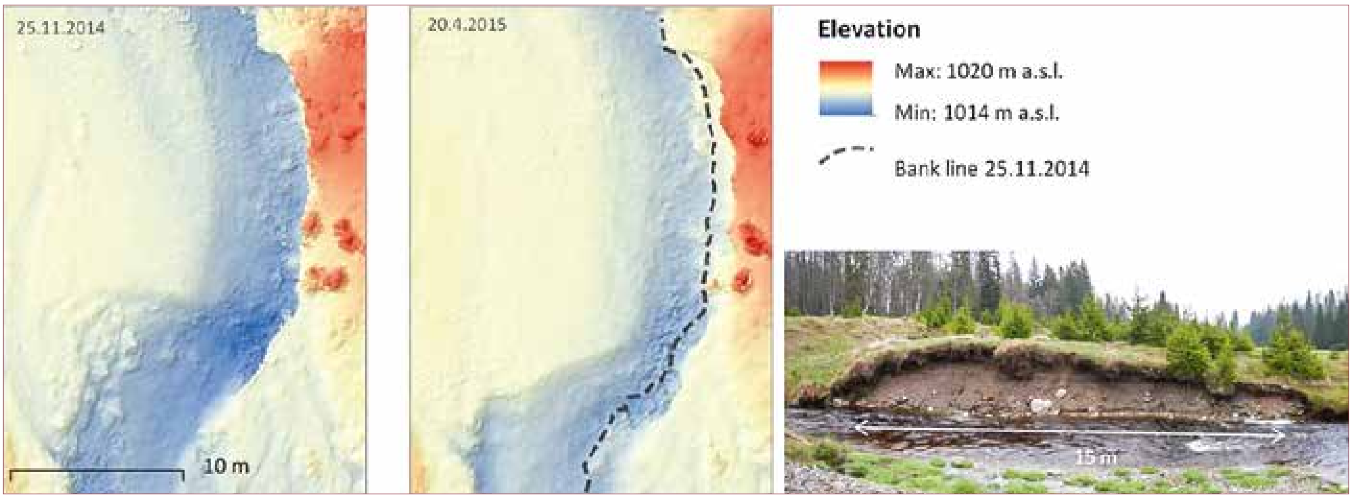

***Fig. 3:** Progress of lateral erosion in a meander of Roklanský brook. Data: Charles University in Prague, 2015.*

4. Conclusions

Application of UAV imaging technologies in water management is a rapidly developing field with high potential for applications in areas, where is required spatial and qualitative information with high level of spatial detail with high flexibility and operability in data acquisition and reasonable costs of operation.

This paper presented the potential of the UAV technologies for monitoring and management of streams based on selected case studies. We have used multirotor imaging platform equipped with calibrated camera to produce high-resolution imagery of streams and floodplains in multitemporal time scales in different environments – urban and montane. The imagery, treated by the photogrammetric analysis using the Structure from Motion algorithm resulted in multitemporal data sets of ortho imagery and precise digital terrain models that allowed analyzing various aspects of the changes in streams. In an urban area, the UAV was employed to track the stream restoration and to identify the changes in hydromorphology and qualitative properties. In the montane area, the UAV was used to calculate areal and volumetric changes in the river channel, resulting from repeated flooding.

The research proved the high suitability of UAV technologies for precise monitoring of streams and high versatility of the technology for a variety of tasks in hydrological research. For water management, the major contribution of the UAV technology is (i) ability to acquire spatial information with unprecedented resolution and quality, (ii) potential for accurate detection of natural or artificial structures in streams and floodplains, (iii) potential for potential for calculations of volumetric and areal changes in streams, (iv) high flexibility and ability of multitemporal monitoring of stream channels and (v) cost-effectiveness of imaging campaigns.

Literature:

[1] FLENER, C. et al. (2013): Seamless mapping of river channels at high resolution using mobile liDAR and UAV-photography. Remote Sensing, 5, č. 12, s. 6382 – 6407.

[2] TURNER, D. et al. (2012): An Automated Technique for Generating Georectified Mosaics from Ultra-High Resolution UAV Imagery, Based on Structure from Motion Point Clouds. Remote Sensing, 4, č. 12, s. 1392 – 1410.

[3] MIŘIJOVSKÝ, J. a LANGHAMMER, J. (2015): Multitemporal monitoring of the morphodynamics of a mid-mountain stream using UAS photogrammetry. Remote Sensing, 7,. 7, p. 8586 – 8609.

[4] BRÁZDIL, K. (2015): Technical report to the 5th generation Digital Elevation Model DMR 5G. Prague, 12 pp.

[5] LORINC, M. (2015): UAV photogrammetry as a tool for analysis of fuvial morphology of streams. Thesis. Charles University in Prague, Faculty of Science, 52 pp.

Fachbeiträge

Odborné příspěvky

Magdeburger Gewässerschutzseminar 2016

Magdeburský seminář o ochraně vod 2016

Extremereignisse

Extrémní situace

Magdeburger Gewässerschutzseminar
MGS
2016
Magdeburský seminář o ochraně vod

The City of Dresden‘s Concept for Urban Water Courses: Integrating Flood Risk Management with the Development and Experiencebility of the Water Bodies

Christian Korndörfer, Harald Kroll

1. Introduction

Dresden holds Germany‘s forth largest city surface and close to 500 brooks and small rivers with a total length of over 400 km as well as 275 ponds and lakes. From 1933 until the beginning of the nineties, the water body maintenance had been woefully neglected.

When in 1999, Dresden‘s municipal environmental authorities began to take over the duties of water body maintenance, most of the water courses were heavily impaired and water facilities were in desperate condition. The sidewalls had been decayed, the runoff hindered by untended green and most of the wells had been cased as a consequence of agricultural engineering measures. Within urban settlement areas, many water courses had lost their accessibility. Almost all brooks were far too undersized to be able to discharge major floods.

The urgently required improvements in the water bodies‘ ecology, their function as sewer drainage, their experiencebility and a timely installation of an up-to-date flood control system were only achievable with the help of an integrative approach, which at the same time differentiates the City‘s manifold water body types. As early as in 2000, a primary functional water body development concept featured the above mentioned management aims according to the respective water body types‘ characteristics (e. g. V-shaped valleys cutting through the Elbe‘s high banks, artificial water bodies along the Elbe valley, wide open valleys of the high plains), but no budget was projected for realization [1].

On August 12th 2002, up to 160 mm of precipitation was measured in the urban area of Dresden, which correlates with an area-wide precipitation event of centennial recurrence. Virtually all municipal water courses‘ banks were flooded at the same time and the majority of the water facilities failed to function or broke down. This resulted in a multi-million damage to water courses, bridges, adjacent roads and buildings. Along with this existentially threatening “August Flood” experience, flood control and water body development climbed the City‘s task ranking. Within a short time, the required staff and monetary settings were provided.

2. Integrative Approach to Flood Management and Water Body Development

The integrative approach leads to the following principles of flood management and water body development which have built and still build the practical guideline to design measures along Dresden‘s “small” water courses:

a) Improvement of flood retention in the upper courses, especially by forestation of highly effective runoff surfaces, renaturation of brooks, temporary retention in polders and green basins.
b) Debris management before the water course enters built-up areas with today‘s over 100 screening units as well as minimizing their freight by promoting erosion-mitigating farming and forestry.
c) Reducing flood peeks by nature-orientated rainwater management in built-up areas, especially along with urban land-use planning and assuring non-hazardous runoff by effective channel profiles. These are designed with bio-engineered banks and near-natural buffer land where ever there is adequate room.

In order to achieve all these aims, a number of quite different measures are required along a certain river course. The crucial point will always be to have enough space available for the brooks and rivers within built-up city areas. The Dresden Landscape Plan and the Dresden Land-Use Plan, which is under way, will provide the according preconditions. In the Landscape Plan‘s spatial structure policy called “The Compact City Within the Ecological Network”, the urban water body system forms the clasp for a network of linked, linear green corridors. The water body system displays the flow channel and contributes to flood control, groundwater reformation, urban climate regulation, local recreation as well as to nature and species conservation [2].

On equal ranks with both ecology and flood control – which are fields of action laid down in the European Water Framework Directive and the European Flood Risk Management Directive and subsequently in the German law – the water courses' experiencebility for human beings is taken into focus of water body development as its third field of action. Past experience has shown that only citizens' acceptance and respect of water body development and flood control measures allow them to be implemented successfully. This means in practise not simply to decorate the measures with maintenance and walk lanes along the water courses, seating elements at the river banks (which at the same time serve as bank protection), benches and works of art, but to embrace the provision of opportunities for the citizens to directly perceive the water course esthetically and sensually as a planning task of equal value. Such a multiplied social welfare effect enhances the willingness of decision-makers to provide the required areas.

3. Basics of Flood Management and Water Course Development of Small Water Courses Exemplified by the Prießnitz River

The Prießnitz River is Dresden's biggest urban river course. The catchment area measures 51,2 km² (see figure 1).

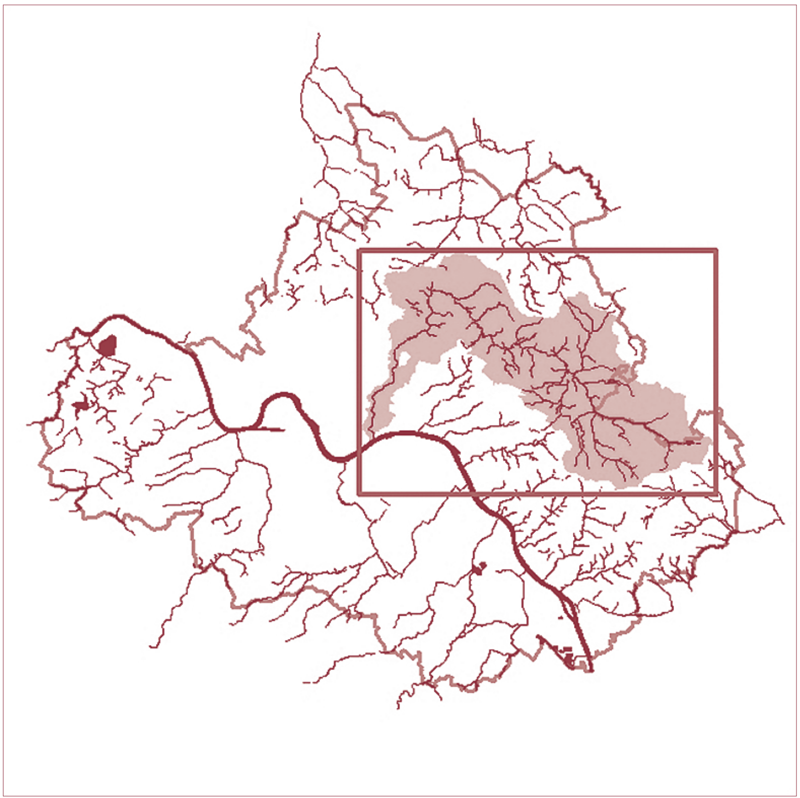

Fig. 1: *Map of Prießnitz Catchment Area*

The Prießnitz was assigned to the water type 5 (coarse-grained, siliceous Central Mountain brook). The 100-year flood peak discharge measures 29 m³/s at its mouth, the mean water discharge collects 0,37 m³/s. In especially dry summers, the discharge will seep into its sandy bed and the Prießnitz may run dry in its lower course. This occurred only recently, from August 10th to August 17th, 2015.

The waterbody's properties alter substantially throughout its course. The source area with Rossendorf Pond widely features a close-to-nature character, but fishery contaminates the pond. Within the following river stretch until the Dresdner Heide (woods), the Prießnitz runs along the city borders through an agricultural area. In the beginning of the 20th Century, the upper course had been straightened. As a consequence, the river bed wears out heavily. Therefore floods can discharge within the bed to a large extend. According to the latest evaluation the ecological state is unsatisfactory.

Within the Dresdner Heide, a landscape protection and FFH area, the Prießnitz's course has predominantly kept its natural or at least close-to-nature characteristics. The Prießnitz then runs, mostly channelized, through Dresden-Neustadt, a densely developed Gründerzeit-style city district, before it discharges into the Elbe River. The latest evaluation depicts a modest ecological state. There is substantial risk of flooding, both by Elbe backwaters and Prießnitz floods.

In order to improve flood retention in the upper course, various measures have already been implemented or are being projected. At the Weißiger Dorfbach and Dammbach, both Prießnitz tributaries, green retention basins were built, the brooks were de-channelized and shaped in a close-to-nature way (see figure 2, I-016 and I-017). Close-to-nature retention areas were established both at the tributary Mariengraben and at the Prießnitz, and ponds were remodeled for flood management purposes (I-041 and I-226). In order to safeguard a commercial area from being flooded, the tributary Kirchweggraben was de-channelized and repositioned. In this process, also a lane along the water course was built (I-051). To safeguard the Weißig city district, the tributary Wiesengraben is currently being de-channelized and repositioned. Here as well, a lane along the water course will improve the experiencebility and link an important path network (I-018). Within the context of compensation measures, several hectares were reforested. The biggest and most important development measure is the project of reshaping and implementing inherent dynamism into the complete Prießnitz upper course (I-266). By raising the river bed, the adjacent plains are to be flooded on a regular basis again. The flow retention is to contribute to flood retention and peak mitigation. The renaturation of the water course is to improve the ecological conditions and to enhance the habitat for brook trout (Salmo trutta morpha fario) and sculpin (Cottus gobio) as well as for benthic invertebrates. The hydraulic engineering's considerations are embedded into a touristic and recreational concept.

Before entering the Dresden-Neustadt district, the Prießnitz is projected to run through a driftwood screen unit which is to predominantly hold off the driftwood from Dresdner Heide (I-237).

Three rainwater retention basins run by the Dresden Stadtentwässerung GmbH (the urban drainage provider), reduce the drainage peaks in the settlements of the Weißig district. Additionally, close-to-nature rainwater retention areas are scheduled.

In the Dresden-Neustadt district, close by the community gardens, the Prießnitz river has to be repositioned (I-050) in order to avert substantial damage to the bank and bed stabilization. This measure will be implemented in accordance with the European Water Framework Directive and European Flood Risk Management Directive requirements, will improve the ecological conditions and will mitigate the Prießnitz's flood peak. By reshaping, part of the Prießnitz flood plains will be made accessable to the public again. The plan provides lanes and playgrounds and recreation areas at the fringes, so that the Prießnitz flood plains may become a central green and recreation area for the Dresden-Neustadt citizens.

On hot days, clean and cool air will be transported along the renaturated Prießnitz flood plains from the Dresdner Heide to the heat-accumulating residential areas of the outer Dresden-Neustadt, which results in a comfortable climate. This way, the reconstructed flood plains will represent an important junction within the concept of the ecological network, in which the densely built-up areas are embedded.

The Prießnitz action plan (see figure 2) demonstrates, that it is possible and neccesary to implement the European Directives to improve the ecological conditions and to manage flood control integratively. Water courses will become experienceable and offer space for recreation, for rainwater infiltration as well as for flood retention. The microclimate will be improved and endangered species will find space to survive.

For further information please see the Gewässersteckbriefe on the City of Dresden's web page: http://www.dresden.de/de/stadtraum/umwelt/oberflaechenwasser.php.

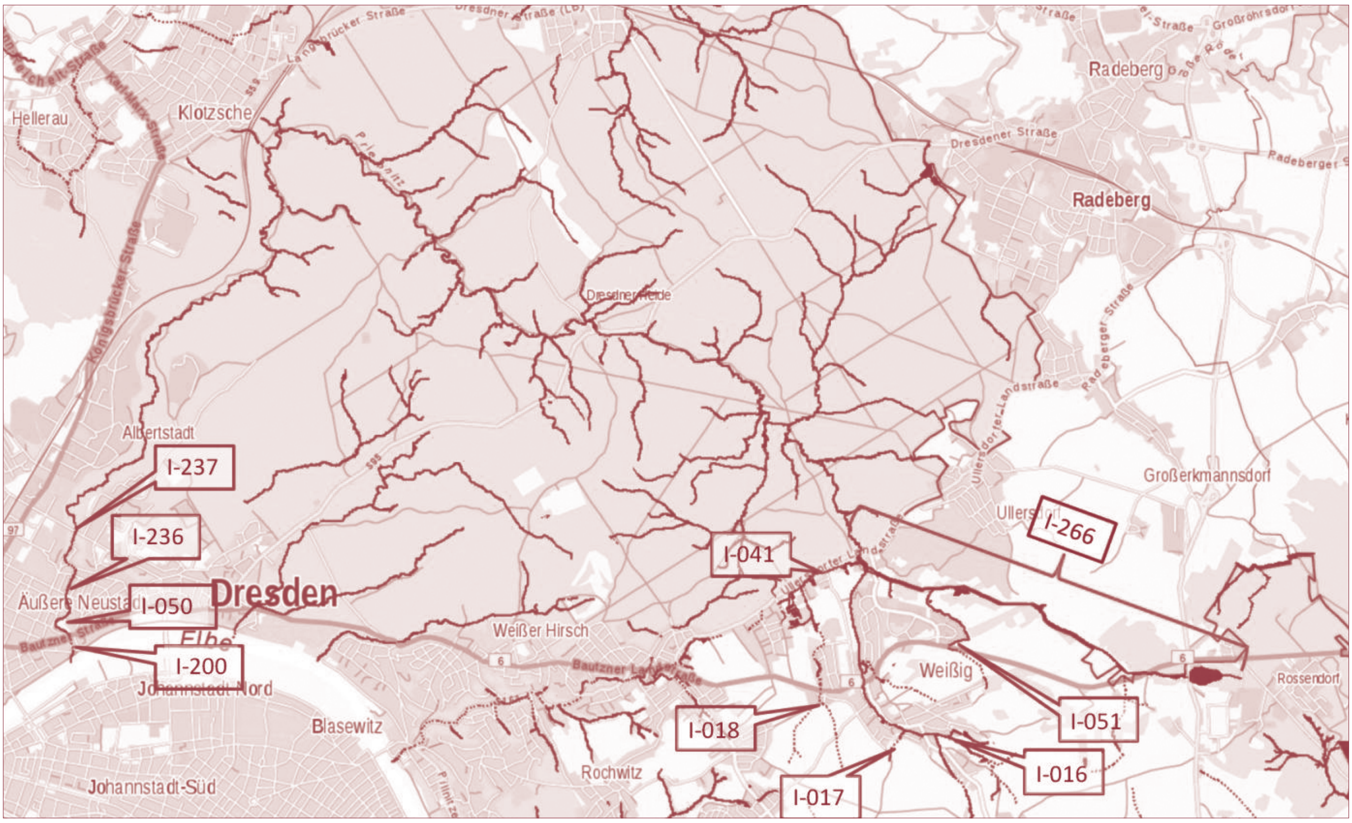

Fig. 2: Prießnitz action plan

I-237 driftwood screening unit
I-236 territiorial protection
I-050 Prießnitz flood plains
I-200 ecological passability arch
I-041 renaturation and flood plain basin
I-018 de-channalizing
I-017 flood retention basin and de-channalizing
I-266 inherent dynamism
I-051 de-channalizing
I-016 flood retention basin and de-channalizing

Literature:

[1] Landeshauptstadt Dresden, Umweltamt, (Hrsg.) (2004) Umweltatlas, Karte 4.11 Gewässerentwicklungskonzept. Dresden.

[2] Korndörfer, C. (2012) Anpassung der Landeshauptstadt Dresden an eine Zukunft mit verändertem Klima und knappen Ressourcen. In Grünewald et al. (Hrsg.) Wasserbezogene Anpassungsmaßnahmen an den Landschafts- und Klimawandel. Stuttgart: Schweizerbart Science Publishers.

Vltava River Cascade – the multipurpose system of water reservoirs in the light of recent hydrological episodes

Tomáš Kendík, Karel Březina

Abstract

Since the year 2000, has been the Vltava Cascade of reservoirs frequently loaded with extreme hydrological situations – floods and droughts. The versatility of the system implies certain restriction in water management and the function of the cascade becomes a subject of criticism from public every time after an extreme situation occurs. Based on the analysis of hydrological data from the last 60 years, the new watermanagement solution has been developed in the year 2014. The paper aims to evaluate the effectivity of the most important reservoir system in the Czech Republic and to clarify its impact on the flow rates of the Vltava river downstream and Elbe river subsequently.

1. Introduction

The Vltava cascade is a multipurpose system of water works built on the Vltava River, in the years 1935 – 1964, exception of Hněvkovice and Kořensko dams, built in the eighties, in relation with construction of the Temelín nuclear power plant. It is the largest system of water works in the Czech Republic and consist of a total of nine water works – eight reservoirs and one submerged-weir. Part of this system are, among the others, Orlík dam which its total volume of 716,5 m^3 is the biggest reservoir in the Czech Republic and Lipno dam, which is the largest lake in the Czech Republic, where the flooded area at the maximum level is total of 48,7 km^2. Already during commissioning of the Vltava cascade to function was considered that it will be a multi-purpose system of water works, with the main purpose of electric power supply and provision of minimal outflow in periods of drought. Complex water management rules [1] currently defines these purposes of the system of reservoirs: water storage function (provision of minimal outflow), electricity production, reduction of flood flows, surface water extractions, improving of navigation conditions on the Vltava and Elbe rivers, influence of flow rates for water quality improvement, winter flow rates influencing, recreation, water sports, sailing in the reservoirs and fishing.

For water handling control have been developed sub-handling rules for each reservoir and for coordination of water handling in this system is used the comprehensive handling regulations rules. Custom control provides the central watermanagement dispatching of Povodí Vltavy, state enterprise in cooperation with the dispatching of the energetic company ČEZ, s.c. Water distribution and water runoff decision-making process is the responsibility of the river basin authority – Povodí Vltavy, state enterprise. In terms of influencing of the flow-rate regime in the lower reaches of the Vltava and Labe river are critical Orlik and Slapy reservoirs. In times of the project was developed expert watermanagement solution of the system of reservoirs to ensure all-purposes demanded by the public at that time. Based on the results of this solution were developed water handling rules that determine the allocation of the reservoir volumes. Some purposes in terms of the use of these volumes are mutually in conflict. For example provision of minimal outflow in seasons of drought, requires enough of water in reservoir and flood protection requires flood-protective volume empty. Although it is a large reservoir, but these are not significant relative to the size of the basin and capabilities to ensure reliable flood protection. All these factors were in the watermanagement solution of reservoirs reflected. The flood-protective effect of the system of reservoirs, at the time of project, was determined for ten-year flood. The fact that the significant hydrological extremes avoided to Orlík water work after its commissioning in 1964, had been positive in terms of flood damage. But the public got the impression that the system is able to perform its purpose, especially flood protection, practically with no limitations. The public got the impression that waters is still plenitude and it never will be significantly more of. That there is no risk of droughts and all of flood episodes Vltava cascade can handle. The first significant hydrological extreme has occurred in August 2002. It was the very first time in the current existence of reservoir the biggest one. Historically the largest recorded, catastrophic flood.

2. Floods

In 1954 Vltava river was affected by flood, which in a few hours filled the unfinished and empty Slapy reservoir. The peak of the flood was significantly reduced. This gave rise to the misconception that the Vltava cascade, is able to protect the lower course of the river against the flood. But experts warned that this is not true and all the simulations suggest that, but this point of view in a society deeply rooted. A period between 1954 – 2002, when significant flood didn't occur, the faulty reasoning strengthened. After a long period of flood-calm, flood event began to occur, which clearly stands out the flood from the August 2002. Worth mentioning is also the floods of March and April 2006 and June 2013, which in its scope and consequences can be described as catastrophic.

The flood in August 2002 was a typical summer flood, caused by regional rains of high intensity and long duration. These rains came in two waves, when the first caused high saturation of basin and the second one already a flood of such magnitude, that in many places in the basin of the Vltava river overstepped the highest recorded water levels and flow rates in duration of the measurement. The Vltava Cascade water works was significantly affected and the biggest impact was recorded to Orlík dam, which is located in the heart of the affected area. The inflow to the reservoir has exceeded the design parameters and thus the maximum water level in the reservoir was overstepped. Although flood caused many damages, dams of the Vltava cascade in this test were successful and helped reduce this flood.

Flood events in spring 2006 and June 2013 had smaller range; however the consequences and the attention of the media classified them as very important in the history of the Vltava River cascade. The spring flood in 2006 was caused especially by spring thaw which was supported by heavy rain precipitations. The Orlík water supply storage was being depleted during whole winter to be able to catch higher spring inflows. Water level drawdown always matched with actual water snow storage in the Orlík dam basin. Thanks to the bigger free storage, the flow on lower Vltava River was regulated under the harmless discharge. Flood in June 2013 was characterised mainly by steep rise and by location near central part of the Vltava River cascade thus near the Orlík and Slapy dams so the pre-depletion of water supply storage was not possible. On top of that this flood event was not predicted by hydrological forecasting service.

Mainly these three flood events have caused, in the Czech Republic, a lot of questions, speculations, polemics and opinions about possibilities of Vltava River cascade to reduce flood impacts. Major part of these opinions took place in media on non-professional level. Many criminal complaints were made nevertheless expert studies found no errors or malpractices. Handling of water during the floods was correct and in compliance with regulations. Subsequently these flood extremes have been balanced by droughts.

3. Droughts

Immediately after the floods in 2002 the strong drought came in 2003. During this period minimum flows were detected. The reservoirs of the Vltava river cascade, especially Orlík and Lipno dams, have shown their potential in improvement of discharge for the first time of their existence, when they were being depleted for the substantial part of this year and helped the lower courses' situation. The very same situation was registered in 2015, when the Vltava river cascade influence was even more significant. The Vltava lower course and the Elbe River were feeding by the Vltava river cascade reservoirs water releasing, with utilization of the Orlík dam at the first place. Authors of this article are convinced that the irreplaceable role of reservoirs in the long-term drought managing has been shown.

4. New water management study of the Vltava River cascade

After the floods in 2002 a lot of opinions to strengthen flood control measures thus extend the flood surcharge of the Vltava River cascade have been appeared. However in 2003 the intensive and long-term drought has confirmed the importance to fulfil the main cascade purpose so to guarantee the minimal residual discharge. Water surface level was decreasing with all consequences for recreation, navigation and other purposes of the Vltava River cascade so it was decided not to change the distribution of the reservoir storages. The next significant floods in 2006 were transformed into harmless discharge thanks to huge drawdown during the whole winter period. At the beginning of the floods in 2013, the free reservoir storage was doubled in comparison to the estimated flood surcharge; nevertheless the harmless discharge on the Vltava lower course was overstepped. Nearly after water level decrease mayors on the lower Vltava course started to demand the

Fig. 1: *Orlík water work – Podolský bridge – 20150927*

augmentation of the flood surcharge even though the experts informed that this flood had highly overstepped the level of possible flood protection by cascade.

Povodí Vltavy, state enterprise decided to commission a water management study to assess possible variations of reservoir storage distribution (increase of flood surcharge) and the impact of these potential changes on main purposes of the Vltava River cascade. One of the variations was extreme and assumed the Orlík dam totally empty. The author of that study is Czech Technical University in Prague, Faculty of Civil Engineering, Department of Hydraulic Structures [2]. The study considers 8 variations of flood surcharge increase and assesses the impact on securing minimal residual discharge during the drought period, level of flood protection, power engineering, navigation and recreation for each of them. In conclusion of the study the author recommends to enlarge the Orlík reservoir flood surcharge by half of its volume to 93 mil. m^3 without any impacts on the other main purposes. This solution provides flood protection increase from 10-year flood to 20-year flood. The new Orlík dam handling regulations approved in December 2015 contains these changes. According to the result of the study from CTU in Prague any other enlarge of the flood surcharge in Orlík reservoir means limitations for the other purposes of the Vltava River cascade.
During 2015 the public was being acquainted with the study results. Municipalities on lower Vltava River have not been satisfied with modification of the Orlík reservoir flood surcharge and have demanded to increase this storage even more. On the contrary municipalities situated near the Orlík dam have accepted this lowering of Orlík water supply storage as the maximum possible. An argument to support this maximum lowering is the recreational purpose of this reservoir which also brings employment opportunities for many people. Furthermore the drought long-term period in 2015 when water level in the Orlík reservoir decreased by more than 10 metres has intensified their opinion of highest possible normal top water level need because the tourist season was significantly affected. At that time, there was a long discussion about harmonization between main purposes of the Vltava River cascade in the Czech Republic. It appears that before any decisions about prioritising one purpose above other, the economical analysis is necessary at least.

New water management planning of the Vltava River cascade was prepared 50 years after the original one from the time of construction. It is built on actual hydrological data and takes into consideration a development of weather trend in recent decades – towards the nearest future.

5. Conclusion and summary

The calm period with no significant floods between 1954 and 2002, has evoked a mistaken impression in public that the danger of hydrological extremes is not too serious. Nevertheless, already before the floods in 2002, the experts have pointed out that the Vltava river cascade has not been capable to protect the Vltava lower course and Prague capital city. Mathematical simulations for a design of the technical flood control measures along the Vltava River confirmed this theory. First part of these flood control measures was finished before the floods in 2002 and passed this test. Therefore the floods in 2002 have become an impulse for a realization of many flood control measures around the Czech Republic. Moreover, the drought in 2015 has increased the effort to solve the problem connected to this hydrological extreme as well. According to knowledge and practical operational experiences of the Vltava River cascade acquired during hydrological extremes is possible to sum them up also with the results of mathematical studies to the conclusion and recommendation as below:

- It is necessary to consider all functions and purposes during the multipurpose reservoirs operation before any modifications which should be considered only on the base of technical expert studies.
- The original concept of the Vltava River cascade reservoir storage distributions has been correct with respect to the purpose's order priorities. The dams' handling regulations allow managing all situations quickly and operationally.
- The water reservoir influence in the long-term drought period is currently indispensable and irreplaceable.
- The very important thing for flood protection is a reliable hydrological forecast in advance besides the correct flood storage determination in the reservoir.
- Multi-purpose water structures have restrictions that have to be respected.

Literature

[1] Komplexní manipulační řád Vltavské kaskády: VD TBD a.s. (1997)

[2] Prověření strategického řízení Vltavské kaskády – parametry manipulačního řádu: Fošumpaur P. (2014), ČVUT v Praze, fakulta stavební

Simulation of urbanized area impact on runoff by means of fully distributed mathematical model MIKE SHE, the Botič (CZ) case

Pavel Tachecí, Michal Korytář, Jana Bernsteinová

1. Introduction

The flood event in June 2013 caused notable damages across several regions of the Czech Republic [1]. A local flood in southern part of Prague city area is focused, which hit rural as well as urban areas. Analysis of land-use changes impact on storm runoff hydrograph was conducted in the upper Botič catchment (Fig. 1). Main aim of the study was to answer a question, whether flood hydrograph entering Hostivař reservoir was affected due to the impact of urbanised area extension across the source catchments in recent period.

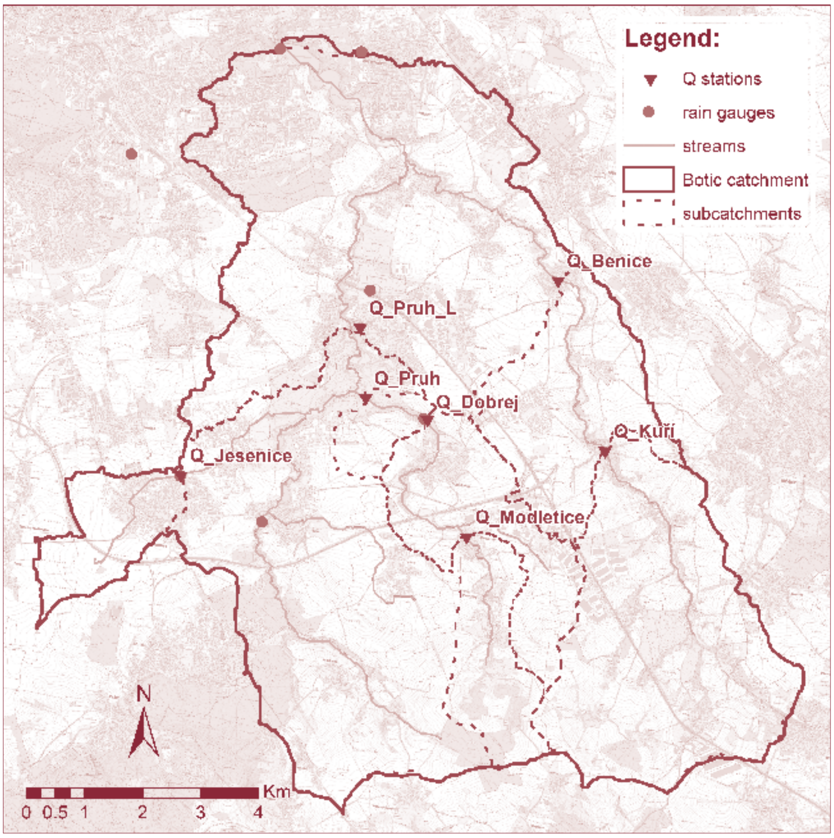

Fig. 1: *The upper part of Botič catchment – modelled area (91 km² upstream of Hostivař reservoir)*

2. Botič catchment description and data used

Area of interest is formed by gently undulated landscape at south, transforming to nearly flat terrain at north. Elevation varies between 500 and 250 m a.s.l. Long-term annual precipitation total reaches 565 mm. Maps were collected for two periods: current status (years 2010 – 2013 denoted here as variant 2013) and for period prior rapid urbanisation (data from 1988 – 1989 years, denoted here as 1988 variant). Soil map was simplified to 6 main categories. Cambisol prevails (39%). Two main hydrogeological structures were distinguished. Land use was classified (based on aerial photo) using 7 main categories (Fig. 2). For 2013 year, 62% of the area forms arable soil, 11% is paved, 13% are houses with gardens, 13% is covered by forests and shrubs. In most of subcatchments, about 10% of the arable land was converted to urban areas between 1988 and 2013, but in two of them changes reached 14 and 20%. Changes between current status and distribution of 1988 year were approximated by modifications of main properties: soil hydraulic characteristics, hydraulic roughness of surface and vegetation parameters (Leaf area index and root depth).

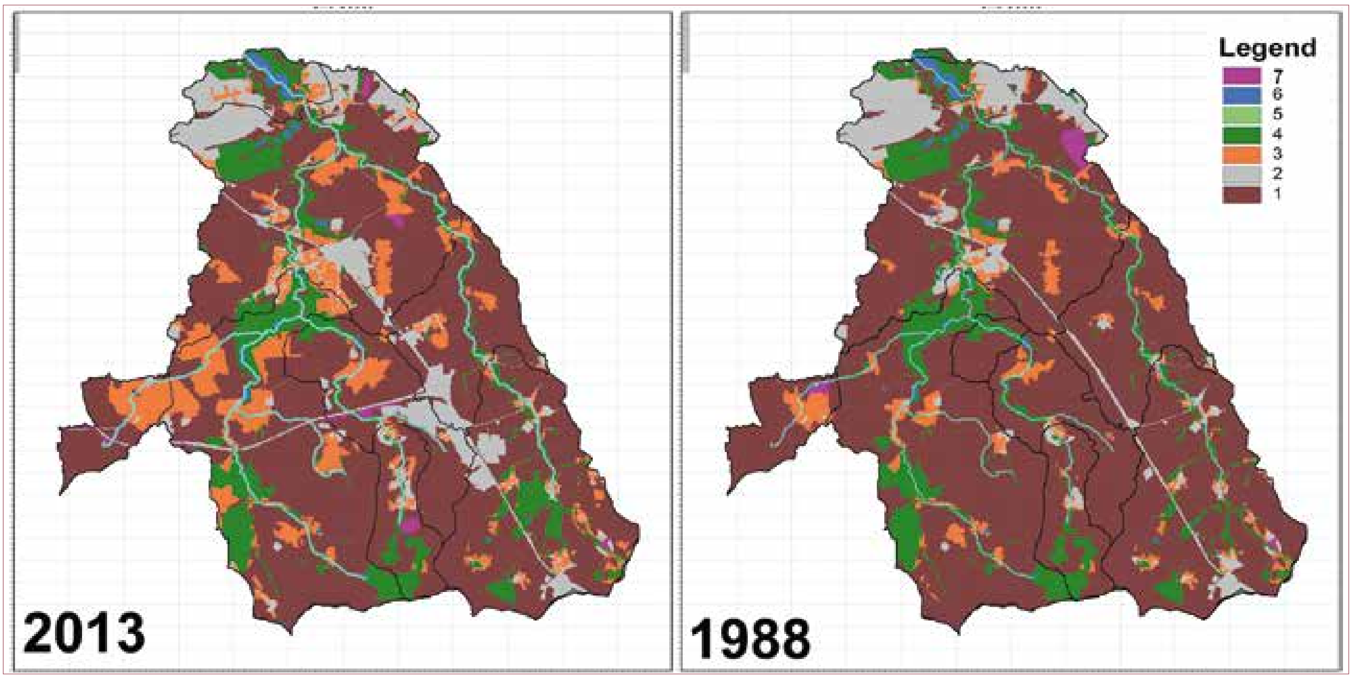

Fig. 2: *Land use map as model input; year 2013 (left) and 1988 (right). 1 and 5 = arable land plus grassland, 2 = paved area, 3 = houses with gardens, 4 = forest and shrubs, 6 = water and wet areas, 7 = other*

Shape of individual stream channels was based on data of Prague Master plan of drainage [2]. Time series used were collected mainly from Czech Hydrometeorological Institute (CHMI) and Lesy hl. m. Prahy databases. CHMI radar data and ground observation formed distributed precipitation field (15 min totals, 1 x 1 km cells). 9 records of water level in flow gauges were converted to discharge. Runoff coefficients calculated for selected subcatchments using observed data are listed in Table 1.

Tab. 1: *Flow gauging stations and subcatchments. Precipitation total and runoff coefficient (6/2013 event).*

Flow gauge	Stream	Subcatchment area	Drained area	Precipitation total	Runoff total	Runoff coefficient
		km²	km²	mm	mm	%
Kuří	Pitkovický	17.0	17.0	95	80	84
Benice	Pitkovický	8.4	25.4	81		
Modletice	Chomutovický	4.5	4.5	94	68	73
Průhonice	Dobřejovický	1.7 + 6.8	12.9	82	70	85
Jesenice	Jesenický	3.7	3.7	67	30	44
Pruhonice	Botič	23.5	40.2	76	61	80

3. Distributed mathematical model

Integrated surface – subsurface flow modelling system MIKE SHE 2014 [3] combined with 1D hydrodynamic model MIKE 11 was used as a simulation tool. Main processes focused were: surface overland flow (2D diffusive wave approximation), unsaturated flow (1D Richards equation approximation), groundwater flow (2D Boussinesq equation approximation) and river channel flow (1D fully dynamic approximation), also evapotranspiration calculation was included. The Botič catchment was described in model set up by 25 x 25 m rectangular computational grid network. Basic time step of simulation was set to 10 minutes. Initial conditions were set by water balance simulation of 1 month prior the event (using the same model). Parameter values were pre-calculated based on previous experience; subsurface hydraulic parameters were refined during calibration. Runoff response of model was calibrated using 6/2013 event records in 4 stations, while another 2 records were used for validation. Calibration has been focused on proper simulation of flood peak value and time. Variant simulation, where maps were modified to describe land use across the catchment for 1988 year conditions, was conducted using calibrated model. Further on, model was checked by another event simulation (5/2011, precipitation total about 42 mm), which occurred after monthly dry period. Additional variant simulations (using dry initial conditions for 2013 and 1988) were conducted.

4. Results

Simulation results show, that increase of urbanised area in the model did not lead to notable increase of discharge peak nor flood volume for this particular flood event (example in Fig. 3). Further simulations, taking into account dry initial conditions, showed increase in range of 10–20% for peak discharge as well as flood volume due to the land use changes (example in Fig. 4).

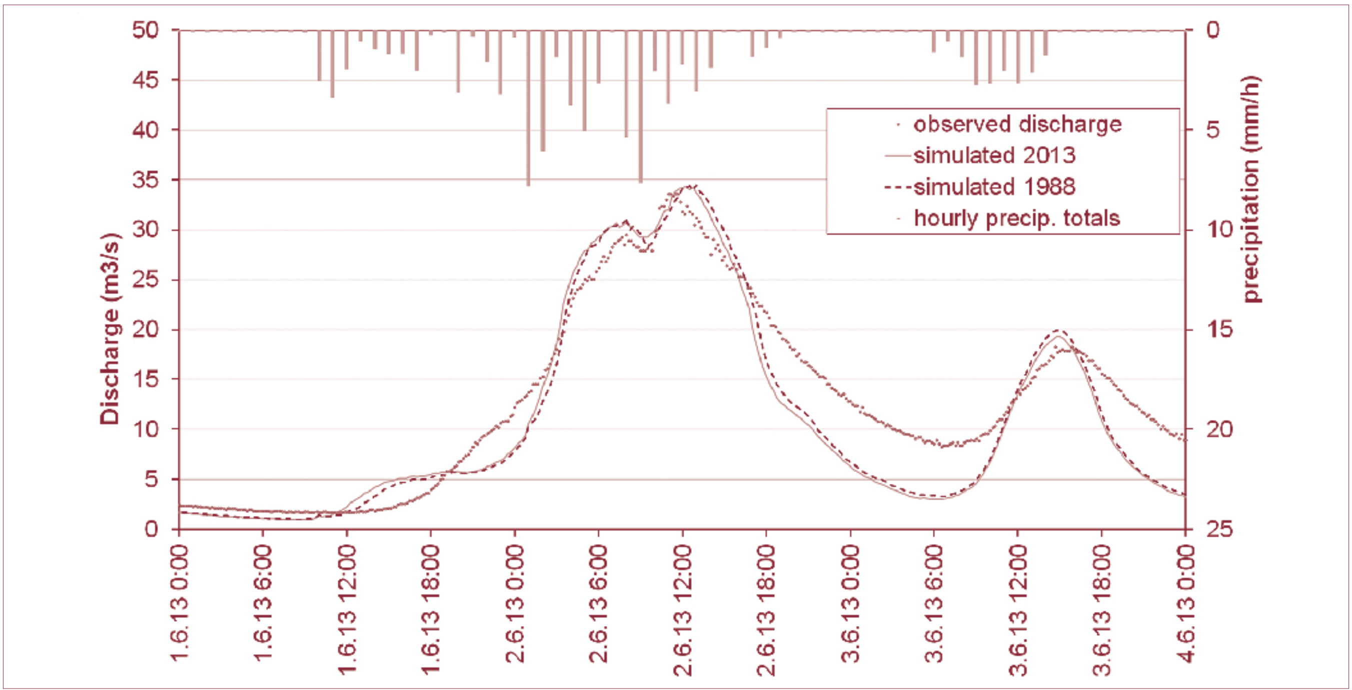

Fig. 3: *Observed (2013, dots) and simulated runoff for 2013 and 1988 conditions, real initial conditions of 6/2013 event (Průhonice station, Botič stream)*

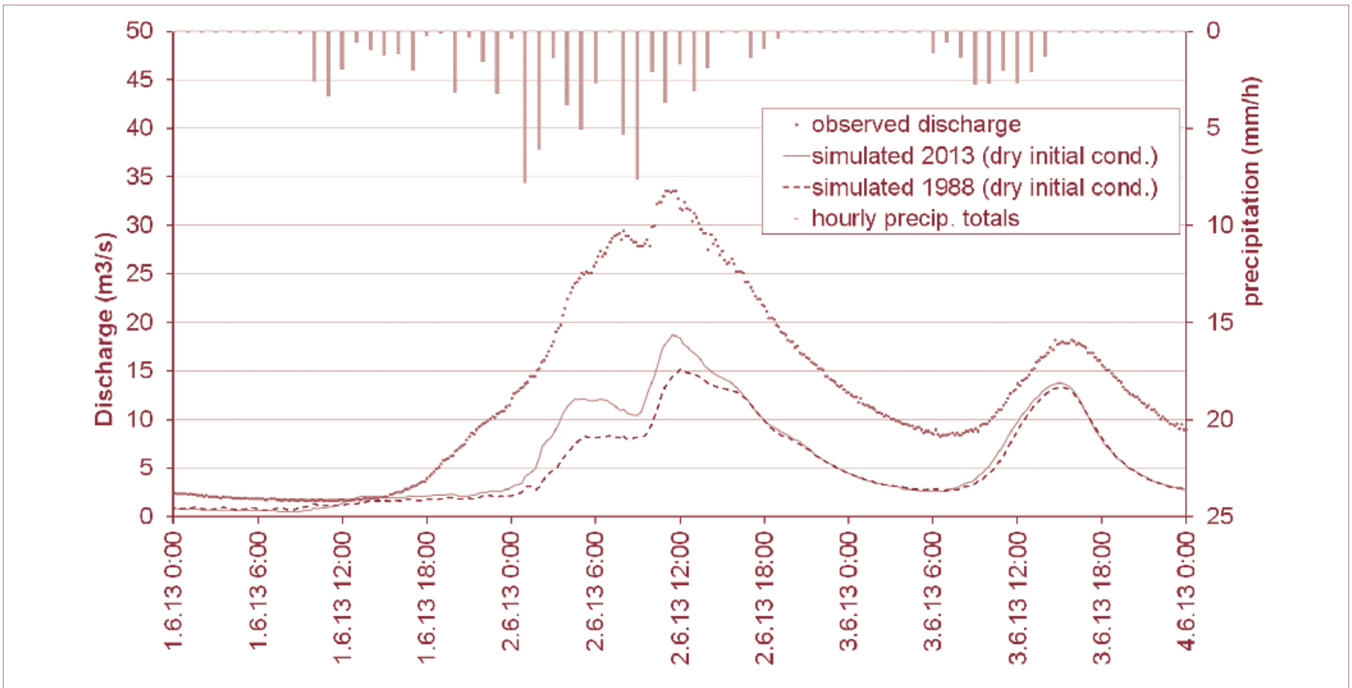

Fig. 4: *Observed (2013, dots) and simulated runoff for 2013 and 1988 conditions, dry initial conditions (Průhonice station, Botič stream)*

Tab. 2: *Summary of simulated results for 3 selected catchments. Percentage of land use changes and simulated runoff coefficients for individual simulation variants*

Catchment		Urban area increase 1988–2013		runoff coefficient simulated			
Q station	drained area	paved	houses + gardens	2013	1988	dry initial 2013	dry initial 1988
name	km^2	%	%	%	%	%	%
Jesenice	3.7	3	14	59	59	22	16
Průhonice - Dobřejovský	13.0	9	4	81	78	52	44
Whole area	95.4	4	6	80	79	46	41

For individual flow gauges and simulation variants were calculated differences in peak discharge, runoff volume, surface runoff and change in subsurface water storage. Examples are given in Tab. 2. Values of runoff coefficient differ from Tab.1 due to the shorter period taken into account.

5. Conclusions

We may conclude that changes in simulated runoff volume and peak discharge were negligible after adopting land use changes to model. This is caused by high saturation of soil at the beginning of 6/2013 event, indicated by extreme values of runoff coefficient. When dry initial conditions applied to the model, difference between 1988 and 2013 variant in runoff volume reaches about 12–14%, peak discharge increased from 29 m^3/s to 35 m^3/s and runoff coefficient about 6%. When comparing wet and dry simulation of 2013 conditions, difference is reasonably higher: peak discharge and runoff volume doubled (73 m^3/s, 46% increase) and runoff coefficient increased about 33%. It is clear, that initial conditions affect storm runoff variables much more than simulated direct impact of land use changes in this particular case of 6/2013 event. But with increase of urbanised (paved) areas percentage, space for rainfall accommodation is reduced, thus higher frequency of high runoff events may be expected in long-term perspective as a kind of indirect impact.

Literature:

[1] ČHMÚ (2013) Předběžná informace o hydrometeorologických aspektech povodní v červnu 2013. ČHMÚ Praha, červenec 2013 (In Czech)

[2] Hydroprojekt (2006) Generel odvodnění Botiče. Koordinátor řešitelského týmu: Hydroprojekt a.s., Praha (In Czech)

[3] Graham, D. N. and Butts, M. B. (2005) Flexible, integrated watershed modelling with MIKE SHE. In: Singh, V. P. and Frevert, D. K. (eds.): Watershed Models, CRC Press

Acknowledgement:

This work was undertaken in frame of "Evaluation of 6/2013 flood" study, coordinated by MoE ČR.

Fachbeiträge

Odborné příspěvky

Magdeburger Gewässerschutzseminar 2016

Magdeburský seminář o ochraně vod 2016

Neuartige Mikroschadstoffe

Novodobé mikropolutanty

Micropollutants in the Rhine

Tabea Stötter

1. Abstract

Today, wastewater contains a diverse group of micropollutants, which are partly not eliminated in the wastewater treatment plants. Very low quantities of these pollutants are detectable in waters and may detrimentally affect life in the Rhine and drinking water production.

The conference of Rhine ministers 2007 assigned the International Commission for the Protection of the Rhine (ICPR) to develop a joint and comprehensive strategy for reducing and avoiding micropollutant inputs from urban wastewater and other (diffuse) sources into the Rhine and its tributaries by improving knowledge on emissions, eco-toxicological reactions in nature and to draft suitable treatment methods.
The evaluation reports for medicinal products for human use, biocidal products and anti-corrosion agents, estrogens, radiocontrast agents, odoriferous substances, complexing agents, industrial chemicals and the report on the integrated evaluation of all analysed micropollutants have been completed. A similar report about diffuse emission pathways, with plant protecting agents as a representative group, will be finished this year.

Additionally, new techniques improve the insight into the variety of substances found in the Rhine. Non-target analysis for example can be an important tool to increase the knowledge about pollution. Therefore, the ICPR launched a new expert group dealing with non-target analysis, which will help to exchange knowledge and increase the co-operation and coordination between the monitoring points in the Rhine catchment.

In addition to the pollution of water, the contamination of biota is a topic the ICPR is concerned with. Last year a pilot programme for measuring the pollutant contamination of biota was performed and will be analysed this year, including substances like industrial chemicals and plant protecting agents. Following the pilot programme, a regular measuring programme will start in 2018 according to the WFD regulations amended in 2013.

2. Strategy for reducing and avoiding micropollutant inputs

The integrated assessment report of micropollutants [1] showed that available data about micropollutants considerably varies according to the substance and the region of the Rhine catchment concerned. However, the data demonstrated that all substance groups considered occur in Rhine water and are detected in measurable concentrations in the main stream as well as in the tributaries. Comparatively high concentrations are detected in the lower course of the Rhine or in water bodies with a high share of treated wastewater. This is in particular true for the groups of medicinal products for human use, biocidal products and anti-corrosive agents as well as radio-contrast agents. Additionally, polar and persistent substances are found in the raw water of drinking water works and are partly also detected in drinking water.

For most of the substance groups dealt with or their indicator substances respectively, there are neither national nor European environmental quality standards for the Rhine catchment.

Wastewater from households, industry and rain water from sealed surfaces in urban areas flow into wastewater treatment plants via the municipal sewer. For most of the micropollutants groups, wastewater of final effluents is the most important discharge pathway for micropollutants into surface water bodies.

The target of the strategy for micropollutants is the reduction of total emissions of micropollutants into water bodies. The reports already published identified several measures to reduce the input of micropollutants.

Measures at the source may in particular prove to make sense in industrial production and in the use of products in companies and households. They might lead to a distinct reduction of emissions, but they are only applicable for a limited number of micropollutants.

Decentralized measures in companies may further reduce the discharges of problematic substances by optimizing process control and using appropriate procedures when treating wastewater split streams or wastewater to be discharged.

Centralized measures in municipal wastewater treatment plants, such as further treatment procedures (e.g. ozonisation, active carbon filtration) can eliminate a broad scope of micropollutants. However, the effectiveness of elimination may differ from one substance or substance group to the other.

Systematically informing the broad public and experts concerning e.g. the impact of consumer products on the environment or drinking water or concerning recycling possibilities may contribute to avoid and reduce possible inputs of micropollutants into water bodies.

Regular updates of existing monitoring programmes are needed to fill gaps of knowledge concerning the occurrence of the substances concerned in water bodies (see also point 3).

Regarding diffusive sources, the emission pathways are more complicated. The ICPR is dealing with diffusive sources with plant protecting agents as a representative group. The diverse emission pathways (Fig. 1) show the importance of measures to be taken at the source. Additionally, decentralized measures like buffer zones can help to reduce discharges into waterbodies. But reducing emissions at the source should always be the first priority of measures.

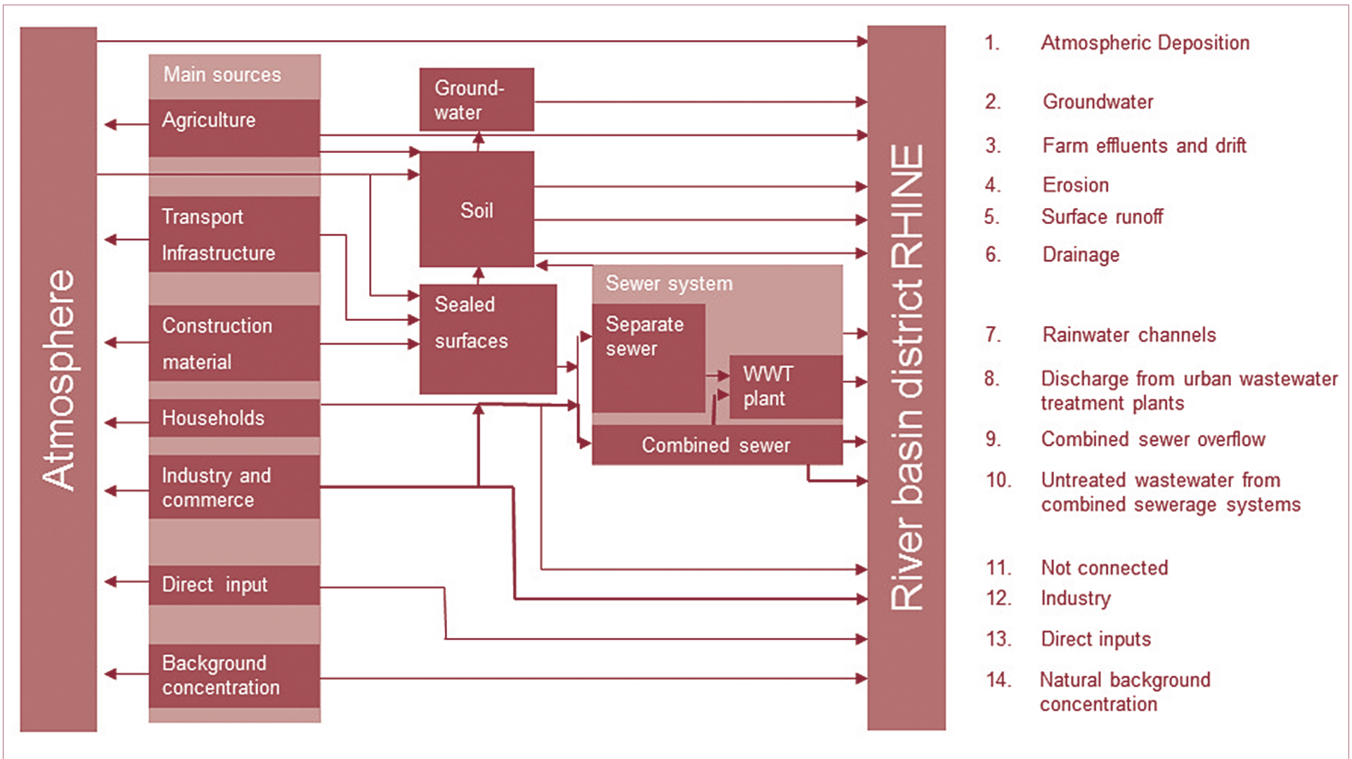

***Fig. 1:** General working scheme of emission pathways*

In 2017 there will be an ICPR workshop about micropollutants. It will provide a platform for the exchange of knowledge, innovative techniques and national developments in the Rhine catchment regarding micropollutants. Based on the results of the workshop, as well as the already published reports about micropollutants, and monitoring results, there will be a synthesis report of the ICPR strategy for micropollutants. Subsequently, there will be a discussion about common measures in the Rhine catchment to reduce the inputs of micropollutants.

3. New expert group dealing with non-target analysis

Non-target analysis is an important tool to increase the knowledge about the pollution in the Rhine as it is able to identify so far unknown contaminations. There are different methods for non-target analysis, and also the time consuming evaluation of the results can differ, depending on the preconditions. Therefore, an important task of the new ICPR expert group is to provide comparable procedures and results along the Rhine, and to develop synergies where possible.

In the year 2017 or 2018 there will be a special monitoring programme including a list of target substances (also micropollutants), and non-target analysis. The monitoring points are spread along the Rhine and its tributaries. Thus the study will give a good overview of the contaminants in the Rhine and might provide useful inputs for future regular monitoring programmes.

4. Biota contamination

Micropollutants can be found in Rhine water and might endanger drinking water quality. Additionally, micropollutants can be incorporated by biota with possible effects on ecology, and via the food web also on humans.

In the years 2014 and 2015 the ICPR started its first joint analysis programme on the pollutant contamination of biota (fish) in the Rhine catchment [2]. The goal is to form a basis for catchment wide comparable results.
A network of representative monitoring stations or river sections in the Rhine catchment should be established analogous to the Rhine monitoring programmes "Biology" and "Chemistry" for a coordinated monitoring.

For this first survey, the fish species roach (Rutilus rutilus), perch (Perca fluviatilis), chub (Leuciscus cephalus) and bream (Abramis brama) should be taken into account. These fish species were chosen, as during time of sampling they behave as sedentary fish, based on their chosen age category and the season. Additionally, these species are abundant in large parts of the Rhine catchment, so monitoring results will be comparable along as long stretches as possible.

There are 14 substances and substance groups which will be analysed. The legal basis of these substances are the EU regulation 1881/2006 [3], EU regulation 1259/2011 [4] and Directive 2013/39/EU [5].

The results of this first joint analysis programme will be analysed this year. In 2018 a regular monitoring programme will start, fulfilling, amongst others, the new requirements of the directive 2013/39/EU about priority substances.

Literature:

[1] ICPR (2012), Technical report No. 203: Strategy for micro-pollutants – Integrated assessment of micropollutants and measures aimed at reducing inputs of urban and industrial wastewater

[2] ICPR (2014), Technical report No. 216: Proposal for a Pilot Programme for Measuring the Pollutant Contamination of Biota/Fish in the Rhine Catchment during 2014/2015

[3] COMMISSION REGULATION (EC) no. 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs

[4] COMMISSION REGULATION (EU) No 1259/2011 of 2 December 2011 amending Regulation No 1881/2006 as regards maximum levels for dioxins, dioxin-like PCBs an non dioxin-like PCBs in foodstuffs

[5] DIRECTIVE 2013/39/EU of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy

Emerging trace pollutants in the River Elbe and its tributaries from the waterworks point of view Water quality report 2014/2015 of the Association of Waterworks in the River Elbe catchment (AWE)

Matthias Krüger, Wido Schmidt, Thomas Fischer, Dirk Hofmann, Uwe Dünnbier, Grit Schnitzer, Wilfried Warech

Introduction

Six companies from the Free State of Saxony have currently teamed up in the Association of Waterworks in the River Elbe Catchment (AWE) with the predominant objective of improving the quality of water in the River Elbe and its tributaries. All waterworks directly or indirectly use surface waters, groundwater recharge or bank filtration at rivers and lakes to produce drinking water. The waterworks strive to use only near-natural methods such as soil passage, slow sand filtration, fast sand filtration and cascade ventilation when treating raw water to turn it into drinking water. Only these options ensure efficient water supply that is affordable for the citizens in the long run.

At the moment, further treatment-technical measures such as the use of oxidative procedures or application of activated carbon are still necessary to remove pollutants relevant for drinking water.

Therefore, the general target for implementation of the EU Water Framework Directive (EU-WRRL) [1] to improve water quality to the grade „good“ is fully supported by the companies.

Good water quality in the catchment area of the River Elbe is a prerequisite for enabling and ensuring drinking water protection for about 5 million persons in the supply areas in the long term using near-natural treatment procedures only.

Quality Report 2014/2015

To assess the quality situation in the rivers of the River Elbe‘s catchment area, the waterworks that have combined in the AWE are performing an independent monitoring program focusing particularly on analysis of organic micro-contaminations.

The primary results of these examinations have been published in the current quality report of the reporting years of 2014/2015, which was drawn up in cooperation with the Technologiezentrum Wasser (TZW) of the DVGW Karlsruhe, office Dresden. In it, the measuring results of selected trace pollutants are compared to the target values of the “European river memorandum“ (ERM) [2] for anthropogenic non-natural substances that are not part of the substance lists of the EU – WRRL. (e.g. pharmaceutics residues, x-ray contrast agents and further persistent compounds)

Results

In the last 25 years, the quality of the River Elbe and its tributaries has improved greatly thanks to a wide range of measures. However, the companies of the AWE had to find in the scope of recent analytic examinations that analyses of the River Elbe and its tributaries continually provide evidence of new organic micro-pollutants, mostly from medicine residues and their metabolites. These substances can enter the groundwater bodies via infiltration of the rivers. Usually, the properties of these individual trace pollutants, and specifically their environmental behaviour, are unknown. A human-toxicological health reference value is not specified.

Thus, the health reference value (gesundheitlicher Orientierungswert; GOW) recommended by the Federal Environmental Office (Umweltbundesamt; UBA) for partially or un-assessable substances in the drinking water after hearing of the drinking water commission of 0.1 µg/l applies. [3]

This reference value matches the originally mentioned target value for selected trace pollutants in the ERM and should always be distinguished from the water-ecologically derived environmental quality standards (Umweltqualitätsnormen; UQN) according to the EU-WRRL.

All in all, 37 trace pollutants are currently documented in the River Elbe and its tributaries at concentrations exceeding 0.1µg/l. These substances are from the following groups:

- medicines / antibiotics / antidiabetics
- endocrine substances / X-ray contrast agents
- halogenated ether compounds (chem. industry)
- MTBE, ETBE (fuel)
- trialkyl phosphates (flame retardants)
- synthetic complex formers (EDTA, DTPA)
- aromatic sulfonates (cleaning agents)
- benzotriazoles (corrosion protection agent, frost protection agent)
- plant protection products and biocides

For 13 of these trace pollutants, the UBA has specified a GOW and only one active medical ingredient (Diclofenac – antirheumatic) is on the „watch list“ according to directive 2013/39/EU from 12 August 2013. [4]

The presence and development of anthropogenic trace pollutants in the catchment area of the River Elbe is to be explained using two examples.

Iomeprol, an organic iodine compound, is used as an X-ray contrast agent in medical diagnosis. It is excreted from the body unchanged after oral or intravenous administration. Since this contrast agent is badly biodegradable, the substance enters the surface water strongly diluted through the drains of the sewage treatment facilities. In the River Elbe, concentrations up to 1 µg/l are measured, with a rising trend. The same is observed in its tributaries.

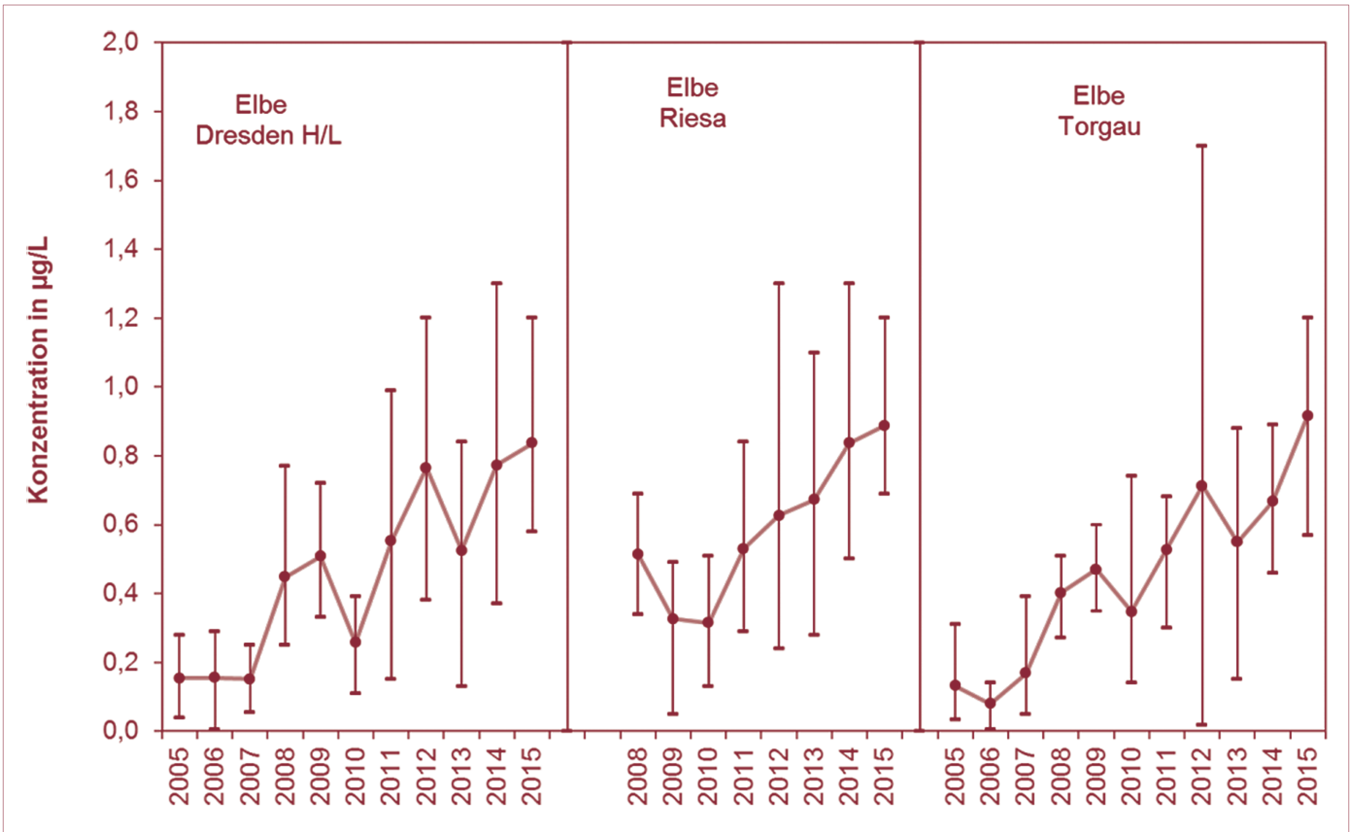

***Fig. 1:** Concentrations of Iomeprol (iodised X-ray contrast agent) in the River Elbe*

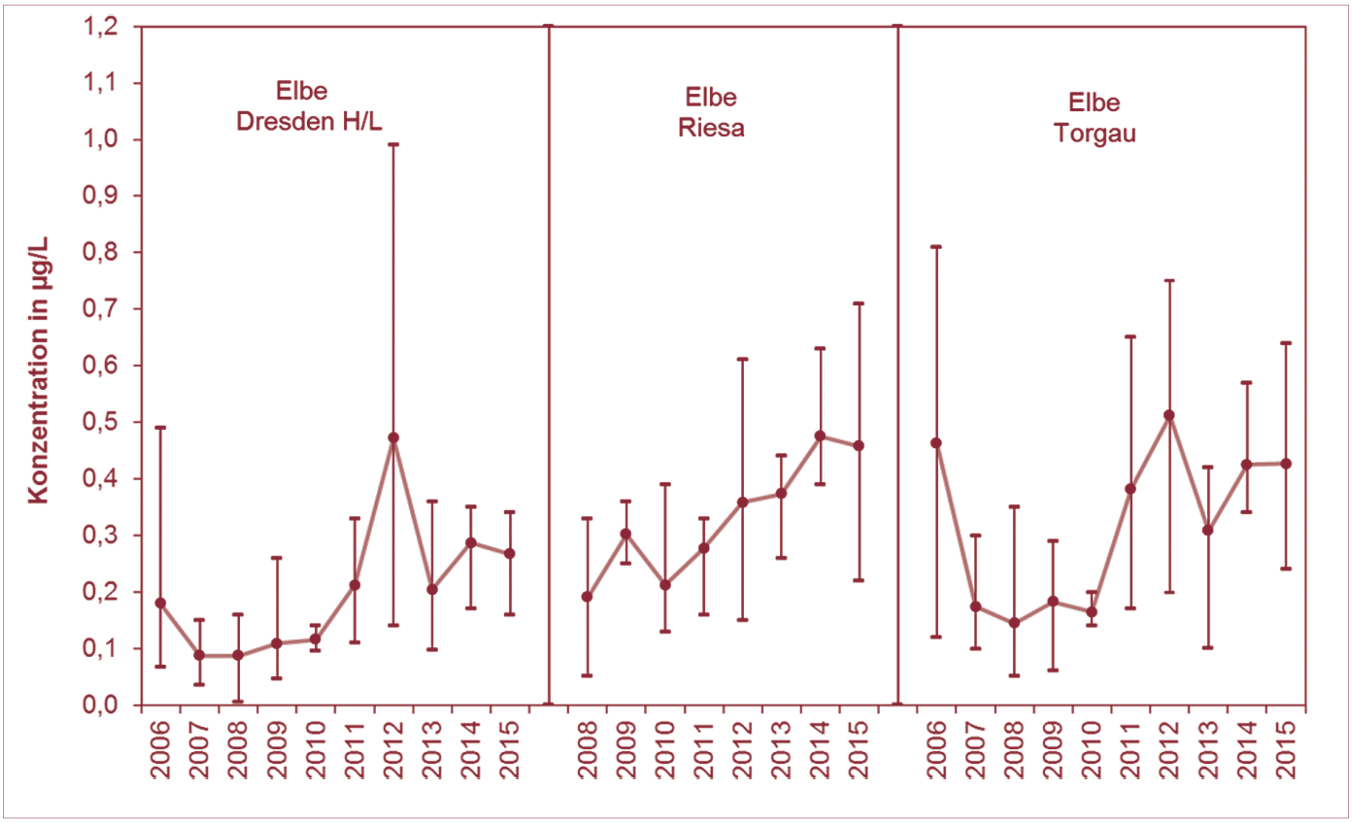

Fig. 2: *Concentration of benzotriazole in the River Elbe*

Benzotriazole is a diverse industrial chemical that is used as a corrosion inhibitor in cooling circuits, in frost protection agents and de-icing fluids, as well as in dishwashers in the domestic area. The substance is characterised by good water solubility, and is persistent in sewage treatment plants. The contents in the River Elbe are at 0.5 µg/l and in the River Havel, and the outflow to Berlin, even at 2.2 µg/l.

Conclusions

Even though many positive results regarding reduction of the pollutant load in the River Elbe and its tributaries have been achieved in the course of the last years, these efforts must be continued subject to the proviso that the provision of high-quality drinking water for the people in the catchment area must have a particularly high status as compared to other use aspects.

Therefore, it is all the more important that the targets and specifications from the management plans and measures programmes of the EU-WRRL [5] are adjusted to permit secure drinking water supply in the catchment area of the River Elbe and its tributaries based on cost-efficient and near-natural treatment procedures in the long run. Use of further technical procedures (e.g. use of activated carbon filters) as „end of pipe“ solution is not considered desirous by the AWE.

The AWE therefore believes that drinking water supply must be given precedence over all other water uses in the scope of safe public service. Reduction of the concentration of individual substances/substance groups below the target values of the ERM is possible using measures to reduce contamination at the source and by substitution of active substances that are difficult to eliminate by biodegradable substances.

The member companies of the AWE consider the application of combined measures that may include, e.g., prohibitions of use, consideration of environmental relevance in substance approvals and registrations, implementing for targeted measures according to the originator principle at the source of introduction, construction of suitable disposal facilities and comprehensive public information, to offer a particularly high chance to achieve the maximum retention of trace pollutants possible.

Literature

[1] DIRECTIVE 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (2000)

[2] Memorandum regarding the protection of European rivers and watercourses in order to protect the provision of drinking water – ERM – (2013) www.awe-elbe.de

[3] Bewertung der Anwesenheit tei- oder nicht bewertbarer Stoffe im Trinkwasser aus gesundheitlicher Sicht (2003) Federal Health Bulletin p. 249 – 251

[4] DIRECTIVE 2013/39/EU of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy (2013)

[5] International management plan for the river area unit Elbe – Part A – Updated 2015 for the period of 2015 – 2021 by the IKSE (2015)

Targeted screening of emerging pollutants in Czech rivers by passive sampling

Vít Kodeš, Roman Grabic

1. Introduction

POCIS – Polar Organic Chemical Integrative Sampler [1] is designed for monitoring of polar compounds. POCIS samplers provide time weighted average concentrations thus overcoming the limitations of conventional grab sampling. On the other hand, the limitation is a lack of calibration data to derive ambient concentrations on rivers. The available sampling rate values are limited to a small number of compounds, therefore the data obtained from POCIS monitoring were used for comparative purposes and POCIS samplers could be used as screening devices.

2. Materials and methods

A screening of emerging pollutants such as pharmaceuticals (analgesics, psycholeptics, antidepressants, antibiotics, beta blockers, NSAIDs etc), perfluorinated compounds (PFCs), illicit drugs, pesticides and their metabolites as well as, personal care products (PCPs) such as UV blockers, musk's, repellents, bactericides was conducted in 2013. POCIS samplers manufactured by ExposMeter AB (Tavelsjö, Sweden) were used in this study. Two types of passive samplers (pesticide and pharmaceutical POCIS) were deployed for 14 days in May and in October at 22 sampling sites, 88 samples were collected in total. Pesticide POCIS (triphasic admixture of a hydroxylated polystyrene-divinylbenzene resin (Isolute ENV +) and a carbonaceous adsorbent (Ambersorb 1500) dispersed on a styrene divinylbenzene copolymer S-X3 Bio Beads) is suitable for monitoring of medium polar compounds. Pharmaceutical POCIS (sorbent Oasis HLB) is suitable for monitoring of very polar compounds. Deployed samplers were stored at -18°C. The chemicals of interest were extracted from the passive samplers according to standardized procedures. LC-MS/MS and LC-MS/HRMS methods were applied for analyses of extracts. In total 265 and 310 target compounds were analysed in pharmaceutical and pesticide samplers respectively.

3. Results

150 compounds in total (48% of analysed) were found in pesticide samplers, 27 substances (pharmaceuticals, PCPs, pesticides, caffeine, nicotine metabolite cotinine) occurred at all sampled sites, additional 39 substances (pharmaceuticals, PCPs, pesticides) occurred at more than 17 (75%) sites. One of perfluorinated compounds (PFOA) occurred at 68% of sites, whilst one of illicit drugs (methamphetamine) was found at 61% of sites. 72 compounds occurred at least in 50% of samples (Fig. 1).The highest number of contaminants found in one POCIS at a single monitoring site was 111. Concentrations of individual substances varied from nanograms up to thousands of nanograms per sampler. Substances occurring in highest concentrations (> 1000 ng/sampler) are: PBSA (UV blocker), caffeine, DEET (insect repellent), imidacloprid (insekticide), terbuthylazine, diuron, metolachlor (herbicides), telmisartan (hypertension drug) and tramadol (pain reliever). Next 30 substances (atrazine, atrazine-2-hydroxy, acetochlor ESA, acetochlor OA, alachlor ESA, alfuzosin, atenolol, bisphenol A, carbamazepine, carbendazim, chloridazon, chlorotoluron, cotinine, dichlorprop, dimethomorph, fexofenadine, ibuprofen, irbesartan, isoproturon, mecoprop, metazachlor, metazachlor OA, metolachlor ESA, sotalol, sulfapyridine, tebuconazole, terbuthylazine-desethyl, terbuthylazine-hydroxy, terbutryn, thiamethoxam) reached maximum concentrations of 100 – 1000 ng/sampler. Majority of pesticides and their metabolites, PCPs (UV blockers, insect repellent, musk substance) were found as well as 50 pharmaceuticals, 5 illicit drugs and their metabolites and almost half of monitored PFCs (Fig. 2, 3). Highest numbers of compounds (> 90) and simultaneously the highest total concentrations (> 3000 ng/sampler) were detected in Odra, Olše, Dyje, Cidlina, Elbe, Morava, Berounka and Ostravice rivers (Fig. 4).

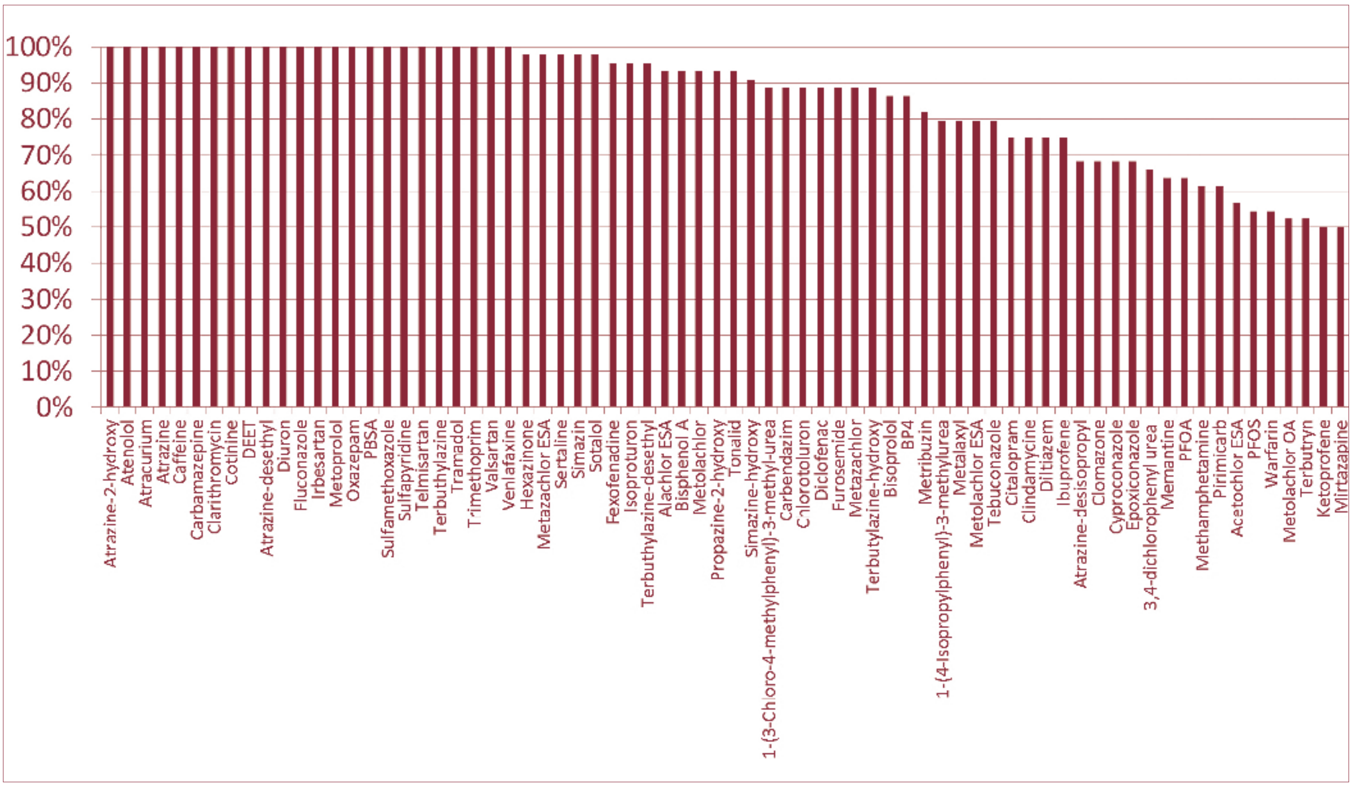

Fig. 1: *Compounds detected in more than 50% of pesticide samplers*

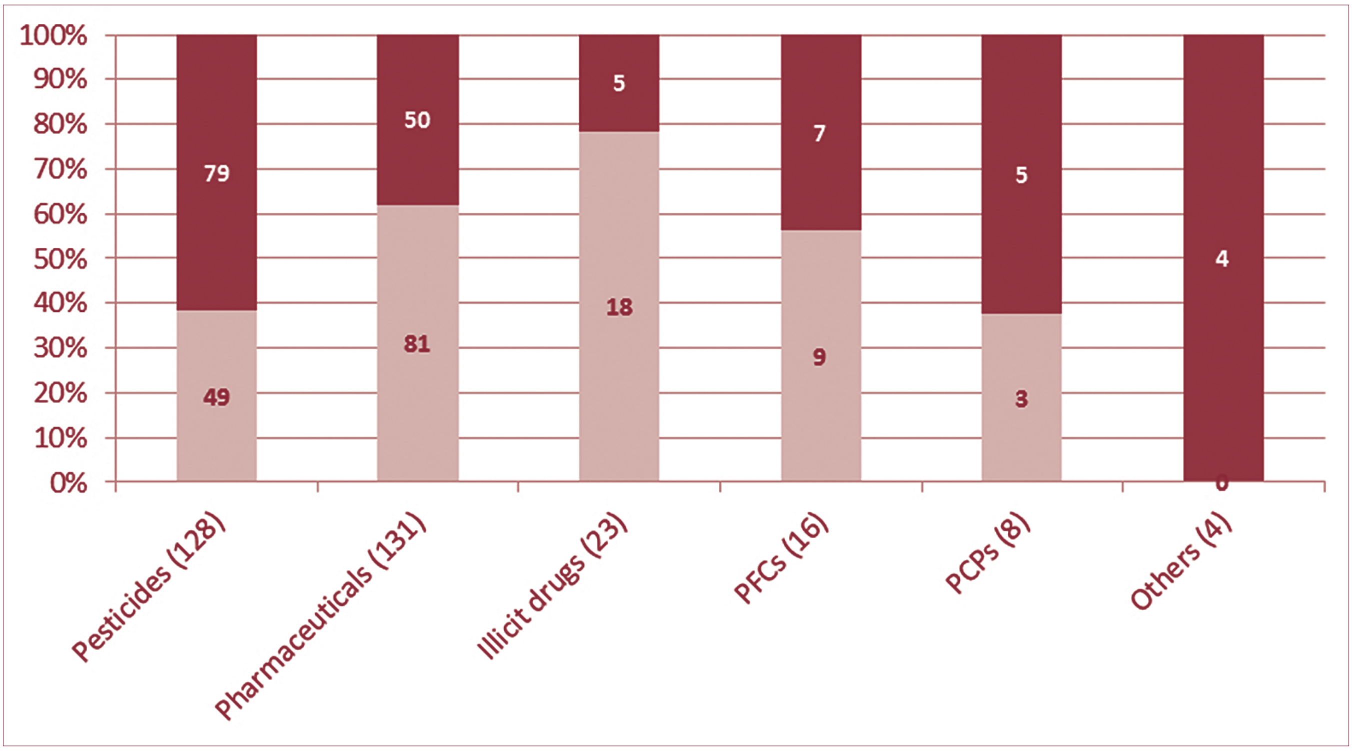

Fig. 2: *Number of compounds found in pesticide samplers (number of analysed compounds is given in brackets)*

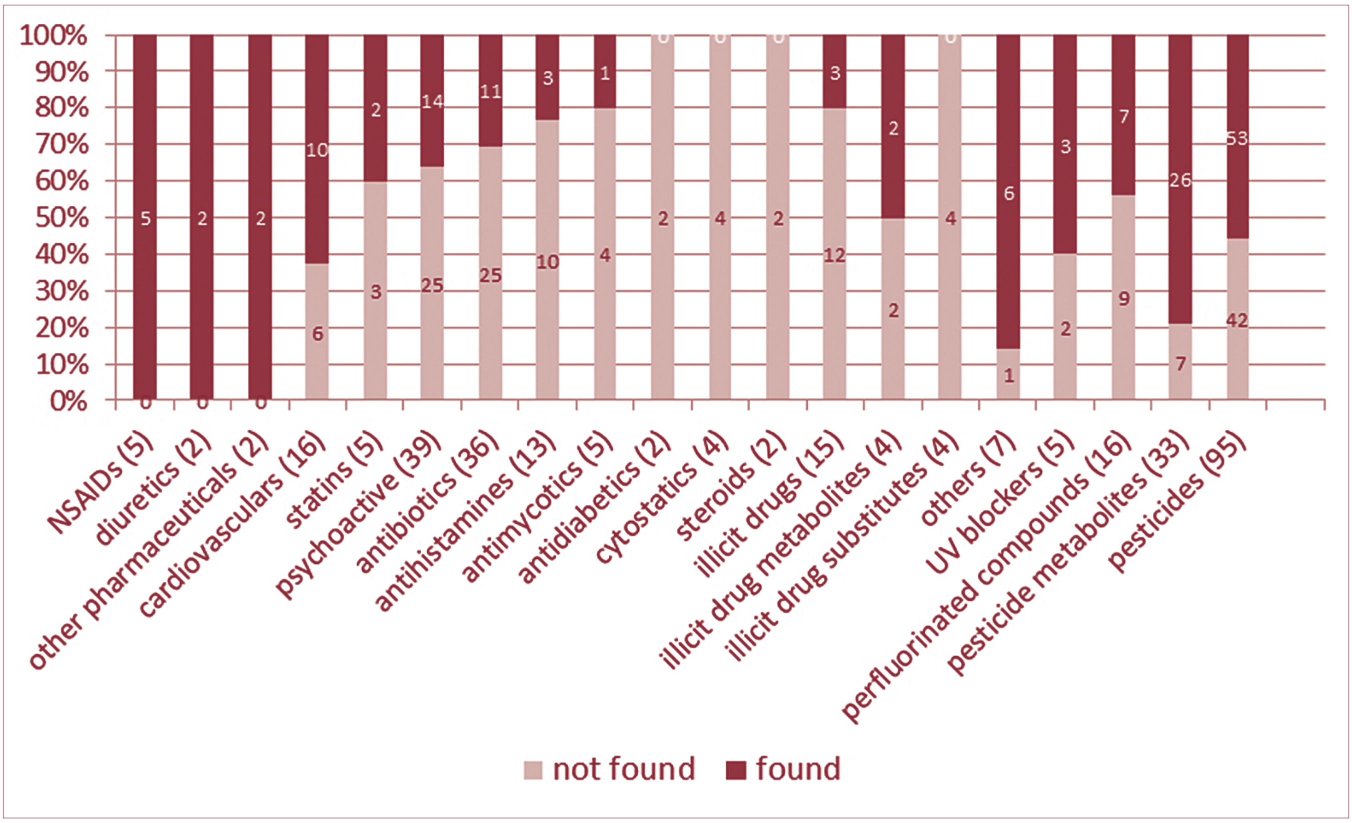

Fig. 3: *Number of compounds found in pesticide samplers (number of analysed compounds is given in brackets)*

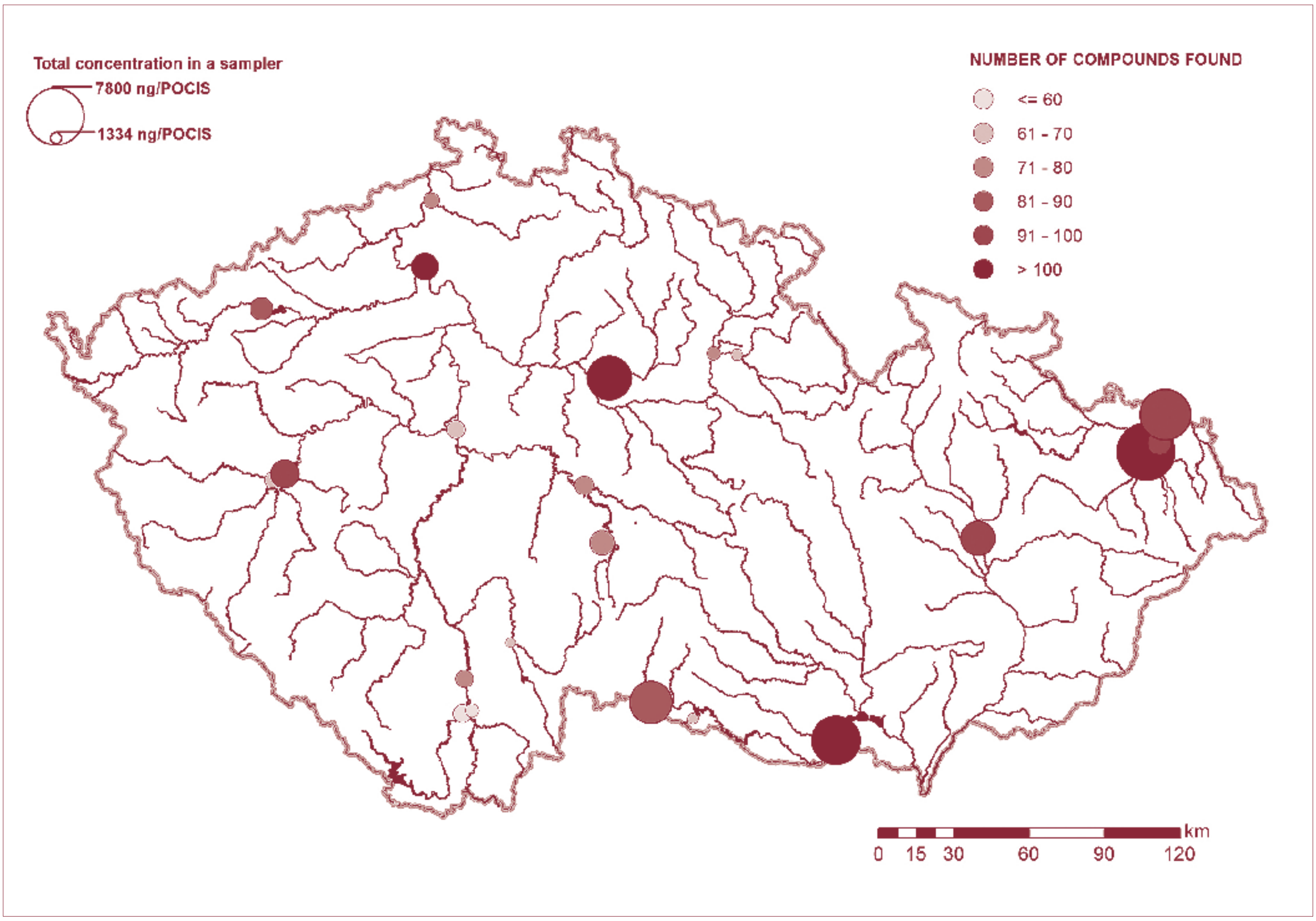

Fig. 4: *Occurrence of compounds at sampling sites*

4. Conslusions

Passive sampling by POCIS is useful for monitoring of polar compounds in aquatic environments. Monitoring in the Czech Republic has demonstrated that many target compounds from various groups of pollutants enter river waters and a number of these compounds reach high concentrations. Moreover passive sampling offers high potential in monitoring of substances that are usually present in very low concentrations in river water such as illicit drugs, pharmaceuticals and other emerging contaminants.

Literature:

[1] Alvarez, D.A., Petty, J.D., Huckins, J.N., Jones-Lepp, T.L., Getting, D.T., Goddard, J.P., Manahan, S.E. (2004) Development of a passive, in situ, integrative sampler for hydrophilic organic contaminants in aquatic environments. Environ. Toxicol. Chem. 23, 1640 – 1648.

Monitoring of pharmaceutical substances in surface waters in Saxony

Kerstin Röske, Sylvia Rohde

1. Introduction

Pharmaceutical substances, used in human and veterinary medicine, have been in the focus of environmental observation for some time. Pharmaceuticals can enter into the environment for instance via patient excretion or the disposal of unused medications into the wastewater.

The decision of the conference of the ministers of the environment in 2003 to consider drugs substantially stronger in the environmental monitoring programme was the reason to include selected pharmaceutical substances in the Saxon environmental monitoring programme for surface waters. Now, long time monitoring data for many surface water bodies in Saxony are available with an enlarged parameter spectrum of pharmaceutical substances including antibiotics.

In 2015, the Watch List under the Environmental Quality Standards Directive was published by the EU. The aim is to support the identification of priority substances for regulation under the Water Framework Directive (WFD) based on monitoring information on the concentrations of polluting substances in the aquatic environment. Diclofenac, 17-beta-estradiol and 17-alpha-ethinylestradiol, had already been selected for inclusion in the first list. Besides other substances, the macrolide antibiotics Erythromycin, Clarithromycin and Azithromycin were included as one group in the Watch list.

2. Monitoring

According to the requirements of the WFD, the Betriebsgesellschaft für Umwelt und Landwirtschaft (BfUL) monitors specific parameters to determine the ecological and chemical status of surface water bodies. The monitoring network includes 646 representative monitoring sites [1]. Now, the substances of the Watch list are analyzed at selected monitoring points. Besides these substances, pharmaceutical substances are monitored at certain monitoring points. The monitoring programme is continuously updated and new substances are included. Today, the monitoring programme includes for example lipid-lowering medications (Gemfibrozil), anticonvulsants (Carbamazepine, Oxcarbazepine, Gabapentin, Lamotrigine, Primidone), analgesic drugs (Diclofenac, Ibuprofen, Paracetamol, Phenazone, Propyphenazone), beta blocker (Acebutolol, Bisoprolol, Celiprolol, Metoprolol, Propranolol, Sotalol), Metformin- a medication for the treatment of diabetes, antidepressants (Fluoxetine, Venlafaxine, Citalopram), the chemotherapeutic agent Cyclophosphamide, radio-opaque substances (Amidotrizoate, Iohexol, Iomeprol, Iopamidol, Iopromide), anaesthetics (Lidocaine), Ivermectin, as well as antibiotics (Ciprofloxacin, Enrofloxacin, Erythromycin, Clarithromycin, Roxithromycin, Sulfamethazine, Sulfamethoxazole, Sulfapyridine, Clindamycin and Trimethoprim). The monitoring data are available for the public (http://www.umwelt.sachsen.de/umwelt/wasser/7112.htm).

For this presentation 45 monitoring points were selected from the over 1000 monitoring points in the saxonian monitoring network according to different criteria. The selection includes both representative monitoring points by the WFD in the Elbe, Mulde and Lausitzer Neiße as well as monitoring points for significant surface water bodies in Saxony (Weiße Elster, Schwarze Elster, Spree) and monitoring points in smaller water bodies with increased wastewater fraction.

To evaluate the measurements of the monitoring programme, the findings can be classified based on ecotoxicological specifications like deduced environmental quality standards (EQS) or Predicted No Effect Concentration (PNEC). If such values are not available, the target value of the European drinking water companies of 0.1 µg/l [4] could be applied.

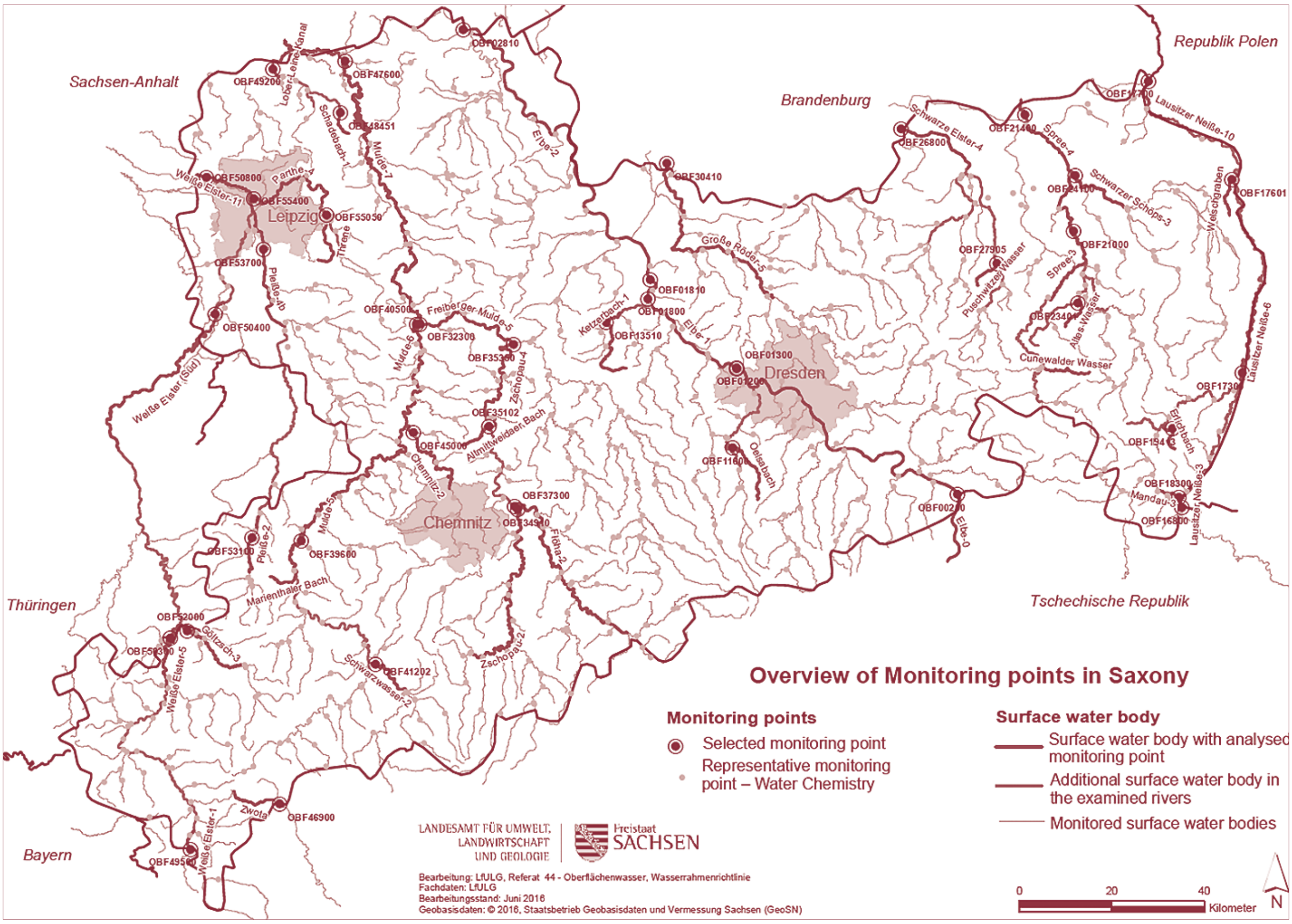

Fig. 1: Overview of monitoring points in Saxony.

3. Results

Pharmaceutical substances could be detected in all investigated surface water bodies. Substances from different groups of pharmaceuticals were selected for this presentation. The results, including the start of the investigation, the number of samples, the maximum single value as well as the maximum annual average are presented in Table 1. For some of the pharmaceuticals, annual average (AA) quality standards (QS) or maximum allowable concentration (MAC) QS were published by the Umweltbundesamt [2] or can be found in the ETOX database (https://webetox.uba.de/webETOX/). Furthermore, the monitoring data were compared with PNEC values [3] and the threshold of 0.1 µg/l proposed by the European drinking water providers [4].

Among the substances that AA-QS or MAC-QS were proposed for, only Diclofenac values exceeded proposed AA-QS (58% of the measured single values) and PNEC (33% of the measured single values) at the analysed monitoring points. Diclofenac could be detected in nearly every water body of investigation, only 5% of the measurements were below the quantification limit.

The antibiotics Ciprofloxacin and Sulfamethoxazole exceeded the PNEC. Nevertheless, the concentration of Ciprofloxacin was in over 90% of the cases below the quantification limit of 0.02 µg/l. Only for a sampling point in the river Chemnitz, the annual average concentration of Ciprofloxacin was always above 0.03 µg/l. Sulfamethoxazole showed besides to the fluctuation of the data a slight increase of the concentration in the river Elbe over the investigation period.

More often, the measured values were above the 0.1 µg/l target value for drinking water of the European drinking water companies (Table 1). Overall, the concentrations of the examined substances in the river Elbe were, on average, smaller than in the smaller rivers. Except for Sulfamethoxazole, no annual or seasonal trend of the concentration could be observed in the investigated surface water bodies.

Tab. 1: *Monitoring results and evaluation of selected pharmaceutical substances.*

* *Values of MAC- or AA- quality standards (QS) and PNEC taken as the basis are shown in parentheses*

[1] https://webetox.uba.de/webETOX/ (data status 09.06.2016)

[2] [2]

	Monitoring						Evaluation			
substance	**since**	**Number of data**	**Quantification limit (QL) year and value [µg/l]**	**Number of data below QL**	**Maximum annual average**	**Maximum single value**	**Number of data > AA-QS***	**Number of data > MAC-QS***	**Number of data > 0,1 µg/l [4]**	**Number of data > PNEC [3]***
Gabapentin	2010	1208	2011–2012: 0.1 since 2012: 0.02	24	8.1 µg/l	32 µg/l	-	-	1149	0 (44 µg/l)
Diclofenac	2005	1456	2007–2009: 0.005 since 2007: 0.010	79	3.2 µg/l	12 µg/l	845 (0.05 µg/l)[1]	-	489	489 (0.1µg/l)
Metoprolol	2010	1208	2010–2011: 0.03 since 2012: 0.005	53	0.7 µg/l	1.2 µg/l	0 (43 µg/l)[2]	0 (180 µg/l)[2]	497	0 (3.2 µg/l)
Metformin	2012	959	0.02	28	9.9 µg/l	40 µg/l	-	-	904	0 (60 µg/l)
Sulfamethoxa-zole	2010	1208	2010–2012: 0.02 since 2013: 0.01	242	0.31 µg/l	1.6 µg/l	0 (0,6 µg/l)[2]	0 (2.7 µg/l)[2]	95	2 (0.59 µg/l)
Clarithromycin	2011	1081	2011: 0.01 since 2012: 0.006	546	0.09 µg/l	0.17 µg/l	0 (0.13 µg/l)[1]	0 (0.6 µg/l)[1]	7	0 (0.2 µg/l)
Erythromycin	2010	1208	2010–2011: 0.02 2012-2013: 0.008 since 2014: 0.006	933	0.048 µg/l	0.15 µg/l	0 (0.2 µg/l)[2]	0 (2.0 µg/l)[2]	1	0 (0.21 µg/l)
Ciprofloxacin	2011	1076	0.2 µg/l	977	0.11 µg/l	0.43 µg/l	-	-	12	57 (0.036 µg/l)
Ivermectin	2011	1081	2011: 0.03 since 2012: 0.01	1081	<QL	<QL	-	-	0	<QL (3*10-8 µg/l)

4. Summary

Pharmaceutical substances are monitored in Saxon surface water bodies for more than ten years and a large number of measurements is available now. For most of the examined substances the measured concentrations were below ecotoxicological specifications like QS or PNEC. On the other hand, regarding the perspective of drinking water, the target value of 0.1 µg/l was exceeded for a number of measurements.

For Ivermectin, the concentration in the water bodies is below the limit of quantification, but the limit of quantification is far above the PNEC. Therefore, a risk assessment for this substance is not possible. Ecotoxicological deduced environmental quality standards are only available for a very limited number of pharmaceutical substances. In addition, summary effects of various substances, as well as degradation and transformation products need to be taken into account when assessing the environmental risk of pharmaceutical substances in surface water bodies.

The issue of pharmaceuticals in the environment requires a multilateral combined approach considering production, usage up to the disposal of pharmaceuticals, as well as wastewater treatment.

The EU develops a strategic approach to pollution of water by pharmaceutical substances. At the moment, the Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) started an initiative to develop a "micropollutant" strategy for Germany.

Literature

[1] Sächsische Beiträge zu den Bewirtschaftungsplänen Elbe und Oder (2015). Landesamt für Umwelt, Landwirtschaft und Geologie. https://publikationen.sachsen.de/bdb/artikel/25830

[2] Revision der Umweltqualitätsnormen der Bundes-Oberflächengewässerverordnung nach Ende der Übergangsfrist für Richtlinie 2006/11/EG und Fortschreibung der europäischen Umweltqualitätsziele für prioritäre Stoffe, UBA Texte 47/2015

[3] Zusammenstellung von Monitoringdaten zu Umweltkonzentrationen von Arzneimitteln, UBA Texte 66/2011

[4] IAWR, IAWD, AWE, AWWR, RIWA (2013): Europäisches Fließgewässermemorandum zur qualitativen Sicherung der Trinkwassergewinnung. Memorandum regarding the protection of European rivers and watercourses in order to protect the provision of drinking water http://www.iawr.org/docs/publikation_sonstige/efg-memorandum_2013.pdf

Pharmaceutical compounds and other contemporary contaminants in surface and sewage water

Marek Liška, Kateřina Soukupová, Lumír Kule, Milan Koželuh

Summary:
The results of pharmaceutical products monitoring (in years 2011 – 2014) in the sewage and surface water in Vltava river catchment are summarised in this contribution. Thirty-two drug substances from the following indication groups were measured: antiflogistics, antirheumatics, antipyretics, antihypertensive drugs, antibiotics, antiepileptics, pain killers, hypolipidemics, X-ray diagnostics substances and stimulanting drugs.The highest drugs concentrations were measured in the small and medium streams located under the towns with 11 000 – 69 000 inhabitants, which have hospitals or specialized medical centres. Analysis has been aimed at the following substances:diclofenac, ibuprofen, carbamazepine, hydrochlorthiazide, metroprolole, gabapentin, tramadol, iopromide and iopamidole. The final drug substance concentration in the stream depends on the income from the sewage water point source (WWTP), degree of dilution and stability of the drug substance in the water environment, i.e. ability of drug substance for degradation in the metabolites.

Introduction:
In general, pharmaceutical compounds are common part of human life. World pharmaceutical corporations produce tens of thousands of tons of drugs with different active substances. Not only the man, but also animals are a terminate consumers of this pharmaceutical production. Natural background for all common pharmaceutical compounds is zero. Significant pollution of surface water by drugs and other PCPs is detected in the Czech Republic and other European countries. Drugs are unoriginal compound for all surface and drinking water and may influence life and reproduction of water animals. Watermanagement laboratories of Povodí Vltavy state enterprise started to provide drug analyses for a few years ago in the surface, drinking and sewage water.

Material and methods
Pharmaceutical compounds, PCPs and its residues have been analysed by methods of Liquid chromatography with the mass detection, based on the triplequadrupole principle (LC-MS/MS). Following active substances according to therapeutic groups have been measured in the „Programs of monitoring of surface and sewage water“:

antiflogistics, antirheumatics: ***naproxene, diclofenac, ibuprofen, paracetamol, ketoprofen,***
antihypertensive drugs: ***atenolol, hydrochlorothiazide, furosemid, metoprolol***
hypolipidemics: ***benzafibrate, gemfibrozil***
antibiotics: ***claritromycin, erytromycin, chloramfenicol, penicilin G, roxithromycin, trimetoprim, sulfamerazin***
sulfonamides: ***sulfamethazin, sulfamethoxazol, sulfanilamid, sulfapyridin***
antiepileptics: ***carbamazepine***
pain killers: ***gabapentin, tramadol***
anticoagulantics: ***warfarin***
X-ray diagnostics substances: ***iopamidol, iopromid***
artificial sugar: ***sacharin***
stimulanting drugs: ***caffein***

Results and discusion:
The highest concentrations of drugs were measured in sewage water and in small streams with disembogued sewage water from outflow of WWTP (water from human settlements, hospitals or special medical centres). This was observed espetially in the streams with low volume of water and on the localities under the medium-sized or big towns (between 10 – 70 thousands inhabitants) with their own hospital or other health care centre (e.g. psychiatric or rehabilitation institutions).

The occurrence of selected drugs in the outlet of WWTPs and in surface water:

Diclofenac: The highest concentrations of diclofenac in the outlet of WWTP were measured in the range 1000 – 2700 ng/l. The highest average concentrations were analysed in surface water of Zákolanský brook (under the Kladno town with 70 thousands of inhabitants), in Příbramský brook under the Příbram town and in Benešovský brook under the Benešov town in range 150 – 500 ng/l, Fig.1. The high value was also recorded in the outlet of WWTP´s of health care institutions.

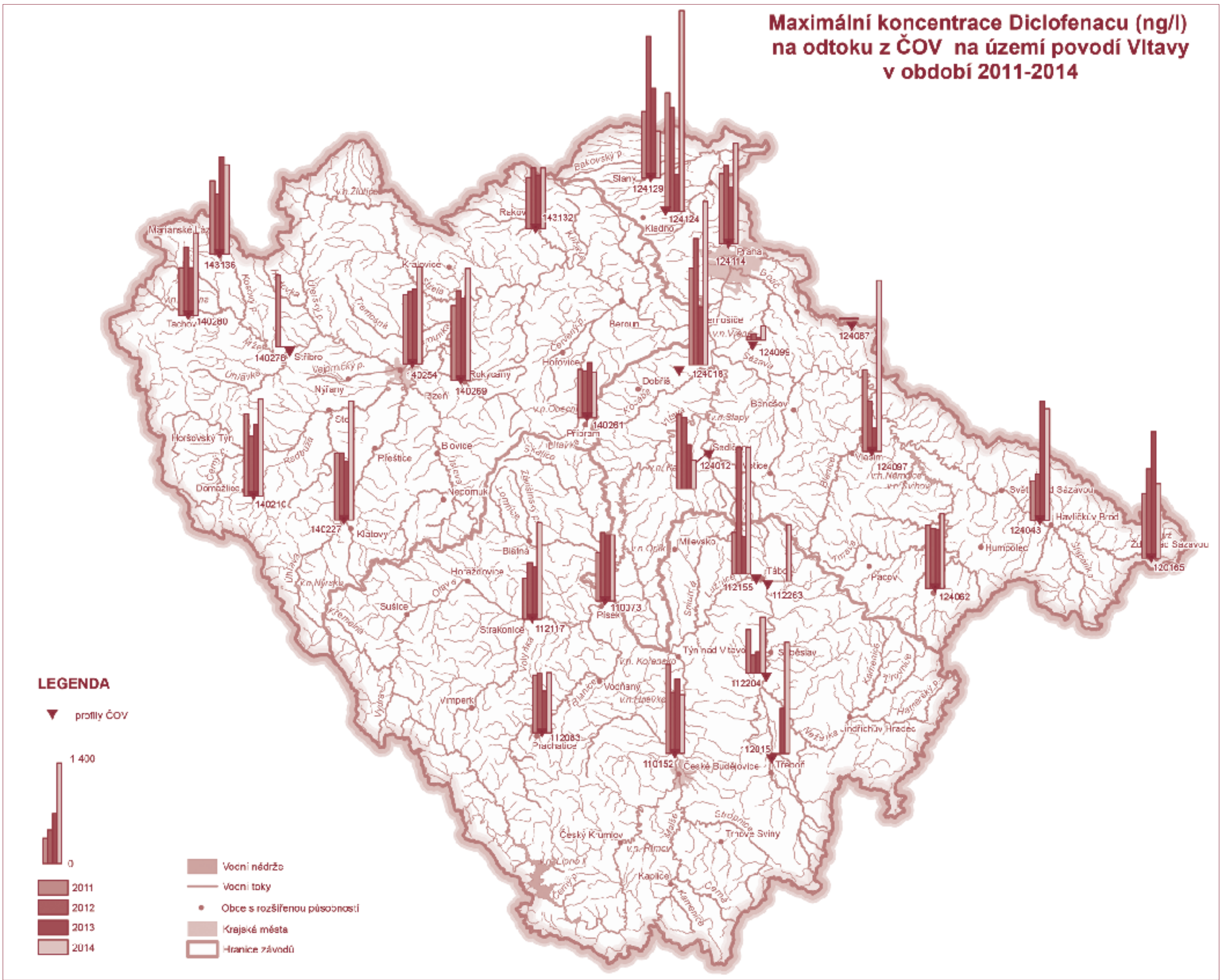

Fig. 1: *Map of the maximum concentrations of diclofenac in outlet of WWTP*

Ibuprofen: The maximum concentrations were observed in range of 500 – 1000 ng/l, sporadically 10 – 30 µg/l were measured in the outlets of WWTP´s: Pelhřimov town, Písek town and Kladruby rehabilitaion centre. High average values of drug concentration were found in the outlets of WWTP´s Strakonice, Příbram and Písek towns for long time period. The highest contaminated streams are: Příbramský brook under town Příbram (max. 5100 ng/l), Rakovnický brook under the Rakovník town (max. 2000 ng/l) and Bělá brook under the Pelhřimov town (max. 1500 ng/l). Ibuprofen has high number of metabolites, unfortunately laboratories of Povodí Vltavy are able to analyse only three of them.

Carbamazepine is a drug with the wide range of use and the contamination of _Czech rivers is significant. The common concentration of carbamazepine in sewage water ranged from 500 to 1000 ng/l, sometimes higher values are measured. The higher concentrations of carbamazepine in surface water are consistently found in Benešovský brook, Živný brook under the Prachatice town, Příbramský brook, Zákolanský brook under the Kladno town and Pstružný brook under the Humpolec town, the higher concentrations reach up to 800 ng/l, Fig 2.

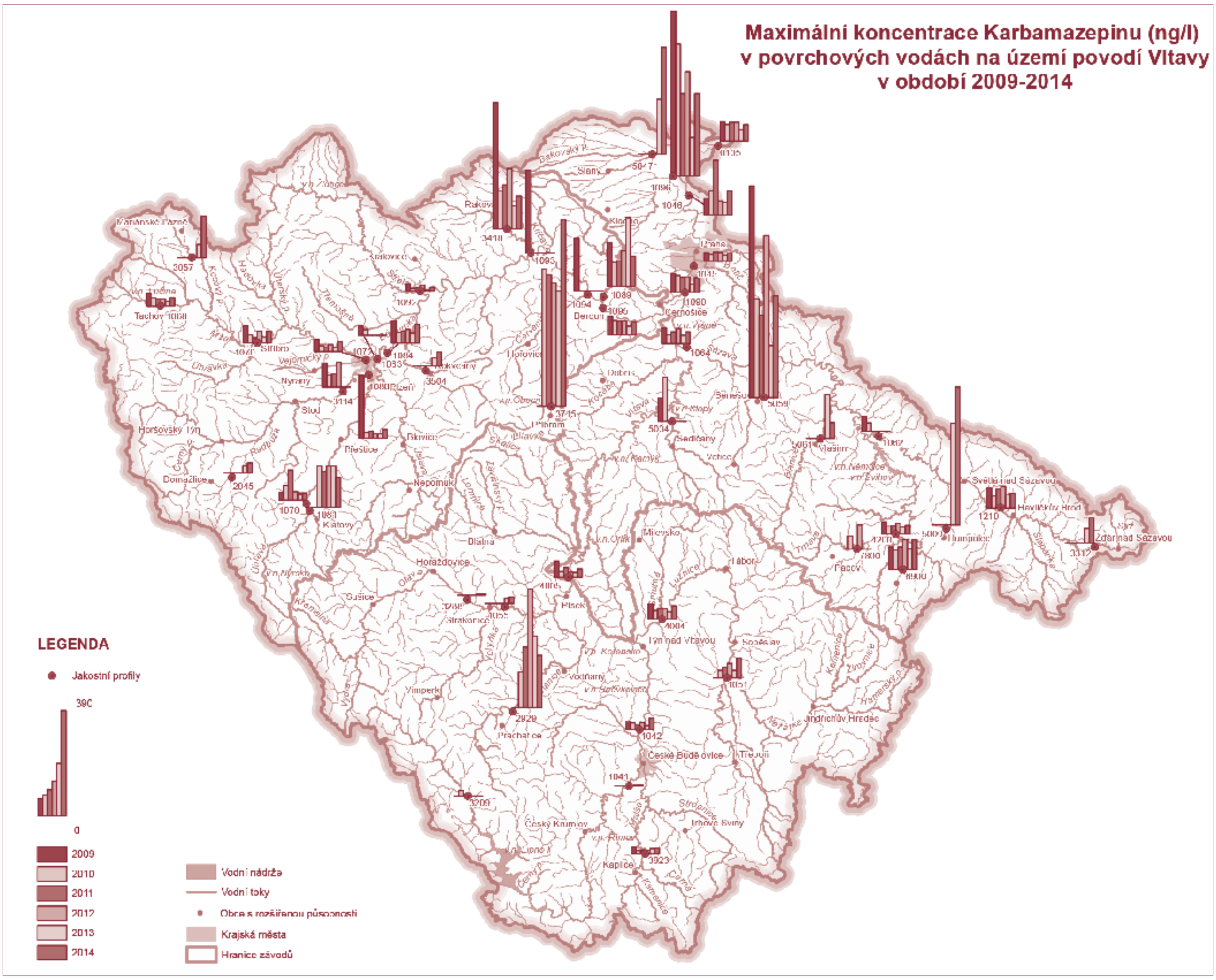

Fig. 2: *Map of the maximum concentrations of carbamazepine in surface water in Vltava river catchment*

<u>Hydrochlorothiazide and Metoprolol:</u> Hydrochlorothiazide is the longest and most common drug used for treatment of high blood preassure. The concentrations in sewage water in the outlets of WWTP´s (in the Vltava river catchment area) ranged from 5 to 20 µg/l. The concentrations of hydrochlorothiazide in surface water usually oscillate from 100 to 200 ng/l, rarely up to 3300 ng/l – Živný brook under the Prachatice town or 2600 ng/l – Benešovský brook under the Benešov town. Metoprolol is modern drug compound, but the concentrations in surface waters of Czech Republic are low for now.

<u>Gabapentin</u> is a drug used for epilepsy therapy and also neuropathy painkiller with a frequent use. The concentrations of gabapentin in surface water are high. Important trait of this substance is low affinity to transformation on metabolic products. This is the reason of high concentration and good stability of gabapentin in surface water. Gabapentin is measured in long distances from the point of source of contamination, and also in drinking water reservoirs. We can say, that gabapentin is a permanent marker of drug contamination of surface water with long term of occurence. Twelve tons of gabapentin has been sold approximately per year on the Czech pharmaceutical market. Due to the gabapentin sold quantity, concentration in sewage and surface water are very high, e.g. Pstružný brook under the WWTP Humpolec (max. 4730 ng/l), Zákolanský brook under the WWTP Kladno, WWTP Kralupy (3100 ng/l) and Benešovský brook under the WWTP Benešov.

<u>Iopromide and Iopamidol</u> belong to group of X-ray diagnostics substances, its occurence is bound to brooks contains sewage water from X-ray diagnostic centres in hospitals. High concentrations of iopromid were measured in

sewage water in the outflow of WWTP Havlíčkův Brod, Tábor a Prachatice in maximum values 6 – 38 μg/l. This diagnostic compounds were measured in surface water in Živný, Příbramský and Benešovský brook (max. 31 ug/l). We suppose that this high value could influence physiological state of water animals.

We didn´t find a significant dependence between the size of point source of pollution and size of the streams. Sometimes is possible, that sewage water from the city with a small population of inhabitatnts has higher values of concentrations of some drugs, than sewage water from city with higher number of inhabitants, drained to smaller river. Final concentration of drugs in rivers depends on: efficiency of technology of WWTP, functionality of technological ponds (following the WWTP), size and therapeutic specialization of hospital, health constitution of inhabitants in the town and drug demand in the catchment of the river. Technology of WWTP, retention time of water in WWTP, efficiency of biological step and inclusion of „GAC step" on WWTP has significant influence to removing or decreasing drugs from sewage water.

Conclusions:
From the text above we can say, that occurrence of drug compounds in surface water is a significant problem and we have to deal with it. It is necessary to pay attention to this important fact and to find out the way for reduction the concentrations of drugs in surface water. The application of separate technologies (e.g. GAC) on the outlet of important sources of drug pollution (hospitals, psychiatric, rehabilitation and other health care centres) is the way to reduction of drug pollution and eliminate influence of this pollution on ecological status of Czech rivers. Moreover the problem of urban sewage water is necessary to solve. Mainly in cities with drug contaminated waste water, which are drained to small brooks or to rivers or reservoirs with drinking water use. Proposed sollutions are very expensive, but at least in the relevant cases is application of functional technologies justifiable. Hopefully will be possible to use some targeted grants or subsidy titles

Changes of the dissolved organic matter during the spring thaw and the effects of the drinking water treatment

Christin Wilske, Peter Herzsprung, Jürgen W. Einax, Wolf von Tümpling

1. Introduction

The composition of the DOM in lakes and reservoirs can change very fast during an extreme rainfall or a spring thaw because the input of the DOM is much higher. This can have a negative effect of the drinking water treatment from raw water because of the different composition. 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 of the human health.

The 2D fluorescence spectroscopy is an innovative and low-cost possibility for measuring the changes in the DOM composition in a very short time. There can be recorded excitation and emission spectra 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. It could be demonstrated that the intensities of 2D fluorescence spectra do not always correlate with the concentrations of DOC. The fluorescence areas can also be used for the calculation of different fluorescence indices. The important areas in the fluorescence spectra provide information about the origin of fulvic acids (FI), the degree of the humification (HIX) and the origin of fluorophore groups (BIX). These results gives first indications of the origin of the DOM (autochthonous or allochtonous) or its degree of humification.

The main focus of this work on the judge- and assessment of 2D spectra observed with its indices at the catchment area of the upper Red and White Mulde, during and after the snow melt in March 2015.

2. Material and methods

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 were artificially drained with grave systems and used for forestry 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. The potential of building DOM is therefore higher than in mineral soils. One result can be the increase of DOC and SAC in the inflows and the Muldenberg dam. [3]

The analyses of the samples are not limited to the dissolved organic carbon (DOC), determined in accordance with DIN EN 1484: 1997-08 and the spectral absorption coefficient (SAC) to the revised DIN 38404-3: 2005-07. [4,5] With the determination of the DOC and SAC statements can be made about the pollution of water.

The central focus is the 2D fluorescence spectroscopy. As a method it finds more widespread use in the last twenty years [6], as it requires little sample preparation and allows a group differentiation of DOM even with short analysis times. There are recorded excitation and emission spectra synchronously.

For the evaluation of the spectra were used the fluorescence indices, like the fluorescence index (FI) [7],

$$FI = \frac{I_{EX\ 370\ nm;\ Em\ 450\ nm}}{I_{EX\ 370\ nm;\ Em\ 500\ nm}}$$

the humification index (HIX) [8]

$$HIX = \frac{\int_{Em\ 434\ nm}^{Em\ 480\ nm} I_{Ex\ 255\ nm}\, dI_{Ex\ 255\ nm}}{\int_{Em\ 300\ nm}^{Em\ 346\ nm} I_{Ex\ 255\ nm}\, dI_{Ex\ 255\ nm}}$$

and the biology index (BIX) [9]

$$BIX = \frac{I_{Ex\ 310\ nm;Em\ 380\ nm}}{Max(I_{Ex\ 310\ nm;Em\ 420-435\ nm})}$$

The FI provides information on the origin of fulvic acids, HIX gives information on the level of the humification and BIX gives information on the origin of fluorophores.

Really important in the evaluation is the separation of humic-like compounds (excitation 300 – 400 nm; emission 400 – 500 nm) and protein-like substances (excitation 220 – 275 nm; emission 300 – 305 nm tyrosine-like and 340 – 350 tryptophan-like). Protein-like substances can be largely ruled out because the catchment area is a drinking water reserve and thus each entry of z. B. fertilizer or sewage is prohibited.

3. Results and discussion

The routine analysis of the water samples showed that the DOC as well as the SAC was higher during the thaw in March 2015 in comparison to the other month of the year 2015 (see Tab. 1). Especially the White Mulde pre-dam sample had a high value but this could be random. The value of the depth 702 meters above sea level was important because this depth was chosen for the drinking water treatment at this moment.

Tab. 1: *Results of the analysis of the different sampling locations in March 2015 and the median values of one year.*

Sampling location	DOC [mg/L]	median DOC	SAC [254 nm]	median SAC
White Mulde	11,3	5,4	,49	,23
White Mulde predam	12,6	6,4	,59	,34
Red Mulde	10,7	7,4	,49	,34
Red Mulde predam	11,5	9,4	,51	,40
Muldenberg dam 702 meters a.s.l.	7,7	6,9	,37	,32

Tab. 2: *Results of the calculated fluorescence indices of the different sampling locations in March 2015 and the median values of one year.*

Sampling location	FI	median FI	HIX	median HIX	BIX	median BIX
White Mulde	1,3	1,2	16,5	14,7	0,6	0,5
White Mulde predam	1,2	1,2	**16,3**	**10,2**	0,5	0,5
Red Mulde	1,3	1,2	**19,9**	**12,8**	0,5	0,5
Red Mulde predam	1,3	1,2	**19,0**	**9,3**	0,5	0,5
Muldenberg dam 702 m a.s. l.	1,3	1,3	**17,6**	**9,5**	0,6	0,5

In March 2015 the dissolved organic material was predominantly of terrestrial and allochthones origin (FI-values ≈ 1.4, BIX-values smaller 0.6) (see Tab. 2). HIX-values over 10 represent fulvic acids extracts. The higher the HIX-values are the more aromatic are the substances. All values were significantly higher than 10, which was likely due to the thaw. During the thaw was entered new organic material with high-molecular structures into water bodies [9 – 11]. In comparison to the other month the thaw in March 2015 was a very special event where a lot of material entered the water bodies.

For the comparison between the sampling locations difference fluorescence spectra were calculated. With Fig. 1 it can be demonstrated that the DOC differences not always correlate with the differences of the fluorescence spectra. That means that samples with DOC difference of 0.2 mg/L can have a greater difference in the fluorescence intensity than a DOC difference of 0.6 or 0.8 mg/L.

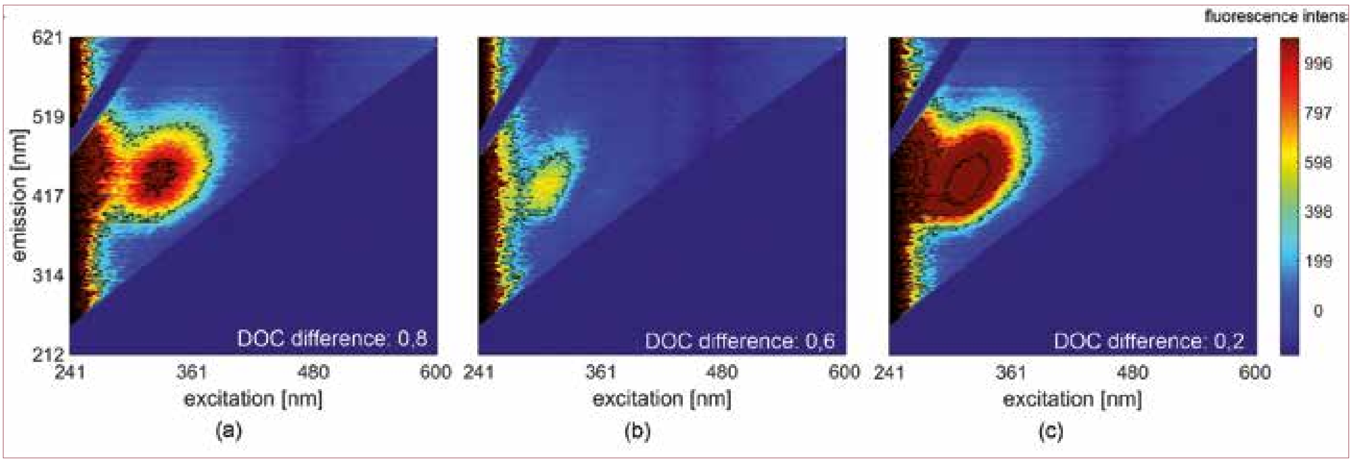

Fig. 1: *Absolute differences of the fluorescence spectra of the Red Mulde and the Red Mulde pre-dam (a), the Red and the White Mulde (b) and the Red Mulde pre-dam and the White Mulde (c). In addition are shown the DOC differences between these sampling locations.*

In Fig 2. it can be seen that the difference fluorescence spectra (a) between the Red Mulde and the Red Mulde pre-dam has a negative fluorescence difference (d). That means that the Red Mulde pre-dam included more substances with higher fluorescence intensity than in the Red Mulde. In the other difference spectra (ef) are shown positive differences. That means that the White Mulde had lower fluorescence intensity than the Red Mulde und the Red Mulde pre-dam.

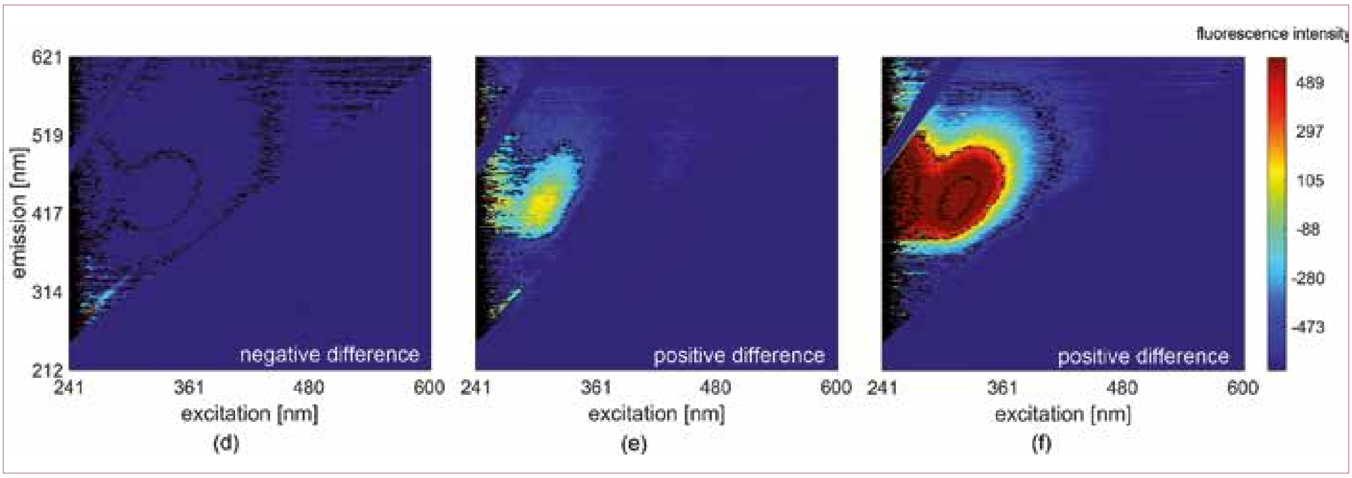

Fig. 2: *Differences of the fluorescence spectra between the water samples. It gives information about the fluorescence intensity of the include substances in the water sampling location of the compared samples.*

4. Conclusion

i) The DOM has a larger and complex molecular structure like fulvic acids extracts, because the HIX-values are higher than 10 in comparisons to the other month. ii) Events like the spring thaw are the reason for the imission of new organic fulvic-like material in large amounts into reservoirs. iii) This material can produce problems due the drinking water treatment because of the high entry in a short time and the high molecular structure of the DOM. In March 2015 a lot of fulvic acids extracts with a high DOC concentration entered in the pre-dams.

The 2D fluorescence spectroscopy results come up with additional information about the different composition of the DOM in the inflows of the pre-dams and dam. Also we get information about the origin of the humine substances and the fulvic acids and their degree of humification. During a spring thaw or an extreme rainfall were entered a lot of substances with a high degree of humification (HIX > 16). Despite small DOC concentration (7.7 mg/L) may be impaired the drinking water treatment because of the complex molecular structure of the dissolved organic material (HIX: 18).

Literature

[1] Grunewald, K. ; Schmidt, W. (2005) Problematische Huminstoffeinträge in Oberflächengewässer im Erzgebirge – Abschlussbericht zum Huminstoffprojekt

[2] Grunewald, K., et.al. (2003) Verstärkte Huminstoffeinträge in Trinkwasserspeicher zentraleuropäischer Mittelgebirge. Wasser und Boden 4, 47 – 51

[3] Freeman, C., et.al. (2001) Export of organic carbon from peat soils. Nature Nr. 412, S. 785

[4] Norm DIN EN 1484:1997-08 (1997) Wasseranalytik – Anleitung zur Bestimmung des gesamten organischen Kohlenstoffs (TOC) und des gelösten organischen Kohlenstoffs (DOC)

[5] Norm DIN 38404-3:2005-07 (2005) Deutsche Einheitsverfahren zur Wasser-, Abwasser- und Schlammuntersuchung – Physikalische und physikalisch-chemische Kenngrößen (Gruppe C) – Teil 3: Bestimmung der Absorption im Bereich der UV-Strahlung, Spektraler Absorptionskoeffizient (C 3)

[6] Murphy, K. R., et. al. (2013) Fluorescence spectroscopy and multi-way techniques. PARAFAC. Analytical Methods 5, (23), 6541 – 6982

[7] McKnight, D.M., et.al. (2001) Spectrofluorometric characterization of dissolved organic matter for indication of precursor organic material and aromaticity. Limnology and Oceanography 46, 38

[8] Zsolnay, A., et. al. (1999) Differentiating with fluorescence spectroscopy the sources of dissolved organic matter in soils subjected to drying. Chemosphere 38, 45

[9] Huguet, A., et. al. (2009) Properties of fluorescent dissolved organic matter in the Gironde Estuary. Organic Geochemistry 40, 706

Persistent and mobile organic contaminants in the water cycle

Thorsten Reemtsma, Urs Berger, Hans Peter H. Arp, Herve Gallard, Thomas P. Knepper, Michael Neumann, Jose Benito Quintana, Pim de Voogt

1. Persistent and Mobile Organic Contaminants in the water cycle

Rivers are an important source for drinking water supplies in Europe, either by direct water abstraction and treatment or, more frequently after river bank filtration. However, rivers are also receiving treated municipal wastewater discharges. In this way partially closed water cycles are established [1]. Persistent and mobile organic compounds (PMOC) are considered as critical contaminants in such partially closed water cycles. PMOC may not be retained by the barriers in such cycles (such as the treatment plants and the subsurface) and may, thus, reach the raw waters used for drinking water production. If drinking water treatment is not suitable to remove PMOC, such partially closed water cycles may turn into cycles for PMOC. Dilution would, then, be the only process reducing their concentration. In the past years single PMOC have been analytically detected. Most of these detections were, however, not made in regular monitoring or screening exercises. Why is it the case?

2. The Polarity Gap

Organic contaminants that we consider mobile in the water cycle are very polar and often of low molecular weight. These properties make PMOC extremely challenging to analyze, because they hamper enrichment from water as well as chromatographic separation. Consequently, knowledge on the occurrence of PMOC in aquatic compartments (including raw waters used for drinking water production) is very limited. It is thus questionable whether sufficient protection of drinking water resources with respect to PMOC is in place. Figure 1 depicts the 'polarity gap' in existing analytical methods. Because analytical methods that allow for a systematic search for PMOC in water are lacking, there is also a knowledge gap with respect to PMOC's occurrence in surface waters as well as in raw waters used for drinking water production. Further, we do not know if PMOC are removed in drinking water preparation and if current regulation is sufficient with respect to assure drinking water quality.

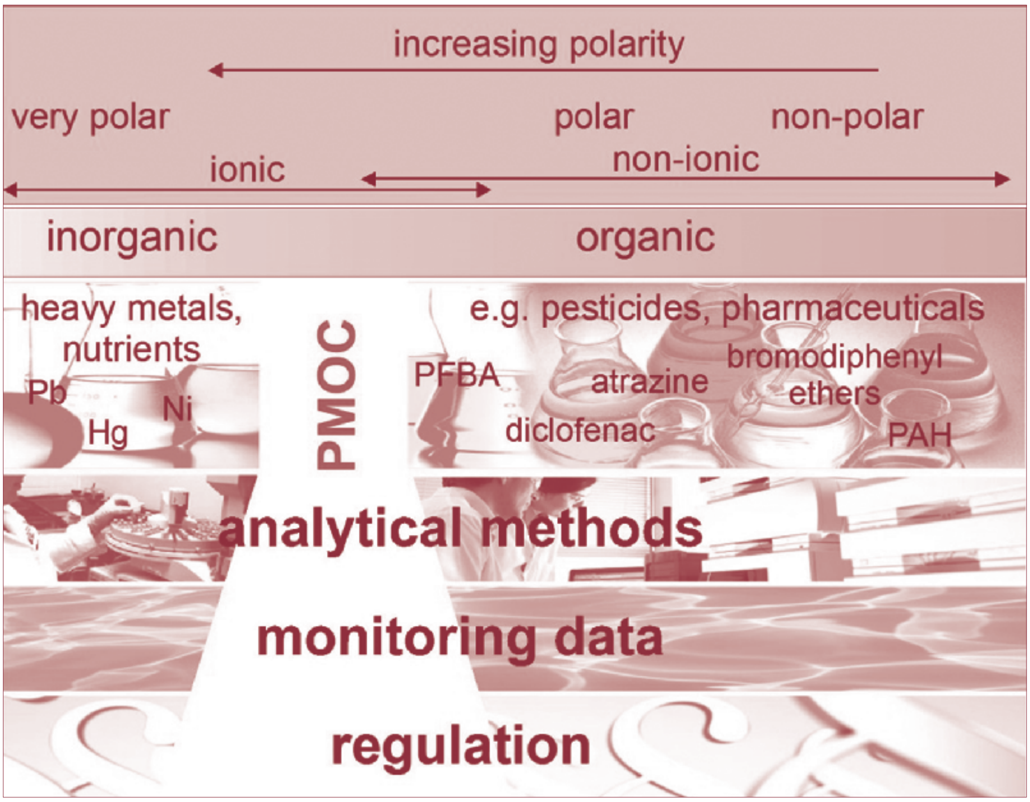

Fig. 1: *Polarity gap in analytical methods, monitoring data (and regulation?) for persistent mobile organic chemicals (PMOC).*

3. The Project PROMOTE

PROMOTE (PROtecting water resources from MObile TracE chemicals) is a recently launched research project under the European Union Joint Programming Initiative "Water Challenges for a Changing World" (Water JPI). Seven partners and seven associated partners (authorities, water supply companies) from five European countries form the consortium.

PROMOTE focuses on PMOC in environmental water cycles and in drinking water production. The objectives are to close the significant knowledge gaps with respect to (a) identification and prioritization of the PMOC of highest concern, (b) trace analytical methods for screening and quantitative determination of PMOC in water, (c) occurrence and levels of PMOC in groundwater and surface water, (d) environmental emissions and (e) removal or transformation of PMOC in the drinking water production. Based on the expected results, PROMOTE strives to develop recommendations with respect to chemical regulation (REACH) and water quality monitoring (WFD watch list).

4. Strategies to Determine PMOC in the Water Cycle

As the lack of analytical methods for PMOC is the underlying problem, the development of analytical techniques that allow to screen for and to monitor PMOC in water samples is the key task. Liquid chromatographic approaches that do not rely on reversed-phase chromatography are being developed, based on either hydrophilic interaction chromatography (HILIC) or mixed-mode chromatography. Besides that also supercritical fluid chromatography (SFC) is being tested for its potential to retain very polar analytes and to make them amenable to mass spectrometric detection.

PMOC may be formed as transformation products from less polar and less persistent environmental contaminants. But besides that, many PMOC are also intentionally produced and used. Within the European Union high-volume production chemicals need to be approved before being marketed, e.g. as pesticides, biocides, pharmaceuticals or industrial chemicals. In these regulatory processes (e.g., REACH regulation for industrial chemicals) much information is provided and collected, such as on physico-chemical properties, on environmental stability, potential transformation products, and use tonnages.

Such data may be utilized to prioritize compounds for their occurrence as PMOC in the environment. Highly ranked compounds could then be included in screening methods to search for their occurrence in the water cycle. The PROMOTE consortium performs such a prioritization exercise for the approx.13000 chemicals registered under REACH. This exercise will also consider chemicals that are likely transformed into PMOC in the environment.

The interplay of these two independent strategies, provision of novel analytical methods and of information on compounds to search for, is one of the major strengths and advantages of PROMOTE in the effective prioritization of target PMOC.

This forms the basis for a monitoring study using representative water samples from five European river basins, WWTP effluents, groundwater samples and raw waters used for drinking water production. This not only provides one of the first comprehensive sets of monitoring data of PMOC in environmental water cycles, but also information on emission sources, transport, dilution and fate of PMOC in aquatic systems with different characteristics and climate.

For PMOC occurring in raw waters (or likely to occur in such waters) PROMOTE studies the potential of different drinking water treatment strategies to remove PMOC. Should PMOC be detected that occur widely and that are associated with an environmental or health concern they may also be candidates for the watch list of the EU Water Framework Directive.

5. First results

By using a new chromatographic approach (HILIC) for screening of water samples by LC-MS one of the PROMOTE partners has recently detected a novel class of contaminants in the water cycle, the halogenated methane sulfonic acids [2]. These novel compounds appear to be widely distributed in the aquatic environment. Their sources, point of discharge into the water cycle, their formation pathway as well as removal options are now being studied in more detail.

With the intensified search for PMOC in the near future, a more comprehensive set of data on the occurrence of such compounds in the water cycle will be gathered. This and the further activities of the PROMOTE consortium will show whether our raw waters used for drinking water production are adequately protected, or, if not, which measures would help to improve their protection.

Acknowledgement:
The authors thank the European Union Joint Programming Initiative “Water Challenges for a Changing World” (Water JPI) with financial support by the Bundesministerium für Bildung und Forschung (BMBF, Germany, 02WU1347A/B), Forskningsrådet (Norway, 241358/E50), Ministerio de Economía y Competitividad (Spain, JPIW2013-117), Office National de l‘Eau et des Milieux Aquatiques (France, IC2MP project PROMOTE).

Literature:

[1] Reemtsma, T. and Jekel M. (2006) Organic Pollutants in the Water Cycle – Properties, occurrence, analysis and environmental relevance of polar compounds. Wiley-VCH, Weinheim

[2] Zahn, D., Frömel, T., Knepper T.P. (2016) Halogenated methanesulfonic acids: A new class of organic micropollutants in the water cycle. Water Res. 101, 292 – 299

Is a fishpond able to retain modern pollutants from our settlements effectively?

Jindřich Duras, Jan Potužák

Fishponds were recognized as very important components of a watershed: they are able to transform fluxes of many substances – organic matter, suspended solids and especially nutrients [1,2]. Because fishponds are water bodies where vigorous biological/biochemical processes take place we hypothesized that possibly also relatively persistent chemical compounds e.g. pharmaceuticals could be metabolized (more or less decomposed).

10 representatives of the Musk compounds group, 27 pharmaceuticals and several other substances (Caffein, Saccharine, Triclosan, Triclocarban, Iopromide, Iopamidol) were monitored during a mass balance study of the hypertrophic fishpond Buzický during 2014 and 2015. Calculations were based on two samples monthly with parallel water flow measurements. Whole the two-year fish production cycle was covered by the monitoring including fish harvesting period in October 2015. The fishpond was strongly exposed to micro-pollutants via waste waters from a waste water treatment plant (WWTP) of the City Blatná.

Main results are given in table 1 and 2. The findings could be summed up in short as follows:

- The regular inflow of the fishpond (the stream Mračovský) exhibited by one or two orders of magnitude lower concentrations of monitored compounds when compared with the flow from WWTP and 20 out of 27 analysed chemicals were not found in detectable amounts in the stream. These relatively favourable results were caused by the fact that the drainage area was inhabited only sparsely. On the other hand, it should be emphasized that psychopharmaceuticals Gabapentin and Karbamazepin as well as painkillers Ibuprofen and Diclofenac were present in the stream regularly. It is clear evidence of alarmingly widespread presence of these chemicals.
- The fishpond ecosystem was loaded by high amounts of (1) psychopharmaceuticals which were eliminated with low effectivity (similarly as Saccharine and Caffein) and of (2) compounds used for high blood pressure treatment (Atenolol, Metoprolol, Furosemide and Hydrochlorothiazide) which were eliminated very effectively (as well as Musk substances).
- During extremely dry year 2015 were the monitored compounds eliminated more effectively (probably due to substantially longer theoretical water residence time) than in the year 2014. Seasonal variability of the elimination efficiency was indicated in case of some compounds, but it is not enough data to describe it more precisely.
- Emptying of the fishpond before the fish harvest was an important period from the mass balance point of view because large amounts of water leaved the pond. Therefore, the most important emissions were found in the case of slowly decomposed substances especially of psychopharmaceuticals that were present in the water in relatively high concentrations.
- During the two-year production cycle the fishpond received about 25 kg of monitored compounds i.e. ~ 0.4 – 0.5 kg ha^{-1}. It also means that 1 inhabitant of the City Blatná contributed per 1 year with ~2.2 g and ~2.3 g of pharmaceuticals during 2014 and 2015 respectively.

***Table 1 and 2:** Fishpond Buzický – results of a mass balance monitoring of selected compounds. Data for 2015 are without emptying and harvesting of the pond, n = not calculated, + retention, - release.*

		Musk keton	Galaxolide (HHCB)	Tonalide (AHTN)	Cashmeran (DPMI)	Karbamazepin	Gabapentin	Tramadol	Ibuprofen	Diclofenac	Atenolol	Metoprolol	Furosemide	Hydrochlorothiazide
		concentration (ng l⁻¹)												
2014	Infow	<5	5	<5	<10	30	58	<10	39	12	<10	<10	<50	<50
	WWTP	7	358	71	28	449	1425	152	655	435	307	287	537	1383
	Pond	<5	6	3	5	114	442	8	112	27	12	8	30	43
2015	Infow	<5	5	<5	<10	26	48	<10	44	29	<10	<10	<50	<50
	WWTP	12	618	68	49	1248	2870	562	1747	795	681	679	415	1134
	Pond	<5	7	<5	<10	167	463	13	83	25	10	8	27	36
		mass balance (g)												
2014	Infow	n	20	8	16	73	122	16	95	51	16	16	84	94
	WWTP	8	388	68	27	478	1737	150	780	454	360	318	493	1106
	Pond	n	34	13	25	561	2003	41	552	156	69	48	163	228
	Retenton	n	374	63	18	-10	-144	125	323	349	307	285	414	973
	Retenton %		92	82	41	-2	-8	75	37	69	82	86	72	81
2015	Infow	4	10	4	8	39	62	9	65	49	8	9	52	42
	WWTP	10	306	39	31	963	2262	279	944	425	319	313	218	545
	Outlow	6	19	6	11	305	964	31	262	109	47	35	62	120
	Emptying	2	5	2	4	224	400	19	128	44	4	4	20	20
	Harvestng	0	1	0	1	13	18	3	17	12	2	3	5	11
	Retenton	4	311	35	21	342	561	247	572	318	286	302	176	446
	Retenton %	41	94	84	62	51	36	88	67	72	85	89	71	77

Year		Sulfamethoxazol	Ketoprofen	Sulfapyridin	Trimetoprim	Naproxene	Triclosan	Bezafibrate	Warfarin	Clarithromycin	Roxithromycin	Erythromycin	Saccharin	Caffein	Paracetamol
		concentration (ng l^{-1})													
2014	Infow	<10	<10	<10	<10	<50	<20		<10	<10	<10	<10	135	107	7
	WWTP	180	31	64	146	149	44		14	11	209	17	1814	2275	499
	Pond	30	5	8	16	25	11		<10	<10	10	<10	366	361	28
2015	Infow	<10	<10	<10	<10	<50	<20	<10	<10	<10	<10	<10	130	105	<10
	WWTP	480	30	169	409	351	63	30	24	470	21	101	2986	4418	2094
	Pond	47	<10	8	17	<50	<20	<10	<10	16	<10	<10	356	267	35
		mass balance (g)													
2014	Infow	17	16	16	16	79	32		n	n	11	n	308	300	20
	WWTP	182	33	79	168	151	48		14	n	76	19	1959	2490	573
	Pond	146	25	41	85	127	52		n	n	34	n	1868	1815	180
	Retenton	52	23	54	99	103	28		6	n	53	9	399	974	413
	Retenton %	26	48	57	54	45	35		n	n	61	n	18	35	70
2015	Infow	8	8	8	8	42	18	8	8	8	8	9	149	127	25
	WWTP	335	24	90	220	203	52	25	25	260	19	57	2289	2618	781
	Outlow	124	11	26	50	63	25	11	13	59	11	13	952	723	298
	Emptying	55	4	4	9	20	8	4	4	4	4	4	440	152	16
	Harvestng	3	1	1	1	3	1	1	1	1	1	1	40	11	6
	Retenton	127	13	68	161	148	28	13	11	194	8	44	722	1675	469
	Retenton %	47	50	69	75	68	50	52	47	76	38	77	41	69	60

It must be stated that in our calculations were not included adequate products of decomposition which could be biologically active, too. Therefore, the decreased concentrations should not be understand as full elimination of the proportion of each of the compound, but better as a transformed proportion of the “mother chemical” only.

The results correspond well with the data obtained by monitoring of the two biological ponds that processed waste waters from the City Pelhřimov (only concentration data are available) [3]. For example, low effective decrease of concentrations was found in the case of widespread psychopharmaceuticals and Caffein + Saccharine, but highly effective decrease in the case of pharmaceuticals used for high blood pressure control.

The results presented here are the first that were obtained with respect to fishponds. Despite the fact that it is too early to make serious conclusions we think it should be stated that fishponds could help us with elimination of some xenobiotics from surface waters substantially. This help is relatively ineffective in the case of resistant compounds like e.g. Gabapentin (potentially hazardous pollutant). These resistant compounds should be treated by the source.

We think that the results presented here confirm one of very important conclusions that we have made during studies concerning nutrient retention in fishponds [1,2,4]. Properly managed fishponds are able to retain or eliminate substances that are unwanted in waters, but when the fishponds are overloaded and self-purification mechanisms overexploited possible assets of ecosystem services disappear.

Literature

[1] Potužák, J., Duras, J. (2015) Nutrient retention in fishponds – importance, assessment and possible use. Vodní hospodářství 65(7): 7 – 15 (In Czech)

[2] Duras, J., Potužák, J., Marcel, M., Pechar, L. (2015) Fishponds and water quality. Vodní hospodářství 65(7): 16 – 24 (In Czech)

[3] Duras, J., Potužák, J. (2016) Fishponds and xenobiotics. Fishponds 2016, June 23. – 24. 2015, Praha, Czech Republic, David V., Davidova T. (Edit.), p. 89 – 100.

[4] Potužák, J., Duras, J. (2015) Ecosystem services of fishponds – retention of nutrients and micropollutants. Abstract Book, SEFS – Symposium for European Freshwater Sciences, July 5 – 10, 2015, Geneva, Switzerland, 526.

A tetrazolium-based, direct cultivation method to detect antibiotic resistance in surface water biofilms

Jakob Benisch, Björn Helm, Thomas Käseberg, Heike Brückner, Gerit Orzechowski, Peter Krebs

1. Introduction

Since the discovery of antibiotics in the early twentieth century their use in medicine has become widespread as well as their variety and modes of action. However, their fate and behavior in the environment received little notice until recent development of analytical methods, which allowed investigations on these topics. Antibiotics in the water cycle are mostly verifiable in effluents of hospitals, more than in municipal wastewater and considerably more than in surface water [1, 2]. Not only the chemical pollution, caused by these compounds, gives reason for concern, but also the fact that they the potential to evoke and distribute resistance genes among microorganisms. A long-term exposure of organisms to sub-therapeutic doses may provide selective pressure for the increase of antibiotic-resistances [3]. Antibiotic resistance spread in the environment is becoming a worldwide concern and a public health issue [4]. For example, the resistance rate of fluorchinolone-resistant E. coli increased, from 4% in 1999 to 29% in 2006. About 70% of the bacteria causing infections are resistant to at least one antibiotic [5]. Antibiotic compounds in the environment and the waste water system are only one cause for this development, but a summary of Baquero and his colleagues may be cited here: “Water is involved as a crucial agent in the genetic reactors but particularly the possibility of reducing the genetic variability of antibiotic resistance depends on the ability of humans to control the flow of active antimicrobial agents, bacterial load and genetically based biological information along these genetic reactors.”

To assess the prevalence of antibiotic resistances biochemical methods like direct cultivation, commonly done with disk diffusion methods for antimicrobial susceptibility testing, molecular-biological methods, like enzyme linked immunosorbent assays (ELISA) and genetic methods, with application of detection by PCR (polymerase chain reaction) or fluorescent in situ-hybridization (FISH) are used. This study presents an experimental setup to employ a direct cultivation method, which can be used to detect the development of antibiotic resistance in creek-biofilm caused by waste water treatment plant (WWTP) effluent, for example. The idea of the underlying method is to proof antimicrobial resistance in biofilm samples by exposing them to a dilution series of an antibiotic compound and measuring the effect of the compound on the enzymatic activity. In this case, the hypothesis would be, that more resistant samples should develop comparative better under stress induced when they are regularly exposed to higher or more frequent antibiotic loads, than bacteria that have less contact with antibiotics and thereby react more sensitive.

To make enzymatic activity of bacteria measurable, a tetrazolium salt, 2,3,5-triphenyltetrazolium chloride (TTC, Merck), was chosen as indicator. This compound is reduced to a formazan by bacterial dehydrogenases, and can be quantified photometrically indicating the enzymatic activity of the sample. Eloff investigated the effects of plant extracts on bacteria and reported that tetrazolium assays yielded results of comparable sensitivity as common agar diffusion techniques for the determination of the minimum inhibitory concentration (MIC). Moussa et al. received similar results for the antimicrobial agent chitosan, using TTC. Another article about the detection of antibiotic resistant *M. tuberculosis* bacteria showed good results with the usage of TTC [9]. Both authors stated that the usage of TTC is an efficient alternative method for qualitative and quantitative determination of antibacterial activity.

2. Material and Methods

Biofilm samples were taken from Lockwitzbach, a creek in the vicinity of Dresden, which is influenced by the discharge of a WWTP with a high load of hospital waste water and several combined sewer overflows within the urban area. The biofilm was grown on a carrier material for trickling bed filters (SESSIL®, Norddeutsche Seekabelwerke GmbH), but have also been successfully used as growth media for biofilm in the sewer network to determine the pharmaceutical load in the wastewater [10]. Sampling of biofilm was performed in the summer and autumn of 2014, by manually removing grown biofilm material from the strip. The harvested biofilm was initially sieved with a 63 mm pore size sieve. Before the experiments were conducted, absorption peaks in the UV-VIS wavelength range induced by formazan concentration as well as the influencing parameters were investigated, including concentrations of nutrient broth, TTC concentration, biofilm sample and incubation time. After the preliminary experiments were completed, the samples were exposed to different concentration steps of the antibiotic doxycycline (doxycycline hyclate, Sigma-Aldrich), in a range from 1 mg/L to 100 mg/L. The compound was exemplarily chosen for the test due to its good solubility in water and its prevalence in the stream. Samples were prepared by pipetting 1.32 mL of biofilm suspension into an autoclaved test tube. Consecutively, a mixture of 3 mL consisting of deionzed water with different volumes of antibiotic stock solution were added. Afterwards a nutrient solution (beef extract and peptone, Carl Roth GmbH + Co. KG, 0.7 mL) and 0.5 % TTC solution (0.1 ml) were added. Additionally, a blank solution without antibiotic and TTC was prepared as control.

The prepared test tubes were mounted on an orbital shaker with a revolution speed of 125 rpm. The inoculation was carried out at room temperature of about 22 °C and formazan concentration was measured after 38 hours. The long inoculation time was chosen as Thomulka et al., who investigated in the effects of antibiotics on Vibrio harveyi using bio-luminescence, found that almost no toxic effects could be seen for short incubation times, however for long-term assays (24 hours), with reproduction as endpoint, a significant effect was detectable. These findings about chronic toxicity were in accordance with other studies using similar methods but other bacteria [12]. After thoroughly mixing and resuspending the sample, 2 mL was filled into centrifuge (Sigma 1-14) tubes and centrifuged for 10 min with 10000 rpm (7379*g). 1.8 mL of the supernatant was decanted with a pipette and the remaining pellet was resuspended in 2 mL ethanol. After a careful fragmentation of the precipitate the sample was shaken, for about 10 min until the formazan, which was enzymatically reduced from TTC, had been completely dissolved in ethanol. The samples were centrifuged once again for 10 min at 10000 rpm and then the supernatant was filled into a 10 mm quartz glass cuvette and the extinction from 190 nm to 800 nm was measured by a spectrophotometer (Hach-Lange DR 5000).

3. Results

The recorded spectra of TTC and the formazan, 1,3,5-triphenylformazan (TPF), were compared with another spectrum from literature [14] and the peaks at the wavelengths of 300 and 480 nm were chosen for further analysis as a good linear correlation could be identified.

As displayed by Fig. 1A, a ratio of at least 10 % of nutrient broth to the total inoculum volume needs to be added to provoke growth. For one inoculum, the dependence on time was also taken into consideration and it was found that the extinction after 303 hours was higher than after 40 hours, caused by continuous activity of the bacteria after incubation time. For the conducted experiments a ratio of 13 % of nutrient broth to the whole sample volume was used. It was kept rather low to prevent an influence of the nutrient broth on the bacterial community and to receive TFP in amounts below the upper detection limit of the spectrometer. Variations in amounts of inoculation material only showed a slight pattern of increased TFP formation by increasing inoculant concentration after 40 hours of incubation time, after 303 hours the pattern became more pronounced (Fig. 1B). A ratio of 26 % of biofilm to the whole sample volume has been used. The optimal amount of TTC was determined in concentration stages experiments. A relationship between the formation of TPF and the amount of added TTC in solution can be seen (see Fig. 1C). The peak in graph C indicates that a maximum extinction can be obtained by adding about 2 % TTC solution to the total sample volume. A higher concentration of TTC has an inhibitory effect on the inocula, as reported in literature [15]. The produced TPF is also dependent on the inoculation time. The formation during the incubation followed a linear trend, until the nutrient broth was exhausted. As seen in Fig. 1D the depletion of the nutrient broth is depending on the microbial activity (relative to extinction of produced TPF), as one biofilmsample enters the decline phase earlier than the other. An incubation time of 38 hours in was chosen in accordance with suggestions from Thomulka et al. After the experimental setup was determined, biofilm was taken from the studied creek and doxycycline was added in decadic concentration steps to the samples. After the preparation, the extinction of the sample with antibiotic concentration stages was measured photometrically. Of the ten values determined at 480 nm, means for every step were calculated and normalized by using the mean extinction of the samples without Dox. as a reference value (Fig. 2A). Then they were logarithmically plotted over the Dox. concentrations. This curve shows the inhibition on the microorganisms caused by the antibiotic. Furthermore, two different equations were tested to fit to the gained results (all R^2 above 0,91): A standard four-parameter logistic function from [16] and a hormesis function from [17] (Fig. 2, B).

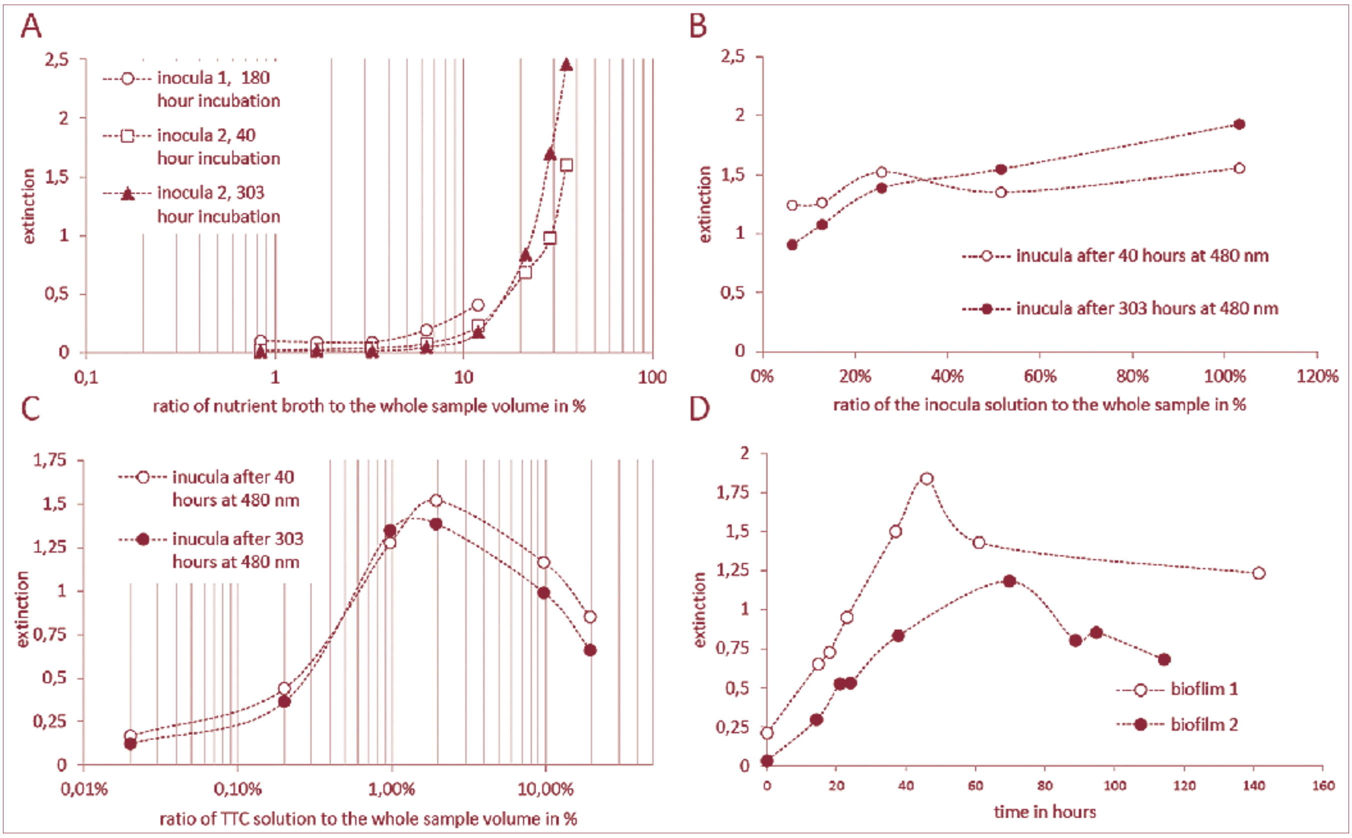

Fig. 1: *Relationship between nutrient broth (in % to the total sample volume) and TPF development (A); Relationship between inocula solution and TPF development (B); Relationship between TTC concentration and FTP formation (C); Measured development of TPF over time for two different biofilm samples (D)*

It was assumed that TTC concentration would decrease proportionally to the amount of created TFP and that this concentration could be determined photometrically as well. Therefore, four samples from every concentration step of the previous experiment were taken before the centrifugation and compared with the final results gained by measuring TPF. A peak in the measurement range at 246 nm could be identified, which showed a linear relationship between extinction and concentration of TTC, and the resulting extinction values were normalized and transformed to be visualized by a dose-response curve (for TPF: Fig. 2C and TTC: Fig. 2D).

4. Discussion

The initial experiments did not indicate major exceptions from the expectations, that there is an influence of the amount of nutrient broth, TTC solution, inoculation time and inoculation material on the amount of formed TPF. The results of the main experiment (determination of dose response curve) also showed that the determined values follow the expected trend of the antibiotic effect on the biofilm. IC50 values, depending on the fitting function, were ranging between 0.84 mg/L and 1.81 mg/L Dox. Unfortunately, IC50s for Dox. were not available in literature, but for tetracycline, which belongs to the same antibiotic group of tetracycline as Dox. (both inhibit the protein synthesis by binding to the 30S subunit of microbial ribosomes), some results from toxicity tests could be found. For samples from an activated sludge reactor a prolonged respiration test (based on OECD 209) showed that IC50 for an exposure time of 30 min was above 100 mg/L whereas for 20 hours the IC50 was between 1 – 10 mg/L [18]. This endpoint is in accordance with the results of the conducted experiment and with the effect of different short and long term toxicities. It was shown that the amount of TTC decreases in the same order of magnitude as TFP was formed (Fig. 2C and D). The function and thereby the IC50 values, 1.29 mg Dox./L (TPF) and 1.57 mg Dox./L (TTC), showed that there is a good correlation between TTC and TPF. Thereby, the testing procedure could be reduced to only measuring the TTC concentration with the advantage that the resuspension step would become obsolete. Problems were cognizable for the different conditions in the creek and under laboratory conditions, which could alter the bacterial community. Unfortunately, these changes could not be further determined. The average standard error of the results of the main experiment was calculated to 10 %. About half of it arose due to uncertainties in the extraction process and the other half is assumed to originate from deviations of the used environmental samples.

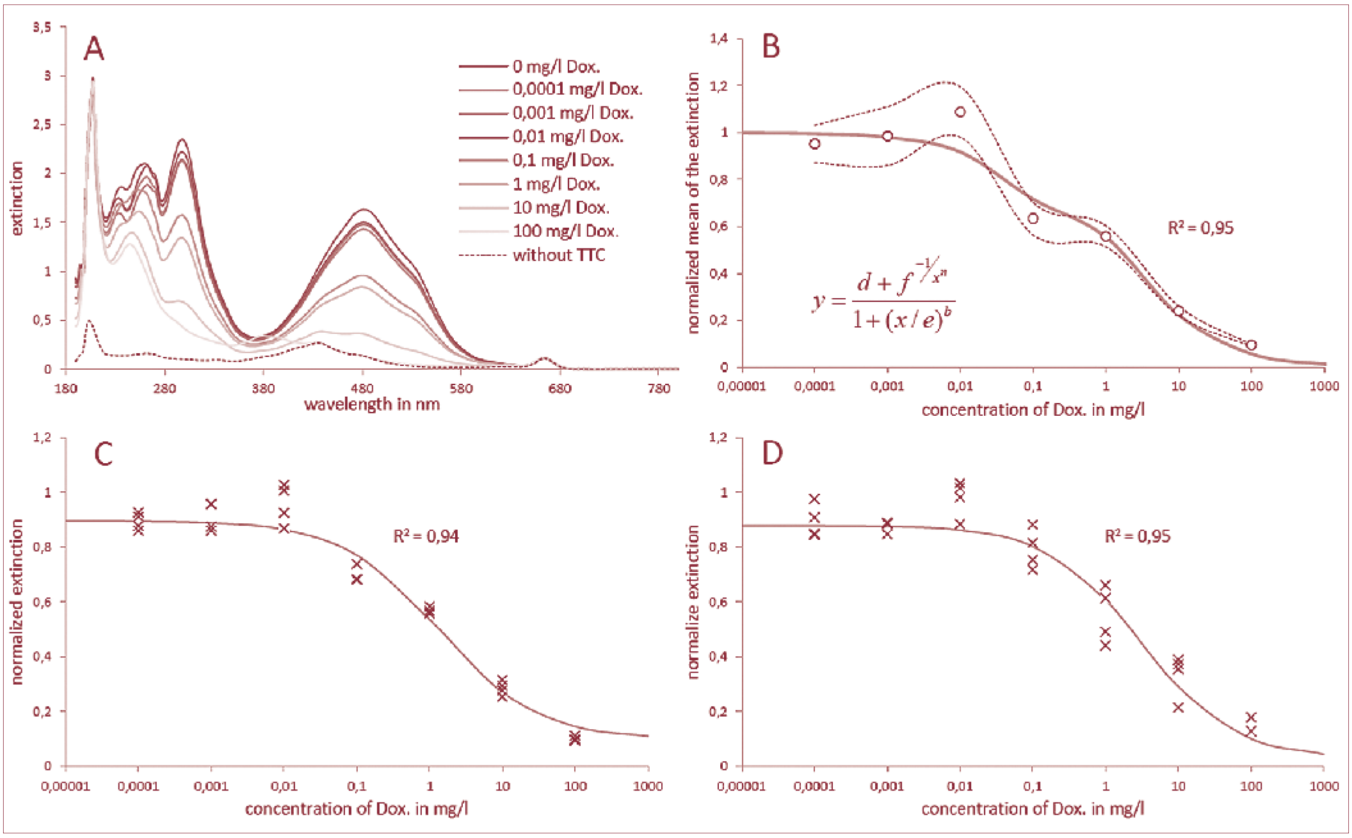

Fig. 2: *Spectra plotted of the medians of every concentration step and pictures of the samples (from 0 to 100 mg/l Dox.) after 38 hours of inoculation (A) Dose-response curve of stream biofilm for doxycycline; fitting functions taken from [18] (B), Points are the mean values; dashed lines represent the 95% confidence interval, (n=10). Resulting dose response curves using mean values of the measurement and standard four-parameter logistic function for TPF (C) and TTC (D), as only four values were available all of them were plotted in the graph.*

Referencess

[1] K. Kümmerer, “Antibiotics in the aquatic environment–a review–part I,” Chemosphere, vol. 75, no. 4, pp. 417 – 434, 2009.

[2] E. Zuccato, D. Calamari, M. Natangelo, and R. Fanelli, “Presence of therapeutic drugs in the environment,” The lancet, vol. 355, no. 9217, pp. 1789 – 1790, 2000.

[3] K. Kümmerer, “Antibiotics in the aquatic environment–a review–part II,” Chemosphere, vol. 75, no. 4, pp. 435 – 441, 2009.

[4] J. Davies and D. Davies, “Origins and evolution of antibiotic resistance,” Microbiol. Mol. Biol. Rev., vol. 74, no. 3, pp. 417 – 433, 2010.

[5] E. A. R. S. S. EARSS, “Annual report 2005,” Bilthoven Neth. RIVM, 2006.

[6] F. Baquero, J.-L. Martínez, and R. Cantón, “Antibiotics and antibiotic resistance in water environments,” Curr. Opin. Biotechnol., vol. 19, no. 3, pp. 260 – 265, 2008.

[7] J. N. Eloff, “A sensitive and quick microplate method to determine the minimal inhibitory concentration of plant extracts for bacteria,” Planta Med., vol. 64, no. 8, pp. 711 – 713, 1998.

[8] S. H. Moussa, A. A. Tayel, A. A. Al-Hassan, and A. Farouk, “Tetrazolium/Formazan test as an efficient method to determine fungal chitosan antimicrobial activity,” J. Mycol., vol. 2013, 2013.

[9] A. Mohammadzadeh, P. Farnia, K. Ghazvini, M. Behdani, T. Rashed, and J. Ghanaat, “Rapid and low-cost colorimetric method using 2, 3, 5-triphenyltetrazolium chloride for detection of multidrug-resistant Mycobacterium tuberculosis,” J. Med. Microbiol., vol. 55, no. 12, pp. 1657 – 1659, 2006.

[10] R. Murzen and C. Zehle, "Abwasserbehandlung-Probenahme-und Analyseverfahren zur kostengünstigen Überwachung von Arzneimittelwirkstoffen im Abwasser," GWF Wasser Abwasser, vol. 152, no. 6, p. 622, 2011.

[11] K. W. Thomulka, D. J. McGee, and J. H. Lange, "Detection of biohazardous materials in water by measuring bioluminescence reduction with the marine organism Vibrio harveyi," J. Environ. Sci. Health Part A, vol. 28, no. 9, pp. 2153–2166, 1993.

[12] T. Backhaus and L. H. Grimme, "The toxicity of antibiotic agents to the luminescent bacterium Vibrio fischeri," Chemosphere, vol. 38, no. 14, pp. 3291–3301, 1999.

[13] K. Froehner, T. Backhaus, and L. H. Grimme, "Bioassays with Vibrio fischeri for the assessment of delayed toxicity," Chemosphere, vol. 40, no. 8, pp. 821–828, 2000.

[14] A. W. Nineham, The Chemistry of Formazans and Tetrazolium Salts. 1955.

[15] E. D. Weinberg, "Selective inhibition of microbial growth by the incorporation of triphenyl tetrazolium chloride in culture media," J. Bacteriol., vol. 66, no. 2, p. 240, 1953.

[16] M. Vargas, "ED50v1.0." 2000.

[17] N. Cedergreen, J. C. Streibig, P. Kudsk, S. K. Mathiassen, and S. O. Duke, "The occurrence of hormesis in plants and algae," Dose-Response, vol. 5, no. 2, pp. 150–162, 2007.

[18] K. Kümmerer, R. Alexy, J. Hüttig, and A. Schöll, "Standardized tests fail to assess the effects of antibiotics on environmental bacteria," Water Res., vol. 38, no. 8, pp. 2111–2116, 2004.

Plastics and Microplastics in the Danube River in Austria

Philipp Hohenblum, Marcel Liedermann

1. Introduction

The term "microplastics" generally summarizes plastic particles that are less than 5 mm in diameter. Comprehensive scientific studies show plastic pollution of the seas, but only little is known about pollution of freshwater systems, soil and air [1,2,3,4].

The Federal Environment Agency Austria was asked in spring 2014 by the Austrian Ministry for Agriculture, Forestry, Environment and Water Management and the Federal Provinces of Upper Austria, Lower Austria and the City of Vienna to carry out a pilot project aiming at investigating plastic and microplastic particle transport in the Danube River in Austria [5]. The project was carried out in consortium with the University for Natural Resources and Life Sciences, Vienna (BOKU) and ViaDonau and started in July 2014. Within nine months of intensive work, a methodology for sampling the Danube River was developed, taking into account the vertical, horizontal and temporal variability of plastic transport in the flow of the river. Two sites were sampled five times at different discharge stages in autumn and winter.

Building on ten samples taken from the Danube River, the transport and the average annual load of plastics were estimated. Chemical analyses of parts of the samples were carried out to identify the plastic species transported in by the river and thus identifying possible sources of origin.

2. Materials and Methods

Sampling sites

In accordance with the customers of the study, two sampling sites were selected, which had to fulfil a number of criteria. They should be easily accessible by lorry (to deploy the devices), should comprise of a bridge and hydrological data should be available for the site (flow measuring site). The sites of Aschach (Upper Austria, close to the border with Germany; upstream) and Hainburg (Lower Austria, close to the border with Slovakia; downstream) were chosen.

Sampling concept

The development of the sampling concept builds on the vast experience of BOKU in the measurement of suspended particles and bed load in the Danube River. In order to consider the vertical and horizontal variability of plastic transport in the flow of the river, a multi-spot sampling structure was assembled to allow for simultaneous skimming from the surface and sampling at two different depth levels. At each level, two drift nets were mounted with mesh sizes of 250 and 500 µm, which could be adapted to the specific discharge and sampling conditions. The concept foresaw sampling at five to 10 verticals in order to examine the spatial distribution of plastics over the river cross section. Sampling was carried out at five different discharge stages to determine the temporal variability.

The assemblage was mounted to a 15 t lorry equipped with a crane to submerge the sampler from a bridge. Time of exposure to the water flow was measured to sample an equivalent of at least 1,000 m^3. The typical sampling time was 20 to 40 minutes. The sampler was hoisted, drift nets were rinsed with fresh water and the sample was collected in the sample container at the end of the drift nets. The procedure was repeated until all verticals were sampled.

Fig. 2: *left picture: the sampling rack with drift nets at three depth stages moments before submerging for sampling; middle picture: lorry with crane during sampling; the rack is submerged in the river, only the upper skimmer is visible at the very right end of the picture; right picture: withdrawal of a sample from the sampling container. C University for Natural Resources and Life Sciences (2014)*

Sample processing

Especially during sampling in autumn, samples contained a high amount of organic matter, which required the isolation of plastic particles from the matrix. Samples were dispersed in dissolved salt solution in order to promote separation by density [1]. Floating material was isolated, rinsed and air dried at 50 °C. From this sample, plastics was isolated manually. While sorting out plastic material from the natural matrix, plastic particles were identified due to their properties like colour, stability or texture. Objects larger than 500 µm can be sorted out by hand (with help of tweezers, supported by use of a microscope, in cases). Macro particles were neglected in this study.

Classification of plastic objects

In line with literature [6], plastic object were classified and handled separately. Five categories were used: Foils, Flakes, Foams, Fibres, Industrial granules.

Particles in all these categories were photographed, counted by means of static image software, and weighed in the categories.

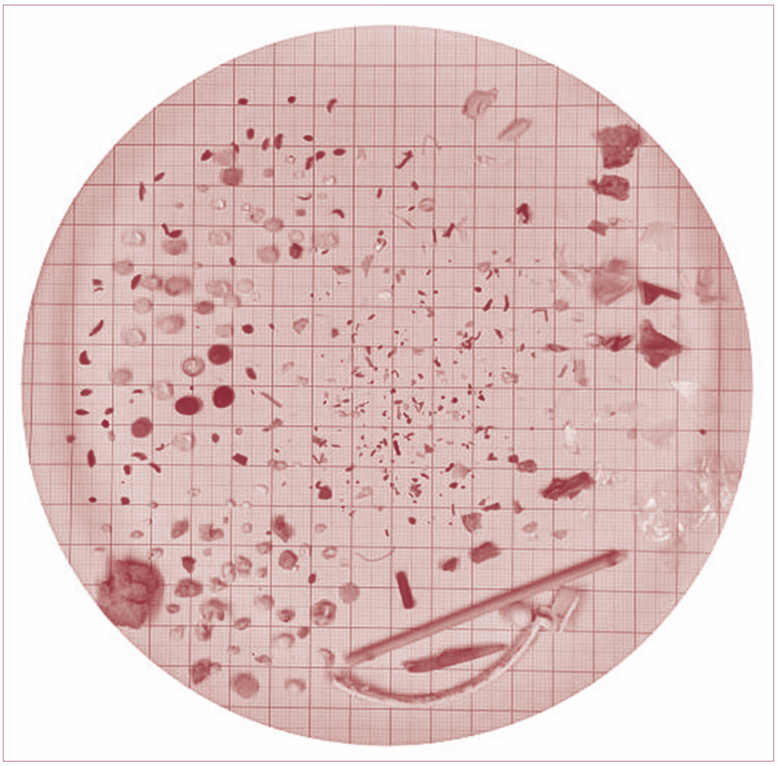

Fig. 1: *plastic particles from the Danube river containing all categories of particles; the mesh size was 500 µm, the image shows 473 particles with a total mass of 1,48 g. C Umweltbundesamt 2014.*

Identification of plastics
Manual identification of plastics is, however, often misleading. Thus, confirmation and identification of plastics was carried out by infrared spectroscopy (IR) in contact measurement with attenuated total reflection (ATR) accessory.

Plastic particles the size of less than 500 µm were analysed by means of FT-IR micro-spectroscopy. This methods combines features of IR microscopy with imaging and allow reliable detection and identification of microplastics from approx. 25 µm to 500 µm. Particles can deliberately be chosen in the microscope and identified by IR measurement and software aided database research.

Source identification
Although it is not feasible to track back to source individual particles found in the samples, a principal distinction between particles of industrial origin and other (diffuse) sources could be done. Pellets are well defined particles which are sold as industrial raw material, adapted to the consumers' demands. They can be emitted into the environment during production, conversion into final products or upon transport (particularly during cleaning of transport means). Other than these sources are much unlikely.

3. Results

Each of the two sampling sites was sampled five times, at three different depth levels and different number of verticals to yield in 15 to 21 sampling points within a profile. For each point, the plastic transport (mg/m^2.h) and concentration (mg/1,000 m^w) was determined both for micro plastics (< 5 mm) and for total plastics. Tab. 1 shows the results accordingly.

Tab. 1: *Danube discharge, average concentrations and transport of micro plastic and total plastic for the two sampling sites and all five measurements; Aschach (upstream) and Hainburg (downstream); *smaller amount of sampling points due to winch difficulties at the measurement lorry*

Sampling site	Discharge	weighted avg. conc.	transport			
			micro plastic		total plastic	
	m^3/s	g/1,000 m^3	g/s	kg/d	g/s	kg/d
Hainburg	1.276	0.029	0.037	3.2	0.127	11.0
Hainburg	1.993	0.085	0.170	14.7	0.464	40.1
Hainburg	3.179	0.188	0.598	51.7	2.283	197.2
Hainburg	3.392	0.428	1.452	125.5	2.583	223.2
Hainburg*	5.704	0.516	2.941	254.1	7.504	648.4
Aschach	765	0.057	0.043	3.7	0.077	6.6
Aschach	765	0.048	0.037	3.2	0.182	15.7
Aschach	1.020	0.039	0.039	3.4	0.067	5.8
Aschach	1.551	0.053	0.083	7.1	0.175	15.1
Aschach	2.575	0.205	0.527	45.5	1.133	97.9

Annual averages of plastic transport were calculated. At Aschach, the average transport amounts to a range of between 6 and 40 kg (at mean discharge +/- 25%) per day for particles smaller than 5 mm and to a range of between 10 and 59 kg per day for the total plastic transport without macro. Accordingly, the average transport at Hainburg (downstream site) amounts to between 6 and 66 kg per day for particles smaller than 5 mm or to a range of between 7 and 161 kg for the total (without macro) plastic load.

An annual load was calculated using the discharge hydrographs of the years 2009 to 2014 for both sites and amounts to < 17 tons/year for microplastic close to the Slovak border. The total annual plastic load amounts to < 41 t/year at the same site. Furthermore, the study shows that it is of major importance to address the whole water body for sampling a rivers cross section, since plastic particles rather have the properties of suspended particles than as floating particles. They are encountered over the entire river profile, depending on the hydrological conditions and thus, a multi spot sampling is indispensable to acquire sound results.

Around 10 per cent of the particles found in the Danube River can be attributed to industrial activities such as production processes, conversion and transport. 90 per cent of the plastic particles in the Danube River, however, are emitted by diffuse sources, these being littering, fragmentation and transport by wind, run-off from sealed surfaces (roads. parking spaces. residential areas), inappropriate use of products, use of cosmetics, construction activities and so forth. By the same pathways, plastic and microplastic can reach soil, air and other environmental compartments and move up within the food chain.

It is well documented that plastic particles in the environment can negatively affect wildlife. Scientific reports especially from marine environments demonstrate, that a high number of species mistake plastics for food. Swallowed particles can lead to injuries or to starvation of the affected animals or kill individuals by entanglement. Micro size particles (micro plastics) are prone to being bioavailable in lower trophic organisms as many of them exert limited selectivity between particles and capture anything of appropriate size. Incorporation of micro plastics in mussels' tissue was observed and inflammatory effects were described after take up of plastic particles in the digestive system. There is, however, still need for research to provide assessment methods for the exposure to plastic particles.

These reports gave us reasons to also investigate fishes from the Danube River. However, investigation of digestive systems of 30 fishes did not reveal any (micro) plastic particle.

4. Discussion

There is a strong dependency between discharge and transport of plastic material. For this reason, the presented transport and load are estimates for the two sampling sites. However, to our knowledge, this study is the first investigation to elaborate a river profile for plastics and microplastics. It has shown that multi spot sampling is a basic requirement to assess a river thoroughly. Transport depends on the river morphology, discharge, season, artificial constructions etc. The sampling site matters – otherwise, measurements will end up in over- or underestimations.

There is plastic input in Austria. Although a balance between the sampling sites does not reflect the net input of Austria as two major contributing rivers discharge the western part of Austria into the Danube River upstream in Germany, an increase of the plastic load between Aschach and Hainburg is obvious. Those estimated 41 tons of plastic leaving Austria each year, however, have to be compared with 875,000 tons of plastic [5], which are treated in waste management annually in Austria.

Although there is much data available from marine regions, freshwater systems are not yet investigated intensively in terms of plastic pollution. Several actions on the European level and in member states, which are currently being carried out, will overcome this gap.

Literature:

[1] Thompson. R., Olsen. Y., Mitchell. R., Davis. A., Rowland. S., John. A., McGonigle. D., Russell. A. (2004) Lost at Sea: Where is all the Plastic? Science, Volume 304. 843.

[2] Zbyszewski. M., Corcoran. L. (2011): Distribution and Degradation of Fresh Water Plastic Particles Along the Beaches of Lake Huron, Canada. Water Air Soil Pollut (2011) 220: 365 – 372.

[3] Imhof. H., Laforsch. C., Ivleva. N., Schmid. J., Nießner. R. (2013) Contamination beach sediments of a subalpine lake with microplastic particles. CurrBiol 2013, 23 (19): 867 – 868.

[4] Faure. F., Corbaz. M., Baecher. H. Neuhaus. V. de Alencastro. L. (2013) Pollution due to Plastic and microplastics in Lake Geneva. Koblenz, Germany. In: 6th International Conference on Water Resources and Environmental Research.

[5] Hohenblum. P., Liedermann. M., Reisinger. H., Frischenschlager. H., Gmeiner. P., Weidenhiller. B., Fischer. N., Rindler. R., Habersack. H. (2014) Plastik in der Donau. Untersuchung zum Vorkommen von Kunststoffen in der Donau in Österreich. REPORT-0547. Umweltbundesamt. Wien.

[6] Free, C.; Jensen, O.; Mason, S., Eriksen, M.; Williamson, N. & Boldgiv, B. (2014): High levels of Microplastic pollution in large, remote mountain lake. Marin Pollution Bulletin 85 (1): 156 – 163.

Posterpräsentationen Posterová sdělení

Magdeburger Gewässerschutzseminar 2016
Magdeburský seminář o ochraně vod 2016

Magdeburger Gewässerschutzseminar
MGS
2016
Magdeburský seminář o ochraně vod

Water quality during hydrological extremes as indicator for long term development of pollution in the Elbe River

Martina Baborowski, Holger Rupp, Ralph Meissner, Wolf von Tümpling

1. Introduction

The water quality during hydrological extremes can provide basic information on the development of pollution on catchment scale. Re-suspension of contaminated soils and sediments is the main driver of water pollution during flood events. During low water, discharges of urban areas and diffuse pollutions become more important. Also re-dissolution of pollutants from contaminated sediments is possible during low water periods. In the presentation, the concentration of heavy metals and arsenic during long lasting low water periods in 2003 and 2015 are compared. The samples were taken at Magdeburg sampling site. In addition, the development of these concentrations in longitudinal direction along a ~ 140 km stretch of the Elbe River from Magdeburg (MD) km 318.1, left bank to Wittenberge (WB) km 454.9, left bank was investigated for the low water event in 2015. The investigations were performed, taking into account the travel time of the water. Below the confluence of the tributaries Mulde and Saale with the Elbe River, the flow path on this stretch is not affected by important entries of pollutions. Therefore, the water quality in this part of the catchment can be considered as characteristic for the water quality of the Middle Elbe.

2. Results and discussion

At Magdeburg sampling site, the concentrations of all investigated elements were lower during the low water period 2015 in comparison to 2003. This relates to arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), lead (Pb), mercury (Hg), nickel (Ni), uranium (U) and zinc (Zn). In Figure 1, the example for Hg and Cd is presented. The decreased concentration values in 2015 indicate the improvement of water quality of the Elbe River over the last years. The results may be partly influenced by contribution of less polluted water from the upper river stretches. For the Elbe River in Děčin/Czech Republic, the lowest daily flow since the construction of large reservoirs in the Vltava River basin in the 1960s was recorded. The effect of the Vltava River basin reservoirs on the increase in low flows in the Elbe River 2015 was preliminarily estimated to a range between 15 and 25 m^3/s, in comparison with an estimated lowest daily flow of about 77 m^3/s [1].

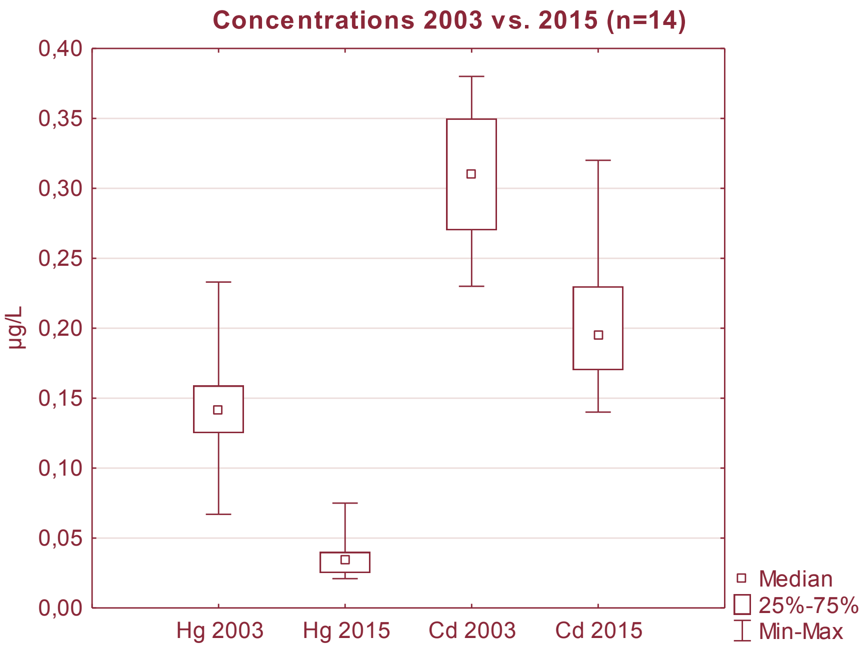

Fig. 1: *Box whisker plots for mercury (Hg) and cadmium (Cd) at Magdeburg sampling site (MD); weekly sampling from July until October of the respective year.*

Along the investigated river stretch between Magdeburg and Wittenberge, the concentrations of elements mainly delivered by the tributaries Mulde and Saale decreased slightly in 2015. It can be explained by both, sedimentation of particulate transported matter and dilution of the tributary entries by lower polluted water of the Elbe River. The concentrations of Hg remain at the same level (Figure 2). For As and Cr elevated concentrations were measured at sampling site Wittenberge. It was caused by the influence of dredging activities near the sampling site during the low water period. The fact, that only the concentrations of As and Cr increased in consequence of the dredging activities indicates that the sediments at this site were comparable lower polluted by the other investigated elements.

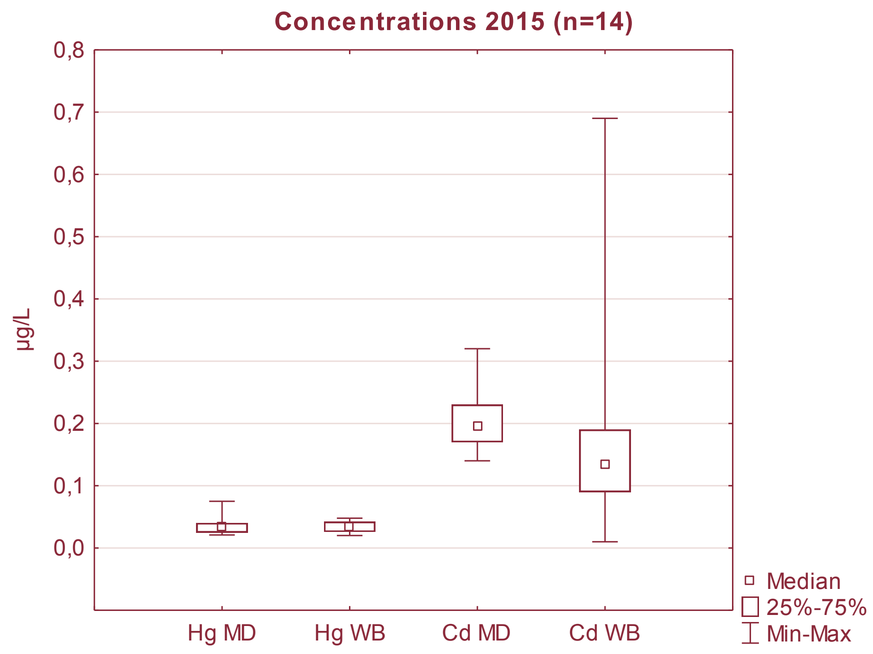

Fig. 2: *Box whisker plots for mercury (Hg) and cadmium (Cd) at the sampling sites Magdeburg (MD) and Wittenberge (WB), weekly sampling from July until October 2015.*

Literature:

[1] Anonymus: Drought in the in the Czech Republic in 2015, A preliminary summary. (Český Hydrometeorologický Ústav) October 2015. Prague. http://portal.chmi.cz/files/portal/docs/meteo/ok/SUCHO/zpravy/en_summary_drought2015_ol.pdf

Sediment pollution of the Elbe River side structures – research since 2001

Dagmar Chalupová, Bohumír Janský, Michal Černý, Miroslav Žáček, Jiří Medek, Stanislav Král

1. Introduction

The contribution brings the summarized results of a long-term research on sediment pollution of side structures of the Elbe River over the last 15 years [1],[2],[3],[4],[5].

2. Methods and Localities

The studied localities were chosen with the respect to the distance from the source of industrial pollution, the intensity of hydrological communication with the river and land use (Fig.1.). Apart from bathymetric measurements, hydrological regime and water quality sampling, the research was focused on sediments. Metal concentrations (Ag, Cd, Cr, Cu, Fe, Hg, Mn, Pb, Zn) were determined in the sediment fraction of 20μm, using Aqua Regia digestion and FAAS and ICP MS methods. At some localities, specific organic compounds (PCBs, DDT, HCH, HCB, PAHs etc.) were measured (2 mm sediment fraction, Czech state norms). The analyses were completed at the laboratories of Charles University in Prague, Faculty of Science and Povodí Labe, s.p. in Hradec Králové. To evaluate the sediment contamination, new method of ICPER was applied [6].

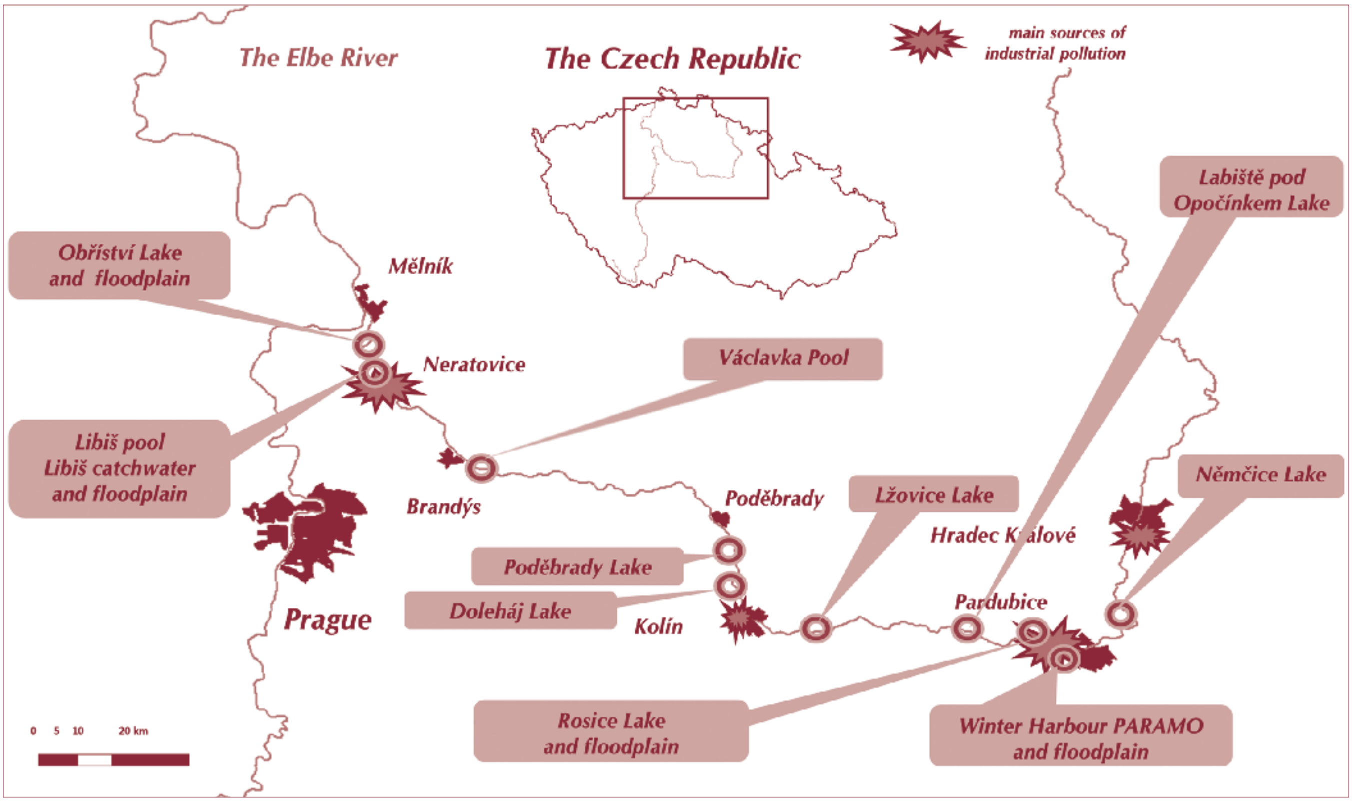

Fig. 1: *Researched lakes*

3. Results and Conclusion

The highest concentrations of metals and specific organic compounds were determined in the sediments taken from fluvial lakes and floodplain (Zimní přístav PARAMO, Rosice fuvial Lake, Libiš pool etc.) situated in the vicinity of the main Elbe River polluters – Synthesia chemical plant and PARAMO refinery in Pardubice or Spolana chemical plant near Neratovice (Tab.1). However, there was also determined a significant role of the hydrological communication with the river proved with lower sediment pollution in separated localities.

4. Acknowledgement

The realization of the above mentioned research was possible thanks to the support of numerous Czech and German projects (GAUK, GAČR, SVV, VaV, PRVOUK, ELSA etc.).

Literature:

[1] Chalupová, D (2011) Chemismus vody a sediment fluviálních jezer Labe. Dis. p. PřF UK, Praha.

[2] Klouček, O. (2003) Limnologické poměry, kvalita vody a sedimentů v Labišti pod Opočínkem. Dip. p. PřF UK, Praha.

[3] Šnajdr, M.(2002)Limnologické poměry, kvalita vody a sedimentů v mrtvém labském rameni u Obříství. Dip. P. PřF UK, Praha.

[4] Turek, M. (2004) Komplexní limnologická studie odstaveného starého ramene Libišská tůň v PR Černínovsko. Dip. p. PřF UK, Praha.

[5] PřF UK (2014) Význam starých sedimentů v Labi a jeho postranních strukturách v úseku od Pardubic po soutok s Vltavou. Zpráva z projektu ELSA – SedLa. PřF UK, Praha.

[6] I CPER (2014) Sedimentmanagementkonzept. Vorschläge für eine gute Sedimentmanagementpraxis im Elbegebiet zur Erreichung überregionaler Handlungsziele.Magdeburg, S. 200.

***Tab. 1:** Sediment contamination assessment using ICPER method (2014)*

Sampling point	Year	Depth of core (cm)	Concentration (mg.kg^{-1})										
			Ag	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn
Němčice Lake	2007	67	2,3	20	0,8	121	61	944	0,44	400	31	76	478
PARAMO winter harbour - PV	2013	113		20	2,9	96	215		2,65		55	272	1528
Rosice Lake - RV1	2013	96		14	2,1	161	65		0,48		39	72	422
Rosice Lake - RV2	2013	115		10	1,6	211	90		0,90		42	123	648
Rosice floodplain - RN2	2013	150		37	0,5	79	21		0,68		45	47	243
Rosice floodplain - RN3	2013	150		38	0,3	75	24		0,30		39	69	221
Rosice floodplain - RN4	2013	150		40	0,3	60	10		0,20		36	44	148
Labiště Lake	2001	50	15,6		4,0	255	87	25520	1,78	569	45	114	1022
Labiště Lake	2002	50	14,6		3,4	214	101	19976	1,50	326	51	117	768
Lžovice Lake - A	2007	151	11,2	20	4,6	232	209	890	3,99	531	38	89	563
Lžovice Lake - B	2007	103	8,5	20	2,2	137	97	900	2,66	540	33	84	557
Doleháj Lake	2001	30	13,0		2,3	94	34	16200	0,41	247	33	72	168
Doleháj Lake - A	2002	30	10,9		1,0	101	37	11523	0,41	128	36	100	206
Doleháj Lake - B	2002	30	3,3		1,3	85	42	23060	0,16	254	41	108	239
Poděbrady Lake	2007	204	2,5	37	1,8	113	85	912	1,80	538	34	96	483
Poděbrady Lake - A	2015	87	3,9	90	2,9	144	110		2,67		32	114	474
Poděbrady Lake - B	2015	77	1,2	91	1,6	119	63		0,81		28	128	347
Václavka Pool	2007	67	0,4	20	0,2	22	58	912	1,17	429	30	50	310
Libiš Pool A	2004	60		43	3,3	119	90	30950	2,80	665	42	109	869
Libiš Pool B	2004	60		20	0,8	69	19	24650	0,25	365	36	38	169
Libiš Pool C	2004	60		20	0,7	78	21	29400	0,10	338	43	44	164
Libiš Pool D	2004	60		37	1,8	72	20	27450	0,35	314	43	47	190
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
Libiš floodplain - LN3	2013	140		35	0,5	73	38		0,55		42	66	246
Libiš floodplain LN4	2013	150		30	0,2	68	16		0,42		41	55	179
Libiš floodplain - LN6	2013	150		25	0,3	62	13		0,55		38	46	172
Libiš floodplain - LN8	2013	150		19	0,2	60	28		0,46		39	53	145
Obříství Lake	2001	60			4,3	241	133	22833	5,80	1950	45	184	943
Obříství Lake	2002	60	8,4		6,4	210	115	28742	3,58	1030	35	376	777
Obříství Lake - A	2007	163	5,8	25	3,1	125	121	928	1,36*	1072	43	124	594
Obříství Lake - B	2007	187	1,6	22	1,6	46	79	936	3,41	784	29	79	629
Obříství - OV1	2013	83		10	2,8	121	137		3,40		36	107	427
Obříství floodplain - ON1	2013	150		47	1,4	108	71		1,88		45	116	398

Drought in connection with the quality of surface water

Jakub Dobiáš, Luboš Zelený

Introduction:

On the last Magdeburg seminar, Povodí Vltavy, state enterprise introduced the poster contribution about water quality during the floods. Two years later, we introduce opposite phenomenon, drought. This fact represents the hydrological conditions in our surface water during the last decade and symbolises the problems, that we will have to face in the near future.

The paper deal with the effect of drought at selected locations in the Vltava river basin management. We evaluate especially surface waters and reservoirs.

Methodics:

The values from long term period as well as values from monitoring of drought (launched on 10th of July 2015) are used in the results. The study is focused mainly on the nutrients (phosphorus and nitrate nitrogen) and basic physicochemical parameters in water, but also some specific organic pollutants, bacteria pollution and concentration of chlorophyll-a are mentioned. Except the long term results, we took into account also the legislative limits to evaluate the drought period.

The monitoring of drought in the three sub-basins of the Vltava River was focused on approx. 36 surface water profiles (river sampling points) and 20 water reservoirs and ponds including their tributaries and basins. The sampling frequency was once per 7 – 14 days, depending on the real situation on the rivers. Extraordinary monitoring of drought conducted together with the main one and was fully ended on 1st of December 2015.

Results:

Extreme decrease of water volume balance in the rivers during the summer caused predicted changes in the water quality. In the most rivers the water temperature and quantity of dissolved compounds increased. Thaks to this, the conductivity (against the average values of years 2013 – 2014) increased too (e.g. left hand tributary of Vltava River – Berounka).

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 prosphorus basicly on the all river profiles, that we checked (e.g. Sázava River). On the other hand, there wasn´t higher deficit of oxygen concentration in the lower part of Vltava River, partly thanks to the positive influence of Vltava cascade, which can to the point control the quantity of water flow.

Increase of nutrients in the surface water (rivers and streams) caused rapid growth of autotrophic organism (green algaes and cyanobacterias). High values of chlorophyll-a was above the long-term average. On the other hand, indicators of organic pollution (CODCr, BODCr and fecal coliforms) were exceeded long-term average rarely, reason for that could be self-cleaning processes (with the consumption of oxygen).

Concentrations of some special organic compounds during the drought were higher too. It happened especially under the point sources, 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. Moreover, the original form of pests transformed to their metabolites in the soil.

The evaluation of the water quality in selected reservoirs during the drought was compared with the previous seasons. The quality of water in the dams is strictly connected with the water quality on the tributaries and teoretical retention time (TRT). The pollution during the dry period is usually increasing, but due to the less water mass, TRT and self-cleaning proceses inside the reservoir are increasing too, but always to a certain extent. Smaller volume of water and warm weather during the summer caused changes in stratification conditions and seasonal phytoplankton dynamics. We observed major cyanobacteria blooms in some reservoirs, which was accompanied with low water transparency. Significant decrease of oxygen concentration on the bottom of the dam caused release of iron, manganese and phosphorus form the sediments in some cases. The parts of the rivers under the dams could be influenced by this too (e.g. Lipno reservoir).

Conclusions:
During the drought period in 2015 was observed limited degradation of quality of the surface water. In some reservoirs (especially with the shorter TRT) stratification conditions during the summer changed, this was connected with oxygen demand, water temperature and pH changes. This conditions may lead to nutrient release etc. (e.g. Žlutice reservoir), but many reservoirs wasn´t influenced yet.

One of the main advantages of intensive extraordinary drought monitorig 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 and quantity of water in the lower part of Vltava River. Especially the control of water volume, better retension of nutrients and insolubles. This fact should be taken into account when we think about the function and use of the Vltava River cascade.

Long-term monitoring of organic micropollutants in the Orlice River at raw water sampling site of waterworks in Hradec Králové by means of passive samplers and comparison with background locality in Orlické hory foothill

Martin Ferenčík, Jana Schovánková, Gregor Vohralík, Luděk Rederer

Surface water quality is influenced by organic micropollutants originating from point sources (industrial wastewater treatment outlets, community wastewater treatment plants (WWTP) effluents, accidental discharges) or diffuse sources (pesticide usage in agriculture, forestry and road and rail communications; untreated sewage from small villages and application of WWTP sludge or manure and slurry containing pharmaceutical residues, etc.). Concentrations of released organic micropollutants in surface water have varying values, depending on the time and amount of rain precipitation or snow melting, treatment plant handling regulations or accidental events. Traditional operational monitoring based on monthly frequency Grab (spot, bottle) sampling have weak representativeness for such episodic or seasonal pollution events. Time-weighted integrative passive sampling have potential to overcome these shortcomings of spot sampling and gives the full picture of the occurrence of organic pollutants (number of occurring analytes and their average concentrations), and enables us to focus on relevant substances and possibly implement mitigation measures to prevent undesirable influence of organic micropollution in watercourses.

In our contribution we deal with monitoring of two sampling sites, first on the River Orlice Hradec Králové, which serves as the source of raw water for drinking water plant in Hradec Králové, and second on the small River Zdobnice at the foothill of the Orlice Mountains as a background locality. Two kinds of passive samplers are simultaneously employed and after a month exposition are being replaced by new ones and repeated for more than a year. Semipermeable Membrane Device (SPMD) with performance reference compounds (PRC) is used to concentrate lipophilic compounds (PCB's, PAH's, OCP's, PBDE's, around 47 analytes) and Polar Organic Chemical Integrative Sampler (POCIS) for more than a hundred analytes: polar pesticides, their metabolites, pharmaceuticals and perfluorinated compounds (PFOC).

Passive samplers were provided by ExposMeter (Tavelsjö, Sweden) and methodology for deployment and extraction of pharm-POCIS and SPMD was taken from Alvarez [1] and Huckins [2] respectively. SPMD dialysates were reconcentrated by rotary vacuum evaporator (RVE), cleaned by gel permeation chromatography (GPC) using PAH Prep column (250 x 16 mm, 5 µm SDB copolymer, supplied by Watrex, Prague, Czech Republic) using dichloromethane as mobile phase at 3 mL/min and consequent SPE Florisil clean-up. GC/MS/MS measurement based on method given by Quick [3]. POCIS-pharma samplers were transferred and extracted by 40 mL of methanol, reconcentrated by RVE to approx. 5 mL and by nitrogen evaporator to 1 – 2 mL and analyzed by LC-MS/MS after 1: 40 dilution with water and adding internal standards similarly like water samples [4]. Spot water samples were analyzed by methods described elsewhere [5]. More details on methodology and first results of monitoring are mentioned in the collection [6].

Findings of integrative samples and simultaneously taken spot samples were evaluated and both localities compared (Tab.1). Concentrations of organic pollutants in spot water samples were mostly below LOQ at Zdobnice, while results of POCIS samplers identified low old contamination with hexazinone used in forestry up to 2006. Rest of parameters were at Orlice Hradec Králové significantly higher (10 – 100 fold). Zdobnice at profile Pěčín is partly influenced by recreational resort Zdobnice and past agricultural usage of relatively small area in its basin.

Tab. 1 Concentrations of selected pesticides, pharmaceuticals in POCIS in ng/POCIS, minimum, maximum, arithmetic mean and the ratio of positive findings to all samples in 2015.

	Zdobnice, ng/POCIS				Orlice HK, ng/POCIS			
Parametre	Min	Max	Mean	Pos/Total	Min	Max	Mean	Pos/Total
atrazine	<2	5,8	<2	2/13	4,7	46	13	13/13
terbutylazine	<2	4,3	<2	3/13	3,4	213	37	13/13
hexazinone	3,8	16,0	7,4	13/13	2,6	9,6	5,3	13/13
metazachlor	<2,0	<2,0	<2,0	0/13	<2,0	7,7	3,3	10/13
metolachlor	<2,0	<2,0	<2,0	0/13	2,6	601	78	13/13
chlorpyrifos-ethyl	0,5	18,0	5,3	13/13	20	120	52	13/13
caffeine	<10	24	<10	4/13	12	107	50	13/13
trimethoprim	<5,0	<5,0	<5,0	0/13	<5,0	20	10	10/13
carbamazepine	<2	2,2	<2	1/13	13	132	58	13/13
diclofenac	<1	1	<1	1/13	23	66	38	13/13
ibuprofen	1,6	17	5,9	13/13	5,4	100	54	13/13
alachlor ESA	<2	6,5	3,7	10/13	35	90	63	13/13
metolachlor ESA	1,8	3,7	2,2	13/13	180	390	320	13/13
metazachlor ESA	<1	2,0	1,3	9/13	29	480	190	13/13

Literature

[1] ALVAREZ, D.A., HUCKINS, J.N., PETTY, J.D., JONES-LEPP, T., STUER-LAURIDSEN, F., GETTING, D.T., GODDART, J.P., GRAVELL, A.: Tool for monitoring hydrophilic contaminants in water: polar organic chemical integrative sampler (POCIS). In: Comprehensive analytical chemistry: Passive sampling techniques in environmental monitoring, 48, 171–197, 2007.

[2] Huckins, J.N., PETTY, J.D., BOOIJ, K.: Monitors of Organic Chemicals in the Environment, Semipermeable Membrane Devices, Springer 2006, ISBN: 978-0387-29077-5.

[3] quick, j. – gendinning, r. – thomas, a.: High sensitivity GC/MS/MS Analysis of Nonpolar Organic Compounds in Water Using the Agilent 7000 Triple Quadrupole GC/MS, Application note 5991-1553EN, Agilent Technologies, Inc., USA, 2013.

[4] FERENČÍK, M. – SCHOVÁNKOVÁ, J.: Determination of pesticides, their degradation products and pharmaceuticals in surface waters and sediments by LC-MS/MS, Collection of the XXXX Conference Hydrochémia 2012, Bratislava, 55–64, ISBN 978-80-89062-86-7, 2012.

[5] FERENČÍK, M.: Different approaches to the determination of semivolatiles in surface waters by GC/MS, Collection of the XLI Conference Hydrochémia 2014, Bratislava, 73–78, ISBN 978-80-89062-97-3, 2014.

[6] FERENČÍK, M. SCHOVÁNKOVÁ, J., Vohralík, g.: Organic micropollutants monitoring by means of once per month spot water sampling and continuos monthly collected passive sampling using SPMD a POCIS samplers, Collection of the XLII Conference Hydrochémia 2016, Bratislava, 121–128, ISBN 978-80-89740-10-9, 2016.

Water quality in Elbe, Mulde and Weißer Elster: Uranium mining remediation processes with reference to legal requirements

Annia Greif, Elke Kreyßig

The EU Water Framework Directive (WFD) aims to achieve a “good status” for water bodies (surface and groundwater) and the implementation of measures to prevent a deterioration of status by 2015, at latest by 2027. In contrast, the German Wismut remediation project, focusing on the elimination of the consequences of a long-lasting uranium industry from the cold war era, starting in 1991, will continue beyond that deadline. At the current stage the long-term tasks are planned by 2045 (Fig. 1). The legacy of the Uranium mining history consists primarily of dewatered aquifers, piled up waste rocks and large tailing ponds, which store the remaining materials from the mining and milling process. Besides them there were a lot of industrial areas and facilities to be remediated [1].

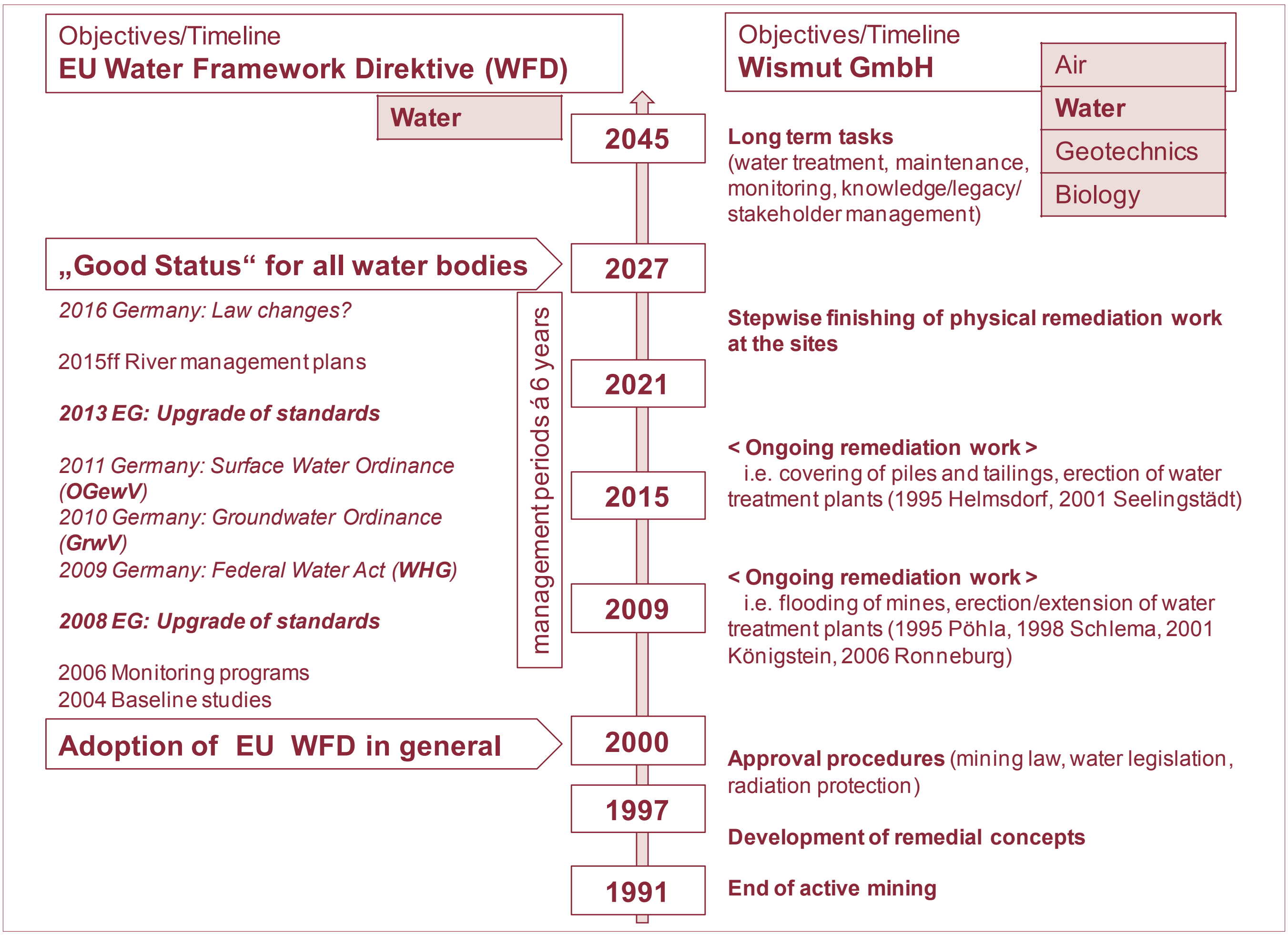

Fig. 1: *Objectives and timeline of EU Water Framework Directive and Wismut GmbH*

After the end of mining in 1991 the retreat from the deep mines started and their flooding followed subsequently. But the upcoming mine water could not be discharged into the surface water system without purification. Water treatment of open/pore water was also required during restructuring of tailings dumps. That’s why altogether six water treatment plants (WTP) were established between 1995 and 2006, which continue to work. In spite of the intensive and costly water management and treatment measures an impact on water bodies surrounding the sites under remediation cannot be totally avoided.

The following rivers are affected by remediation: the Zwickauer Mulde river between Aue and Crossen as well as the Weiße Elster river between Greiz and Gera by its tributaries Culmitzsch and Wipse. Impacts on the Elbe river between Schmilka and Dresden can be neglected. Table 1 shows the mean quantity and quality of the river sections influenced by WTPs as examples.

Tab. 1: *Quantity and quality of the important surface water bodies influenced by treated mine/tailing water (2015) in relation to remediation targets and to environmental quality standards (EQS) according to OgewV (2011)*

Federal state	**Saxony**			**Thuringia**		
River system	**Elbe**	**Zwickauer Mulde**		**Weiße Elster**		
River				Culmitzsch	Wipse	Weiße Elster
Remediation Site/WTP	Königstein	Schlema	Crossen	Seelingstädt	Ronne-burg	after impact
Gauge [m^3/s]	219*	12.6*	14.4*	0.2	0.2	15.6*
WTP treated volume [m^3/s]	0.1	0.2	0.01	0.2	0.06	-
Parameters in water phase without EQS						
U [mg/l]	0.001	0.007	0.007	0.10	0.027	0.005
As [mg/l]	0.001	0.015	0.008	0.002	<0.001	0.002
Sulfat [mg/l]	53	62	63	2800	2300	250
Parameters in water phase with EQS						
Cd [µg/l] EQS 0,25**	<0.25	<1	-	<0.3	<0.2	<0.1
Ni [µg/l] EQS 20	1.5	6.4	4.8	7.4	17	3.4
Pb [µg/l] EQS 7,2	-	<0.5	<0.5	<1	<1	<0.5
Parameters in sediments/ suspended matter with EQS						
As [mg/kg] EQS 40	-	160	110	28	27	25
Cu [mg/kg] EQS 160	-	190	-	64	140	100
Cr [mg/kg] EQS 640	-	55	-	41	41	120
Zn [mg/kg] EQS 800	-	950	-	230	230	680

* long-term data series of federal states **up to 0,25 µg/l depending on water hardness

In case of Zwickauer Mulde an elevated background value (e.g. As) and other recent mining industrial influences (e.g. Ni, Zn) are to note.

Wismut GmbH is obliged to improve its treatment efficiency as far as possible. If, despite these endeavours, the goals of WFD could not be achieved until 2027 or involves an unreasonable effort, less stringent requirements values can be defined. Initial approaches are submitted for sites Ronneburg and Seelingstädt [2]. Eventually the long-term goal of the remediation of Wismut sites have to be the achievement of self-regulating near-natural systems without active water treatments.

Literature:

[1] Kreyßig, E.; Götze, J. (2015): Contamination of Water Bodies Affected by Post-Mining Activities in the Light of the European Water Framework. – in: Merkel, B.J.; Arab, A.: Uranium – Past and Future Challenges. – Proceedings of the 7th International Conference on Uranium Mining and Hydrogeology, Springer, 617 – 624.

[2] Paul, M. et al. (2014): Stellungnahme zur zukünftigen Bewirtschaftung der von der Wismut GmbH beeinflussten Oberflächenwasserkörper in Thüringen in Umsetzung der EU-WRRL. – Wismut GmbH, http://www.thueringen.de/ mam/th8/tlug/content/wasser/aktion_fluss/ga_stellungnahme_bewirtschaftung_owk_uranerzbergbau.pdf

Triclosan Occurrence in Watercourses in the Czech Republic

Jarmila Halířová

Triclosan (TCS) is a polychlorinated phenoxy-phenol with antibacterial and antifungal activity. It is an ingredient added to many consumer products as antibacterial agent. It may be found in products such as clothing, kitchenware, furniture and toys. It may also be added to antibacterial soaps and body washes, toothpastes, and some other cosmetics. Studies have shown that triclosan alters hormone regulation in animals, it could contribute to the development of antibiotic-resistant germs and might be harmful to the immune system. Because of its widespread use, triclosan finds its way to waste water treatment plants. Depending on the technical capabilities of the plant, between 58% and 99% of the triclosan is removed before the treated water is released, but the rest will end up in surface waters. It is hypothesized that triclosan is transformed into toxic dioxin compounds through chlorination of triclosan-containing wastewater and sunlight exposure in rivers that receive chlorinated wastewater. There are toxicity data available in the literature, suggesting potential risk to aquatic organism at environmental concentrations.

The occurrence of triclosan was verified in surface waters for the first time in the framework of the research project which was conducted in the 2006 – 2009 period in the Czech Republic,. This project was dealing with the influence of the Brno urban agglomeration on the contamination of particular environmental water components in the Svratka river focusing on the identification of the endocrine disruptors. Based on the project results, triclosan was introduced in monitoring of sediments and suspended solids quality by the Czech Hydrometeorological Institute (CHMI) in the following years.
This paper presents information regarding the occurrence of triclosan and its metabolite methyltriclosan in individual water ecosystem matrices in profiles of the water quality monitoring in the 2010 – 2015 period, especially in the Elbe river basin. The paper is based on CHMI monitoring data and on data related to triclosan concentrations in surface water samples from the operational monitoring of the river basin administrators (River Basin Authorities).

Triclosan in Surface Waters
In the Elbe basin, triclosan was analyzed in 2797 surface water samples. 92% of the measured concentrations were below the limit of quantification (LOQ = 5 $ng.l^{-1}$, resp. 10 $ng.l^{-1}$). Measurable concentrations ranged between 5 and 67 $ng.l^{-1}$. Based on a comparison with published data regarding triclosan occurrence in European basins it can be said that the data from the Elbe basin are in accordance with these findings and do not exceed the values found in surface waters elsewhere (11 – 98 $ng.l^{-1}$) [1]. Table 1 shows the distribution of triclosan occurrence in time. The most samples with triclosan concentrations above the LOQ were observed between 2010 and 2011. In terms of spatial distribution, there was a higher frequency of triclosan above LOQ and overall higher concentrations measured at smaller watercourses (Úpa, Loučná, Cidlina, Chrudimka, Orlice, Jizera). The profiles on the Elbe river had long-term concentrations usually below LOQ, measurable concentrations were relatively stable, ranging from 5 to 20 $ng.l^{-1}$ (Lysá n.L. occasionally up to 62 $ng.l^{-1}$). Between 2012 and 2014 the occurrence of triclosan in surface waters was sporadic. An increase in occurrence was observed in 2015, most frequently during summer months with hydrological drought. Highest values around 60 $ng.l^{-1}$, just like in 2010 – 2011, were measured in Elbe tributaries.
Highest values of triclosan in surface waters outside the Elbe basin were observed in 2015 at the profile of Lužická Nisa river in Hrádek n.N. (458 $ng.l^{-1}$). Lužická Nisa in general has a high frequency of positive triclosan measurements in a long-term. The time distribution of triclosan occurrence for the Lužická Nisa basin is given in Table 2.

Triclosan and Methyltriclosan in Sediments and SPMs
Triclosan is a relatively hydrophobic compound with high octanol-water partition coefficient (log Kow of 4.8) and exhibits a high potential for sorption to organic matter [2]. Sediments show great capacity for triclosan accumulation due to triclosan hydrophobic properties and can therefore present an important sink for TCS. In the Elbe basin, triclosan was analyzed in a total of 264 samples, 60% of which had values below the LOQ. Measurable concentrations were in the range of 5 and 123 $\mu g.kg^{-1}$, median and average concentrations of 15 $\mu g.kg^{-1}$ and 24 $\mu g.kg^{-1}$ respectively. Highest values were observed in Bílina river at Ústí n.L. and Elbe river at Lysá n. L. (near chemical plants).

The measured concentrations are in accordance with data published in Germany and Switzerland [1,3]. Methyltriclosan concentrations above LOQ were detected in sediments in 5% of samples only, ranging from 6 to 23 µg.kg^{-1}. Similar results were found in SPMs, where the values ranged between 5 and 75 µg.kg^{-1} (median concentration of 7 µg.kg^{-1}). Yearly maximum methyltriclosan concentration was repeatedly measured in Bílina river at Ústí n.L. (median 21 µg.kg^{-1}).
Similarly to the surface waters, the highest triclosan values found in SPMs were in Lužická Nisa at Hrádek n. N. where the measured triclosan concentrations were in the range of 6 to 512 µg.kg^{-1} (median 169 µg.kg^{-1}) and for methyltriclosan between 6 and 32 µg.kg^{-1}.

***Tab. 1:** Triclosan occurrence in surface waters of Elbe basin*

Elbe River basin	2010	2011	2012	2013	2014	2015
concentration range [ng.l^{-1}]	< LOQ - 24	< LOQ - 62	< LOQ - 14	< LOQ - 54	< LOQ - 35	< LOQ - 67
Mean	9	12	-	20	-	22
Median	7	9	-	12	-	17
Frequency	298	506	461	499	495	494
> LOQ	128	62	1	5	2	27

***Tab. 2:** Triclosan occurrence in surface waters of Lužická Nisa basin*

Lužická Nisa River basin	2010	2011	2012	2013	2014	2015
concentration range [ng.l^{-1}]	< LOQ - 35	< LOQ - 29	< LOQ - 10	< LOQ - 54	< LOQ - 25	< LOQ - 458
Mean	15	20	-	22	15	81
Median	20	19	-	16	12	40
Frequency	14	24	24	24	24	24
> LOQ	13	5	1	6	9	11

Conclusion

In the surface waters, sediments and SPMs of Elbe river basin, triclosan occurs at measurable concentrations with variable frequency. In case of the surface waters, higher concentrations are observed at smaller watercourses, in case of the sediments and SPMs, the highest concentrations are found in watercourses that are contaminated in long term – middle Elbe and Bílina rivers. A significant triclosan contamination was found in the Lužická Nisa river basin, where the concentrations in surface waters and especially in SPMs, exceeded the average values measured in the Elbe basin several-fold. Lužická Nisa river as a water course with low discharge and high triclosan concentrations can therefore present a potential risk for its water ecosystems, in particular during periods of hydrological drought.

Bibliography:

[1] H. Singer, S. Müller, C. Tixier, L. Pillonel (2002) Triclosan Occurrence and fate of a widely used biocide in the aquatic environment: field measurements in wastewater treatment plants, surface waters, and lake sediments. Environ. Sci. Technol., 36 (2002), pp. 4998–5004

[2] G.-G. Ying, X.-Y. Yu, R.S. Kookana (2007) Biological degradation of triclocarban and triclosan in a soil under aerobic and anaerobic conditions and comparison with environmental fate modelling. Environ. Pollut., 150, pp. 300–305

[3] J.-L. Zhao, G.-G. Ying, Y.-S. Liu, F. Chen, J.-F. Yang (2010] Occurrence and risks of triclosan and triclocarban in the Pearl River system, South China: From source to the receiving environment J. Hazard. Mater.,179, pp.215–222

Transport of contaminants during extreme flood and low flow events of the River Elbe

Gerd Hübner, Daniel Schwandt

1. Introduction

The June 2013 flood and the low flow from July until October 2015 of the River Elbe were extreme events, affecting the entire course of the river in Germany. During the flood in 2013 and again during the low flow period in 2015, a special monitoring programme of the River Basin Community Elbe (FGG Elbe), coordinated by the Federal Institute of Hydrology (BfG), concentrated on inorganic and organic contaminants [1] [2]. Water quality, and during the flood event additionally suspended solids taken by centrifuge, were investigated at several sites along the Elbe and at sites close to the mouth of the major tributaries Saale, Mulde and Havel. Results are presented in the Undine Information System (http://undine.bafg.de/). For the June 2013 flood, load balances of heavy metals and arsenic bound to suspended solids were calculated for the sections of the Elbe from Wittenberg to Magdeburg [3] and from Magdeburg to Dömitz [4]. Here we compare the loads of suspended solids (SS), total organic carbon (TOC), heavy metals and arsenic analysed from water samples taken within the special monitoring programmes in 2013 and 2015 to show typical effects of flood and low flow events on the transport of contaminants.

2. Methods

Sampling sites along the Elbe were located at Schmilka (flood: Bad Schandau), Wittenberg, Magdeburg (left bank), Cumlosen, Schnackenburg (flood: Dömitz) and Seemannshöft (flood only). Tributaries were sampled at Dessau/Mulde, Rosenburg/Saale, Toppel/Havel (flood) and Havelberg/Havel (low water). Seven to twelve water samples per site were collected during the flood event (3.–20.6.2013 = 18 days), while six water samples per site (Mulde and Havel: four) were taken during low flow (20.7.–5.10.2015 = 78 days). Suspended solids were measured as total suspended solids. Heavy metals and arsenic were analysed in filtered and unfiltered water samples. Daily loads were calculated from the concentration of the unfiltered water sample and the mean daily discharge at the corresponding gauge. Missing daily loads were computed using linearly interpolated concentrations. Concentrations below the limit of quantification were given the value of half of this limit. The event load is the sum of all daily loads.

3. Results

Heavy metals and arsenic are transported partly bound to particles and partly dissolved. During floods and low flows this proportion differs from mean flow conditions (year 2012), with the dissolved portion being lowest during flood and highest during low flow (Fig. 1). Table 1 shows the significance of floods for the transport of contaminants. The daily load of heavy metals at Wittenberg/Elbe (7.6.2013), one day before the flood crest at the corresponding gauge, was 39 times higher for uranium and more than 500 times higher for lead, respectively, compared to the daily load during extreme low flow (17.8.2015). At Magdeburg the ratio of the loads of SS, TOC and heavy metals for these days was significantly lower than at Wittenberg, mainly due to the influence of tributaries (especially Mulde and Saale) and the deposition on floodplains.

Tab. 1: *Proportion of the daily load of SS, TOC, heavy metals and arsenic in the River Elbe on 7.6.2013 (extreme flood) and 17.8.2015 (extreme low flow)*

	Ratio: daily load 7.6.2013 / daily load 17.8.2015								
Sampling site	SS	TOC	Pb	Cd	Cu	Hg	U	Zn	As
Wittenberg	673	89	532	164	93	(575)*	39	75	73
Magdeburg	132	47	222	39	52	149	21	19	74
* 17.8.2015: load calculated with half of the limit of quantification									

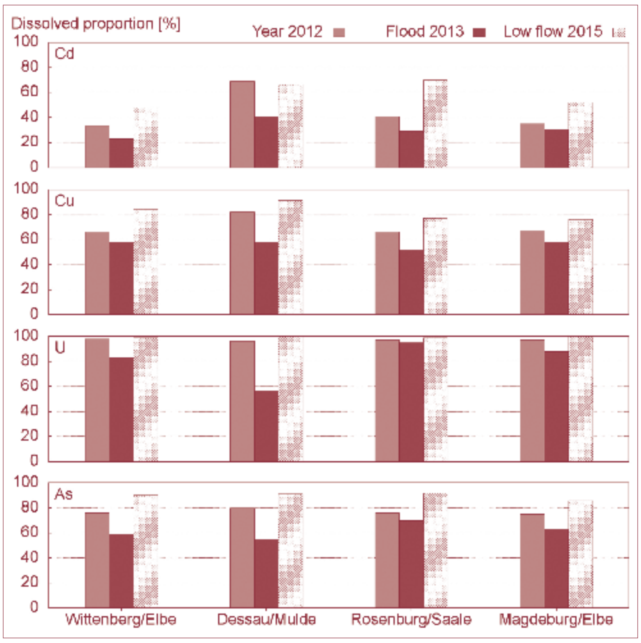

Fig. 1: *Dissolved proportion (mean) of cadmium, copper, uranium and arsenic in the Rivers Elbe, Mulde and Saale in the year 2012, during the flood event (3.–20.6.2013) and the low flow event (20.7.–5.10.2015)*

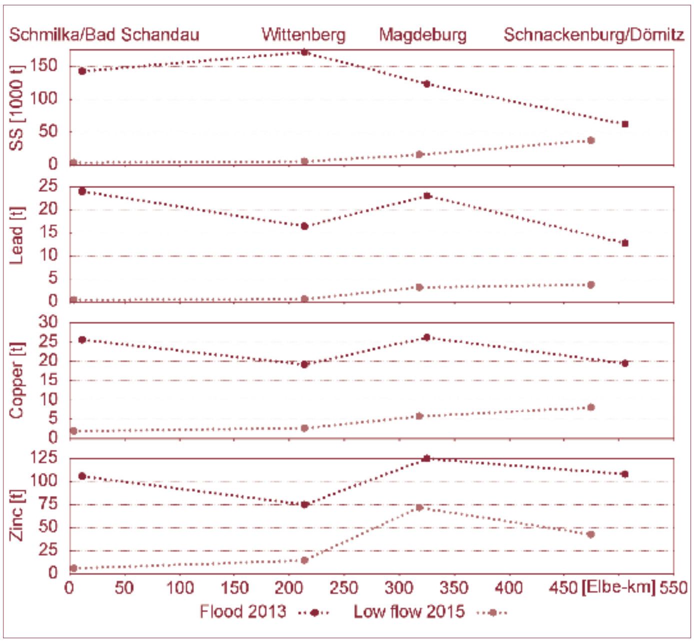

Fig. 2: *Load of suspended solids (SS), lead, copper and zinc in the River Elbe during the flood event (3.–20.6.2013) and the low flow event (20.7.–5.10.2015)*

In case of the 2013 flood, the event load of SS increases from Bad Schandau to Wittenberg and decreases further down the Elbe due to deposition on the floodplains (Fig. 2). Conversely, for heavy metals the load of the flood event decreases from Bad Schandau to Wittenberg and increases until Magdeburg due to the input of contaminants from the tributaries Mulde and Saale. Regarding the 2015 low flow, the event loads of SS and some heavy metals (lead, copper) increase nearly continuously along the Elbe (Fig. 2). For zinc and uranium, the distinct increase of the event load between Wittenberg and Magdeburg indicates the influence of the tributaries Mulde and Saale on these contaminants. As the water samples from Magdeburg were taken on the left side of the Elbe (incomplete mixing of Saale and Elbe) the event load at Magdeburg is most likely to be overestimated.

Data collected by the special monitoring programme form a base to characterise the specific conditions for the transport of contaminants during extreme flow events. Experiences with the programme will be used for its enhancement. A report of the 2015 low flow event such as [2] is in preparation.

Literature:

[1] FGG Elbe (ed.) (2015) Messprogramm für hydrologische Extremereignisse an der Elbe. http://www.fgg-elbe.de/elbe-datenportal/messprogramme.html

[2] Schwandt, D. & Hübner, G. (2014) Das Messprogramm Extremereignisse beim Junihochwasser der Elbe 2013. FGG Elbe (ed.), Fachberichte Hochwasser; http://www.fgg-elbe.de/dokumente/fachberichte.html

[3] Hübner, G. & Schwandt, D. (2016) Ereignisbezogener Schadstofftransport im Elbegebiet. Korrespondenz Wasserwirtschaft 9 (1), 33–38 (DOI: 10.3243/kwe2016.01.003)

[4] Hübner, G. & Schwandt, D. (2015) Transport and Deposition of Heavy Metals/Arsenic during the June 2013 Flood of the River Elbe. In: Fuchs, S. & Eyckmanns-Wolters, R. (ed.) River Basins 2015 – Monitoring, Modelling & Management of Pollutants. Conference Proceedings KIT, 99–100; https://www.riverbasins.kit.edu/

Flood risk management and flood protection optimization on the lower Vltava River

Petr Jiřinec, Kateřina Kubalová, Petr Sklenář

1. Introduction

The aim of the study was to provide detailed analysis of flooding processes in the area of interest along the Vltava River in river reach from Prague to confluence with the Elbe River using the 2D mathematical modeling. Detailed 2D mathematical model in software package MIKE 21C (DHI, Hørsholm, Denmark) with high spatial resolution – computational grid size along the river app. 5 to 15 m and ca. 3 to 10 m in transversal direction – has been used for simulation. The mathematical model has been successfully calibrated on data from the 3 biggest flood events in the last decade – in August 2002, April 2006 and June 2013. The outputs are detailed analyses of a function and efficiency of all flood protection measures including the moment of their overflowing and potential flood mitigation effect based on changed operation rules of the reservoirs on the Vltava River upstream Prague.

2. Flood protection efficiency of individual dikes

The flood protection safety level and the fact whether a protected area is completely dry at the moment of a dike overtopping or already partially flooded by a by-pass flow from behind the dike have been studied. Rating curves describing the ration between discharge and water level along individual dike lines have been prepared so that they could be used for determination of discharge which overtops this individual dike – Fig. 1. Also influence of a discharge ratio in both rivers (in the Vltava and the Elbe Rivers) on flow characteristics in the confluence area has been evaluated and considered in “dike rating curves” (Fig. 1).

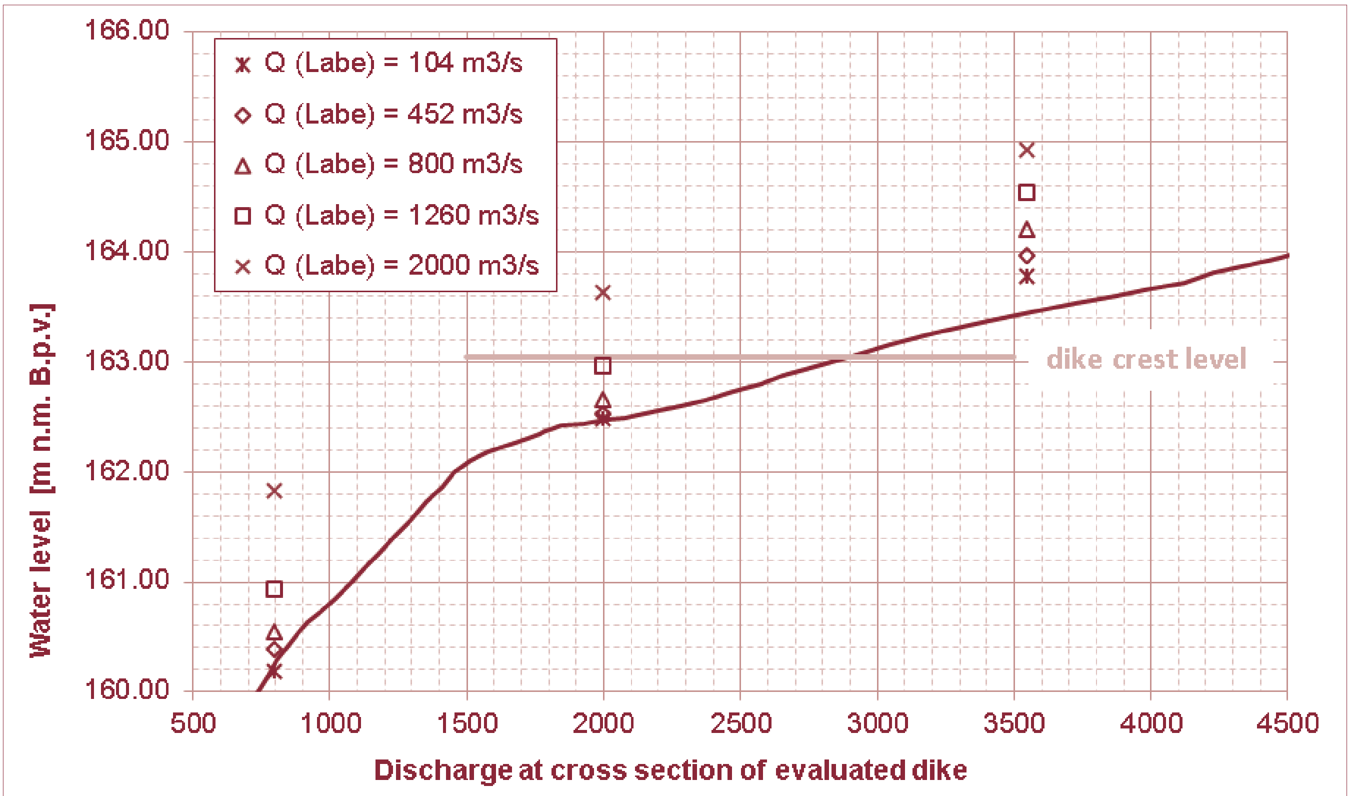

Fig. 1: *Rating curve for determination of overtopping discharge for the Zelčín – Vrbno dike*

3. Impact of the proposed changes of operation rules of the reservoirs on the Vltava River upstream Prague on flood management

Effect of the proposed changes of the operation rules of the reservoirs on the Vltava River upstream Prague has been analyzed and evaluated from two points of view:

- analysis of the possibility to increase the maximum discharge which can be released from the cascade before the approach of the forecasted flood without causing significant damages in order to enable temporary increasing of the flood control storage in the reservoir
- potential flood mitigation effect (analyzed on the real flood event from June 2013), i.e. decreasing of the peak discharge and delay of the flood approach in order to gain more time for preparations (mobile barriers, etc.) – Fig. 2.

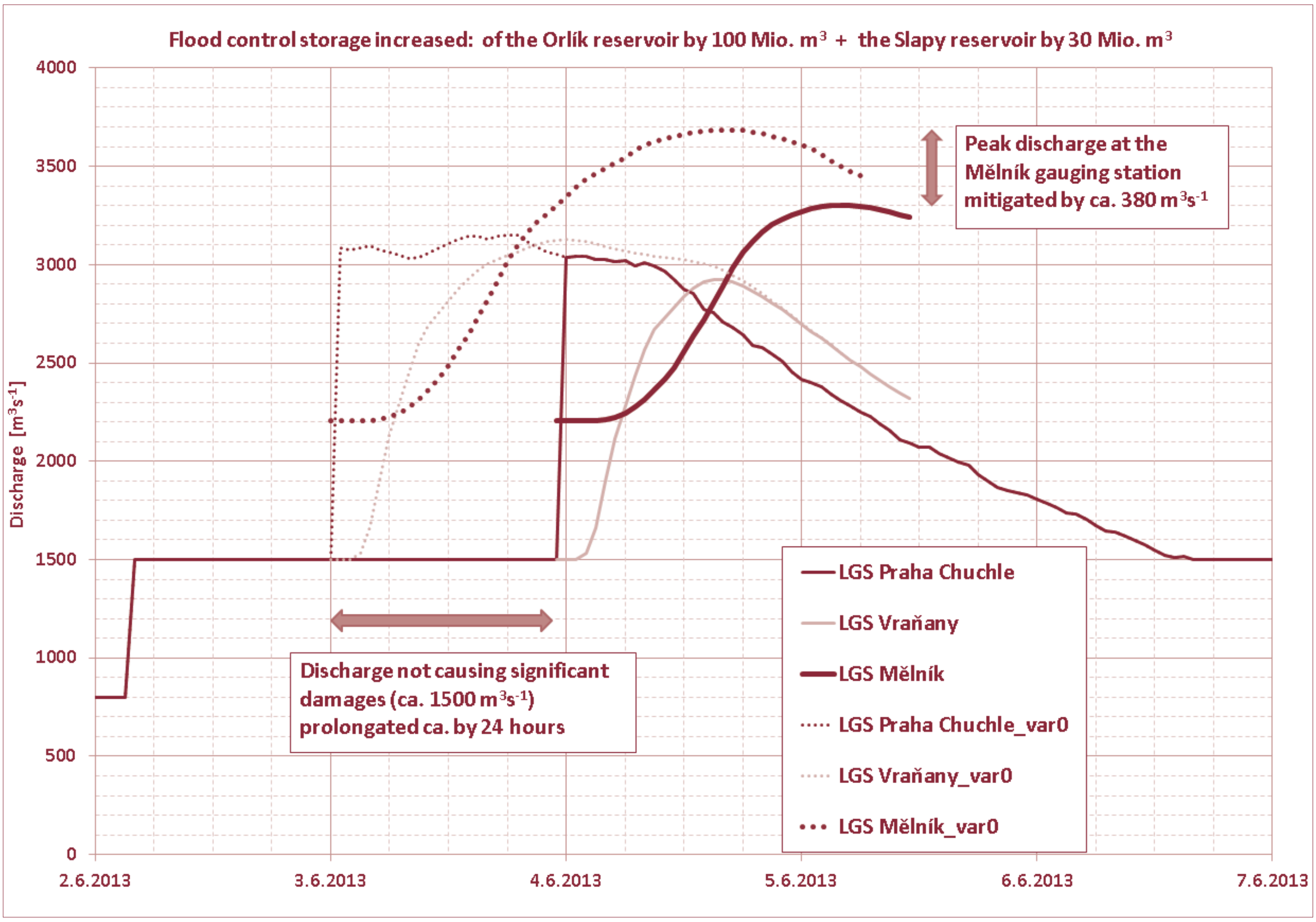

Fig. 2: Evaluation of proposed increased flood control storages of the Orlík and the Slapy reservoirs

4. Analysis of the newly built flood measures

The study also includes the analysis of the newly built flood measures influence on the flood wave propagation (peak discharge and flood routing] in the area. Analyses are documented in the form of detailed maps of the flood extent, water depths and water levels along the river.

Literature:

[1] Sklenář, P. and Jiřinec, P.: (2015) Analysis for flood risk management and flood protection on the Lower Vltava River. DHI a.s., Prague, September 2015

River water quality dependence on flow rate – estimating the pollution source character

Eva Juranová, Eduard Hanslík, Diana Marešová, Barbora Sedlářová, Radek Vlnas

1. Introduction

Recently, the potential of climate change impact on surface water quality is being increasingly recognised. Current studies [1 – 5] have shown that water quality can be directly influenced by several related mechanisms on both a short and long-term basis. It is, for instance, the influence of increase in air temperature, changes in hydrologic characteristics (decrease in dilution capacity of pollution from point sources during low flow rates), terrestrial factors (changes of vegetation and soil structure) or water use (increased water demand, higher need of cooling water) [6]. In this study, influence of flow rate variations on water quality is assessed on several examples of river sites for general parameters of the water quality. Furthermore, ratios of average parameter values during low and high flows were calculated, which enabled to assess the character of the pollution sources. Thanks to that, the study helps to identify critical water quality parameters during the dry season.

2. Methods

In this study, the catchment of the Orlík Reservoir was assessed. The catchment was represented by sites at main reservoir tributaries (Vltava Hněvkovice, Lužnice Koloděje, Vltava Kořensko, Otava Topělec) and at the reservoir outflow (Vltava Solenice).
Flow rate values were monitored at all the concerned river sites once in a month, together with the water quality parameters: Temperature, pH, dissolved oxygen, chemical oxygen demand permanganate and dichromate, biochemical oxygen demand and suspended solids, nitrate and ammonia nitrogen, total and phosphate phosphorus, dissolved solids, dissolved inorganic salts, calcium, magnesium, potassium, chlorides, sulphates. The assessed period was 1997 – 2013.
At the monitored sites, the low flow rates (Q_L) were determined as flow rates exceeded at 75 % and lower (lower than the 1st quartile) and the high flow rates (Q_H) were determined as flow rates exceeded at 25 % and higher (higher than the 3rd quartile). Then, average values of quality parameter concentrations corresponding to the low (c_L) and high (c_H) flow rates were calculated.
Furthermore, index for the prevailing pollution source characterization, based on the pollution behaviour related to the flow rate, was calculated as:

$$I_{PS} = \frac{c_L}{c_H}$$

where I_{PS} is index for pollution source characterization
c_L average parameter concentration during the low flow rates
c_H average parameter concentration during the high flow rates

3. Results and discussion

The I_{PS} index was evaluated for the above mentioned water quality parameters at the monitored sites. The index values were in range from 0,31 to 2,74. The values significantly lower than 1 (lower than 0,9) imply the direct dependence of the parameter concentration on flow rate, which can indicate prevailing influence of nonpoint pollution sources. This is the case of the I_{PS} index of nitrates and suspended solids through all monitored sites. This is connected to washing the soil away from the agricultural areas by strong precipitation, often resulting into increase of the flow rates.
The I_{PS} index values significantly higher than 1 (higher than 1,1) indicate the influence of the point pollution sources, where the pollution is the more diluted the higher flow rate is in the recipient. The elevated I_{PS} index values were found for the biochemical oxygen demand, ammonia nitrogen, phosphorus (phosphate and total) and some parameters of inorganic dissolved pollution at some sites. The reasons can be found in the above catchments.
Low values of the I_{PS} index were found also for dissolved oxygen and higher values of the I_{PS} index for temperature. This results from the fact that these parameters are connected to the dry and warm summer season, when the increased water temperature causes oxygen deficits.

4. Summary

The purpose of this study was to find the rules that influence the quality of river water during low and high flows occurring in dry and flood periods. Better understanding of this question led to identification of the character of the source for the studied water quality parameters. This may allow application of effective measures for preserving the appropriate water quality even during unfavourable conditions.

Literature:

[1] Shrestha, R. R., Dibike, D. B., and Prowse, T.D. (2012) Modelling Climate Change Impacts on Hydrology and Nutrient Loading in the Upper Assiniboine Catchment. J. of the Am. Wat. Res. Ass., Vol. 48, 1, pp. 74 – 89,

[2] Johnson, T., et al. Modeling Streamflow and Water Quality Sensitivity to Climate Change and Urban Development in 20 U.S. Watersheds (2015) J. of the Am. Wat. Res. Ass., Vol. 51, 5, pp. 1321 – 341,

[3] Momblanch, A. (2015) Managing water quality under drought conditions in the Llobregat River Basin. Sci. of the Tot. Env., Vol. 503 – 504, pp. 300 – 318,.

[4] Mosley, L. M. (2015) Drought impacts on the water quality of freshwater systems; review and integration, Earth-Scie. Rev., Vol. 140, pp. 203 – 214.

[5] van Vliet, M. T. H. and Zwolsman, J. J. G. (2008) Impact of summer droughts on the water quality of the Meuse River, J. of Hyd., Vol. 353, pp. 1 – 17,

[6] Buceti, G. (2015) Climate Change and Vulnerabilities of the European Energy Balance, J. of Sustain. Dev. of En., Wat. and Environ. Sys., Vol. 3, 1, pp. 106 – 117.

Updated International Management Plan for the Elbe River Basin District (Part A) for the Period 2016 – 2021

Pavel Knotek, Lenka Běhounek

The International Commission for the Protection of the Elbe River (ICPER) published the updated "International Management Plan for the Elbe River Basin District" (part A) for the period 2016 – 2021 on 17 December 2015.

1. Assessment of the Ecological Status / Ecological Potential of the Surface Water Bodies

Most surface water bodies in the international Elbe river basin district did not achieve a good ecological status/good ecological potential in 2015, namely 91% of the water bodies classified as rivers, 77% of the water bodies classified as lakes and 5 out of 6 water bodies of the transitional and coastal waters.

A comparison of the assessment of the ecological status for the updated plan 2015 with the original plan 2009 is only possible to a limited extent. The changes of the assessment results are mainly due to changed requirements for the good status of the water bodies and methodological changes of the assessment or can be attributed to the variability of the values of the biological quality components.

2. Assessment of the Chemical Status of the Surface Water Bodies

Most surface water bodies did not achieve a good chemical status in 2015 as well. The environmental quality standards of ubiquitous substances that are persistent, bioaccumulative and toxic (e.g. mercury) have been frequently exceeded. That's why the results for the other relevant substances on the water body level are not discernible. For this reason, the results of the chemical status of the surface water bodies without ubiquitous substances was shown in a separate map in the management plan.

3. Supra-Regional Environmental Objectives on the International Level

Supra-regional environmental objectives for *improving the surface water body structure:*

- Re-establishing adequate habitats for aquatic organisms, lateral connectivity between rivers and the river meadows
- Recommendations according to the ICPER publications [1], [2]
- Optimised and coordinated maintenance activities that aim at balanced sediment conditions in the tidal Elbe, and hydromorphologically effective river-engineering measures in order to reduce fine sediment transport in the estuary

Supra-regional environmental objectives for *improving river continuity*:

- The selection of the supra-regional priority water courses was slightly modified in the updated plan: The aim is to restore river continuity for migrating fish at all significant transverse structures of the Elbe river and 53 other water courses in its basin (Table 1).

Table 1: *Restoring passage for fish in the supra-regional priority water courses – implementation and operational objectives*

State	Number of supra-regional priority water courses	Implemented in the first management period1)	Plan for the second anagement period2)
Germany	Elbe + 41	60	172
Czech Republic	Elbe + 12	25	130
Total	Elbe + 53	85	302

1) Number of sites with transverse structures where river continuity for fish was restored in the period 2010 – 2015.

2) Number of additional sites with transverse structures where river continuity for fish is to be restored in the period 2016 – 2021.

Reducing the impact of excessive nutrient and pollutant entry on the North Sea ecosystem is a supra-regional environmental objective that can only be achieved by implementing measures throughout the river basin. Table 2 shows the marine ecological target concentrations for nitrogen and phosphorus at the Elbe monitoring profiles Schmilka/Hřensko and Seemannshöft as annual average values.

Table 2: *Supra-regional targets and need for action to reduce nutrient input in the international Elbe river basin district*

	Ntot [mg/l]	Ptot [mg/l]
Data for the German-Czech monitoring profile Schmilka/Hřensko		
Average annual concentration for the period 2009–2012	4.09	0.117
Marine-ecological target concentration (annual average)	3.2	0.1
Annual average concentration expected by 2021 as a result of the Czech programme of measures	3.74	0.110
Need for further action until 2027	0.54	0.010
Data for the limnic-marine monitoring profile Seemannshöft		
Average annual concentration for the period 2009–2012	3.4	0.16
Marine-ecological target concentration (annual average)	2.8	0.1
Annual average concentration expected by 2021 as a result of the Czech and the German programme of measures	3.0	0.146
Need for further action until 2027	0.2	0.046

The reasons for the *contamination of the waters with heavy metals, pesticides and organic pollutants* are mainly pollutant deposits from the past (inherited burdens) and contaminated sediments. Within the framework of the *"ICPER sediment management concept"* [2], a comprehensive analysis, assessment and risk analysis of the qualitative sediment conditions was conducted. The concept contains recommended actions for reducing pollutant entry.

4. Meeting environmental objectives

The assessment shows that the majority of the surface water bodies in the international Elbe river basin district did not achieve a good status in 2015. For these water bodies exemptions were used in the updated plan, in many cases extensions of the deadline (most often until 2027) and to a lesser extent less stringent environmental objectives. The results for groundwater targets are better, mainly in view of quantitative aspects. It is expected that there will be only a one-digit increase in the percentage of surface and groundwater bodies meeting the environmental objectives until the end of 2021.

Literature:

[1] IKSE (2013) Unterhaltung schifffahrtlich genutzter Oberflächengewässer im Einzugsgebiet der Elbe im Hinblick auf die Verbesserung des ökologischen Zustands / Potenzials. Abschlussbericht. Magdeburg: IKSE

[2] IKSE (2014) Sedimentmanagementkonzept der IKSE. Vorschläge für eine gute Sedimentmanagementpraxis im Elbegebiet zur Erreichung überregionaler Handlungsziele. Magdeburg: IKSE

[3] IKSE (2015) Internationaler Bewirtschaftungsplan für die Flussgebietseinheit Elbe, Teil A, Aktualisierung 2015 für den Zeitraum 2016–2021. Magdeburg: IKSE

[4] IKSE (2016) Informationsblatt der IKSE Nr. 5 zur Umsetzung der Wasserrahmenrichtlinie im Einzugsgebiet der Elbe. Magdeburg: IKSE

Sorption and dissipation of selected pharmaceuticals in representative soils

Radka Kodešová, Martin Kočárek, Oksana Golovko, Aleš Klement, Olga Koba, Miroslav Fér, Ondřej Jakšík, Roman Grabic

1. Introduction

It has been documented in several studies that soil water and consequently surface and ground-water may be contaminated by human or veterinary pharmaceuticals. Our two studies [1] and [2] were therefore focused on the evaluating sorption and dissipation of selected pharmaceuticals in soils, as main factors affecting contaminant transport in water environment.

2. Methods

Batch sorption and degradation tests were performed for 7 pharmaceuticals and 12 representative soils within the Czech part of the Elbe catchment. The Freundlich equations were used to describe adsorption isotherms. The first-order kinetic expressions were used to evaluate dissipation rates and half-lives. The resulting Freundlich adsorption coefficients and half-lives were related to measured physical and chemical soil properties (soil particle density, soil texture, oxidable organic carbon content, $CaCO_3$ content, pH_{H2O}, pH_{KCl}, exchangeable acidity, cation exchange capacity, hydrolytic acidity, basic cation saturation, sorption complex saturation), using the simple and multiple regression analyses, and to soil types using the principal components analysis.

3. Results

The lowest adsorption (i.e. the largest mobility) was measured for carbamazepine and increased as follows: sulfamethoxazole, clindamycin, metoprolol, atenolol, trimethoprim and clarithromycin. Sorption of ionisable pharmaceuticals was, in many cases, highly affected by soil pH. Sorption of trimethoprim, clindamycin, clarithromycin, metoprolol and atenolol, which depending on soil pH occurred in cationic form (atenolol, metoprolol, clarithromycin), and cationic and neutral (trimethoprim, clindamycin), was positively related to the base cation saturation and cation exchange capacity. The sorption of carbamazepine (neutral) and sulfamethoxazole (neutral and anionic) was positively related to the organic matter content and hydrolytic acidity, respectively.

The greatest persistence in soils was measured for carbamazepine, followed by clarithromycin, trimethoprim, metoprolol, clindamycin, sulfamethoxazole and atenolol. Dissipation half-lives (at least partly) reflected the sorption of the studied pharmaceuticals in different soils and increased with increasing sorption (sulfamethoxazole and clindamycin), which is usually presumed. However, in 3 cases (atenolol, metoprolol and trimethoprim) the dissipation half-lives decreased with increasing sorption and carbamazepine and clarithromycin mostly did not considerably degrade during our experiments. Regression analyses mostly did not show significant relationships between half-lives and soil properties. However, principal components analysis showed dependence on soil types. For compounds that were degradable in the studied soils, lower average dissipation half-lives and variability were calculated for soils of better quality (soils with well-developed structure, high nutrition content and associated biological conditions as Chernozems) in comparison to those of lower quality (Cambisols). We may conclude that while sorption affinity of studied compounds depends on their ionization and soil properties, pharmaceutical persistence in soils is mostly depended on soil type.

Regarding the dissipation rates and sorption affinities of the studied compounds, the highest potential to migrate in the soil water environment is expected for carbamazepine, followed by sulfamethoxazole, trimethoprim and metoprolol. Based on our findings, extended transport of clindamycin, clarithromycin and atenolol through the vadose zone seems improbable.

Acknowledgement: Authors acknowledge the financial support of the Czech Science Foundation (Project No. 13-12477S).

Literature:

[1] Kodešová, R., Grabic, R., Kočárek, M., Klement, A., Golovko, O., Fér, M., Nikodem, A., Jakšík, O. 2015 Pharmaceuticals' sorptions relative to properties of thirteen different soils. Science of the Total Environment 511, 435 – 443

[2] Kodešová, R., Kočárek, M., Klement, A., Golovko, O., Koba, O., Fér, M., Nikodem, A., Vondráčková, L., Jakšík, O., Grabic, R. 2016 An analysis of the dissipation of pharmaceuticals under thirteen different soil conditions. Science of the Total Environment 544, 369 – 381.

Targeted Monitoring and Balance Analysis of Plant Protection Products (Pesticides and their Metabolites) in the Uhlava River Basin – Water Supply for the Pilsen Agglomeration (2013 – 2015)

Milan Koželuh, Václav Tajč

1. Introduction

The Uhlava River and its tributaries provide water for nearly 200 thousand of people as a supply for treatment of drinking water. River basin is mostly agricultural with a high proportion of industrial crops (oilseed rape and maize). The main attention for surface water was focused on the use of plant protection products (herbicides). Herbicides are applied every spring and autumn, and their penetration into the aquatic environment depends on the hydrological conditions (amount and intensity of precipitation), on a compliance buffer zones and may be the most important - on the character of landscape profile. Targeted monitoring of pesticides was conducted in 2013 – 2015. There were monitored final sampling point (Plzen Doudlevce) and 11 sampling points on main tributaries of the Uhlava river basin. Scheme of monitoring was 10 sampling days each year. More than 150 organic analytes was determinated and balance analysis of runoff pesticides was made. The report was created each year [1 – 4]. In addition, the samples were available from the automatic samplers located in Pilsen waterworks, which provided weekly cumulated samples (can be divided into the daily samples).

2. Aims of the project

The main aim of the project was the mapping of pesticide contamination in the Uhlava river basin. Data from chemical analysis were used in technology process of treatment of drinking water. Another aims were to demonstrate the complementarity of the results (i), to make an annual comparison between the years 2013 – 2015 (ii), to obtain essential information on a range of pesticide contamination (iii) and to get conclusions useful for quality assessment of surface water (iv).

3. Results

In all tributaries metabolites of chloroacetanilides were found periodically. Terbuthylazine and its metabolites were determined in 2013 – 2014 (then decreased significantly). Glyphosate and AMPA were found periodically during the application time. Concentrations of bentazone, chlorotoluron, propiconazole, tebuconazole, prohexadione, clomazone etc increased during the seasonal applications. The method of calculation of pesticide runoff is based on the values of concentrations of pesticides and values of flow rate in real time at the time of sampling [5]. The total balances of pesticide runoff in tributaries is comparable with the final sampling point Uhlava - Doudlevce. The total pesticide runoff depends on the total water amount (Tab. 1).

Tab. 1: *Uhlava Doudlevce - final pesticide and water amount balance*

Period	Water amount (mil. m^3)	Pesticides runoff (kg)
2013	155	165
2014	82	58
2015	41	14

3.1. Cumulated Samples

The monitoring with using of automatic 24 h sampler was located at the point of water withdrawal of Pilsen waterworks; it was launched in April 2015 and performed continuously. The cummulated sample consisted of seven daily samples; each of those daily samples included twelve discrete samples (sampling period two hours). The advantage of cummulated samples is the extermination of short-term fluctuations which is typical for discrete sampling type. Results of daily pesticide runoff is shown in Fig. 1. All season monitoring is justified especially in a year with low rainfall because the highest daily pesticides runoff (up to 1000 g / day) are recorded in the winter, it means out of the period of pesticide application.

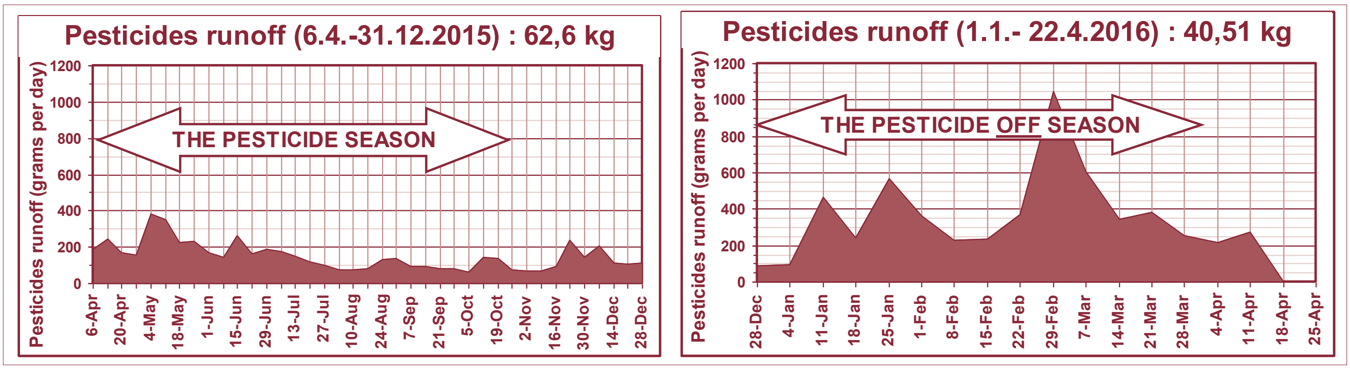

Fig. 1: Pesticides runoff – comparison of season with and without application of pesticides in the cumulated samples

4. Conclusions

Concentration of pesticides in rivers and the total amount of pesticides runoff depends on the amount of water. Final mass balance of pesticides for each year was: 2013 (165 kg pesticides at 155 mil. m^3 water); 2014 (58 kg at 82 mil. m^3); 2015 (14 kg at 41 mil. m^3). It shows a difference in pesticide runoff in dry or rainfall rich year. Good agreement of monitoring was confirmed in balance of final point of river basin (in Doudlevce point) and all tributaries. Chloroacetanilides metabolites (42%) and AMPA (41%) are the largest part of pesticide contamination. The estimate amount of applied pesticides was approximately thousand times higher than concentrations measured in water. We can supposed, that most pesticides are metabolized in plants, or in soil, alternatively are evaporated.

Literature:

[1] Tajč, V., Liška, M., Koželuh, M., Marcel, M.: Screeningový monitoring pesticidních látek v povodí řeky Úhlavy, závěrečná zpráva z prací provedených v rámci projektu v roce 2012 (2012)

[2] Tajč, V., Liška, M., Koželuh, M., Marcel, M.: Screeningový monitoring pesticidních látek v povodí řeky Úhlavy, závěrečná zpráva z prací provedených v rámci projektu v roce 2013 s využitím dat a údajů získaných v roce 2012 (2013)

[3] Tajč, V., Liška, M., Koželuh, M., Marcel, M.: Screeningový monitoring pesticidních látek v povodí řeky Úhlavy, závěrečná zpráva z prací provedených v rámci projektu v roce 2014 s využitím dat a údajů získaných v roce 2012 – 13 (2014)

[4] Tajč, V., Liška, M., Koželuh, M., Marcel, M.: Screeningový monitoring pesticidních látek v povodí řeky Úhlavy, závěrečná zpráva z prací provedených v rámci projektu v roce 2014 s využitím dat a údajů získaných v roce 2012 – 14 (2015)

[5] Hejzlar, J.: Metodika bilanční analýzy zdrojů živin v povodí, Biologické centrum AV ČR, v.v.i. – Hydrobiologický ústav, České Budějovice (2010)

Impacts of hydrological drought in 2015 on water levels and river shipping conditions on the regulated part of the river Elbe in the Czech Republic

Jiří Kremsa, Jiří Petr

1. Hydrological drought in 2015

The summer drought in 2015 which hit the Czech Republic ranked among its most serious historical drought episodes, which can be compared to the timeline and occurrence of extreme temperatures of the known episodes in 1947 and 2003. The precipitation deficit began to manifest itself in the Czech Republic as early as 2014, and from February 2015, it slowly continued during the spring months and had risen to 150 mm by the end of August. At the beginning of summer, the country had been already relatively dry, and the situation was also gradually worsened by recurring heat waves, some of which were extreme and lasted several days in a row. The precipitation deficit was comparable with the most significant cases of drought in 1921, 1976 and 2003, and partially also in 1911 and 1947. In terms of the surface water deficit on the Elbe river basin, the year 2015 ranks among the worst years ever [1].

The mean annual air temperature in 2015 for the Czech Republic was 9,4 °C (+1,9 °C relative to the 1961 – 1990 climate baseline). The year 2015 also together with last year was the warmest in the observational record beginning in 1775. The temperature for the summer months has been the second highest (after the year 2003) during the monitoring period since 1961. Similarly, the total precipitation has been the second lowest (after the year 2003). The highest deviation 5,1 °C above the mean (21,3 °C) was recorded in August when the maximum daily air temperature reached 40 °C at some measuring stations. The mean annual precipitation 532 mm ranks the year 2015 strongly below-normal. It represents one fifth lower value compared with long-term mean 674 mm for the 1961 – 1990 climate baseline [1].

Hydrological drought in 2015 affected the whole country. The water levels of most streams declined significantly below the 355-day discharge value over several weeks, as evidenced by field measurements. In some regions, some streams dried out completely. Mid-August can be considered the peak of the drought, when there were abundant rainfalls which significantly helped the country and its vegetation. However, these rainfalls were not enough to end the overall drought situation. The drought thus continued throughout September and early October, when the precipitation deficit had risen up to 180 mm. The situation of surface streams was only improved by the precipitation period in mid-October. From the evaluations completed so far, it follows that the recurrence intervals of 30-day and 7-day annual runoff minima varied in a relatively wide range from 10 to 100 years [1].

2. Development of water flow and levels on the lower Elbe

Hydrological drought in 2015 was reflected in the Elbe below the confluence with the Vltava river, which drains two-thirds of the territory of our republic. On the river Elbe from the confluence with the Vltava at Mělník along the state border with Germany the stream flows were recorded lower than the corresponding long-term monthly mean except January, while from May to October at flow rates of about 50% long-term mean and lower. At the rate of water flow during the spring months had a negative impact on the snow poor winter 2014 – 2015. Very low flows were observed mainly in the summer months due to lack of rainfall and high air temperatures. During this period, the mean monthly flows in Ústí nad Labem ranged from 85 to 91 $m^3.s^{-1}$ and represented 41 – 47% of long-term monthly mean. Absolute minimum was reached in late July, when the flow rate in Ústí nad Labem corresponded to 64.9 $m^3.s^{-1}$ in the daily average.

Fig. 1: Dry river bed of the Elbe in Ústí nad Labem

Fig. 2: Low water level in the dam Orlík on the Vltava

3. The significance of water reservoirs

In the summer season hydrological regime of the Elbe below the confluence with the Vltava was positively affected by water reservoirs in Vltava cascade with significant storage volumes. The minimum outflow 40 $m^3.s^{-1}$ from the dam Vrané was ensured for a long time, even at the cost of emptying the storage space of the dam Orlík to historically low levels. In Prague (profile Malá Chuchle) the flow consistently remained around 45 $m^3.s^{-1}$. According to the CHMI (Czech Hydrometeorological Institute) in the season of minimum flow rates in mid-August, the overall affected outflow from Vrané due to Vltava cascade reached up to 25 $m^3.s^{-1}$. Hypothetical minimum (without affecting the flow by Vltava cascade) in Malá Chuchle reached 16.8 $m^3.s^{-1}$. Positive impact on the rate of water flow on the lower Elbe also had the dam Nechranice on the river Ohře which guaranteed the flow 7 $m^3.s^{-1}$ and flow contribution in total amount of 5.0 $m^3.s^{-1}$ from the dams Rozkoš and Pastviny laying in the upper part of the Elbe catchment. Overall affected flow on the lower Elbe amounted to about 37.0 $m^3.s^{-1}$, which is more than half of the lowest recorded flow rate in Ústí nad Labem.

4. Shipping conditions on the regulated Elbe

The Elbe shipping traffic was strongly limited by extreme drought. Water level in Ústí nad Labem reached values of 150 cm or less, ie. below the economic utilization for 147 days, after more than a third of the year. Duration of extremely low water levels in 2015 in Ústí nad Labem has been evaluated as the longest for the entire observation period since 1980. Conversely, the water level higher than 275 cm guaranteeing unlimited shipping conditions, lasted only 32 days. During the peak of the drought the water level in Ústí nad Labem reached its minimum of 115 cm, which is the lowest recorded value for the month of August since 1963 (after the construction of the Vltava cascade).

From mid-May to mid-November the intensity of navigation on the regulated Elbe was minimal, particular sport boats were locked through. The total number of ships locked through Střekov in 2015 reached 55% of calculated average over the past 10 years. Short-term improvement of the navigation conditions was ensured at the request of carriers in 100 cases, mostly from the capacity of the weir Střekov, but also due to transitory increase in runoff from the Vltava cascade. This took advantage of cargo and passenger ships with higher draught for passing through a critical part of the Elbe between Střekov and Děčín.

Literature:

[1] CHMI (2015), Drought in the Czech Republic in 2015, October 2015, Prague

Estimation of high flood sedimentation and its consequences for soils in polder and dike relocation areas

Frank Krüger, Jochen Rommel, Ingo Runge

1. Introduction

“Amount and impact of fine grained sediments in intended retention areas for high flood control” was a 2015 applied research project, initiated by the LHW of federal state Saxony-Anhalt (Germany). In the frame of this project an approach to estimate sedimentation quantities and pollutants entries was gathered and exercised for new, projected polder and dike relocation areas. Because of the lasting contamination situation of the Elbe River and its main tributaries Mulde and Saale the input of contaminants is to be expected. The study aimed a) to assess these new contaminations with respect to soil quality and land use and b) to develop basics for a field monitoring and, if necessary, measures to mitigate future problems. The study focused on four investigation sites at the Rivers Elbe, Saale and Mulde (Fig.1), representative for different contamination situations in sediments as well as for different high flood suspended loads. The investigation sites included mainly polder (intentionally flooded at high flood levels), but also dike relocation areas in the River Elbe and Mulde floodplains.

Fig. 1: *Investigation sites.*

2. Methods

Investigations based on available data. Data about topography, soil types and land uses as well as soil background contaminations were gathered from public authorities of federal state Saxony-Anhalt (LAU, LAGB, LLG). Site specific sediment contamination data were delivered from LHW of federal state Saxony-Anhalt and were available from the FGG-Elbe database. Daily suspended sediment concentrations were provided by the BfG. Further more data about the extreme floodings in 2002 and 2013 were published in Schwandt and Hübner (2013). Sediment retention calculation in dike relocation areas based on an approach, which was developed for the Elbe River Sediment management concept (Krüger et al. 2014). To estimate sedimentation quantities in polders we followed an apprpach from Kühlers et al. (2010). Fig. 2 gives an overview about selected calculation scenarios.

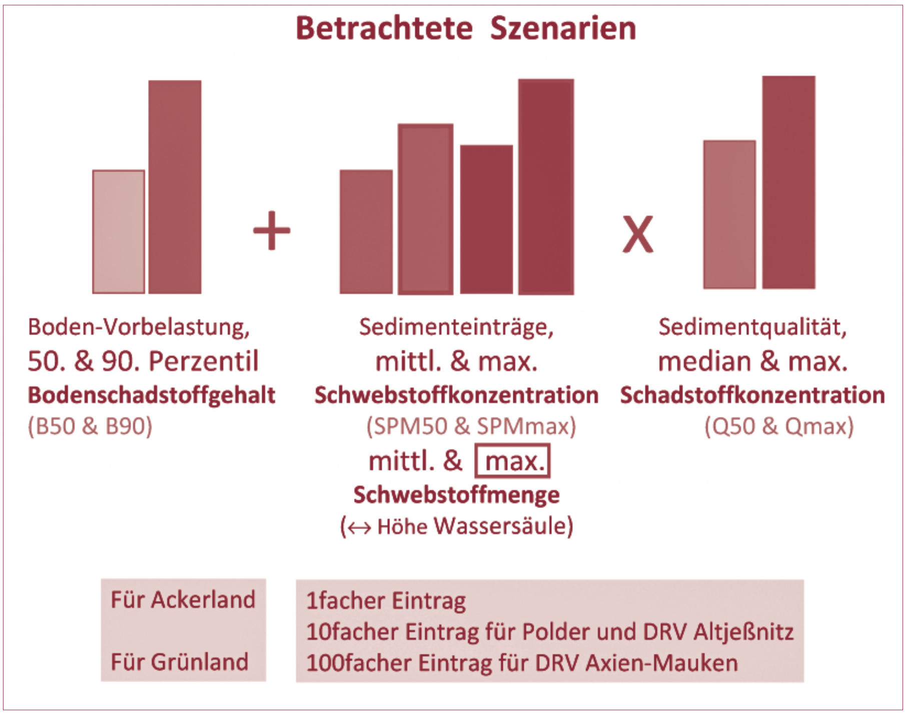

Fig. 2: *Scenarios and varied parameters to calculate potential new soil qualities.*

3. Results

Estimated results underline on the one hand, that few floodings of polder areas do not have the potential to impair soil quality of grassland and arable land in a sustainable way. On the other hand, in dike relocation areas frequent future floodings will cause an ongoing high flood sedimentation. In consequence increasing soil contamination and land use impairment will be unavoidable. Tab. 1 gives an idea about new, long term, high flood induced and site specific soil qualities for grasslands.

Tab. 1: *New grassland soil qualities for selected contaminants. On the assumption of 10 floodings for polder sites and 100 floodings of dike relocation sites, B50: mean qualities of silty (U) soils, Q50 & Qmax: mean and worst case sediment qualities, SPM50 & SPMmax: mean and worst case sediment loads, DRV: dike relocation area.*

	Mean Soil quality (B50) Mean Sedimentation potential (SPM50), Mean Contamination (Q50)					Mean Soil quality (B50) Worst case Sedimentation potential (SPMmax), Worst case Contamination (Qmax)				
Standorte		As mg/kg	Hg mg/kg	PCB/6 µg/kg	PCDD/F ng I- TEQ/kg		As mg/kg	Hg mg/kg	PCB/6 µg/kg	PCDD/F ng I- TEQ/kg
Axien-M., Polder	U	20	0,17	12	4,1	U	23	0,6	26	6,6
Axien-M., DRV_n=100	U	29	0,8	76	13	U	48	3,4	153	28
Altjeßnitz, DRV n = 10	U	56	0,12	ng	3,4	U	60	0,1	n.g.	3,9
Calbe, Polder	U	19	0,17	5,3	4,1	U	20	0,5	6,4	15,2
Schartau-B., Polder	U	19	0,15	5,5	3,9	U	21	0,2	6,54	5,7

International Flood Risk Management Plan for the Elbe River Basin District (Part A)

Petr Kuřík

Floods are natural events that may have devastating consequences in densely-populated cultural areas. This is also reflected by the extreme flood events that affected the Elbe river basin in 2002, 2006, 2010, 2011 and 2013. Human activities resulting in increasing settlement areas in flood plains as well as a loss of natural retention areas can substantially increase the probability of flood events and their adverse consequences. That is why countries make every effort in order to reduce these risks. Appropriate measures need to be coordinated in the entire river basin in order to be effective. Therefore the "Directive on the Assessment and Management of Flood Risks" (Directive 2007/60/EC) was adopted on EU level on 23 October 2007 and is now being implemented by the EU member countries.

The countries located in the Elbe river basin agreed to prepare an "International Flood Risk Management Plan for the Elbe River Basin District" (hereinafter referred to as "International Plan"). This plan consists of the jointly prepared part A [1] with summary information for the international level and the national parts B prepared by the individual states.

For the implementation of the Directive on the Assessment and Management of Flood Risks the same designation of the international Elbe river basin district and the same responsible authorities were used as for the Water Framework Directive (Directive 2000/60/EC). Since 17 December 2015 part A of the International Plan has been available on the ICPER website (www.ikse-mkol.org).

1. Preliminary Flood Risk Assessment

In view of the results of the preliminary flood risk assessment in the international Elbe river basin district, flood hazard and flood risk maps as well as subsequent flood risk management plans were prepared for a total of 9,905 km of rivers (393 areas with significant flood risk), among them 7,858 km (282 areas) in Germany and 2,047 km (111 areas) in the Czech Republic. No areas with a significant flood risk were determined in the Polish and in the Austrian parts of the international Elbe river basin district, which amount to about 0.8% of the total area of the Elbe river basin district.

2. Flood Hazard and Flood Risk Maps

The flood hazard and flood risk maps show the extent of the hazard and the risk due to floods from surface waters and floods from the sea with low, medium and high probability. The central access to these maps for the international Elbe river basin district has been made possible by way of an interactive map application:

- http://geoportal.bafg.de/mapapps/resources/apps/IKSE_DE/index.html?lang=de (in German)
- http://geoportal.bafg.de/mapapps/resources/apps/MKOL_CZ/index.html?lang=en (in Czech)

This application shows the potential flood plains in the entire Elbe river basin district. It can be used for selecting specific areas and for being redirected to detailed national maps.

3. General Objectives of Flood Risk Management

In both countries, these objectives are based on the following principles:

- Avoiding new risks in flood risk areas
- Reducing existing risks and the areas with flood risks
- Reducing flood risks and adverse flood impact
- Increasing precautions and resilience of society against the adverse effects after floods

4. Measures

Part A of the International Plan contains the measures in Germany and in the Czech Republic for which common solutions are needed in some parts. Where required, Polish and Austrian aspects will also be taken into consideration, when the target is to describe the uniform or coordinated approach in the international Elbe river basin district. This plan constitutes the consistent continuation of the “Elbe Flood Protection Action Plan” 2003 – 2011 [2, 3] by incorporating its objectives and activities and integrating them in the overall strategy of the flood risk management.

Part A mainly comprises measures that can have an effect for the complete river basin district. On the one hand, these are measures on a regional level with supra-regional effect in the river basin district. On the other hand, there are measures, among them many non-structural measures, that due to their character need to be implemented for the complete river basin district in order to achieve the desired effect. This mainly includes flood forecasting, warning and information systems. Germany and the Czech Republic have developed an efficient communication and information system which has already proved its worth in cases of concrete cross-border emergency response, mainly during the floods in 2002, 2006, 2010, 2011 and 2013.

5. Examples for Supra-regional Measures

- Setting up floodplain areas
- Activities for refining the flood forecasting service system
- Increasing retention capacity in some existing dams (particularly measures at Orlík Dam)
- Optimizing and adapting the polders at Havel river and weir design of Havel and Spree

6. Conclusion

This International Plan does not only constitute the complete implementation of the European Directive on the Assessment and Management of Flood Risks, it also demonstrates the shared understanding and approach for tackling flood risks in the international Elbe river basin district. It has a particular added value because it helps to review the efficiency of the measures elaborated together in the past, particularly for managing the floods in recent years. In this regard the plan is a living document that has already turned out to be highly relevant. At the same time it lays the foundation stone for a sustainable, systematic cross-border continuation of the flood risk management for the coming decades.

Literature:

[1] IKSE (2015) Internationaler Hochwasserrisikomanagementplan für die Flussgebietseinheit Elbe. Teil A. Magdeburg: IKSE

[2] IKSE (2003) Aktionsplan Hochwasserschutz Elbe. Magdeburg: IKSE

[3] IKSE (2012) Abschlussbericht über die Erfüllung des „Aktionsplans Hochwasserschutz Elbe“ 2003 – 2011. Magdeburg: IKSE

Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) occurrence in biota in Czech rivers for the period 2010 – 2015

Drahomíra Leontovyčová, Tereza Hájková

1. Introduction

Since 2000 Czech Hydrometeorological Institute (CHMI) has conducted surveillance monitoring of surface waters; important part is a bioaccumulation monitoring of selected pollutants in biota. Monitoring comprises two profile sets containing 21 and 22 monitoring sites. Sampling at those two site sets alternates in the three-year cycles. Sites are located at important parts of main Czech rivers (country borders, before confluences, downstream industrial sites or large cities, etc.). Assessment was made for following matrices: juvenile fish, benthos (Hydropsyche sp., Erpobdella sp., Gammarus sp.), mussels (Dreissena polymorpha) and fish (Leuciscus cephalus). The analyses of fish were conducted for following tissues: muscle, blood and liver.
All values are on a wet weight.

This paper compares perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) concentrations detected in biota within CHMI bioaccumulation monitoring program from years 2010 – 2015. PFOS concentrations were evaluated according to the Water Framework Directive 2000/60/ES.

PFOS and PFOA belong to the group of per- and polyfluorinated compounds (PFCs). PFOS is listed in Annex B of the Stockholm Convention on Persistent Organic Pollutants. PFOS was used as the key ingredient in surface-active agents, it is applied in e.g. pesticides, paints, semiconductor industry, metal plating, in hydraulic fluids for commercial aviation etc.. PFOAs industrial application is as an aid in the manufacturing of fluoropolymers and in aqueous fluoropolymer dispersions - paints, textile finishing industry etc.. PFOS and PFOA have been used as components of fire-fighting foams.

These substances can be released to the environment during every lifecycle step. They are found ubiquitously in the environment, they can be transported over long distances via water and air. This results in findings in rivers, oceans, drinking water, atmosphere and also biota.

PFOS and PFOA are persistent, bioaccumulative and toxic organic pollutants. PFOS and PFOA do not accumulate in fat tissue, due to its binding to proteins in a blood and a liver. PFOS has been proven to bioconcentrate in fish, when concentrations in blood, kidney and liver exceed concentrations found in muscle tissues [2]. PFOA was not found to significantly bioaccumulate in aquatic organism due to uptake from aqueous phase diffusion via the gills. Compared to PFOS, PFOA is more water soluble; it could be the reason for the effective excretion of PFOA via gill permeation [1].

2. Results

In general the highest PFOS concentrations were found in fish, except fish muscle as expected. PFOS highest values were detected in fish blood (10 – 3030 $\mu g.l^{-1}$). Concentrations in fish liver (0,5 – 317 $\mu g.kg^{-1}$), juvenile fish (1,2 – 312 $\mu g.kg^{-1}$) and benthic organisms (0,05 do 61 $\mu g.kg^{-1}$) significantly exceeded levels of PFOS found in fish muscle (0,4 do 38 $\mu g.kg^{-1}$). The lowest PFOS concentrations were found in mussels (0,01 – 2 $\mu g.kg^{-1}$).

PFOA concentrations compare to PFOS reached significantly lower levels in all monitored matrices. Range of values was between 0,01 – 3,1 $\mu g.kg^{-1}$, where minimum represents the smallest concentration found in mussels and the maximum represents concentrations in juvenile fish. PFOA highest values were detected in juvenile fish (0,01 – 3,1 $\mu g.kg^{-1}$), followed by benthic organisms (0,02 – 2,5 $\mu g.kg^{-1}$) and fish blood (0,06 – 1,8 $\mu g.l^{-1}$). Small concentrations were found in mussels (0,01 – 1 $\mu g.kg^{-1}$), fish muscle (0,02 – 0,5 $\mu g.kg^{-1}$) and fish liver (0,02 – 0,07 $\mu g.kg^{-1}$).

All collected fish blood samples and more than 50% of collected samples of fish-liver and juvenile fish exceeded EQS for PFOS (9,1 $\mu g.kg^{-1}$), see Tab. 1.

***Tab. 1:** Median PFOS concentrations and percentage of concentrations exceeding EQS in monitored matrices*

Matrices	Number of measured values	Median ($\mu g.kg^{-1}$)	% EQS exceedance (9,1 $\mu g.kg^{-1}$)
fish blood*	91	90	100%
fish liver	15	19	60%
juvenile fish	127	9,5	51%
benthic organisms	105	3,6	20%
fish muscle	80	2,7	15%
mussels	52	0,22	0%

*fish blood concentrations are given in $\mu g.l^{-1}$

Literature:

[1] Annex XV Proposal for a Restriction: Perfluorooctanoic acid (PFOA), PFOA salts and PFOA – related substances, European Chemical Agency, 2014, p. 340.

[2] Perfluorooctane sulfonate (PFOS), Dossier prepared in support for a nomination of PFOS to UN-ECE LRTAP Protocol and the Stockholm Convention. 2004, Swedish Chemicals Inspectorate Swedish EPA: Keml. p. 46.

Urban Environment as a source of organic micropollutants – impacts on surface water monitoring

Jiří Medek

Urban environment (residential areas, urban areas, industrial agglomeration) is an important source not only of classical pollution of surface waters, but also a source of a wide range of organic micropollutants. It is caused not only by wastes from industrial enterprises, but also by common use of such substances in the daily life of the inhabitants. Micropollutants are contained in a wide range of directly used substances and products (e.g. personal care products, cosmetics, pharmaceuticals, drugs, ..), but also they sink into water from the residential and office buildings, civil engineering or transport. Urban environment is a place too, where can arise from ordinary human activities different situations that have a significant negative impact on the quality of the hydrosphere. Some substances from the urban environment can be found in List of priority and priority hazardous substances according to Directive 2013/39 / EU, others can be found in the "1st Watch List" of 2015.

The monitoring programs of surface and waste water must correspond with the possible presence of these substances in the hydrosphere and with the necessity of verification their relevant occurrence. This gives more new topics for work of the laboratories.

The poster shows some examples of the negative impact of urban environment on the quality of water and sediments in the Elbe River, for example repairing work contamination of old paint on the railway bridge in Ústí nad Labem as a significant source of PCB´s-contamination of suspended matter. Another example is the repeated emergency occurrence of haloethers, that comes from the chemical industry in Ústí nad Labem. There are also presented examples of the real occurrence of some pharmaceuticals and drugs in the Elbe River in the Czech-German border measuring profile "Hřensko-Schmilka".

Water quality in the Mastnik catchment area

Luboš Mrkva, Bohumír Janský

1. Introduction

On the territory of the Czech Republic, we can find main European watersheds as well as springs of some major European rivers that contribute to the eutrophication of the North, Baltic and Black Sea. Not only due to these facts, the whole territory of the Czech Republic is classified as a sensitive area [3] and that is why it is essential to pay attention to the economization on water resources. The Czech Republic should reduce all sources of pollution and prevent the worsening of the surface water quality. Despite large investments into municipal sewage remediation and a change of farming methods, the quality of surface water in smaller streams in the rural areas is still relatively low. Typical representative of a small stream is Mastník. The aim of this paper is to analyze the quality of source waters in Mastník river basin and to evaluate its impact on the Slapy Water Reservoir.

2. Basic characteristics of the river basin

Mastník river basin is part of the Lower Vltava catchment area. As its right-side inflow, Mastník runs into Vltava River, more precisely into Slapy Water Reservoir, on Vltava´s 103rd kilometer. Location of the river basin is depicted on the picture no.1. The river flows through Czech Midlands (Středočeská pahorkatina) and its length is 49,5 km. Long-term average flow-rate on closing profile amounts to 1,25 $m^3.s^{-1}$. Size of the river basin is 332 km^2 and 70 % of its area belongs to the agricultural soil fund. From this reason, only 23 % of the area are afforested whereas arable land constitutes 46% of the river basin surface. These numbers are a definite proof for the fact that this area is agriculturally based. In the river basin, industry is represented minimally and it is centralized into the largest residence area of Sedlčany. Sedlčany and its nearby surroundings are the biggest source of municipal wastewater that is cleansed in the local sewage disposal plant. Sedlčany has an equivalent population of 23 000. In the whole area of the river basin, there are 17 000 inhabitants which points to a very low density of population (51 inhabitants/ km^2).

3. Evaluation of surface waters quality

The quality of surface waters was analysed on the basis of Povodí Vltavy, State Enterprise's data. Povodí Vltavy has 2 stable and 7 complementary profiles available. To these profiles, we have attached our 6 profiles. Their location was chosen to illustrate better global water quality in the river basin. Our field search has been carried out in the years 2012 – 2013 and we took 15 monthly samples altogether. There are various approaches to water quality evaluation. In this study, we emphasize the evaluation based on the Czech standards: Water quality – Classification of surface water quality (ČSN 75 7221). We also used the evaluation of water quality in dependence on flow-rate.

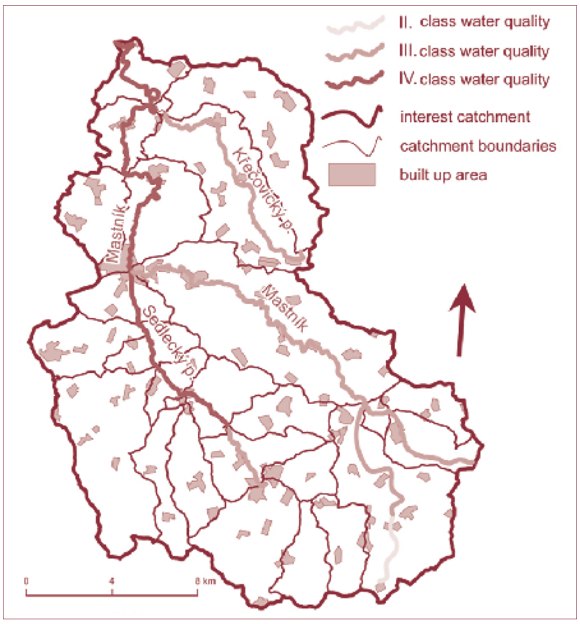

Fig. 1: *Final quality of surface waters in the Mastník river basin*

Surface waters in the Mastník river basin are of low quality and, on its closing profile, the river is ranked within the IV. class of water quality. Classification of individual river sections as to water quality classes is depicted in figure 1. As mostly problematic are evaluated the indicators of organic substances, nutrients and chlorophyll – α. In the case of nitrates concentrations, the dominance of surface sources of pollution has been proved, in contrast to phosphates where the dominant source of pollution has been represented mainly by point sources. The dependence on flow rate is insignificant in case of organic substances. Positive findings of the research are represented by the fact that the rivers contain significant amount of dissolved oxygen which increases the river´s self-cleaning ability. Moreover, a positive effect of certain steps leading to restrict municipal sources of pollution has been observed in the area. These findings are reflected in a drop or stagnation of the monitored parameters' concentrations. As problematic has been seen a remarkable eutrophication in the creek of Mastník by the river Vltava mouth. After Slapy´s water level has risen and the speed of the stream has slowed down, a huge increase of algae, mainly in the vegetative season, has been observed as well. In the creek of Mastník, the concentrations of chlorophyll has been rising although the overall supply of phosphor has dropped. The increased expansion of algae is probably connected with the increased temperatures of the surface waters. This tendency is evident in figure 2. There are two profiles located in the stream of Vltava and one profile in the creek of Mastník. The chart was processed on the basis of data from PVL. However, Mastník's long-term effect on concentration of monitored substances has been not proved.

***Fig. 2**: Average concentration of chlorophyll in Slapy water reservoir (2005–2012)*

4. Conclusion

The quality of water is influenced by many factors. It is obvious that global change of climate, mostly the increase of average temperature (more than 4,0 °C in the 21th century) [1], and changes in distribution and intensity of precipitation will lead to the intensification of weather and water extremes. These situations effect the real amount of water and it's quality [2]. This is why the quality of water in the smaller rivers in the rural areas is so topical.

Literature:

[1] Bates, B.C, Kundewicz, Z.W., Wu, S. (2008): Climate change and water. Geneva: Technical paper of the Intergovermental Panel on Climate change. IPCC Secretariat 2008

[2] Hrdinka, T. et al. (2012): Possible impacts of floods and droughts on water quality. J. of Hydro-enviroment Research 6, 145–150

[3] Punčochář, P., Desortová, B. (2003): Informace o stavu trofie našich vodních zdrojů pro veřejnost. SOVAK 5, 1–3.

Are the aquatic ecosystems under the drug influence?

Věra Očenášková, Petr Tušil, Danica Pospíchalová, Alena Svobodová, Petra Kolářová

The range of substances which are found in all types of water in the last two decades is constantly expanding. Nowadays, more and more sophisticated instrumental equipment and analytical methods enable to monitor these substances in nanogram and subnanogram quantities. One of these groups of substances are also illicit drugs. These substances were detected in surface waters throughout of the world and the Czech Republic is no exception.[1,2,3,4,5,6] It is safe to assume that the main sources of contamination of surface water by illegal drugs are, although cleaned, wastewaters.

Within the project *„Determination of the amount of illicit drugs and their metabolites in municipal wastewater – a new tool to complement data on drug consumption in the Czech Republic“* the illicit drugs were monitored primarily in wastewater. Illicit drugs in the wastewater were monitored not only in samples taken from WWTP influent but also from effluent and drugs were detected in all types of samples. In the wastewater treatment plants amphetamine was eliminated the best, meth was eliminated approximately by 40%, ecstasy by 20% and benzoylecgonine, the main metabolite of cocaine, by 60%. THC metabolite was eliminated by 70%, Tramadol, methadone and its metabolite EDDP go through the wastewater treatment plants practically without change.

We also analyzed samples of surface water taken from Czech rivers – the Elbe, Vltava, Oder, Olše, Morava, Thaya. In samples of surface water we found especially methamphetamine, THC-COOH (metabolite of THC), MDMA (ecstasy), cocaine and its metabolite benzoylecgonine, methadone and its metabolite EDDP and *cis*-tramadol. The composition of found drugs corresponds with the cleaned wastewaters. Figure no. 1 shows the contamination of Elbe water in the Schmilka profile.

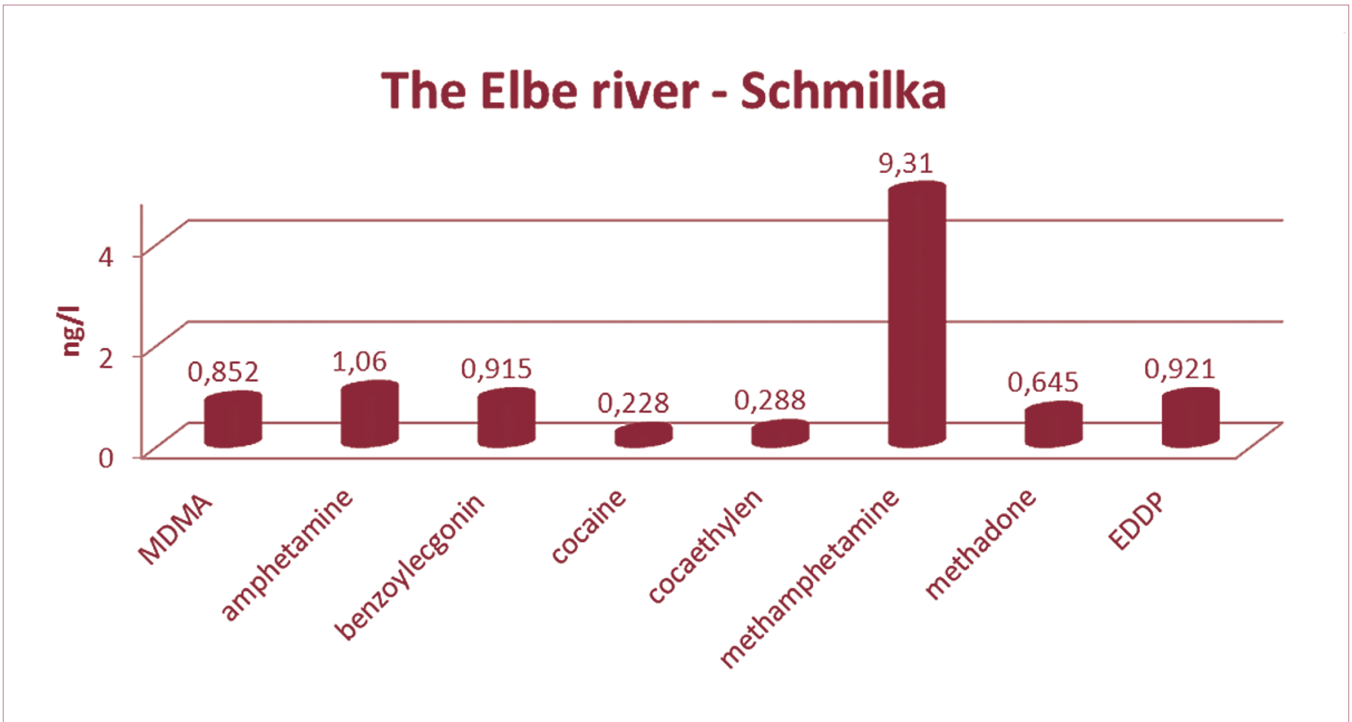

***Fig.1:** Concentration of illicit and licit drugs in the Elbe river, border profile Schmilka*

Concentrations of illicit drugs in the surface water samples were in the range from 1 to 40 ng/l for methamphetamine, 5 to 100 ng/l for cis-tramadol, 0.5 to 69 ng/l for THC-COOH, 0.1 to 5 ng/l for methadone, 0.2 to 2 ng/l for EDDP and 0.1 to 1 ng/l for MDMA.

Conclusions

Illicit drugs are not persistent, their half-lives are relatively short but they can be pseudo-persistent and wide array of aquatic organism can be sensitive to them. The next research focused on environmental fate of these compounds and their effects on aquatic ecosystems at the concentrations that typically occur in the environment is needed.

Acknowledgements

The results have been obtained in the Project No. VG 20122015101 performed under the Security Research Program of the Czech Republic in 2010–2015 (BII/VS) and funded through grants from the budget section of the Czech Ministry of Interior. This project could not have been conducted without close cooperation with the following key institutions and entities operating in the water mains and sewerage industry: Pražské vodovody a kanalizace, a. s.; CHEVAK Cheb, a. s.; Moravská vodárenská, A. s.; Severočeská vodárenská polečnost, a. s.; Vodárna a kanalizace Karlovy Vary, a. s.; and ČEVAK, a. s.

Literature

[1] BOLEDA, M Rosa, M Teresa GALCERAN and Francesc VENTURA (2009) Monitoring of opiates, cannabinoids and their metabolites in wastewater, surface water and finished water in Catalonia, Spain. *Water Research.* **43**(4), 1126–1136.

[2] GHEORGHE, Adriana, Alexander VAN NUIJS, Bert PECCEU, Lieven BERVOETS, Philippe G. JORENS, Ronny BLUST, Hugo NEELS a Adrian COVACI (2008) Analysis of cocaine and its principal metabolites in waste and surface water using solid-phase extraction and liquid chromatography–ion trap tandem mass spectrometry. *Analytical and Bioanalytical Chemistry.*, **391**(4), 1309–1319.

[3] MADDALONI, Massimo, Sara CASTIGLIONI, Ettore ZUCCATO, et al. (2014) Presence of Illicit Drugs in the Sarno River (Campania Region, Italy). *Pharmacology.*, **05**(07), 755–761.

[4] POSTIGO, Cristina, María José LÓPEZ DE ALDA a Damià BARCELÓ (2010) Drugs of abuse and their metabolites in the Ebro River basin: Occurrence in sewage and surface water, sewage treatment plants removal efficiency, and collective drug usage estimation. *Environment International.*, **36**(1), 75–84.

[5] ROBERTS, P a K THOMAS (2006) The occurrence of selected pharmaceuticals in wastewater effluent and surface waters of the lower Tyne catchment. *Science of The Total Environment.* **356**(1-3), 143–153.

[6] ZUCCATO, Ettore, Chiara CHIABRANDO, Sara CASTIGLIONI, Davide CALAMARI, Renzo BAGNATI, Silvia SCHIAREA a Roberto FANELLI (2005) Cocain in surface waters: a new evidence-based tool to monitor community drug abuse. *Environmental Health: A Global Access Science Source.*, **4**(1), 14–21.

Fishponds as heavily modified water bodies (HMWB): How to evaluate their ecological potential?

Jan Potužák, Jindřich Duras

The European Water Framework Directive requires member states to restore aquatic habitats in order to comply with a criterion of a good ecological status (quality). Good ecological status is defined as slightly different from high status, which, according to the Directive, means negligible human influence. This requirement poses enough problems even for a restoration of natural habitats and artificial water reservoirs cannot be assessed in this way at all. Therefore, they should be restored to a good ecological potential. Definition of the ecological potential must show a clear relationship to the definition of the ecological status but the fact must be considered that the reference state for ecological status (quality) is near absence of human impact [1]. Artificial water reservoirs and fishponds can never attain the self-regulation of natural systems. They were constructed with the aim to serve purely to human utilisation and therefore it is quite complicated to achieve the good ecological potential of these ecosystems.

There are two types of Water Bodies of surface water in category “Lake” in the Czech Republic. The first type is water reservoirs (dammed river valley) and the second one is fishponds (man-made shallow lakes). Both of them were classified as artificial (AWB) or heavily modified water bodies (HMWB). Our national methodology of ecological potential evaluation of HMWB and AWB was completed on the basis of the main physical-chemical parameters (water transparency, oxygen saturation, pH and TP concentration) near the dam and phytoplankton, macrophyte and fish community multi-metric indexes [2].

Fishponds are the most common type of stagnant water bodies in the Czech Republic. There are approximately 24,000 of fishponds with the area of 51,800 ha. Most of them are situated in the Vltava and Labe river watershed. However, only nineteen large fishponds were set as individual Water Bodies (fifteen in Vltava and Labe river watershed).

Fishponds, however, represent managed aquatic ecosystems where the water level, fish stock and, partially, also nutrient input are under the control of fish farmers. Most of the fishponds are several hundreds of years old and at the first glance they look like natural shallow lakes. Although particularly the large fishponds may resemble the ecosystem of the shallow lakes, a certified methodology for the assessment of the ecological potential of HMWB´s that was designed – and suits well – for water bodies like reservoirs cannot be used for fishponds. The reason is several specifics of fishponds:

- The input of phosphorus (key eutrophication factor) is not only from watershed but also from the fishery management (fish stock supplementary feeding and fertilizing) [3].
- The fish stock biomass is many times higher than in water reservoirs, it is periodically harvested and the main part of fish biomass is formed by common carp (*Cyprinus carpio L.*) [4].
- Aquatic submerged vegetation is usually completely eliminated by high fish biomass [5].
- Due to their small average depth fishponds naturally have higher production potential than most of water supply reservoirs.

Regardless the fishponds were primarily constructed for freshwater fish production, they also offer versatile spectrum of other benefits. Fishponds play a key role in nutrient (phosphorus and nitrogen) transformation through the river basins. They have high natural potential of nutrient, especially phosphorus (P) retention and could serve as important self-purification units which are able to eliminate the residual P coming to the watershed with the waste water (after its treatment), that originates mainly from the small settlements in the rural landscapes, but also from diffuse or non-point sources. On the other hand, fishponds could be also remarkable source of P that is not easy to handle. Efficiency of P retention in fishpond is probably independent of its water quality. More important seems to be an intensity of supplementary feed as well as fertilizer application and/or presence of old ecological burden, i.e. high phosphorus content occurring in unstable forms in fishpond bottom sediment. Phosphorus rich sediment serves as a bottomless nutrient pool and/or nutrient buffer and it should be considered as the crucial factor definitely limiting possible effort to improve water quality in fishponds. In conclusion, the fishponds historically overloaded by nutrients can represent an important factor causing considerable resilience of particular drainage area against remediation effort. On the other hand, the fishpond sediment, mostly rich in nutrients, could be effectively used for arable field fertilizing and thus the using of fishponds in the system of P recycling within small catchments is a good opportunity to control eutrophication.

It seems that the self-purification effect is important not only in the case of nutrients. The fishponds are obviously able to eliminate/metabolise the omnipresent contamination of water environment by xenobiotics like pharmaceuticals including antibiotics or musk substances [6].

It is necessary to formulate at least a general approach for ecological potential evaluation of fishponds. Objective lack of information concerning the nutrient sources for fishponds (e.g. wastewaters, agriculture, fish breeding) but also the functioning of the whole fishpond ecosystem at different trophic levels and under varying intensities of fishery management is the major obstacle in the fulfilment of this task. Moreover, it is still poorly understood how the fishponds influence the short water cycle and the climate of the surrounding landscape, or how they affect biodiversity of the other water ecosystems in the same catchment (e.g. impact on aquatic macroinvertebrate community structure, water bird species diversity or risks of invasive species).

The main aim of the poster presentation is to implicate a new method of ecological potential evaluation in fishpond, based on the estimation of their ecological services (water and nutrients retention in the landscape, biodiversity functions, self-purification processes etc.).

Literature

[1] Moss, B. (2008) The kingdom of the shore: achievement of good ecological potential in reservoirs. Freshwater Reviews (1) 29 – 42

[2] Borovec, J., Hejzlar, J., Znachor, P., Nedoma, J., Čtvrtlíková, M., Blabolil, P., Říha, M., Kubečka, J., Ricard, D., Matěna, J. (2014) Metodika pro hodnocení ekologického potenciálu silně ovlivněných a umělých vodních útvarů – kategorie jezero [Methodology of assessment of the ecological potential heavily modified water bodies and artificial water bodies – lake category]. Certifikovaná metodika Ministerstvem životního prostředí České republiky 1828/ENV/15. Biologické centrum AV ČR, v.v.i., Hydrobiologický ústav, České Budějovice (In Czech)

[3] Potužák, J., Duras, J. (2015) Nutrient retention in fishponds – importance, assessment and possible use. Vodní hospodářství 65(7): 7 – 15 (In Czech)

[4] Adámek, Z., Linhart, O., Kratochvíl, M., Flajšhans, M., Randák, T., Policar, T., Masojídek, J., Kozák, P. (2012) Aquaculture in the Czech Republic in 2012: modern European prosperous sector based on thousand-year history of pond culture. Aquacult Eur 37(2): 5 – 14

[5] Duras, J., Potužák, J., Marcel, M., Pechar, L. (2015) Fishponds and water quality. Vodní hospodářství 65(7): 16 – 24 (In Czech)

[6] Potužák, J., Duras, J. (2015) Ecosystem services of fishponds – retention of nutrients and micropollutants. Abstract Book, SEFS – Symposium for European Freshwater Sciences, July 5 – 10, 2015, Geneva, Switzerland, 526.

Diffuse nutrient losses from an agriculturally used drainage area – results of a case study

Holger Rupp, Denise Bednorz, Nadine Tauchnitz, Ralph Meissner

1. Introduction

The EC Water Framework Directive (WFD) calls for a good ecological and chemical status of the waters in the European Community by 2015. By contrast, the current state assessment showed for Germany water quality deficits. Diffuse pollution is considered as one of the main impacts on water quality. Tile drainage areas are in the focus of discussion, as they carry a high risk of diffuse nutrient pollution into surface waters even with good agricultural practice. At present, only few reliable data of diffuse pollution from drained areas are available. Therefore, investigations were carried out in northern part of the German federal state Saxony-Anhalt with the objective, to capture diffuse nutrient losses with high temporal resolution at standard agricultural management and thereby to contribute to the development of mitigation strategies.

2. Material and Methods

The study site is located in the northern part of the federal state Saxony-Anhalt (Germany) within the catchment area of the River Elbe. The studies were carried out at the farm co-operative Lueckstedt (Saxony-Anhalt, rural district Stendal), where a plot with tile drainage was customised for the investigations. The plot was equipped with a systematic sub-soil-drainage system with PVC-suction drains (inner diameter of 63 mm to 110 mm) installed at a depth of about 0.8 m in the 1970's due to low hydraulic conductivity of the soil types (waterlogging). The lateral drains are characterized by a drain spacing of about 10 m discharging the water to the collector. The drain division was provided with a central measuring shaft at the outlet, which enables us to measure discharge continuously (water level measurement in a Venturi - flume). Furthermore, an auto sampler allows continuously gathering of drainage water samples. These samples were subsequently chemically analysed (anions, cations, and dissolved carbon compounds) and nutrient loads from the drain division comprising an area of 26 ha have been be calculated.

The field site shows a homogenous distribution of boulder sand overlaid by boulder clay as a result of soil characterization. The agricultural site is managed conventionally (including slurry application).

Concentrations of the main ions NO_3^- and K^+ were analysed in filtered samples by ion exchange chromatography (IC). The DOC was analysed by injection of the filtered water in a C-analyser (Dimatec, Germany), in accordance with German Industrial Standards. The total content of Phosphorus (Pt) was photometrical measured in the unfiltered sample by applying the molybdenum blue method.

3. Results and Discussion

The present results indicate a relation between precipitation events and drainage discharge. Rainwater is discharged quite fast via drainage (Figure 1a). Thus, the residence time of water in the soil is comparatively short. Therefore, substance transformation and degradation processes can only contribute to a limited extent to nutrient retention or removal. This became particularly evident by means of measured nitrate concentrations often exceeding the critical value of 50 mg NO_3 L^{-1}. Also, the measured concentrations of DOC often exceeded the value of 10 mg L^{-1}, which is regarded as characteristic for natural waters (2 – 10 mg L^{-1}) (Figure 1b). The level of K^+ leaching was usually very low during the investigation period. A significant increase of up to 64.6 mg L^{-1} occurred in July and August 2015 as a result of heavy rainfall. The concentrations of P_t reached in March 2014 and in March 2015 the maximum values of up 0.078 mg L^{-1}. These concentration peaks are mainly attributed to the land management, including the spreading of organic fertilizers.

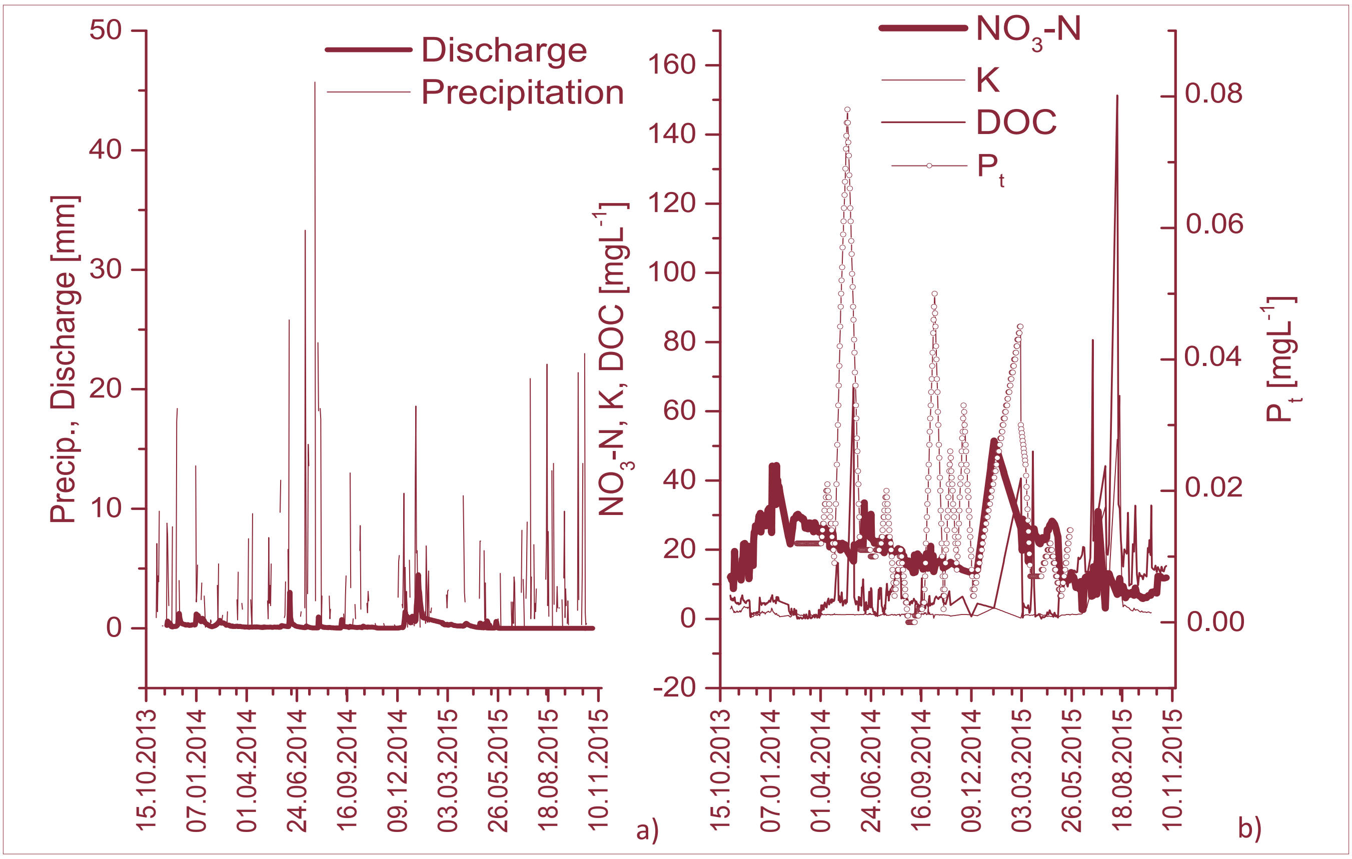

Fig. 1: *a) Discharge, Precipitation (Nov. 2013 – Oct. 2015) and b) Concentrations of NO3-N, K, Pt and DOC*

4. Conclusions

The paper presents results from a two year measuring period. Diffuse pollution is closely related to the agricultural management and climate conditions. The cooperation with an agricultural farm opens the chance to gain realistic information regarding nutrient leaching in field scale. Further investigation should focus on nutrient transformation processes to develop effective management strategies to reduce non-point pollution and finally to fulfil the objectives of the European water protection policy.

Acknowledgement – This publication is based on a research project funded from the German Environment Foundation (DBU), funding code--31086.

PCBs in the Elbe – Occurrences and trends, causes and consequences of increased release in 2015

René Schwartz, Michael Bergemann, Ilka Carls, Ute Ehrhorn, Henrich Röper

As persistent organic pollutants polychlorinated biphenyls (PCBs) are known to belong to the so-called „dirty dozen“. They have been detected for almost four decades in the river Elbe, to some extent in significant contents [1]. First analyses go back to the work of the ARGE Elbe were initial samples were retrieved from a profile at the former West-/East-German border in Schnackenburg (German-Elbe-km 474.5). While during the early 1980s the detection of PCBs' production residues was focused on (e.g. clophenes A60), beginning with the 1990s characteristic PCB-congeners (so-called Ballschmiter PCB) have been recorded and evaluated along the main stream of German and Czech Elbe as well as in the relevant tributaries [2].

Both, then and now, the largest contribution of high chlorinated PCBs in the Elbe catchment area originates from the Czech Republic. In this context, historic PCB point sources such as the Skoda plant in Mlada Boleslav (on the Jizera, dexter tributary of the Elbe) and the SPOLCHEMIE in Ústí nad Labem have been identified as particularly relevant [3, 4]. In contrast to the high chlorinated PCBs, most of the low chlorinated PCBs result from stoping regions, where PCBs have been used in hydraulic oils for the underground extraction of ore, and are – via remaining drainage galleries – still emitting into the rivers Mulde and Saale and subsequently into the Elbe. The Middle Elbe itself is now regarded to as a relevant buffer and secondary source for persistent contaminants such as PCBs. Here, temporary or permanently connected still water areas (e.g. oxbow, lakes, backwaters, groin fields) change their predominant function from acting as a sink at low to medium headwater discharge to presenting a source in the event of a flood [5].

Since spring of 2015 historically high PCB contents (up to 6.000 µg/kg sum 6 PCB-congeners) have been detected in the Elbe. In large areas (hundreds kilometres of river) and over long periods of time (nearly one year) critical exceedance of PCB – environmental quality standard of 120 µg/kg for sum 6 PCB-congeners occur relevant. By now, significantly elevated PCB levels are detected up to the area of the lower Middle Elbe at Schnackenburg (German-Elbe-km 474.5) (Tab. 1). The ICPER confirmed that the source of contamination can be traced back to the Czech Republic metropolitan area of Ústí nad Labem (Czech-Labe-km 39.0). According to the Czech Environmental Inspectorate, PCB release was largely caused by maintenance dredging works in the waterway. In contrast, the state water management of the Elbe (Povodí Labe), attributes the cause of the extremely elevated concentrations to a construction site, where the removal of PCB-containing paint of a railway bridge crossing the Elbe in the city of Ústí nad Labem has been conducted improperly.

Due to the distinct low water levels in the middle and upper Elbe in 2015, PCB-loaded suspended solids have deposited preferentially in the adjacent still water areas. With an increased headwater discharge of about 700 m³/s in December 2015 (reference gauge: Neu Darchau, German-Elbe-km 536.4 km) increased levels of PCB have entered the Elbe estuary for the first time. This is documented by results of the Hamburg monitoring station Bunthaus (German-Elbe-km 609.2). Particularly striking here is the disproportionate increase of PCB congeners 180, 153 and 138 [2]. It can fairly be assumed that upcoming floods will elevate PCB levels in Bunthaus again. To date, the environmental quality standard of 20 µg/kg for single PCB-congeners has not been exceeded in Hamburg. It turns out that due to increased mixing with unloaded marine/estuarine suspended particles/sediments in Seemannshöft (German-Elbe-km 628.9) no PCB increase has been observed yet. It is currently still unclear how the PCB event will effect the sediment quality in the Port of Hamburg in mid to long-term. Here, every year millions of cubic meters of sediments have to be dredged and subsequently disposed of on land or have to be relocated in the river system to secure shipping and navigation. In a worst-case szenario the quality of sediments would deteriorate in a way that parts of the fine sediments will no longer be able to be relocated within the river due to environmental constraints. A complete removal, treatment and disposal of these sediments on land is technically and logistically impossible. As a result, the access to the Port of Hamburg for seagoing vessels would be jeopardized [2].

To develop a valuable lesson from this incident will require implementation of recommendations as stated in the sediment management concepts of the FGG Elbe and ICPER. This particularly has to include measures to sustainably reduce contaminants in the upstream area and will serve the fulfilment of legal environmental requirements such as the EU Water Framework Directive (WFD) and the EU Marine Strategy Framework Directive (MSFD). Permanently securing a good quality of suspended solids and sediments can only be achieved on the basis of solidarity within the FGG Elbe and ICPER via management plans and the WFD program of measures. The integrated sediment management approach is scientifically sound. It is based on a comprehensive understanding of processes and systems. Therefore, relevant prerequisites are deep knowledge of morphodynamics and river bed dynamics of waters in the observed catchment area. Decisive parameters are recipient conditions, substrate distribution in the longitudinal and transverse profile as well as sediment transport and sediment balance.

Tab. 1: *Sum 6 PCB-congeners contents in 2015 in the Elbe catchment area (data: LfULG, LHW, NLWKN)*

µg/kg MMP*	NI Schnacken-burg	ST Wittenberg	SN Dommitzsch	SN Zehren	SN Schmilka	CZ Děčín
Jan.	34	51	65	112	87	178
Febr.	41	62	81	107	289	68
March	46	85	173	430	662	204
April	57	337	372	709	1.600	1.710
May	103	479	741	1.620	6.010	3.730
June	54	459	697	1.130	1.840	3.600
July	103	386	518	771	1.080	1.450
Aug.	58	322	464	497	1.090	1.440
Sept.	90	354	331	467	666	1.260
Oct.	65	453	381	525	541	1.410
Nov.	73	478	233	331	512	1.480
Dec.	118	439	344	535	1.140	1.990

Σ 6 PCB ≤ 120 µg/kg, at least one congener > 20 µg/kg

Σ 6 PCB ≤ 1.200 µg/kg

Σ 6 PCB > 1.200 µg/kg

Σ 6 PCB > 6.000 µg/kg

*MMP = monthly pooled sample

Literature:

[1] Schwartz, R., Bergemann, M., Keller I. (2015): Entwicklung der partikulären Schadstoffbelastung der Elbe. Hydrologie und Wasserbewirtschaftung, Heft 59/6, 396 – 413

[2] ELSA (2016): PCB in der Elbe – Vorkommen und Trends sowie Ursachen und Folgen der erhöhten Freisetzung im Jahr 2015. Behörde für Umwelt und Energie, Projekt Schadstoffsanierung Elbsedimente. Hamburg

[3] Heinisch, E., Kettrup, A., Bergheim, W., Martens, D., Wenzel, S. (2006): Persistent chlorinated hydrocarbons, source-oriented monitoring in aquatic media. 5. The Polychlorinated Biphenyls (PCBs). In: Fresenius Environ Bull 15, 1344 – 1362

[4] Heinisch, E., Kettrup, A., Bergheim, W., Wenzel, S. (2007): Persistent chlorinated hydrocarbons, sourceoriented monitoring in aquatic media. 6. Strikingly high contaminated sites. In: Fresenius Environ Bull 16, 1248 – 1273

[5] IKSE – Internationale Kommission zum Schutz der Elbe (Hrsg.) (2014): Sedimentmanagementkonzept der IKSE – Vorschläge für eine gute Sedimentmanagementpraxis im Elbegebiet zur Erreichung überregionaler Handlungsziele. 200 Seiten. Magdeburg

Threat to the aquatic organisms by not observing the technological procedures when application the pesticide substances

Jan Špaček, Pavel Hájek, Martin Ferenčík

Within its suface-waters monitoring programme The Povodí Labe, State Enterprise has been monitoring a wide spectre of organic compounds. Great attention has been paid to a group of pesticides. Apart from the regular monitoring of these compounds The Water Management Laboratories of Povodí Labe do often cooperate with water authorities when solving emergency situations like for example contamination of surface waters by pesticides. The pesticides have been widely used in agriculture and forestry these days.

By nature these substances pose a serious threat to the enviroment. Despite the correct technological procedure it does often come to some surface-water contamination. In some cases there may be no observable consequences. Problems appear when the technological procedures are not being observed on a large scale. Consequences for the enviroment may be fatal. We come across similar cases in the water-management practice quite often. Two such cases were recorded in the year 2014.

In one case the NURELLE insecticide, which contains the chlorpyrifos and cypermetrin substances, had escaped through sewers from an agricultural cooperative into the Doubravka river. The well preserved watercourse was declared fish conservation area. Species to protect were the brown trout (Salmo trutta) and the noble crayfish (Astacus astacus). The official investigation recorded 8500 dead crayfish. In the area of 7,5 km the fish stock and water invertebrates community have died out. It will take years to recolonize community in this stream and it will hardly restore to its original state.

The other case was the Kocbeřský brook. VAZTAK incecticide which contains alpha-cypermethrin was applied to spruce seedings, which were placed into the stream pools when planting a new forrest. Material Safety Data Sheet of this preparation does not permit planting of chemically treated seedings at distance shorter than 8 metres far from the surface water. On sloping terrains it is even more than8 m. As a consequence of this error hundreds of crayfish and water invertebrates community have died out in the area of 3 kilometres.

Even the laic public is able to notice a large-scale death of bigger organisms like fish or crayfish and it is usually possible to detect the escape of pesticides. Unfortunately in the case of smaller water invertebrates it is only a speialist to know.

„In_StröHmunG“ – A case study for corporate implementation of stream restoration and flood risk management

Bernd Spänhoff, Andreas Stowasser, Lars Stratmann, Corina Niemand, Wanja Bilinski, Uwe Müller

1. Introduction

„In_StröHmunG“ is an ongoing project dealing with practical solutions for a corporate planning and implementation of measures to improve the ecological status of streams considering the demands of flood protection [1]. The project is funded by the Federal Ministry of Education and Research from 2015–2018. Main topic of the project is to analyse the actual framework of water management especially for restoration measures to improve the ecological status of streams. Currently ca. 5 % of the streams within the German catchment of the River Elbe reached the environmental objective according to the water framework directive [2]. The majority of the measures to improve the ecological status within the period of the next river basin management plan focuses on mitigation of negative effects of anthropogenic flow regulation and morphological alterations.

2. Case Study Mortelbach

The Mortelbach within the town of Waldheim is completely morphologically degraded; the demands of protection against flooding are very high. Stream bed and bank were reinforced against erosion by mainly concrete walls, a locally typical situation of smaller upland streams in urban areas (Fig. 1). Planned measures mainly focus on the restoration of the stream bed to improve the continuity of the stream from the mouth to upstream stream sections in a rather near to natural state. The potential for the recolonization of restored stream sections by fishes and macroinvertebrates will be analysed.

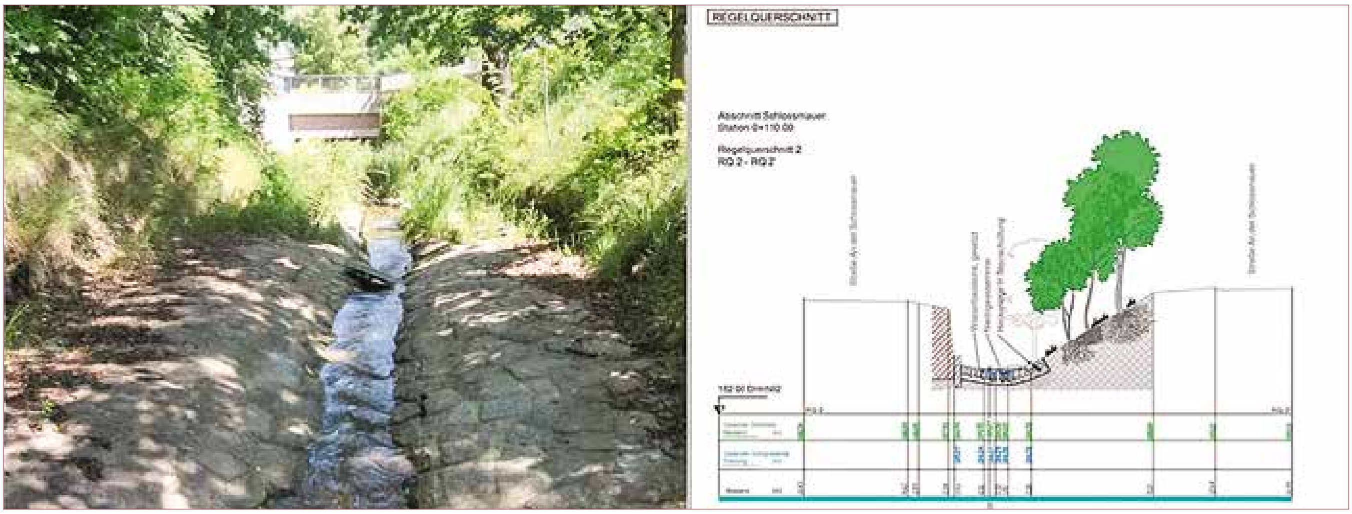

Fig. 1: Left: Outline situation in urban areas. Watercourse of the Mortelbach within Waldheim modified by concrete bed and bank stabilisation. These sections are subjected to a potentially significant flood risk (source: Landesamt für Umwelt, Landwirtschaft und Geologie), right: construction plan for hydromorphological mitigation measures of the Mortelbach considering the high demands of flood protection (source: Stowasserplan GmbH & Co. KG)

3. Case Study Mutzschener Wasser

The Mutzschener Wasser is a representative stream for catchments mainly used for agricultural purposes. Measures to improve the stream morphology focus on re-establishment of natural tree vegetation at the stream banks and to initiate natural processes of stream bank development. These measures will have to consider the demands of land users and the mainly private property of areas adjacent to the stream.

Fig. 2: Left: Outlined situation in arable areas. Anthropogenically modified watercourses for maximized agricultural land use purposes requiring regular stream maintenance measures such as slope mowing (Mutzschener Wasser, source: Landesamt für Umwelt, Landwirtschaft und Geologie), right: willow cuttings as an example of a bioengineering measure from the software SOFIE© (source: IngBioTools: www.ingbiotools.de)

4. Conclusion

The case studies of the Saxony water bodies Mortelbach and Mutzschener Wasser within the project "In_StröHmunG" will analyse the potential to implement stream restoration measures under different aspects of land use (urban and arable). Both streams are representative for smaller streams within the Saxony catchment of the Elbe River. To reach the environmental objectives of the WFD including the FD aspects will need a modern approach of water management focussing on a sustainable development of stream ecosystems. For further information about the project "In_StröHmunG" please visit: www.in-stroehmung.de.

Literature:

[1] FD (2007), Directive 2007/60/EC of the Parliament and the Council of 23 October 2007 on the assessment and management of flood risks. Off. J. Eur. Union 2007, L288/27–L288/34.

[2] WFD (2000), Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 22.12.2000.

Concentrations of selected chemical substances in components of aquatic environment within the Elbe river basin during extreme water level episodes

Pavel Stierand

The Czech Hydrometeorological Institute (CHMI) as the National reference center for monitoring operates the information system ARROW. This national water quality information system stores results of water quality monitoring programs for chemical and ecological status assessment in various compartments of aquatic environment (water, suspended solids, sedimented solids, sediment, biota).

Relevant hydrological and chemical data were collected at several gauging stations at Elbe river and in outlet sections of its significant tributaries in 16-years long period (2000 – 2015). Representatives of diverse chemical groups (e.g. radionuclides, heavy metals, organic substances) based on regular long-term monitoring conducted by CHMI were selected for an assessment.

Data from station Děčín near state border where Elbe river leaves Czech territory, station Němčice at Elbe river in the middle part of Elbe river basin and station Benešov at Ploučnice river whose basin is known as an area of uranium deposits were used in the assessment.

This study compares concentrations during periods with altered water levels; particularly drought and flood episodes. However, normal water levels were also evaluated for more detailed overview.

The extreme flow rate (low, high) are shown in table for evaluated gauging station:

Extreme flow rate ($m^3.s^{-1}$) in period 2000 – 2015			
Station / river	**Němčice / Elbe**	**Děčín / Elbe**	**Benešov / Ploučnice**
min	5	68	2
max	517	3 900	189

It was shown that amounts of some of transported chemicals differ significantly with changing water level. Computations were performed for each matrix separately.

Differences in concentrations of selected chemicals vary more than hundredfold.

The similar situation as described above was observed for dynamics of transported suspended solids. Ten-fold or ever higher concentrations of suspended solids [mg/l] were regularly observed during floods consequently increasing a load of chemicals bound to solid particles.

The impact of particular sources of pollution on eutrophication of Nechranice reservoir – Nechranice case study

Vlastimil Zahrádka, Jindřich Hönig

The aim of this presentation is to evaluate the impact of particular sources of pollution on eutrophication of Nechranice reservoir. It uses „Methodology of proposal optimization in the catchment of reservoirs leading to an effective reduction of eutrophication“. This methodology assumes, that phosphorus (dissolved or bound) is the main element responsible for eutrophication in freshwater systems. Both anthropogenic and natural sources of phosphorus are considered.

The evaluation considers retention of phosphorus in the water system. Relation between the location of source of pollution and the location of reservoir is an important factor. The location of pollution source is therefore taken into account using a parameter named potentional of eutrophication. Potential of eutrophication allows to compare different sources of phosphorus and their impact on eutrophication of the reservoir.

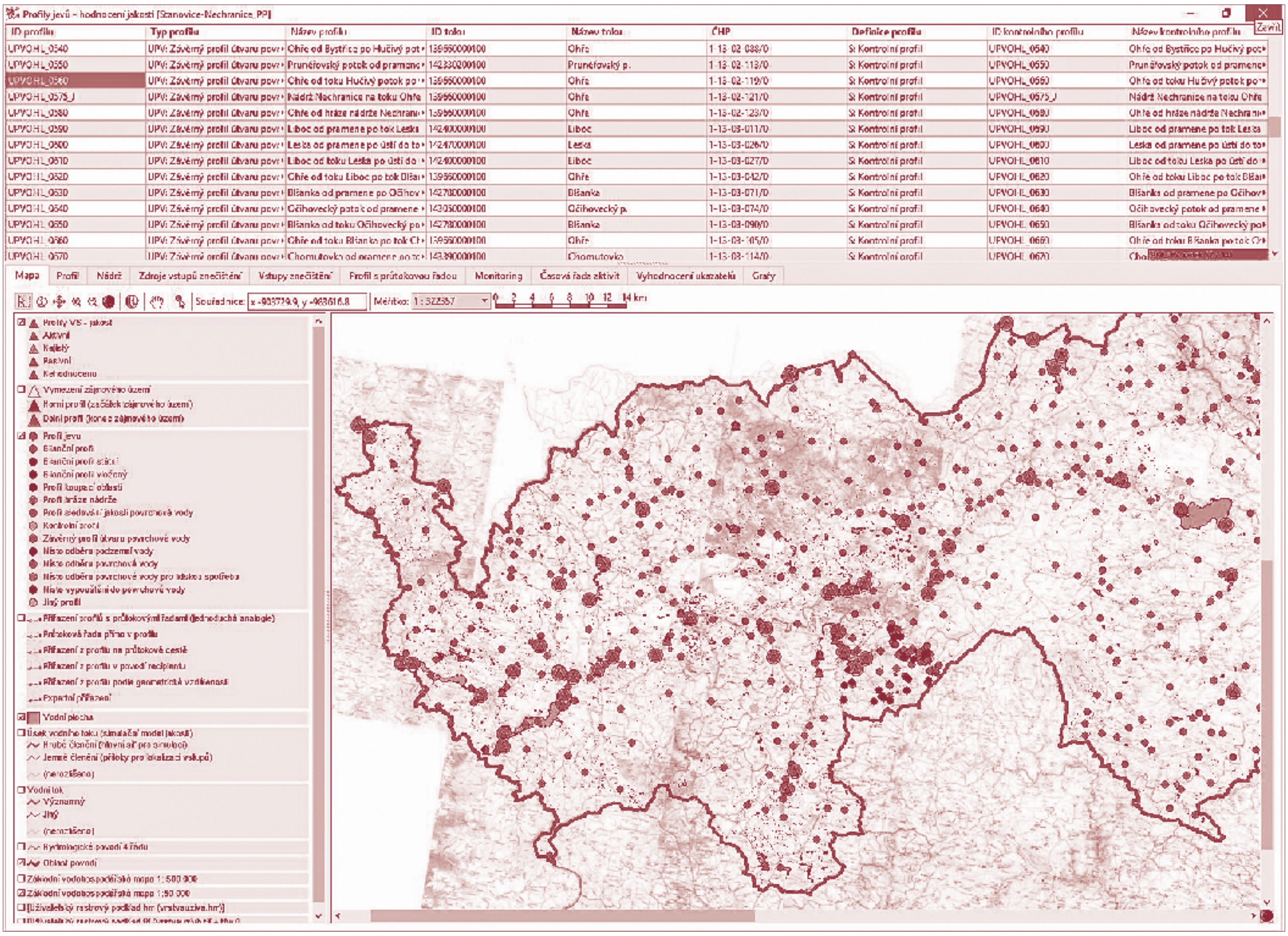

Fig. 1: *Simulation of natural concentrations and loads of total and dissolved phosphorus in water bodies for the catchment area of Nechranice water reservoir. For the simulation were used inputs of phosphorus derived from geological and soil types. Simulation made by software VSTOOLS.EUTRO (Picek, Rosendorf et al., WRI, 2015)*

The evaluation proceeds in four phases. In the first phase the reference values of concentration of phosphorus in the catchment areas were defined. In the second phase the evaluation of anthropogenic inputs of phosphorus was carried out. In the third phase the potentional of eutrophication of individual pollution sources was assessed. In the last phase the rank of importance of particular sources of phosphorus was defined, taking into account the potentional of eutrophication and the reservoir operation regime.

In the case study, the coefficients used in calculation of potentional of eutrophication that were proposed by the methodology were tested.

The study applied instructions for an evaluation of particular sources of phosphorus in the catchment area of a Nechranice reservoir. The methodology should be used as a support for decision making as a part of management of reservoirs vulnerable to eutrophication.

This paper was supported by the Technology Agency of the Czech Republic program Alfa TA02020808 „Methods for the optimisation of the design within the reservoir catchment leading to the decrease of the eutrophication“.

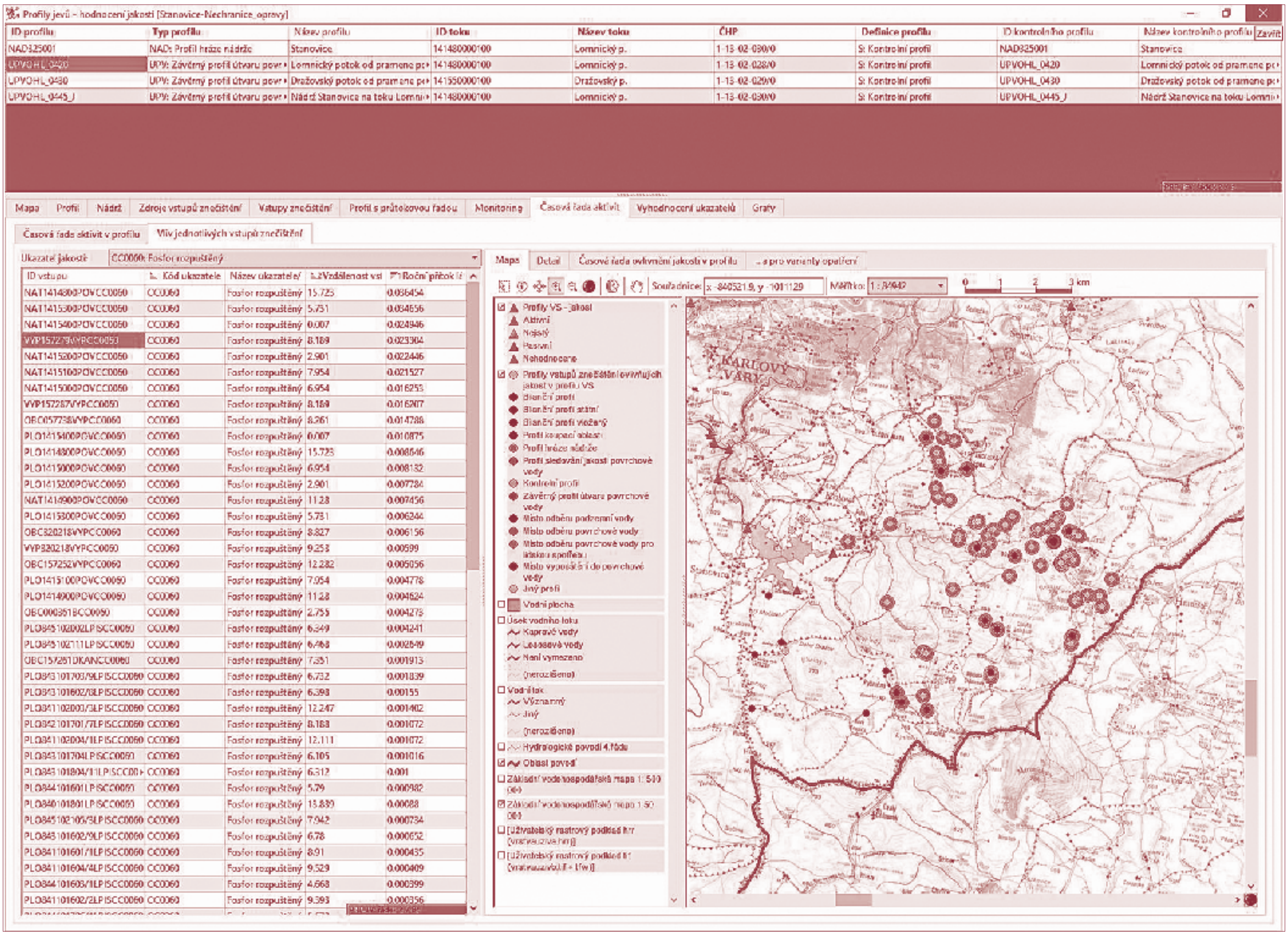

Fig. 2: An example of the evaluation of dissolved phosphorus sources contribution to the phosphorus load in the closure profile of the water body OHL_0420 Lomnický potok od pramene po vzdutí nádrže Stanovice. On the left side of the picture is a list of sources ordered descending by amount of dissolved phosphorus coming into the profile.

Autorenverzeichnis

Rejstřík autorů

Magdeburger Gewässerschutzseminar 2016

Magdeburský seminář o ochraně vod 2016

MGS

Magdeburger Gewässerschutzseminar

2016

Magdeburský seminář o ochraně vod

Arp Hans Peter H.
Norwegian Geotechnical Institute (NGI)
analytik@ufz.de

Baborowski Martina
Helmholtz Centre for Environmental Research – UFZ
Department River Ecology
martina.baborowski@ufz.de

Barankiewicz Miroslav
T. G. Masaryk Water Research Institute, p.r.i.
miroslav.barankiewicz@vuv.cz

Bärthel Hans
Federal Waterways and Shipping Agency, Magdeburg office
hans.baerthel@wsv.bund.de

Bednorz Denise
Martin Luther University Halle-Wittenberg
Department of Agronomy and Organic Farming
denise.bednorz@landw.uni-halle.de

Běhounek Lenka
International Commission for the Protection of the Elbe River, Secretariat
behounek@ikse-mkol.org

Benisch Jakob
TU Dresden
Institut für Industrie- und Siedlungswasserwirtschaft
jakob.benisch@tu-dresden.de

Bergemann Michael
Ministry of Environment and Energy, Hamburg
Michael.Bergemann@bue.hamburg.de

Berger Urs
Helmholtz Centre for Environmental Research – UFZ
Department of Analytical Chemistry
analytik@ufz.de

Bernsteinová Jana
DHI a.s.
j.bernsteinova@dhi.cz

Bilinski Wanja
Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG)
wanja.bilinski@smul.sachsen.de

Bölscher Jens
Freie Universität Berlin, Institute of Geographical Sciences
AG Environmental Hydrology
jens.boelscher@fu-berlin.de

Bölscher Judith
Freie Universität Berlin, Institute of Geographical Sciences
AG Environmental Hydrology
jens.boelscher@fu-berlin.de

Borůvka Tomáš
MGE Data, spol. s r. o.
tboruvka@mge.cz

Brabec Jan
J. E. Purkyně University in Ústí nad Labem
brabec@ireas.cz

Březina Karel Povodí Vltavy, state enterprise
karel.brezina@pvl.cz

Brückner Heike TU Dresden
Institut für Industrie- und Siedlungswasserwirtschaft
heike.brueckner@tu-dresden.de

Carls Ilka Ministry of Environment and Energy, Hamburg
ilka.carls@bue.hamburg.de

Černý Michal Geomin, s.r.o.
geomin@geomin.cz

Chalupová Dagmar Charles University in Prague, Faculty of Science
Department of Physical Geography and Geoecology
dada@natur.cuni.cz

de Voogt Pim University of Amsterdam
analytik@ufz.de

Dobiáš Jakub Povodí Vltavy, state enterprise
jakub.dobias@pvl.cz

Dumm Michaela Freie Universität Berlin, Institute of Geographical Sciences
AG Geoecology
jens.boelscher@fu-berlin.de

Dünnbier Uwe Berliner Wasserbetriebe AöR
uwe.duennbier@bwb.de

Duras, Jindřich Povodí Vltava, state enterprise
jindrich.duras@pvl.cz

Ehrhorn Ute Ministry of Environment and Energy, Hamburg
ute.ehrhorn@bue.hamburg.de

Einax Jürgen W. Friedrich-Schiller-University of Jena
Institute of Inorganic and Analytical Chemistry
juergen.einax@uni-jena.de

Engelmann Rolf Universität Leipzig
AG Spezielle Botanik und Funktionelle Biodiversität
engelmann@uni-leipzig.de

Fér Miroslav Czech University of Life Sciences Prague
mfer@af.czu.cz

Ferenčík Martin Povodí Labe, state enterprise
ferencikm@pla.cz

Fischer Thomas DREWAG NETZ GmbH Dresden
thomas_fischer@drewag-netz.de

Gallard Herve
University of Poitiers, France
analytik@ufz.de

Golovko Oksana
University of South Bohemia in České Budějovice
ogolovko@frov.jcu.cz

Grabic Roman
University of South Bohemia in České Budějovice
rgrabic@frov.jcu.cz

Greif Annia
Wismut GmbH
a.greif@wismut.de

Hájek Pavel
Povodí Labe, state enterprise
hajekp@pla.cz

Hájková Tereza
Czech Hydrometeorological Institute
tereza.hajkova@chmi.cz

Halířová Jarmila
Czech Hydrometeorological Institute
jarmila.halirova@chmi.cz

Hanslík Eduard
T. G. Masaryk Water Research Institute, p.r.i.
Department of Radioecology
eduard_hanslik@vuv.cz

Hartmann Timo
Helmholtz Centre for Environmental Research – UFZ
Department Conservation Biology
timo.hartmann@ufz.de

Heinrich Jürgen
Universität Leipzig, Institut für Geographie
jhein@rz.uni-leipzig.de

Helm Björn
TU Dresden
Institut für Industrie- und Siedlungswasserwirtschaft
bjoern.helm@tu-dresden.de

Herkelrath Anna
Universität Leipzig, Institut für Geographie
anna.herkelrath@uni-leipzig.de

Herzsprung Peter
Helmholtz Centre for Environmental Research – UFZ
Department Lake Research
peter.herzsprung@ufz.de

Hladík Milan
Water Management Development and Construction joint stock Company, VRV a.s.
hladik@vrv.cz

Hofmann Dirk
Wasserversorgung Riesa/Großenhain GmbH
d.hofmann@wasser-rg.de

Hohenblum Philipp
Environmental Agency Austria
philipp.hohenblum@umweltbundesamt.at

Hönig Jindřich Povodí Ohře, state enterprise
honig@poh.cz

Hübner Gerd Federal Institute of Hydrology (BfG)
huebner@bafg.de

Ibrahimovič Ibra www.ibraphoto.net
ibraphoto@gmail.com

Jakšík Ondřej Czech University of Life Sciences Prague
jaksik@af.czu.cz

Janský Bohumír Charles University in Prague, Faculty of Science,
jansky.b@seznam.cz

Jiřinec Petr DHI a.s.
p.jirinec@dhi.cz

Juranová Eva T. G. Masaryk Water Research Institute, p.r.i.
Department of Radioecology
eva_juranova@vuv.cz

Käseberg Thomas TU Dresden
Institut für Industrie- und Siedlungswasserwirtschaft
thomas.kaeseberg@tu-dresden.de

Kasperidus Hans Dieter Helmholtz Centre for Environmental Research – UFZ
Department Conservation Biology
hans.kasperidus@ufz.de

Kendík Tomáš Povodí Vltavy, state enterprise
tomas.kendik@pvl.cz

Klauer Bernd Helmholtz Centre for Environmental Research – UFZ
bernd.klauer@ufz.de

Klement Aleš Czech University of Life Sciences Prague
klement@af.czu.cz

Knepper Thomas P. Hochschule Fresenius
analytik@ufz.de

Knotek Pavel International Commission for the Protection of the Elbe River, Secretariat
knotek@ikse-mkol.org

Koba Olga University of South Bohemia in České Budějovice
okoba@frov.jcu.cz

Kočárek Martin Czech University of Life Sciences Prague
kocarek@af.czu.cz

Kubalová Kateřina
Povodí Vltavy, state enterprise
katerina.kubalova@pvl.cz

Kujanová Kateřina
Charles University in Prague, Faculty of Science
Department of Physical Geography and Geoecology
katerina.kujanova@natur.cuni.cz

Kule Lumír
Povodí Vltavy, state enterprise
lumir.kule@pvl.cz

Kuřík Petr
International Commission for the Protection of the Elbe River, Secretariat
kurik@ikse-mkol.org

Langhammer Jakub
Charles University in Prague, Faculty of Science
jakub.langhammer@natur.cuni.cz

Leontovyčová Drahomíra
Czech Hydrometeorological Institute
leontovycova@chmi.cz

Liedermann Marcel
University of Natural Resources and Life Sciences (BOKU)
marcel.liedermann@boku.ac.at

Liška Marek
Povodí Vltavy, state enterprise
marek.liska@pvl.cz

Macháč Jan
J. E. Purkyně University in Ústí nad Labem
jan.machac@ujep.cz

Marešová Diana
T. G. Masaryk Water Research Institute, p.r.i.
Department of Radioecology
diana_maresova@vuv.cz

Maroušková Kateřina
Charles University in Prague, Faculty of Science
Department of Physical Geography and Geoecology
katerina.marouskova@natur.cuni.cz

Matoušková Milada
Charles University in Prague, Faculty of Science
Department of Physical Geography and Geoecology
milada.matouskova@natur.cuni.cz

Medek Jiří
Povodí Labe, state enterprise
medekj@pla.cz

Meissner Ralph
Helmholtz Centre for Environmental Research – UFZ
Department Soil Physics
ralph.meissner@ufz.de

Motlík Martin
Povodí Ohře, state enterprise
motlik@poh.cz

Mrkva Luboš
Charles University in Prague, Faculty of Science
mrkval@natur.cuni.cz

Müller Uwe
Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG)
uwe.mueller@smul.sachsen.de

Musil Jiří
T. G. Masaryk Water Research Institute, p.r.i.
jiri.musil@vuv.cz

Neumann Michael
German Environment Agency (UBA)
analytik@ufz.de

Niemand Corina
Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG)
corina.niemand@smul.sachsen.de

Očenášková Věra
T. G. Masaryk Water Research Institute, p.r.i.
vera_ocenaskova@vuv.cz

Orzechowski Gerit
TU Dresden
Institut für Industrie- und Siedlungswasserwirtschaft
gerit.orzechowski@tu-dresden.de

Pergl Michal
Charles University in Prague, Faculty of Science
Department of Physical Geography and Geoecology
michal.pergl@natur.cuni.cz

Petr Jiří
Povodí Labe, state enterprise
petrj@pla.cz

Pospíchalová Danica
T. G. Masaryk Water Research Institute, p.r.i.
danica_pospichalova@vuv.cz

Potužák, Jan
Povodí Vltavy, state enterprise
jan.potuzak@pvl.cz

Quintana Jose Benito
University of Santiago de Compostela
analytik@ufz.de

Rederer Luděk
Povodí Labe, state enterprise
redererl@pla.cz

Reemtsma Thorsten
Helmholtz Centre for Environmental Research – UFZ
Department of Analytical Chemistry
analytik@ufz.de

Rehfeld-Klein Matthias
Senatsverwaltung für Stadtentwicklung und Umwelt
matthias.rehfeld-klein@senstadtum.berlin.de

Riedel Jens
Stadt Leipzig, Amt für Stadtgrün und Gewässer
jens.riedel@leipzig.de

Rieth Kristina
Sächsisches Staatsministerium für Umwelt und Landwirtschaft
kristina.rieth@smul.sachsen.de

Rohde Sylvia
Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG)
Sylvia.rohde@smul.sachsen.de

Rommel Jochen
Beratender Geologe
geo-rommel@web.de

Röper Henrich
Hamburg Port Authority
Henrich.Roeper@hpa.hamburg.de

Röske Kerstin
Sächsisches Staatsministerium für Umwelt und Landwirtschaft
kerstin.roeske@smul.sachsen.de

Runge Ingo
Landesbetrieb für Hochwasserschutz und Wasserwirtschaft Sachsen-Anhalt
ingo.runge@lhw.mlu.sachsen-anhalt.de

Rupp Holger
Helmholtz Centre for Environmental Research – UFZ
Department Soil Physics
holger.rupp@ufz.de

Schmidt Wido
Technologiezentrum Wasser (TZW), Außenstelle Dresden
wido.schmidt@tzw.de

Schnitzer Grit
Kommunale Wasserwerke Leipzig GmbH
grit.schnitzer@L.de

Scholz Mathias
Helmholtz Centre for Environmental Research – UFZ
Department Conservation Biology
Mathias.scholz@ufz.de

Schovánková Jana
Povodí Labe, state enterprise
schovankovaj@pla.cz

Schulte Achim
Freie Universität Berlin, Institute of Geographical Sciences
AG Environmental Hydrology
jens.boelscher@fu-berlin.de

Schwandt Daniel
Federal Institute of Hydrology (BfG)
schwandt@bafg.de

Schwartz René
Ministry of Environment and Energy, Hamburg
Rene.Schwartz@bue.hamburg.de

Sedlářová Barbora
T. G. Masaryk Water Research Institute, p.r.i.
Department of Radioecology
barbora_sedlarova@vuv.cz

Seele Carolin
Universität Leipzig, AG Spezielle Botanik und Funktionelle Biodiversität
carolin.seele@uni-leipzig.de

Sigel Katja
Helmholtz Centre for Environmental Research – UFZ
katja.sigel@ufz.de

Sklenář Petr	DHI a.s. p.sklenar@dhi.cz
Škuta Svatopluk	MGE Data, spol. s r. o. sskuta@mge.cz
Slavíková Lenka	J. E. Purkyně University in Ústí nad Labem lenka.slavikova@ujep.cz
Socher Martin	Sächsisches Staatsministerium für Umwelt und Landwirtschaft martin.socher@smul.sachsen.de
Soukupová Kateřina	Povodí Vltavy, state enterprise katerina.soukupova@pvl.cz
Špaček Jan	Povodí Labe, state enterprise spacekj@pla.cz
Spänhoff Bernd	Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG) bernd.spaenhoff@smul.sachsen.de
Stierand Pavel	Czech Hydrometeorological Institute pavel.stierand@chmi.cz
Stötter Tabea	International Commission for the Protection of the Rhine (ICPR) tabea.stoetter@iksr.de
Stowasser Andreas	Stowasserplan GmbH & Co. KG info@stowasserplan.de
Stratmann Lars	Stowasserplan GmbH & Co. KG info@stowasserplan.de
Suthfeldt René	Freie Universität Berlin, Institute of Geographical Sciences AG Environmental Hydrology jens.boelscher@fu-berlin.de
Svobodová Alena	T. G. Masaryk Water Research Institute, p.r.i. alena_svobodova@vuv.cz
Tachecí Pavel	DHI a.s p.tacheci@dhi.cz
Tajč Václav	Povodí Vltavy, state enterprise vaclav.tajc@pvl.cz
Tauchnitz Nadine	Saxony-Anhalt State Institute for Agriculture and Horticulture Nadine.Tauchnitz@llg.mlu.sachsen-anhalt.de
Terytze Konstantin	Freie Universität Berlin, Institute of Geographical Sciences AG Geoecology jens.boelscher@fu-berlin.de

Tichý Vojtěch
Charles University in Prague, Faculty of Science
Department of Physical Geography and Geoecology
vojtech.tichy@natur.cuni.cz

Tušil Petr
T. G. Masaryk Water Research Institute, p.r.i.
petr_tusil@vuv.cz

Vlnas Radek
T. G. Masaryk Water Research Institute, p.r.i.
Department of Hydrology
radek_vlnas@vuv.cz

Vogt Benjamin
Freie Universität Berlin, Institute of Geographical Sciences
AG Environmental Hydrology
jens.boelscher@fu-berlin.de

Vohralík Gregor
Povodí Labe, state enterprise
vohralikg@pla.cz

von Tümpling Wolf
Helmholtz Centre for Environmental Research – UFZ
Department River Ecology/Water Analysis
wolf.vontuempling@ufz.dewolf.vontuempling@ufz.de

Warech Wilfried
Zweckverband Fernwasserversorgung Sdier
warech@fw-sdier.de

Wilske Christin
Helmholtz Centre for Environmental Research – UFZ
Department River Ecology
christin.wilske@ufz.de

Wirth Christian
Universität Leipzig, AG Spezielle Botanik und Funktionelle Biodiversität
cwirth@uni-leipzig.de

Žáček Miroslav
Geomin, s.r.o.
geomin@geomin.cz

Zahrádka Vlastimil
Povodí Ohře, state enterprise
zahradka@poh.cz

Zbořil Aleš
T. G. Masaryk Water Research Institute, p.r.i.
ales.zboril@vuv.cz

Zelený Luboš
Povodí Vltavy, state enterprise
lubos.zeleny@pvl.cz

Notizen / Poznámky

Notizen / Poznámky

Notizen / Poznámky

Magdeburger Gewässerschutzseminar 2016 – Magdeburský seminář o ochraně vod 2016
MGS 2016
Programmkomitee – Programový výbor

Helmholtz-Zentrum für Umweltforschung (UFZ)	**Wolf von Tümpling** Vorsitzender / předseda	Středisko výzkumu životního prostředí H. Helmholtze (UFZ)
Technische Universität Dresden	**Peter Krebs**	Technická univerzita Drážďany
Helmholtz-Zentrum für Umweltforschung (UFZ)	**Dietrich Borchardt**	Středisko výzkumu životního prostředí H. Helmholtze (UFZ)
Ministerium für Umwelt der Tschechischen Republik (MŽP ČR)	**Josef Nistler**	Ministerstvo životního prostředí České republiky (MŽP ČR)
Ministerium für Landwirtschaft der Tschechischen Republik (MZe ČR)	**Pavel Punčochář**	Ministerstvo zemědělství České republiky (MZe ČR)
Ministerium für Umwelt, Landwirtschaft und Energie des Landes Sachsen-Anhalt (MULE)	**Brigitte Schwabe-Hagedorn**	Ministerstvo životního prostředí, zemědělství a energetiky spolkové země Sasko-Anhaltsko (MULE)
Center for Advanced Water Research (CAWR)	**Eike Dusi**	Center for Advanced Water Research (CAWR)
Center for Advanced Water Research (CAWR)	**Greta Jäckel**	Center for Advanced Water Research (CAWR)
Behörde für Umwelt und Energie der Freien und Hansestadt Hamburg (BUE)	**René Schwartz**	Úřad životního prostředí a energetiky Svobodného a hanzovního města Hamburk (BUE)
Flussgebietsgemeinschaft Elbe (FGG Elbe)	**Ulrike Hursie**	Společenství oblasti povodí Labe SRN (FGG Elbe)
Staatlicher Wasserwirtschaftsbetrieb Moldau	**Petr Kubala**	Povodí Vltavy, státní podnik
Staatlicher Wasserwirtschaftsbetrieb Eger	**Jindřich Břečka**	Povodí Ohře, státní podnik
Staatlicher Wasserwirtschaftsbetrieb Elbe	**Petr Ferbar**	Povodí Labe, státní podnik
Forschungsinstitut für Wasserwirtschaft T.G. Masaryk, öffentlich-rechtliche Forschungsinstitution	**Mark Rieder**	Výzkumný ústav vodohospodářský T.G.M., v.v.i.
Generaldirektion Wasserstraßen und Schifffahrt – Außenstelle Süd –	**Detlef Aster**	Generální ředitelství vodních cest a plavby - pobočka Jih
Bundesanstalt für Gewässerkunde (BfG)	**Jürgen Pelzer**	Spolkový ústav hydrologický (BfG)
Landesbetrieb für Hochwasserschutz und Wasserwirtschaft Sachsen-Anhalt (LHW)	**Erwin Becker**	Zemský podnik povodňové ochrany a vodního hospodářství Saska-Anhaltska (LHW)
Wasserchemische Gesellschaft (WG)	**Martina Baborowski**	Společnost pro chemii vody (WG)
Internationale Kommission zum Schutz der Elbe (IKSE)	**Slavomír Vosika**	Mezinárodní komise pro ochranu Labe (MKOL)

Herausgeber / Vydavatel:
Programmkomitee des Magdeburger Gewässerschutzseminars 2016 / Programový výbor Magdeburského semináře o ochraně vod 2016
Internationale Kommission zum Schutz der Elbe (IKSE) – Sekretariat / Mezinárodní komise pro ochranu Labe (MKOL) – sekretariát

Fotos Umschlag / Fotografie na obalu: M. Lühr (IKSE-MKOL), TUD/Eckold

Layout, Satz / Úprava, sazba: Harzdruckerei GmbH Wernigerode

Druck / Tisk: Harzdruckerei GmbH Wernigerode

Druckpapier / Tiskařský papír: 100 g/qm Omni Bulk

Umschlag / Obal: 300 g/qm BVS matt

Auflage / Náklad: 200 Stück / 200 ks

FSC
www.fsc.org
MIX
Papier aus verantwortungsvollen Quellen
FSC® C109625