VODOHOSPODÁŘSKÉ TECHNICKO-EKONOMICKÉ INFORMACE

(WATER MANAGEMENT TECHNICAL AND ECONOMIC INFORMATION)

VTEI/2024/3

60 years ago in VTEI

PROPERLY MANAGED IMPROVEMENT MOVEMENT BRINGS GOOD RESULTS

J. Bednář, the Ministry of Agriculture, Forestry and Water Management

On 12th March 1965, the activity of the improvers of the Danube – Váh organization took place in the new building in Piešťany. Director of the Danube – Váh organization, Ing. Lacko, critically evaluated the work of the improvers to date and their contribution in the field of technology.

Number of submitted proposals in	1961	1962	1963	1964
Number of proposals introduced	89	91	84	44
Savings arising from the introduction	354,000 CS crowns	263,000 CS crowns	307,300 CS crowns	428,669 CS crowns

In addition, proposals were submitted for which it is not possible to express the effect financially because their merit is to reduce the effort of workers, increase safety of the operation, and work hygiene. When analysing the results, it became clear that the main factor is the correct direction of the activities of the improvers and their focus on solving the tasks that the organization needs.

For the following period, the improvers of the Danube – Váh organization must focus on the rationalization of maintenance work:

A. a) of the actual Orava, Váh, and Morava watercourses,

B. b) of the Danube river,

C. c) of waterworks.

These main directions are then specified in detail and divided into the following disciplines:
d) construction,
e) machine-hydraulics,
f) electrical engineering.

From the TGM WRI archives

VTEI Editorial office

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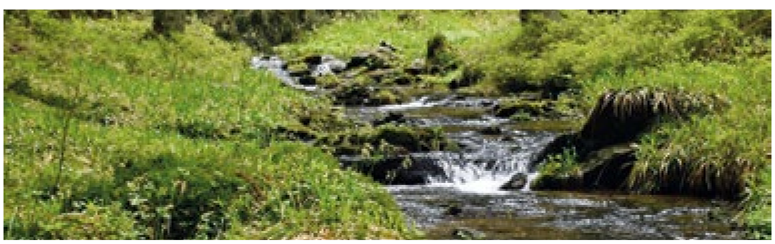
Content



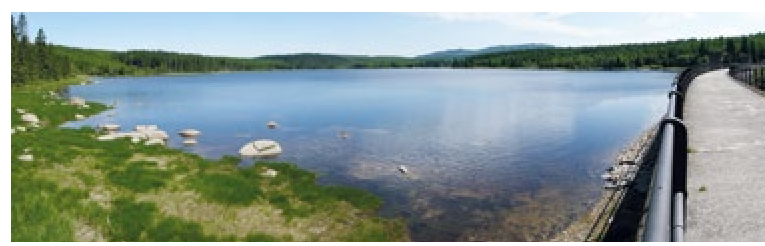



Photo: J. Unucka

Dear Readers,

You get the third issue of our journal *Vodohospodářské technicko-ekonomické informace* (VTEI) for 2024, where, as usual, you will find expert peer-reviewed papers as well as informative articles from the field of water management. The expert articles of our collaborators reflect current research and analysis in areas that are of key importance for the development and protection of water resources, and the informative articles mainly reflect the importance of national and international cooperation and education in the field of water resource protection.

The article by Josef Fuksa (TGM WRI) describes the history of pond farming and the various functions of ponds – specifically, the development of fish production as food, the effect of ponds on the quality of surface water, the effect on the climate and hydrological regime of the landscape, the issue of removing pond sediments and their further use, etc. You will learn more in the article titled "Ponds as part of the surface water network – overview, history, function".

In his article "Evaluation of the state of surface water bodies in the Czech Republic for 2019–2021", Petr Vyskoč (TGM WRI) presents a summary evaluation of the ecological and physico-chemical state of surface water bodies, as well as a comparison of relevant chemical and physico-chemical indicators from 2019–2021 with those of 2016–2018, processed on the basis of data from the monitoring of Povodí state enterprises and CHMI.

In the article "Verification of the usability of methods for modelling erosion and connectivity of sediments in the Slavíč basin in the Moravian-Silesian Beskydy based on geomorphological mapping of fluvial processes", Tereza Macurová, Jan Unucka, and a team of authors from CHMI present the results of their research focused on the influence of deforestation and land use changes on rainfall-runoff relationships and fluvial erosion. The article deals with the possibilities of analyses of fluvial processes and the disconnection of watercourses in the Slavíč basin in the Moravian-Silesian Beskydy.

The citation rate of a professional journal is one of the indicators of its quality. Libor Ansorge's analysis (TGM WRI) follows on from his already published articles on various aspects of VTEI journal citations. His new analysis compares the number of citations of articles published in the VTEI journal in the two most important citation databases. You can read about his results in the article "Comparison of citations of the VTEI journal in the Web of Science and Scopus databases".

At the end of June, we will commemorate the 30th anniversary of the founding of the International Commission for the Protection of the Danube River (ICPDR) and also the 20th anniversary of the declaration of Danube Day. To mark this occasion, we have included an interview with the Executive Secretary of the ICPDR, Professor Birgit Vogel, in the June issue. Our questions focused not only on her current role in the largest international commission for water protection in the world, but also on her beginnings in the water management field. The interview is followed by brief information about the ICPDR and the announcement of Danube Day, which is celebrated throughout the Danube region.

The last article is dedicated to the successful seminar "Researchers of Jizera Mountains in Podbaba", whose main organizer was our colleague Zuzana Hořická (TGM WRI). At the seminar, which was attended by around a hundred experts, there were 22 lectures presenting research projects in the territory of the Jizera Mountains. They concerned, for example, atmospheric precipitation, restoration of forest stands and soils, water and its recovery, from the period of peak acidification to current phenomena associated with climate change.

In closing, we would like to thank you for your continued trust and interest in VTEI journal, which is a vibrant forum for the exchange of ideas and knowledge thanks to you, our readers and contributors. We believe that this issue will also appeal to you and bring you new information, inspiration, and stimuli for your work.

With respect

VTEI Editorial office

Fishponds as an element of surface waters network – overview, history, function

JOSEF K. FUKSA

Keywords: fishpond – fish production – carp – sediment – climate

ABSTRACT

Historically, fishponds are a part of our landscape and Christmas carp is also a part of our culture. This paper describes the history of fishpond management and the different functions of fishponds – the development of fish production as food, the influence on quality of surface waters, the influence on climate and on hydrological regime of the landscape, and the issue of fishpond sediments – their removal and further use.

As there is no general pond register in the Czech Republic, so (as part of the DivLand project) we created the Map of water bodies and fishponds in Czech Republic, based on the ZABAGED (primary base of geographical data in the Czech Republic). For water bodies with an area over 1.0 ha, a public database (xls) was created; bodies over 5.0 ha were classified into groups (fishponds, reservoirs, flooded areas, lakes). The database also contains accessible data on the quality of fishpond sediments. Fishpond sediments are a favourable material for improving the quality of agricultural soils; problems with their use are mostly technical and economical.

INTRODUCTION

History of fish farming

The Czech Republic is widely known as a fish farming country, and ponds have been a standard part of the Czech and Moravian landscape since the Middle Ages. Monastery ponds have been documented since roughly the 11th century, and the system of their dams and outlets gradually developed. An important written confirmation for the then already established fish farming was the draft *Majestas Carolina* code, by which Charles IV wanted to support the development of cities and economic entrepreneurship; however, under pressure from the nobility, he had to declare it lost on 3rd October 1355. Charles's chronicler, Beneš Krabice [1], in addition to general attention to the royal support for pond farming, explicitly mentions the establishment of the Great Pond, today Mácha's Lake, in 1366 (and the "discovery" of a new fish, barbel, in Bohemia). After the end of the general economic decline during the Hussite Wars, economic recovery began, limited among other things by a significant decrease in the population and workforce (wars, plagues). A significant factor was the change in the attitude of the nobility, who no longer made money from warfare (big and "small") and started business. That started disputes with cities, etc. The establishment of ponds had one paradoxical advantage – the possession of flooded land was "definitive" and not as many people were needed to operate the ponds as for field farming [2]. In addition, the "Friday fasting" still applied, limiting the consumption of meat to "less nutritious types", i.e. fish, crayfish, etc., including imported saltfish and dried codfish. This is how fish farming began to develop successfully for fish production, but also for landscape regulation – its drying and irrigation. Today, South Bohemia is a classic pond area; however, in the 15th century it was different – the historical Pernštejn fishponds on the Elbe pond systems in Moravia, etc. were particularly important. In fertile landscapes, however, a substantial part of ponds was drained and turned into fertile fields in the 18th century.

Among the "fishmasters", knight Kunát mladší Dobřenský of Dobřenice (1465?–1539) clearly stands out; he worked as a royal fishmaster before 1500, and later worked for the Czech nobility, including the Rožmberk family (Dvořiště, Koclířov, Tisý). In 1513, he began systematically working for the Pernštejn family. For them, he managed, for example, the completion of the Opatovice channel and the construction of Čeperka, apparently the largest pond in Bohemia (> 1,000 ha, later converted into a field; the village of Čeperka is documented since 1777). His descendants collected debts for work even after Ferdinand I. He had a stork in his coat of arms, which today is a direct symbol of wetland fauna, and the Dobřenský family still own estates in the region. Josef Štěpánek Netolický (1460–1538), a simple serf, who learned the "craft" from Kunát Dobřenský (probably during surveying of Horusický pond) worked in the Třeboň region, and, for example, introduced targeted summer pond drying to increase fish production. Štěpánek was rewarded, among other things, by being freed from serfdom (1515). A generation later, in the middle of the 16th century, his work was followed up by the famous "Rožmberk regent" Jakub Krčín, from Jelčany and Sedlčany (1535–1604), who surveyed his first pond in 1565. Unlike the Dobřenský family, however, the Krčín family did not continue after the battle of Bílá hora (many daughters, evangelical religion, etc.).

The still-cultivated Třeboň tradition somewhat overshadows the Pernštejn fish farming on the Labe, especially the activity of Vilém II of Pernštejn (1438–1521) who, in 1491–1498, built the Opatovice Canal on the Labe to supply his pond system, which is still functioning today. According to Dubravius and the commentary on translation [3], Pernštejn claimed, among other things, that a pond is more stable than a field against the vagaries of the weather. Other writings dealing with the issue of fish farming have also appeared. In 1540, Jan Brtvín from Ploskovice published *This book contains two pages...* , a general guide to holding the right faith and running a proper farm, which also deals with fish farming. The work was then republished under the title *Hospodář (Farmer)* in 1587 by Daniel Adam from Veleslavín. Dubravius – Jan Skála from Doubravka and Hradiště (1486–1553) has an essential place among the "wise old men". He studied law and successfully managed the economy of Olomouc Bishop Stanislav Thurzo for a long time. In 1541, he received priestly ordination almost at the same time and was appointed bishop of Olomouc as Jan XVIII. In Wroclaw (the second largest city of the Kingdom of Bohemia) in 1547, Dubravius publisher the book *De Piscinis* – a systematic "technical manual" on pond management, which he wrote at the request of one of the Fugger family. The Fuggers (related to the Thurzo family) were an important business family, perhaps the richest in Europe at the time, which financially supported the Habsburgs, owned Slovak copper mines, etc. By 1599, Dubravius's book had already been published in English, and then it was repeatedly published in Latin. It wasn't until 1906 that a well-edited German translation was published in Vienna; it was a sensation for Czech pond owners. Parts of the work were published in Czech only after 1900, and a complete Czech translation only in 1953 [3]. A. Schmidtová's translation *O rybnících (On fishponds)* also contains her thorough historical commentary. Dubravius described pond farming in detail – from the selection of a place, construction and maintenance of the pond, via the selection and breeding of fish (carp) to the economic side, including sales. Historically, ponds have developed and disappeared according to the general economic situation, which is basically still true today. A typical example is the disappearance of a significant part of the ponds around the Elbe, giving way to profitable agricultural land, in contrast to the relatively less productive (but romantic) Třeboň region, and others. Also, the list of functions of the ponds (in addition to the original source of fish as meat once allowed during Lent – the Lent used to be 140–160 days per year, of which 51 days of strict fasting) is considerably broader and generally also includes the regulation of water regime and microclimate as well as other ecosystem functions [4]. Historically, ponds were important for fortification and also in the field of unifying ownership and land use – flooding the area was a general solution. Today, recreational, sports, and other functions have been added; the other functions were already known by Charles IV and his chronicler Beneš Krabice from Weitmile. In contrast, fortification and power engineering functions, often associated with fish production, disappeared. Until the "steam age", the power of water, fed by ponds, was practically the only major source of kinetic energy for mills, hammer mills, sawmills, etc. Local droughts often meant hunger because there was nowhere to grind grain.

Importance of ponds and fish production today

There can be found many lists of ponds in various historical periods and regions of the Czech Republic. However, if we are looking for a systematic recording of their occurrence, we will find that there is no list or register of ponds in the Czech Republic. The basic source of information are therefore "only" various yearbooks, which, on the other hand, provide validated data. There is a so-called *Modrá zpráva (Blue Report)* – Report on the state of water management in the Czech Republic in 2020, published jointly by the Ministry of Agriculture and the Ministry of the Environment [5]. From it we learn only the following general data, which are repeated in other documents and differ only slightly for previous years. According to this report, there are approximately 24,000 ponds in the Czech Republic covering a total (cadastral) area of 52,000 ha. The area of ponds and valley reservoirs used for fish farming is 41,000 ha; however, the area of reservoirs is insignificant in the balance of fish farming. The total yield from the ponds is 19,300 tons of fish, with 85 % being carp. (Approximately half of the rest is taken up by the breeding of salmonid fish in flow-through systems, i.e. not in ponds.) By simple calculation, the average production of all Czech, Moravian, and Silesian ponds is 471 kg/ha/year. The given production does not include coarse fish, but with standard two-year management, this means that during the fishing out the second year after stocking, the production or yield is 940 kg of three-year-old carp per hectare. In the chapter "How many carp should be stocked in each pond", Dubravius says: *"After choosing the carp, we must first decide on how many carp should be placed in each pond according to its size. For, if you burdened the ponds with a greater number of carp than they can support, you could also burden yourself with a loss, because fish withered and thin from hunger must also be sold at a thin and meagre price. If you stocked fewer carp in the pond than there should be, you could again suffer quite a lot of damage due to the loss of fish. However, it is possible to avoid both problems, namely by using the right amount, which is desirable for each pond."* Today's yields far exceed anything the old fishermen could even imagine before World War 1 – it is the result of intensive fertilization of ponds and artificial feeding of fish at today's technological level. However, this applies to food production in general. Today, the basis for calculating the yield of the pond, or the number of fish stocked, is the so-called natural production, which is, however, much higher than before artificial fertilizers. The situation report of the Ministry of Agriculture "Fish 2021" [6] states: *"More than half of the total production of the main farmed fish – common carp – is based on natural food (zooplankton, benthos), which has a high content of animal protein. The energy component of the feed ration is supplemented by unmodified cereals. That results is carp of high consumption quality."* (We dare to question this optimistic statement of the producers further.)

About 42 % of the fish produced are sold alive in the Czech Republic, about 47 % are exported, the rest is "processed fish products". The average citizen of the Czech Republic consumes 1.2 kg of freshwater fish per year; if we include sea fish, it is 6 kg per year. Recorded catches "on the rod" amount to about 3–4 thousand tons, again mainly carp. Therefore, if all the catches of fishing union members were eaten, theoretically a maximum of 0.4 kg of fish consumption per average citizen would be added. The given data on production, catches and consumption are supplemented by data from the Statistical Yearbook of the Czech Republic 2019 [7]. The basic document for the development of the Czech fishery, the Fisheries Operational Programme 2021–2027 [8], on fish consumption in the Czech Republic states: *"Fish consumption in the Czech Republic does not change much over time and is very low (2018: 5.5 kg per person per year, or only 1.29 kg per person per year of freshwater fish) compared to the EU average (25.1 kg per person per year)."* The Operational programme also confirms the above-mentioned data on ponds: *"In the Czech Republic, fish is bread for production by more than 93.5 % in ponds, the most represented fish is common carp (over 82 %). There are over 24,000 ponds and small water reservoirs with a total area of approximately 53,000 ha in the Czech Republic, which hold more than 420 million m^3 of water. Most of the ponds that are in run today were built in the 15th and 16th centuries and are still used for fish production."*

METHODS AND RESULTS

Database of ponds

The question still remains: What is hidden behind the "standard" annual data *"There are about 24,000 ponds in the Czech Republic with a total area of 52,000 ha"*? It is certainly a cadastral area, and in 2021–2023 we dealt with this issue as part of the project "*DivLand – Centre for Landscape and Biodiversity*" (TA CR, No. SS02030018). In the sub-task of WG C – "Agrosystems and soil", part of WPC3 includes the sub-project WA C 3.3 "*Application of sediments to soil*", focused on the use of pond sediments as a means of improving the quality of agricultural land. One of the outputs is the "Map of water bodies of the Czech Republic" [9], processed primarily as a map of ponds as possible sources of sediments to improve soil quality. Like all outputs of the *"DivLand"* project, it is processed in the one kilometre network (grid) used by the European Environment Agency (EEA). As the basis for the database of water bodies, we chose the Basic Geographical Data Base of the Czech Republic (ZABAGED), Chapter 4 Water management. According to ZABAGED data, there are over 8,500 water bodies larger than 1 ha in the Czech Republic. It shows that the majority of the 24,000 ponds mentioned in the yearbooks are small ponds. For such small ponds, a significant difference between the cadastral area and the actual area of the water surface can generally be expected. It can also be assumed that their economic importance is at most local and that they do not represent a serious technical issue for handling sediments. That is why we did not include them in our database.

All water bodies larger than 1.0 ha (8,728 items) are included in the database, but we did not further specify water bodies between 1 and 4.99 ha. For water bodies larger than 5 ha, we classified them into basic types according to various sources:

- RYB (pond): The structure has a dam and a discharge device, it is possible to fish it out, or it shows in the documents that it is kept a fishery.
- PN (reservoir): The structure has a dam but does not have the attributes of a pond (discharge, outfishing system, etc.).
- ZP (flooded area): The structure usually does not have a raised artificial dam, the surface is at the level of the terrain, a nearby watercourse, or groundwater in the floodplain. There are usually two basic types: flooded mining facilities (sand pits, gravel pits) and separate river branches.
- JEZERO (lake): It includes the Šumava lakes, regardless of possible anthropogenic interventions. They are the subject of nature conservation, i.e. outside the project area.

In many cases, the inclusion of a water body in a type is not absolute; however, this should not be an obstacle to using the map and database (second generation 2023), which is generally accessible at *www.dibavod.cz/divland-rybniky-sedimenty*. Under the recommended abbreviation FUKOMAT, it is already commonly used as a tool for various purposes. Anyone can download and save the database (xls) and, in case of "disagreement", send proposals for modifications to TGM WRI.

Database content and comparison with general data

A comparison of our results shows that the summary "yearbook" data on the number and area of ponds in the Czech Republic do not contradict the data from our database. Our bottom-up analysis thus confirms the yearbook top-down data; the classic potential concerns about the existence of a "second globe inside the Earth" [10], always necessary when compiling overall balance sheets, etc., were not confirmed. The unspecified share (difference) consists of small ponds (< 1 ha), which have an average area of 0.37 ha – they are therefore economically insignificant and also without fundamental issues with handling sediments. There is not a lot of available data on sediments, but it seems that the issue with their contamination applies mainly to small ponds, village ponds, etc. If their sediments were to be classified as waste, their volumes do not represent a fundamental issue for disposal, landfilling, etc.

The summary of results and data comparison can be seen in *Tab. 1*; we recommend opening the Map and Database for details.

Tab. 1. Comparison of summary budget of fishponds [5] with the Map and Database DivLand

Balance	Number	Total area [ha]	Average area [ha]	[% of areas]	[% of number]
Ponds according to MoA [5] and Yearbook	52,000	24,000	2.17	100.00	100.00
Map of DivLand ponds (according to ZABAGED)					
Ponds > 1 ha (record)	46,143	8,304	5.56	88.74	34.60
Ponds < 1 ha (calculated)	5,857	15,696	0.37	11.26	65.40
Of which ponds > 5 ha	32,400	1,839	17.62	62.31	7.66

DISCUSSION

In the following text, we would like to comment on three important aspects of the function of ponds – productive and non-productive fishponds and pond sediments.

Production function of ponds

However optimistic the above "official" assessment of the situation of pond farming practices and the "natural quality" of carp meat by fish producers is, data from hydrobiologists shows a less optimistic development. Around 1850, the production of Třeboň ponds was 30 kg/ha/year; the "classic" Šusta [11, 12] gives a range of 11–94 kg/ha. Among other things, Šusta introduced an innovation that increased production – the breeding one age fish/carp from stocking to fishing. Data from 1950–2010 were processed for a large set of production ponds of the Třeboň and Blatná fishpond systems by Pechar et al. [13]; their data is summarized in *Tab. 2*.

Tab. 2. Progress of fish production of Třeboň and Blatná fishpond areas according to Pechar et al. [13]

Period	Production [kg/ha]
1951–1960	190
1961–1970	290
1971–1980	420
1981–1990	520
1991–1993	480
1994–1997	490
2000–2001	530
2009–2012	510

The production jump in the period from 1971 is the result of additional feeding; until then, the development of natural food was supported by fertilization (organic fertilizers, mineral nitrogen, phosphorus) as a standard. Gradually, however, the production ponds switched to highly hypertrophic systems with a high supply of nutrients in the sediments, and standard trophic, or ecological relationships/pyramids "nutrients > phytoplankton > zooplankton (and benthos) > fish" [14, 15] play a secondary role in production ponds today [16], despite the declarations of producers [6] about the ratio of natural fish food. In addition, there appears now mundant production of trash fish and relatively high water temperatures, which threaten hypertrophic systems with fatal drops in the concentration of oxygen in water (nighttime declines and consumption during accumulation of fish in the fishing grounds). Currently, we see high production of fish, achieved by fertilizing ponds with nitrogen and phosphorus to increase primary production and production of natural food (zooplankton, zoobenthos) and the necessary artificial feeding, especially with cereals. With high stocks in the second production year (i.e. before fishing out), natural food is often insignificant and production is conditioned by feeding. Intensive disturbing up of sediment by the carp leads to zero abundance of zoobenthos and probably also to more intensive mineralization of the sediment and generally to a lower production of greenhouse gases (methane, nitrous oxide), as the sediments are mechanically aerated. This can be positive news. In the overall balance of greenhouse gases today, the production of methane (and nitrous oxide) in agriculture is equal to the role of carbon dioxide, but with the fact that the production of methane and nitrous oxide cannot be separated from food production. The greenhouse gases production (and release into the atmosphere) also increases in sediments and wetlands and is supported both by increasing production and eutrophication of aquatic and wetland ecosystems and by increasing average temperature [17, 18]. Nijman et al. [19] experimentally demonstrated how removing sediment (and phosphorus with it) reduces the total production of greenhouse gases under a unit surface area. There are many options and procedures for "sustainable farming" in ponds [20], but they generally conflict with yields and other economic factors. However, they undoubtedly support the quality of the meat of fish produced [6]. The actual effect of the feed on the composition of the pond sediments does not need to be considered in general as an increase. In addition, feed control excludes the supply of toxic or "problematic" substances, etc., that is, with the exception of the possible application of "medicines and dietary supplements" for fish stock, vegetation control, etc., in line with Section 39, paragraphs 7 and 12 of the Water Act (Act 254/ 2001 Coll., as amended in 2018).

Ways to efficient fish production obviously affect water quality in ponds as well as water quality in watercourses below them, both during the growing season and draining during outfishing. In addition, a significant proportion of sediments from ponds enters the downstream river basin during the harvest; both management and erosion in the basin contribute to their formation. However, the share of sediment input by erosion in the basin is probably significant even at high stocks. It is generally stated that about 50 % of agricultural land in the Czech Republic is threatened by erosion today and the average loss is calculated as 2.8 tons of soil/ha/year. The current limits in the so-called anti-erosion decree (*Decree on the Protection of Agricultural Land from Erosion, No. 240/2021 Coll.*) are set at a loss of 9 tons per year for deep and 2 tons per year for shallow soils. The routes by which erosion material reaches the ponds are complicated – on the one hand, it is a direct flush, which can be prevented by modifying the surrounding vegetation, and, on the other hand, it is the already mentioned gradual transport through the pond system from harvest to harvest. e.g. from draining to draining. General erosion details are the subject of other *"DivLand"* sub-projects in WG C – "*Agrosystems and Soil*". Thus, the ponds in the catchment function as a phosphorus retention system (including phosphorus in fish biomass); however, the system does not last forever – it functions on the assumption that it is occasionally dredged up with sediments and taken away from the reach of erosion. Therefore, the general issue is how to extract the sediments and how to store them – economically and for the general benefit. The most reasonable is traditional storage in agricultural land as their main original source. All literary sources recommend it, but in practice there are many obstacles – legislative, technical, and economic (more on that later).

Other pond functions

A pond/fishpond is a general term, but it is and must be always legally defined. In Czech legislation, Act No. 99/2004 Coll., on pond farming, etc., defines the term pond as follows: *"A water work which is a water reservoir intended primarily for fish breeding, in which the water level can be regulated, including the possibility of its discharge and fishing out; the pond is made up of a dam, a reservoir, and other technical devices."* What applies fundamentally and at all times is the technical possibility of level regulation, discharge, and fishing. What is meant by "primarily fish breeding" is in a loose relationship to other "non-production" functions of ponds, important since the Middle Ages and today complemented by recreational, sports and certainly also cultural and aesthetic functions (landscape protection, etc.). For a broader concept of more general functions, we can find a comment on the mentioned "production" definition on the website of the Ministry of the Environment: *"The term 'pond' is not defined by the Nature Conservation and Landscape Protection Act. For the purposes of Act No. 99/2004 Coll., on pond farming, exercise of fishing rights, fishing guard, protection of marine fishing resources and on the amendment of certain laws (Fisheries Act), a pond is understood as* 'a water work which is a water reservoir intended primarily for fish breeding, in which the water level can be regulated, including the possibility of discharge and fishing; a pond is made up of a dam, a reservoir, and other technical devices'. *This definition cannot be considered sufficient for the protection of ponds as important landscape elements. In addition to reservoirs meeting the definition according to the Act on Fisheries, the term 'pond' in the sense of an important landscape element must also include small water reservoirs that fulfil the ecological stabilization functions of a pond in the landscape (e.g. types of semi-natural stabilization and purification reservoirs, reservoirs with a predominance of recreational functions etc.)."* However, special status is defined for a number of ponds and pond systems within the framework of nature conservation and landscape protection, especially protection within the framework of the Ramsar Convention, to which the Czech Republic acceded in 1990 (Communication No. 396/1990 Coll.). Of the 14 Ramsar sites or Wetlands of international importance in the Czech Republic, five are focused on pond systems and river landscapes (RS 2 Třeboňské rybníky, RS 3 Novozámecký and Břehyňský rybník, RS 4 Lednické rybníky, RS 5 Litovelské Pomoraví, RS 6 Poodří). A fundamental European document in the field of water protection is the EU Water Framework Directive (2000/60/EC), which requires the definition of standing water bodies from an area of 50 ha. The corresponding "implementation" Decree No. 49/2011 Coll., on water bodies defines a total of 74 water bodies of standing water (reservoirs) in the Czech Republic, of which only 15 are ponds (including Mácha's lake). Other large ponds (there are almost 100 ponds with an area of more than 50.0 ha in the Czech Republic) in the system of water bodies function as parts of sub-basins and, of course, as "heavily modified" water bodies. The objectives of the Framework Directive – to bring ponds to a "good ecological potential" – therefore respect their purpose, i.e. fish farming, or other functions arising from their status (nature conservation, etc.). The relevant River Basin Management Plans necessarily include monitoring of sediments; however, in contrast with routine monitoring of e.g. water quality, they have a six-year evaluation cycle, and thus a specific approach to evaluating the success of bringing them to the level of Good ecological potential. Regarding the sustainability and other functions of ponds in the landscape, the Situation Report "Fish 2021" [6] says: *"In addition to fish production, ponds are also used to fulfil indispensable non-production (ecosystem) functions in the landscape, such as water accumulation and retention, flood protection, and biological purification of water. Ponds are important refugia for nesting birds and create suitable protective territories for animals, fulfil a recreational function, eco stabilization functions and contribute to the preservation of species biodiversity."* According to the letter of the Situation Report, these functions are therefore generally fulfilled. However, the Fisheries Operational Programme 2021–2027 [8], approved by the government of the Czech Republic and adopted by the European Commission, is an instrument for drawing funds according to Regulation (EU) 2021/1139 of the European Parliament and of the Council of 7th July 2021. Its goals are summarized in chapter 1.2.1. Vision of Czech aquaculture in 2030:

"Visions of the future development and state of Czech fisheries must reflect the current state and focus of production fisheries in the Czech Republic. Furthermore, it is necessary to take into account other non-production functions that ponds and fishermen fulfil on the one hand and on the other environmental and climate goals, including the SRP goal. The following visions were defined in the VNSPA (= Multi-year National Strategic Plan for Aquaculture):

- *Strengthening the importance of traditional and modern forms of aquaculture.*
- *Maintaining production from traditional aquaculture at least at the current level through modernization and innovation of existing technologies and breeding facilities, including preservation of the environmental benefits of fish farming.*
- *Increasing the production of other species of fish, especially fish of prey, through the construction of new, modern, environmentally friendly fish farms.*
- *Increasing the share and assortment of processed freshwater fish, modernization, innovation and concentration of processing capacities.*
- *Strong market position of fishing enterprises.*
- *An aquaculture sector resilient to climate change, public health and environmental crises."*

Pond farming is a Czech specialty in Europe, or, in the sense of the previous text/quotation, rather a "traditional form of aquaculture". In the Czech Republic, there are a number of subsidy programmes supporting the "non-production functions" of ponds, which are, however, managed and subsidized by several centres (Ministry of Agriculture, Ministry of Environment, Ministry of Industry and Trade), so it is not easy to summarize them. Within one of these programmes, for example, up to 10,000 CZK/ha/year can be obtained for summarized "individual non-production functions" for ponds with an area of 2–5 ha, which approximately corresponds to the final retail price (including VAT) of a 100 kg of Christmas carp in 2023 (= a quarter of the average production/ha/year). Beyond the area of landscape and climate protection, there are also live issues between production management and the protection of species (e.g. cormorants), which are also dealt with by the subsidy system.

Pond sediments — both waste and raw material

The total volume of water ponds is estimated at up to 600 million m^3, which corresponds to the average depth of a Czech pond of about 1.2 meters. The real volume or depth is estimated in the cited sources to be about a third lower – the cause is a high degree of silting. Based on the summary data, the average height of the mud layer is 40 cm, which corresponds to the data from the Operational Programme [8] and the real water volume of 420 million m^3. The mud at the bottom of the pond has a variable structure; the upper layer is "light", the lower layers are compacted, so the balance includes the question of estimating the total dry matter. The areal distribution of sediments in ponds is also significantly heterogeneous – lighter organic sediments migrate to deeper parts of ponds, etc. During draining ponds, the horizontal migration of sediments is particularly pronounced, and after discharge, the remaining sediments are partially drained and compacted opposite to the state in a full pond. As a standard for "general balancing", the value of 40 % of dry matter for a mixed sample of the upper 15 cm of muddy sediment from the middle part of the production pond can be taken, with an organic carbon content of about 10 % of dry matter. Sediments are created in two ways: as residues of primary and secondary production in the pond itself (fish excrement, feed residues, etc.) and as a supply of material from the catchment area – mainly soil washes – directly into the pond from its surroundings or with a tributary. Both inflows have a significant seasonal character, in the basins of some ponds there occur discharges of treated municipal wastewater, including sewer overflows. Sediment transport through the catchment downstream is determined by the natural hydrological regime (rainfall and flows), but also significantly by the operation/regime of the pond area. Even during the production season, the sediments in the pond travel to the deepest part; when discharging the pond, they are concentrated here, and they leave the discharge device further downstream, mostly to the next pond of the pond system. This is associated on the one hand with a general threat to the quality of water in watercourses, and on the other hand with a threat to the fish stock concentrated close to the dam before the fishing out due to a lack of oxygen. In the current period of increased frequency of warm autumns, this risk is increasing. Silting of ponds is an undesirable phenomenon known to the "old men" as well, and the mud exported from the ponds during desilting was then provided to the estate employees as a reward to improve the soil. Summer drying, already known under Štěpánek Netolický, led to the mineralization of the mud and the subsequent increase in pond production. From the point of view of pond management, sediments ("mud") are generally waste that must be removed from ponds to maintain their function and productivity, but not "waste in today's sense".

A number of expert studies are available on the actual desilting of ponds, handling of sediments and the importance of application to soil [20–24]; our study deals only with the pond register and the analysis of the legislative environment.

From the point of view of the circular economy, extracted pond sediments are a suitable material for improving the quality of agricultural soils. On a general level, the advantage of their application is therefore quite clear. It is important that the pond sediments are not yet contaminated by point sources in the lower reaches of the rivers. The current Waste Act (Act No. 541/2020 Coll.) respects the classic definition of waste and states in Section 4 "Waste" that:

1. *Waste is any movable property that a person gets rid of, has the intention to get rid of or obligation to get rid of.*
2. *It is considered that a person has the intention to dispose of a movable property if it is not possible to use it for its original purpose.*

However, sediments extracted from ponds are exempted and discussed in the law in Part 2 "Biologically degradable waste" in Section 70 "Sediments": "*If the sediments extracted from the beds of watercourses and water reservoirs are intended for use on land constituting an agricultural land fund in accordance with the requirements established by the Act on Fertilizers and the Act on the Protection of Agricultural Land Funds, the plots constituting an agricultural land fund on which they will be used do not have to be equipment intended for waste management; their originator and the person who uses them on the plots of land forming the agricultural soil fund do not keep ongoing records for these sediments in accordance with Section 94 and do not submit reports in accordance with Section 95. For these sediments, records are kept in accordance with the Act on Fertilizers (No. 229/2021 Coll.) and according to the Act on the Protection of Agricultural Land Funds (No. 231/1991 Coll.).*" In essence, this means that the role of pond sediments is shifting from "waste" to "raw material or fertilizer" in the sense of the new waste law, in line with the development of the European circular economy. The use of sediments intended for storage on agricultural land is based on Section 3a of Act No. 334/1992 Coll., on the protection of agricultural soil funds (as amended) and Decree No. 257/2009 Coll., which determines the limit values of pollutants both in the sediment itself and in the soil to which the sediment is to be applied. This corresponds to the standard of the European circular economy, even though Czech pond farming is unique within the European concept of aquaculture. In addition to ponds, the Operational Programme [8] also assumes the development of more intensive aquaculture, which is not the subject of this text.

From a general point of view, the usability of pond sediments for improving agricultural land is complicated mainly due to technical and economic issues. The sediments must be extracted from the ponds, drained (= solidified, which requires an intermediate landfill) and transported to suitable locations at the appropriate time and applied to the soil. The time suitable for application to the soil is generally very limited, which is associated with "social" problems, i.e. the will and willingness of agricultural landowners to use pond sediments.

CONCLUSIONS

— Ponds are an important part of the Czech landscape and culture, as well as part of food production. It is also an important grant title.
— From the point of view of food production, fish farming is not essential for nutrition in the Czech Republic, but it has a significant share in the total consumption of fish meat. However, the cultural and landscape-forming importance of ponds is essential.
— There is no official pond database available in the Czech Republic.
— We analysed the records of ponds in the Czech Republic based on ZABAGED and prepared a publicly accessible map of water bodies in the Czech Republic with an attached database of ponds over 5 ha. Both the map and the database can be accessed at *www.dibavod.cz/divland-rybniky-sedimenty*. Anyone can download the database and we will be grateful for comments.
— The production of carp meat in ponds is high today due to supplemental feeding, which is associated with the loss of diversity of the original pond fauna and flora. However, part of the ponds is under control of nature conservation.
— Pond sediments generally represent an important source of material for improving the quality of agricultural land. The issues with their application are more technical and economic than purely legislative; however, it is necessary to respect the current regulations for the protection of soils from pollutants.

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References

[1] KRABICE Z WEITMILE, B. Cronica ecclesiae Pragensis – Kronika pražského kostela. 1374. In: BLÁHOVÁ, M. et al. (ed.). *Kroniky doby Karla IV*. Praha: Svoboda, 1987, pp. 173–268.

[2] ČORNEJ, P. *Český stát v době jagellonské*. Praha, Litomyšl: Paseka, 2012. 236 pp.

[3] DUBRAVIUS, J. *De piscinis*. 1547. Překlad a historický komentář A. Schmidtová „O rybnících". Prague: Nakladatelství Československé akademie věd, 1953. 77 pp.

[4] FUKSA, J. K. Ekosystémové služby – nový pohled na ochranu a užívání vod. *Vodní hospodářství*. 2008, 58(11), pp. 398–403.

[5] FOUSOVÁ, E., KOUBOVÁ, J., JIROUDOVÁ, L. (eds.). *Zpráva o stavu vodního hospodářství České republiky v roce 2020*. Prague: Ministry of Agriculture, Ministry of the Environment, 2021. 151 pp.

[6] MOŘICKÝ, J., MAREŠ, L., ŽENÍŠKOVÁ, H., CHALUPA, P. (eds.). *RYBY. Situační a výhledová zpráva 2021*. Prague: Ministry of Agriculture, 2022. 39 pp.

[7] Český statistický úřad. *Statistická ročenka České republiky 2021*. Prague: Czech statistical office, 2022. 815 pp.

[8] Anon. *Operational Programme Fisheries 2021–2027. Text Approved by Resolution of the Government of the Czech Republic No. 101/22, Sent to the European Commission for Approval.* Prague: Ministry of Agriculture, 2022. 54 pp.

[9] MAKOVCOVÁ, M., KOŘÍNKOVÁ, B., FUKSA, J. K. *Zdroje sedimentů pro potenciální využití na zemědělské půdě. Mapa ČR s vyznačením potenciálních zdrojů sedimentů pro využití na zemědělské půdě (> 1 ha) s databází. Verze 2, 2023*. Output of the DivLand project, accessible at www.dibavod.cz/divland-rybniky-sedimenty

[10] HAŠEK, J. *Osudy dobrého vojáka Švejka za světové války. Kniha 1, kapitola 1*. Prague: Published by A. Sauer and V. Čermák at Žižkov, Kolárovo nám. 22, Part I, Book 1–8, 1921, pp. 5–253.

[11] ŠUSTA, J. *Výživa kapra a jeho družiny rybničné*. 1884. Translation and reissue. Třeboň: CARPIO, 1997. 180 pp.

[12] ŠUSTA, J. *Fünf Jahrhunderte der Teichwirtschaft zu Wittingau: ein Beitrag zur Geschichte der Fichzucht mit besonderer Berücksichtigung der Gegenwart. Pět století rybničního hospodaření v Třeboni*. 1898. Translation and reissue. Třeboň: CARPIO, 1995. 212 pp.

[13] PECHAR, L. Století eutrofizace rybníků – synergický efekt zvyšování zátěže živinami (fosforem a dusíkem) a nárůstu rybích obsádek. *Vodní hospodářství*. 2015, 65(7), pp. 1–6.

[14] HRBÁČEK, J. Relation between Some Environmental Parameters and the Fish Yield as a Basis for a Predictive Model. *SIL Proceedings, 1922–2010*. 1969, 17(2), pp. 1 069–1 081. Available at: https://doi.org/10.1080/03680770.1968.11895953

[15] KOŘÍNEK, V., FOTT, J., FUKSA, J., LELLÁK, J., PRAŽÁKOVÁ, M. Carp Ponds in Central Europe. In: MICHAEL, R. G. (ed.). *Managed Aquatic Ecosystems*. Amsterdam: Elsevier, 1987, pp. 29–62.

[16] VRBA, J., BENEDOVÁ, Z., JEZBEROVÁ, V., MATOUŠŮ, A., MUSIL, M., NEDOMA, J., PECHAR, L., POTUŽÁK, J., ŘEHÁKOVÁ, K., ŠIMEK, K., ŠORF, M., ZEMANOVÁ, K. Nevstoupíš dvakrát do téhož rybníka – předběžná zpráva o stavu dnešních hypertrofních rybničních ekosystémů. *Vodní hospodářství*. 2018, 68(8), pp. 1–5.

[17] BEAULIEU, J. J., DELSONTRO, T., DOWNING, J. A. Eutrophication Will Increase Methane Emissions from Lakes and Impoundments during the 21st Century. *Nature Communications*. 2019, 10(1), p. 1 375.

[18] DAVIDSON, T. A., AUDET, J., JEPPESEN, E., LANDKILDEHUS, F., LAURIDSEN, T. L., SØNDERGAARD, M., SYVÄRANTA, J. Synergy between Nutrients and Warming Enhances Methane Ebullition from Experimental Lakes. *Nature Climate Change*. 2018, 8(2), pp. 156–160.

[19] NIJMAN, T. P. A., LEMMENS, M., LURLING, M., KOSTEN, S., WELTE, C., VERAART, A. J. Phosphorus Control and Dredging Decrease Methane Emissions from Shallow Lakes. *Science of the Total Environment*. 2022, 847, 157584. 12 pp.

[20] FAINA, R. Alternativy k tradičnímu pojetí rybářské intenzifikace na rybnících v CHKO Třeboňsko a na rybničních rezervacích. In: POKORNÝ, J., ŠULCOVÁ, J., HÁTLE, M., HLÁSEK, J. (eds.). *Třeboňsko 2000. Ekologie a ekonomika Třeboňska po dvaceti letech*. Třeboň: UNESCO/MAB. ENKI, o. p. s., 2000, pp. 192–196.

[21] KUBÍK, L. *Hodnocení sedimentů vodních ploch (toky, rybníky, vodní nádrže). Průběžná zpráva 1995–2017*. Brno: UKZÚZ – Central Institute for Supervising and Testing in Agriculture in Brno, Agricultural Inputs Section, 2019. 116 pp.

[22] BAXA, M., ŠULCOVÁ, J., KRÖPFELOVÁ, L., POKORNÝ, J., POTUŽÁK, J. Výsledky dlouhodobého screeningu kvality rybničních sedimentů v České republice. *Vodohospodářské technicko-ekonomické informace*. 2020, 62(1), pp. 4–10.

[23] BAXA, M., ŠULCOVÁ, J., KRÖPFELOVÁ, L., POKORNÝ, J., POTUŽÁK, J. The Quality of Sediment in Shallow Water Bodies – Long-Term Screening of Sediment in Czech Republic. A New Perspective of Nutrients and Organic Matter Recycling in Agricultural Landscapes. *Ecological Engineering*. 2019, 127, pp. 151–159.

[24] BAXA, M., BAXOVÁ CHMELOVÁ, I., BENEDOVÁ, Z., DURAS, J., HRUBEC, R., KRÖPFELOVÁ, L., NOVOTNÝ, O., POKORNÝ, J., POTUŽÁK, J., SVOBODA, T., ŠULCOVÁ, J. *Technologický postup recyklace živin z rybničních sedimentů s využitím sacího bagru, integrované stanice pro dávkování flokulantu a geotextilních vaků pro lokální aplikaci v mikropovodí. Certifikovaná metodika schválená osvědčením č. UKZUZ 113316/2017*. Třeboň: ENKI, o. p. s., PLOSAB, s. r. o., 2017. 51 pp.

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Assessment of the status of surface water bodies in the Czech Republic for 2019–2021

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Keywords: chemical status of water — ecological status of water — water body — water quality indicators — pollutants

ABSTRACT

The article presents the results of the assessment of the status of surface water bodies in the Czech Republic for 2019 to 2021. The status assessment has been carried out by T. G. Masaryk Water Research Institute, p. r. i. (TGM WRI), Biology Centre CAS, and the Czech Hydrometeorological Institute (CHMI). The status of the water bodies was evaluated according to monitoring data from the River Boards state enterprises and – in the case of selected priority substances in biota – from the CHMI. The assessment procedures were the same as in the previous status assessment for 2016 to 2018, which was incorporated into the river basin management plans for the third planning period. The article focuses on presenting the results of the assessment, which was prepared by the TGM WRI. It is a summary assessment of the ecological and chemical status of water bodies, an evaluation of chemical and physico-chemical indicators and a comparison of the results of the assessment for 2019 to 2021 with the assessment for 2016 to 2018. In 2019 to 2021, good chemical status was not achieved in 57.6 % of water bodies; the problematic pollutants are mainly polyaromatic hydrocarbons; in the 'biota' matrix there was also mercury and brominated diphenyl ether. Good ecological status/potential has not been achieved in 92.3 % of water bodies; the problematic indicators are mainly biological quality elements and phosphorus.

INTRODUCTION

The environmental goals specified by the Water Framework Directive (WFD) [1] include the achievement of good status of water bodies (or good potential of heavily modified and artificial water bodies). In the case of surface water and in the conditions of the Czech Republic, this involves achieving a good status of surface water bodies in the "river" and "lake" categories.

According to the Water Act [2], status of surface water means a general status of a surface water body determined by its ecological or chemical status according to which is worse. Good chemical status of surface waters means the chemical status necessary for achieving the goals of water protection as a component of the environment, in which the concentrations of pollutants do not exceed environmental quality standards. An environmental quality standard means the concentration of a pollutant or group of pollutants in water, sediments or living organisms, which must not be exceeded for reasons of protection of human health and the environment. Ecological status means the quality of the structure and function of aquatic ecosystems linked to surface waters. Ecological status is assessed by comparing the current status with nearby natural or reference conditions. The ecological status of a water body is determined by its lowest rated quality element. Biological, hydro-morphological, chemical (specific pollutants), and physico-chemical elements of quality are assessed. Ecological potential determines the status of a heavily modified or artificial surface water body. Good status of surface waters is defined as the status of a body of surface water where its ecological and chemical status is at least good.

Assessment of the status of water bodies is an integral part of river basin management plans according to the WFD, which are processed in six-year cycles. The results of the assessment are subsequently a fundamental basis for the proposal of a programme of measures to improve water status (or the determination and justification of exceptions to achieving good status) and other activities in the field of water management at the level of both the country and sub-basins. As part of the plans for the third planning period (2022–2027), the status of surface water bodies was evaluated according to monitoring data in 2016–2018 [4]. According to Section 4 of Decree No. 98/2011 Coll., on the method of assessing the status of surface water bodies, the method of assessing the ecological potential of heavily modified and artificial surface water bodies and the requirements of programmes for the detection and assessment of the status of surface water, as amended [3], the status of surface water bodies should be assessed every three years. The status of surface water bodies, which is the subject of this article, was evaluated for 2019–2021.

METHODOLOGY AND MATERIAL

Methodological procedures and official methodologies approved by the Department of Water Protection of the MoE for the third planning period (2015–2021) were used for the assessment itself. These procedures fully respect the requirements of the WFD and related documents (other EU directives and relevant directive documents); at the same time, these procedures respect the requirements of national legislation and other relevant documents. In connection with the overall assessment of the chemical status and ecological status/potential, and with the assessment of individual chemical and physico-chemical indicators, it was [5–11].

Chemical and ecological status/potential was assessed based on actual measured data in representative monitoring sites of surface water bodies. The evaluation of individual priority substances (chemical status) and specific pollutants (ecological status/potential) was carried out separately for the individual years 2019, 2020, and 2021 and aggregated into the final outputs for the entire three-year period. The final assessment was determined by the worst year of the assessed period. General physico-chemical indicators of ecological status/potential were evaluated for the entire three-year period. The resulting assessment of the chemical and ecological status/potential was related to the entire water body to which the representative monitoring site relates.

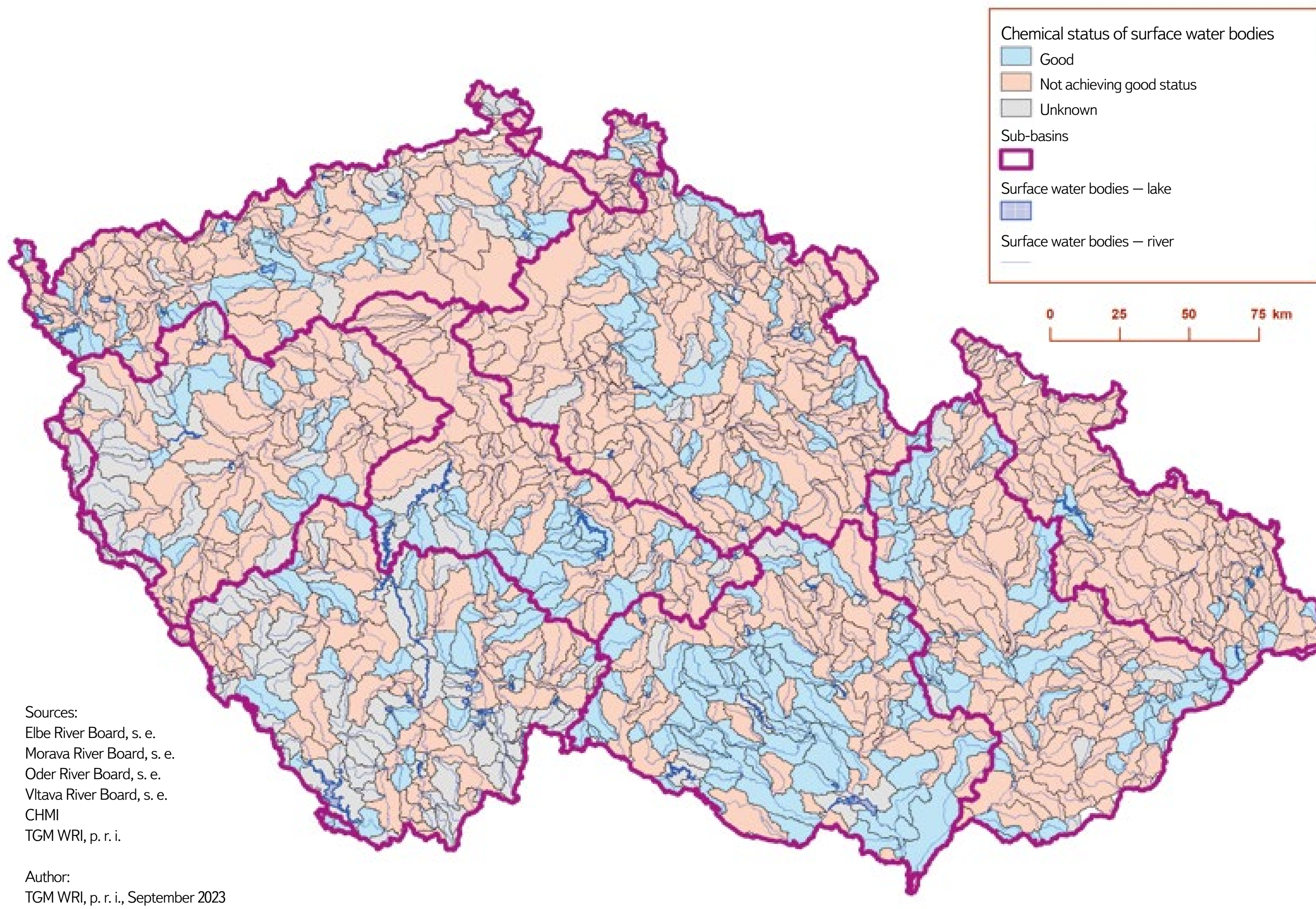

Fig. 1. Chemical status of surface water bodies 2019–2021

The evaluation of chemical and physico-chemical indicators was carried out using modified software tools developed by TGM WRI and updated in 2019.

The delineation of water bodies, their categories and hydromorphological character (i.e., division into natural, heavily modified and artificial water bodies) corresponded to the third planning period. A total of 1,118 bodies of surface water were assessed, of which 1,045 were in the "river" category and 73 in the "lake" category. For water bodies in the "river" category, 942 were defined as "natural", 98 as "highly modified", and five as "artificial". For the bodies in the "lake" category, 69 were defined as "heavily modified" and four as "artificial".

The "one out – all out" principle was always observed in the system for assessment the status of surface waters, in accordance with the requirements of relevant legislative regulations at the level of the Czech Republic and the EU. It therefore applies that the worst of the results of the relevant partial elements or indicators is always decisive for the final assessment.

The assessment results for 2019–2021 were subsequently compared with the results for 2016–2018. Both the assessment of the chemical and ecological status/potential of individual water bodies and the evaluation of individual chemical and physico-chemical indicators were compared. In order for the comparison to be relevant, it is necessary to fulfil the conditions regarding the evaluation procedures and input data. The evaluation procedures, including the criteria for classification of status, were the same for both assessed periods. In 2019–2021, monitoring was carried out on an approximately 10 % larger scale. When applying the "one out – all out" principle, this can lead to slightly worse results in the ecological status/potential or the chemical status of individual water bodies. The evaluation of 2019–2021, on the other hand, does not include hydromorphology (when evaluating the status for 2016–2018, the "one out – all out" principle was not applied to the hydromorphological element).

The status of surface water bodies for 2019–2021 was evaluated based on data from the monitoring of the River Boards state enterprises. The data was provided mainly from the IS Arrow, managed by CHMI. Data from the monitoring of selected priority and priority hazardous substances in biota used for the assessment of the chemical status of surface water bodies was obtained from the monitoring of solid matrices, which is provided by CHMI. TGM WRI participated in the assessment of the status, evaluating chemical and physico-chemical indicators and the overall ecological and chemical status and compared the results of the assessment with the results for the previous three-year period 2016–2018; the Biological Centre CAS, p. r. i., evaluated the biological elements of the ecological status of the water bodies in the "lake" category; CHMI evaluated the biological elements of the ecological status of the water bodies in the "river" category. The following results are focused on the assessment prepared by TGM WRI. The assessment was created (on the basis of a contractual relationship) in 2023 for the River Boards state enterprises.

In addition to the results of the actual assessment, an even more detailed comparison was processed of the most important physico-chemical and chemical indicators between the two three-year periods. This was done by comparing the percentage of unsatisfactory results to the classified ones, which is especially important for indicators that are not classified across the board, either because of the smaller scope of monitoring, or a high number of measurements, which could not be evaluated mainly due to the high limits of determination (compared to the very low values of environmental quality standards). Also, the proportion of monitored and classified water bodies against the total number of water bodies was compared.

RESULTS

Chemical status

The results of the assessment of chemical status of surface water bodies during the monitoring period 2019–2021 are illustrated by the map in *Fig. 1* and the graph in *Fig. 2*. In 2019–2021, good chemical status was achieved for 285 bodies (270 bodies in the "river" category and 15 in the "lake" category); 644 bodies were classified in "not achieving good status" category (639 in the "river" category and five in the "lake" category); and for 189 bodies the chemical status was evaluated as unknown (136 in the "river" category and 53 in the "lake" category).

Tab. 1 and *2* shows a comparison of the evaluation of chemical status for 2019–2021 with the evaluation for 2016–2018. The comparison shows a slight increase in the total proportion of water bodies classified in "not achieving good status" category (by 8 % of formations) compared to 2016–2018, which is caused by polyaromatic hydrocarbons (mainly benzo[ghi]perylene and benzo[k]fluoranthene). In water bodies of the "lake" category, an increase in the proportion of water bodies of unknown chemical status is noticeable, caused by a reduction in the scope of priority substance monitoring. The graph in *Fig. 3* shows the evaluation of priority substances for which the environmental quality standards (EQS) were not met in at least 10 % of water bodies in 2019–2021. It is apparent that polyaromatic hydrocarbons are particularly problematic. For substances evaluated in the "biota" matrix, EQS are not fulfilled, especially for mercury and brominated diphenyl ether. For both substances, the EQS is not met in the long term in any of the monitoring profiles. The monitoring range of substances in the "biota" matrix is very low (maximum 3 % of water bodies).

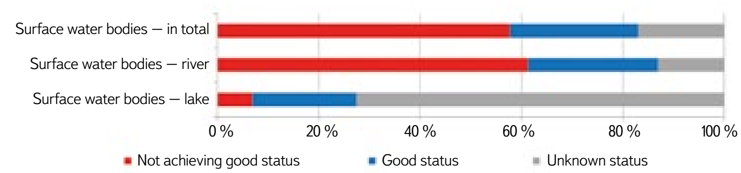

Fig. 2. Chemical status of surface water bodies 2019–2021 in categories "river" and "lake"

Tab. 1. Chemical status of surface water bodies 2019–2021 and 2016–2018

Category of water body	Number of water bodies	Chemical status 2019-2021 [% of water bodies]			Chemical status 2016-2018 [% of water bodies]			Difference [% of water bodies]		
		2	3	N	2	3	N	2	3	N
River	1,045	25.8	61.1	13.1	32.2	51.1	16.7	-6.4	+10	-3.6
Lake	73	20.5	6.8	72.7	35.6	20.5	43.8	-15.1	-13.7	28.9
Total	**1,118**	**25.5**	**57.6**	**16.9**	**32.5**	**49.1**	**18.4**	**-7**	**8.5**	**-1.5**

Status classification in *Tab. 1*: 2 = good status; 3 = not achieving good status; N = unknown status

Tab. 2. Changes in the assessment of the chemical status of surface water bodies between 2016–2018 and 2019–2021

Change in chemical status	[% of water bodies]
Deterioration from good status to not achieving good status	10.1
Improvement from not achieving good status to good status	7.8
Change from good status to unknown status	7.8
Change from not achieving good status to unknown status	1.6
Change from unknown status to good status	3.2
Change from unknown status to not achieving good status	7.8
Good status remains the same	14.4
Not achieving good status remains the same	39.6
Unknown status remains the same	7.4

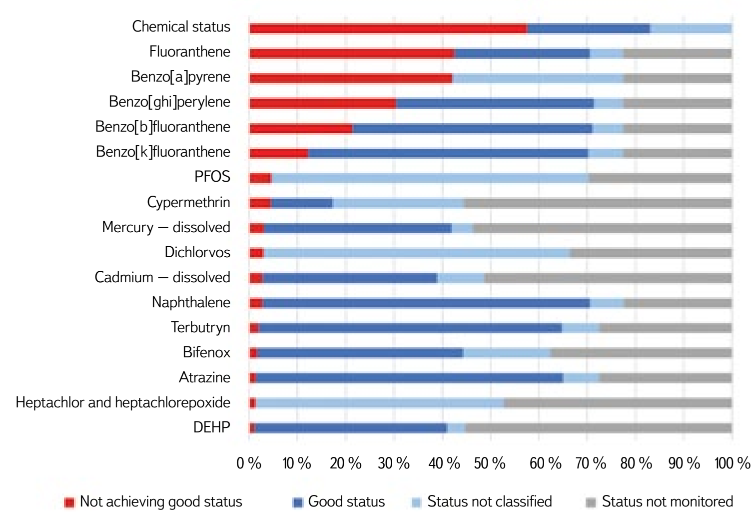

Fig. 3. Chemical status of surface water bodies 2019–2021 by selected priority substance assessment

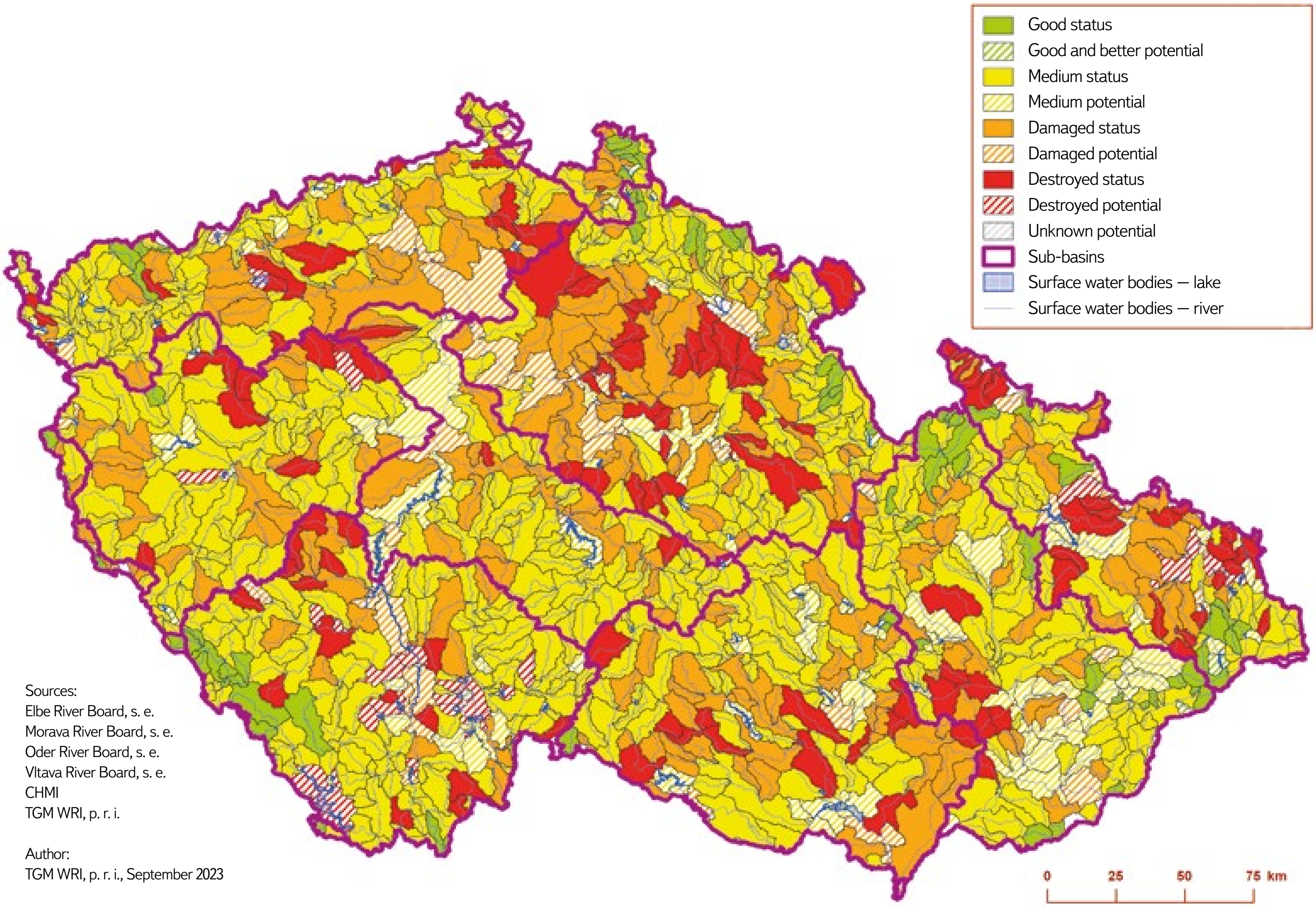

Fig. 4. Ecological status/potential of surface water bodies 2019–2021

Ecological status/potential

The map in *Fig. 4* and the graph in *Fig. 5* show the results of the evaluation of ecological status/potential of surface water bodies in 2019–2021. In 2019–2021, good ecological status or good and better potential was achieved in 83 bodies (77 in the "river" category and 6 in the "lake" category), medium status/potential was classified for 633 bodies (600 in the "river" category and 33 in the "lake" category), damaged status/potential was classified for 246 bodies (234 in the "river" category and 12 in the "lake" category), destroyed status/potential was classified for 153 bodies (134 in the "river" category and 19 in the "lake" category), and unknown status/potential was classified for 3 bodies (all in the "lake" category). Very good status was not achieved for any water body. *Tabs. 3* and *4* show a comparison of the evaluation of the ecological status/potential for 2019–2021 with the evaluation for 2016–2018. The comparison shows only very slight changes between the three-year evaluations. For bodies in the "lake" category, a slight increase in the proportion of bodies in an unknown status/potential is noticeable, caused by a reduction in the scope of monitoring. The assessment of biological elements (in total) and general physico-chemical indicators is shown in the graph in *Fig. 6* for bodies in the "river" category and in *Fig. 7* for bodies in the "lake" category. The evaluation of specific pollutants is shown in the graph in *Fig. 8* (only substances that do not comply in at least two water bodies are listed). The graphs show that the resulting ecological status or potential is most affected by the evaluation of general physico-chemical elements (almost 86 % of bodies do not reach good status/potential) and biological elements (72 % of bodies are in worse than good status/potential) – see *Figs. 6* and *7*. The proportion of unsatisfactory water bodies due to specific pollutants is smaller (44 %) – see *Fig. 8*.

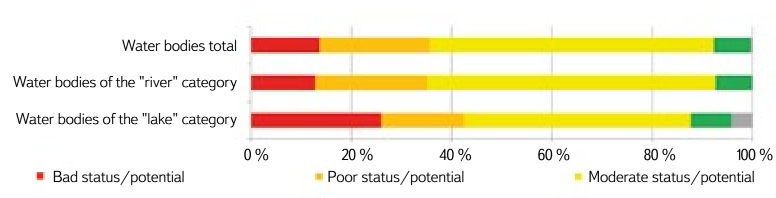

Fig. 5. Ecological status/potential of surface water bodies 2019–2021 in categories "river" and "lake"

Tab. 3. Ecological status/potential of surface water bodies 2019–2021 and 2016–2018

Category of water body	Number of water bodies	Ecological status/potential 2019–2021 [% of water bodies]			Ecological status/potential 2016–2018 [% of water bodies]			Difference [% of water bodies]		
		2	3–5	N	2	3–5	N	2	3–5	N
River	1,045	7.4	92.6	0	5.4	94.6	0	2	-2	0
Lake	73	8.2	87.7	4.1	13.7	86.3	0	-5.5	1.4	4.1
Total	**1,118**	**7.4**	**92.3**	**0.3**	**5.9**	**94.1**	**0**	**1.5**	**-1.8**	**0.3**

Status classification in *Tab. 3*: 2 = good status/potential; 3 = medium and worse status/potential; N = unknown status/potential

Tab. 4. Changes in the assessment of the ecological status/potential of surface water bodies between 2016–2018 and 2019–2021

Change of ecological status/potential	[% of water bodies]
Deterioration from good and above to moderate and worse status/potential	3.0
Improvement from moderate and worse to good and above status/potential	4.5
Change of moderate and worse to unknown status/potential	0.3
Good and above status/potential remains the same	3.0
Moderate and worse status/potential remains the same	89.0

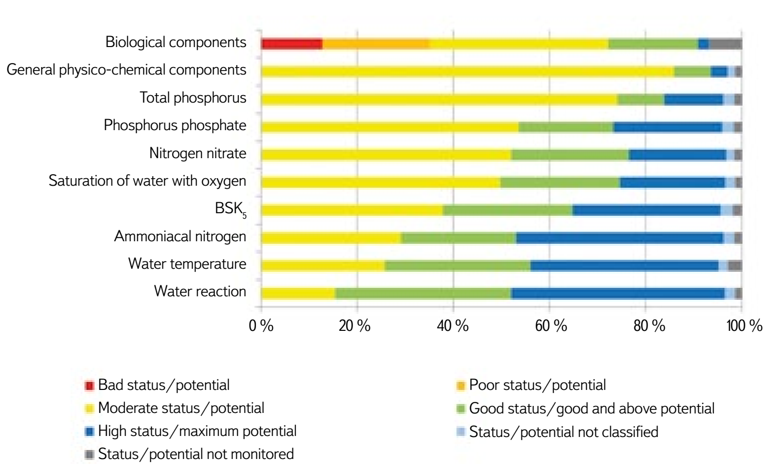

Fig. 6. Ecological potential of surface water bodies of the category "river" according to the assessment of biological and physico-chemical elements for 2019–2021

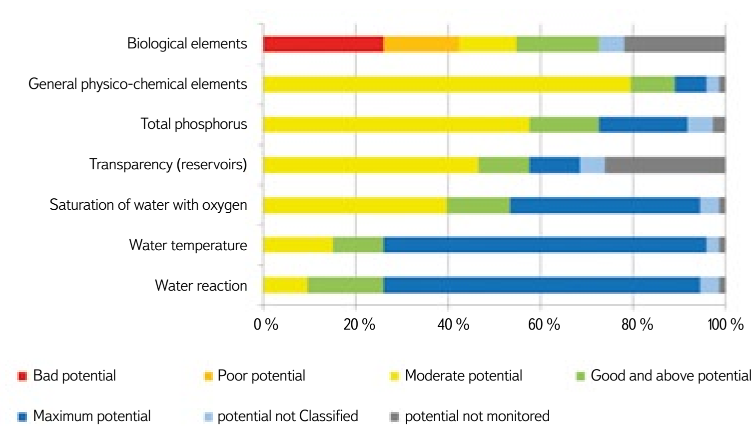

Fig. 7. Ecological potential of surface water bodies of the category "lake" 2019–2021 according to the assessment of biological and physico-chemical elements for 2019–2021

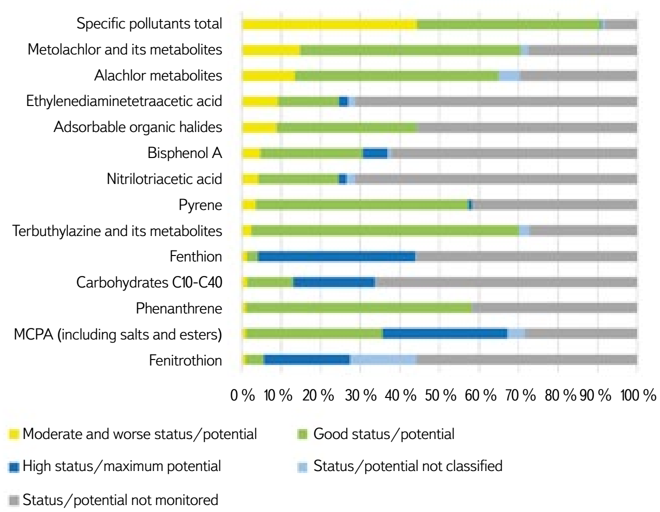

Fig. 8. Ecological status/potential of surface water bodies according to the assessment of selected specific pollutants for 2019–2021

Evaluation of chemical and physico-chemical indicators and their comparison with 2016–2018

If we want to find out where the Czech Republic fails to achieve good status, it is necessary to focus on individual indicators or elements; the same applies to an even greater extent for comparing the results of chemical and ecological status. At the same time, there are a lot of indicators of chemical status and specific pollutants of the ecological status assessed (54 priority substances and 83 specific pollutants); in addition, for a significant part of the indicators, no unsatisfactory water body was found (for 23 priority substances and 42 specific pollutants), therefore a more detailed evaluation focuses on those indicators that do not exist for at least 10 water bodies in the Czech Republic and, at the same time, are probably not of a natural origin (applies to iron and manganese). Fifteen priority substances (*Fig. 3*) and thirteen specific pollutants (*Fig. 8*) correspond to these conditions.

The periods 2019–2021 and 2016–2018 are suitable for comparison because the same methodologies and relevant limits (e.g. EQS) were used for the status/potential classification. Similarly, there was no change in the delineation of water bodies or their inclusion in natural, heavily modified and artificial bodies. However, at the level of the overall chemical and ecological status/potential, the results (and comparability of the period) are affected by the range of monitored indicators in a representative profile ("one out – all out" principle).

The evaluation results for individual elements and indicators are similar to the evaluation of the previous three-year period. For the chemical status, polyaromatic hydrocarbons (fluoranthene, benzo[a]pyrene, benzo[ghi]perylene, benzo[b]fluoranthene, benzo[k]fluoranthene, naphthalene), perfluorooctanesulfonic acid and its derivatives (PFOS) showed poor results most often, less often metals – mercury and cadmium – and some pesticides – cypermethrin, dichlorvos, bifenox and terbutryn (*Fig. 3*). The biggest differences between the current (2019–2021) and the previous (2016–2018) three-year period can be found for cypermethrin – see *Tab. 5* (improvement by 75 % of the proportion of classified bodies). This is due to the fact that the number of monitored bodies increased significantly, mainly in the sub-basin of the Upper and Middle Labe, whereby 133 new satisfactory water bodies were found, compared to none in the past three years, while 47 (originally 15) bodies were unsatisfactory. In contrast, the biggest deterioration was for benzo[ghi]perylene (by 7 % of the proportion of classified bodies) and benzo[k]fluoranthene (by 6 % of the proportion of classified bodies); in the case of benzo[ghi]perylene, this is mainly due to the fact that a significant amount of water bodies that were satisfactory in the last three years were not monitored in the current three-year period. In the case of benzo[k]fluoranthene, a partial deterioration was manifested in particular in the Upper Odra sub-basin; there were no significant changes in the other sub-basins.

For easier orientation, changes in the assessment of indicators are shown in colour in *Tabs. 5*, *6*, *7*, and *8*: blue indicates significant improvement (over 5 %), green moderate improvement (2–5 %), grey stable status (0–2 %), yellow moderate deterioration (2–5 %), and red significant deterioration (over 5 %).

Tab. 5. Changes in the assessment of the selected chemical status of surface water bodies between 2016–2018 and 2019–2021

Pollutant	**Number of water bodies not achieving good status**	**Improvement (-) / Deterioration (+)**
Fluoranthene	445	+4.0 %
Benzo[a]pyrene	440	+0.3 %
Benzo[ghi]perylene	318	+7.3 %
Benzo[b]fluoranthene	224	+3.2 %
Benzo[k]fluoranthene	127	+6.0 %
PFOS	48	-2.1 %
Cypermethrin	47	-74.9 %
Mercury and its compounds	32	-7.6 %
Dichlorvos	31	0.0 %
Cadmium and its compounds	29	+2.9 %
Naftalin	28	+3.4 %
Terbutryn	19	+1.6 %
Bifenox	17	+3.7 %
Heptachlor and heptachlor epoxide	14	-2.0 %
Atrazine	14	+2.1 %
DEHP	12	+0.8 %

-6.6 %	Significant improvement (over 5 %)
-4.0 %	Slight improvement (2–5 %)
0.5 %	Stable (0–2 %)
3.2 %	Slight deterioration (2–5 %)
10.3 %	Significant deterioration (over 5 %)

In order to better understand the differences between the assessment in 2019–2021 and 2016–2018, it is necessary to look at the changes between the number of classified and monitored bodies for selected indicators (*Fig. 9*). If we were interested in all 54 priority substances, the difference between the three-year periods is minimal – in the current three-year period, the number of classified bodies slightly decreased (by 0.2 percentage points); monitored bodies, on the other hand, increased by 3 percentage points. The summary for the individual indicators is much more interesting – the highest decrease of the monitored bodies is visible for mercury and cadmium, which was due to the fact that, in the last three-year period, those bodies were included in the assessment for which undissolved forms of metals were also monitored (and for the sake of the assessment, recalculated to dissolved form), whereas in the current three-year period, the water bodies with monitoring of only undissolved metals were included in non-monitored ones. The highest decrease in classified bodies was again for mercury and cadmium (for the same reason).

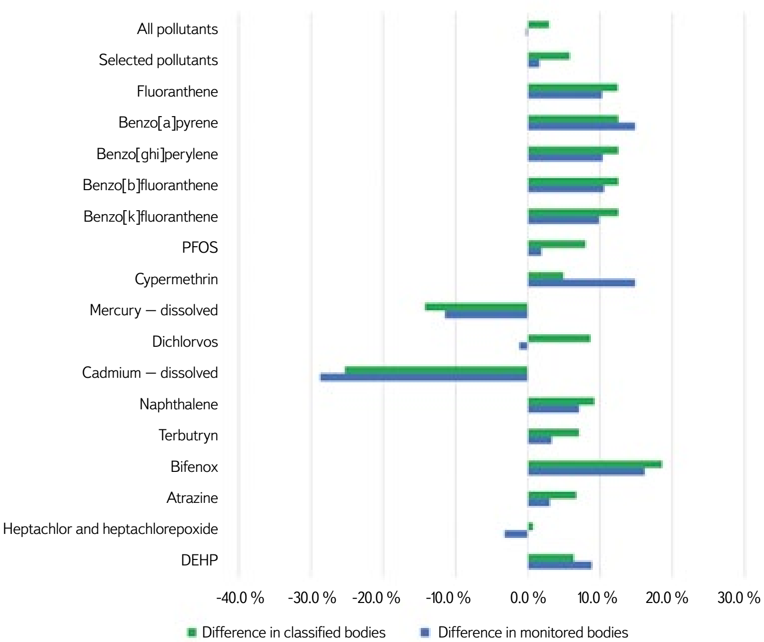

Fig. 9. Changes in the proportion of the selected priority substances classified and monitored between 2016–2018 and 2019–2021

The most common reason for poor ecological status/potential are general physico-chemical indicators: total phosphorus, phosphorus phosphate, nitrate nitrogen (applies only to the "river" category), water saturation with oxygen, five-day biochemical oxygen consumption, ammonia nitrogen (applies only to the "river" category), water temperature, and water reaction (*Figs. 6* and *7*). A smaller proportion of unsatisfactory water bodies can be seen in the case of some specific pollutants – most often pesticide metabolites (metolachlor and its metabolites, alachlor and its metabolites, less terbuthylazine and its metabolites) and ethylenediaminetetraacetic acid (EDTA) – see *Fig. 8*.

In the case of rivers, the biggest differences between the current (2019–2021) and the previous (2016–2018) three-year period can be found in water oxygen saturation (improvement by 7 percentage points from the proportion of classified bodies) and water temperature (by 5 percentage points from the proportion of classified bodies) – see *Tab. 6*. In the case of lakes, the situation was significantly different; only water reaction showed a significant improvement (by 8 percentage points). On the other hand, the biggest deterioration was in transparency (by 15 percentage points from the proportion of classified bodies) – see *Tab. 7*.

Tab. 6. Changes in the assessment of surface water bodies category "river" of physico-chemical elements between 2016–2018 and 2019–2021

Element	Number of water bodies not achieving good status	Improvement (-) / Deterioration (+)
Total phosphorus	773	-2.0 %
Phosphorus phosphate	560	-4.0 %
Nitrate nitrogen	544	+4.2 %
Saturation of water with oxygen	520	-6.6 %
Biochemical oxygen consumption	392	-1.4 %
Ammoniacal nitrogen	304	-2.8 %
Water temperature	271	-5.1 %
Water reaction	161	-1.5 %

Tab. 7. Changes in the assessment of surface water bodies category "lake" of physico-chemical elements between 2016–2018 and 2019–2021

Element	Number of water bodies not achieving good status	Improvement (-) / Deterioration (+)
Total phosphorus	47	+3.5 %
Transparency	36	+14.6 %
Saturation of water with oxygen	23	+0.6 %
Water reaction	13	-8.1 %
Water temperature	6	-4.6 %

The biggest differences for specific pollutants were for adsorbable organic halides (AOX) – an improvement of 12.3 percentage points. In contrast, the biggest deterioration was for metolachlor and its metabolites – by 11.5 percentage points. In the case of AOX, there was a reduction in the proportion of monitored and classified bodies (*Fig. 10*); however, this concerned almost exclusively those units that were in good status in the last three-year period. In the case of metolachlor and its metabolites, the increase in the proportion of unsatisfactory bodies was probably a combination of two factors: the actual deterioration in 64 water bodies, and the expansion of monitoring revealing quite a high number of unsatisfactory bodies (albeit significantly less than those newly found in good status).

As for the changes between the number of classified and monitored bodies for selected specific pollutants (*Fig. 10*), the changes for all indicators are again minimal. The highest decreases of both monitored and classified bodies are evident for bisphenol A (by 3.7 and 4.5 percentage points, respectively) and slightly less for fenthion and AOX. In all these cases, mainly the monitoring of water bodies in good status in the last three-year period was limited. In all other cases, there was an increase in both monitored and classified bodies.

Tab. 8. Changes in the assessment of the selected specific pollutants between 2016–2018 and 2019–2021

Pollutant	Number of water bodies not achieving good status	Improvement (-) / Deterioration (+)
Metolachlor and its metabolites	154	+11.5 %
Alachlor metabolites	141	-3.4 %
EDTA	96	+0.5 %
AOX	92	-12.3 %
Bisphenol A	49	-4.7 %
NTA	44	+4.1 %
Pyrene	37	-3.9 %
Terbuthylazine and its metabolites	26	+2.8 %
Hydrocarbons C10-C40	15	-0.9 %
Fenthion	14	-1.8 %
Fenitrothion	12	-5.5 %
Phenanthrene	11	-4.5 %
MCPA (including salts and esters)	11	+0.3 %

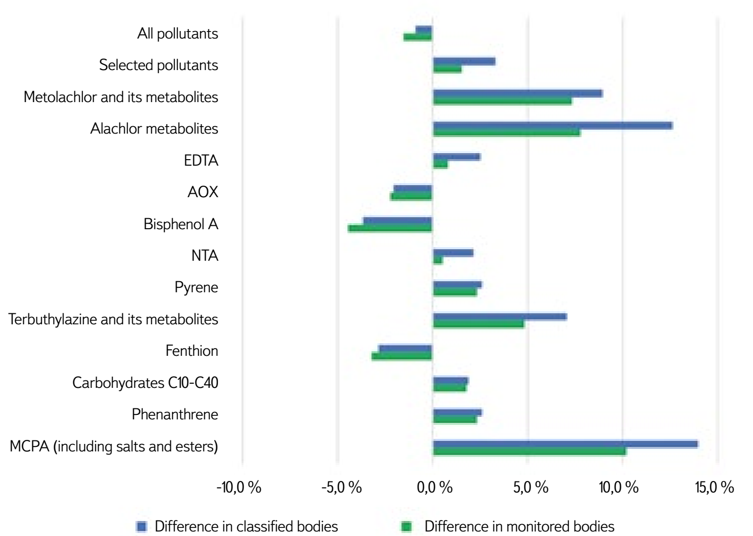

Fig. 10. Changes in the proportion of the specific pollutants classified and monitored between 2016–2018 and 2019–2021

CONCLUSION

The status of surface water bodies was evaluated based on actual measured data for 2019–2021. 1,118 water bodies were assessed (1,045 in the "river" category and 73 in the "lake" category), as defined for the third planning period. Also, the methodological procedures corresponded to the procedures for the previous evaluation period 2016–2018, which was incorporated into the third river basin management plans. The same delineation of water bodies and evaluation procedures made it possible to assess the development of the status in the last two evaluated three-year periods, at least at the level of individual chemical and physico-chemical indicators. (At the level of the overall chemical and ecological status/potential, the comparison limits the increased scope of monitoring in the period 2019–2021 when applying the "one out – all out" approach.) Good chemical status was not achieved in 61 % of water bodies. The occurrence of polycyclic aromatic hydrocarbons (especially fluoranthene and benzo(a)pyrene, where EQS were exceeded in more than 40 % of water bodies) had an effect on the failure to achieve good chemical status. In the "biota" matrix, long-term problematic substances are mercury and brominated diphenyl ether. When compared to the previous assessment in 2016-2018, there was a deterioration in benzo[ghi]perylene and benzo[k]fluoranthene. In contrast, there was an improvement in the assessment of mercury in the "water" matrix. Good ecological status or potential was not achieved in 92.6 % of water bodies. The failure to achieve good ecological status/potential was mainly influenced by the status of biological elements and the occurrence of total phosphorus (for the "river" category, the criteria for achieving good status are not met in more than 70 % of water bodies). When compared to the previous assessment in 2016–2018, there were no significant differences in general physico-chemical indicators for the "river" category; for the "lake" category, the assessment for transparency worsened, and the assessment for the water reaction indicator improved. For specific pollutants, the assessment of metolachlor and its metabolites worsened, and the assessment of AOX and fenitrothion improved. Simultaneously, an increase in the proportion of both monitored and classified water bodies was confirmed for almost all significant indicators of priority and specific pollutants compared to the previous three-year period, and, with the exception of cadmium and mercury (where conversions of total metals to dissolved form were not used for the first time), the other reductions were overwhelmingly due to better knowledge of pollution by individual pollutants in individual bodies, where it was possible to omit mainly bodies that were in good status in the previous three-year period from monitoring in the current three-year period.

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References

[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.*

[2] *Act No. 254/2001 Coll., on Water and on the Amendment of Certain Laws (Water Act), as Amended.*

[3] *Decree No. 98/2011 Coll., on the Method of Assessing the Status of Surface Water Bodies, the Method of Assessing the Ecological Potential of Heavily Modified and Artificial Surface Water Bodies, and on the Requirements of Programmes for the Detection and Assessment of the Status of Surface Water Bodies, as Amended.*

[4] MIČANÍK, T., VYSKOČ, P., PRCHALOVÁ, H., POLÁŠEK, M., NĚMEJCOVÁ, D., DURČÁK, M., RICHTER, P. Hodnocení stavu útvarů povrchových vod v České republice pro 3. plánovací období plánů povodí. *Vodohospodářské technicko-ekonomické informace.* 2020, 62(6), pp. 4–17.

[5] ROSENDORF, P., TUŠIL, P., DURČÁK, M., SVOBODOVÁ, J., BERÁNKOVÁ, T., VYSKOČ, P. *Metodika hodnocení všeobecných fyzikálně-chemických složek ekologického stavu útvarů povrchových vod tekoucích.* Prague: TGM WRI, p. r. i., 2013. MoE Certified Methodology.

[6] DURČÁK, M., TUŠIL, P., MIČANÍK, T., ROSENDORF, P., KRISTOVÁ, A., VYSKOČ, P. *Metodika hodnocení ekologického stavu/potenciálu útvarů povrchových vod – specifické znečišťující látky.* Prague: TGM WRI, p. r. i., 2013. MoE Certified Methodology.

[7] DURČÁK, M., TUŠIL, P., MIČANÍK, T., ROSENDORF, P., KRISTOVÁ, A., VYSKOČ, P. *Metodika hodnocení chemického stavu útvarů povrchových vod*. Prague: TGM WRI, p. r. i., 2013. MoE Certified Methodology.

[8] ROSENDORF, P., PRCHALOVÁ, H. *Metodika hodnocení všeobecných fyzikálně-chemických složek ekologického potenciálu útvarů povrchových vod kategorie řeka*. Prague: TGM WRI, p. r. i., 2019.

[9] PRCHALOVÁ, H., DURČÁK, M., VYSKOČ, P., ROSENDORF, P., MIČANÍK, T. *Metodika hodnocení chemického a ekologického stavu útvarů povrchových vod kategorie řeka pro třetí cyklus plánů povodí v ČR*. Prague: TGM WRI, p. r. i., 2019.

[10] MIČANÍK, T., DURČÁK, M., KRISTOVÁ, A. *Metodika odvození biologicky dostupných koncentrací vybraných kovů pro potřeby hodnocení chemického stavu útvarů povrchových vod*. Prague: TGM WRI, p. r. i., 2019. MoE Certified Methodology.

[11] BOROVEC, J., HEJZLAR, J., ZNACHOR, P., NEDOMA, J., ČTVRTLÍKOVÁ, M., BLABOLIL, P., ŘÍHA, M., KUBEČKA, J., RICARD, D., MATĚNA, J. *Metodika pro hodnocení ekologického potenciálu silně ovlivněných a umělých vodních útvarů – kategorie jezero*. České Budějovice: CAS Biological Centre, p. r. i., 2014. MoE Certified Methodology.

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Verifying the applicability of methods for modelling erosion and connectivity of sediments in the Slavíč catchment in the Moravian-Silesian Beskydy mountains based on geomorphological mapping of fluvial processes

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Keywords: Slavíč catchment — Moravian-Silesian Beskydy Mountains — erosion — fluvial processes — stream network disconnectivity

ABSTRACT

As part of the research activities of the Hydrology Department of CHMI Ostrava, field investigations and measurements are being carried out in several catchments to verify the outputs of GIS tools, empirical formulas, and mathematical models focused on surface runoff, fluvial erosion, and sediment transport. The main emphasis is placed on the influence of deforestation and land use changes on rainfall-runoff relations and fluvial erosion, especially within the framework of the NAZV *"DEFOREST"* and *"CLIMCFOR"* projects, in which CHMI collaborates with the Forestry and Game Research Institute (VÚLHM), the Bishopric of Ostrava-Opava, and Water Management Development, and Construction joint stock Company (VRV). The presented article deals with the possibilities of analysing fluvial processes and disconnectivity of flows in the Slavíč catchment in the Moravian-Silesian Beskydy Mountains. ESRI ArcGIS and GRASS GIS tools were used for these analyses. Field verification of outputs took place at several sampling points within the main stream Slavíč.

INTRODUCTION

Together with organic material, sediments form an essential part of fluvial systems and, along with the energy of the flowing water, they shape the varying morphology of the riverbed. Individual parts of riverbed sections or catchments are connected to each other in natural systems, which we collectively call "connectivity". This research focuses on the geomorphology and material connectivity in torrents, which are usually characterized by high potential energy for water and material transport [1].

Anthropogenic as well as natural structures (e.g. wood jams stabilized by gravel bars) can have a disconnective effect in a watercourse, and thus limit downstream transport of material. However, this does not apply to hydrological connectivity, which is not greatly affected by this disconnectivity. Disruption of hydrological connectivity can be seen to a certain extent in, for example, dam reservoirs where manipulations are carried out, and modified flows enter the watercourse below the reservoir dam, which also has a retroactive effect on sediment connectivity [2].

Unfortunately, a number of negative anthropogenic barriers have been introduced into these naturally functioning systems through human activities, which significantly disrupt these interconnections both longitudinally (retention barrages, stabilization drops, weirs, waterworks, etc.) and laterally (e.g. bank reinforcement). These anthropogenic structures in the catchment cause so-called disconnectivity in different long time scales and with different intensity [2]. Retention barrages, for example, are most effective in the basin immediately after construction and then until the retention space is completely filled with transported sediment. Depending on the intensity of sediment transport, the disconnectivity may only last for a limited period of time, after which material transport may resume. In contrast, for comparison, reservoir dams form an essentially insurmountable and permanent barrier for all sediments that are transported there. This creates a significant problem from the point of view of the downstream connectivity of bedload when, due to the lack of sediment supply to the bed below the dam, together with water management manipulations, it can result in sediment starvation [3].

Research on the connectivity of sediments and material in the catchment can bring us useful information about the erosion-transport-accumulation conditions in the catchment and also help outline appropriate management. In terms of connectivity, source areas of sediments are significant that can be represented by active landslides in the connection of the slopes with the riverbed, and in terms of connection of the banks themselves with the riverbeds they can be represented bank scours. The transport of material takes place along the entire length of the riverbed and is slowed down by natural structures, especially woody matter or local accumulation of sediments. In contrast, sections of the bed with exposed bedrock can act as so-called accelerating zones [2]. Sediment accumulations are formed by fragments of rocks

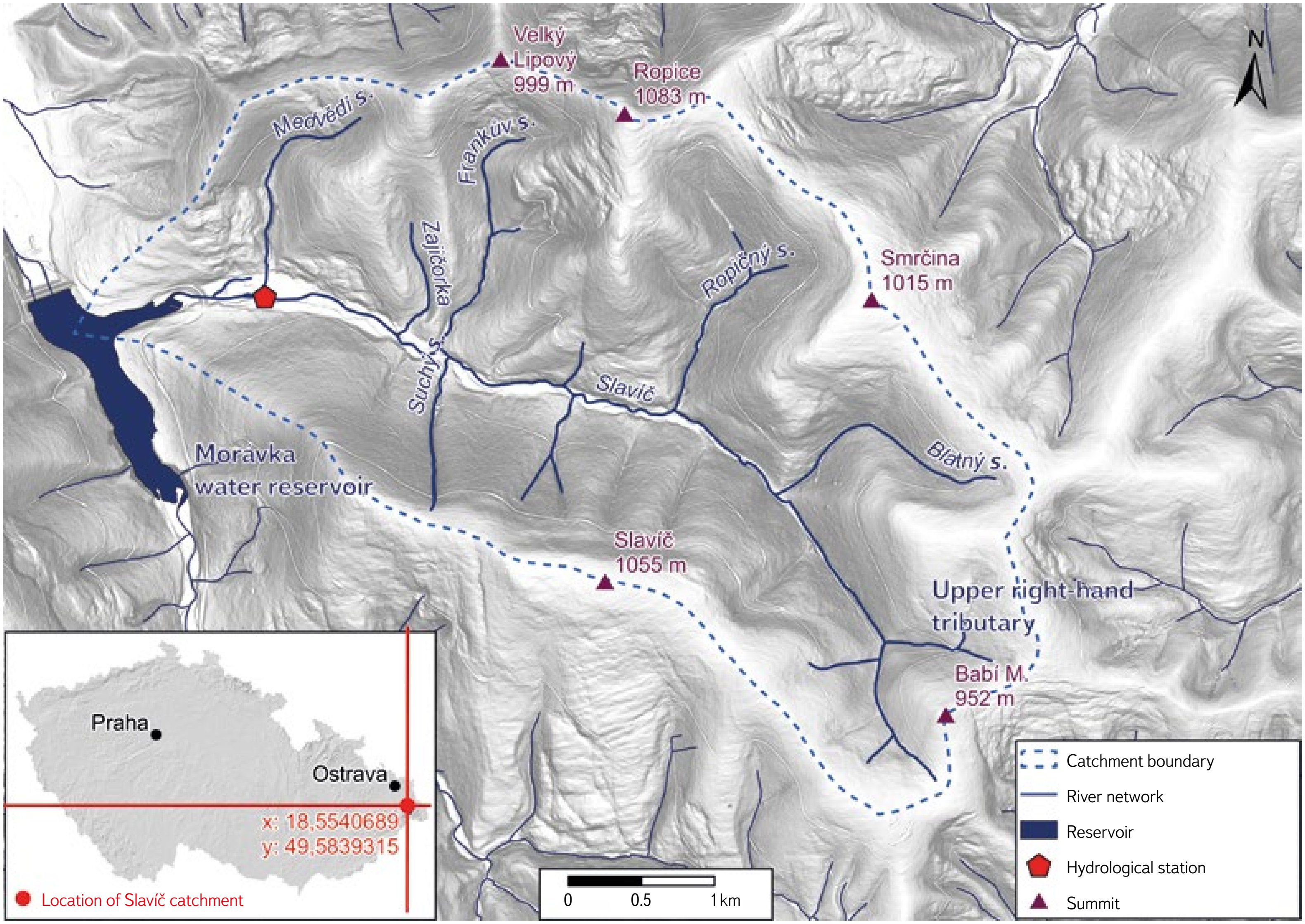

Fig. 1. Study area of the Slavíč river catchment in the Moravian-Silesian Beskydy Mountains

of different degrees of abrasion (according to the length of transport and petrographic composition) and size (gravel, stony to boulder fraction), creating accumulation shapes in the form of so-called gravel bars. Accumulation structures are represented by gravel bars, which, depending on the intensity of flood rate, can be either in a potentially mobile state (with sporadic growth of vegetation) or significantly stabilized by vegetation (trees with a developed root ball). All these erosion, transport, and accumulation processes are most significantly affected by the previously mentioned anthropogenic structures.

Approaches to detecting these erosion-transport-accumulation ratios can be carried out in two steps; the first step involves the identification of potential connectivity using spatially based models [4, 5, 6]; the second step is a field survey, ideally one that is supported by monitoring ongoing processes under different events, especially during floods or droughts.

STUDY AREA

The Slavíč catchment, covering 17.4 km^2 (fourth order catchment, ČHP (hydrological sequence number): 2-03-01-0410-0-00) is part of the Oder catchment and extends SE towards the village of Morávka, or E-SE of Morávka water reservoir, at an altitude of about 505 m above sea level. The Slavíč catchment is bordered by the Slavíč, Babí vrch, Kalužný, Smrčina, Ropice, Velký Lipový, and Kyčera hills; these reach an altitude of 834 to 182 m above sea level.

From a geomorphological point of view, the study area is part of the Alpine-Himalayan system, the Western Carpathian province, the Outer Western Carpathian subprovince, the Western Beskydy region, the Moravian-Silesian Beskydy unit, the Lysohorská hornatina subunit, and the Ropická rozsocha district. Lysohorská hornatina covers an area of 362 km^2, has an average altitude of 709.9 m, and has an average slope of 14° 45'. It is a rugged rock formation, which is built by the assemblage of Godula and Istebna layers. Traces of periglacial formation represented by boulder chutes, frost cliffs, and pseudokarst fissures can be observed in the relief. Ropická rozsocha is located in the north-eastern part of Lysohorská hornatina and represents a rugged mountain range covered with spruce-beech forest [7].

The rock massif is eroded in the axis of the basin, in the E-W direction, by fluvial processes into a deeply incised valley through which the Slavíč stream flows. In the valley floodplain of the watercourse, clayey, sandy, and gravelly fluvial to deluviofluvial sediments are found in the overburden of the rock massif, while in its vicinity there are loam sand to loam stone proluvial and, further from the stream, deluvial sediments of Quaternary age.

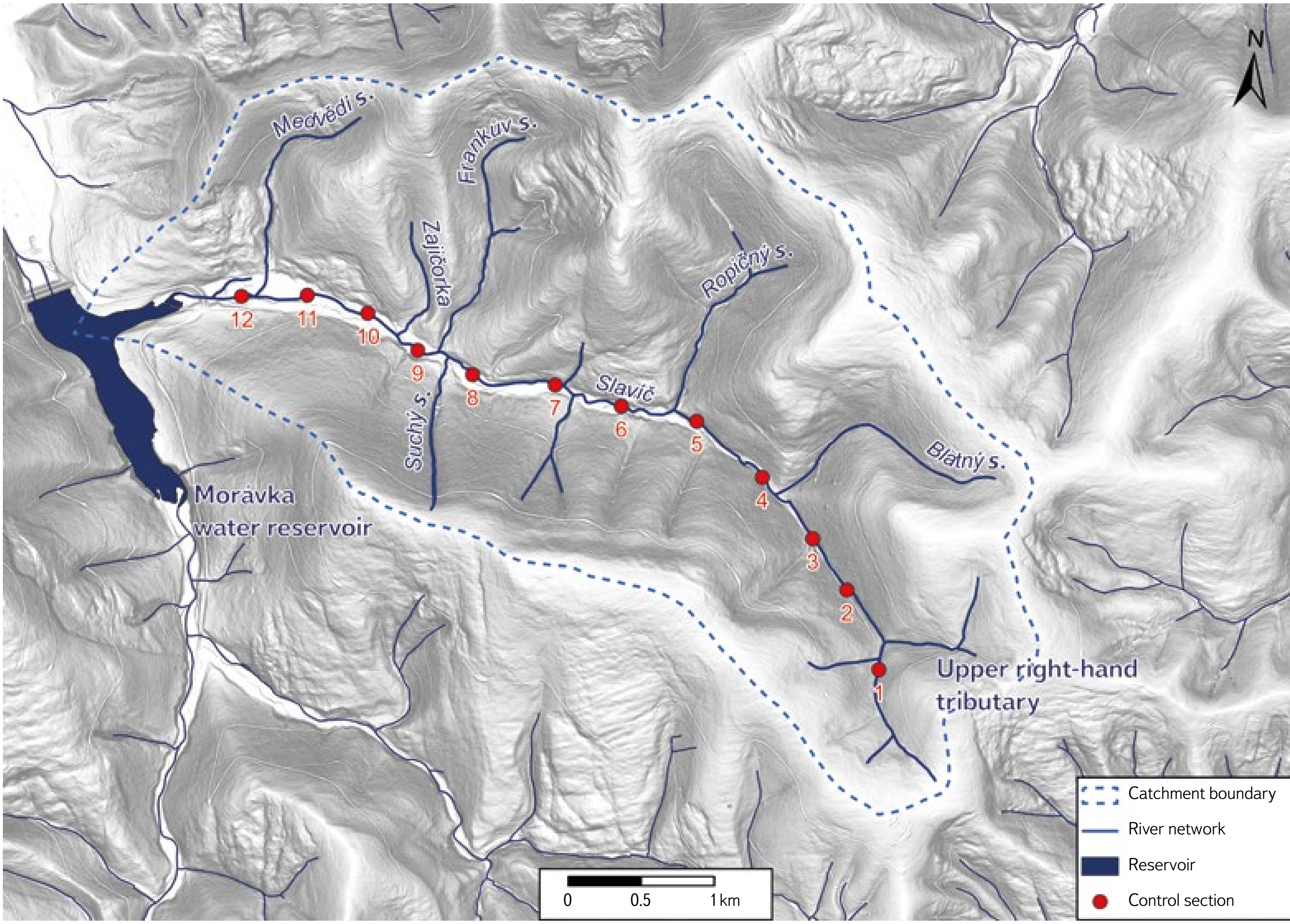

Fig. 2. Sampling points on the Slavíč river using Wolman granulometric measurement method

Due to the steepness of the slopes, a number of slope deformations in the form of landslides and streams occur in the entire Slavíč catchment, which are both calm and active, i.e., they represent the source area of alluvial material gradually transferred to the Slavíč watercourse.

The Slavíč stream originates on the border of the villages of Morávka and Horní Lomná at an altitude of about 900 m (*Fig. 1*). It flows through a gravel bed and its length is 7.85 km. It empties from the right side into the Morávka reservoir at an altitude of 505 m above sea level. There is a CHMI gauging station on the watercourse, for which the N-year flows were derived according to ČSN 75 1400 in the range of 5.01–65.8 $m^3 \cdot s^{-1}$ (*Tab. 1*).

Tab. 1. Slavíč stream discharges with N-year return period (Source: CHMI)

N-year discharges [$m^3 \cdot s^{-1}$]				
Q1	Q5	Q10	Q50	Q100
5.01	17.70	25.80	51.40	65.80

In connection with the main topic of this study, i.e. the modelling of erosion and connectivity of sediments, it is also necessary to mention anthropogenic interventions in the Slavíč catchment, which have a direct influence on its present-day form and the processes in it. In the past, the watercourse was affected by timber rafting and torrent regulation. For the purpose of timber rafting, a splash dam was also built in the upper part of the Slavíč catchment, which served as a control dam, with a length of about 12 m. It was destroyed by a flood in 1880. Other regulatory modifications that also helped timber rafting are dry-stacked stone walls [8]. Practically along its entire length, the stream runs along an asphalt road, so there are culverts, bridges, footbridges, and various bank reinforcements. There are retention barrages and stabilization drops in the watercourse itself. Of the natural elements, there are mainly rock steps, gravel bars, and river wood. Bank erosion and scours can also be observed.

METHODS

Nowadays, there is a number of sophisticated software tools that allow us to model various scenarios based on our chosen requirements and base data. One of these tools for identifying connectivity in the basin is the Connectivity Index Target (CI), which works on the ArcGIS ArcMap platform in the form of a so-called toolbox [9]. The model enables the identification of sediment

Tab. 2. Base layers which were used for individual analyses

Layer name	Digital model of the relief of the Czech Republic, 4th generation	Orthophoto of the Czech Republic	River network and basin boundaries	Digital vector database of the Czech Republic ArcČR®	Bank scour, rock outcrop, gravel bar, wood jam, bank reinforcement, stabilization drop, retention barrage, boulder chute, culvert
Data source	Czech Office for Surveying, Mapping and Cadastre (ČÚZK)	Czech Office for Surveying, Mapping and Cadastre (ČÚZK)	Digital Base of Water Management Data (DIBAVOD)	ARCDATA PRAHA – ArcČR®	Terrain mapping – GPS eTrex® 30x
Coordination system	S-JTSK / Krovak East North, Baltic Height System – after alignment	S-JTSK / Krovak East North	S-JTSK / Krovak East North	S-JTSK / Krovak East North	S-JTSK / Krovak East North
Layer format	Raster	Raster	Vector	Vector	Vector
Resolution	5 × 5 m grid	0.2 × 0.2 m grid	-	-	-
Year of acquisition / update	2009–2013	2016–2020	2006–2010	2023	2018–2020
Accuracy	Absolute mean height error of 0.3 m in open terrain and 1 m in forested terrain	-	-	-	1 m

source areas and the potential connectivity of sediment transport into a channel network. The input data includes a modified, hydrologically correct Digital Relief Model (DMR), a generated river network from the DMR with an envelope layer of an average channel width of 5 m, and a layer of vectorized *land use* categories (LU), specifically based on an orthophoto from 2016 (ČÚZK – Czech Office for Surveying, Mapping and Cadastre). The result is a map with a rendered colour scale of potential connectivity in a basin, or by connectivity values that are dimensionless. However, depending on coarser resolution, the model cannot identify disconnectivity inside and outside the stream channel (retention barrages, bank reinforcements), which have a smaller area than the individual pixels of the grid. Therefore, when researching connectivity, it is important to know the natural and anthropogenic structures in the basin. Natural and anthropogenic structures located in the channel were identified by a simple method – fluvial-geomorphological mapping of the channel and the surrounding area. To record the occurrence of individual structures, a handheld GPS, type *eTrex*® 30*x*, and a measuring tape for measuring the dimensions of individual structures were used.

Verifying connectivity in the context of the whole catchment was also carried out using erosion empirical formulas (USPED), DMR hydrological analyses (Terraflow for GRASS GIS), and dynamic erosion models (SIMWE for GRASS GIS).

The USPED (Unit Stream Power-based Erosion Deposition) method provides us with a detailed insight into the erosion threat in the area – it defines the areas of sediment collection and accumulation in a basin. The input data includes the Digital Relief Model (DMR) layer, Soil Maps 1 : 50 000, and the R factor

Tab. 3. Results of fluvial-geomorphologic mapping in the Slavíč channel network

Watercourse	Catchment area [km²]	Length of the main stream [km]	Length of the main stream [m]	Bank scour [m²/počet]	Gravel bar [m²]	Rock outcrop (number)	Wood jam (number)	Bank reinforcement [m]	Bank reinforcement per length of watercourse [%]	Stabilization drop (number)	Stabilization drops per km of watercourse (number)	Retention barrage (number)	Retention barrages per km of watercourse (number)	Boulder chute (number)	Boulder chutes per km of watercourse (number)	Culvert (number)	Culverts per km of watercourse (number)
Slavíč	17.4	7.8	7,780.6	201.0	1,801.5	74	22	3,745.0	48.1	13	1.7	2	0.3	1	0.1	2	0.3
Upper right-hand tributary	0.8	0.8	754.7	-	731.0	-	3	-	-	1	1.3	-	-	-	-	1	1.3
Blatný stream	1.7	1.8	1,827.2	8.9	671.0	3	3	-	-	1	0.5	1	0.5	-	-	1	0.5
Ropičný stream	2.4	1.4	1,434.0	355.6	1,259.2	5	16	454.4	31.7	-	-	1	0.7	1	0.7	-	-
Nameless left-hand tributary	0.7	0.8	816.9	-	-	-	-	-	-	-	-	1	1.2	-	-	-	-
Suchý stream	0.5	1.1	1,089.0	34.6	129.0	-	2	-	-	-	-	4	3.7	-	-	1	0.9
Frankův stream	1.9	2.0	1,981.5	78.6	66.8	3	6	-	-	-	-	-	-	-	-	-	-
Zajičorka	0.5	0.9	900.5	-	-	-	-	-	-	-	-	-	-	-	-	1	1.1
Medvědí stream	1.2	1.7	1,696.3	14.1	58.0	1	6	-	-	1	0.6	1	0.6	-	-	3	1.8

Note: Natural/anthropogenic forms with explanation in parentheses (number) – means a single occurrence of the given form/data in parentheses, e.g. (m) means that it is the length of the given form, e.g. bank reinforcement. To show the representation of individual forms along the length of the stream, for anthropogenic forms, a recalculation of the percentage occurrence of the given form per 1 km of the stream was done (columns distinguished by italics)

(Regionalized Erosion Efficiency Factor of Torrential Rain) and is used to calculate the long-term soil loss due to water erosion using the USLE equation (CHMI, VÚMOP). Sheet flow was assumed for the calculation. The calculation itself was performed in the ArcGIS Pro environment using the determined runoff using the Multiple Flow Direction (MFD) method. This method can identify source and sedimentation areas and potential lines of sediment connectivity; however, it is not an erosion model in the true sense of the word in terms of implemented numerical and analytical methods.

The SIMWE (SIMulated Water Erosion) model is part of the GRASS GIS geographic information system. Originally it was only available as an add-on module; since version 6.2.2, it is implicitly included in hydrological analysis tools. The same data enter the model as the above-mentioned erosion model, supplemented with coefficients for surface runoff calculated according to McCuen [10, 15] as a function of vegetation cover and soil hydrologic group and precipitation data. Its output is the spatial distribution of steady sediment flow rate, sediment concentration, and soil erosion/deposition rate. SIMWE is a fully distributed model whose resolution depends on the resolution of the input rasters. The r.sim.water module enables a distributed solution of infiltration and surface runoff. The surface runoff is solved in 2D using the Saint Venant equations and the diffusion wave approximation. The sediment outflow is solved by the r.sim.sediment module [6]. The model produces outputs in raster form.

Base layers for individual analyses are shown in *Tab. 2*.

Twelve sections of 200 clasts each were measured in the main flow according to Wolman [20] using the granulometric method (*Fig. 2*). Clasts were sampled randomly from the upper layer from the grain size ($D \geq 2$ mm), for which the length of the axis *b* was always measured. In each section, the channel slope and the geometric parameters (the width and depth of the full channel state) were also measured with an accuracy of 0.1 m. Direct and regularly formed sections of the watercourse (preferably without anthropogenic modifications) were selected for sampling. To determine downstream trends, the percentiles D_5, D_{25}, D_{50}, D_{95} were calculated from the measured values of the *b* axis lengths (mm) from the entire sample of each section [4]. A percentile is a grain size value that is given by a cumulative distribution curve for a given percentage of "finer particles". So, for example, "$D_{50} = 30$ mm" means that 50 % of the particles in the entire sample have a grain size smaller than 30 mm. D_{50} is the median of the distribution curve that divides the sample into two equal parts. The D_{25} and D_{75} percentiles are quartiles.

In addition, in order to determine the potential energy of the riverbed for sediment transport, Stream Power Index (SPI) was calculated. Main factors determining the resulting SPI value include the longitudinal slope of a riverbed (S) and the size of a contributing sub-basin. SPI was calculated to find the potential energy of the stream at the potential flow of Q_1. SPI is denoted by the unit ω (W^{m-2}) and, according to Bagnold [11], bears the following relation:

$$\omega = \frac{QS\rho g}{W}$$

where:

Q	is	flow rate ($m^3 \cdot s^{-1}$)
S		slope (m/m)
ρ		water density (1,000 $kg \cdot m^{-3}$)
g		gravitational acceleration ($m \cdot s^{-2}$)
W		channel width before rated flood (m)

For high-gradient flows, a direct relationship between the SPI during the full channel state (ω_{bf}) and the catchment area (A) with an area of < 10 km^2 was demonstrated, when the parameter (ω_{bf}) was simplified to the following form:

$$\omega_{bf} \approx \frac{AS\rho g}{W_{bf}}$$

where:

A is the catchment area (km^2)
W_{bf} full channel width,

which reflects the downstream increase in flow rate:

$$Q_{bf} \approx cA^d$$

However, in the research conducted by Galia and Škarpich [12, 13], a modified relationship was used for the small basins of the Lichnovský, Lubina, Malý škaredý, and Veřovický streams, which have a similar catchment area and similar morphological, hydrological, and geological parameters as the Slavíč catchment. Therefore, the same relationship was used in this case:

$$Q_2 = Q_{bf} = 0{,}55A^{0{,}88}$$

RESULTS

The highest connectivity was manifested near the river network, especially in the tributary areas, where the slopes directly connect to the channel. From the point of view of LU influence, clearcuts were the most significant, which indicate artificially accelerated transport of material into the riverbed. Here, the slopes reach high slope values and the river floodplain has not developed. On the other hand, the lowest connectivity was found in the areas of the individual sub-basins, where the slopes are low and transport of material is probably quite limited. Low connectivity is also characterized by the river floodplain, which forms a natural temporary barrier for the transport of sediments into the channel. In the case of the main watercourse, the south-facing slopes are better connected to the bed because the left bank of the watercourse has a wider floodplain than the right bank. The resulting connectivity map is shown in *Fig. 4*.

Fluvial-geomorphological mapping revealed a large number of natural and anthropogenic structures in the channel network of the Slavíč catchment. The mapping results are presented in *Tab. 3*.

The results of the granulometric method showed downstream refinement of clasts with a grain size of D_{95} with a sudden increase in the fourth section. On the other hand, the D_5 percentile values increase downstream with a slight fluctuation, and a sudden drop was also manifested in the fourth section. SPI generally shows higher values in the upper part of the channel, however, depending on the slope, these values fluctuate considerably. A sudden increase was evident in the second and tenth sections (*Fig. 3*).

When compared to the outputs of erosion models, it is possible to see that the modelling of mountain basins gives very similar results even when using different methodologies (static vs. dynamic models), which correlate with the results of sediment connectivity modelling. All three types of models used can reliably model potential sites of sediment concentration and contributing areas.

Erosion modelling by USPED and SIMWE shows the sensitivity of the mountain (mainly forested) catchment model especially in open terrain. Due to the characteristics of the terrain relief with large slopes and their local changes, the effects of other factors (land cover, soil, and erosion efficiency of rain) are erased. The output of the USPED method for the Slavíč catchment is shown in *Fig. 5*. The result of the SIMWE model in the form of soil erosion/deposition for the study area is shown in *Fig. 6*.

The combination of Connectivity Index Target, USPED and SIMWE models, supplemented by fluvial-geomorphological mapping of the riverbed and the surrounding area, helps us connect the methods of identifying erosion areas as well as hydrological connectivity with sediment transport connectivity, which is strongly linked to longitudinal and lateral disconnective structures in the riverbed. All the models used are a static image of the real situation in the basin and are dependent on the details and accuracy of the input data. The Connectivity Index Target model only deals with connectivity and sediment movement routes in the basin; the USPED and SIMWE models also work with hydrological connectivity. The advantages of the individual models lie in the fact that they are not demanding on the amount of input data and relatively fast calculation. For comparison, in the outputs of the Connectivity Index Target and SIMWE models, the potential routes of sediment transport are clearly visible, and both are also able to identify the deposition zones, which are shown in blue in both models. Moreover, the SIMWE model can recognize out-of-channel erosion, which is shown in red. The resulting USPED map differs from the other two models in that it has a clearly identifiable influence of forest roads, which act as erosion paths for sediment transport.

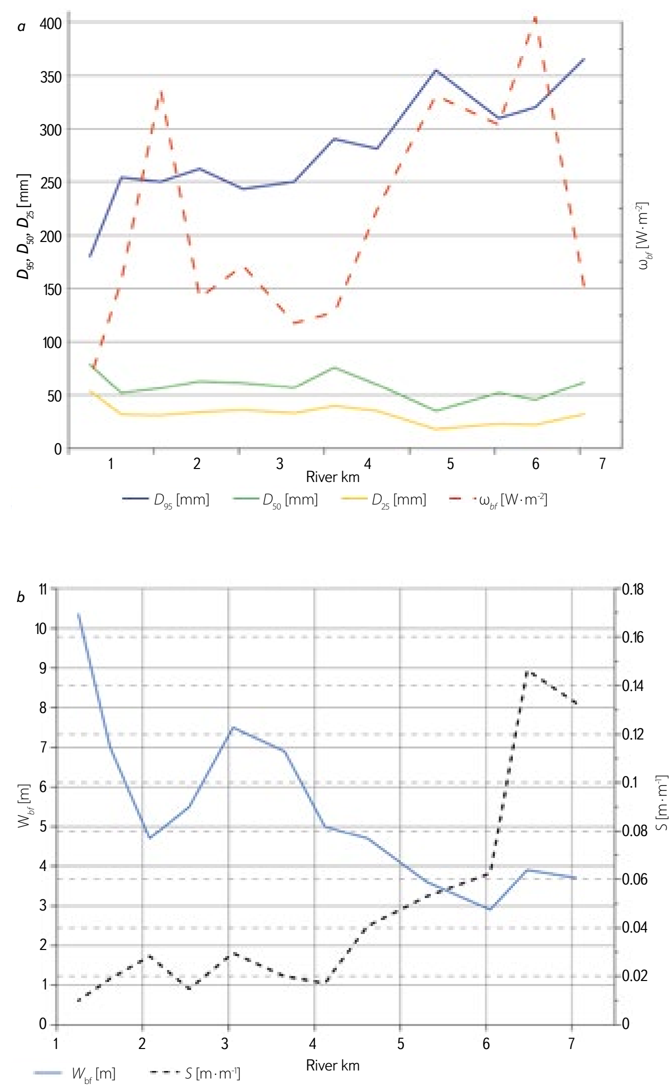

Fig. 3. a) Downstream grain size trends of sediments D_{25}, D_{50}, D_{95} and SPI; b) downstream trends of width (W_{bf}) and slope (S) of the Slavíč channel

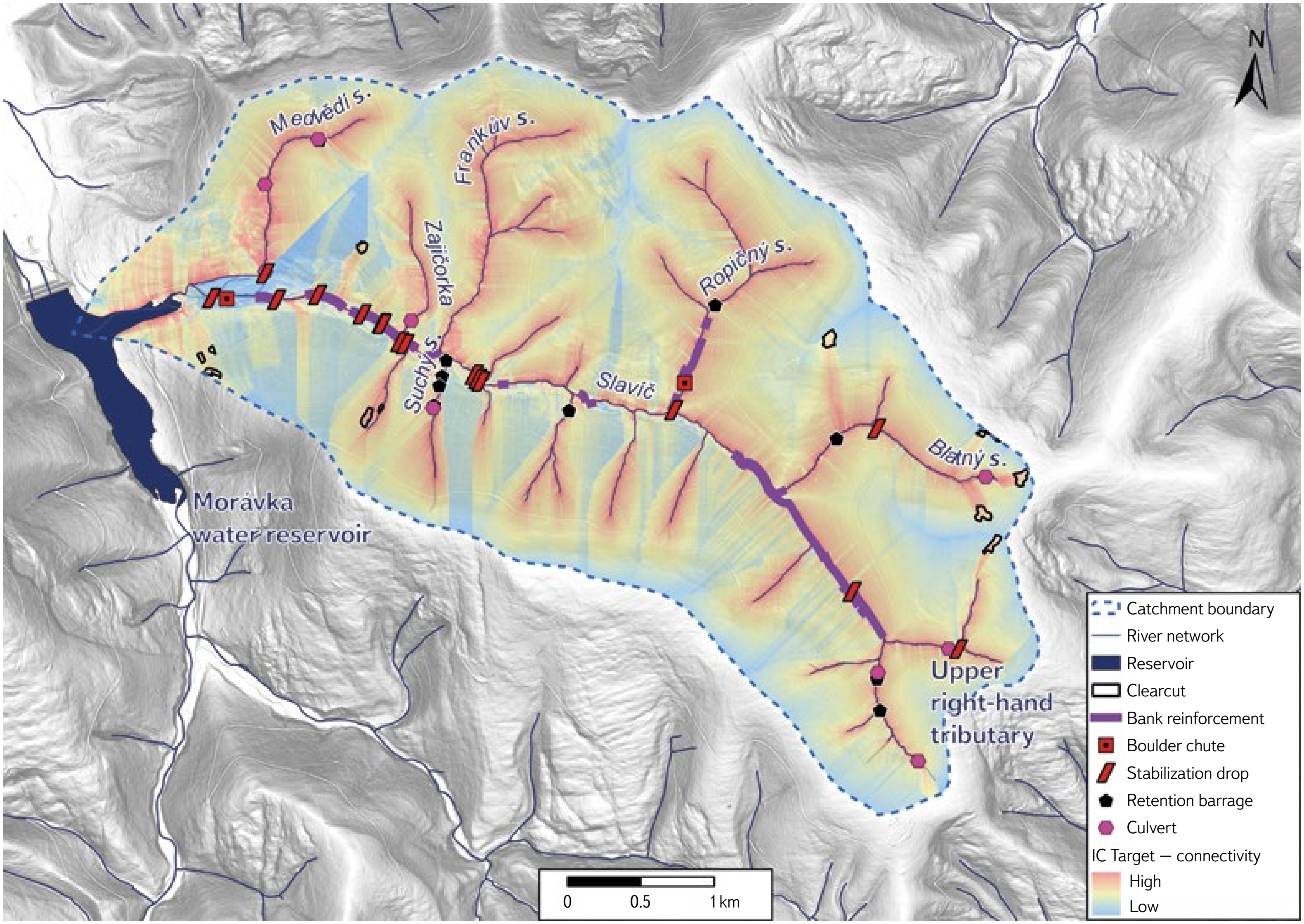

Fig. 4. Output connectivity map of the Slavíč catchment, which are combined methods of Connectivity Index Target, identified clearcuts, and terrain mapping

DISCUSSION

In this study, modelling approaches were used in combination with fluvial-geomorphological mapping and the granulometric method. Each of these approaches has its advantages and disadvantages. Modelling software gives us a quick insight into potential connectivity in a basin; however, for proper interpretation, it needs to be complemented by other methods, in this case field survey. The field survey revealed a lot of out-of-channel disconnectivity affecting sediment transport. This method brings very detailed results when done correctly, but it is quite time-consuming. Last but not least, it is important to obtain data on the grain size of the sediments, from which, in combination with the previously mentioned methods, it is possible to interpret, for example, the effect of disconnectivity on the downstream connectivity of sediments, to reveal sediment starvation, etc. The disadvantage of granulometric methods also lies in the time-consuming nature of not only analysing clasts in the field, but also in the subsequent statistical processing of the measured values.

By modelling connectivity using the Connectivity Index Target (CI) tool, it was proven that the slopes are quite well connected with the riverbeds in terms of sediment transport. High connectivity values in the tributary area are mainly due to high values of slope gradients, in many places supported by anthropogenic LU change. Clear-cutting has a negative effect on the stability of the slopes, which are easily eroded, and thus a large amount of wood material, sediments and fine soil particles are transported into the watercourse, where, especially during the period of increased rainfall, gully erosion occurs and the soil is flushed into the riverbed. The river floodplain located especially in the lower part of the main stream acts as a natural buffer zone, which due to its low slopes limits the transport of material from the slopes to the channel [2]. However, a major problem in the context of the entire Slavíč catchment is the occurrence of the Morávka reservoir, where all material transported from the higher parts of the basin ends its route.

In the Slavíč catchment, field mapping revealed a large number of disconnectivities, mainly of anthropogenic origin. The most significant disconnective elements include retention barrages located especially on tributaries (*Fig. 4*). In certain cases, e.g. in the Suchý stream, there is a large number of old barrages whose retention space is already largely filled up, and the original retention function is thus significantly limited. As for the supply of sediments to the riverbed, the most important structures are bank scours, which are mostly situated on tributaries. These scours are of an active nature and thus supply the riverbed with material in the case of increased flows. Accelerating zones occur most often in the main bed in the form of rock outcrops and thus make transport more efficient. The numerous occurrence of these rock outcrops can be attributed to the cumulative effect of anthropogenic

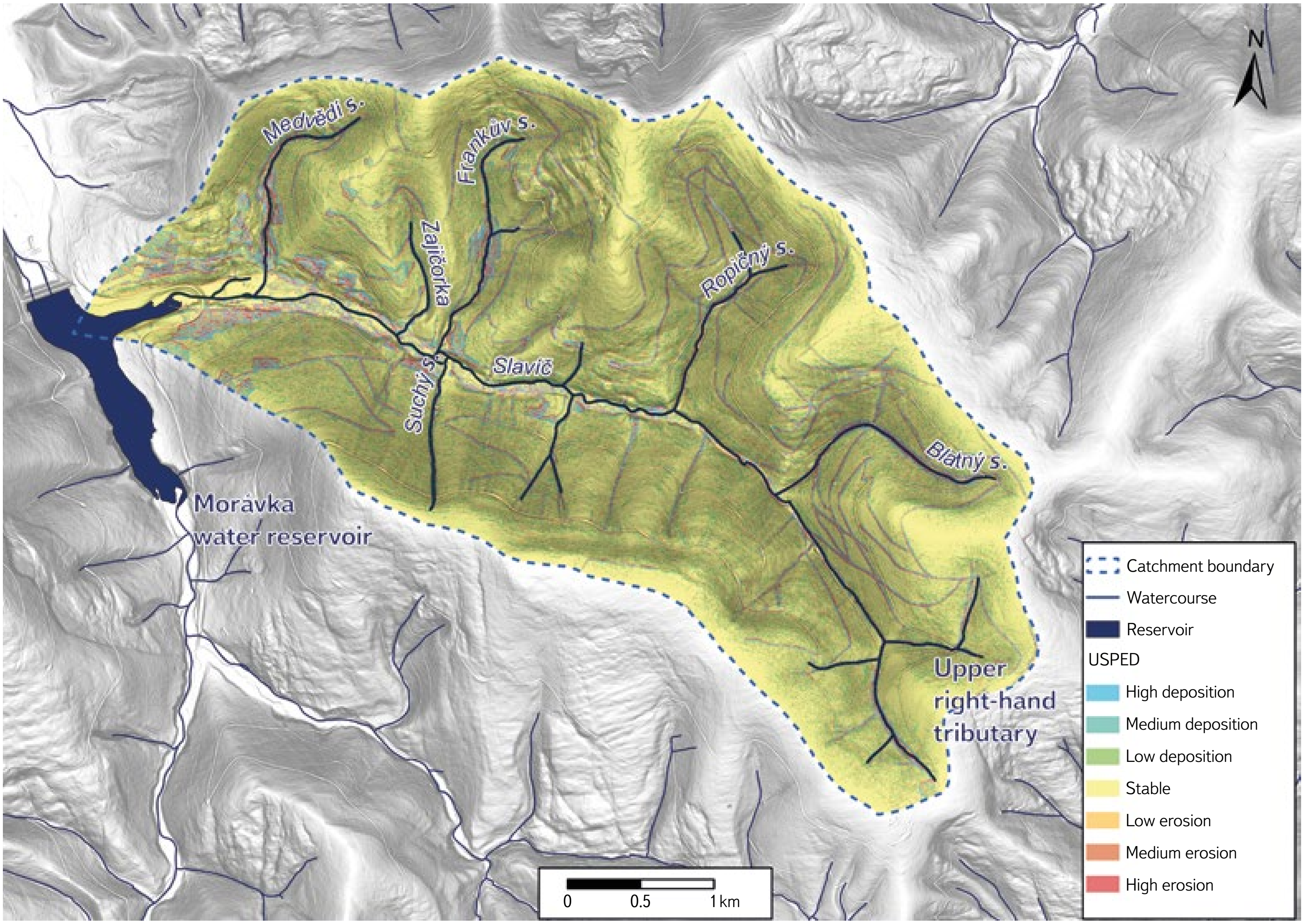

Fig. 5. Resulting map of erosion and accumulation rate using the USPED method within the Slavíč catchment

structures, especially bank reinforcements, which prevents the supply of material from the banks to the riverbed, and thus the gradual washing out of sediments and their downstream coarsening occurs. Stabilization drops also have an effect on the coarsening of sediments, which was found in the research conducted by Galia et al. [12]. However, stabilization drops do not always mean slowing down of sediment transport; by canalization and channel modifications, the transport can be accelerated, which was found during research on the Malý Lipový and Bystrý streams [13, 14]. Last but not least, the accumulation zones are represented by gravel bars, which are dynamic and during the flood season they regularly overflow and transport material further down the stream.

A natural feature of torrents is the episodic transport of material, especially during floods, and therefore it is important to look at the transport of bed-load from a long-term perspective, e.g. in the context of several consecutive flood events during the last decades. The main stream bed has a high potential energy for sediment transport in the upper part. Unfortunately, this is limited by low flows under normal hydrological conditions or during dry season. In such a period, the bed can be described as a channel with a limited transport capacity [17]; there is a sufficient amount of material, but no energy to transport it.

The SIMWE model is a relatively powerful model; its main advantages include multi-scale simulation, which, within the small resolution of the study area, allows for a more detailed solution of a certain part of the area using dynamic sampling points, so-called walkers. Another advantage is the modification of the wave approximation equations for higher stability of the solution in DMR areas with a lower slope and hydraulic gradient or in areas with a difficult to determine flow direction, e.g. in a terrain depression.

The SIMWE model for GRASS GIS represents a suitable tool for the evaluation of rainfall-runoff relations together with erosion and transport-accumulation processes. However, it is necessary to verify its outputs; the version for Linux OS shows better calculation stability than the version for OS Windows, which can be reflected in the functionality of the program itself and sometimes also in the actual numerical values of the results. For more detailed analyses, it will also be appropriate to use the simulation of sediment transport in the hydraulic models HEC-RAS and MIKE 11, while the latest version of the HEC-RAS model offers increasingly proficient tools in this regard.

CONCLUSION

In conclusion, it can be stated that, among other things, by combining both methods (i.e. spatially based modelling of potential connectivity using GIS software

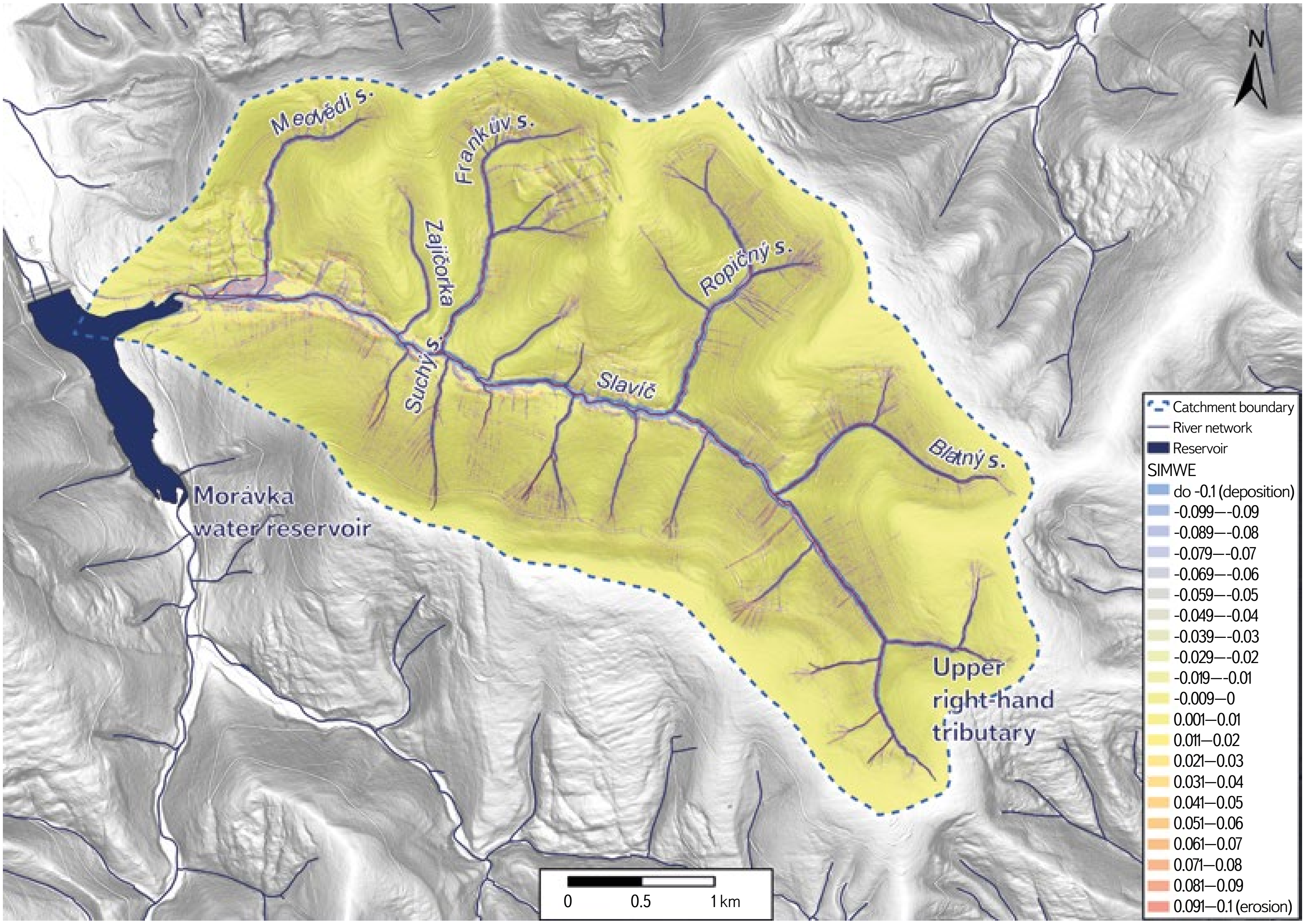

Fig. 6. Model output of SIMWE for GRASS GIS catchment presented in ArcGIS Pro representing erosion and deposition rates within the Slavíč river catchment

and terrain mapping) it is possible to deal with the connectivity of sediments in mountain basins effectively. However, the research verified the importance of fluvial-geomorphological mapping, which brought detailed results about the occurrence of natural and anthropogenic structures in the riverbed and their influence on the morphology and downstream trends of sediments; generalized input geographic data and model results showing potential connectivity of sediments do not give a comprehensive picture of the real state of the basin and the watercourse itself. The Slavíč catchment is a significantly anthropogenically modified basin, especially in the area of the main stream. However, some tributaries (e.g. Frankův stream) have very little anthropogenic modification, and there is a semi-natural character of the bed with a lot of organic material. The tributaries with their numerous bank scours serve as the main sediment source zones. Connectivity modelling together with the results of field mapping provided an insight into erosion-transport-accumulation conditions in the basin and, simultaneously, showed the degree of anthropogenic influence. Analyses on other pilot catchments (Slučí, Sokolí, Suchý stream in the Černá Opava catchment, and Svinný stream in the Osoblahy catchment) will undoubtedly bring interesting data for comparison, among other things with regard to the different lithological and geomorphological conditions of the catchment.

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Fig. 7. Anthropogenic disconnectivity within the Slavíč catchment: a) old embankment on the upper part of the Slavíč stream; b) stabilization step on the lower part of the Slavíč stream; c) retention barrier build on the Ropičný stream; d) old retention barrier on the source area of the Slavíč stream

References

[1] BRIERMAN, P. R., MONTGOMERY, D. R. *Key Concepts in Geomorphology.* New York: Freeman, 2014.

[2] FRYIRS, K. A., BRIERLEY, G. J., PRESTON, N. J., KASAI, M. Buffers and Blankets: The (Dis)connectivity of Catchment-Scale Sediment Cascades. *Catena*. 2007, 53, pp. 49–67.

[3] KONDOLF, G. M. Hungry Water: Effects of Dams and Gravel Mining on River Channels. *Environmental Management*. 2017, 21, pp. 533–551.

[4] BATISTA, P. V. G., LACEBY, J. P., DAVIES, J., CARVALHO, T. S., TASSINARI, D., SILVA, M. L. N., CURI, N., QUINTON, J. N. A Framework for Testing Large-Scale Distributed Soil Erosion and Sediment Delivery Models: Dealing with Uncertainty in Models and the Observational Data. *Environmental Modelling & Software*. 2021, 137, 104961. 494 pp. ISBN 1429238607.

[5] CHO, S. J., WILCOCK, P., GRAN, K. Implementing Landscape Connectivity with Topographic Filtering Model: A Simulation of Suspended Sediment Delivery in an Agricultural Watershed. *Science of the Total Environment*. 2022, 836, 155701.

[6] UNUCKA, J. Modelování vlivu lesa na srážkoodtokové vztahy a vodní erozi s pomocí GIS. *Vodní hospodářství*. 2008, 7, pp. 225–231.

[7] HOLUŠA, O. et al. *Lesy Karpat České republiky*. Vydání první. Brandýs nad Labem: Ústav pro hospodářskou úpravu lesů Brandýs nad Labem, 2020. ISBN 978-80-88184-32-4.

[8] POLÁŠEK, J. Nádrže na plavení dřeva v povodí řeky Morávky. *Informační zpravodaj ČAS, pobočky pro severní Moravu a Slezsko*. 2007.

[9] CAVALLI, M., TREVISANI, S., COMITI, F., MARCHI, L. Geomorphometric Assessment of Spatial Sediment Connectivity in Small Alpine Catchments. *Geomorphology*. 2013, 188, pp. 31–41.

[10] CHANG, M. *Forest Hydrology. An Introduction to Water and Forests*, Third Edition. 2013. 598 pp. ISBN 978-1-4665-8667-3.

[11] BAGNOLD R. A. An Approach to the Sediment Transport Problem from General Physics. *US Geological Survey Professional Paper*. 1966, 422-I, pp. 1–37.

[12] GALIA, T., ŠKARPICH, V., RUMAN, S. Impact of Check Dam Series on Coarse Sediment Connectivity. *Geomorphology*. 2021, 377, 107595.

[13] GALIA, T., ŠKARPICH, V., RUMAN, S., MACUROVÁ, T. Check Dams Decrease the Channel Complexity of Intermediate Reaches in the Western Carpathians (Czech Republic). *Science of the Total Environment*. 2019, 662, pp. 881–894.

[14] GALIA, T., ŠKARPICH, V. Do the Coarsest Bed Fraction and Stream Power Record Contemporary Trends in Steep Headwater Channels? *Geomorphology*. 2016, 272, pp. 115–126.

[15] McCUEN, R. H. *Hydrologic Analysis and Design*. Upper Saddle River: Prentice Hall, 2005. 859 pp. ISBN 0-13-142424-6.

[16] WOLMAN, M. G. A Method of Sampling Coarse Bed Material. *American Geophysical Union Transactions*. 1954, 35, pp. 951–956.

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Comparison of VTEI citations in the Web of Science and Scopus databases

LIBOR ANSORGE

Keywords: VTEI — citation analysis — Scopus — Web of Science — database coverage

ABSTRACT

A journal's citation rate is an indicator of its quality. The presented study builds on analyses of the citation rate of the VTEI journal published in previous years. A new analysis of VTEI journal citations using Web of Science data was conducted and the citation analysis using Scopus data was updated. A comparison of citations in both bibliometric databases was performed to determine the degree of overlap between the two databases and whether it is more appropriate to monitor the citation rate in one or both bibliometric databases. The citation analysis confirmed a high degree of overlap between the two databases. For monitoring the citation rate of the VTEI journal, it is sufficient to track citations in the Scopus database; unique citations found in the Web of Science database represent only a small portion of all citations. The citation analysis also confirmed the increasing trend in the number of citations of articles published in the VTEI journal, which was noted in previous years.

INTRODUCTION

The VTEI journal readers may already be used to citation overviews of the VTEI journal over recent years [1–3] based on Elsevier's Scopus citation database. As stated by Teixeira da Silva [4], one could argue that no bibliometric analysis is complete without using the "titans" of bibliometric databases [5], i.e. the Scopus and Web of Science databases. Therefore, this year, the summary of VTEI journal citations is done in the form of a comparison of the citations in these two main bibliometric databases, despite the fact that these databases cannot be considered a global overview of scientific knowledge [6] and, for example, Google Scholar provides much greater coverage [7, 8].

The Web of Science and Scopus databases were chosen by the Government Research, Development and Innovation Council (R&D&I Council) as source databases for bibliometric assessments in the M2 module according to the so-called Methodology 17+ [9]. A number of studies in the past have shown that the two databases overlap considerably [10, 11]. Since the use of two paid databases for bibliometric studies is relatively expensive, even the R&D&I Council refrains from using both databases in parallel and uses Scopus for the evaluation of humanities, with Web of Science for the evaluation of other fields.[1]

The aim of this study is to assess both databases from the point of view of the journal publisher, which is not indexed in any of the mentioned databases. The main research question that this study tries to answer is whether it is sufficient to monitor the journal citation in one of these databases, or whether it is more appropriate to monitor it in both bibliometric databases and combine the results.

DATA AND METHODOLOGY

Data collection was carried out in several steps on 7–11th February 2024; consequently, the data was continuously updated until 2nd March 2024. First, data from both databases was collected and stored in a spreadsheet. The results from both databases were then compared and if a citation from one database was missing from the other, the source file and source database were checked. In this way, several citations that were not found during the initial search were added to each database.

The procedure described in the 2022 citation analysis [2] was used to collect data from the Scopus database using the following search query:

REF ("technicko-ekonomick* inf*") OR REF ("Vodohosp* techn*") OR REF ("Wat* manag* tech* econ* inf*") OR REF ("Wat* manag* tech* and econ* inf*") OR REF (vtei) OR REF ("Vodoh* Tech.-Ekon* Inf*") OR REF (10.46555/vtei)

Using this query, 181 records were found, of which only 153 cite the VTEI journal. After analysing the Web of Science data, the search query was expanded to:

REF ("technicko-ekonomick* inf*") OR REF ("Vodohosp* techn*") OR REF ("Wat* manag* tech* econ* inf*") OR REF ("Wat* manag* tech* and econ* inf*") OR REF (vtei) OR REF ("Vodoh* Tech.-Ekon* Inf*") OR REF (10.46555/vtei) OR EID (2-s2.0-84908355749) OR EID (2-s2.0-85160256067) OR EID (2-s2.0-85021403793) OR EID (2-s2.0-14844301688) OR EID (2-s2.0-27544497058)

On 2nd March 2024, the query returned 191 results in the Scopus database. Of these, only 163 cite the VTEI journal.

A procedure based on the search of cited documents was used to collect data from the Web of Science database. In the Web of Science web interface, the following query was made to all databases on the Cited References tab: 10.46555/VTEI.* (Cited DOI) or VODOHOSPOD* TEC* (Cited Work) or VTEI (Cited Work)

By analysing the results found, the search query was gradually enlarged to:

10.46555/VTEI.* (Cited Work) or VODOHOSP* TEC* (Cited Work) or Wat* Manag* Tech* Econ* Inf* (Cited Work) or Journal of Vodohosp* (Cited Work) or Vodohosp* tech-nicko-ekonom* inf* (Cited Work) or VTEI Vodohosp* (Cited Work) or TECH* EKON* INF* (Cited Work) or Vodn* hosp* VTEI (Cited Work) or Vodoh* Tech*-ekon* Inf* (Cited Work) or VTEI* (Cited Work)

This query returned 123 cited references, which were cited by 122 papers indexed in the Web of Science database. Similar to the Scopus database, all citations were manually checked to ensure they actually cite the VTEI journal, and only one citation was discarded due to an incorrect VTEI citation record.

After analysing the Scopus database, the query was complemented to: 10.46555/VTEI.* (Cited DOI) or VODOHOSPOD* TECH* (Cited Work) or VTEI* (Cited Work) or Water Manag* Tech* Econ* Inf* (Cited Work) or Journal of Vodohosp* (Cited Work) or Vodohosp* tech-nicko-ekonomicke inf* (Cited Work) or VTEI Vodohosp* (Cited Work) or Vodni hospodarstvi VTEI (Cited Work) or TECHN EKONOM INFORM (Cited Work) or Vodoh. Tech.-ekon. Inf. (Cited Work)

The resulting query offered 126 cited references, which were cited by 124 works indexed in Web of Science. Eight additional citations were manually added that were found in the Scopus database but were not retrieved by the search query in Web of Science, although manual inspection found these citing papers. On 3rd February 2024, the query was applied for the last time. One of the issues with the Web of Science database is that the query returned different numbers of results on different days.

The query results were exported to a spreadsheet and the same citing and cited articles were linked in it. A key consisting of information on the year of publication of the citing article, the DOI of the citing article, and the identifier of the cited article was created to link the citing articles. The DOI for articles assigned to it, or a combination of year of publication, volume, issue, and page range, was used as the identifier of a cited article. Citing articles that failed to be matched automatically were checked manually in both databases in two steps. In the first step, articles were searched using their title, and in the second step, they were searched according to the source (journal) and the year in which they were published. Thanks to this pairwise linking, several overlooked citations were found and added to the list.

RESULTS AND DISCUSSION

In total, 163 citing articles were found in the Scopus database, which cited the VTEI journal 227 times, and 133 citing articles were found in the Web of Science database, which cited the VTEI journal 179 times. *Fig. 1* shows the number of citing articles in 2009–2023; *Fig. 2* shows the number of citations in the same period. Citations before 2009 are very sporadic in both databases. There is no point in displaying the data for the year 2024 as the analysis is carried out at the beginning of the year and the data for the year 2024 is not yet complete. The graphs confirm that the course of citations in both databases has a similar development. They also demonstrate that the higher number of citations in the Scopus database is a matter of the last five years. For the sake of completeness, it is appropriate to add that in the period before 2009 the number of citations and citing articles in both databases was similar.

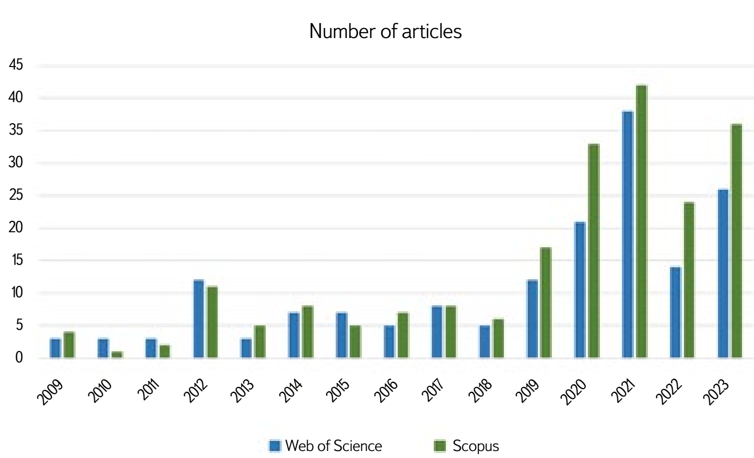

Fig. 1. Number of articles in the Web of Science and Scopus databases that cite the VTEI journal

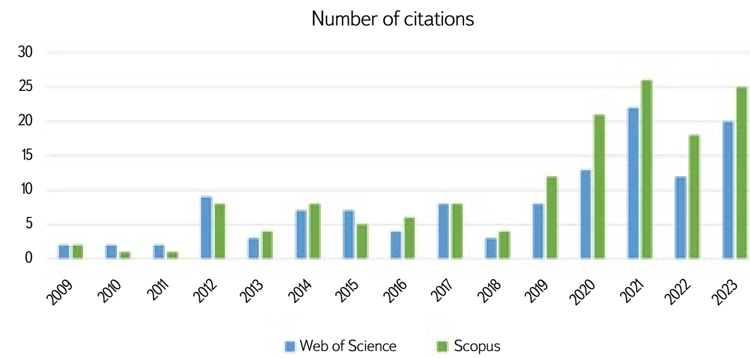

Fig. 2. Number of citations of VTEI journal indexed in Web of Science and Scopus databases

The overlay of both databases is shown in *Tab. 1.* In the Scopus database, one article [12] was found under two EIDs (2-s2.0-72149085715 and 2-s2.0-84898078896). In reality, 162 articles recorded in the Scopus database cite the VTEI journal a total of 225 times.

The total number of unique citations is therefore 240, of which 93.75 % is covered by the Scopus database and 74.6 % by the Web of Science database. If only the Scopus database were monitored, the 15 unique citations in Web of Science make up 6.7 % of the citations found in the Scopus database. In contrast, if only the Web of Science database were monitored, the 61 unique citations in the Scopus database make up 34.9 % of the citations in the Web of Science. There is thus a relatively simple answer to the main research question, i.e. whether it is possible to monitor citations in only one database, or whether it is necessary to monitor citations in both databases: simply monitor the citations in the Scopus database..

Tab. 1. Number of citations of the VTEI journal in the Scopus and Web of Science databases

Number of citations	**Scopus**	**WoS**
Total	225 + 2*	179
Those found in the other database	166 + 2*	164
Those not found in the other database	61	15

* In Scopus, there is a duplicate record of one article with two EIDs: 2-s2.0-72149085715 and 2-s2.0-84898078896

The second part of the analysis focused on sources of unique citations in individual bibliometric databases. There are 15 unique citations in the Web of Science database. A summary of them is presented in *Tab. 2.* Of the 13 papers that cited VTEI papers 15 times, there is one dissertation, two journal articles, and 10 conference papers. However, some conference papers were published in special issues of scientific journals.

The situation with articles in scientific journals is interesting. The *Knowledge and Management of Aquatic Ecosystems* journal is indexed in the Scopus database, but the article [13] that cites the VTEI journal is not indexed. There is a similar case of an article in *Journal of Environmental Protection and Ecology* [14] – the journal is also indexed in the Scopus database, but in this case, the Scopus database is missing practically an entire issue in which this article was published. The article in the *Folia Zoologica* journal [15] is indexed in the Scopus database with EID 2-s2.0-0021579833, but no information about the references is provided. Another example is the *European Journal of Sustainable Development*, which was briefly indexed in the Scopus database in 2020 and 2021 (this journal has been continuously indexed in the Web of Science database since 2013); however, the articles citing VTEI were published in issues that are not indexed in the Scopus database. There is a similar situation in an article in the *Československá psychologie* journal [16] from 1990, while this year was not yet indexed in the Scopus database. It is worth mentioning here that this article cites "VTEI" but is probably not a citation of the VTEI journal. Unfortunately, the data in Web of Science is very incomplete, so it is impossible to make a clear deduction.

A summary of unique citations in Web of Science originating from scientific journals again shows a large overlap in both databases. For publishers seeking indexing in one of these prestigious databases, it is advisable to continuously monitor both databases, as it may happen that some articles are not recorded or indexed correctly by the respective database. In such a case, it is possible to report erroneous or missing citations by using the correction mechanisms that the operators of both databases offer.

Sources of unique citations in the Scopus database are listed in *Tab. 3*. As *Fig. 3* shows, the largest share of 61 unique citations in the Scopus database is made up of citations from Czech journals (16 citations). A total of 13 (9 + 4) citations come from conference papers that were published in proceedings or proceedings journals. They thus form the second largest group of citations. The third largest group is represented by citations from books (7 citations). Slovak journals (5 citations) are in a shared fourth place, which is probably due to the language similarities and historical ties of the Czech and Slovak scientific communities. The same number, i.e. 5 citations, was also achieved from Polish journals. This can be attributed to the relatively large representation of Polish journals in the Scopus database (in the field of Environmental Science, there are a total of 45 journals in the Scopus database, according to SCImago data; 16 are Czech and only 6 are Slovak).

Tab. 2. Summary of citing articles unique to WoS

WOS ID	Number of citations	Source	Type
PQDT:64775072	1		Dissertation
WOS:000280166500013	1	Knowledge and Management of Aquatic Ecosystems	Conference paper
WOS:000300453700008	1	Bioclimate: Source and Limit of Social Development	Conference paper
WOS:000366461200049	1	Mendelnet 2012	Conference paper
WOS:000380590500015	1	14th International Symposium – Water Management and Hydraulic Engineering 2015	Conference paper
WOS:000383856800068	1	Proceedings of the 3rd International Conference on Chemical Technology	Conference paper
WOS:000392678700029	2	Uclio 2010: University Conference in Life Sciences – Proceedings	Conference paper
WOS:000566785300036	1	Journal of Environmental Protection and Ecology	Journal article
WOS:000576735500055	1	Mendelnet 2019: Proceedings of 26th International Phd Students Conference	Conference paper
WOS:000727955100021	1	European Journal of Sustainable Development	Conference paper
WOS:000807376700001	2	European Journal of Sustainable Development	Conference paper
WOS:A1984SY20100008	1	Folia Zoologica	Journal article
WOS:A1990EX37200007	1	Československá psychologie	Journal article

Tab. 3. Summary of sources of unique citations in Scopus

Source	Number of citations	Source type
Journal of Urban and Environmental Engineering	3	Brazilian journal
Journal of Hydrology and Hydromechanics	1	DeGruyter journal
Hydrology and Earth System Sciences	1	EGU journal
Studies in Environmental Science	2	Elsevier journal
Case Studies in Chemical and Environmental Engineering	1	Elsevier journal
Water Supply	1	IWA journal
Waste Forum	5	Czech journal
Geografie-Sborník CGS	4	Czech journal
Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis	3	Czech journal
Acta Universitatis Carolinae, Geographica	1	Czech journal
Archaeologia Historica	1	Czech journal
Praktický lékař	1	Czech journal
Příroda	1	Czech journal
The Adaptive Water Resource Management Handbook	2	Book
A Catalogue of Ecosystem Services in Slovakia: Benefits to Society	1	Book
Springer Water	4	Book
Pollack Periodica	1	Hungarian journal
Journal of Water and Land Development	3	Polish journal
Scientific Review Engineering and Environmental Sciences	2	Polish journal
WSEAS Transactions on Environment and Development	1	Greek journal
SGEM Conference	2	Proceedings
31st European Modeling and Simulation Symposium, EMSS 2019	1	Proceedings
Proceedings of the IAHR World Congress	1	Proceedings
E3S Web of Conferences	5	Proceedings journal
AIP Conference Proceedings	2	Proceedings journal
IOP Conference Series: Earth and Environmental Science	2	Proceedings journal
Acta Hydrologica Slovaca	3	Slovak journal
Ekologia Bratislava	2	Slovak journal
Acta Hydrotechnica	3	Slovenian journal
Documenta Praehistorica	1	Slovenian journal

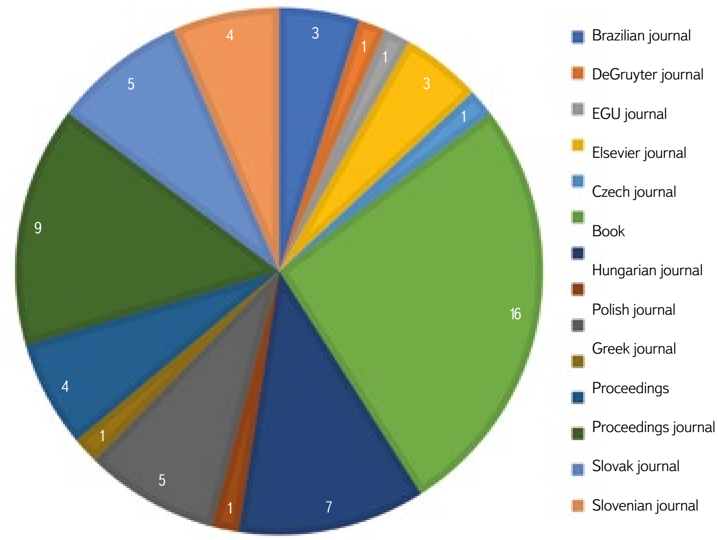

Fig. 3. Unique sources of citations in Scopus by type of source

Errors and uncertainties in the analysis

Several errors were found when comparing the two bibliometric databases. In Web of Science, there is an obvious error in importing data on cited articles for five records. Two records (WOS:000537175800007 and WOS:000391291500003) had incomplete VTEI citation data imported, and two records (WOS:000363210700001 and WOS:000323402700035) did not have VTEI citation data imported at all. For the entry WOS:A1990EX37200007 [16], it cannot be clearly decided whether the VTEI journal was cited or not. For Scopus record EID 2-s2.0-85145674435, or BCI:BCI202300160752 in WoS, different data on the number of citations are given. While there are 45 references in the Scopus database, three of which cite an article in VTEI, there are only 24 references in Web of Science, and only one of them refers to an article published in VTEI.

In total, three articles published at the turn of 2023 and 2024 (2-s2.0-85183954325, 2-s2.0-85183058560 and 2-s2.0-85185194161) were found in the Scopus database which are not yet indexed in Web of Science; however, in the future, they will be included there, as they are published in journals indexed by the Web of Science database. Similarly, there may also be an increase in the number of citations for 2023 due to citations in proceedings and books.

The main issue of using these databases for citation studies of regional journals is the exclusivity of both bibliometric databases, which only index selected journals and choose the indexed journals based on their own criteria. These indexing databases represent a certain standard of quality for a number of academics, which is also proven by the use of these databases by the R&D&I Council as a data source for bibliometric analyses according to Methodology 17+ [9]. In bibliometrics, a number of researchers have confirmed the so-called "Matthew effect" [17], where articles published in journals included in "prestigious" databases tend to receive a higher number of citations than articles in other journals.

Nevertheless, the increasing number of VTEI citations in both databases over the past five years can be considered as some evidence of the increasing quality of the VTEI journal. On the other hand, it is also necessary to consider the fact of the gradually expanding scope of both databases covering more and more journals every year, which will undoubtedly bring with it an increase in the number of citations in non-indexed journals. Another possible explanation is the increasing number of cited works in individual articles.

This phenomenon is documented by several studies and referred to as "citation inflation" [18]. A deeper analysis of the influences explaining the increase in the number of VTEI citations in the Web of Science and Scopus databases was not the subject of this study and will perhaps be the goal of some future bibliometric studies focused on the VTEI journal.

CONCLUSION

The citation analysis showed that the VTEI journal citation rate in articles that are indexed in the Web of Science or Scopus databases is stable and the number of citations is on the rise. Both databases recorded a higher number of citations than in 2022, although lower than in the most successful year so far, 2021. In terms of citations, 2023 thus became the second most successful year in the history of the VTEI journal.

The higher number of citations in the Scopus database can be attributed to the different focus of the two databases; Scopus covers a larger spectrum of journals, while Web of Science focuses more on the "core" of academic journals. Scopus thus indexes a larger number of regional journals. However, the overlap between the two databases is large and it can be said that it is not necessary for the journal publisher to monitor both databases; with accepting some inaccuracy, it is sufficient to monitor the citations in the Scopus database.

Note

1. Although on the R&D&I Council website (https://m17.rvvi.cz/m2/calculation-procedure-and-output-design/) (04/03/2024) we can read that additional analyses from the Scopus database are performed for selected field groups 2 Engineering and Technology, 4 Agricultural and Veterinary Sciences, 5 Social Sciences, and 6 Humanities and The Arts, the data on inclusion in quartiles according to the Scopus database for 2017–2021 contained only group 6, while the data for 2016–2020 contained all four groups.

References

[1] ANSORGE, L. Vývoj citovanosti časopisu VTEI. *Vodohospodářské technicko-ekonomické informace* [on-line]. 2021, 63(2), pp. 50–51. ISSN 0322–8916, 1805-6555. Available at: https://www.vtei.cz/2021/04/vyvoj-citovanosti-casopisu-vtei/

[2] ANSORGE, L. Citační analýza časopisu VTEI. *Vodohospodářské technicko-ekonomické informace* [on-line]. 2022, 64(4), pp. 47–54. ISSN 0322–8916, 1805-6555. Available at: doi: 10.46555/VTEI.2022.05.001

[3] ANSORGE, L. (Mezi)národnost časopisu VTEI. *Vodohospodářské technicko-ekonomické informace* [on-line]. 2023, 65(2), pp. 40–42. ISSN 0322–8916, 1805-6555. Available at: https://www.vtei.cz/2023/04/mezinarodnost-casopisu-vtei/

[4] TEIXEIRA DA SILVA, J. A. Citations to Papers Published in European Science Editing from 2020 to 2022: Assessment Using Scopus, Dimensions, Google Scholar, and Altmetrics. *Scientometrics* [on-line]. 2024, 129(2), pp. 1–6. ISSN 1588-2861. Available at: doi: 10.1007/s11192-024-04953-0

[5] PRANCKUTĖ, R. Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World. *Publications* [on-line]. 2021, 9(1), pp. 12. ISSN 2304-6775. Available at: doi: 10.3390/publications9010012

[6] TENNANT, J. P. Web of Science and Scopus Are Not Global Databases of Knowledge. *European Science Editing* [on-line]. 2020, 46, e51987. ISSN 2518-3354. Available at: doi: 10.3897/ese.2020.e51987

[7] MARTÍN-MARTÍN, A., ORDUNA-MALEA, E., DELGADO LÓPEZ-CÓZAR, E. Coverage of Highly-Cited Documents in Google Scholar, Web of Science and Scopus: A Multidisciplinary Comparison. *Scientometrics* [on-line]. 2018, 116(3), pp. 2 175–2 188. ISSN 1588-2861. Available at: doi: 10.1007/s11192-018-2820-9

[8] DELGADO LÓPEZ-CÓZAR, E., ORDUÑA-MALEA, E., MARTÍN-MARTÍN, A. Google Scholar As a Data Source for Research Assessment. In: GLÄNZEL, W., MOED, H. F., SCHMOCH, U., THELWALL, M. (eds.). *Springer Handbook of Science and Technology Indicators* [on-line]. Cham: Springer International Publishing, 2019 [accessed 15/1/2022]. Springer Handbooks, pp. 95–127. ISBN 978-3-030-02511-3. Available at: doi: 10.1007/978-3-030-02511-3_4

[9] RVVI. *Metodika hodnocení výzkumných organizací a hodnocení programů účelové podpory výzkumu, vývoje a inovací* [on-line]. Prague: Czech Government Office, 2018. ISBN 978-80-7440-215-9. Available at: https://vyzkum.gov.cz/FrontClanek.aspx?idsekce=799796&ad=1&attid=998031

[10] VISSER, M., VAN ECK, N. J., WALTMAN, L. Large-Scale Comparison of Bibliographic Data Sources: Scopus, Web of Science, Dimensions, Crossref and Microsoft Academic. *Quantitative Science Studies* [on-line]. 2021, 2(1), pp. 20–41. ISSN 2641-3337. Available at: doi: 10.1162/qss_a_00112

[11] ABDULHAYOGLU, M. A., THIJS, B. Use of Locality Sensitive Hashing (LSH) Algorithm to Match Web of Science and Scopus. *Scientometrics* [on-line]. 2018, 116(2), pp. 1 229–1 245. ISSN 1588-2861. Available at: doi: 10.1007/s11192-017-2569-6

[12] BLAŽKOVÁ, Š., BEVEN, K. A Limits of Acceptability Approach to Model Evaluation and Uncertainty Estimation in Flood Frequency Estimation by Continuous Simulation: Skalka Catchment, Czech Republic. *Water Resources Research* [on-line]. 2009, 45(12), W00B16. ISSN 1944-7973. Available at: doi: 10.1029/2007WR006726

[13] VLACH, P., HULEC, L., FISCHER, D. Recent Distribution, Population Densities and Ecological Requirements of the Stone Crayfish (*Austropotamobius torrentium*) in the Czech Republic. *Knowledge and Management of Aquatic Ecosystems* [on-line]. 2009, 394–395, 13. ISSN 1961-9502. Available at: doi: 10.1051/kmae/2010005

[14] ŠAUER, P., DVOŘÁK, A., PRÁŠEK, J., HADRABOVÁ, A., NENCKOVÁ, L. Introducing Circular Economy in Small Municipalities: Methodology and a Case of Sewage Sludge Composting. *Journal of Environmental Protection and Ecology*. 2020, 21(3), pp. 1 127–1 135. ISSN 1311-5065.

[15] BARUS, V., GAJDUSEK, J., PAVLOV, D. S., NEZDOLIJ, V. K. Downstream Fish Migration from Two Czechoslovakian Reservoirs in Winter Conditions. *Folia Zoologica*. 1984, 33(2), pp. 167–181.

[16] SMETACEK, V., HOLUBAR, Z. Reshaping of the Text by Subjects – Experience with Automatic Methods of Optimization. *Československá psychologie* [on-line]. 1990, 34(6), pp. 530–539. ISSN 0009-062X. Available at: https://www.webofscience.com/wos/alldb/full-record/WOS:A1990EX37200007

[17] MERTON, R. K. The Matthew Effect in Science, II: Cumulative Advantage and the Symbolism of Intellectual Property. *Isis* [on-line]. 1988, 79(4), pp. 606–623. ISSN 0021-1753. Available at: doi: 10.1086/354848

[18] NICOLAISEN, J., FRANDSEN, T. F. Number of References: A Large-Scale Study of Interval Ratios. *Scientometrics* [on-line]. 2021, 126(1), pp. 259–285. ISSN 1588-2861. Available at: doi: 10.1007/s11192-020-03764-3

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Conflict of interest statement

The author is part of the TGM WRI management, which publishes the VTEI journal, and the chairman of the Editorial Board of the VTEI journal. However, these facts had no influence on the results of the presented study. TGM WRI did not provide any funds for the preparation of this study.

Data availability statement

All data used in the study can be obtained from the Web of Science and Scopus databases using the procedures described in this study. On request from the author, it is possible to obtain the source file in MS Excel format, in which all analyses were performed.

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Interview with Mrs. Prof. Dr.-Ing. Birgit Vogel, ICPDR Executive Secretary

One of the biggest international activities in water protection is the multilateral cooperation in protecting the Danube. It originally started in the 1980s in the form of the Declaration signed in Bucharest in 1985, which concerned the Danube River itself. In 1992, at the initiative of the European Communities, the internationally supported Danube Environment Programme was launched, covering the entire Danube basin including its tributaries. In parallel, work was underway to prepare a Convention on Cooperation for the Protection and Sustainable Use of the Danube. The Convention was submitted for signature in Sofia on 29th June 1994 and entered into force on 22nd October 1998. The Contracting Parties to the Convention are Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Moldova, Slovakia, Slovenia, Serbia, Montenegro, Romania, Ukraine, and the European Union. In August 2022, for the first time, a woman became the Executive Secretary of the International Commission for the Protection of the Danube River (ICPDR) – Prof. Dr.-Ing. Birgit Vogel.

Mrs. Vogel, before we talk about your work in the International Commission for the Protection of the Danube River, I cannot leave out your beginnings in water management. Do you remember the moment when you decided to take up water professionally?

It was during my university years that my interest in rivers and their management began to intensify. I was determined to focus on the assessment of human impacts on water ecology and quality. To achieve this, I combined courses in hydrobiology at BOKU, the University of Vienna and Innsbruck with studies in wastewater treatment and sanitation at the Technical University Vienna. Additionally, I pursued legal lectures. It was important to me to adopt an integrative and holistic approach to fully grasp the picture of river basin management as it is also reflected in the EU Water Framework Directive. My academic journey was incredibly exciting and paved the way for me to embark on challenging and enriching jobs.

You have extensive experience in the field of water management. Do you still remember your beginnings, for example in the form of a project and in which institution was it?

My first job was at BOKU within the Department for Hydrobiology where I was tasked with organising an international water conference in Vienna titled "Assessing the Ecological Integrity of Running Rivers". Following the conference, I contributed to the development of the related proceedings. It was an incredible experience to collaborate with world-renowned experts from across the globe who were pioneers in assessing the ecological water status and its impacts. This conference and the work environment fuelled my motivation to pursue international work in the future. Later, when I worked at the Technical University in Vienna, I had the opportunity to serve as core team member in the first ICPDR Joint Danube Survey. This was a truly unique experience that forged a lasting connection with the Danube River and its management that holds until today.

From what I have read about you, for several years you also worked in India, Southeast Asia, China, Africa, and the South Caucasus. With what idea did you go to these destinations?

During my student years I travelled a lot and became deeply fascinated with Asia – its unique approach to life and landscape fascinated me. Eventually, I felt that I needed to broaden my horizons and deepen my understanding of river basins beyond Europe and the communities living in these regions. Somehow it was therefore a logical professional but also passionate step for me to apply for the position of Chief Technical Advisor for the IWR Project at the Mekong River Commission and luckily, it worked out. Working with the Mekong Commission was very challenging in an extremely interesting and also positive way. Especially coordinating the prior notification and prior consultation process for the Xayaburi Dam, the first mainstream hydropower project in the Mekong below the Chinese border. This role was a steep and fast learning curve for me regarding such management matters. Then projects in China and Africa followed, each offering a unique set of experiences and learning opportunities. In my last post before my current role with the ICPDR, I was involved with GIZ and the India-EU Water Partnership. India with its vast diversity and numerous water management challenges proved to be a fascinating country to work in. The impacts on rivers are significant and complex, largely due to the country's dense population. In India, adopting an integrative approach to problem-solving is a must.

What benefit did these non-European countries get from your experience in and what, in contrast, enriched you?

In my opinion, the EU Water Framework Directive (EU WFD) stands as the most comprehensive water legislation in the world. While its philosophy and methodologies cannot be directly applied to countries and river basins outside of the EU, we successfully integrated the EU WFD's approach with related transboundary cooperation processes in the Mekong region and India. In India, we developed a river basin management plan for the Tapi Basin which has the size of Austria and is shared by three states. This initiative was highly successful and much appreciated by the Indian Ministry for Water and related agencies. The National Mission for Clean Ganga adopted this approach for a sub-basin of the Ganga River and is now considering its expansion. What enriched me? The list is long if not endless. Working with colleagues from and in different countries is always an enriching experience despite the often different ways of thinking and communicating. Adapting to these differences has allowed me to learn immensely from my river basin management colleagues abroad, many of whom have become friends. What also enriched me is the beauty of the countries and river basins I've worked in. Understanding the challenges they face and contributing to their solutions is an invaluable experience I wouldn't have wanted to miss.

Before you took up the position of executive secretary of ICPDR, you worked there for five years as a technical expert for river basin management. What was the impulse to work in this international commission?

My connection to the Danube River Basin is profound, blending professional engagement with a deep emotional bond. This unique relationship was sparked by my participation in the first Joint Danube Survey (JDS 1) and further cemented during my position from 2000–2005 as RBM Technical Expert. JDS 1 ignited my passion for large rivers, a shift from my earlier focus on alpine rivers. The history, landscape and people of the Danube Basin are globally unique and make the Danube River a connector for all the countries sharing the basin. Even in difficult times. ICPDR was founded on the basis of the Convention on Cooperation for the Protection and Sustainable Use of the Danube with the intention of initiating solutions to serious problems in the basin.

What vision does the fourth secretary general have in her position?

This year marks the 30th anniversary of the Danube Protection Convention. This is a very special year for the ICPDR and I am proud to be part of this milestone. As for my vision, I believe that we live in extremely challenging times where the necessity and the ability for transformation is essential. The effects of climate change are unmistakably present and related impacts add up to many of the challenges we are dealing with anyway (e.g. pollution). Thus, adaptation is high on the agenda and adaptation is very high on my vision for the future. Action is essential and I foresee the need for us to respond more flexibly and swiftly to the impacts on water quality and quantity. The topic of droughts and potential water scarcity during certain seasons has now arrived in the Danube River Basin. Addressing this challenge is crucial and the ICPDR has already begun to take steps towards enhancing water resilience.

What are the current topics that ICPDR and its secretariat are currently dealing with?

In our role, we are dedicated to the implementation of the Convention alongside with coordinating international management plans that cover transboundary river basin management and flood risk management. We address key management topics like point source and diffuse pollution, pollution through hazardous substance but also the structural alterations of rivers in the Danube River Basin. A significant focus within this context is to ensure the free migration of all Danube fish species with particular attention to our flagship species, the sturgeon. Achieving this requires a productive dialogue with hydropower operators and the cooperation of all Danube countries to make hydropower dams passable for fish, thereby supporting their natural reproductive processes. As mentioned, climate change presents a significant challenge for the ICPDR, prompting us to address emerging issues such as droughts and water quantity management.

This year we will commemorate 30 years since the Convention was presented for signature in Sofia, Bulgaria. How would you imagine the functioning of this commission in the next 30 years?

Cooperation in tackling and solving water resource challenges remains a cornerstone of efforts in the Danube Basin and will continue to be crucial even in 30 years from now. It is difficult to predict the challenges that will emerge in the next three decades. Yet, I am convinced that if the ICPDR countries maintain their current level of cooperation – based on trust and willingness – we will be well-prepared to face future challenges – also new ones. I envision the ICPDR keeping tackling all these challenges in an innovative and transformative way. This foundation, coupled with the openness and readiness to adapt our approaches as necessary, will ensure that the ICPDR remains a champion in transboundary river basin management. I am highly convinced of this.

On the occasion of the signing of the Convention, Danube Day has been celebrated since 2004. How are you going to celebrate this day?

On the occasion of Danube Day, celebrated since 2004 to commemorate the signing of the Convention, we are set to honour this important day with a series of collaborative and educational events throughout the basin. Such events are held every year, but 30 years is an anniversary that deserves special attention. The events are designed to underscore the critical importance of water resource management and celebrate the achievements of cooperation across the Danube Basin. Our celebrations will aim to deepen the understanding of the challenges confronting the Danube River Basin, especially those related to climate change and the imperative of sustainable management practices. Highlighting this, a special event on 25th June in Bratislava, under the auspices of the Slovak Presidency of the ICPDR, will feature an exhibition and a panel discussion. This gathering will not only inspire action but also strengthen the spirit of cooperation that has been fundamental to our collective efforts. Furthermore, we will spotlight the innovative and transformative strategies the ICPDR has implemented to address these challenges, reaffirming our dedication to a cleaner, healthier and safer Danube River Basin for the benefit of future generations.

Mrs. Vogel, thank you very much for the interview.

Ing. Josef Nistler

Prof. Dr.-Ing. Birgit Vogel

Prof. Dr.-Ing. Birgit Vogel, born on 12th November 1961, has been involved in international water management throughout her professional life, both in Austria and in Asia and Africa. She studied at the University of Natural Resources and Life Sciences (BOKU Vienna) and the University of Leicester (UK). She is the founder of RBM solutions – River Basin Management with many projects in Europe, Asia, and Africa; she worked as a project manager in India at the German Society for International Cooperation (GIZ) GmbH and was, among other things, the chief technical advisor of the Mekong River Commission. The new role of Executive Secretary of the ICPDR is another milestone in her professional career.

This year's Danube Day is marked with round anniversaries

30th ANNIVERSARY

This year we commemorate the 30th anniversary of the foundation of the International Commission for the Protection of the Danube River. This is a significant event; the signing of the Convention on the Protection of the Danube River initiated cross-border cooperation aimed at the protection of the Danube and its tributaries. The Convention was signed on 29th June 1994 in Sofia, Bulgaria.

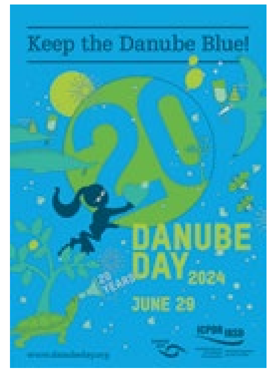
20th ANNIVERSARY

Danube Day was announced by the International Commission for the Protection of the Danube River on the 10th anniversary celebration of the signing of the Convention. So, this year marks 20 years since the first celebrations took place of this important day for the Danube.

Thanks to the joint efforts of various organizations, Danube Day celebrations have become an annual event that pay tribute not only to the river itself, but also to its tributaries. Over the course of 20 years, organizations and institutions at all levels of society have gradually joined the celebrations, from kindergartens, primary and secondary schools, through non-governmental organizations and scientific institutions, to national and local governments as well as churches.

The celebrations commemorate the vital role that the Danube and its tributaries play in people's lives – providing water, food, energy, recreation, and livelihoods. At the same time, Danube Day is considered a platform for raising awareness of the diversity of the common Danube habitat and the interconnectedness of the individual elements of this complex ecosystem. Also, it creates opportunities for informing citizens about the possibilities of improving this ecosystem and for strengthening cultural, economic, and ecological integration.

The aim of various activities (such as water-related games, excursions, round tables, workshops, and educational and awareness-raising activities for the public) is to strengthen the emotional connection of the entire society with



the Danube basin and its unique biodiversity. Artists and other well-known personalities who inspire the public in the field of sustainable behaviour are also involved in these activities. Danube Day should not only send a clear message, but also set the direction in the area of future management of the Danube ecosystem in order to ensure its preservation for future generations.

In cooperation with the Ministry of the Environment, TGM WRI plans to celebrate Danube Day on Tuesday 25th June 2024 by organizing an Open Day for public and present interesting examples of the work of its scientific teams.

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Fig. 1. Danube Day celebrations are held every year in many countries

Fig. 2. Croatia, Vukovar, 2023

Fig. 3. Hungary, 2021

Fig. 4. Austria, Vienna, 2019

Fig. 5. Ukraine, 2018

Fig. 6. Austria, Vienna, 2016

Fig. 7. Austria, 2012

Fig. 8. Ukraine, 2010

Fig. 1. View of the Bukovec Mt., a basalt cone above the Jizerka settlement (1,005 m a.s.l.), from the Vlašský hřeben mountain range with apparent signs of forest recovery; July 2007 (Photo: J. Křeček)

Jizera Mountains researchers in Podbaba

On 25th January 2024, a seminar Meeting of researchers in the Jizera Mountains was held in the conference centre of T. G. Masaryk Water Research Institute (TGM WRI) in Prague. It presented (mainly long-term) research projects implemented in the Jizera Mountains and focused on atmospheric precipitation, forest soils and forests, waters and their biota in recent decades, i.e. from peak acidification to current phenomena associated with climate change. However, no less important was the personal meeting of people who research, permanently work or live in the Jizera Mountains and are interested in the development of the situation in this area, as well as the final debate open to all.

Apart from researchers from the Museum of North Bohemia in Liberec, universities and academic and non-academic research institutions, we therefore also invited representatives of nature conservation authorities (primarily Jizera Mountains PLA Administration, but also Krkonoše National Park, Šumava National Park, and the Nature Conservation Agency of the Czech Republic), Povodí Labe, state enterprise, water industry-oriented companies (W&ET Team, Severočeská servisní) and water management (DHI), as well as the Czech Fishery Association. The meeting was also attended by university students, representatives of the Czech Society for Ornithology and ecological consultancy (EKOEX Jihlava), a volunteer ranger working for the Jizera Mountains PLA Administration, and others. Together with former and current TGM WRI employees, over a hundred people gathered in the hall.

As a hydrobiologist at TGM WRI, who has long been involved in the study of water reservoirs on the upper plateau of the Jizera Mountains within the long-term concept of the development of a research organization (DKRVO), I prepared the seminar with the organizational and financial support of the Institute and a financial contribution from the company Aon Central and Eastern Europe. I was inspired by the previous seminar, Jizera Mountains – meeting across scientific disciplines, which was organized in December 2012 at the Faculty of Agrobiology, Food and Natural Resources of the Czech University of Life Sciences in Prague (FAPPZ CZU) by prof. Radka Kodešová (Department of Pedology and Soil Protection, FAPPZ CZU) and Mgr. Šimon Bercha (Department of Applied Hydrology, CHMI) [1]. Its originally intended focus on hydrology and soil hydrology was expanded to include other research fields, as well as the activities of various public administration institutions in the Jizera Mountains, making this informal seminar a very interesting event. The second meeting of the Jizera Mountains researchers, defined by a professional focus on precipitation, waters, soils, and forests, was also prepared in such a way that, despite the large number of participants and the number of lectures, it retained an informal and friendly character.

The Jizera Mountains, part of the so-called Black Triangle, are one of the regions of the world that were most affected by acidic atmospheric deposition in the second half of the 20th century. Despite significant recovery from acidification and apparent restoration of waters and forests, this area faces many old and new issues. The main purpose of the meeting of experts who have been participating in its research and administration for a long time was therefore for them to find out about each other, their work and results – taking into account the fact that many of them are already close to retirement or already retired. It was also intended to be an inspiration for further work and collaboration.

Why was the seminar on the issue of the Jizera Mountains held under the Baba folly on the Vltava promontory in Prague? In addition to the simple reason that TGM WRI in Prague's Podbaba is now my workplace, which had supported me in the later years of my thirty-year research on the Jizera Mountains reservoirs and which has a suitable facility for such a meeting,

Fig. 2. Contribution of Ing. Ladislav Kašpárek to the importance of experimental basins (not only) in the Jizera Mts. for the assessment of changes in the hydrological regime in connection with deforestation. (Photo: V. Mrázek)

Fig. 3. Water, later drinking water reservoir Souš, built in 1915 on the Černá Desná river. The dam was reconstructed in the 1920s and 1970s, after the catastrophe of a reservoir in the parallel Bílá Desná river valley; June 2012 (Photo: D. Vondrák)

there are also other connections. Between 1942 and 1964, the first limnological study of all reservoirs in the Labe and Lužická Nisa basins was being developed in the Institute by Dr. Věra Řeháčková (later Rozmajzlová) [2]. The results regarding the water chemistry of the Bedřichov and Souš reservoirs confirm their high acidity, at that time still attributed only to the peaty character of the basin. The only data on the water chemistry of the Jizera Mountains reservoirs in the 1980s, summarized by Ing. Martina Bednářová [3, 4], are the output of projects of Ing. Ladislav Kašpárek from TGM WRI [5]. The research of his working group (similarly as in the case of the team of Ing. Libuše Bubeníčková from CHMI) dealt with the effect of deforestation on the hydrology and quality of surface waters in the headwater area of the Jizera Mountains. This immission calamity as well as extremely low water pH values in the 1980s were already clearly associated with acid rain.

In the course of the day, which was started with humour and ease by TGM WRI director Ing. Tomáš Fojtík, 22 short lectures were given. They were divided into four specialist sections – hydrology and hydrochemistry, forest soils and forests, waters, and water biota. Chairing the sections were Dr. Vít Kodeš (CHMI), doc. Pavel Jurajda (Institute of Vertebrate Biology, CAS), Dr. Jan ("Jeňýk") Hofmeister (Faculty of Forestry and Wood Sciences of the Czech University of Life Sciences in Prague, FLD CZU), and Ing. Pavel Vonička (Museum of North Bohemia, Liberec). Thanks to their strict time monitoring, there was room for refreshments, meetings, and offstage discussions during the day. a short film with commentary by doc. Petr Dolejš (W&ET Team) from his flight over the Jizera Mountains reservoirs was also shown.

It was a great honour to be able to welcome the leading ladies of Czech hydrology to the seminar – prof. Milena Císlerová (Faculty of Civil Engineering, CTU), Ing. Libuše Bubeníčková (CHMI), Ing. Alena Kulasová (TGM WRI), and prof. Radka Kodešová (FAPPZ CZU). Among the special guests who did not make a contribution were also the head of the Bedřichov dam, Petr Noswitz (Povodí Labe, state enterprise), Dr. Miroslav Švátora (Faculty of Science, Charles University), Ing. Tomáš Kava (Czech Fishery Association), Dr. Iva Bufková and Ing. Eva Zelenková (Šumava NP), prof. Jaroslav Vrba (Faculty of Science, University of South Bohemia) and former colleagues Rudolf Hancvencl (CHMI), Ing. Vladimír Vršovský (Jizerské hory PLA Administration), and Ing. Petr Navrátil (Forest Management Institute, ÚHÚL). I gladly passed on greetings from Dr. Miloslav Nevrlý, Roman Karpaš, Dr. František Pelc (NCA CR Director), Dr. Daniela Fottová, Ing. Miroslav Tesař (Institute of Hydrodynamics, CAS), doc. Iva Hůnová (CHMI), and Ing. Jana Hubáčková, who are also closely connected with the Jizera Mountains, but could not participate in person.

In the hydrology and hydrochemistry section, Ing. Ladislav Kašpárek (TGM WRI) pointed out the contribution of experimental basins in the Jizera and other mountains to the substantial reduction of estimates of the extent to which deforestation will affect changes in mean and maximum flows. His former colleague, Ing. Martina Bednářová, described the slow deterioration of surface water quality (in the sense of acidification and leaching of metals from soils) between 1982 and 1987, which occurred due to the gradual exhaustion of the acid-neutralizing capacity of waters and soils. Mgr. Šimon Bercha from the Department of Applied Hydrology, CHMI, briefly presented the current CHMI activities in experimental basins in the Jizera Mountains. As for experts from the Faculty of Civil Engineering, CTU, doc. Jaromír Dušek presented results of modelling runoff dynamics and isotope transport in a slope soil; doc. Martin Šanda with prof. Milena Císlerová presented a study of water flow under the surface within the hydrological cycle of small mountain basins (especially the Uhlířská and Velká Jizerská louka basins). In his lecture, Dr. Filip Oulehle (Czech Geological Survey and Global Change Research Institute, CAS) addressed small GEOMON (GEOchemical MONitoring) basins in our country and their importance for understanding landscape hydrology and biogeochemistry. Of great interest was the lecture by prof. Jakub Hruška from the same team on the results of long-term monitoring of the Uhlířská basin on the Černá Nisa river (precipitation and river water chemistry), with a warning about persistent issues associated with acidification as well as new issues caused by climate change.

Similarly extensive and interesting was the summary of the history of Jizera Mountains forests by doc. Ivan Kuneš (FLD CZU) in the section dedicated to forest soils and forests. The lecture was also a presentation of a new article [6] – a joint effort of FLD CZU experts and colleagues from ÚHÚL and the Jizera Mountains PLA Administration. Dr. Jan Hofmeister, from another FLD CZU working group, focused on the structure of forest stands in Jizerskohorské bučiny NNR and their importance within the Czech Republic. An overview of the soil situation in the Jizera Mountains in recent decades, which was presented by prof. Luboš Borůvka and Dr. Václav Tejnecký (FAPPZ CZU), was also important. Dr. Radek Novotný outlined the activities of Forestry and Game Management Research Institute (VÚLHM) in the Jizera Mountains, focused on the condition of forest soils and the level of nutrition of woody plants. Dr. Ondřej Špulák (VÚLHM – Opočno Research Station) presented (also on behalf of his colleague Dr. Dušan Kacálek) the results of microclimatic investigations on cultivation and ecological experiments in the Jizera Mountains. Ing. Otto Kučera with Ing. Lucie Podroužková (ÚHÚL) chose the topic of water retention in the landscape, using the example of the upper stream of the Smědá river – an investigation and subsequent proposal of measures to restore the landscape's water regime and to slow down water runoff.

The afternoon programme was devoted to waters. The film screening was followed by a comprehensive lecture by Dr. Pavel Dobiáš and doc. Petr Dolejš from the W&ET Team company, mapping the development of technology in the Souš

Fig. 4. Water reservoir Bedřichov, built in 1905 on the Černá Nisa river. On the horizon, the Ptačí kupy (1,013 m a.s.l.) and Holubník (1,071 m a.s.l.), reforested after many years; June 2012 (Photo: D. Vondrák)

Fig. 5. Field work – a study of the brook trout (Salvelinus fontinalis) population and benthic organisms in the Černá Nisa river. From left to right: Zuzana Hořická, Jiří Hušek Jr., Kamil Farský, Miroslav Švátora, and Lucie Burdová; June 2008 (Photo: M. Kaftan)

Fig. 6. Sampling the zooplankton – the Šolcův pond near Raspenava, situated in beech stands of the northern slope of the mountains, was a control site in studies of the upper plateau reservoirs; July 2004 (Photo: the author's archive)

Fig. 7. The "Burst" Dam on the Bílá Desná river – ruins of the dam burst in 1916, less than one year after the construction; June 2012 (Photo: D. Vondrák)

Fig. 8. Typical brown waters of the Jizera Mts., rich in humic substances (Photo: D. Vondrák)

and Bedřichov water treatment plants over the last 30 years. The treatment process was complicated here by a high content of humic substances and dissolved aluminium, and in certain periods also with a large concentration of dinoflagellates and cyanobacteria (*Merismopedia* sp.) in the raw water of the Souš and Josefův Důl reservoirs. Both treatment plants underwent significant modernization and transition from direct filtration to flotation-filtration treatment plants, with a higher separation efficiency and thus also a higher safety of drinking water production. No less extensive was the presentation of four decades of monitoring of drinking water reservoirs in the Jizera Mountains, Souš and Josefův Důl, by their manager, Povodí Labe, state enterprise. Ing. Luděk Rederer and Dr. Václav Koza showed the results of the liming of Souš between 1996 and 2016 and trends related to the decline in water acidity and climate change. In addition to the basic water chemistry, they commented on the structure and abundance of phytoplankton, including the excessive development of picosized algae (*Merismopedia* sp.) in Josefův Důl over the last 15 years.

Dr. Lenka Procházková (Faculty of Science, Charles University) and Dr. Zuzana Hořická (TGM WRI) showed the development of phytoplankton and zooplankton of the Bedřichov, Souš, and Josefův Důl water reservoirs between 1992 and 2021 with the gradual recovery from acidification. Their lectures were supplemented by the enthusiastic contribution of Dr. Martin Pusztai (CXI and Faculty of Science, TUL, and Faculty of Science, Charles University) about the significance and beauty of Chrysophyceae, which are the most numerous group of planktonic algae in Josefův Důl and Souš. Dr. Olga Lepšová-Skácelová (Faculty of Science, University of South Bohemia) contributed with a study of periphyton in the tributaries of all three reservoirs in 1996 and then in 2008, when the anthropogenic acidification had subsided, but the unstable chemistry and natural acidity of the Jizera Mountains waters continued to manifest. Doc. Pavel Jurajda (on behalf of the team from Institute of Vertebrate Biology, CAS, and Povodí Labe, state enterprise) spoke about the fish communities in the Souš and Josefův Důl drinking water reservoirs since 2016, mentioning the results of the research by Dr. Miroslav Švátora (Faculty of Science, Charles University) from 1997–2015 regarding the successful reintroduction of brook trout in Bedřichov and Souš. Brook trout and brown trout are currently released in Souš (where the share of brown trout is increasing); brook trout, common minnow and (since 2023) also brown trout in Josefův Důl. On behalf of his colleagues from Faculty of Science, MUNI, and Faculty of Science, University of South Bohemia, Dr. Jan Sychra presented results of the study of littoral communities of invertebrates in standing waters of the Šumava, Ore, and Jizera Mountains in the context of their recovery from acidification. In particular, he dealt with true bugs and water bugs (Heteroptera) of the Jizera Mountains. Together with Ing. Pavel Vonička (Museum of North Bohemia, Liberec) and other collaborators, he proved that these mountains are extremely rich in them [7]. The lecture part of the seminar was complemented by the presentation of doc. Josef Křeček (Faculty of Civil Engineering, CTU) about the Earthwatch project (as an example of citizen science) applied in the multidisciplinary research in the Jizera Mountains basins.

To conclude the event, a discussion was opened about the recent development and current state of nature and tourism in the Jizera Mountains and about the possibilities and difficult compromises in planning the future development. The discussion was led by Ing. Jiří Hušek (Director of Jizera Mountains PLA Administration), prof. Luboš Borůvka (FAPPZ CZU), prof. Jakub Hruška (Czech Geological Survey and Global Change Research Institute, CAS), doc. Ivan Kuneš (FLD CZU), and Dr. Jan Sychra (Faculty of Science, MUNI). The starting point for the questions and the exchange of views was the fact that the condition of soils is still unfavourable, waters have only partially recovered from acidification, the mountains are excessively burdened by tourists, and spruce monocultures are growing again in the basins. The fact that management of this area is complex and creates potential conflict was manifested by some verbal arguments on the usual topic of ecology (more nature-friendly forest management) versus wood production. Nevertheless, there were also other, interesting and helpful contributions.

The opportunity to discuss and chat even after the seminar was over was provided to some of the participants by the "lobby" – a room provided by a nearby restaurant.

Despite the rich and demanding programme, the day-long meeting had a good atmosphere and was met with a warm response. Proceedings are being prepared from the responses of a questionnaire prepared for researchers and "administrators" of the Jizera Mountains. The questionnaire aimed mainly on their focus in research or their role in maintenance and management, on the results of their work, and their opinion on the current state of the mountains. It already seems that a similar meeting could take place again, and even bring researchers back to the Jizera Mountains. It will probably be organized by Jizera Mountains PLA Administration in 2027 to mark the 60th anniversary of designation of the PLA.

References

[1] BERCHA, Š., KODEŠOVÁ, R., ŘIČICOVÁ, P., KIMLOVÁ, M. (eds.). *Jizerské hory – setkání napříč vědeckými disciplínami. Sborník abstraktů ze semináře.* Prague: CHMI, 2014. 40 pp.

[2] ŘEHÁČKOVÁ, V. *Zhodnocení dosavadních výsledků limnologického výzkumu nádrží v povodí Labe a Lužické Nisy. Závěrečná zpráva.* Prague: TGM WRI, 1965. 139 pp.

[3] BEDNÁŘOVÁ, M. Sledování kvalitativních ukazatelů povrchových vod v pramenných oblastech Jizerských hor. In: *Sborník z konference Vodohospodářské důsledky imisní kalamity v Jizerských horách, Liberec, 8.–10. listopadu 1988.* Ústí nad Labem: ČSVTS, 1988, pp. 188–194.

[4] BEDNÁŘOVÁ, M. Jakost povrchových vod ve vybraných pramenných oblastech. In: URBAN, J. et al. (eds.). *Změny hydrologického režimu v pramenných oblastech. Závěrečná zpráva.* Prague: TGM WRI, 1990, pp. 90–121.

[5] BEDNÁŘOVÁ, M., KAŠPÁREK, L., VOTRUBA, L. *Změny odtokového režimu v extrémně postižených oblastech. Závěrečná zpráva.* Prague: TGM WRI, 1988. 81 pp.

[6] KUNEŠ, I., PODRÁZSKÝ, V., BALÁŠ, M., REMEŠ, J., NAVRÁTIL, P., KUC, M., SMEJKAL, J., BURSÍKOVÁ, J., PALUCH, J. G. The History of the Jizera Mountains Forests in the Former Heavily Polluted Area of Central Europe. *The Anthropocene Review*. 2023, November, 9. 38 pp. Available at: doi: 10.1177/20530196231204344.

[7] HRADIL, K., SYCHRA, J., VONIČKA, P., PREISLER, J. Ploštice (*Hemiptera: Heteroptera*) Jizerských hor. *Sborník Severočeského Muzea, Přírodní Vědy*. 2019, 37, pp. 3–121. ISBN 978-80-87266-38-0.

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Abbreviations:

CAS – Czech Academy of Sciences [in Czech: AV ČR]
CHMI – Czech Hydrometeorological Institute [ČHMÚ]
CTU – Czech Technical University in Prague [ČVUT]
CXI TUL – Institute for Nanomaterials, Advanced Technologies and Innovation
MUNI – Masaryk University (Brno)
NCA CR – Nature Conservation Agency of the Czech Republic [AOPK ČR]
NNR – National Nature Reserve [NPR]
PLA – Protected Landscape Area [CHKO]
TUL – Technical University of Liberec [TUL]

Fig. 9. The Rašeliniště Jizerky moorland with blooming cotton grass – a valuable nature territory (NNR), strongly devastated by human activities and acid rain in the past; June 2012 (Photo: D. Vondrák)

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REMINISCENCE OF THE DISAPPEARED MILL RACE ON THE ČERNÁ OPAVA

When looking at watercourses in the Jeseníky and other mountain ranges, especially the Sudeten Mountains, it is sometimes difficult to determine whether they are natural watercourses or man-made channels; in these mountain areas, they most often functioned as races for mills, saws mills, and hammer mills. A typical example is the Gangloff race in Brdy, where it is practically impossible to tell whether it is still a water works or a natural watercourse called Buková. There are several such places in Jeseníky as well. Here we can find large races, such as the Weisshuhn flume near Žimrovice or the race leading from the confluence of the Krupá and Morava to Hanušovice. At the same time, there are – from the point of view of the flow rate of the riverbed – smaller water works, such as a race on the Podolský and Stříbrný streams near Rýmařov (the village of Žďárský potok) or the defunct inoperative races on the Černá Opava. Among them is also the race that once brought water from the edge of Rejvíz to Horní údolí (see photo) around Wurzl's mill, which Sotiris Ioannidis also writes about in his book *Pracující potoky* (*Working streams*, 2007). In addition to paying homage to the technical skill and tenacity of the inhabitants of Jeseníky at that time, these water works also make us awe at the power of the forest, which prevails in the landscape again years later, if humans allow it. As Jan Obenberger wrote in the introduction to his famous book *S kamerou za zvěří našich lesů* (*To the wildlife of our forests with a camera*, 1940): *"How different, more beautiful is our forest than the dry grey forests of the south, the sun-burnt macchias or the sad forests of America. Perhaps that is why we like it so much and why we return to it again and again. Peace and quiet are a characteristic feature of our forest."* So, let us hope that, despite all the problems in today's landscape, the forests will once again return to their old strength and majestic calm, and people will use their gifts judiciously and humbly like good caretakers.

Text and photo: doc. RNDr. Jan Unucka, Ph.D.