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(WATER MANAGEMENT TECHNICAL AND ECONOMIC INFORMATION)

VTEI/2022/3

8th June – World Oceans Day

World Oceans Day is a relatively new event, announced at the Rio de Janeiro Conference on Environment and Development in 1992. Through it, scientists and conservationists want to draw attention to the fact that marine protection should not only focus on coastal ecosystems and tropical coral reefs. It is necessary to realize that due to industrial fishing, a huge number of fish disappear every year thanks to ever better technology enabling fishermen to catch several times more than in the past. According to the World Wide Fund for Nature (WWF), at this rate, some fish species (such as cod and tuna) may become extinct within 15 years. Trawling destroys around 150 million square kilometres of seabed each year. Also, it often involves so-called bycatch, such as sharks and rays. These destructive fishing practices not only destroy the caught fish, but the entire marine ecosystem and its biodiversity. This disrupts the natural food chain, leading to the loss of other marine species, such as sea turtles and coral reefs.

However, overfishing and often totally unregulated fishing is not the only problem for the oceans. Other issues include climate change, air and water pollution, rubbish and plastics, global warming and melting glaciers, and offshore drilling. The organizers of *The Ocean Project* and the *World Ocean Network* want to fight all this. After all, water makes up about 70 per cent of the Earth's surface and more than 97 per cent is salt water. Oceans are virtually the cradle of life, and almost all living organisms are dependent on water, as well as on oxygen, which the oceans produce.

Ocean care has long been neglected, although it is absolutely crucial for the future and the climate of our planet. That is why the United Nations and the European Union are now making a strong commitment to protecting the seas and oceans. In 2008, the EU adopted a strategy for the protection and conservation of the marine environment. Every year, World Oceans Day hosts countless events that seek to raise awareness of all these issues; the Czech Republic is no exception. For example, every year, Jihlava Zoo launches a campaign called "Which fish", focused on sustainable fishing.

VTEI Editorial

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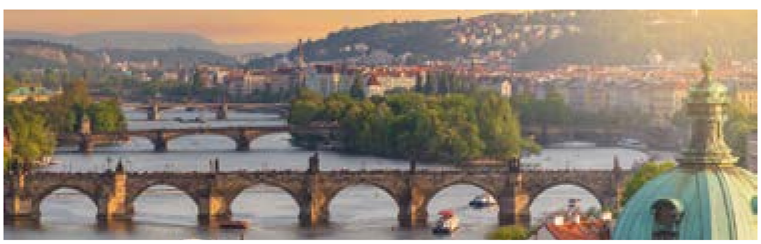

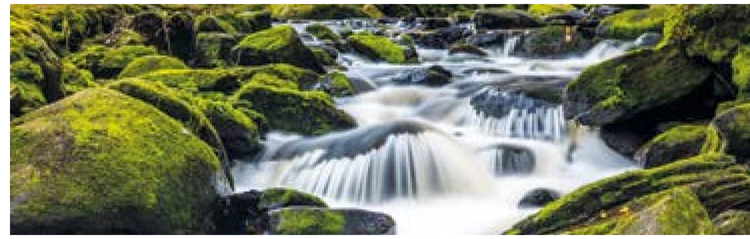

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Dear readers,

I cannot help but touch again on a topic that has been resonating in Europe and around the world for several months, and that is the war in Ukraine. History has taught us how easily a friend becomes an aggressor and a friendly connection turns into a deep trench of hatred that is very difficult to fill or bridge. The proximity of the conflict (it is closer from Ostrava to Ukraine than to Cheb) inevitably affects us, and although it does not take place in our country, we cannot hide from its impact. We are finding out that we are a standard Western society that can make decisions for itself and take responsibility, that we are actually one of the richer European countries, and to our surprise we are morally at such a level that we are not only able to help others, but we actually do it.

Shortly before the start of the conflict, our Institute responded to the World Bank's call and expressed interest in a project to improve the purity of the Black Sea with the poetic subtitle "How to make the Black Sea blue". Of course, the project mainly concerned the countries around it, and that was the reason why we involved scientist Yelizaveta Chernysh from the university in the Ukrainian city of Sumy. However, due to the outbreak of war, the project failed not only to start, but even to evaluate the winners. Nevertheless, the expression of interest eventually had its bright side. We naturally offered asylum to the aforementioned Ukrainian scientist and her loved ones, and provided them with accommodation in our inspection rooms. In addition to a good feeling, we have acquired a new colleague who, as an employee, is already involved in our research projects. Based on excellent experience, we have opened several professional positions in Prague and Ostrava. We are preparing an interview for one of the next VTEI issues, which will introduce you to her.

In connection with the suffering we hear about every day in the media, the problems of the environment, climate change, as well as drought, may seem trivial; however, we will not be able to escape from them either. Whatever we think about the reasons for climate change, it is here and we must adapt to it. Once again, the drought is near – we had a quite good two years, but it is back. Winter was practically without snow; March, April and the beginning of May were almost without precipitation, and watercourses are almost without water. This assessment is, of course, exaggerated, but 15 to 65 per cent of the flow usual for this period in most of our country speak for itself. The HAMR forecasting system, now operated on the CHMI website, shows us the state of drought not only in surface waters but also in groundwater and, above all, evaluates the risk of water shortages. So far, it is clear from the system that the agricultural drought has actually begun, the hydrological underground drought is close, and the surface and meteorological droughts have so far been trying to keep at normal levels. However, the key is that despite the declines in watercourse levels, the indication of water scarcity is still relatively favourable. It is difficult to reliably predict future developments, but it is clear that this year will not be easy. In order not to be surprised again in the coming years, when another dry season may occur, it is necessary to implement all kinds of adaptation measures urgently. And, as is good practice, it is best to start with ourselves. In the context of our times, the concept of adaptation should be understood not only as adaptation to climate change, but also to the security situation and new challenges in our society.

Ing. Tomáš Urban
Director of TGM WRI, p. r. i.

The influence of Prague on water quality in the Vltava and the Czech Elbe

JOSEF K. FUKSA, LENKA SMETANOVÁ MATOUŠOVÁ

Keywords: Vltava — Elbe — Prague — longitudinal profile — water quality — anthropogenic pressure — wastewater — nitrogen — phosphorus — eutrophication — pharmaceuticals — urban rivers

SUMMARY

This paper deals with the development of water quality in the Elbe in the section between its confluence with the Vltava and the Hřensko border profile in 1980–2020, and with the influence of Prague on its pollution levels. After a significant improvement in 1985–2000, the quality of water discharged through the Hřensko profile today is at least at the level of the Federal Republic of Germany. Evaluation of substance transport shows that the Vltava contributes a larger share of pollution to the Elbe simply because it has higher flows. Prague contributes to pollution of the Vltava and the Elbe by discharging phosphorus. As for other long-term indicators, it is an insignificant source.

In 2010–2020, there is a significant level of concentrations of pharmaceuticals, which come exclusively from the discharge of municipal wastewater treatment plants (WWTP). Many pharmaceuticals regularly occur in concentrations of tens to hundreds of [ng/l], and resistant pharmaceuticals (gabapentin, metformin, oxipurinol, carbamazepine) are transported to Prague from the Vltava basin through the Orlík and Slapy reservoirs with a high theoretical retention time. The transport of resistant pharmaceuticals through relevant profiles corresponds mainly to the number of inhabitants in their river basins because they obviously pass through WWTP and do not degrade further in the river either.

The main source of pollution in the Vltava is the Central Wastewater Treatment Plant in Prague (see text). Here is its original outlet, today it is strengthened by a new water line. (Photo: J. K. Fuksa)

INTRODUCTION

Prague is potentially the largest source of pollution of the Vltava and, after the confluence, the Czech section of the Elbe. We therefore tried to assess this source objectively, based on available data on water quality in the lower Vltava and the lower Czech Elbe, i.e. the section between the profiles Podolí and Zelčín (Vltava above Prague and above the confluence) and Obříství (Elbe above the confluence) and the profile Hřensko/Schmilka (Elbe on the state border). The text is based on a paper of the same name presented at the 20th year of the Magdeburg Seminar [1]. Both the Vltava and the Elbe have approximately the same long-term average flow at the confluence but they differ significantly in the size of the river basin, in the total population with the same average population density, in location of industry and in morphology of the river and river landscape *(Tab. 1)*. The morphology of the river valley enabled the construction of important valley reservoirs on the Vltava, which regulate the flow through Prague, especially in dry periods when they maintain the flow above about 50 m^3/s. The Elbe does not have these possibilities even potentially and, in dry years, the influence of flow regulation by discharge and accumulation in the Orlík reservoir is evident even in the Hřensko profile. In terms of the relative load of the watercourse, the discharge of wastewater into the river at the local long-term average flow for Prague represents 1.25 %. For important settlements on the Elbe it is only 0.52 % for Hradec Králové and Pardubice (calculated in relation to the Elbe, not for Velká

Tab. 1. Basic characteristics of subbasins studied

Characteristics of sub-basins:	Vltava at the confluence	Elbe at the confluence	Elbe at Hřensko
Catchment area [km^2]	28,090	13,696	50,176
Average flow [m^3/s]	150	148	319
Population [in thousands]	3,331	1,603	6,118

Fig. 1. Concentrations of pollution components – ten/years means; left columns are the year means of data of Ullik (Elbe – Děčín, 1877) and Schulz (Vltava downstream Prague, 1913)

Fig. 2. Ten-years means of transport through monitored profiles in thousand tons per year; second column represents the sum of transport/supply by Elbe and Vltava at the confluence

Strouha), 0.075 % for Kolín and below the confluence with the Vltava only 0.059 % for Ústí nad Labem and 0.026 % for Děčín. This proportion changes significantly at low flows and becomes vital during long-term off-season drought. Clearly, the definition of "drought" differs for individual profiles and their river basins; however, if we consider it a reliable limit of 25 % of the long-term average flow, we must consider a fourfold load of polutants to a watercourse compared to the average. The only source for possible improvement of flows is the Vltava cascade, and manipulation of the flow are reflected even in the Hřensko border profile. The Elbe above the confluence does not have these technical possibilities, so in dry periods the flow in the Elbe profile of Obříství is significantly lower than in the Vltava profile of Zelčín.

The development of water quality and its monitoring in the area is described in older publications [2, 3]. Good reference data characterizing the whole annual cycle of water quality are available for assessing the development. The paper of Franz Ullik [4] is essential; in the period from 13 January 1877 to 13 January 1878, he took one sample every day from the Elbe in Děčín (from the ferry, i.e. roughly from the middle of the river) and published the complete results. For Vltava, it is the work of František Schulz from 1913 [5]. After that, only individual publications are available and systematic data begin around 1970, when systematic monitoring of the quality of Czechoslovak rivers gradually began to take place, managed by the Czechoslovak (now the Czech) Hydrometeorological Institute (CHMI). Until 2008, data from this monitoring were fully accessible for public; now they can be obtained on the basis of an application and a relevant contract for their use for precisely specified purposes. The historical development of water quality in the Vltava and in its catchment area above river km 100 (profile Živohošť on the Slapy reservoir) has been reconstructed and is systematically monitored, by the team formerly led by L. Procházková, now by J. Kopáček. Its links with waste management, agriculture, deposition, and discharge in the river basin are published [6-9].

METHODOLOGY

The data presented in the text were obtained within the project *"Water for Prague"* [3], but mainly from excerpts from printed and digital yearbooks Water quality in streams published by CHMI and from public databases managed by CHMI. The data series from the Zelčín profile was linked to the historical profile of Vepřek, similarly the data from the Obříství profile to the historical profile of Na Štěpáně. Data from 2008 come (through CHMI) directly from their acquirers – Povodí Vltava and Povodí Labe State Enterprises. Data on daily flows on the days of sampling were obtained by downloading from the public database on the CHMI website.

RESULTS

The results are based on processing of the data from monitoring on the following profiles:

Tab. 2. Localization of monitored river profiles

Profile	Acronym	Location	Note
Hřensko/ Schmilka	HRE	Elbe, river km 729	border profile
Obříství	OBR	Elbe, river km 842	above the confluence
Zelčín	ZEL	Vltava, river km 4.5	above the confluence, about 39 km under the mouth of the CWWTP
Podolí	POD	Vltava, river km 56.2	above Prague

The development of concentrations of basic components – water quality indicators – in the section between the confluence of the Elbe and Vltava and the border profile Hřensko/Schmilka (section of about 110 km) is shown in *Fig. 1*. The graphs are processed as ten-year averages, with some values still missing in the "beginning" period 1981–1990. The first series of columns in the graphs presents the reference historical data of Ullik (Elbe, 1877) and Schulz (Vltava, 1913) after recalculation to the current methods of presentation (N-NO3, P_{total}, etc.). Significantly, today's ion concentrations are generally higher compared to "history", even though they now have a steady or declining trend. Ammonia nitrogen is now at its original level, but the overall supply and transport of nitrogen by rivers has increased significantly. At present, nitrate is completely predominant in rivers (a hundred years ago an unknown or insignificant anion in the world's rivers). Sulphate and calcium concentrations are generally decreasing. The development is in line with the supply from the Vltava basin [7, 9] and certainly also with the changes in the discharge of industrial wastewater into the Elbe above the confluence, which took place mainly in 1985–2000. The increase in flow between the Podolí and Zelčín profiles is insignificant, so the graphs also show the contribution of Prague in the form of an increase in concentrations between the Podolí and Zelčín profiles, which is mostly insignificant. The favourable development of water quality in the Elbe in the Němčice-Hřensko section and in the Zelčín profile is documented, for example, by the content of toxic metals (As, Cd, Pb, Hg) in benthic organisms [10].

Even though concentrations are considered as a basic indicator of water quality in rivers, enabling the quality control, search for pollutants, etc.; however, for the purposes of our work, the transport of pollution components through individual relevant profiles is important for the purposes of our paper (i.e. concentrations multiplied by the daily flow – Qd). In general, fluctuations in transport data are significantly more affected by fluctuations in daily flows

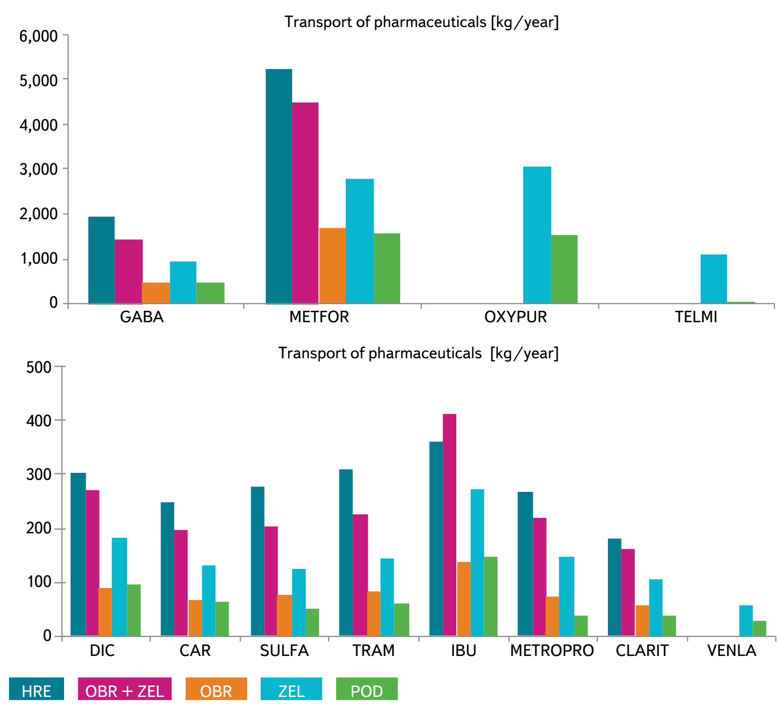

Fig. 3. Transport of pharmaceuticals through river profiles [kg/yr] – means for the period 2010–2020. Second column represents the sum of transport by Elbe and Vltava upstream the confluence. For acronymes see *Tab. 3.*

than fluctuations in concentrations; nevertheless, monitoring data provide 12 evenly distributed "situations" each year for which transport can be calculated by multiplying concentration and flow. It is clear from the development

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of concentrations that the last twenty-year period is already stable – that is, relatively constant concentrations (their annual courses), and thus that transport is controlled mainly by flow and depends on the type of supply of individual substances to the flow. The graphs for transport are processed similarly to the concentrations in *Fig. 2*. The sum of the transport through the Elbe and Vltava above the confluence is included in the graph (OBR + ZEL), to demonstrate a clear difference from transport through the Hřensko border profile. The Podolí (POD) profile is not included here because the differences in the flow through the Podolí and Zelčín profiles are negligible and the transport differences are given only by the concentration difference shown in *Fig. 1*. BOD5 and COD-Cr values are generally considered as non-conservative components of pollution, controlled by microbial degradation of organic carbon in the stream, but their development (decrease) over time generally corresponds to other components.

Over the last 20 years, we have gathered more and more quality information about the "new" component of pollution – pharmaceuticals that, after use, entered into WWTP via sewage and from them into watercourses [11]. Reliable data series based on standardized LC/MS techniques have been available for the last 10 years or so. This reliable analytics is the precise work of the teams of colleagues M. Koželuh (Povodí Vltavy, State Enterprise) and M. Ferenčík (Povodí Labe, State Enterprise), and we can only look forward to further data and hope that they will be published in a comprehensive manner. *Fig. 3* provides similar data on pharmaceuticals' transport in the period 2010–2020 for substances that commonly occur in the Vltava and Elbe in determinable concentrations. Their list, with a brief comment, is given in *Tab. 3*. For the long-term study items (ibuprofen, carbamazepine, and diclofenac), data are available for this whole period, for other pharmaceuticals for a shorter period – for gabapentin, tramadol, and clarithromycin for 7–9 years, for metformin for 4 years. Only from the Vltava do we have data for oxipurinol and telmisartan (2019–2020) and for venlafaxine (5 years). Only those pharmaceuticals whose concentrations were reliably higher than the limits of quantification of the analytical methods used (0.01–0.05 μg/l) were included in the evaluation. In the case of the relatively clean Podolí profile, we accepted cases "below the limit of quantification" if they occurred a maximum of two to three times a year, and we included them in the graphs as values corresponding to the limits of quantification. Therefore, the values of transport to Prague, for example for ibuprofen, are slightly overestimated.

DISCUSSION

The graphs characterizing the development of concentration and transport of long-term monitored classic components/indicators of pollution show that Prague and the Vltava below Prague today is not a significant source of pollution for the Czech Elbe river basin (for exceptions, see below). This is due to the gradual modifications of the WWTP on the Vltava and the Elbe, as well as the disappearance or transformation of significant industrial pollution sources. The water in the Elbe above the confluence has a significantly higher concentration of sulphate and calcium; however, we do not have historical data from the turn of the

Tab. 3. List of pharmaceuticals dealed in Figs 3 and 4

Acronym	Name	Note
GABA	gabapentin	antidepressant
METFOR	metformin	type 2 diabetes
OXYPUR	oxipurinol	allopurinol metabolite, treatment of gout, etc. (Vltava 2019-2020 only)
TELMI	telmisartan	high blood pressure (Vltava 2019-2020 only)
DIC	diklofenak	NSAIDs (parent compound only, no metabolites)
CAR	karbamazepin	antiepileptic
SULFA	sulfamethoxazol	antibiotic
TRAM	tramadol	opioid (for pain)
IBU	ibuprofen	NSAIDs (parent compound only, no metabolites)
METOPRO	metoprolol	beta-blocker (cardiac problems)
CLARIT	clarithromycin	antibiotic
VENLA	venlafaxin	antidepressant (Vltava 2019-2020 only)
IBU2	ibuprofen-2-hydroxy	ibuprofen metabolite
THIA	hydrochlorothiazid	diuretic (common in high blood pressure medicines)
AZIT	azithromycin	antibiotic
IOPR	iopromide	contrast agent
IOHEX	Iohexol	contrast agent
ACES	acesulfam	artificial sweetener
PARX	paraxanthine	artificial sweetener

19th and 20th centuries from the Obříství profile. Historically, the concentrations of the monitored components in the Elbe were higher than in the Vltava, and in the last decade the Vltava has had a higher share in the pollution of the Elbe only because it has higher flows. These are, as already mentioned, supported in the summer by discharge from Orlík reservoir. The development of nitrogen and phosphorus transport by the Vltava River corresponds to the results of Kopáček et al. [7, 9], including their reconstructions of the historical state. For nitrogen, now predominantly present only as nitrate, about 75 % comes from non-point sources, while phosphorus comes mostly from point sources, even with relatively efficient chemical removal in WWTP [2]. Nitrogen in ammonia form occurs today only in river sections below the effluents from WWTP, especially in winter when the water temperature limits the metabolism of nitrifying bacteria. However, winter discharge of N-NH4 is supported by Government Decree 401/2015 Coll., which allows it to treatment plants with up to 10,000 connected inhabitants at temperatures up to 12 °C (in WWTP), even if this means a threat to rivers, especially to smaller watercourses. In the monitored section of the lower Vltava and Elbe, this probably does not affect the measured values much. Nitrate concentrations also show a seasonal course, namely a slight negative correlation with water temperature and a positive correlation with flow, which can be explained by both the activity of non-point sources and the intensity of nitrification. A similar cycle for

View from the right bank of the Vltava - every historic town today has an old castle and a modern wastewater treatment plant. The "old" spout is visible in the right part of the image. (Photo: J. K. Fuksa)

Sampling in the Central Wastewater Treatment Plant. (Photo: J. K. Fuksa)

N-NH4 and N-NO3 can be observed in the Ullik data set [4]. The improvement is evident because, in the period 1980–1990, the concentrations of ammonia nitrogen in the Hřensko profile were still so high that the theoretical oxygen consumption for its nitrification was comparable to the BOD5 values, for which a significant share of oxygen consumption is due to organic carbon oxidation. It is important, however, that nitrate nitrogen, today in concentrations of 3-4 mg/l N-NO3 in Hřensko, will reach the sea without any losses. The decrease in sulphate and calcium transport also corresponds to a general decrease in acidification, industrial pollution, etc. [9]. In this respect, it can generally be said that the current pollution of rivers is, according to long-term indicators, consistently at a low level, and only nitrogen and phosphorus remain an issue. This also applies to BOD5 and COD-Cr, whose values are now on the border of the natural background in the monitored area. However, because the "excess" of phosphorus persists despite its regulation, the course of BOD5 and COD in the rivers downstream shows a seasonal character, determined by the production of phytoplankton, still insufficiently limited by the discharged phosphorus. The proportion of total phosphorus determined as P-PO4 is of particular importance, the so-called soluble or phosphate phosphorus, which largely comes from WWTP and is directly accessible as a source of phosphorus for the biomass of photosynthetic organisms in the river (biofilms and phytoplankton). In the graphs and budgets, we work only with the values of the concentration of total phosphorus (P_{total}) which, in contrast to the share of P-PO4, are relatively robust and we have longer time series for them.

This article deals with the problem of pollution and eutrophication at a general level and therefore avoids comparisons with legislative standards and limits. Enforceable limits are often a compromise between the need to protect rivers/wastewater recipients and the protection of the standard technical capabilities of WWTP operators. However, it should be noted that the level of pollution of watercourses and the search for problematic sections must be assessed according to the concentrations and transport budget for individual components and

Vltava above Prague, view from Vyšehrad to the south. The Vltava flows through the Orlík and Slapy reservoirs, which affect its quality and temperature regime - in summer it is still cold in Prague and gradually warming up, in winter it is relatively warm and therefore it does not freeze for years. The Berounka flows from the left, which is not yet perfectly mixed with the Vltava in this section due to temperature differences. (Photo: J. K. Fuksa)

according to their seasonal and long-term development. Simplified approaches, such as historical determination of purity classes (with "updated limits"), tend to obscure the solution. Moreover, if we take into account the trend of climate change, i.e. long periods of low flows with constant discharge from WWTP, the assessment according to average annual data is not sufficient in general.

For comparison with the development of water quality in the Elbe further downstream, the latest public data of the International Commission for the Protection of the Elbe River (ICPER) from 2010 are available [12]. Even then, the water quality parameters in the Hřensko/Schmilka border profile were "better" than in the Magdeburg profile [2]. The values for downstream transport increase with the size of the stream; if the concentrations do not increase, it can be said that the substance transport by the Elbe from the Czech Republic to Germany cannot be considered as pollution, but is a picture of comparable levels of river load, wastewater treatment, etc. in both countries.

Specific pollutants are a new problem; in addition to pesticides, these are especially pharmaceuticals. Their consumption is difficult to reduce. Their supply into the streams is determined only by their amounts, which after use and excretion, pass through the sewerage and the treatment plants into the rivers. The graphs in *Fig. 3* show that Prague is a significant source of pharmaceutical pollution, but that many substances already come from the river basin upstream. About 30 % of the long-term flow through Prague comes from the Berounka and Sázava. If we consider the theoretical retention times in the Vltava cascade on the Vltava section above Prague (Orlík about 99 days, Slapy about 37 days), the resistance of metformin, gabapentin, oxipurinol (metabolite of allopurinol), and so on is remarkable. However, theoretical retention times can only be used in general to estimate the effect on the flow rate of substances downstream, as they only apply to the long-term average flow through a full and non-stratified reservoir. In reality, the water from the influx migrates through the stratified reservoir according to the current temperatures/densities and the individual layers proceed separately (according to the discharge to the turbines). In addition, the volume of Orlík fluctuates during dry years according to the fortification of flow through Prague, which further shortens the real retention times.

If we recalculate the transport of resistant pharmaceuticals to the number of inhabitants upstream the individual monitored profiles, the differences between the profiles are significantly reduced because the consumption of pharmaceuticals is uniform in the population. Therefore, we can generalize data from downstream river sections, in contrast to the monitoring of small river basins [13], in which "islands" with specific pharmaceutical production (hospitals, etc.), as well as dilution by rainwater overflows can have a significant effect. *Fig. 4* shows the concentrations of selected pharmaceuticals in the longitudinal profile of the Vltava during its flow through Prague (section 14.3 km) in two flow and temperature situations. By selected pharmaceuticals, we mean those with regular occurrence. Orlík and Slapy reservoirs affect the temperature regime of the Vltava; therefore, the Berounka gradually mixes into it from the left and the river is not thermally homogeneous until the profile of Železniční most (the Railway Bridge). Therefore, the graph shows the profiles of Železniční most (above the centre of Prague, river km 55.4) and Sedlec (about 2 km below the outlet from the WWTP). At the two control profiles between them, the ratios correspond to the Železniční most profile (for more detailed information, see [3]). In contrast to *Fig. 3*, other substances of typically anthropogenic origin are shown in the graphs – tracers, artificial sweeteners, and the most common metabolite of ibuprofen. The results correspond to the transport balance in the whole river basin, shown in *Fig. 3*. For pharmaceuticals, we practically do not have any data below the Hřensko profile, but the comparability of the Elbe pollution level in the Czech Republic and Germany probably also applies to them, although different habits in their consumption may occur.

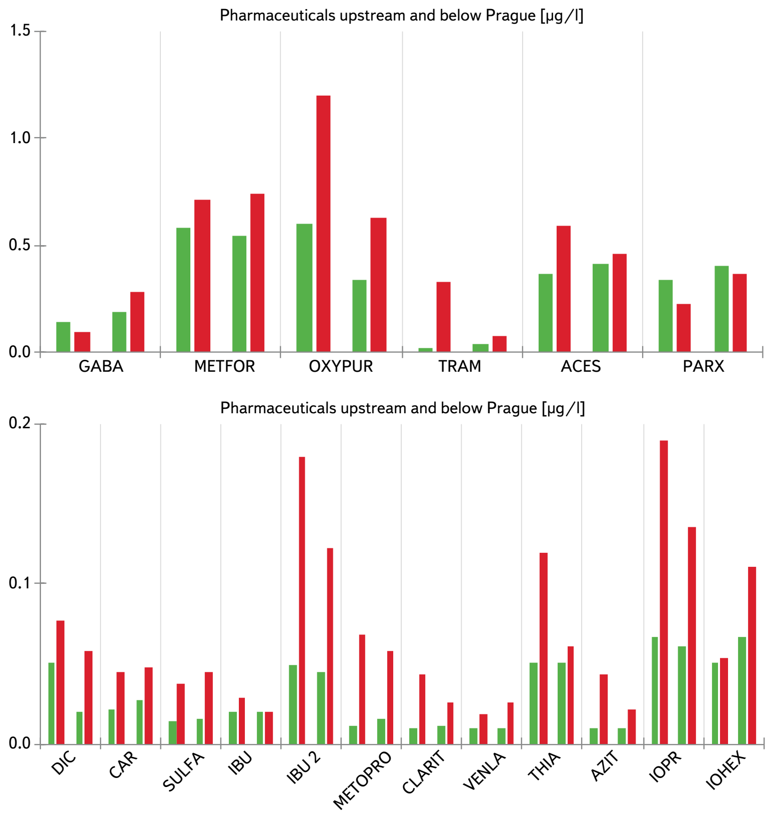

Fig. 4. Concentrations of pharmaceuticals upstream (Železniční most, green columns) and downstream (Sedlec, downstream discharge from Prague WTTP, red columns) Prague. Situation on 8 November 2017 (left pairs) and 19 July 2018 (right pairs). Beside of frequent pharmaceuticals (see *Fig. 3*) some substances are added, incl. artificial sweeteners. For acronymes see *Tab. 3*.

Discharge and transport of pharmaceuticals is a serious problem and, in general, an undertaking for further monitoring. These are mostly substances that are not "interesting" for microbial communities in WWTP as a source of carbon and energy. Their concentrations are low, so they do not support the selection of degrading microbial strains or the activation of appropriate enzymes. Their degradation is therefore at most only partial, and if they are not absorbed into sludge, etc., they largely pass into rivers. Technologies for their effective disposal in WWTP are still far away and disposal in large drinking water treatment plants (sorption technology) is not a solution for wastewater discharge. Due to the fact that WWTP are the only source of pharmaceuticals, their transport can also affect groundwater in the floodplain, including sources of drinking water. The influence of pharmaceuticals on river communities is constantly demonstrated – they act as endocrine disruptors, they influence behaviour (perception of predators and protection against them) and so on, although many publications show these effects at concentrations significantly higher than the actual concentrations in watercourses – Czech as well as global ones. Again, there is a risk of long-term low flows due to climate change – supply from WWTP is stable, but in long-term drought the proportion of treated wastewater in streams increases and the impact of residual pollution may be more pronounced, especially when low flows affect the hydromorphological characteristics of streams and their temperature regime. This applies not only to pharmaceuticals, but also to phosphorus and other substances.

One of the issues in the interpretation of discontinuous monitoring data is the possible effect of rainfall overflow dilution by the sewerage system during rainfall events. For a city the size of Prague, with sewerage connected at one central WWTP, it can be assumed that in the event of rainfall, dilution effect will not be active for the entire city. Therefore, in the case of lower streams of rivers and large settlements, this phenomenon will be significantly less significant than in small streams and can, therefore, be neglected. For small settlements with a smaller area on smaller rivers, i.e. on watercourses with lower flow and a smaller catchment area, the effect of short-term rainfall dilution is far more significant and makes it practically impossible to generalize at the level we are using for the lower Vltava and Czech Elbe. Our text attempts to synthesize data from the last 40 years and compare it with historical development. We assume that our generalizations will lead to a deeper analysis of large data sets on water quality in the rivers of the Czech Republic and the factors that affect it.

CONCLUSIONS

1. In the area of classic pollution indicators, Prague is not a significant source of pollution of the Vltava or the entire Czech Elbe river basin. The only exception is the supply of phosphorus. Further reduction of phosphorus supply from WWTP is therefore essential, regardless of compliance with current discharge limits.

2. The level of classic pollution indicators in the Hřensko/Schmilka border profile is completely comparable to the level further downstream in Germany.

3. From a historical point of view, the concentrations of pollution indicators, but also chloride, sulphate, alkali metals (Na, K), and alkaline earth metals (Mg, Ca), are significantly higher than those found in 1873 (Elbe) and 1913 (Vltava), but they are gradually declining.

4. Prague is a significant source of pharmaceutical pollution because the level of their elimination in WWTP is generally insufficient. In the current state of treatment technologies, this is mainly due to the number of inhabitants in the river basins as consumers and producers of pharmaceuticals and other PPCPs. The transport of resistant pharmaceuticals by rivers is long-distance and depends mainly on the number of inhabitants in their catchment area.

5. The development of river quality in the Czech Republic should be examined in detail, partly because the increasing occurence of long-term low flows (due to climate change) can lead to serious problems with river quality with the constant supply of standardly treated wastewater, even when meeting current discharge limits. A solid methodological apparatus and basic data sets are already available for monitoring the load of rivers by discharging pharmaceuticals, and it is necessary to start a targeted survey of the mechanisms of their supply, including the functions of WWTP and sewerages, including rainfall overflow dilution effect.

6. The monitoring of water quality in watercourses itself should support the development and implementation of more sensitive methods for the detection of pollutants that are "new" or have been below the limit of quantification of established methods for a long time. As a result, the regular water quality monitoring used here would also communicate better with the monitoring operated in accordance with the requirements of the EC Water Framework Directive (2000/60/EC).

This stream with clean banks in the picture is an outlet from the new water treatment plant of the WWTP, which has been in trial operation since 2018 and opens just above the "old" outlet. (Photo: J. K. Fuksa)

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Authors

RNDr. Josef K. Fuksa, CSc.
✉ josef.fuksa@vuv.cz

Ing. Lenka Smetanová Matoušová
✉ lenka.smetanova@vuv.cz
ORCID: 0000-0003-0271-8473

T. G. Masaryk Water Research Institute, Prague

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A retrospective view of the Šumperk water supply system from the 1960s to the present

ALEŠ LÉTAL, RENATA PAVELKOVÁ, JINDŘICH FRAJER

Keywords: water industry — waterworks — drinking water supply — Šumperk

SUMMARY

In the second half of the 20th century, the long-term problem of supplying the town of Šumperk with drinking water was finally solved. New sources of drinking water supplemented the missing capacities in the form of surface abstraction from Divoká Desná within the newly built collective water supply system, together with the use of sources in Rapotín and Olšany. A significant contribution to solving the problem was the reconstruction of the water supply network, water reservoir, and intake facilities, which reduced losses. An important factor that has reduced the water consumption of the population is, of course, the significant increase in water and sewerage prices in the last 20 years, which had an impact on Šumperk as well. The operational and organizational conditions of the town's drinking water supply were negatively affected by society-wide development, which ultimately meant an increase in operating losses in the water supply network due to limited funds for the renewal and upgrading of the water supply network. The political changes in 1989 and the following period were reflected not only in the organizational conditions of the town's drinking water supply, but also in the final consumption and price of drinking water, both in the Šumperk region and across the whole of the Czech Republic. With the example of Šumperk, it is also possible to illustrate the transformation of the water industry after 1989 and possible difficulties, new starting points, and challenges for its future development.

INTRODUCTION

In the second half of the 20th century, the long-term problem of supplying the town of Šumperk with drinking water was finally solved. New sources of drinking water supplemented the missing capacities in the form of surface abstraction from Divoká Desná within the newly built collective water supply system, together with the use of sources in Rapotín and Olšany. A significant contribution to solving the problem was the reconstruction of the water supply network, water reservoir, and intake facilities, which reduced losses. An important factor that has reduced the water consumption of the population is, of course, the significant increase in water and sewerage prices in the last 20 years, which had an impact on Šumperk as well. The operational and organizational conditions of the town's drinking water supply were negatively affected by society-wide development, which ultimately meant an increase in operating losses in the water supply network due to limited funds for the renewal and upgrading of the water supply network. The political changes in 1989 and the following period were reflected not only in the organizational conditions of the town's drinking water supply, but also in the final consumption and price of drinking water, both in the Šumperk region and across the whole of the Czech Republic. With the example of Šumperk, it is also possible to illustrate the transformation of the water industry after 1989 and possible difficulties, new starting points, and challenges for its future development.

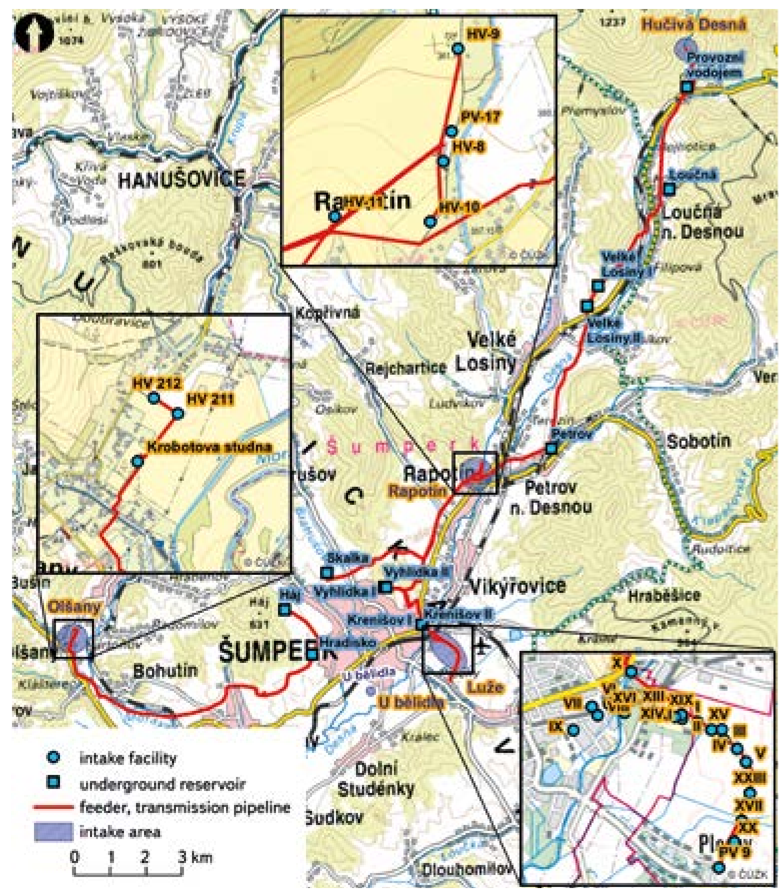

Fig. 1. Intake facilities supplying the Šumperk water supply in the period 1883–2020

THE PERIOD UP TO THE 1960s

The development stages of the Šumperk water supply system before 1970 are described in detail in an article published in VTEI issue 5/2021. It is possible to take up several important findings that influenced the development in the following period. An important aspect that affected the drinking water supply to municipalities after 1945 was the changes in the political regime. One of the

Tab. 1. Šumperk town population development with selected water supply network parameters

Year	No. houses	Population	Length of water supply network [m]	Annual consumption [m³]
1880	602	8,517	12,000 (1883)*	not known
1890	719	10,493	not known	126,396 (1889)*
1900	789	11,636	16,742 (1904)*	161,225 (1904)*
1910	924	13,329	17,192 (1911)*	290,343 (1911)*
1921	996	13,117	not known	not known
1930	1,373	15,718	28,949 (1929)*	512,547 (1929) *
1950	2,014	17,192	41,500 (1941)*	997,352 (1945)*
1960	1,890 (1961)*	19,266 (1961)*	not known	not known
1970	2,013	23,683	not known	2,500,000 (1976)*
1980	2,197	28,101	not known	3,113,000 (1981)*
1990	2,255	30,530	not known	3,600,000
2000	3,282 (2001)*	29,490 (2001)*	129,000 (2002)*	2,800,000 (2002)*
2010	2,616 (2011)*	26,737 (2011)*	not known	2,503,000
2020	2,775 (2021)*	25,836	146,831	2,344,658

Adjusted according to [4, 13, 14].
**Year of available data.*

negative consequences of the central planned economy during the Communist era was the centralization of water supply after 1948 and the setting of regulated water and sewerage prices, whose amount for households did not reflect the real costs of producing and distributing drinking water. Interestingly, the regulated price for households remained until 1991. The municipal company Šumperské vodárny (Šumperk Waterworks) lost its own source of electricity after nationalization – a small hydroelectric power plant, which provided electricity for water pumps. As a result, costs increased significantly because the company had to buy electricity. Drinking water to Šumperk was supplied from underground wells, which were gradually built on several springs within the alluvium of the river Desná in the immediate vicinity of the town of Šumperk *(Fig. 1)*.

Given the town's post-war development, these resources were, of course, not sufficient to cover drinking water consumption satisfactorily. Until the construction of the new source, the public water supply system provided for about 60 % of the population out of the total number of 19,266 in 1961 *(Tab. 1)*. In 1960, the main source was 13 wells in the Luže spring with a flow rate of about 40 l/s *(Fig. 1)*. In the post-war period, the town tried to initiate a remedy and required several expert opinions, but the bad condition was not resolved until 1971. In 1961, a study was prepared for the investment task "Collective Water Supply of Šumperk and its Surroundings" by the Hranice project department of the Regional Water Management Development and Investment Centre. The study addressed the supply of the municipalities of the Šumperk region, with a total population of 43,538 in 1962 and with a future supply forecast of over 54,000 inhabitants in 1980 [1]. Two alternatives were developed in the study. The first of them was finally selected by the opposition proceedings of prof. A. Sukovitý from Brno University of Technology and later built with modifications. This alternative included the construction of surface water intake facilities from Hučivá Desná (140 l/s), Divoká Desná (60 l/s), and a central water treatment plant in Kouty, using the existing groundwater sources in Šumperk (40 l/s). The second alternative focused on the construction of intake facilities in Hučivá Desná, Divoká Desná, and Merta, which were to form separate operating units with their own water treatment plants. At the end of the study, this alternative was evaluated as less suitable for economic and operational reasons.

ŠUMPERK COLLECTIVE WATER SUPPLY

On the basis of an elaborated and approved study for the investment task for the Šumperk collective water supply system (SVŠ), an introductory project for the SVŠ was prepared in 1966 and, on 4 April 1967, a zoning decision was issued. The construction itself was only started in 1970. The general designer was the Regional Centre for Water Supply and Sewerage Ostrava, project department Hranice, the general contractor of the construction part was Ingstav, Brno state enterprise, and the general contractor of the technological part was Sigma, Hranice state enterprise. Adamovské strojírny, Chepos Chotěboř state enterprise, ZPA Praha, and ZVVZ Milevsko became subcontractors. The proposed system was mostly gravitational (75 %), with 25 % pumping [2]. Due to the height differences of the network, it was necessary to interrupt the hydrostatic pressure by means of two diversion storage water reservoirs for the municipalities of Velké Losiny and parts of the municipalities of Rapotín and Petrov nad Desnou.

In the first phase, due to acute problems with the water supply of Šumperk, an intake facility, a temporary water treatment plant (micro-sieve, chlorination), and a supply pipeline to the existing upper pressure zone reservoir (HTP) of Šumperk were constructed. For the town's needs, this procedure provided about 30 l/s in 1971 [3]. The temporary solution had to optimize the network, pressure interruption, and venting. Prior to the construction of interruption

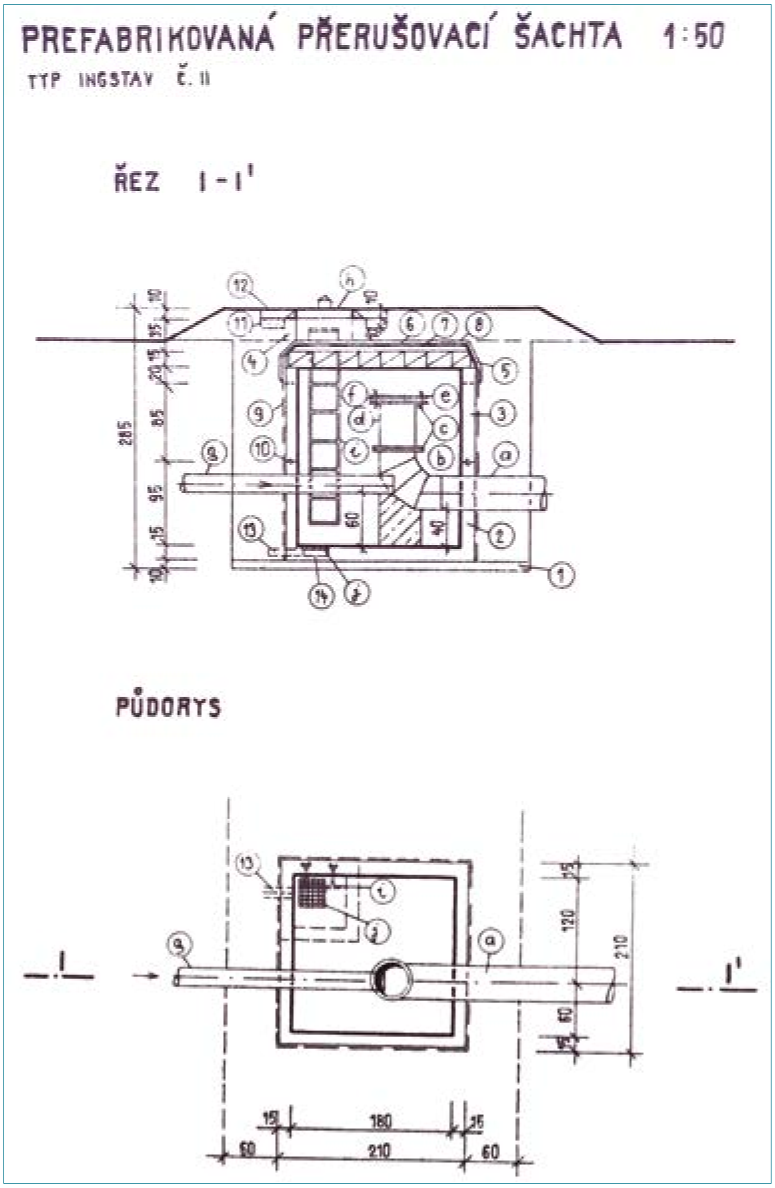

Fig. 2. Intermitent manhole on the supply pipeline of the Šumperk group water supply system in the project documentation [3]

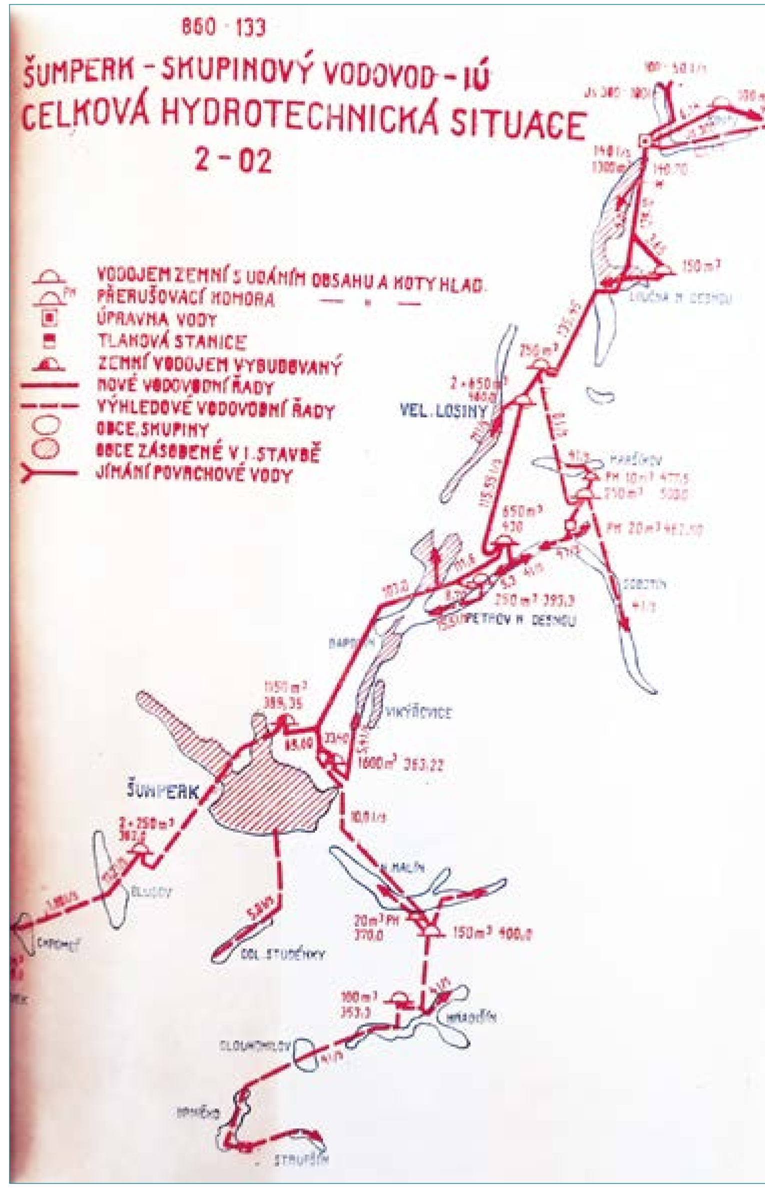

Fig. 3. Overall hydrotechnical situation of the group water supply system Šumperk in the project documentation from 1966 [2]

water reservoirs, the interruption shafts provided the said function *(Fig. 2)*.

The complete drinking water supply system of all municipalities within the SVŠ was not completed until 1974, with a final price of 42 million Czechoslovak crowns. Interruption water reservoirs with a total volume of 2,200 m^3 were built on the Kouty nad Desnou-Šumperk route. Water is supplied to the village of Loučná nad Desnou from a water reservoir with a volume of 150 m^3, to Loučná from a water reservoir of 250 m^3, Velké Losiny is supplied from a water reservoir of 2 x 650 m^3, and Petrov from a water reservoir of 650 m^3 *(Fig. 3)*. The project also included the reconstruction of the armature chambers of the existing water reservoirs in Šumperk. The SVŠ system has gravity-fed water mains that transport both 350 mm raw water and 400 mm treated water. In addition to the water treatment technology itself, chemical, physical, and bacteriological laboratories and housing units were built in the two-storey water treatment plant in Kouty nad Desnou *(Fig. 4* and *5)*.

1971–1989

The key investment for the period is the completion of the Kouty-Šumperk collective water supply system, which was the most important regional water management investment in the second half of the 20th century. Its construction solved the long-term shortage of drinking water for the Desná valley municipalities and the issue of drinking water supply for the 26 municipalities, including Šumperk. The collective water supply system, to which a special subsection is dedicated, provides almost 70 % of the region's needs. Due to population growth in Šumperk – from 23,683 inhabitants in 1970 to 28,101 in 1980 – the capacity of the existing resources was no longer sufficient and it was necessary to address their expansion. The construction of Dlouhé Stráně pumped storage power plant had a negative impact on plans to increase surface water abstraction and the capacity of resources from the upper Desná river basin in the 1980s. The large concentration of machinery and equipment, as well as extensive construction work in the Divoká Desná river basin, caused contamination with oil substances and the planned source of drinking water could not

Tab. 2. Newly built water reservoirs

Name [water level in m above sea level]	Volume [m³]	Description
Water treatment plant operating reservoir (596)	650	Ingstav type reservoir with monolithic bottom and walls and prefabricated ceiling with slide shaft 210 × 360 cm
Loučná Reservoir (531)	150	Underground type HDP 1215–3972/D with armature chamber 180 × 240 cm HDP Prague
Velké Losiny I Interruption Reservoir (531)	250	Underground reservoir HDP 1215/3972/C with armature chamber 465 × 270 cm
Velké Losiny II Interruption/Storage Reservoir (460)	2 × 650	Underground reservoir – prefabricated Ingstav type with monolithic bottom and walls, 2 round reinforced concrete chambers, common armature chamber between the chambers
Petrov interruption/storage reservoir (430)	650	Underground reservoir – prefabricated Ingstav Brno type, with monolithic bottom and walls, reinforced concrete round chamber with armature chamber 500 x 500 cm
New Vyhlídka II reservoir (383.8)	1,500	Underground reservoir – two-chamber prefabricated Ingstav Brno type made of prefabricates 2 × 12 × 18 m, with armature chamber 6 × 5.1 m
Skalka Reservoir (389.35)	2 × 750	Underground reservoir – prefabricated Ingstav Brno type 42–115/82, 18.5 × 12 m with armature chamber 5.35 × 6 m
Hradisko Reservoir (363.2)	2 × 1,500	Underground reservoir – two-chamber with a pumping station for the Háj reservoir
Háj Reservoir (389.35)	2,000	Underground reservoir – monolithic

Adjusted according to [3, 6, 8].

be used [7]. Therefore, a hydrogeological survey was carried out in the region in 1985–1988, which resulted in the drilling of wells in the future intake areas of Šumperk-Bělidlo, Olšany, and Rapotín *(Tab. 4)*. In the Bělidlo intake area, Bělidlo well was used for supply purposes, originally belonging to the Moravolen company and with a flow rate of about 5 l/s. This source was connected by a transmission pipeline to the lower pressure zone reservoir in Šumperk. The actual connection of the planned intake areas with the use of wells only took place after 1989. Another investment in the water supply network was the construction of a new reservoir in Vyhlídka. The water reservoir solved the increase of the storage space for the upper pressure zone, necessary for the future construction of the Šumperk-Temenická housing estate. The project planned the construction of a reservoir with a volume of 5,000 m³, but the requirement was rejected by the investor – Severomoravské vodovody a kanalizace Ostrava – stating that the capacity of 1,500 m³ is sufficient for local consumption in the future [6]. In 1985, a new 1,500 m³ reservoir was built, at a cost of 3,255,125 Czechoslovak crowns, next to the existing 1,150 m³ upper pressure zone reservoir *(Fig. 6)*.

In 1987, the project concept of a water supply solution with a view to 2010 was prepared. Within the framework of this concept, the use of Rapotín and Olšany springs, the construction of a control room, and the headquarters of waterworks in Šumperk on Jílová Street were envisaged. The construction of the Skalka, Hradisko, and Háj water reservoirs was also planned. Back in 1989, a two-chamber underground reservoir Skalka was built with a volume of 1,500 m³, upgrading the water supply from SVŠ to the Horní Temenice area and housing estates in the northern part of Šumperk. The technological solution of the supply pipeline was designed with regard to the possible interconnection of the water reservoir supply from Rapotín spring, which would ensure a possible replacement of the outage from SVŠ.

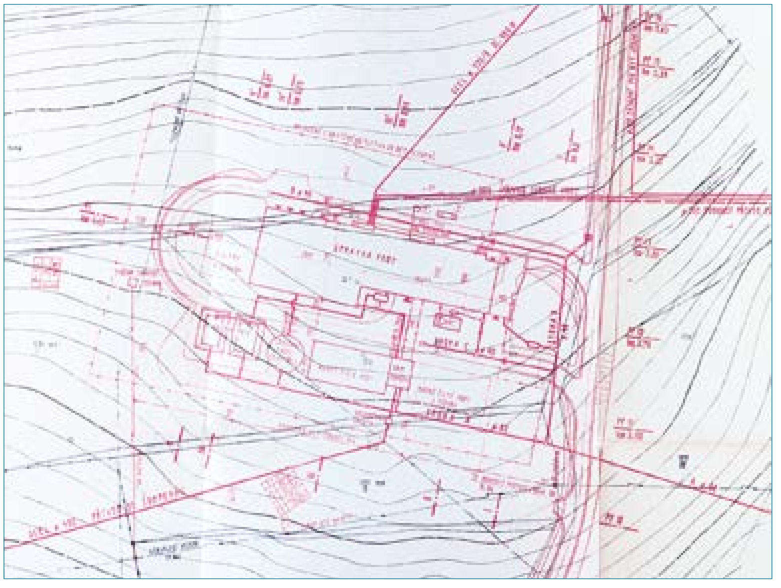

Fig. 4. Situation plan of the water treatment plant of the Šumperk group water supply system on the project documentation [2]

AFTER 1989 TO PRESENT

The end of 1989 brought political changes that had an impact on society as a whole, including water management. In 1991, a gradual transformation of water management companies began under the supervision of the Ministry of Agriculture. Šumperk company 09 created a separate unit called Vodovody

The town hall building in Šumperk
Photo: Shutterstock.com

Fig. 5. Water treatment plant at the time of construction (ŠPVS archive), after reconstruction in 2008, the filters hall with reaction tank and filters, filter scrubbing (March 2022, A. Létal)

Tab. 3. Development of water and sewerage prices in the period 1991–2020 in crowns

Year	Water price	Sewerage price	Total
1991	1.5	1.5	3.0
1996	9.5	8.0	17.4
1997	11.0	9.0	20.1
1998	12.6	10.5	23.1
1999	13.9	13.2	27.1
2000	15.3	15.5	30.9
2001	16.8	17.9	34.7
2002	18.9	17.9	36.8
2003	21.0	18.9	39.9
2004	22.1	20.0	42.0
2005	23.9	20.6	44.5
2006	24.2	22.9	47.0
2007	24.8	24.2	48.9
2008	26.4	26.8	53.2
2009	29.0	29.5	58.5
2010	31.0	31.5	62.5
2011	34.1	34.6	68.8
2012	36.8	37.3	74.1
2013	39.1	39.7	78.8
2014	39.1	39.7	78.8
2015	39.1	39.7	78.8
2016	40.3	40.7	81.0
2017	41.6	42.1	83.6
2018	44.9	43.7	88.6
2019	46.0	45.7	91.7
2020 – 15 % VAT	49.3	48.7	98.0
2020 – 10 % VAT	47.1	46.6	93.7

Adjusted according to [4, 14].

a kanalizace Šumperk, state enterprise. As part of the development and maintenance of water management infrastructure, the period is characterized by the effort of all companies to repair the damage to the infrastructure caused by the underfunding of the sector in the previous period and to reduce network losses. The sharp increase in prices, which covered the actual costs of production and distribution of drinking water, caused a corresponding reduction in water consumption by households, which eased the limiting capacities of resources, but also reduced the amount of funds paid for water abstracted *(Tab. 3)*. The process therefore led to network optimization, operation automation, measurement and control, and especially to reduced water losses.

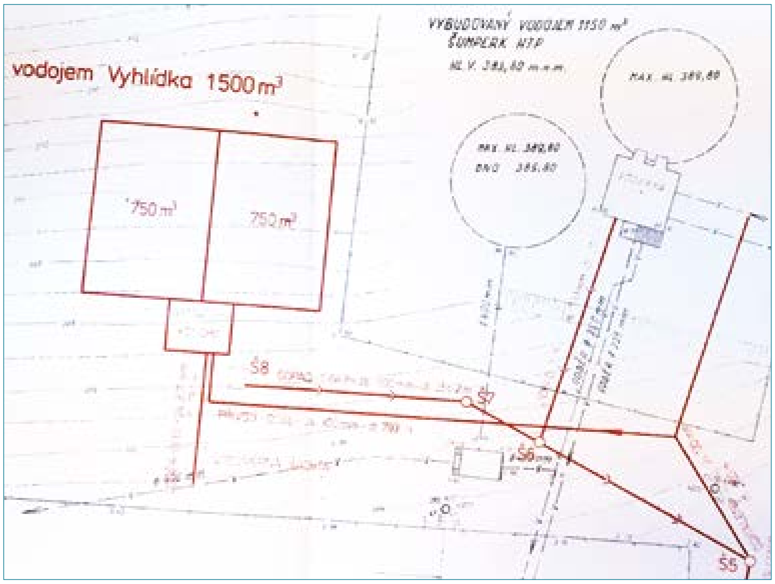

Fig. 6. Situation of the new 1,500 m³ water reservoir in the Vyhlídka locality on the project documentation [6]

Fig. 7. Rapotín Water Treatment Plant with intake well (left), engine room (right) (March 2022, A. Létal)

It was not until 1991 that the water and sewerage prices for households were increased. From 1991, in Šumperk, the water price was set at 1.50 Czechoslovak crowns per 1 m³, and the sewerage price at 1.50 Czechoslovak crowns per 1 m³. As shown in *Tab. 4*, prices have been constantly rising. Even at the beginning of the 1990s, the planned constructions, which ensured the expansion of water resource capacities, were being finished. As part of the upgrading of water resources, abstraction from the Bělidlo intake area was increased to 13 l/s in 1991 and a new Rapotín intake area was built *(Fig. 7)* with six wells with a capacity of 30 l/s *(Tab. 4)*. As with other groundwater sources, the water quality is sufficient and it is treated only by chlorination, while the water treatment plant in Rapotín is fully automatic.

Together with the source at Hučivá Desná (100 l/s) and Luže spring (45 l/s), the capacity of all sources was 188 l/s in 1992. In 1994, the Olšany intake area was connected to the available capacities with two wells with a flow rate of about 80 l/s *(Tab. 5)*, which is intended to upgrade the supply of Šumperk and Zábřeh. The Olšany intake area was supplied by two intake wells HV-211 and HV-212 from 1992. Based on the hydrogeological survey and pumping tests, a maximum flow rate of up to 200 l/s was derived [7]. The capacity of the spring is limited by the diameter of the pipeline to about 80 l/s, with the fact that 70 l/s should be provided for Zábřeh and Šumperk and 7 l/s for the surrounding municipalities [7]. The water is of very high quality and does not require further treatment, except chlorination. In addition to the increase in sources, due to the contamination of groundwater at Luže spring, the abstraction of some wells was limited and the original main water source is gradually losing its importance in the new millennium. Bělidlo spring was transferred to the emergency mode after connection of the Šumperk collective water supply system with the Olšany intake

Tab. 4. Overview of intake structures built after 1970

Name	Location	Year	Depth[m]	Diameter [mm]	Flow rate [l/s]
HV-8	Rapotín	1985	41.5	273	5
HV-9	Rapotín	1988	33	324	4
HV-10	Rapotín	1988	39.2	273	4
HV-11	Rapotín	1988	42	324	4
HV-12	Rapotín	1988	41.5	273	5
PV-17	Rapotín	1985	41.5	273	5
HV-1	Šumperk	1985	70	273	4.5
Studna Bělidlo	Šumperk	–	9	1,500	5
HV-211	Olšany	1992	85	530	13
HV-212	Olšany	1992	57	530	67

Adjusted according to [5, 7, 15].

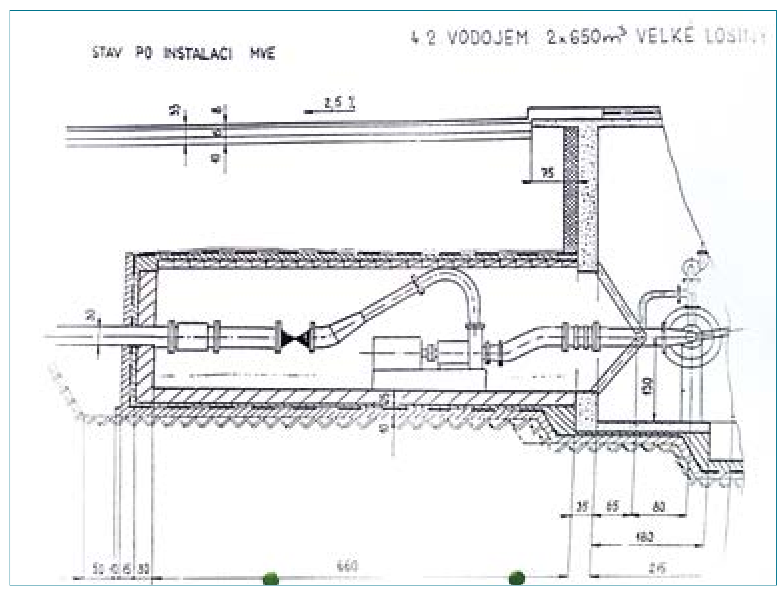

Fig. 8. Small hydropower plant in the Velké Losiny water distribution reservoir on the project documentation

area. In 2002, the water supply for the town of Šumperk amounted to 2.8 million m³, of which production from surface water accounted for approximately 10.7 %. This means that the importance of a key water source in the 1970s–1990s is again replaced by groundwater sources. The length of water supply lines in the town has reached 129 km, of which 42 km are supply pipelines and 87 km are water mains.

An interesting achievement was launching the operation of small hydropower plants in the distribution chambers of Rapotín and Velké Losiny in 1993 *(Fig. 8)*. This approach follows up on the beginning of the 20th century, when a hydroelectric power plant was built for the needs of pump propulsion, which provided the city waterworks with energy to propel their pumps until nationalization in 1946. The facility was designed by Výzkumný ústav čerpadel (Pump Research Institute), a. s., Olomouc. The turbine station is located in the armature

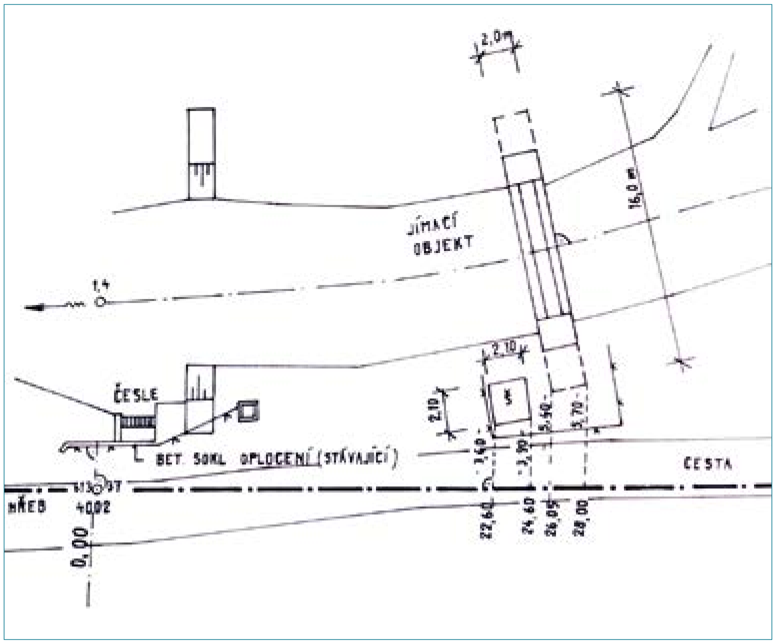

Fig. 9. Intake facilities of the Kouty-Šumperk group water supply system on Hučivá Desná in the project documentation: the original destroyed facility (left), the new facility (right) [10]

chamber of the water reservoirs and consists of a set with a radial spiral turbine with an output of 4 to 55 kW and an asynchronous generator. The small hydropower plants with automatic operation are connected to the supply pipe DN400. Unfortunately, the sets were designed for flow rates from 60 l/s. Due to the decrease in water consumption for Šumperk from the Hučivá Desná intake area, the facility is currently out of operation.

In July 1997, catastrophic floods occurred in Moravia, which also affected the SVŠ water supply infrastructure. At Hučivá Desná, the intake facility and part of the supply line were destroyed. A temporary solution managed to prevent the interruption of water supplies and a project for a new intake facility was developed. Due to the need for a stable solution, its construction was started in the same year. Originally, the water was taken by a side intake, which was later supplemented by a bottom steel intake located on a stone step. The outdated technical solution of water intake from the stream was replaced by a bottom intake facility located 20 m above the original intake point *(Fig. 9)*. It is a transverse bottom reinforced concrete sill with an intake trough, covered with screens downstream with gaps of 1 cm, which are detachable *(Fig. 10)*.

Thanks to sufficient investments in new sources and accumulation, conditions were created for the long-term maintenance of a functioning water supply system. Since 2000, investments have been directed to the automation of operations and the reduction of losses. ŠPVS annual reports show a significant reduction in losses from 38 % in 1996 to 16 % in 2020, when they approached the national average of 15.3 % in 2020 [12]. Investment projects that helped reduce losses include the reconstruction of the infrastructure in the historic city centre in 2003, which replaced some of the original elements from 1883. In 2001, the original reservoirs HTP (1935) and DTP (1883, 1935) were renovated, including the reconstruction of the outlet pipe of the 1,000 m^3 reservoir from 1935. In 2008, complete reconstruction of the water treatment plant in Kouty was carried out to an amount of approximately 95 million CZK.

The population of Šumperk has been steadily declining since 1992, which means that, as of 1 January 2021, Šumperk returned to the situation around 1970. In 1989, the consumption of drinking water in Šumperk was 171 l/person/day. In 2020, the average consumption of drinking water invoiced to households, industry, and other entities in Šumperk reached 116.5 l/person/day (the national average is 129.2 l/person/day), while in households it was 83.2 l/person/day [12, 14]. In terms of future development, investments in all elements of water management infrastructure can be expected. The main priority is the reconstruction of the feeder from the water treatment plant in Kouty nad Desnou, which was started in 2021 and is divided into several stages. Pipeline repair will be done by non-excavation technology of putting the pre-deformed pipeline (close-fit technology) into the existing steel pipeline DN400 *(Fig. 11)*; a part will be done by non-excavation burstlining technology, which will draw new ductile iron pipeline DN400 into the damaged existing pipeline. Completion of the reconstruction of the 25-kilometre feeder is planned within the next seven years.

Fig. 10. Intake structure on Hučivá Desná river, state after construction in 1997 (ŠPVS archive), current state on the right (March 2022, A. Létal)

CHANGES IN ORGANIZATION OF THE TOWN WATERWORKS MANAGEMENT AFTER 1945

After 1945, the municipal waterworks was part of the municipal enterprises and was located in the municipal gas works (Žerotínova 448/36). In 1947, the company became an independent part of the town's enterprises. It was supervised by the council of the town's national committee. On 1 July 1951, the Regional Water Management Services were established with the regional administration in Šumperk. The investment activity was managed by the water management department of the Olomouc Regional National Committee.

In 1960, Krajská správa zásobování vodou a kanalizací in Olomouc (with operations in Šumperk) was closed and new water management organizations were established within the new administrative division into districts [4]. The development of the company is summarized in *Tab. 5*. The centralized management of the company ended in 1989. In 1991, an independent organization was established – Vodovody a kanalizace Šumperk, state enterprise. After the privatization of water companies started in the Czech Republic in 1993, two new companies were established in Šumperk in 1994 – Vodohospodářské

Fig. 11. Example of the repair of the feeder using close-fit technology, implemented by Vodohospodářský rozvoj a výstavba, a. s.

Tab. 5. Changes in the management organisation of the municipal waterworks Šumperk

Year	Name of the company, unit
1883	Městská vodárna (Municipal Waterworks) in Šumperk (Wasserwerk Mährisch Schönberg)
1917	Městská vodárna a elektrárna (Municipal Waterworks and Power Station) Elektrizitätswerk
1947	Městská vodárna (Municipal Waterworks)
1951	Krajská vodohospodářská služba, oblastní správa v Šumperku
1954	Krajská vodohospodářská služba (Regional Water Management Service), regional administration in Šumperk
1960	Okresní vodohospodářská správa Šumperk (District Water Management Administration Šumperk, OVhs)
1966	Okresní vodovody a kanalizace (District Water Supply and Sewerage, OVaK)
1977	Severomoravské vodovody a kanalizace Ostrava (North Moravian Water Supply and Sewerage Ostrava, SmVaK), branch 09
1991	Vodovody a kanalizace Šumperk (Water Supply and Sewerage Šumperk), state enterprise
1994	Vodohospodářská zařízení Šumperk, a. s. (Water Management Facilities Šumperk, VHZ) Šumperská provozní vodohospodářská společnost, a. s. (Šumperk Operational Water Management Company, ŠPVS)
2001	Vodohospodářská zařízení Šumperk, a. s. (Water Management Facilities Šumperk, VHZ) Šumperská provozní vodohospodářská společnost, a. s. (Šumperk Operational Water Management Company, ŠPVS) – change of main shareholder – SUEZ WATER, s. r. o (SUEZ GROUP)
2021	Vodohospodářská zařízení Šumperk, a. s. (Water Management Facilities Šumperk, VHZ) Šumperská provozní vodohospodářská společnost, a. s. (Šumperk Operational Water Management Company, ŠPVS) – change of main shareholder – VHZ

Adjusted according to [4, 14].

zařízení Šumperk, a. s. (VHZ), established as a company of water management infrastructure owners (the municipalities and towns of the Šumperk district), and Šumperská provozní vodohospodářská společnost, a. s. (ŠPVS), which is in charge of operation. In 2001, the ŠPVS main shareholder was changed to the French-Belgian consortium SUEZ WATER, s. r. o. The biggest change in the water industry in the region since 1991 came on 27 July 2020. At the General Meeting of Vodohospodářská zařízení Šumperk, a. s., the representatives of 28 municipalities in Šumperk agreed to purchase ŠPVS shares from SUEZ GROUP. The sale of shares took place on 2 November 2020 at a price of 94 million CZK. Funds that were paid abroad to the main shareholder in the form of an annual dividend exceeding 20 million CZK could thus be fairly invested in the infrastructure in the future.

Fig. 12. View of the building for the administration of the VHZ and ŠPVZ with a control room and facilities for service equipment (March 2022, A. Létal)

CONCLUSION

The issues with drinking water supply for Šumperk and the entire Desná river basin, which the region was struggling with, were solved in the long run by building the Šumperk collective water supply system, which covers 70 % of the region's needs from. The strategic water management infrastructure built in the second half of the 20th century ensures sufficient quality drinking water without significant restrictions in the future. Due to its dynamic development in the 1970s and 1980s, the town of Šumperk was forced to build additional sources of drinking water, which were provided by wells in the Bělidlo, Rapotín, and Olšany intake areas. The change in Šumperk demographic development after 1989, which meant a permanent decline in population, together with a slowdown in textile production and a sharp rise in water and sewerage prices, brought about a significant reduction in water consumption after almost a hundred years. Of course, this trend was also reflected in the structure of the use of water resources in favour of groundwater abstraction. The transition from a centrally planned economy to a market economy entailed, in addition to an unpleasant sharp rise in prices, an increase in the amount of funds that can be effectively invested in automation and traffic regulation, as well as in the renewal and reconstruction of existing buildings and network. The acquisition of the ownership majority from the foreign owner of the VHZ operating company in 2021 marked the beginning of a new stage in the region's water management infrastructure, ensuring fair investment in the renewal and maintenance of valuable infrastructure left to us by our predecessors.

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Authors

RNDr. Aleš Létal, Ph.D.
✉ ales.letal@upol.cz
ORCID: 0000-0001-6830-2644

RNDr. Renata Pavelková, Ph.D.
✉ r.pavelkova@upol.cz
ORCID: 0000-0002-9352-5863

Mgr. Jindřich Frajer, Ph.D.
✉ jindrich.frajer@upol.cz
ORCID: 0000-0003-0817-3128

Department of Geography, Faculty of Science, Palacký University Olomouc

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Impact of climate change on runoff and development of forest composition in the coming decades in a selected river basin in Slovakia

PETER RONČÁK, JUSTÍNA VITKOVÁ, PETER ŠURDA

Keywords: forest composition — climate change — hydrological modelling

SUMMARY

In this study, the authors dealt with the impact of climate change on the hydrological regime and runoff in a selected river basin in Slovakia. The research also aimed to estimate changes in forest communities during climate change to runoff processes in the river basin. Two scenarios of change of land use with forest communities and two global climate change scenarios were used. Land use change scenarios were created for the entire territory of the Slovak Republic at the Technical University in Zvolen. Outputs from the Koninklijk Nederlands Meteorologisch Instituut (KNMI) and Max-Planck-Institut (MPI) regional climate change models – both with the A1B emission scenario – were also used for this research. Assuming these scenarios, the characteristics of the hydrological regime were simulated by the distributed WetSpa rainfall-runoff model. Based on the research results, it can be estimated that the air temperature will increase, especially in winter, which could result in less snow accumulation and increased runoff in the basin. The Hron river basin will manifest itself in an increase in mean monthly flows, especially during the autumn and winter months. This may be due to higher temperatures and earlier snowmelt in the area. However, we see that due to climate change, runoff will react in the opposite way in the summer. Compared to the current situation, we assume that there will be an increase in the extremes of the runoff regime in the winter and a decrease in the summer and autumn. Climate models suggest a change in the distribution of atmospheric precipitation, which may result in an increase in floods, droughts, and other extreme weather events.

INTRODUCTION

Environmental change (including land use change and climate change) and its impact on water resources are current topics in recent scientific studies [1–3]. The direct or indirect effects of land use and climate change on the hydrological regime have undoubtedly contributed to issues such as drought and water scarcity, increasing flash floods, and damage caused by massive deforestation.

Rainfall-runoff models are often used as a tool to assess the effects of climate change and land use change on the hydrological cycle. While the outputs of climate change models can be used in conceptual rainfall-runoff models, models with spatially disaggregated parameters are needed to simulate the impact of land use change on runoff in a river basin.

Climate change caused by rising concentrations of greenhouse gases in the atmosphere may affect the hydrological cycle and the development of forest composition. The expected increase in greenhouse gases means a change in the minimum and maximum values of air temperature, potential evapotranspiration, and the amount of total precipitation [4].

In Central Europe, many different hydrological models have been used to simulate runoff processes in changing conditions of land use and climate change, such as the WetSpa model [5–7]; SWAT [8]; MIKE SHE [9, 10]; TUW [11]. This article builds on already published articles [7, 12] and also uses outputs from global and regional models, climate change scenarios, and various conceptual or distributed hydrological models in Slovakia [7, 12–15].

The aim of this paper is to evaluate the impact of climate change and land use change on the runoff regime in a selected river basin, where the simulation of future changes in runoff processes is based on outputs from regional climate models (RCMs) KNMI and MPI. For the purpose of this research, the Hron river basin was selected as a pilot river basin.

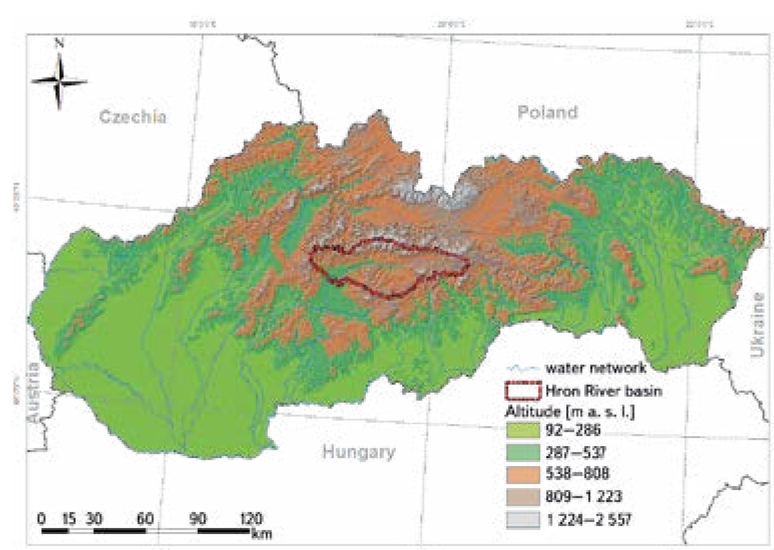

Fig. 1. Location of the Upper Hron river basin in Slovakia

AREA OF INTEREST

The Hron is a left tributary of the Danube, with its basin located in central Slovakia. The basin stretches along a long main river with numerous shorter tributaries. The upper part of the river basin, with the final profile in the Banská Bystrica gauging station, was selected for this study as a representative river basin for mountain regions in Slovakia. The basin has an area of 1,775 km^2, the minimum altitude of the basin is 332 m a.s.l., the maximum altitude is 2,042 m a.s.l.,, and the average altitude is 842 m a.s.l., The location of the Upper Hron basin is shown in *Fig. 1.*

The Upper Hron basin is located in a cool, humid to very humid climate area; the average annual air temperature is between 4 °C and 5 °C. July is the warmest month, with the average monthly air temperature oscillating between 14 °C and 16° C. January, on the other hand, is the coldest month; the average monthly temperature ranges from -4 °C to -6° C. The Upper Hron basin shows a relatively well-preserved natural runoff regime.

MATERIAL AND METHODS

Land use change and climate change scenarios

Land use scenarios were created for the entire territory of the Slovak Republic by the Technical University in Zvolen and published in Atlas krajiny SR [16]. Subsequently, they were modified and categorized by ArcGIS for the needs of the WetSpa rainfall-runoff model. Land use scenarios (changes in forest composition) for the 2075 time horizon were created based on the assumption of climate change according to global circulation models (GCM) and incremental models created within the NCP (National Climate Programme).

In the case of climate change scenarios, outputs from general atmospheric circulation models, the Dutch KNMI and the German MPI were used (both with the A1B emission scenario). The KNMI and MPI regional models represent a more detailed integration of the dynamic equations of atmospheric and oceanic circulation in a network of nodal points at a distance of 25 x 25 km, while taking the boundary conditions for solving the equations from the outputs of the ECHAM5 global model. In Slovakia, the KNMI and MPI models have up to 19 x 10 nodal points (190 in total) and quite realistic orography with a good expression of all mountains with a horizontal dimension greater than 25 km. Selected regional models have daily values of several climatological elements in their outputs from 1951, with prediction until 2100. These models and their outputs were selected based on a detailed analysis of 20 different models, of which 15 were RCMs and 5 GCMs.

RCM outputs characterizing climate change for the coming decades have been divided into 30-year time horizons (2011–2040, 2041–2070, 2071–2100), wherein horizons 2025, 2055, and 2085 represent the midpoints of these periods.

Rainfall-runoff model

The WetSpa model is a rainfall-runoff model that simulates both flow and inputs in a river basin, in this case in a daily time step [17]. The availability of a spatially distributed data set (digital relief model, soil types, and land use) in conjunction with GIS allows the WetSpa model to perform spatially distributed calculations. In this study, daily step input data from 1981–2010 were used. The following hydrometeorological data were used in the model: daily precipitation totals from point measurements at 15 stations and average daily air temperature values from 5 climatological stations. Hydrological data consisted of mean daily flows in the final profile Hron-Banská Bystrica.

In this case, the calibration period ranges between 1981–1995. The aim of the WetSpa rainfall-runoff model was to determine global parameters for

Tab. 1. Long-term mean monthly values of an areal air temperature and precipitation of the reference period (1981–2010) and the changes in their values [in °C, mm] for the future time horizons of 30 years from 2010–2100 in the Hron river basin

Temperature [°C]			**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
	1981–2010		**−4.1**	**−3.1**	**0.5**	**5.9**	**11.1**	**14**	**16**	**15.4**	**11**	**6.4**	**1.1**	**−3.1**
Hron	KNMI	2025	0	0.8	1	0.4	0.9	0.9	0.9	0.9	0.9	1.6	0.5	0.1
		2055	1.3	2.6	1.4	1	1.6	2	1.9	1.9	1.5	2	1.5	1.8
		2085	2.8	2.8	2.3	1.7	2.7	3.5	3.7	3.3	2.4	3	3.1	3.4
	MPI	2025	0.1	0.8	0.4	0.1	0.6	0.7	0.6	1	0.9	1.5	0.9	0.3
		2055	1.9	2.9	1.3	0.7	1.3	1.3	1.5	2.2	1.7	1.9	1.9	1.6
		2085	3.3	3.4	2	1.4	2.1	2.9	2.8	3.5	3.2	3.2	3.3	3.4
Precipitation [mm]			**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
	1981–2010		**48.2**	**45.1**	**53.6**	**56.1**	**94**	**101.3**	**93.7**	**82.2**	**66**	**59.3**	**67.3**	**62.6**
Hron	KNMI	2025	−3.1	3.4	0.4	−4.2	−9.2	0.8	−11.4	3.9	34.3	−2.1	4.2	20.4
		2055	5.2	8.8	11.7	16.4	−0.6	−15.7	−9.5	2.9	19.4	8.5	2.5	19.9
		2085	14.1	21.8	24.9	10.3	−19.9	−32.9	−22.1	−3.1	37.7	14.6	6.8	24.1
	MPI	2025	−0.7	8.8	3.4	−3.6	−8.4	19.7	9.5	−3.3	25.1	−3.9	8.5	13.1
		2055	7.8	6.8	16.7	21.8	−10.5	7.8	−3.7	−8.3	16.4	7.8	1.6	17.1
		2085	15.5	18.1	26.2	18.3	−14.7	0.1	−10.1	−3.8	30.3	18.6	13.9	14.8

the model for each selected river basin; by using these, the best agreement between the measured and simulated mean daily flows in the final river basin profile will be achieved. The model uses 12 global parameters that need to be calibrated. The chosen coefficient in this work (Nash-Sutcliffe [18]) as an optimization criterion is especially suitable for minimizing differences in mean values and overall balance.

RESULTS

Using the globally calibrated WetSpa model parameters and outputs from the KNMI and MPI climate scenarios, a simulation of hydrological runoff was performed in the final profile for future time periods up to 2100. The 30-year period from 1981 to 2010 was chosen as the reference period.

On the current land use map *(Fig. 2)*, arable land accounts for 6 % and grassland for 24 % of the total river basin. Three forest types occupy the following percentage of the total area: coniferous (36 %), deciduous (17 %), and mixed forest (13 %). Other land use categories occupy only low to negligible percentages. Coniferous forest occupied the largest area of the basin. In the first scenario of land use change, deciduous forest (36 %) and mixed forest (17 %) dominate. Compared to the current state, the area of deciduous forest increased, but the total forest area decreased compared to the current state. This change in forest composition may have the effect of increasing evapotranspiration and runoff; in contrast, the proportion of interception, i.e. the ability to retain water in the river basin, will decrease. In the second scenario, the area of deciduous forest reaches only 9 %, while the area of mixed forest increased to 44 %. Thus, certain differences in forest composition can be seen between the scenarios and the current situation. Deciduous forest area should increase, while coniferous forest should move to higher altitudes, mainly due to global warming.

From the results of climate scenarios, we can say that we can expect a change in the mean monthly runoff in the analysed Hron river basin. We can also see a connection with the increase in long-term runoff, which has a linear relationship with the increase in average precipitation in the coming decades. In the Hron river basin, there will be an increase in the mean monthly runoff values, especially during the autumn and winter months. This will apply to both scenarios and all time horizons (except horizon 2025 in the MPI climate scenario). According to the KNMI scenario *(Fig. 3)*, the runoff in January and February in the last horizon may reach a 100 % increase. The reason may be the higher average daily air temperature and the associated earlier snowmelt in this area. On the other hand, it is obvious that due to climate change, runoff will react in an opposite way in the summer. According to the KNMI scenario, monthly runoff will gradually decrease by 2 % to 40 % from May to August. A similar situation can be expected in the MPI climate scenario *(Fig. 4)*; the difference can only be seen in the 2025 horizon, where the runoff would increase compared to the reference period. In the autumn, an increase in the runoff in both scenarios can be expected compared to the runoff values in the reference period.

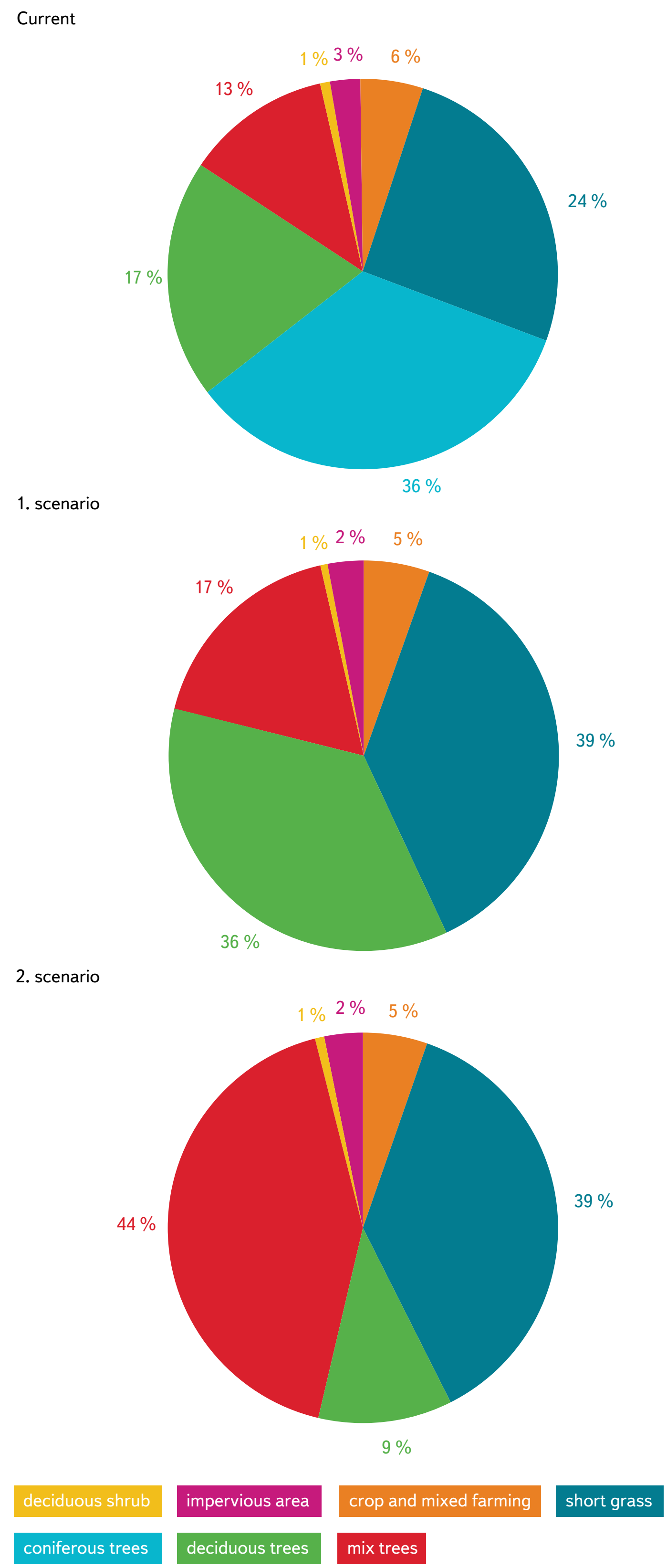

Fig.2. Current land use and land use change scenarios in the Hron river basin

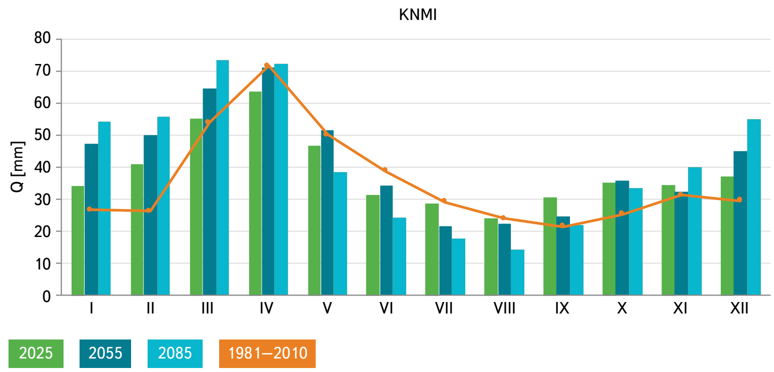

Fig. 3. Comparison of the long-term mean monthly runoff between the KNMI climate change scenario and the reference period

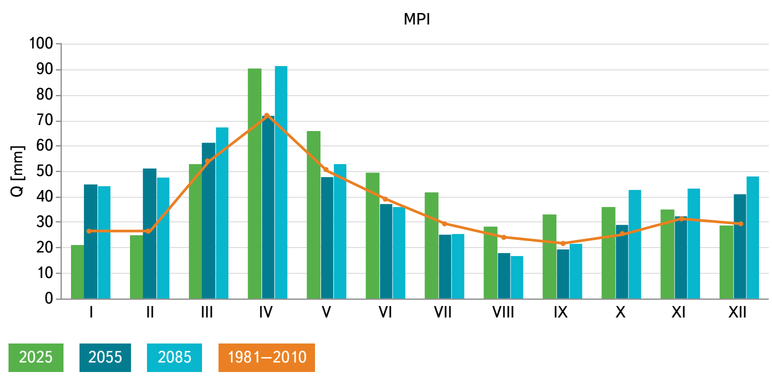

Fig. 4. Comparison of the long-term mean monthly runoff between the MPI climate change scenario and the and the reference period

DISCUSSION AND CONCLUSION

From the presented results, it can be concluded that the climate scenarios KNMI and MPI give similar forecasts in the coming decades. They predict a general increase in total precipitation, expecting higher precipitation from September to April and lower from May to August. Air temperature should increase, especially in the winter, which could result in less snow accumulation and increased runoff from the basin in the winter months, while droughts could be more frequent, characterized by low rainfall and low runoff. Evapotranspiration is expected to be most significantly affected by climate change. Drought periods may be interrupted by heavy rainfall or storms with heavy rainfall, with the number of stormy days not changing compared to the current amount (15–30 days in summer); however, the incidence of extreme rainfall events will be higher.

Climate models indicate a change in the distribution of atmospheric precipitation, a change in the frequency and intensity of extreme weather events. A much more uneven distribution of total precipitation during the year is expected, as well as in individual regions of Slovakia. The development in the distribution of atmospheric precipitation will closely correspond to the development of the runoff regime in Slovakia.

Following the similarly published works mentioned in the introduction, it can be said that the results correspond to these publications. Various river basins in Slovakia were investigated in the mentioned articles. The trend of the impact of climate change and land use change on runoff processes is obvious. Based on the results of the modelled Hron river basin and the results in the cited publications, it is probable that the magnitude of the impact of climate change and land use change will also apply to the rest of Slovakia.

Changing climatic conditions may also manifest themselves as a persistent reduction in the potential of surface and water resources, which should also be taken into account when planning and managing water resources in the future.

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Authors

Mgr. Peter Rončák, Ph.D.
🖂 roncak@uh.savba.sk
ORCID: 0000-0001-6981-7172

Ing. Justína Vitková, Ph.D.
🖂 vitkova@uh.savba.sk
ORCID: 0000-0003-4192-9724

Ing. Peter Šurda, Ph.D.
🖂 surda@uh.savba.sk
ORCID: 0000-0002-1367-9820

Institute of Hydrology, p. r. i., Slovak Academy of Sciences, Bratislava

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The Výrovka river basin as a suitable area for monitoring and comparing hydrological and landscape characteristics

PAVEL RICHTER, PAVEL ECKHARDT, JOSEF KRATINA, VÁCLAVA MAŤAŠOVSKÁ, SILVIE SEMERÁDOVÁ

Keywords: GIS — water in the landscape — hydrology — geology — pedology

SUMMARY

The Výrovka river basin, as a compact area covering 542.5 km^2, is very suitable for monitoring hydrological characteristics and comparing them in different landscape types. It is located on the border of the Lower Vltava and Upper and Middle Elbe sub-basins, extending in a range of 175–555 m above sea level, with a total of six landscape types according to the typology of the contemporary landscape of the Czech Republic. Simultaneously, there is a varied mosaic in terms of geological subsoil and soil types. There have also been major changes in land use in this basin, mainly due to intensive agricultural activity and related watercourse modifications and amelioration. Monitoring activities within the project SS02030027 *"Water systems and water management in the Czech Republic in conditions of climate change"* are currently taking place in the Výrovka river basin.

INTRODUCTION — PAST AND PRESENT ACTIVITIES IN THE VÝROVKA RIVER BASIN

In the past, several expert articles were published about the Výrovka river basin, dealing mainly with historical development of the landscape and change of land use, or the changing location of wetland habitats [1–3]. Part of the Výrovka river basin was chosen as one of the sites analysing the change of wetlands in the landscape of lowlands and hills of the Czech Republic [4]. Recently, on the initiative of the Central Bohemian Region and with support from the Operational Programme Environment, a study of runoff conditions and proposals for possible flood control measures in the Výrovka river basin was completed [5, 6]. The Local Action Group (LAG) Podlipansko, o. p. s., [5, 7] significantly participated in the implementation of this study. The above articles and the current study show that the Výrovka river basin is a suitable model area for proposing measures to improve water retention in the landscape, representing densely populated and intensively agriculturally used areas of Central Bohemia, specifically the Elbe river basin.

For the needs of other projects, a detailed analysis of the area presented in this article was performed. Currently, the Výrovka river basin is used as a model river basin to identify the origin of pollution sources for selected indicators causing failure to achieve good surface water status according to Directive 2000/60/EC of the European Parliament and of the Council (Water Framework Directive) in the TA CR project SS02030027 *"Water systems and water management in the Czech Republic in conditions of climate change"*. Within this project, in 2021–2022, selected environmental components are monitored in the Výrovka river basin and, based on this monitoring and other available data, the significance of individual pollution sources and pollution routes for this river basin will be evaluated and general conclusions drawn; if needed, the follow-up monitoring programme will also be updated.

VÝROVKA RIVER BASIN

The Výrovka river basin is located in the Central Bohemian Region in the districts of Kutná Hora, Kolín, Nymburk, and Praha-východ. In terms of altitude, the area extends between 175–555 m a.s.l. The Výrovka springes at 493 m a.s.l. near Kochánov (part of Uhlířské Janovice); other significant watercourses in the basin are the Bečvárka, rising near Miletín at 440 m a.s.l., and the Šembera, rising near Vyžlovka at 404 m a.s.l. The confluence of the Výrovka and Bečvárka is in the area of Zalešany-Žabonosy-Plaňany, at an altitude of 219 m. This is followed by the confluence of the Výrovka and Šembera at 184 m a.s.l. near the village of Zvěřínek; after 3.5 km, near the village of Písty, the Výrovka flows into the Elbe at an altitude of 175 m [8] *(Fig. 1)*.

HYDROLOGY

The entire territory of Výrovka 3rd order basin 1-04-06 is located in the Elbe basin at the boundary of the Lower Vltava and Upper and Middle Elbe sub-basins. It covers 542.5 km^2 and consists of 54 river basins of the 4th order (hydrological basin – HLGP). However, from the point of view of hydrology, this river basin can be divided into two, or even three, parts. There are two main watercourses in the Výrovka river basin: the Výrovka and Šembera. The Šembera should, according to most characteristics, form a separate river basin; but they have a common river basin due to the fact that the Šembera flows to Výrovka 3.5 km before Výrovka enter the Elbe, where both watercourses fall within 5th order of watercourses according to Strahler. The Výrovka has as a significant right-bank tributary, the Bečvárka, which flows into the Výrovka before Plaňany, at its 23.2 river km. According to the Strahler order of watercourses, at the confluence the Výrovka is in the 5th order and Bečvárka in the 4th order. From this point of view, the Výrovka 3rd order basin 1-04-06 can be divided into three parts: the Výrovka basin, consisting of 31 HLGPs with an area of 289.1 km^2; the Bečvárka basin, consisting of 7 HLGPs with an area of 64.3 km^2; and the Šembera basin, consisting

Fig. 1. The 3rd order Výrovka river basin in terms of hydrology and altitude – data source [8]

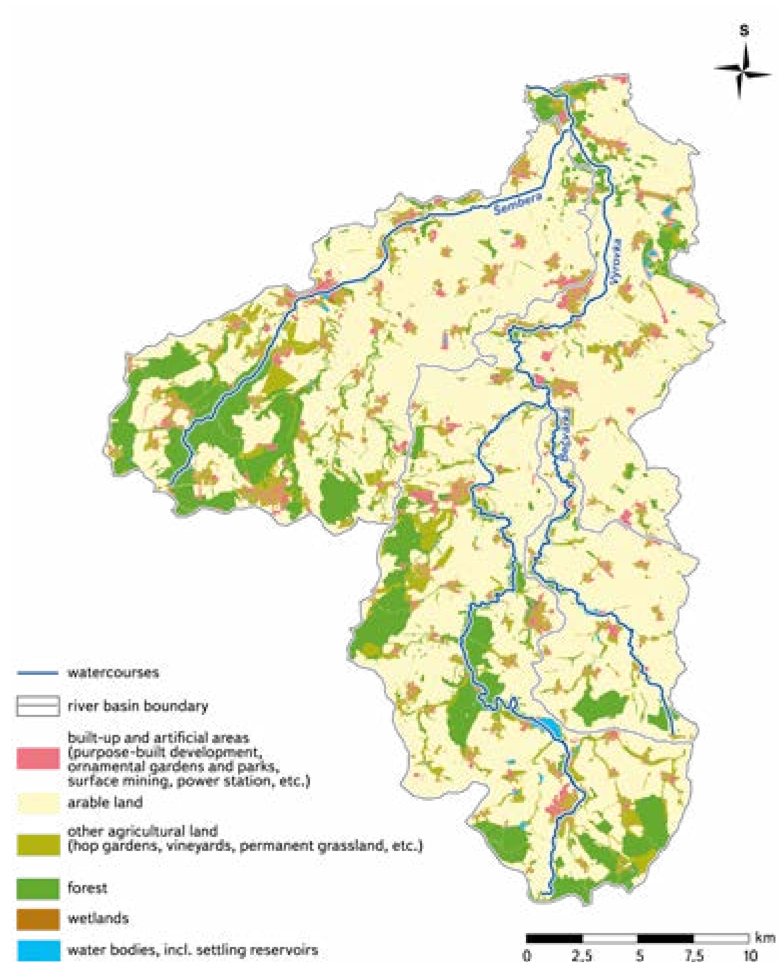

Fig. 2. Map of land cover in the 3rd order Výrovka river basin – data source [9]

of 16 HLGPs with an area of 189.1 km^2. The length of the Výrovka watercourse is 61.8 km, the Bečvárka 22.9 km, and the Šembera 28.2 km; the Výrovka watercourse in its upper part and the entire Bečvárka watercourse are significantly more fragmented than the Šembera watercourse [8] *(Fig. 1)*.

LANDSCAPE COVER AND TYPOLOGY OF THE CURRENT LANDSCAPE OF THE CZECH REPUBLIC

According to ZABAGED® land cover classification [9], arable land (67.74 %) prevails in the Výrovka 3rd order basin 1-04-06; a significant part is also covered by forests (16.20 %) and other agricultural areas (10.74 %). In contrast, the representation of water bodies and wetlands is marginal (0.74 % and 0.07 %, respectively). Built-up and artificial areas cover 4.51 % of this basin.

In terms of landscape cover within the river basin, arable land is most represented in the Bečvárka river basin (78.89 %); in the Výrovka and Šembera river basins it is 67.85 % and 63.79 %, respectively. Forests occupy the largest area in the Šembera and Výrovka river basins (especially in higher altitudes and spring areas): 19.36 % and 15.57 %, respectively; it is 9.75 % in the Bečvárka river basin. Other agricultural areas and built-up areas show a similar relative composition within individual river basins. The least abundant (but for the landscape very important) types of land cover, i.e. water bodies and wetlands, occur most in the Bečvárka river basin. In the remaining two river basins, the representation of water bodies differs; it is higher in the Výrovka river basin, while wetlands occur more often in the Šembera river basin *(Tab. 1; Fig. 2)*.

In the entire Výrovka 3rd order basin 1-04-06, there are six types of landscapes according to the typology of the current landscape of the Czech Republic. Three general types of natural landscapes and three functional landscape types. There are a total of three general types of natural landscapes in the catchment area. The source areas of the Výrovka and also partly the Bečvárka are in a slightly cool landscape of hills and highlands, the upper part of the Výrovka, Bečvárka and Šembera river basins, including the spring area, are in moderately warm landscapes of basins and hills, and the rest of the whole basin is located in warm lowlands. There are also a total of three functional landscape types in the catchment area. The source areas of the Výrovka, and partly also the Bečvárka and the upper part of the Šembera river basin, are in the forest-field landscape; the source parts of the Šembera river basin are located in the field landscape with forests and heterogeneous agricultural areas. The rest of the whole river basin falls within the field landscape [10].

GEOLOGY

Geologically, the entire Výrovka river basin is part of the Bohemian Massif. The geological composition of the area is relatively diverse, while the geological interfaces do not correspond exactly to the hydrological watersheds.

The subsoil of the upper and middle Výrovka is mainly part of the Kutná Hora crystalline basement of the Kutná Hora-Svratka region. The rocks of the

Photo: 123RF.com

Tab. 1. Representation of land cover classified according to ZABAGED® [9] in individual parts of the catchment area of the 3rd order Výrovka river basin

Land cover/basin	Výrovka		Bečvárka		Šembera	
	[km²]	[%]	[km²]	[%]	[km²]	[%]
Built-up and artificial areas	12.75	4.41	1.90	2.96	9.79	5.18
Arable land	196.15	67.85	50.74	78.89	120.61	63.79
Other agricultural areas	32.56	11.26	4.48	6.96	21.24	11.23
Forests	45.00	15.57	6.27	9.75	36.60	19.36
Wetlands	0.11	0.04	0.08	0.13	0.22	0.11
Water bodies	2.52	0.87	0.84	1.31	0.62	0.33

Kutná Hora crystalline basement are represented mainly by orthogneiss to migmatites, mica-schists to schist gneisses, etc. To a lesser extent, there are also more subsilicic metamorphic rocks, such as serpentinites (body near Bečváry), amphibolites, and similar rocks.

The subsoil of the upper and middle Šembera are of the Permocarbon structure of Blanická brázda, the southwestern part is of the Central Bohemian pluton. The sedimentary filling of the Blanická brázda consists mainly of breccias, conglomerates, sandstones, arkoses, siltstones, and claystones. The Central Bohemian pluton is mainly represented by biotite granite from Říčany.

Denudation relicts of sediments of the Czech Cretaceous Basin occur on older rocks in the Výrovka and Šembera river basins. Sedimentation began with the Peruc–Korycany Formation of the Cenomanian age. Locally, there are basal Peruc layers, which are mainly composed from sandstones, siltstones, claystones, and conglomerates. The overlying Korycany strata are formed mainly by marine sandstones. Above them, the marine sediments of the Bílá Hora Formation of the Lower Turonian age have been preserved, consisting of marlstones, claystones, limestones, spiculites, calcareous sandstones, and siltstones. The thickness of Upper Cretaceous sediments generally increase from south to north. The confluence area of the Výrovka and Šembera is thus built of Czech Cretaceous Basin rocks; the underlying older rocks no longer rise to the surface. The highest member of the Upper Cretaceous sedimentation is represented by the denudation relics of the Jizera Formation of Middle Turonian age, especially kaolinic sandstones, marlstones, and limestones.

The surface of both compared river basins is covered by Quaternary sediments. Pleistocene Aeolian sediments – loess and loess clays are significantly represented. Especially in the north of the area there are Pleistocene fluvial sandy gravels of river terraces. Diluvium's are very widespread – diluvial aluminous-sandy and aluminous-stone sediments. There are also anthropogenic deposits, such as material from construction and landfilling [8, 11].

HYDROGEOLOGY

From the hydrogeological point of view, the area of interest is part of the hydrogeological regions of the base layer 6531 – Kutná Hora crystalline basement, 4350 – Velim Cretaceous and 4360 – Elbe Cretaceous. In the northern part of the area of interest, there is the Upper Layer District 1152 – Elbe Quaternary up to Nymburk.

The upper and middle basin of the Výrovka form hydrogeological district 6531 – Kutná Hora crystalline basement. The crystalline rocks have slight fracture permeability. From the hydrogeological point of view, the shallow aquifer in the Quaternary sediments and the zone of subsurface disengagement of rock fractures is dominant in the area of interest with the crystalline bedrock. The area is usually only suitable for smaller groundwater abstraction for local supply.

The upper and middle basin of the Šembera are mostly part of the hydrogeological district of the base layer 4350 – Velim Cretaceous. Most of the subsoil of the area consists of Permocarbon sediments of the Blanická brázda. These are characterized by irregular alternation of aquitards and collectors with fracture and intrinsic permeability and are generally more permeable than crystalline basement in the Výrovka river basin.

Of the overlying relics of Cretaceous sediments, psammitic Cenomanian sediments tend to be very permeable. They occur either as denudation relics alone or are partially covered by younger formations of the Czech Cretaceous Basin. The most widespread collector of the area of interest is the so-called basal Cretaceous collector, from which groundwater is locally obtained for the municipality needs.

Another very permeable environment is the fluvial psammitic sediments of river terraces and floodplains of larger streams. Groundwater is pumped from them for smaller villages in the area. Other Quaternary sediments are less permeable, such as loess, diluviums, and flood clays. Some of them have the character of local aquitards.

The confluence area of the Výrovka and Šembera is in the hydrogeological district of the base layer 4360 – Elbe Cretaceous and to Upper Layer District 1152 – Elbe Quaternary up to Nymburk. From a hydrogeological point of view, the area is generally much more permeable than the upper and middle parts of the Výrovka and Šembera river basins. This is mainly due to the highly permeable fluvial gravel and sands of river terraces, which cover most of the area. The second important aquifer is the basal Cretaceous aquifer in the Cenomanian sandstones. In contrast, less permeable rocks form (semi) aquitards here, such as marlstones and Turonian claystones, flood clays, and loess; these are not very favourable for the formation and circulation of groundwater [8, 12–14].

GROUNDWATER – SUMMARY

The height of the groundwater level in this basin depends on the morphology of the terrain, local permeability, and precipitation totals. In general, the water level at higher elevations is the deepest, and in valleys near watercourses it is closer to the surface.

Regarding the occurrence of a significant amount of groundwater, the crystalline basement in the upper and middle catchments of the Výrovka and Šembera is rather a deficit area. Better conditions are found within the denudation relics of the Cretaceous sandstones, more permeable Quaternary sediments along watercourses, and in the Permocarbon rocks of Blanická brázda. The confluence area of the Výrovka and Šembera has the best conditions for concentrated abstraction of higher amounts of groundwater; this is due to important collectors in the Quaternary gravel of river terraces and in the Cretaceous sandstones [8, 11–14].

PEDOLOGY

Soil conditions in the entire Výrovka river basin are very diverse; there is a wide range of soil types *(Fig. 3)*. In the immediate vicinity of the watercourses, there are mainly:

— pseudogley (characterized by the presence of a pronounced marbled, redoximorphic diagnostic horizon due to alternating flooding and drying of the soil profile),
— fluvial soil (with fluvic diagnostic features caused by periodic sediment deposition and the occurrence of new formations which develop when water infiltrates during a flood),
— gleys (with a significant reductomorphic diagnostic gley horizon due to long-term saturation with high groundwater levels),
— phaeozems (deep-humus semi-hydromorphic soils developed from unconsolidated carbonate or at least sorption-saturated substrates with a phaeozem horizon, with a third degree of hydromorphism, indicated by a higher humus content than the surrounding chernozem, and with redoximorphic traits in the humus horizon and in the substrate).

In the wider vicinity of the rivers in the basin, these are:

— chernozem (deep humus soils developed from carbonate sediments),
— brown soils (soils with a profile differentiated into a slightly lightened eluvial horizon, transitioning without linguoid infiltrations to a homogeneous brown luvic horizon),
— cambisols (soils that are formed mainly in sloping conditions, to a lesser extent in flat relief, with a wide diversity in terms of their properties),
— grey earth (soils with the presence of the luvic horizon with dark clays, located locally on the periphery of the chernozem extension from loess),
— pararendzina (soils from disintegrations and from basal and shallow main formations of carbonate-silicate consolidated rocks, occurring in different climatic conditions, mainly in the areas of Cretaceous and flysch consolidated sediments).

The relative representation of soil types in individual river basins is shown in *Tab. 2*. In terms of soil-forming substrates, polygenetic clays and glacial deposits, dust loam, gneiss deluviums, loess, solid and consolidated sedimentary rocks, and others are found in the monitored area [15].

In connection with the diversity of the monitored area, we can also observe different levels of threat to agricultural land by water erosion in individual river basins [16]. It is – in addition to the characteristics of the relief – the result of the creation of large plots without anti-erosion measures and the cultivation of row crops on slopes [15]. In the upper areas of watercourses in particular there is a large proportion of soils which are slightly or severely threatened by erosion. In the lower parts, in the places where the Bečvárka and then the Šembera join the Výrovka (eventually flowing into the Elbe near the village of Písty), soils not endangered by erosion predominate. In the Bečvárka river basin, soils highly endangered by erosion are located in the area of the source near Miletín (brown earths, cambisols), to a greater extent in the section between the villages of Červený Hrádek and Bečvárky (brown earths, luvisols), around Mlýnský (Podbečvárský) pond (brown earths) and in front of confluence with Výrovka between Přeboz and Žabonosy (chernozems). In the case of the Výrovka river basin, there are soils severely endangered by erosion in the initial parts of the watercourse near Uhlířské Janovice (pseudogleys, cambisols), then also in the section between Zásmuky and Pečky (brown earths, cambisols, luvisols), especially in the vicinity of municipalities and cities, where there are large, agricultural lands. In the case of the Šembera river basin, the situation is similar; the most soils endangered by erosion are found in the vicinity of towns and villages; large areas with the highest degree of threat lie in the zone between the villages of Masojedy, Mrzky, and Tismice (luvisols, brown earths, cambisols). In the immediate vicinity of the Šembera watercourse, it is mainly around Mlýnský and Podviňák ponds before Český Brod (brown earths, cambisols), to a lesser extent in the vicinity of Poříčany and Sadská (chernozems, phaeozems) [16].

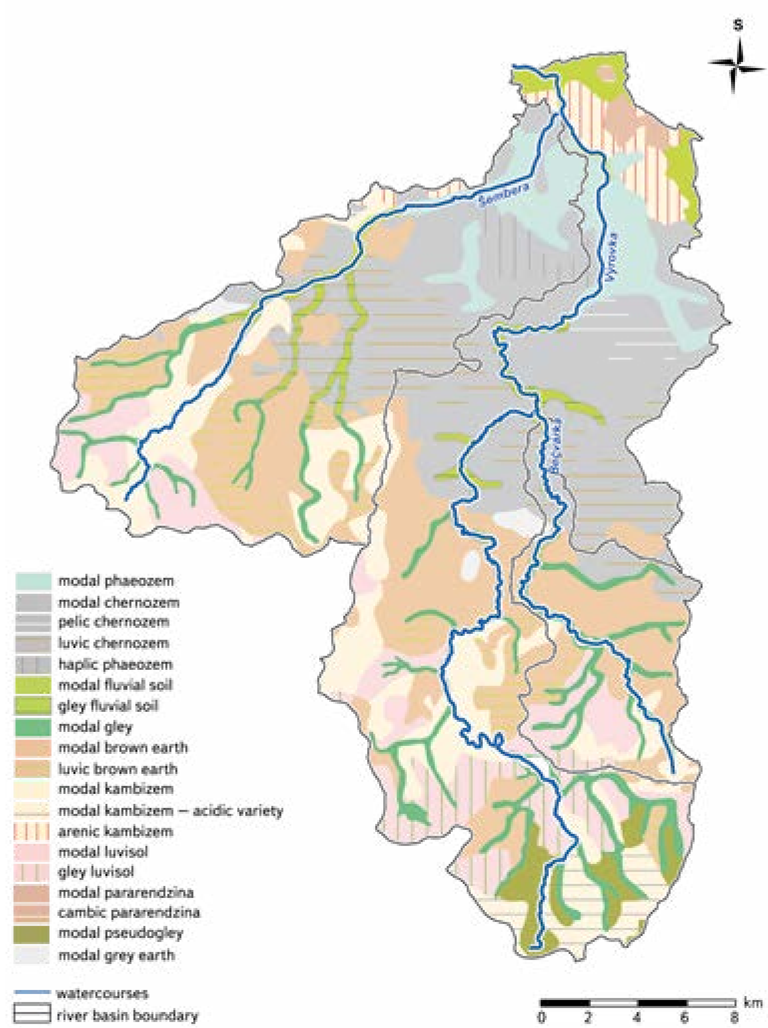

Fig. 3. Map of soil types in the 3rd order Výrovka river basin – data source [8, 15]

DISCUSSION AND CONCLUSION

The Výrovka river basin is a compact area covering 542.5 km^2; due to its diverse landscape mosaic and an appropriate number of landscape types from the typology of the contemporary Czech landscape, as well as for its diversity of geological subsoil and represented soil types, it is very suitable for monitoring and comparing landscape types and hydrological characteristics, especially the status of surface waters under the Water Framework Directive. In particular, the different characteristics in the upper and lower part of both the entire 3rd order basin and the individual river basins of the three most important watercourses (i.e. Výrovka, Bečvárka, and Šembera) provide suitable conditions for studies dealing with differentiation of proposed measures, dependant on different landscape and hydrological characteristics in this river basin, which

Tab. 2. Representation of soil types in individual parts of the catchment area of the 3rd order Výrovka river basin

Land cover/basin	Výrovka	Bečvárka	Šembera
	[%]		
modal phaeozem	6.07	–	8.38
modal chernozem	18.27	6.57	15.13
pelic chernozem	2.17	–	0.16
luvic chernozem	7.19	8.03	13.28
haplic phaeozem	0.41	–	3.45
modal fluvial soil	3.54	–	1.05
gley fluvial soil	4.00	3.62	3.55
modal gley	6.12	16.56	5.29
modal brown earth	14.68	37.85	15.77
luvic brown earth	3.14	3.42	10.29
modal kambizem	9.59	7.75	15.07
modal kambizem – acidic variety	4.54	–	–
arenic kambizem	3.70	–	0.70
modal luvisol	3.88	12.38	7.32

could then be applied to similar types of territory within the Czech Republic. The Výrovka river basin has also undergone major changes in terms of land use, caused mainly by intensive agricultural activity and related watercourse modifications and land reclamation. The proposed activities within the Study of runoff conditions, including proposals for possible anti-flood measures in the Výrovka watercourse river basin are partially trying to respond to this situation. Within this study, field surveys of the area were carried out and a hydrotechnical inspection of water works (pond dikes, culverts, piping and watercourse beds) took place. Among other things, the collected data showed that, in the upper part of the river basin, there is excessive surface runoff with a large loss of soil from agricultural land, which clogs the riverbeds and reservoirs. This finding is consistent with the results reported in the pedology chapter of this article. Rapid runoff causes a risk of floods and was the main cause of floods in the Výrovka river basin in 2013. In the lower part of the river basin, the state of watercourses needs to be improved to avoid rapid runoff of rainwater from the river basin, and subsequent floodplain drainage [5]. One of the measures developed into the documentation phase for issuing a decision on the construction location is the proposal of semi-natural restoration of the Výrovka watercourse, including the floodplain at 4.39–10.70 river km [6]. After project completion in individual cadastral areas, these documents will be available to municipalities, which can project them into their zoning plans or land adjustments; however, the study does not include the financing of the proposed measures. These measures should increase the flood protection of endangered buildings and reduce the negative effects of water and wind erosion as well as drought. Podlipansko LAG is prepared to provide assistance in finding financial resources for the implementation of the proposals arising from this study [5]. It would be appropriate for other associations of municipalities to be involved in such activities, as it now seems to be a suitable procedure for enforcing changes with a positive effect on water retention in the landscape. Following this study, a strategy for adaptation to climate change was developed for the territory of Podlipansko LAG, where the analytical part presents, among others, the meteorological characteristics, assessment of erosion and flood risks, and maps of sources and wetlands [7]. However, the historical state of the landscape is not taken into account here, which is important for the indication of sites suitable for the restoration of water retention elements in the river basin.

The above study covers a significant part of the Výrovka river basin and focuses mainly on proposals for restoration of watercourse beds, an inventory of ponds and reservoirs, as well as on the assessment of the area's vulnerability to climate change. It is certainly a commendable act, which seems to be a breakthrough in terms of the approach of state administration and local authorities to the current problems caused by climate change in combination with contemporary farming in the landscape.

Despite the above facts, there is still significant scope for designing landscape adjustments in the entire Výrovka river basin in order to retain water in the landscape, and to improve the chemical and ecological status of surface waters under the Water Framework Directive. The expected results of ongoing monitoring could possibly be used for this.

The subject is very topical. Although the issue of long-lasting drought has been a burning problem in the Czech Republic for a long time – since 2014 we have been experiencing an almost constant threat of drought; however, to this date, neither systematic proposals have been made, nor any specific measures in the landscape have been taken that would at least partially eliminate this situation. That the climate is changing and that the distribution of precipitation during the year is different from previous decades is evident, for example, in the adoption of emergency measures for periods of prolonged drought. As for now, a period of prolonged drought was declared throughout the Central Bohemian Region on 24 March 2022, until further notice. This happened on the recommendation of the Fire and Rescue Service of the Central Bohemian Region due to the current drought and an increase in the number of wildfires, as well as taking into account Czech Hydrometeorological Institute forecasts [17]. The measures taken in the countryside in connection with a period of prolonged drought include, among other, a ban on open fires, smoking, operating steam locomotives, and using water from fire-fighting sources for purposes other than fire-fighting [17, 18]. These bans could be expected in the summer months, when a period of prolonged heat is not unusual; however, it is only the end of March (this article was created at the end of March 2022, ed. note), and such a measure is not taken for no reason from day to day. Therefore, it is very important to return water to the Czech landscape through the massive implementation of appropriately designed measures leading to water retention in the landscape.

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Authors

Ing. Pavel Richter, Ph.D.
✉ pavel.richter@vuv.cz
ORCID: 0000-0001-6338-3481

Mgr. Pavel Eckhardt
✉ pavel.eckhardt@vuv.cz
ORCID: 0000-0002-4218-5344

Ing. Josef Kratina, Ph.D.
✉ josef.kratina@vuv.cz
ORCID: 0000-0001-6095-586X

Ing. Bc. Václava Maťašovská
✉ vaclava.matasovska@vuv.cz
ORCID: 0000-0001-9229-463X

Mgr. Silvie Semerádová
✉ silvie.semeradova@vuv.cz
ORCID: 0000-0002-6633-9424

T. G. Masaryk Water Research Institute, Prague

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Authors VTEI

RNDr. Josef K. Fuksa, CSc.
TGM WRI, p. r. i., Praha

josef.fuksa@vuv.cz
www.vuv.cz

RNDr. Josef K. Fuksa, CSc., studied hydrobiology at the Faculty of Science, Charles University in Prague (1968), and defended his dissertation at the Hydrobiological Laboratory of the Botanical Institute of the Czechoslovak Academy of Sciences (1982). Between 1969 and 1989, he worked in the Civil Geology State Enterprise as the head of the microbiological laboratory, and since 1989 he has been an employee of TGM WRI, p. r. i. He deals with water quality and the transformation of pollution in rivers, and anthropogenic pressures on surface waters. He teaches the courses of Microbial Ecology of Water and Ecology of Running Waters at the Faculty of Science, Charles University; he is the head of the working group "Voda" of the Committee for Landscape, Water and Biodiversity of the Government Council for Sustainable Development.

RNDr. Aleš Létal, Ph.D.
Faculty of Science, Palacký University Olomouc

ales.letal@upol.cz
www.upol.cz

RNDr. Aleš Létal, Ph.D., has been an assistant professor at the Department of Geography, Faculty of Science, Palacký University in Olomouc since 1997. In 1997, he completed the master's programme of teaching biology, geography, protection and creation of the environment at the Department of Geography, Faculty of Science, Palacký University in Olomouc. In 2005, he successfully completed the doctoral study programme Physical Geography at the Department of Physical Geography, Faculty of Science, Charles University in Prague. He specializes in research activities in the field of landscape archaeology, GIS applications in geoscience disciplines, and the use of advanced landscape mapping methods.

Mgr. Peter Rončák, Ph.D.
Institute of Hydrology, Slovak Academy of Sciences, Bratislava

roncak@uh.savba.sk
www.savba.sk

Mgr. Peter Rončák, Ph.D., graduated from the Faculty of Natural Sciences of Comenius University in the Master's degree programme Physical Geography and Geoecology and completed his PhD studies at the Faculty of Civil Engineering, Slovak University of Technology, in the Landscape Engineering programme; in his dissertation, he focused on the parameterization of precipitation-runoff models for runoff modelling in climate change conditions. Since 2019 he has been a researcher at the Institute of Hydrology, Slovak Academy of Sciences. His scientific research activity is focused on mathematical modelling of water, substance and energy processes in the soil-plant-atmosphere (PRAT) system with the aim of diagnostics and prognosis of substance and energy regimes. He also deals with the impact of climate change on rainfall-runoff processes and water reserves in soil. He has been a responsible leader and a member of many research teams in various projects. He also participates in scientific research projects in the form of field and laboratory experiments. As an author and co-author, he has published more than 60 scientific papers. He currently has more than 50 responses, of which 40 are registered in the WoS and Scopus databases.

Ing. Pavel Richter, Ph.D.
TGM WRI, p. r. i., Praha

pavel.richter@vuv.cz
www.vuv.cz

Ing. Pavel Richter, Ph.D., has been an employee of the Department of Water Protection and Informatics at TGM WRI, p. r. i., since 2007. In 2008, he completed the Regional Environmental Administration study programme at the Faculty of Environment of the Czech University of Life Sciences in Prague in the Landscape Engineering Master's degree programme. In 2015, he successfully completed the field of study Applied and Landscape Ecology in the Environmental Sciences doctoral study programme. He is a member of the Czech Limnological Society and the Czech Society for Landscape Ecology, which is a regional organization of the International Association of Landscape Ecology (IALE) for the Czech Republic. In research projects, he focuses on the issue of surface water monitoring, water retention in the landscape, and the development of the landscape based on the interpretation of archival map data, especially landscape changes in wetlands, water surfaces, and watercourses, including their floodplains. Within the operation of the Hydroecological Information System, he mainly deals with ISVS-VODA records and records of administrative divisions, protected areas, watercourses, water surfaces, and hydrological river basins.

Interview with Petr Havel, founder of the Naše voda web portal

Mr. Havel, at our last meeting, you said you started out as a drummer in a big beat band and you also wrote lyrics. How long is the journey from music to water management and environmental protection?

It is, of course, a long journey and has been lined with a number of unrepeatable coincidences and life situations, which ultimately resulted in the "transformation" of the lyricist and poet into a journalist. In this profession, I went through a range of positions – from regular journalist to editor-in-chief – as well as a variety of media from radio, press, internet portals to social networks, which I consider very important because each position and each type of media have represented a different inspiring experience that I try to make the most of.

In the meantime, however, you also worked in a bakery. What does the logistics of delivery bring to a young man's life?

A lot, actually! For example, the need to plan and create some (delivery) strategy, in which, at the same time, it is necessary to leave room for improvisation according to the development of the situation, which is actually true for life in general. However, it was also a great school of communication, as the number of people I came in contact with on a daily basis included virtually all types of personalities and behaviour. Each required a slightly different approach in order to reach the desired agreement, if possible, for all parties. Such an experience is always useful, and in journalism in particular.

How does these practical knowledge and activities combine with poetry and literature? You also take part in many book projects, you write poems and have a collection in samizdat, you performed in Viola Theatre – is it a kind of regression and purification from the not very romantic reality of today's state of nature?

I started writing poetry mainly because, after I got married, I finished with music and I lacked contact with the cultural environment. Therefore, I participated in various literary competitions (surprisingly for me, very successfully), which eventually resulted in the author's theatre of poetry and public reading of my texts, including Viola Theatre. At that time, I wrote mainly about Prague, which was unusual in a way, and therefore perhaps successful. However, I wrote about nature as well, again in a romanticized way, but also with the aim of improving the then state of the environment and because, for me, nature has always represented relaxation and a certain escape from the anonymity and hecticity of the city.

What made you set up the Naše voda web portal eleven years ago? And how strong was the competition in the market then?

It was, in a way, a logical reflection on the topics of agriculture and the environment, which I specialized in as a journalist. There, I would repeatedly come across the topic of water, water quality, resources and uses, but also very little public awareness of water. Even today, many people take it for granted because it flows from the tap, and apart from the price of water or the amount of water in wells, the actual topic is not very interesting for them. Having said that, this partly changed after our country had been negatively affected by several consecutive dry years. However, the Naše voda portal was created before that, in 2011. Therefore, the competition was not very great at that time, especially in terms of the topic of water, which we try to perceive comprehensively and in context on our portal. Most websites on water only follow a section of this issue, either according to professional interests and priorities, or they consider the topic of water as a sort of marketing strategy, or they even use it to promote lobbying interests.

So now you are the creator of the most watched portal on water in the Czech Republic. When you see the numbers of followers, are you proud of yourself?

I would be lying if I said I wasn't. When my colleague and I were launching the portal, I didn't think we would reach thousands of hits a day and, along with our portal's Facebook page, tens of thousands of hits a month. At that time, my main goal was to create a media product in our market which everyone claimed to be beneficial, but no one did it in practice. I didn't intend to do it either, but my belief in the importance of online news and raising awareness about water as a whole ultimately made me make a voluntary commitment that actually takes a lot of my time. But I don't regret it.

You said that Naše voda is actually a family business. Do you really have no employees or collaborators? Is it manageable?

The content is mainly the work of me and my wife, who takes photos and makes water-related videos. We still have a fellow colleague – co-founder, but he is not an employee. It is very time consuming, especially due to illustrative and documentary photographs from the field, but photographs increase the attractiveness of texts and can often attract attention better than text. Fortunately, a large number of water organizations send us their press releases, which we reprint without editing so that there are no interpretive shifts. In any case, when you enjoy what you do, it is a pleasure.

You mentioned that you already have 150,000 photos…

In reality, we have even more photos in the family archive. Many of them are not on the website; we would flood it with data and slow it down for users. With a few exceptions, their author is my wife Nina Havlová.

Your portal has a very wide range of topics. You will find everything from the government's programme statement on agriculture and the environment, negotiations on Turów in Poland and the issue of power stations, to ponds, Czech strawberry growers, and news about weather, floods and the like. There is also practical advice on how to choose an economical washing machine or when not to leave the house due to wind. Do you consult with anyone about the choice of topics?

The choice of topics is up to me; I intuitively try to follow what seems important to me and at the same time is somehow associated with water. The breadth of topics can be unnecessarily large for someone, but the goal of this tactic is for as many people as possible who visit the site or follow it regularly to find some interesting information on Naše voda portal.

You are also very active in agriculture – you have been an advisor to several agriculture ministers, including Mr. Jurečka. Do you remember what you really managed to win as an advisor, what you helped to achieve, for example?

I saw these activities more as an attempt to provide politicians, if interested, with some feedback – either from agricultural practitioners who, for some reason, were not heard or did not have the opportunity, or from the non-agricultural public. However, I was also actually involved in some of the measures taken, such as rejecting efforts to "double tax" ponds when talking about water, or limiting the complete destruction of bee colonies during bee plague. However, it was always in cooperation with people who had the same opinion on the solution to the problem as I did.

Do you not think that the protection of the environment and biodiversity, the effort to retain water in the landscape, support of regional farmers, the fight against bark beetle and erosion, etc., are promised at the beginning by every government?

Of course, those are long-term "sexy" topics. However, their importance is growing not only in theory but also in practice, and I must say that much has changed for the better, for example in the area of water retention in the landscape. A lot of it is not visible at first glance, so the public often feels that nothing is changing for the better. I am convinced that there is still a lot to improve in the Czech Republic in landscape protection, as well as the attitude to agriculture and forestry, but it is not that nothing is happening. Among others, Naše voda portal (www.nase-voda.cz) is about the fact that something is happening.

As a journalist working for years in water management and ecology, how do you take, for example, the news that a car park will be built in Jablonec instead of the planned wastewater treatment plant?

The construction of new or the reconstruction of existing wastewater treatment plants should be one of the highest strategic priorities in terms of water and water quality management anywhere and at any time. This is also because the demands on water quality are constantly growing, and not only drinking water. The later this problem is addressed at the national and local level, the more expensive it will be, regardless of the potential health risks.

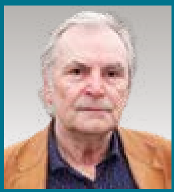
In the last issue of VTEI, we published an interview with the Minister of the Environment, Anna Hubáčková, where we talked, among other things, about one of her announced priorities, which is the protection of drinking water. Have you offered the new Minister cooperation with your water portal?

So far, there has not been opportunity for it, and it is not just up to me either. I am personally prepared to cooperate online with anyone sensible, because meaningful communication can be a means of meaningful problem solutions, if people listen to each other.

Thank you for your useful work on the Naše voda web portal and for the time you spent with our interview.

Mgr. Zuzana Řehořová

Petr Havel



Petr Havel, born on 19 April 1956, is an agrarian analyst dealing with agriculture, the environment, forestry, and water management. He has been working in media since 1994. He was involved in the creation of information portals such as agris.cz and foodnet.cz, and for many years he worked in the management of the Club of Agricultural Journalists and Publicists. At present, he is a member of IFAJ (International Federation of Agricultural Journalists). In 2010, he received the Antonín Švehla Foundation Award for defending democracy and the peasant state. In 2011, he founded the news and education portal Naše voda, of which he is a co-owner and editor-in-chief. As a co-author, he participates in various publications, such as Krajina a voda and Půda a život civilizací, whose main author is Václav Cílek. Petr Havel is married and has two children.

BÍLINA – The story of the purple river

Ibra Ibrahimovič (1967) has been photographing his black-and-white series *"Střepy severních Čech"* (Pieces of Northern Bohemia) since the early 1990s. He became known to the public as a photographer of the struggle to save the village of Libkovice in 1993, and later in 2003 with an award-winning series about farmer Rajter.

With the support of the Ministry of the Environment and TGM WRI, the book *Příběh fialové řeky* (The Story of the purple river) was published in 2015, describing through photographs the turbulent fate of the Bílina river, perhaps the only river in our country that is said to have burned due to pollution. Ibra Ibrahimovič takes photographs mainly on black and white film, 6 x 12 cm, and thus tries to follow the pictorial message of Josef Sudek and Josef Koudelka, who recorded the local landscape in a similar way in the 1970s and 1990s.

In his wanderings around the Bílina river, he looks for places that tell of man's relationship to this river, as well as those that reflect its turbulent history. His goal is to testify to what this river, which flows in the vicinity of surface lignite mines and chemical plants, looks like today, because from his childhood, he remembers it as a dark sewer stinking of phenols.

The work is very time consuming, demanding on light conditions (reflections of the sun in the water), and therefore especially reliant on the weather. The photographing itself takes place mainly at the beginning of spring and at the end of autumn, when the trees – still or already – lack leaves, which allows views of the surrounding landscape and maintains the visual context.

The Bílina river, on its 83-kilometre-long course, was displaced many times and destroyed by wastewater from factories and mining operations. Its pollution reached tragic proportions during the Second World War, when a chemical factory was built near its riverbed in Záluží near Litvínov. During Allied bombing, the wastewater treatment plant was damaged and chemicals leaked into the riverbed for a long time. It served as a poisoned phenolic sewage system for local chemical plants until the early 1980s.

Today, the purity of the water in the Bílina river is almost standard. In contrast to other watercourses, it also contains historical traces of phenolic sediments and is polluted mainly in connection with industrial accidents.

Not even a kilometre of its flow is original. It rises in wetlands, former forest land reclamation from the 1970s, and can only meander on the slopes of the Ore Mountains from the source to Jirkov reservoir. However, even here in the deep forests, the regulation of its banks is evident, especially near the ruins of the foundations of Sudeten farm buildings.

From Jirkov it already flows in strengthened banks, often concrete. The last natural part of the river disappeared in the early 1990s, on the 16th to 18th km of the river, near Rtyně. At that time, the forgotten request of the Želany collective farm (JZD) was complied with and the riverbed was straightened and strengthened even against the will of the owners, who newly re-acquired the land around the river.

The positive news is that in the foreseeable future, after 35 years, the Bílina river will hopefully return from pipes to a new open channel on the three-kilometre section of the Ervěnice Corridor (in the vicinity of the Czechoslovak Army Mine, currently in the process of closing) and flow through shrubs and trees again.

The fate of the Bílina river captured in the photographs is a living project. The original book from 2015 has no end and is supplemented again and again by new stories and pictures.

The editorial staff thank Mr. Ibra Ibrahimovič for his kind permission to publish his photographs in VTEI. March 2022

2019 – The Bílina river rises in wetlands above Černé jezírko near Mezihoří in the Ore Mountains, in an area of forest land reclamation from the 1970s

2020 – The inflow of the Bílina river into the Újezd reservoir, former Kyjice; the passage of a historic train to celebrate the 150th anniversary of Most Railway on the Most–Chomutov line

2018 – Along the Ervěnice Corridor, the Bílina river flows in pipes for three kilometres, within sight of the Czechoslovak Army lignite quarry

2016 – The flow of the Bílina river in the village of Světec, not far from Ledvice coal power plant

2017 – Bílina river, Úpořiny

2017 – Bílina river, Velvěty, the site of the former Lybar factory, today Czech Aerosol

2019 – Želenice bathtub race on the Bílina river has a tradition since the 1980s (1st year – 1982), that is, since functional waste treatment plants were set up on its course

Ibra Ibrahimovič

Ibra Ibrahimovič got his name from his father of Albanian descent. He was born in the old town of Most in 1967 and grew up in the mining settlement of Meziboří on the slopes of the Ore Mountains, from where he still sets off to take photographs, and where his parents live. After completing the Secondary School of Mechanical Engineering in 1986, he began to photograph as a hobby. In October 1989, he returned from compulsory two-year military service, and in 1991 he left his job at the Záluží Chemical Plant and decided to take photographs professionally. At the beginning of his career, he worked closely with Zelený dům Litvínov, with the help of which he launched the *"Střepy severních Čech"* project (Pieces of Northern Bohemia). He has been working on this ongoing project ever since. The best known are his series about the demolition of the North Bohemian village of Libkovice (1993) and the story of farmer Rajter (2002). He has also participated in a number of publications and exhibitions. Since 1995, he has lived alternately in Prague, where he runs a studio and a dark room with friends. Ibra Ibrahimovič has been free all his life and is co-raising one fantastic daughter.
www.ibraphoto.net

SMART WATER

"SMART WATER" is a project funded from the Norwegian Financial Mechanisms as part of the REINE programme, running from 2nd August 2021 to 30th June 2022. The project is coordinated by the non-profit research and training centre METCENAS, o. p. s., its partner being the organisation AVAS, s. r. o., which is responsible for the dissemination and delivery of the results.

Fig. 1. Two artificial wetlands in the village of Zbenice, Czech Republic

"SMART WATER" is focused on information and educational activities contributing to environment protection in terms of reducing the negative impact of human activities on water quality. It comprises two main information lines, reflected in all project outputs, which are particularly represented by the book Does clean water ever exist? A book about what is discovered by labs in aquatic environments, several public education programmes on the Czech radio, two films and a series of expert tutorials.

The first line deals with the impacts of the so-called "emerging contaminants", such as pesticides and pharmaceuticals, on the quality of water that we use on a day-to-day basis, including the mechanisms of their entry into surface waters. Real-life risks of how the environment can be affected by these new substances are discussed, in particular potential impacts of their presence in waters on human health as well as the options for their removal from ground and surface waters. Examples of good practice are presented along with instances of removal of pharmaceuticals and pesticides from groundwater by means of natural attenuation.

The second education line deals with the applicability of constructed wetlands for enhancing local infiltration and final treatment of the infiltrated water. The constructed wetland technology has been developed based on the knowledge of natural wetlands, which are highly dynamic ecosystems where a number of transformations take place and aerobic and anaerobic conditions alternate, resulting in the purification of wetland water. Constructed wetlands are typically small, simple, low-cost nature-based technologies that are easy to maintain. They are mainly designed for areas for which centralised water treatment technologies are not suitable, and water can be directly infiltrated into the soil. It is for the simplicity and general low-maintenance status of constructed wetlands that they are especially well-suited for Third World countries, where regulations do not oppose infiltration of rainwater and community sewage, and thus the cleansing capacity of constructed wetlands can be fully taken advantage of. It is (not only) these possibilities that the second film, partly set in Nepal, is about.

Fig. 2. Artificial wetland in Satya Sai Sikshya Sadan, Nepal

The activities of the "SMART WATER" project enhance the competencies of target groups (expert community as well as the general public) in the area of sustainable water management and are a follow-up to the projects promoted by the project coordinator METCENAS, o. p. s., in the field of applied research and the use of nature-based technologies along with non-technological measures for the provision of sufficient amount of good-quality water both for drinking purposes and for agriculture.

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Author

RNDr. Zuzana Boukalová
✉ zuzana.boukalova@metcenas.cz
ORCID: 0000-0002-0155-6559

METCENAS, o. p. s., Plzeň

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RIVER WATER-CROWFOOT
is an aquatic plant from the buttercup family that thrives in clean, flowing water. In May and June, it develops showy white flowers. The river water- crowfoot from this photo grows at the bottom of a deep gorge of the Kamenice river, near Dolský mlýn in Bohemian Switzerland National Park. Due to its cellar-like climate, the river does not freeze here even during long-lasting frosts, so we can see its evergreen plants even in winter, when they become the favourite food of deer.
Text and photo by Václav Sojka, www.vaclavsojka.cz.

VÝZKUMNÝ ÚSTAV
VODOHOSPODÁŘSKÝ
T.G. MASARYKA
veřejná výzkumná instituce