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Water quality trends and concentration-discharge changes during different rainfall-runoff conditions in headwaters – Blanice River case study

(Trendy kvality vody a změny koncentrace a odtoku během různých srážko-odtokových podmínek v pramenných oblastech - případová studie řeky Blanice)

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Abstrakt: Ekosystémy pramenných oblastí jsou mimořádně citlivé na jakékoli přírodní nebo antropogenní vlivy, jako jsou změna klimatu, půdního pokryvu a využití půdy nebo změny chemismu srážek. Pramenná oblast řeky Blanice je dobrým příkladem horské pramenné oblasti mírného pásma, které je částečně pod ochranou přírody. Tento ekosystém je unikátní také tím, že se zde nachází nejpočetnější populace kriticky ohrožené perlorodky říční (*Margaritifera margaritifera*) ve střední Evropě. Se zaměřením na změny fyzikálně-chemických koncentrací v závěrovém profilu byl u N-NO_3^- pozorován výrazný klesající trend ve většině části roku a také v roční datové řadě od roku 2003. Průměrná roční koncentrace N-NO_3^- klesla z 1 175 µg·l^{-1} v roce 2004 na 587 µg·l^{-1} v roce 2018. Také ostatní sloučeniny dusíku a fosforu vykazovaly v průběhu roku některé významné klesající trendy. V povodí malého zalesněného přítoku byly zjištěny mírně odlišné výsledky. Hodnoty *pH* se zvýšily, což koresponduje s celkovým trendem a zotavením z acidifikace ve střední Evropě. Spolu s touto změnou byl zjištěn pokles koncentrací SO_4^{2-}. Zvýšily se však koncentrace některých kovů (Fe, Al, Mg) a N-NO_3^-. Během srážko-odtokových událostí byly pozorovány zvýšené koncentrace vybraných ukazatelů kvality vody (Al, Fe, TP, organické sloučeniny), které mohou negativně ovlivnit populaci perlorodky říční.

Klíčová slova: Blanice – biogeochemismus – perlorodka říční

Abstract: Headwater ecosystems are extremely sensitive to any natural or anthropogenic influences, such as climate change, land cover and land use or changes in the precipitation chemistry. Blanice River headwaters is a good example of temperate mountain spring areas, which is partially under nature land protection. This ecosystem is also unique because of the most abundant population of the critically endangered freshwater pearl mussel (*Margaritifera margaritifera*) in Central Europe. With focus on changes in physical-chemical concentrations in outlet profile, a significant decreasing trend was observed for N-NO_3^- during most of the months and also in the annual data series since 2003. Mean annual N-NO_3^- concentration decreased from 1 175 µg·l^{-1} in 2004 to 587 µg·l^{-1} in 2018. The other nitrogen and phosphorous compounds also showed some significant decreasing trends during the year. In small forested tributary catchment was detected slightly different results. Values of *pH* increased, which corresponds with the overall trend and recovery from acidification in Central Europe. Together with this change, decreases in SO_4^{2-} concentrations were detected. However, some of the metals (Fe, Al, Mg) and N-NO_3^- concentrations increased. During rainfall-runoff events have been observed increased concentrations of selected water quality parameters (Al, Fe, TP, organic compounds) which negatively affect freshwater pearl mussel populations.

Keywords: Blanice River – biogeochemistry – freshwater pearl mussel

1. Introduction

Headwater ecosystems are extremely sensitive to any natural or anthropogenic influences, such as climate change, land cover and land use or changes in the precipitation chemistry (Oulehle a Hruška 2009). They are, though, an indispensable part of the ecosystem and important drinking water sources, both actual and potential. Knowledge of their status and dynamics is therefore crucial. Blanice River headwaters is a good example of temperate mountain headwater areas, which is partially under nature land protection with implemented measures improving water quality. This ecosystem is also unique because of the most abundant population of the critically endangered freshwater pearl mussel (Margaritifera margaritifera) in Central Europe (Simon et al. 2015).

2 Data

There were several sources of data. For analysing the seasonality and trend analyses, monthly data of biogeochemistry from Povodí, s.p. for Blanický mlýn (BLM; 2003–2019) together with daily data of discharge from Czech hydrometeorological institute for BLM (2004–2019) and monthly data of biogeochemistry and discharge from the Czech Geological Survey for Spálenec (SPA; 1994–2006) was used. Additionally, field data of *pH*, conductivity, dissolved O2 and own data of seasonal biogeochemistry in 9 sites (2018–2019) were used. For detailed analyses of electric conductivity changes for Zbytinský brook in Zbytiny village during Wastewater treatment construction between 11/2007−11/2009 10-minute data of electric conductivity (*EC*) and discharge from data of the Department of Physical Geography and Geoecology, Charles University (CUNI 2023) were used.

3 Methods

Seasonality was analysed using seasonal indexes. Significant trends in long term monthly and annual data series (2003−2019) for the BLM site were identified using the Mann-Kendall (MK) trend test (Mann 1945, Kendall 1975). Significance of the trend was tested at the level *alpha* = 0.05. Additional analyses of continual (10-minutes data) *EC* changes during WWTP construction in Zbytiny (before and after) was done for sites above and under WWTP.

4 Results and conclusion

If we look at seasonal changes of individual physicochemical parameters (an example is shown in Fig. 1) we can observe *pH* minimum in March, which is probably influence of highest Q_d during sampling. Values of electric conductivity was maximal in February and minimal in March at site Spálenec and in April at site Blanický mlýn, which seems to be influence of discharge as well. Maximal discharge was observed in April, as it was an influence of snow melting. Concentration of base cations (Ca^{2+}, Mg^{2+}, Na^+) was minimal in March at site Spálenec, which correlates with low electric conductivity. SO_4 was maximal from November to April and lower during summer. Al max. January–March at Spálenecký site. CODCr max. in June and July, min. in January (BLM) influenced by temperature and the amount of organic matter in water.

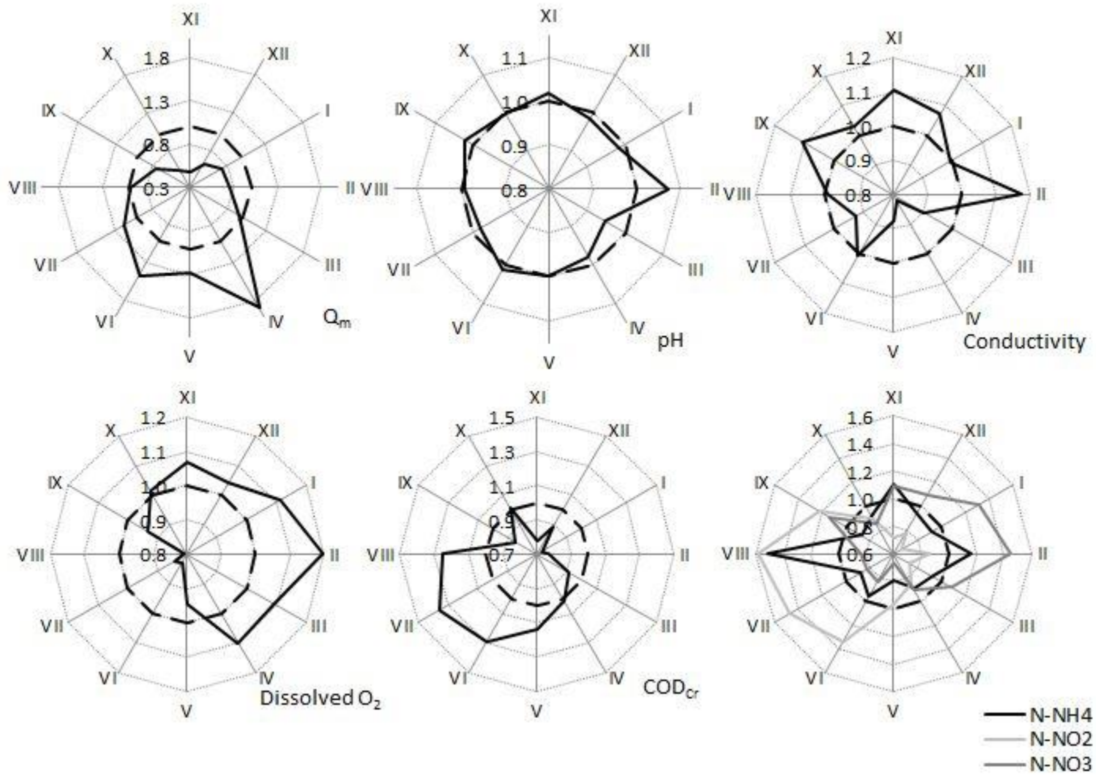

Fig. 1 Seasonality of selected physicochemical parameters. Data source: Povodí Vltavy (2023).

With focus on changes in physical-chemical concentrations in outlet profile Blanický mlýn, a significant decreasing trend was observed for N-NO_3^- during most of the months and also in the annual data series since 2003 according to data from Povodí Vltavy, State Enterprise. Mean annual N-NO_3^- concentration decreased from 1 175 $\mu g \cdot l^{-1}$ in 2004 to 587 $\mu g \cdot l^{-1}$ in 2018. The other nitrogen and phosphorous compounds also showed some significant decreasing trends during the year. In small forested tributary catchment was detected slightly different results according to the comparison of data from CGS in 1994–2006 and our data in 2018–2019. Values of pH increased, which corresponds with the overall trend and recovery from acidification in Central Europe. Together with this change, decreases in SO_4^{2-} concentrations were detected. However, some of the metals (Fe, Al, Mg) and N-NO_3^- concentrations increased.

Analyses of conductivity changes during Wastewater treatment plant (WWTP) Zbytiny construction in 2009 shows strong decrease of mean *EC* under the WWTP (Fig. 2). While above Zbytiny village was *EC* values before and after WWTP construction almost the same (around 70 $\mu S \cdot cm^{-1}$), under the Zbytiny village and also under WWTP *EC* values have changed from 175 $\mu S \cdot cm^{-1}$ before WWTP construction to 71 $\mu S \cdot cm^{-1}$ after WWTP construction.

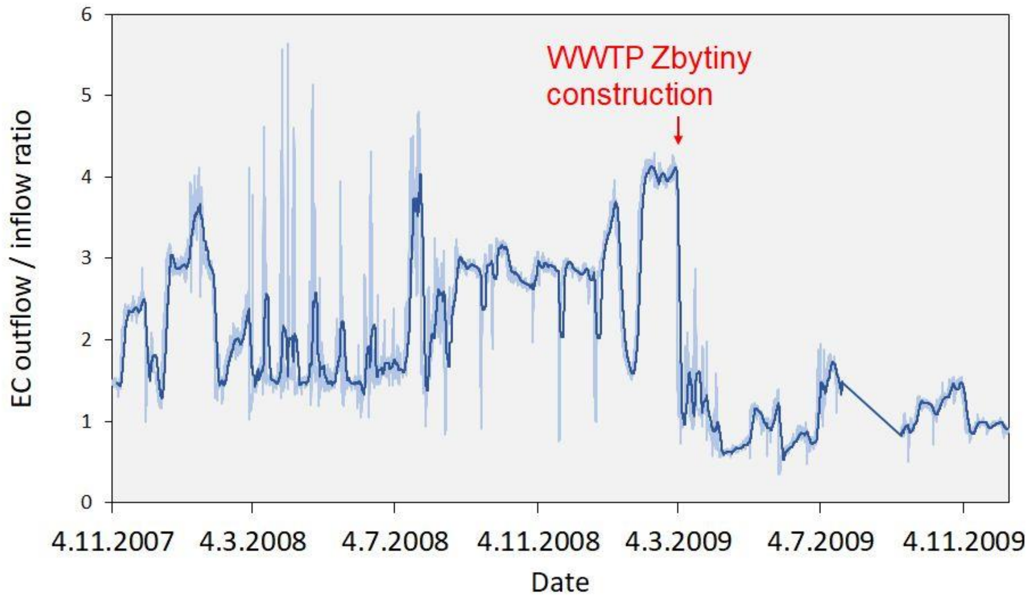

Fig. 2 Electric conductivity (EC) outflow/inflow ratio for Zbytinský brook in Zbytiny village between 11/2007−11/2009. WWTP Zbytiny was built in the beginning of 2009. Hourly EC outflow/inflow ratio is represented as light blue line and ten hours moving average as dark blue line. Data source: CUNI (2023).

With regard to runoff conditions, there was an obvious increase in Al, CODMn, DOC and TP in all studied sites during a rainfall-runoff event. The largest increases were registered for Al concentrations, where the Al concentrations were more than three times higher during the rainfall-runoff event than under normal conditions in all sites.

In four sites the Al concentrations were more than five times higher and in two sites were ten times higher than under normal conditions. The concentrations of Al reached almost 1000 $\mu g \cdot l^{-1}$ during the increased discharge in these two catchments, which could affect freshwater pearl mussel population negatively (Taskien et al. 2011). Apart from one site, the concentrations of CODMn were more than three times higher in all sites. Higher concentrations were also observed for DOC, but this parameter was measured only at four sites. A significant increase in *TP* concentrations was also registered. The highest increase more than five times higher was detected in one site, and in four sites was more than three times higher.

Acknowledgements

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References

CGS, 2016. GEOMON network data, Czech geological Survey, Prague.

CUNI, 2023. Hydro-Meteorological Monitoring Network, Charles University, Prague.

Czech hydrometeorological institute, 2023. Data průtoků pro vybraný profil Blanický mlýn, Český hydrometeorologický ústav.

KENDALL, M., G., 1975. Rank Correlation Methods. Griffin, London.

MANN, H., B., 1945. Nonparametric tests against trend. *Econometrica*, **13**, 3, 245−259.

OULEHLE, F., HRUŠKA, J., 2009. Rising trends of dissolved organic matter in drinkingwater reservoirs as a result of recovery from acidification in the Ore Mts., Czech Republic. *Environmental Pollution*, **157**, 12, 3433−3439. https://doi.org/10.1016/j.envpol.2009.06.020

Povodí Vltavy, State Enterprise, 2023.

SIMON, O.P., VANÍČKOVÁ, I., BÍLÝ, M., DOUDA, K., PATZENHAUEROVÁ, H., HRUŠKA, J., PELTÁNOVÁ, A., 2015. The status of freshwater pearl mussel in the Czech Republic: Several successfully rejuvenated populations but the absence of natural reproduction. *Limnologica*, **50**, 11−20. https://doi.org/10.1016/j.limno.2014.11.004

TASKINEN, J., BERG, P., SAARINEN-VALTA, M., VÄLILÄ, S., MÄENPÄÄ, E., MYLLYNEN, K., PAKKALA, J., 2011. Effect of pH, iron and aluminum on survival of early life history stages of the endangered freshwater pearl mussel. *Margaritifera margaritifera*. *Toxicological & Environmental Chemistry*, **93**, 9, 1764−1777. https://doi.org/10.1080/02772248.2011.610798