

CHARLES UNIVERSITY IN PRAGUE, FACULTY OF SCIENCE

Institute for Environmental Studies

Ph.D. study program:
Environmental Sciences



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**Freshwater macroinvertebrates and their use
for assessment of environmental changes in
running waters**

Summary of the Ph.D. thesis

Supervisor: Doc. RNDr. Evžen Stuchlík, CSc.

Prague, January 2013

Outline of the thesis

The dissertation thesis consists of five articles, bringing together results from investigations of macroinvertebrates in running waters. The use of freshwater macroinvertebrate organisms to assess environmental changes was based on the following facts: a) the presence/absence of taxa provide information about abiotic factors and/or about the pollution status of the site, b) they are indigenous and sedentary species, so that the environmental implications can be related to the site they live on, c) the organisms accumulate xenobiotic elements or compounds, thus reflecting the contaminant level in the environment.

Localization of the sampling sites was related to the “hot-spots” of environmental problems. The particular investigations were carried out in the Elbe River catchment and in the Czech mountains on the selected headwater streams of the GEOMON network of the Czech Geological Survey. The Elbe was considered one of the most polluted rivers across Europe in the second half of the past century until the socio-economic transformation after 1989. The headwater streams in the Czech Republic were chosen with respect to the problem of acidification.

The ability of bioaccumulation of xenobiotics in macroinvertebrate organisms was used to assess the long-term load of the Elbe ecosystem with trace elements and organochlorine pesticides. The long-term study of occurrence of the Elbe macroinvertebrate taxa was assessed with respect to long-term changes in structure of macroinvertebrate communities in relation to changes of water quality after 1990. The problem of acidification was investigated in nine selected headwater streams of the GEOMON network. The effects of acidification on a) the diversity of macroinvertebrates, b) the whole-stream metabolism, and c) stream food webs were studied.

Přehled dizertační práce

Dizertační práce je založena na pěti publikacích, které se zabývají využitím makrozoobentosu pro studium environmentálních změn v tekoucích vodách. Využití sladkovodních bezobratlých organismů pro hodnocení environmentálních změn je založeno na několika známých skutečnostech: a) samotný výskyt/absence druhů podává informaci o abiotických faktorech a/nebo o míře znečištění v dané lokalitě b) druhy žijí v daném místě a příliš nemigrují nebo jsou dokonce přisedlé, takže získaná environmentální data mohou být vztažena k dané lokalitě, c) organismy makrozoobentosu akumulují cizorodé látky ve svých tělech, a tím mohou odrážet úroveň zatížení okolního prostředí těmito látkami.

Studované lokality byly vybrány v oblastech, která se v minulosti potýkala s environmentálními problémy. Jednotlivé studie byly provedeny na řece Labi a v pramenných oblastech vybraných toků sítě GEOMON České Geologické Služby. Labe bylo v druhé polovině minulého století považováno za jednu z nejznečištěnějších řek v Evropě, a to až do socio-ekonomické transformace po roce 1989. Menší potoky horských oblastí a pahorkatin v České republice se zase potýkaly s problémem acidifikace.

Schopnost bezobratlých organismů akumulovat cizorodé látky byla využita pro studium dlouhodobých zátěží ekosystému Labe stopovými látkami a organochlorovanými pesticidy. Dlouhodobé sledování výskytu taxonů bezobratlých v Labi bylo vyhodnoceno z hlediska dlouhodobých změn ve struktuře společenstev makrozoobentosu ve vztahu ke změnám kvality vody po roce 1990. Problém acidifikace byl zkoumán v devíti vybraných horských potocích sítě GEOMON. Byly studovány vlivy acidifikace na a) diverzitu makrozoobentosu, b) metabolismus toku a c) potravní síť v potoku.

ABSTRACTS OF PUBLICATIONS COMPRISING THE THESIS

Long-term changes in the bioaccumulation of As, Cd, Pb, and Hg in macroinvertebrates from the Elbe River (Czech Republic)

Kolaříková, K., Stuchlík, E., Liška, M., Horecký, J., Tátošová, J., Hardekopf, D., Lapšanská, N., Hořícká, Z., Hovorka, J., Mihaljevič, M., Fuksa, J.K., von Tümpling, W.
Water, Air & Soil Pollution 223 (6): 3511–3526, (2012)

The Elbe River was extremely loaded by heavy metals and arsenic during the second half of the 20th century as a consequence of intensive chemical industry activities. To assess long-term contamination trends in the Elbe after socio-economical changes in 1989, selected macroinvertebrate species were used to identify biotic accumulation levels in the period from 1993 to 2005. Concentrations of As, Cd, Pb, and Hg were determined in *Asellus aquaticus* (Crustacea), *Bythinia tentaculata* (Mollusca), *Erpobdella* spp. (Hirudinea) and larvae of the family Chironomidae (Diptera) over a 3-year period along the longitudinal profile of the Czech part of the Elbe River and the lower Vltava (the main Elbe tributary). In this study, new evaluative approaches were used to assess these multiparameter data sets. The results showed that the most contaminated Czech sites were located in the industry-heavy middle Elbe region between Valy and Obříství. Surprisingly high concentrations of As, Cd, and Pb were observed in the upper stretch near the headwaters. Probably as a consequence of former mining activities and the metallurgic and glass industries, the lower Vltava was loaded with Cd and Pb. Despite substantial improvements in the water quality of the Elbe within the studied time period, we found no general decreasing trend of As, Cd, and Pb in macrozoobenthos. A significant decrease of Hg was revealed, however, occurring already between 1993 and 1996. The results of interspecies comparisons showed that the investigated elements were most accumulated by chironomid larvae and *Erpobdella* spp.

Bioaccumulation of HCH isomers in selected macroinvertebrates from the Elbe River: sources and environmental implications

Kolaříková, K., von Tümpling, W., Bartels, P.
Environmental Monitoring and Assessment (In press)

Sediments of the Elbe River have been extremely polluted by contaminants originating from previous large scale hexachlorocyclohexane (HCH) production and the application of γ -HCH (lindane) in its catchment in the second half of the twentieth century. In order to gain knowledge on bioaccumulation processes at lower trophic levels, field investigations of HCHs in macroinvertebrates were carried out along the longitudinal profile of the Elbe and tributary. Among the sites studied, concentrations in macroinvertebrates ranged within five orders of magnitude (0.01–100 $\mu\text{g}/\text{kg}$). In general, lower values of HCH isomers were observed at all Czech sites (mostly $< 1 \mu\text{g}/\text{kg}$) compared with those in Germany. At the most contaminated site, Spittelwasser brook (a tributary of the Mulde), extremely high concentrations were measured (up to 234 $\mu\text{g}/\text{kg}$ α -HCH and 587 $\mu\text{g}/\text{kg}$ β -HCH in Hydropsychidae). In contrast, the Obříství site, though also influenced by HCH production facilities, showed only negligibly elevated values (mostly $< 1 \mu\text{g}/\text{kg}$). Results showed that fairly high levels of α -HCH and β -HCH compared to γ -HCH can still be detected in aquatic environments of the Elbe catchment, and these concentrations are decreasing over time to a lesser extent than γ -HCH. Higher HCH concentrations in sediments in the springtime are considered to be the result of erosion and transport processes during and after spring floods,

and lower concentrations at sites downstream are thought to be caused by the time lapse involved in the transportation of contaminated particles from upstream. In addition, comparison with fish (bream) data from the literature revealed no increase in tissue concentrations between invertebrates and fish.

Benthic macroinvertebrates along the Czech part of the Labe and lower section of the Vltava from 1996–2005 with a particular focus on rare and alien species

Kolaříková, K., Horecký, J., Stuchlík, E., Liška, M., Jíchová, M., Tátosová, J., Lapšanská, N., Hořícká, Z., Chvojka, P., Beran, L., Košel, V., Matěna, J., Čiamporová-Zaťovičová, Z., Krno, I., Bulánková, E., Šporka, F., Kment, P.
(*Manuscript*)

Taxonomic composition of macroinvertebrate communities was studied at 7 sites on the Czech part of the Labe River and 2 sites on the lower part of the Vltava tributary from 1996 to 2005 in a 3-years interval to detect expected changes concerned with improvements of water quality resulting from socioeconomic changes in the Czech Republic in the 1990's. Four biological metrics used (Number of taxa, BMWP, Number of sensitive taxa, and Number of EPT taxa) demonstrated improvement of water quality and slightly improvement of the Labe microhabitats during the investigated period. The increasing number of taxa over time was observed at most of the sites. Two (main) concurrent ecological processes are recently occurring in the Labe: return of native species and expansion of alien species, some of them being invasive. Caddisfly *Setodes punctatus* as well as beetle *Pomatinus substriatus*, considered as regionally extinct in the Czech Republic, were rediscovered during our investigations. Finding of crustacean *Hemimysis anomala* (invasive) and chironomids *Stenochironomus* sp. and *Lipiniella* sp. were the first records of these taxa in the Czech Republic.

Stream benthic macroinvertebrates of nine selected catchments of the GEOMON network

Krám, P., Traister, E., **Kolaříková, K.**, Oulehle, F., Skořepa, J., Fottová, D.
Reports from geological survey in 2007: 160–166 (2008)

This project examined relationships between stream physical and chemical characteristics, whole-stream metabolism, and the associated biotic communities in 9 small, selected headwater streams of the GEOMON network. This paper documents the benthic macroinvertebrates found at each site. At each catchment, a 100-m reach was established and 3 replicate samples were collected from each major habitat type (pool, riffle, run), for a total of 9 samples per site. Benthic macroinvertebrates were collected using a net and by scrubbing all rocks and disturbing sediment within 1 ft of the net frame. Specimens were usually identified to the family level. Stream pH at the time of sampling ranged from 4.0 (LYS) to 7.7 (PLB). As expected, taxa richness declined with increasing acidity ($R^2 = 0.83$; $p < 0.001$). The lowest biodiversity (9 taxons) was at LYS, the highest (22 taxons) at SAL. The flies (Diptera) from families Chironomidae (midges) and Simuliidae (black flies), the stoneflies (Plecoptera) from families Leuctridae and Nemouridae, the caddisflies (Trichoptera) from families Limnephilidae and Polycentropodidae, and the worms from class Oligochaeta were present in all streams. However, acid-sensitive taxa such as mayflies (Ephemeroptera) were absent from the two most acidic streams.

Persistent effects of acidification on stream ecosystem structure and function

Traister, E.M., McDowell, W.H., Krám, P., Fottová, D., **Kolaříková, K.**

(Revised manuscript)

Acidification of surface water is a persistent threat to aquatic ecosystems throughout the world. While several international policies have succeeded in reducing the emissions of acidifying gases, recovery of surface water quality has been modest. Associated biological communities continue to suffer, and research on ecosystem functional response is sparse. In 9 small forest streams exhibiting a pH gradient from 4.0 to 7.7 and belonging to the GEOMON Network in the Czech Republic, we investigated (1) shifts in macroinvertebrate communities, (2) shifts in whole-stream metabolism, (3) whether whole-stream metabolism is as sensitive an indicator of acidification as is benthic community structure, and (4) shifts in stream food webs. Acidification was related to changes in macroinvertebrate communities including reduced taxa richness, and reduced Ephemeroptera family richness and abundance. Whole-stream metabolism was not significantly related to stream pH and may be less sensitive to acidification than macroinvertebrate community metrics. ^{13}C and ^{15}N isotopic signatures of the Chironomidae and Leuctridae families shifted away from periphyton isotopic signatures and towards isotopic signatures of allochthonous food sources at acidified sites, suggesting either species-level dietary changes or replacement of species by those that rely more heavily on detritus. Our results document long-lasting changes in the ecosystem structure of these small streams in response to acidification. Differences in the response of structural and functional metrics to acidification have implications for stream monitoring programs and are discussed.

Curriculum vitae

Name: Kateřina KOLAŘÍKOVÁ, Mgr.

Born: 7.8.1982, Přerov

Nationality: Czech

Citizenship: Czech Republic

Education

2002–2007 Mgr. (M.Sc.) in Environmental Protection, Charles University in Prague, Faculty of Science

2007–2013 Ph.D. study of Applied and Landscape Ecology, Charles University in Prague, Faculty of Science

Employment

10/2009–12/2010 Hydrobiologist at the Nature Conservation Agency of the Czech Republic

10/2010– Research Assistant/Head of the Laboratory of Environmental Chemistry, Institute for Environmental Studies, Faculty of Science, Charles University in Prague

Research experience

- 2005: Project ELBE (Ministry of the Environment of the Czech Republic, principle investigator: Doc. Evžen Stuchlík). Research team member.
- 2007: Metabolism of acidified streams. Project of M.Sc. Elena Traister (University of New Hampshire, U.S.A.) on Czech streams. Research team member (sampling and determination of macroinvertebrates).
- 2006, 2011: EURO-LIMPACS. Project of the European Commission Framework Programme 6 (principle investigator: Doc. Evžen Stuchlík). Research team member
- 2011: 3-week stay in Germany. Helmholtz Centre for Environmental Research in Magdeburg. Laboratory training.
- 2009–2013: CLIMHEAD. The integrated impact of climate change, air quality, and forest management on water ecosystem in headwater catchments. Project of Czech Foundation (GAČR) (principle investigator: Doc. Evžen Stuchlík). Research team member.

Research stay

2000–2009: 12-month scholarship in Germany financed by German Federal Foundation for Environment. Helmholtz Centre for Environmental Research in Magdeburg. Advisor: Dr. Wolf von Tümpling. Field and laboratory work focused on organochlorine pesticides accumulated in the Elbe macroinvertebrates.

Teaching and academic activities at Faculty of Science

- Limnology – excursions
- Methods in Limnology – practical course
- Bachelor students:
 - Lenka Hanzlíková, 2011 - Bioaccumulation of heavy metals in macroinvertebrates: relationship between concentrations and organism size
- Diploma students:
 - Lenka Hanzlíková - Use of TXRF to biomonitor the load of benthic organisms with trace elements in urban stream Botič in Prague
 - Zbyněk Miller - Historical records of Hg emission in the city of Prague by using dendrochronology
- Organization of seminars at the Institute for Environmental Studies, Faculty of Science, Charles University in Prague

Membership in scientific societies:

Czech Limnological Society

Language skills:

Certificate in German: C1 – Zentrale Mittelstufenprüfung

Certificate in English: B2 – First Certificate

Conferences:

2009 Kolaříková, K., von Tümpling, W., Bartels, P. (2009) HCHs accumulated in macroinvertebrates in the Elbe River basin two decades after the end of their production, pp. 128–129. Abstract. In: Kröpfelová, L & Šulcová, J. (eds.), Book of papers of the 15th Conference of Czech Limnological Society & Slovak Limnological Society, 22.–26. June 2009, Třeboň, Czech Republic. (Poster)

2009 Krám, P., Traister, E., **Kolaříková, K.,** Oulehle, F., Skořepa, J., Fottová, D. (2009) The limnology of running waters at nine selected catchments of GEOMON stream

- network, pp. 146–149. Abstract. In: Kröpfelová, L & Šulcová, J. (eds.), Book of papers of the 15th Conference of Czech Limnological Society & Slovak Limnological Society, 22.–26. June 2009, Třeboň, Czech Republic. (Presentation)
- 2009 Kolaříková, K.,** von Tümpling, W., Bartels, P. (2009) HCHs accumulated in macroinvertebrates in the Elbe River basin two decades after the end of their production, pp. 177–182. Paper. In: Holoubek, I., Kosthounova, R. & Tupova, L. (eds.), Book of papers of the 10th International HCH and Pesticides Forum. 6.–10. September 2009, Brno, Czech Republic. (Presentation)
- 2010 Kolaříková, K.,** von Tümpling, W. (2010) Recent bioaccumulation level of HCHs, HCB and DDTs in the Elbe River macroinvertebrates, pp. 191–193. Paper. In: Book of papers of the Magdeburg conference on water protection, 4.–6. October 2009, Teplice, Czech Republic. (Poster)
- 2012 Kolaříková K.** (2012) The long-term trends in the bioaccumulation of heavy metals in the Elbe macrozoobenthos: what to do with the inhomogeneous data set, pp. 65–68. Paper. Book of papers of the 16th Conference of Slovak Limnological Society & Czech Limnological Society, 25.–29. June 2012, Jasná, Nízké Tatry, Slovak Republic. (Presentation)

C u r r i c u l u m v i t a e

Jméno: Kateřina KOLAŘÍKOVÁ, Mgr.

Datum narození: 7.8.1982, Přerov

Národnost: Česká

Občanství: Česká republika

Vzdělání

2002 - 2007 Mgr. studium, obor Ochrana životního prostředí, Přírodovědecká fakulta, Karlova Univerzita v Praze

2007 - 2013 Ph.D. studium, obor Aplikovaná a krajinná ekologie, Přírodovědecká fakulta, Karlova Univerzita v Praze

Zaměstnání

10/2009–12/2010 Hydrobiolog, Agentura ochrany přírody a krajiny ČR

10/2010– Vědecký pracovník/vedoucí Laboratoře environmentální chemie, Ústav pro životní prostředí, Přírodovědecká fakulta, Karlova Univerzita v Praze

Výzkumná praxe

- 2005: Projekt LABE (Ministerstvo životního prostředí ČR, koordinátor projektu: Doc. Evžen Stuchlík). Člen výzkumného týmu.
- 2007: Metabolismus acidifikovaných toků. Projekt M.Sc. Eleny Traister (Universita v New Hampshire, U.S.A.) na českých potocích. Člen výzkumného týmu. (odběr vzorků, determinace makrozoobentosu).
- 2006, 2011: EURO-LIMPACS. Projekt Evropské komise 6 (koordinátor projektu: Doc. Evžen Stuchlík). Člen výzkumného týmu.
- 2011: 3-týdenní pobyt v Německu. Helmholtz-Centrum pro výzkum životního prostředí v Magdeburku. Laboratorní školení.
- 2009–2013: CLIMHEAD. Integrovaný vliv klimatických změn, kvality ovzduší a lesního hospodaření na vodní ekosystémy horských povodí. GAČR. (koordinátor projektu: Doc. Evžen Stuchlík). Člen výzkumného týmu.

Pobyt v zahraničí

2008 – 2009: Roční stipendijní pobyt v Německu financovaný Německou nadací pro životní prostředí. Helmholtz-Centrum pro výzkum životního prostředí v Magdeburku. Školitel: Dr. Wolf von Tümpling. Terénní a laboratorní výzkum zaměřený na organochlorované pesticidy akumulované v labském makrozoobentosu.

Pedagogická činnost na PfF UK

- Limnologie – exkurze
- Limnologické metody – praktikum
- Bakalářský student:
 - Lenka Hanzlíková, 2011 - Bioakumulace těžkých kovů v makrozoobentosu: závislost koncentrace na hmotnosti organismu
- Magisterští studenti:
 - Lenka Hanzlíková - Využití TXRF pro sledování zatížení makrozoobentosu stopovými látkami v urbanizovaném povodí toku Botič v Praze
 - Zbyněk Miller - Historický záznam emisí Hg na území města Prahy s využitím dendrochronologie
- Organizace odborných seminářů na Ústavu pro životní prostředí, Přírodovědecká fakulta, Karlova Univerzita v Praze

Členství ve vědeckých organizacích:

Česká limnologická společnost

Znalost cizích jazyků:

Certifikát z německého jazyka: C1 – Zentrale Mittelstufenprüfung

Certifikát z anglického jazyka: B2 – First Certificate

Konference:

- 2009 Kolaříková, K.**, von Tümpling, W., Bartels, P. (2009) Úroveň akumulace HCHs v makrozoobentosu v řece Labi dvě desetiletí po skončení produkce, str. 128–129. Abstrakt. In: Kröpfelová, L. & Šulcová, J. (eds.), Sborník příspěvků 15. konference České limnologické společnosti a Slovenskej limnologickej spoločnosti. 22.–26. června 2009, Třeboň. (poster)
- 2009 Krám, P.**, Traister, E., **Kolaříková, K.**, Oulehle, F., Skořepa, J., Fottová, D. (2009) Limnologie tekoucích vod devíti vybraných povodí sítě GEOMON, str. 146–149. Abstrakt. In: Kröpfelová, L. & Šulcová, J. (eds.), Sborník příspěvků 15. konference České limnologické společnosti a Slovenskej limnologickej spoločnosti. 22.–26. června 2009, Třeboň. (prezentace)
- 2009 Kolaříková, K.**, von Tümpling, W., Bartels, P. (2009) HCHs accumulated in macroinvertebrates in the Elbe River basin two decades after the end of their production, str. 177–182. Příspěvek. In: Holoubek, I., Kostrhounová, R. & Tupová, L. (eds.), Sborník příspěvků 10. Mezinárodního fóra o HCH a pesticidech. 6.–10. září 2009, Brno. (prezentace)
- 2010 Kolaříková, K.**, von Tümpling, W. (2010) Recent bioaccumulation level of HCHs, HCB and DDTs in the Elbe River macroinvertebrates, str. 191–193. Abstrakt. Magdeburský seminář o ochraně vod v Teplicích - Sborník 2010. 4.–6. října 2010, Teplice. (poster)
- 2012 Kolaříková K.** (2012) Dlouhodobé trendy v bioakumulaci těžkých kovů v makrozoobentosu Labe: co si počít s nehomogenním souborem dat, str. 65–68. Příspěvek. Sborník příspěvků 16. konference Slovenskej limnologickej spoločnosti a České limnologické společnosti. 25.–29. Juna 2012 Jasná, Nízké Tatry. (prezentace)

COMPLETE PEER-REVIEWED PUBLICATION LIST:

Krám, P., Traister, E., **Kolaříková, K.**, Oulehle, F., Skořepa, J., Fottová, D. (2008) Stream benthic macroinvertebrates of nine selected catchments of the GEOMON network. Reports from geological survey in 2007. Czech Geological Survey, Praha, pp. 160–166. [In Czech with English abstract] (*Peer-reviewed*)

Kolaříková, K., Stuchlík, E., Liška, M., Horecký, J., Tátošová, J., Hardekopf, D., Lapšanská, N., Hořická, Z., Hovorka, J., Mihaljevič, M., Fuksa, J.K., von Tümpling, W. (2012) Long-term changes in the bioaccumulation of As, Cd, Pb and Hg in macroinvertebrates from the Elbe River (Czech Republic). *Water, Air & Soil Pollution* 223 (6): 3511–3526, DOI: 10.1007/s11270-012-1129-1 (IF = 1.6)

Kolaříková, K., von Tümpling, W., Bartels, P. (*In press*) Bioaccumulation of HCH isomers in selected macroinvertebrates from the Elbe River: sources and environmental implications. *Environmental Monitoring and Assessment*. DOI: 10.1007/s10661-012-2872-x (IF = 1.4)

Traister, E.M., McDowell, W.H., Krám, P., Fottová, D., **Kolaříková, K.** (*Manuscript*) Persistent effects of acidification on stream ecosystem structure and function. (*Revised manuscript resubmitted to Freshwater Science in January 2013, IF = 2.8*)

Kolaříková, K., Horecký, J., Stuchlík, E., Liška, M., Jíhová, M., Tátošová, J., Lapšanská, N., Hořická, Z., Chvojka, P., Beran, L., Košel, V., Matěna, J., Čiamporová-Zaťovičová, Z., Krno, I., Bulánková, E., Šporka, F., Kment, P. (*Manuscript*) Benthic macroinvertebrates along the Czech part of the Labe and lower section of the Vltava from 1996–2005 with a particular focus on rare and alien species.

Other works:

Stuchlík, E., Horecký, J., Hardekopf, D., Jíhová, M., **Kolaříková, K.**, Lapšanská, N., Mihaljevič, M. (2006) Changes of the macrozoobenthos communities' structure and their load with selected contaminants in the Elbe River and the lower Vltava. Final Report of the Project ELBE. Faculty of Science, Charles University in Prague, 15 pp.

Kolaříková, K. (2007) Accumulation of heavy metals in macrozoobenthos in the Elbe River and the lower Vltava River. Diploma thesis, Faculty of Science, Charles University in Prague, 66 pp. [In Czech with English abstract]