AN ECO-HYDROLOGICAL ASSESSMENT OF A WATERCOURSE EXAMPLIFIED BY A CASE STUDY

EKOHYDROLOGICKÉ HODNOCENÍ VODNÍHO TOKU NA PŘÍKLADU PŘÍPADOVÉ STUDIE

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Abstract

A small stream and its alluvial plain is an important component of a landscape. The mapping of actual condition of the stream basin and the proposal of its restoration study took place in the area of the Vařešinka stream basin. Monitoring and analyzing the selected parameters for a hydro-ecological evaluation is a useful basis for working out the System of Ecological Stability of the Landscape (USES) as a part of the municipal plan of the town of Hlučín.

Abstrakt

Významným krajinným prvkem v území je drobný vodní tok a jeho niva. Mapování aktuálního stavu a návrhu revitalizační studie proběhlo na území povodí Vařešinky. Monitoring a analýza vybraných parametrů pro hydroekologické hodnocení toku je vhodným podkladem pro řešení ekologické stability území v rámci ÚSES, který je součástí územního plánu města Hlučína.

Key words: Revitalization, small stream, cultural landscape, System of Ecological Stability of the Landscape (USES), hydrological regime, hydrobiological samples, diversity index.

1 INTRODUCTION

Under the natural conditions in the Czech Republic, brooks, torrents, and streams are of the highest ecological importance due to the considerable variability of their morphology. The most common topography type is upland, characterized by a high density of water streams.

Revitalization in general consists of activities leading to the activation of ecosystem functions in landscape, and, respectively, their stabilization. Revitalization deals with „new life“ (revitae in Latin) not only of streams, water bodies and wetlands, but also of the whole catchment area enclosed by its natural boundary.

Revitalization of streams includes a set of hydro-technical and biotechnical activities, leading to the restoration of degraded parts of the stream and their basins; the rectification of their unsuitable parameters enables not only to improve the stream conditions, but to establish the basis for its future favourable evolution as well. The background ideas of these methods are to support and increase the retention ability of landscape, to systemically remedy negative effects of previous landscape alterations and to restore natural functions of water streams and their beds, river alluvial plains, accompanying vegetation and riparian vegetation.

With regard to the variability of river systems and landscape in Europe, the case study is the latest trend in presenting these methods. This paper deals with the case study of the Vařešinka stream.

2 MATERIALS AND METHODS

The monitoring of selected hydrological and biological parameters was carried out on site in the Vařešinka stream basin. Five profiles were selected to obtain both hydrobiological samples and hydrological data (see Tab. 1). These profiles represented not only individual sections of the stream but also the types of land use of surrounding landscape. The first and second sites – "Pramen" ("Source") and "Les" ("Forest") – represent the landscape intensively used for agricultural purposes, including extensive draining during eighties. The landscape of next two sites – "Mokřad" ("Wetland") and "Pole" ("Field") – is characterized by an open and spacious profile with water easily overflowing its banks, and with the presence of reed (Phragmites australis). The last site "Travní porost" ("Grassy stand") is surrounded by a successional meadow (see Fig. 1).

Hydrometrical measurements were carried out during hydrological drought (minimal rate of flow), and during spring and summer maximal rate of flow in accordance with methodology [1]. The Greisinger STS 005 flow measuring probe for water was used for measurements themselves.

Fig. 1 The orthophotomap cut-out of the Vařešinka basin with the sampling sites of microzoobenthos monitoring, at a scale of 1:22 818 (By: Moravskoslezský kraj- Krajský úřad, ČSÚ, ortofotomapa GEODIS BRNO spol.s.r.o, http://mapy.kr-moravskoslezsky.cz/tms/ortofoto)

Legends: Stanoviště Pramen – "Source Site", Stanoviště Les – "Forest Site", Stanoviště Mokřad – "Wetland Site", Stanoviště Pole – "Field Site", Stanoviště Travní porost – "Grassy Stand Site".

In this study, macroinvertebrate communities were sampled using a standard 3-minute kick-sampling regime with a Surber sampler. The samples were taken at the affected site on two occasions: one in Spring 2010 and the other in Autumn 2010.

All major habitats (bottom substrata, vegetation, margins, etc.) within the site were included. The samples were washed, preserved and sorted in the laboratory. Individuals were counted and taxa were identified [2]. The identified macroinvertebrates taxa were analysed using the Shannon diversity index [3]. The biological monitoring working party index (BMWP) was used to evaluate the biotic integrity of communities. The BMWP at each site was calculated by adding the individual scores of the families. The ASPTs was calculated by the ratio of BMWP values to the number of families [4].

At the same time, the mapping of riparian and streamside vegetation took place. The data were obtained in the field, and the results were compiled and presented as maps using the GIS software.

Volume LVII (2011), No.4
p. 1-8, ISSN 1802-5420

3 RESULTS AND DISCUSSION

The Vařešinka stream is a small alluvial plain brook, which, before an extensive alteration of the stream flow and its catchment, meandered. The part of the area under our scrutiny has, according our measures, the shape of a fan. The density of the stream network is 1.125 km per square kilometer of the basin. The inclination of the area is 2.11%.

Tab. 1 Basic hydrological data of the studied Vařešinka stream

Stream:	Vařešinka
Basin:	2-02-03-022/0
Stream management:	Zemědělská vodohospodářská správa (ZVHS) Ostrava
Cadastral area:	Hlučín, Kozmice
Province:	Moravia-Silesian Region
Total stream length:	5. 390 km
Stream length monitored:	3. 940 km
Basin area:	8. 64 km2
Basin area monitored:	5.38 km2
Long term average discharge:	Qar = 8. 81 m3. s-1 , Q100 = 37. 60 m3. s-1 (1)
Hydrometrically measured Q value:	Qd =3.393 l . s-1
Long term average value of rainfalls in the basin area: 709 mm (1)	

(1)Data CHMU Ostrava

In the eighties, the Vařešinka stream channel was altered both in longitudinal and transversal profiles. As for the transversal profile in the middle part of the stream, a simple trapeze shape was proposed. The enclosed part of this stream is now constructed from reinforced concrete pipes of 0.40 m in diameter, placed 1.30 m below the surface. Slopes of the channel are in the ratio of 1:1.5. Such a slant can already lead to a stability violation and the channel is excessively prone to erosion. The width of the stream bed ranges between 0.5-0.6 m, an average depth of the channel is 1.2 m. In stable channels, the width-to-depth ratio ranges from 4:1 to 10:1. The higher the ratio is, the higher the channel stability [5].

The channels are adjusted to the Q5 capacity, corresponding to a discharge ranging from 0.48 to 0.7 m3.s-1. Due to running through rural areas and arable land, the channels are oversized in order to match the depth of drain mouths. In connection with the drainage of the catchment area, the low level of water starts to show itself; it corresponds to the low designed channel capacity. Unfortunately, there is no overflowing any more at Q_{30d}, usually typical for alluvial plain streams. In summer, during the monitoring period, there was even drying up of a certain part of this stream, 1460 meters in length. When calculating the average annual discharge from our own hydrometric measurements, we discovered low order results than in the records of the long term discharge mean in CHMU (Czech Hydrometeorological Institute) Ostrava. This fact can indicate continuing drying up of this stream. The evaluation of current hydrological regime of the area can be found in Fig. 2.

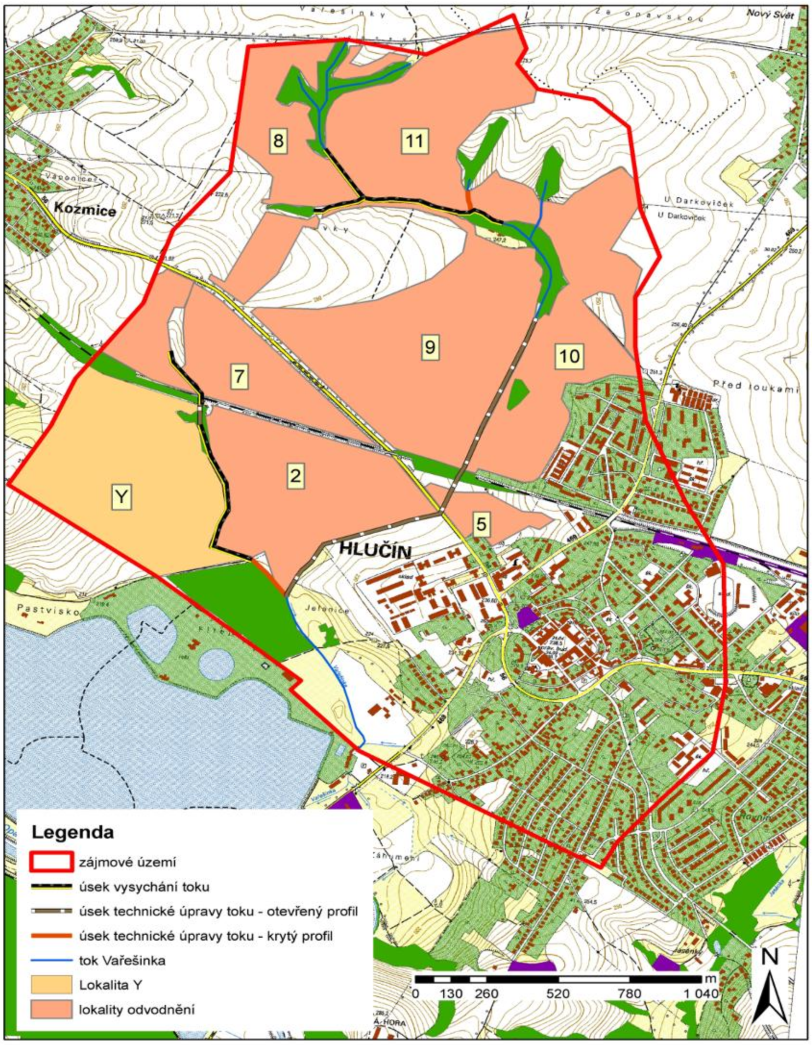

Fig. 2 The evaluation of current hydrological regime of the area. The map was processed by the GIS software. The numbers of individual areas mean the monitored drainage areas without Y site.

Legends: red closed line – monitoring area, black line – part of stream drying, brown line – part of technical altered profile (uncovered profile), orange line - part of technical altered profile (covered profile), blue line – Vařešinka stream, orange areas – locality Y, pink areas – monitored drainage areas without Y locality (Y site).

Biological indices based on macroinvertebrates offer advantages for testing water quality. The biological indices to assess water quality based on macroinvertebrates are easy to sample, at least with regard to qualitative measurements or relative abundance. In addition, good identification keys are available for most orders, and for many orders there is ample information concerning pollution tolerance [6]. In this study, the BMWP (Biological Monitoring Working Party Score System) and ASPT biotic indices (Average Score Per Taxon) were calculated. One of the most common biotic indices in use is the BMWP score system. This index allocates a single score to benthic macroinvertebrates at the family level that is a representative of the family's tolerance to water pollution. The greater their tolerance to pollution is, the lower the BMWP score and vice versa [4].

The total BMWP Score can also be divided by the total number of taxa to produce the Average Score Pe r Taxon (ASPT). The ASPT is independent of the sample size, i.e. a larger sample is likely to include more families, thus inflating the BMWP Score if not standardized [7].

In this study, the water quality according to the BMWP index is low in autumn samples at all sites (see Fig. 3). Spring sampling was richer both in numbers of taxa and their abundances. The BMPW index points out that the water quality decreases from the sources to the estuary; however there was a slightly better quality in the last profile –"Travní porost" ("Grassy stand"). Based on the BMWP Score Category Interpretation, the site

”Pole” (“Field”) belongs to a very poor category with heavy pollution, rest sites can be described as poor - polluted or impacted [9].

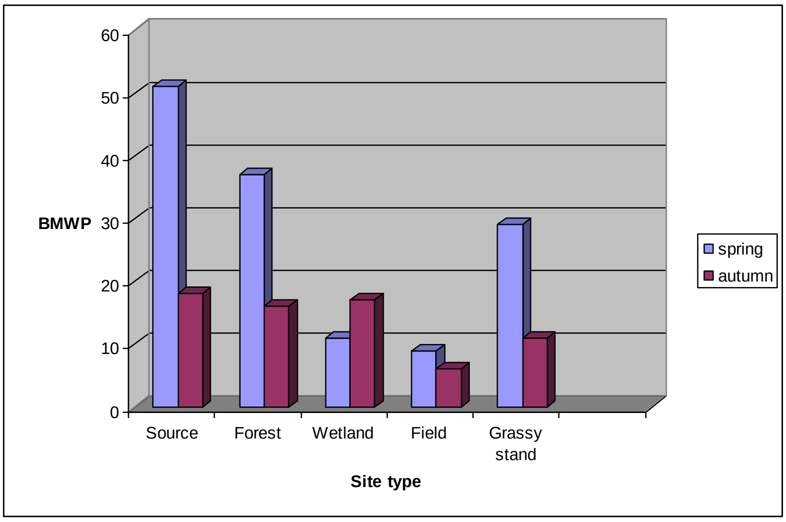

Fig. 3 The resulting values of the BMWP index

The similar results of water quality were obtained with the use of the ASPT index, where the better water quality of the last “Grassy stand” profile was obtained in spring samples (see Fig. 4). The differences between spring and autumn samples were in the number of species, which, obviously, was higher in spring. The lower ASPT score associated with the impacted site also indicates a reduction in ecological quality [8].

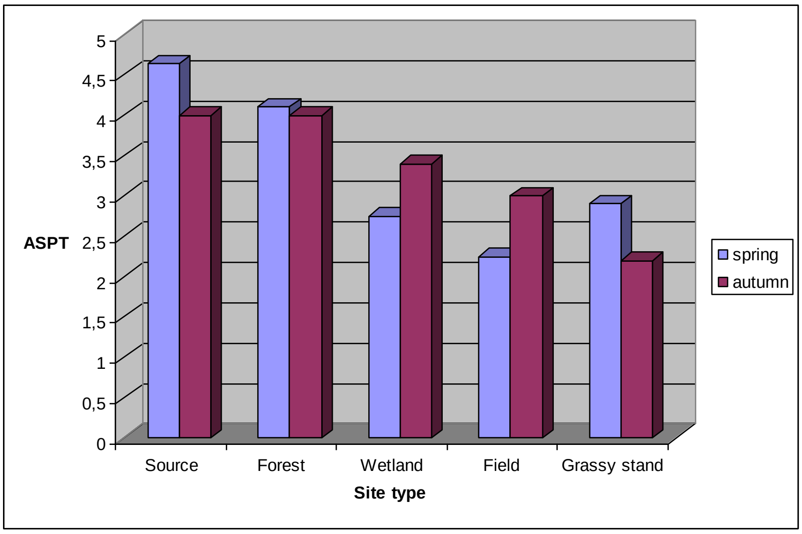

Fig. 4 The resulting values of the ASPT index

In addition to those two indices, which are based on the identification of animal families, the Shannon-Wiener diversity index (H) was determined, based this time on genus identification. The Shannon diversity index is lower in the wetland and field profiles (see Fig. 5). These profiles were specific; almost without higher streamside vegetation and with low articulation of the channel. In addition, the “Wetland” profile had also a muddy bottom. In general, the profiles with a lower diversity of streamside vegetation and a lower structural variability of the stream bed – the “Wetland” and “Field” profiles – were inhabited with a smaller diversity of macrozoobenthic species, but rather a high number of species which do not require high water quality: especially leeches (Erpobdella octoculata) and midges larvae (Tanitarsus sp., Chironomus sp.). A high diversity was, in contrast, found in the “Pramen” (“Source”) and “Travní porost” (“Grassy stand”) profiles. Particularly, in the “Pramen” (“Source”) profile, two species of caddisflies were identified: Microptera lateralis and Plectrocnemia sp.

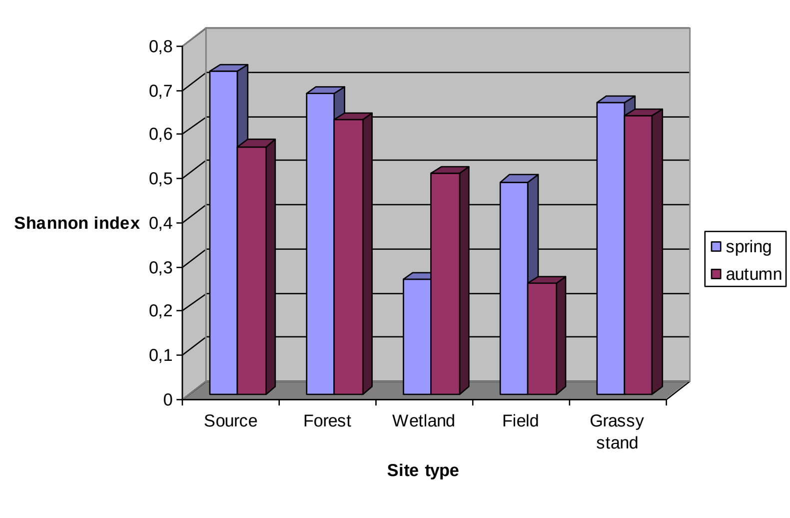

Fig. 5 The resulting values of the Shannon indexes

The low taxon richness and ASPT score, indicate the degradation of the overall biological water quality of the small stream of Vařešinka.

From Tab. 2 and mapping (see Fig. 6) we have found out, that the area of forest or other higher vegetation covers approximately 0.277 square km; this comprises only about 5% of the monitored area. The whole catchment area is situated in the territory of intensive agricultural management; accompanying vegetation can be found only as isolated patches within valley depressions and it is insufficient for the water retention in the landscape. Riparian and accompanying vegetations increase the ecological stability of the landscape; these are structural elements of the USES system, and significantly influence the self-cleaning ability of the stream.

Tab. 2 The state of riparian vegetation according to the methodological evaluation [10]

	1. Good conditions of streamside vegetation	2. Local changes, substitutions of original vegetation	3. Extensive changes, reconstruction of streamside vegetation
Points	5-6	7-8	≥9
Sites	Groves, accompanying vegetation	Meadow communities, wetlands	Agricultural areas
Colour on map Fig.6.	Green	Yellow	White

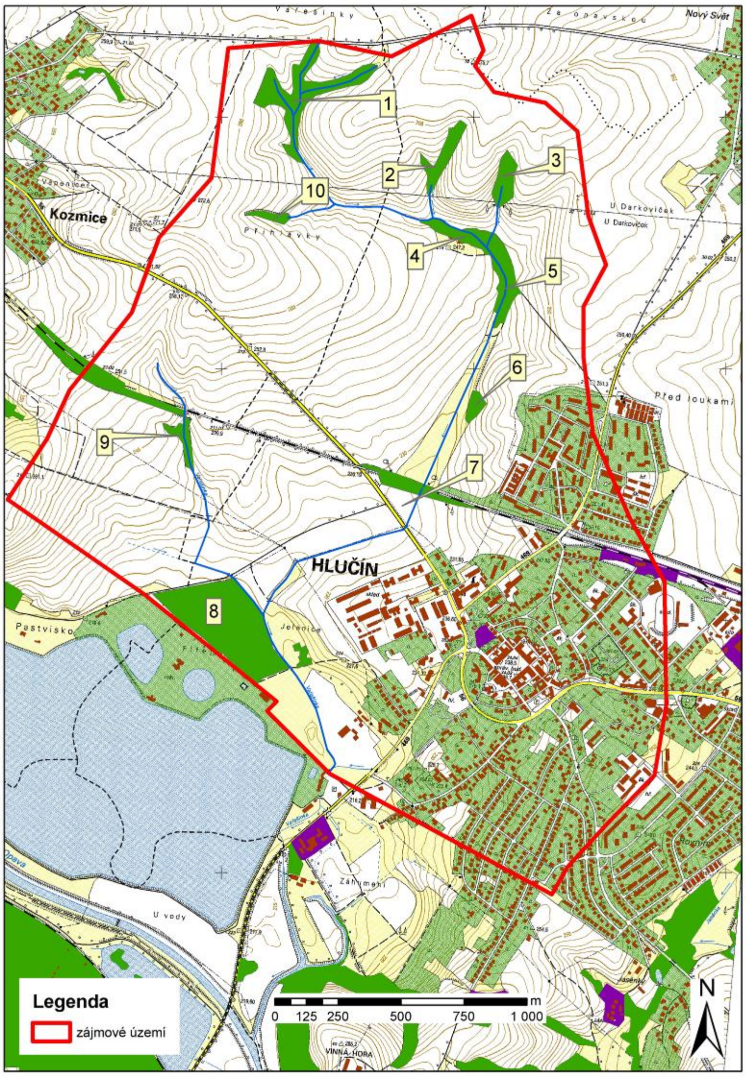

Fig. 6 The evaluation of riparian vegetation of the area. The map was processed by the GIS software. The numbers of individual areas mean the monitored areas.

Legends: red closed line – monitoring area

3 CONCLUSIONS

The technical alterations of the channel that have been carried out in the Vařešinka stream in the past were supposed to prevent the flooding. In the process of time, oversizing the Q5 channel capacity for discharge led to the destruction of the stream. The capacity of the channel makes a difference in linking between a stream and an alluvial plain.

The channels in areas of intensive agricultural land management should be designed individually, with regard to the type of cultivation, shape of the terrain and other local conditions. These channels should have a low discharge capacity in between Q30d and Q1 (30 day and 1 year water level). And this level of discharge we can anticipate periodic spring and summer overflowing, in dependency on the yearly course of rainfalls and their climatic deviations. One of the basic issues of our landscape is its drying-up, insufficient retention of water. This study confirms the necessity of field evaluation of small streams, including the determination of stream flow regime, runoff regime, serving as a base for a river bed and floodplain modelling. Small streams in an agricultural landscape are usually not monitored by the network of CHMU stations, neither (following recent changes in small water streams administration) by hydrometrical measurements of the Agricultural and Water Management Administration. Therefore, the channel capacity is more likely based on a statistical evaluation of the whole or partial river catchment. Low water levels, actually measured in the Vařešinka stream, were not reflected either by statistically obtained value of residual rate of flow.

All revitalization proposals regarding changes in the hydrological regime, restoration of vegetation were elaborated into map bases that will be used for the implementation of this revitalization study. The revitalization of the stream will help to restore the functionless components of the USES (System of Ecological Stability of the Landscape), thus increasing the ecological stability of the given area.

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RESUMÉ

V tomto článku byl stanoven hydrologický režim a na základě biologického monitoringu i kvalita povrchové vody v zájmovém území povodí drobného toku Vařešinka. Na základě zjištění režimu průtoků nebyla dosažena hodnota vodnosti v monitorovacím období ani hodnoty minimálního průtoku, to se odráželo i na kvalitě povrchové vody v recipientu. Koryto toku Vařešinka bylo technicky dimenzováno na Q5 ve zjištěných úsecích otevřeného profilu, což samozřejmě zabraňuje přirozené dynamice a tvorbě říční krajiny, pravidelnému vybřežování tzv. rozlivům, typickým pro tento geomorfologický typ vodního toku. Doporučená kapacita koryta u malých vodních toků je Q30. Hydrometrování drobných toků v zemědělské krajině většinou není zahrnuto do sítě měřících stanic ČHMÚ, nově se změnou správy malých vodních toků ani do sítě Zemědělské a vodohospodářské správy. Režim průtoků vychází pouze ze statistických hodnot větších ploch povodí. V oblasti hydrometrování malých vodních toků v zemědělské krajině se doporučuje provádět vlastní terénní šetření, stanovovat přesný režim průtoků, odtokových poměrů, který je následně základem pro modelování morfologie říčního koryta i říční nivy. Protože vodnost toku ovlivňuje i procesy samočištění, je nutné provádět kontinuální monitoring celého území a zpřesňovat hydrologický režim malých vodních toků v zemědělské krajině.