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Ecohydrological evaluation of a selected small stream and its catchment

Master´s Thesis (Joint Degree Programme)

Natural Resources and Management and Ecological Engineering, ČZU & BOKU

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8.4. 2016

I declare that the Diploma Thesis ,,Ecohydrological evaluation of a selected small stream and its catchemnt,, is my own work and all the sources I cited in it are listed in Bibliography.

In Prague 8.4. 2016 Signature: ………………………

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Summary

This paper deals with ecohydrological evaluation of Litovicko - Šárecký stream´s basin and its four major tributaries. Jenečský, Zličínský, Nebušický and Lysolajský. The ecohydrological evaluation was performed by EcoRivHab methodology (Matoušková, 2008). The methodology uses three main parameters for evaluation: riverbed, river banks and floodplain. The method was complemented with research on a development of surface water quality in watershed and alterations in land cover.

The aim of the evaluation is to determine the degree of anthropogenic influence on stream´s units and consequently on watershed .

In total, 59 sections with total length of 34 km of heterogeneous length, but homogeneous quality were rated.

Litovicko - Šárecký river´s basin was evaluated as strongly anthropogenically affected because 62% of the watershed is Rated as III. to V. stage, a moderate to strong level of anthropogenic influence. The main reason for this is that the basin is directly affected by high concentration of urban influence affecting the quality of the watershed.

Key words

ecohydrology, hydromorphology, EcoRivHab, stream fortification, stream restoration, catchment, stream bed, stream bank zone, flood plain, runoff, flow pattern, habitat, water quality, sediment

Obsah

1. Introduction

Over time, a man dared to change and modify streams according to their needs, and generally tried to keep the water as quickly as possible drained from the city and to occupy as little space as possible. Streams and reservoirs in urban catchments are more burdened mainly by adjustments in the channel flow, paved areas in the basin and by the effect of various anthropogenic sources of pollution. This has a negative effect on the water quality, because the flow is receiving more contaminants than would have happened in the natural landscape. Ecosystems of the city's modified flows and reservoirs are typically poorer and have less resiliance, often eutrophic and community structure is changing in favor of more tolerant species so long as man inhabits the planet Earth, shaping and changing local environment, for their better life. Since the first great civilizations is quite clear that a pivotal role in the localization of former settlements, and therefore the organization manner of human life played water.Substantial changes in the relationship between man and water bodies can be seen in particular during the early Middle Ages, when the passive approach gradually developed into an active use of water resources. Somewhat lower incidence of truly massive flooding while also building a certain flood protection measures should not result in the gradual subsiding interest on flood issues. Floods were thus increasingly seen as relatively insignificant risk, which prevention in the particular environment completely overpowered Czech countryside is not justified. Until the flood events of the last two decades convinced the society that not only large water flows beneath the windows of human settlements can under certain circumstances involve great risk. Besides the society's expansion into the river environment susceptible to develop of flooding, many other factors related to increasing the level of flood risk, one of which is again a significant part directly or indirectly affected by anthropogenic activities. While the "old river" flowed freely trough the landscape, creating bends or meanders flowed across the floodplain and thus subtly changed its position in space in existing waterways are in many ways these options severely limited. On the one hand, the current state of the hydrographic network of czech landscape is the result of long - term development, to which the most important changes occurred roughly during the last 150 years. By straightening and recessing riverbeds, through the fortification of the banks until after the construction of dams, flumes or dam reservoirs - these were the most common adjustments primarily related to the aquatic environment.

2. Scientific hypothesis and objective of work

The main objective of this work is to :

Evaluate and compare ecohydrological parameters of selected small streams

To assess ecohydromorphological status of Litovicko – Šárecký creek and its four main tributaries according to EcoRivHab methodology,

- in addition to the ecohydromorphological reasearch provide a quality assessment of water with selected hydrochemical parameters,
- to analyze land cover in streams vicinity,
- to propose in general revitaliaztion measures in selected locations to ensure better ecohydrological stability.

3 **Literature overview**

3.1. Historical developments of river channel alternations

For hundreds of years humans have altered river coridors by over – engineering, pollution, over – abstraction of resources and ineffective management. In Europe water supply and land drainage schemes were implemeneted more than five thousand years ago with the construction of embankments and weirs . Intensive and exponential human use of European rivers started more than five hundred years ago, and the basins lost, step by step, their naturalness and ecological integrity (Smits et al., 2000). Rivers were canalised for the purpose of navigation and regulated by weirs and sluices for water resource control and flood defence, habitats were fragmented and floodplain land was reclaimed for urban and industrial purposes (Makásek, 1982). Rivers were treated as sewers carrying waste and drainage away from the urban environment (Walsh, 2000).

3.2. Ecohydrology

Ecohydrology can be defined as "the science which seeks to describe the hydrologic mechanisms that underlie ecologic patterns and processes", (Rodriguez-Iturbe 2000). The main goal of Ecohydrology is twofold. First "to explain how hydrological processes influence the distribution, structure, function, and dynamics of biological systems" and secondly, "how feedbacks from biological systems affect the water cycle" (Jin 2009). As a result, Ecohydrology is the discipline linking hydrology and ecology (Jin 2009). Harper and Zalewski (2008) distinguish three subject areas in Ecohydrology. The first is focused upon plant-water dynamics on land, the second is connected with quantities in the water cycle and the impact of changes in quantity upon ecology in rivers and the third one advocates an integrated vision of physical and biotic processes driving the dynamic evolution of river basins. In this research Ecohydrology will deal with the first of these subject areas. Ecohydrological research is fundamental to the understanding of the linkages between ecosystem dynamics and the water cycle, in particular in arid and semi-arid environments, where water is an important limiting resource. Not only because of its scarcity, but also for its intermittent and unpredictable character (D'Odorico and Porporato 2006). Organisms in arid lands have to concentrate and conserve resources such as water, nutrients and soils, and one of the mechanisms to resource concentration is the redistribution of resources to concentrated patches, resulting in heterogeneous soil properties. Physical and chemical properties exhibiting such heterogeneity are linked to maximising water and nutrient availability, and are therefore Ecohydrological properties, for they are a result of coupled hydrologic, vegetation and climate systems (Bedford and Small 2008).

3.2.1. Ecohydrological evaluation

The basic prerequisite for defining possible rating is called the reference state that serves as a comparator element (Matouškova, 2003). System of water flow is monitored using a variety of parameters that differ in sensitivity to different types of disturbances such as degradation of habitat, landscape changes, fluctuations in water surface level. The goal of comprehensive environmental assessment is to evaluate the influence of human activities on natural resources and use of the results in the form of management measures (Verdonschot, 2000). Ecohydrological evaluation should assess the extent of anthropogenic impact on the flow compared to the reference state. Generally, two approaches are applied. The first is a verbal description of the parameters evaluated, whose advantage is a more detailed description of the aquatic ecosystem and the possibility of adaptation to a given watershed. Its disadvantage is its finality, personality and inability of mutual comparison. The second approach is to calculate the index, when to certain characteristics of water ecosystems are assigned certain numeric values derived from a comparison with a stnadard (potential natural state), which allows comparison between assessment for certain types of aquatic ecosystems. The advantage is a reduction in the level of evaluation subjectivity (Matoušková, 2003).

3.3. Directives and norms

The Water Framework Directive (2000/60 / EC), of the European Union, dated October 23, 2000, represents the most significant and far the most comprehensive legislation in the field of water. WFD considers water management as a whole and its main objective is to prevent any deterioration of water bodies and protect and improve the status of aquatic ecosystems and adjacent wetlands. It aims to promote sustainable water use and will contribute to mitigating the effects of floods and droughts. The Water Framework Directive covers all waters - inland surface water, groundwater, transitional and coastal waters.

Establishes the principle of pan - european integrated approach to issues related to water quality and quantity, and with the problems of surface water and groundwater for water management directive introduces a principle management based on unit of the river basin - in the Czech Republic this principle is implemented since the 60s of the last century. Water is therefore considered as a coherent whole (WFD, 2010).

3.4. Methods used to determine ecohydrological evaluation

3.4.1. RBP

According to Raven et al. (1998) the Rapid Bioassessment Protocols were originally developed in the 1980's to provide cost-effective, efficient biological survey techniques. Rapid bioassessment is based on comparing habitat, water quality, and biological measures of a given stream with an expected state, or stream reference condition, that would exist in the same type of stream in the absence of human disturbance. Reference conditions are established by assessing "minimally" impaired stream sites, as it is rarely possible to find streams with no impairment at all. Reference sites should be established in good examples of the different types of streams found in the region . Regional reference characteristics represent the best attainable conditions for all streams with similar physical characteristics. The site-specific control is a segment of the stream being studied that represents the best attainable conditions for that stream. Stream sites are classified into categories that would have similar aquatic communities under ideal conditions. The classification is based on characteristics that are intrinsic to the site (such as elevation, watershed size, stream gradient, soils, geology and other factors), not those resultant from human-induced change (RBA, 2008).

3.4.2. HEM

Methodology designed to map alterations of river flows, floodplains and flood consequences (Langhammer, 2007). Accoring to Langhammer (2008), the rating is based on the principle of scoring individual parameters evaluated in terms of their impact on hydromorphological quality of stream. Evaluation is based on a total of 17 indicators that evaluate the main aspects of hydromorphological quality zone of streambed, bottom, shore and inundation zones, including the characteristics of flow and hydrological mode. To determine the values of the indicators of hydromorphological condition, terrain mapping serves as a main method. Part of the indicators is possible to evaluate according to the nature of the flow and availability of materials by distant processing of materials (Langhammer, 2014).

3.4.3. River habitat survey

River habitat survey is a system for assessing the character and habitat quality of rivers based on their physical structure (Raven *et al.*, 1997, 1998b). The RHS field method is a systematic collection of data associated with the physical structure of watercourses. Data collection is based on a standard 500 m length of river channel. Map information is collected for each site and includes grid reference (or latitude, longitude), altitude, slope, geology, height of source and distance from source. During the field survey, features of the channel (both in-stream and banks) and adjacent river corridor are recorded. This method is highly detailed, regarding the data collection - more than 200 compulsory data entries are made at each site (Environment Agency, 1997b). Both the map - derived and field data are computerised.

3.4.4. Lawa method

A method originated in Germany (Landesamt für Wasserwirtschaft). This method was created for assessing the ecomorphologica status of small and medium-sized watercourses in rural highlands, uplands and lowlands. It is done by assessing quality structures of watercourse in the meaning of spatial, substrate spatial differentiation of watercourse, hydraulic, morphological and hydrobiological characteristics that are in close dependence on morphological shapes and structures of watercourse. They are therefore the dominant criteria for determining of resulting, so called, ecomorfological state (LAWA, 1994). The resulting value quality structure of watercourse section is determined by six main parameters: the route of watercourse, hydromorphological characteristics of longitudinal and transverse profile modifications to streambed, shore structures and land use along the watercourse. These 6 main parameters group is further divided into 27 individual parameters, which are divided into two subclasses: ecologically valuable and environmentally worthless. Ranked watercourse, respectively. its intermediate portion, is divided into homogeneous 100 m sections, in which is made ecomorphological evaluation. The resulting value is assigned to one of seven defined quality mark (Matoušková, 2008).

3.4.5. EcoRivHab

The method is a tool for assessing the condition of waterways in intra - and extravilans. It is based on a combination of field survey and processing of distance data (Matoušková, 2003). The method is a tool for assessing the quality of watercourses ecohydrological with emphasis on hydro - morphological characteristics of streambed, state of coastal zones and floodplains. The goal is to find stretches with natural or near - natural habitat and identifying the degree of anthropogenic impact on water flow. Up to 31 parameters are rated (Matoušková, 2004). This method will be further described into details.

4. Characteristics of the river basin

Litovicko - Šárecký stream rises near Chýně in the western part of the central region. It empties into Vltava river in Prague - Sedlec in area where ends the Imperial Island. The most important tributaries include Jenečský, Zličínský, Nebušický and Lysolajský stream. Litovicko - Šárecký stream flows first through a system of ponds (Litovický, Kala, Břve, Strnad) and close outside of Prague´s borders it flows trough Jíviny retention basin. Underneath the prison of Ruzyně, the stream has a length of 800 meter and it leads into a conduit flowing in a concrete round shaped structure. Before reaching the Šárka Valley water works Džbán is built on the creek, which is mainly used for recreational purposes. A large part of the stream flows through Šárka valley, where the waterflow is cut by a hard rock of silicite in a defile. Water from Litovicko - Šárecký creek was used not only to drive water mills, but also to supply nearby Prague Castle with potable water. Historical supply system dates back to the reign of Rudolf II. Potable water was supplied from seven ponds in Litovice, Břvech, Chýne and Zličín, where the water was drained, using so called royal ditch to Libocký pond. From the pond an open artificial channel route was kept in direction Veleslavín - Střešovice to cleaning stations and reservoirs in Střešovice, from where it continued by wooden pipeline to the Castle. Litovický creek ends by entering the Džbán reservoir. Šárecký creek then originates under the dam of Džbán and empties into the Vltava river (LŠP, 2014).

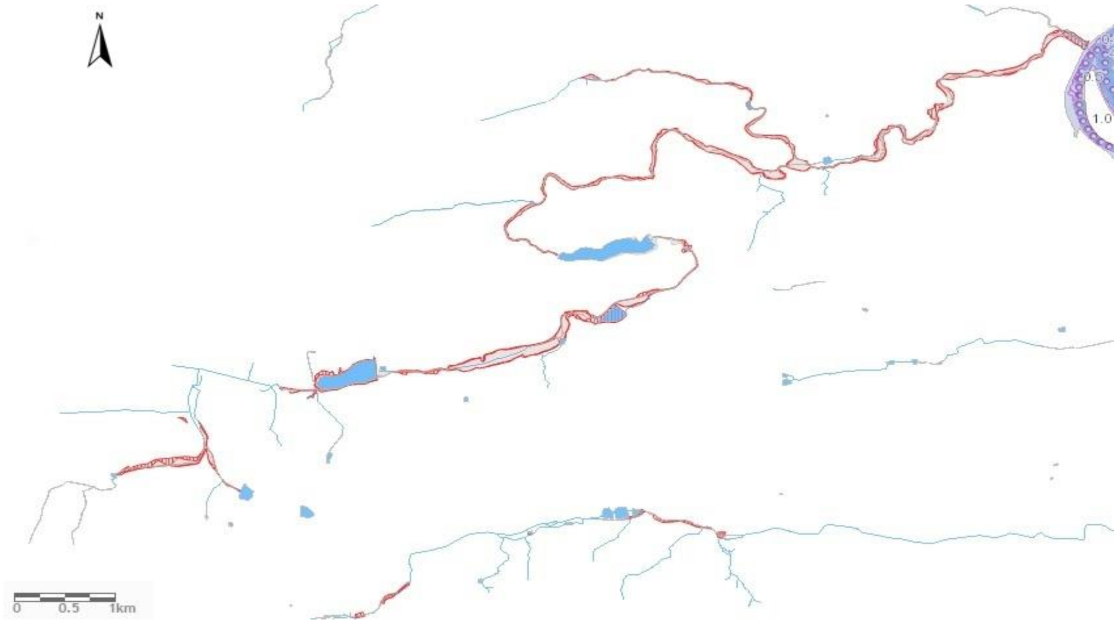

Fig. 1: River basin of Litovecko – Šárecký creek (GIS, author)

- River length: 21.28 km
- Catchment area: 62.9 km2
- Tributaries: Jenečský, Zličínský, Nebušický and Lysolajský
- Manager: City of Prague represented by organization Prague city´s forests
- Funding and management: Department of Environmental Protection
- Flow maintanance: Administration of the City of Prague, Prague city´s forests

The number of hydrological order of sub-basin.	**The number of hydrological order of source basin**	**Name of the main watercourse in the sub - basin**	**Area of sub - basin [km2]**	**Catchment area for profile of the junction [km2]**
1-12-02-0040-0-00	1-12-02-0020-0-00	Litovický creek	25.02	50.92
1-10-01-0750-0-00	1-10-01-0750-0-00	Šárecký creek	19.54	19.54

Tab. 1: Hydrological list of detailed structuring of river´s basin (CHMI, 2016).

4.1. Geomorphology

As listed in Atlas České Republiky (2009), in terms of geomorphological classification, basin of litovecko – šárecký creek is situated in the northwest of Prague on the Kladenské board. On one of its four geomorphological districts (Hostivické board). Hostivická board is located in the continuous extension of the Upper Cretaceous rocks and is characterized by extensively aligned surfaces. From the southwest to the northeast slightly inclined. On the rocks of Protorerozic, Paleozoic and their cover of Permo - Carboniferous and Cretaceous period rugged hills with two levels of aligned surface was created. At resistant silicites and bazalts, at certain areas knots and structural rimes, were created. On the territory of the urban fabric a wide valey of depression reveals a chalk subsoil of odrovic rocks. Deeply incised valley of middle and lower part of Šárecký creek is of epigenetic origin. Edges of Šárkas creek valley are lined by silicite knots that form part of the exhumed pre - creataceous surface.

4.2. Geolog

Němec, Ložek et al. (1997) states that Prague territory was flooded in the course of geological history by three seas, and now the bedrock is formed by sediments of those seas. The oldest formation on the territory is the upper Proterozoic. There is characteristic changing of greywacke and shale (Bouček, 1951). Of the Paleozoic sediments Ordovician rocks are mostly present, alternating shale and sandstone, and sporadically carbonate rocks. Characteristic for this area are so called Šárka Formations (Kovanda, 2001) with a thickness of 30 to 150 meters, which had been developed in two phases: slate and volcanic. There were found rocks of the Upper Cretaceous and claystone, siltstone, sandstone, limestone and cretaceous, with a thickness of up to several tens of meters (Kovanda, 2001). The youngest sediments are sandy gravel, loess loam and loess, windblown sand, loam deluviofluvial and fluvial sediments from the Quaternary (Chlupáč, 1999).

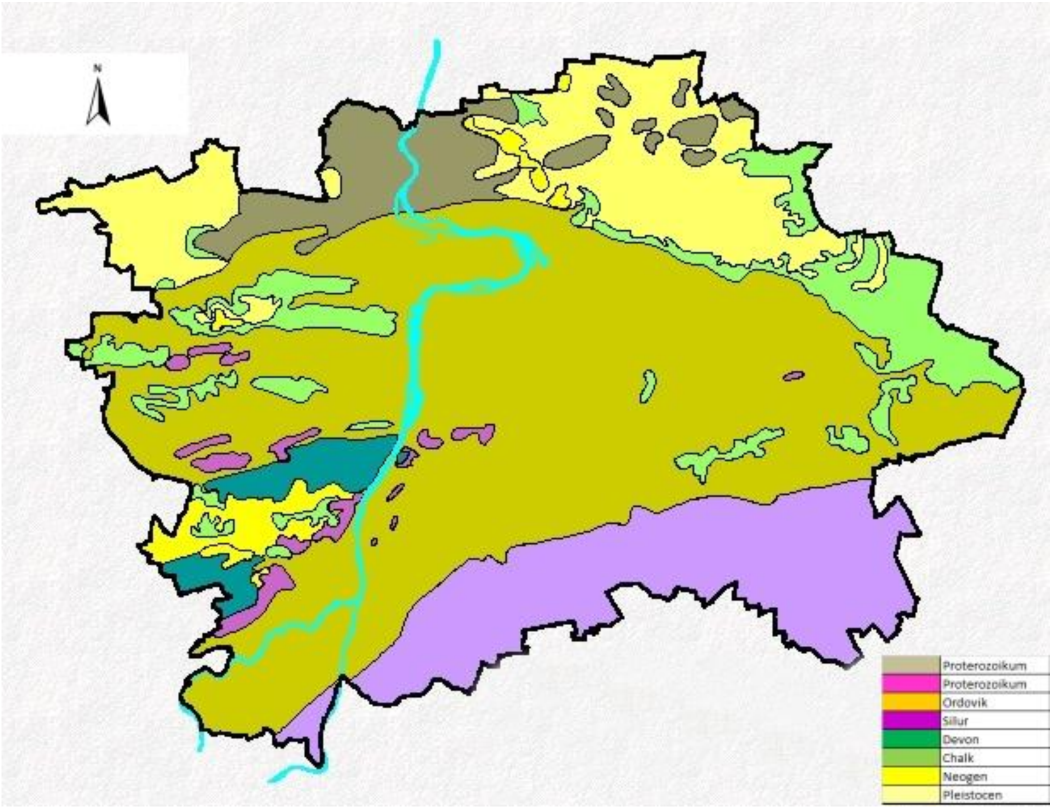

Fig. 2: Geological map of Prague (Geo mapy, 2015), processed by author.

4.3. Clima

The area, is in general, characterized by overall favorable mild and wet climate and by four season changes during the year. The climate is influenced by so – called city´s heat island. In the city center, the average air temperature at the same altitude is about 1 ° C higher than in the open countryside, which slightly affects the area of Litovicko – Šárecký creek. This is due to a large concentration of heat sources, but mainly by smaller losses during evaporation, due to urbanization of active surfaces, where hard surfaces significantly prevail over natural surfaces with vegetation, and where the significant amount of rainfall immediately flows into the sewer system. Long - term annual average of air temperatures thus moves from 9.9 ° C in the center of Prague (Klementinum) to 7.9 ° C in the higher altitudes on the outskirts of the city (Ruzyně) (ČHMI). According to the

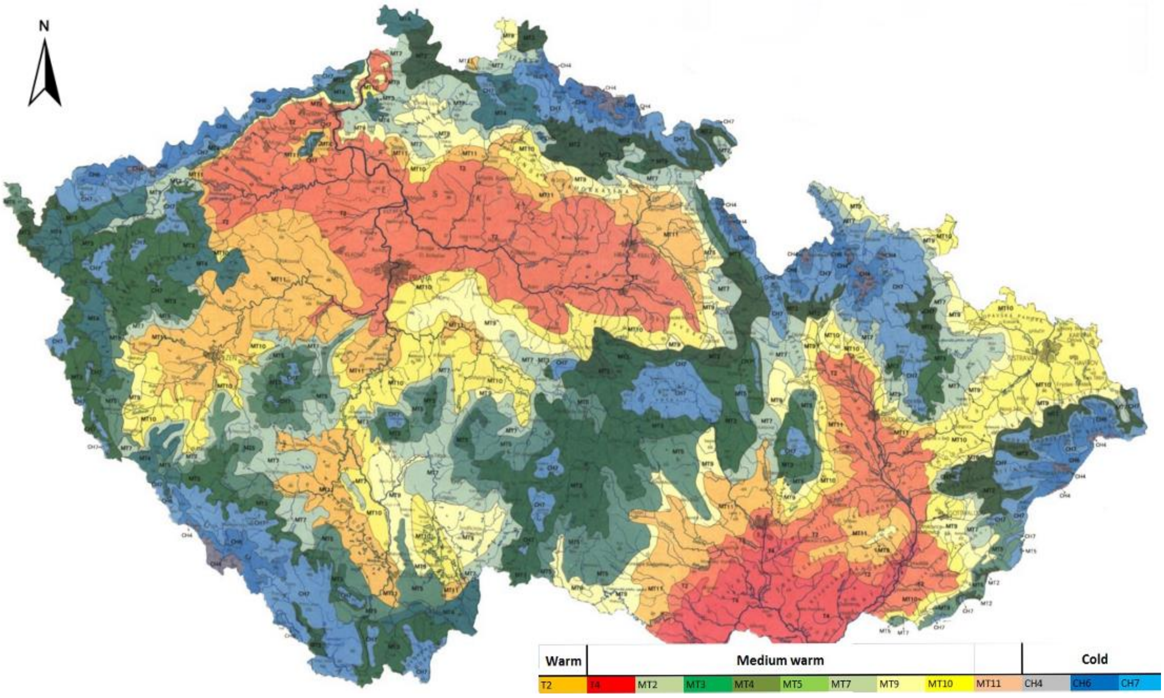

Fig. 3: Climatic conditions of area according to Quitt (1971), processed by author.

climatic classification, the area belongs to a site with slightly warm climate. For the area of T2: Long, warm and dry summers. Very short transitional period with warm spring and autumn. Moderately warm and dry short winter, with very short durations of snow cover is typical (Quitt 1971).

Characteristics	**Climatic area T2**
Summer days	50 – 60
Days with avg. temperature >10 °C	160 – 170
Frost days	100 – 170
Ice days	30 – 40
Avg. temperature in January (°C)	-2 to -3
Avg. temperature in July (°C)	18 – 19
Avg. temperature in April (°C)	8 – 9
Avg. temperature in October (°C)	7 – 9
Days with precipitation > 1 mm	90 - 100
Total rainfall in vegetation period (mm)	350 – 400

Total rainfall in winter period (mm)	200 – 300
Days with snow coverage	40 – 50
Cloudy days	120 – 140
Bright days	40 - 50

Tab. 2: Climatic characteristics of T2 area (Quitt, 1971).

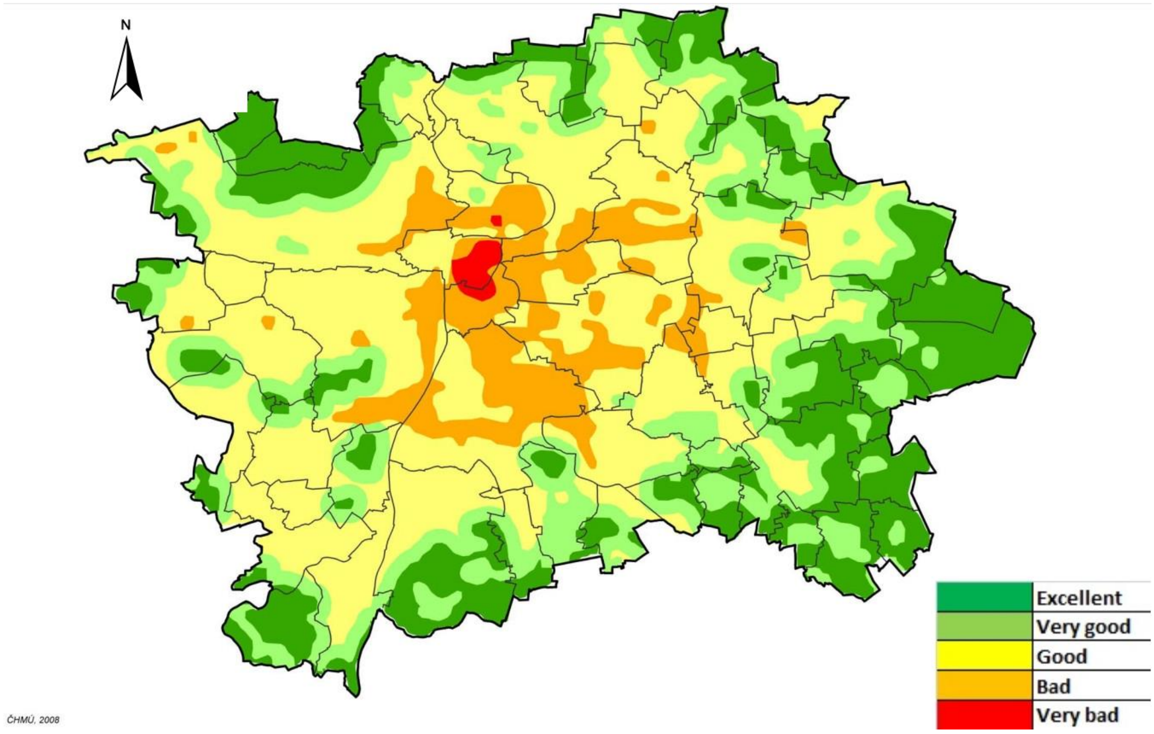

Fig. 4: Categories of climate class pollution (URM, 2008), processed by author.

Air pollution is not in the true sense climatic characteristics, but in urban areas, air quality significantly affects the characteristics of individual sites and some constituents of air quality are the best indicator of the union meteorological effects, and consequently the climatic variables (Raven, 1998). The overall processing of the above mentioned six founded phenomena result in chmate map, that evaluates territory in five categories relatively to quality, reflecting local differences in a city (URM, 2008).

Targeted area is situated between two zones. Good climatic pollution and bad climatic pollution (Categories II & III) according to figure 4.

4.4. Pedology

Mostly brown soils predominant the area, for example at the spring of Litovecký creek, but cambisols are also densely represented along with islands of chernozems and luvizems. Hydromorphic black soils have evolved in the depression of Hostivice. Brown soils are mainly formed in flatlands. and Loess and polygenetic clay are located below the original hornbeam and oak forests. There are more cambisols towards the Vltava River represented in the area.

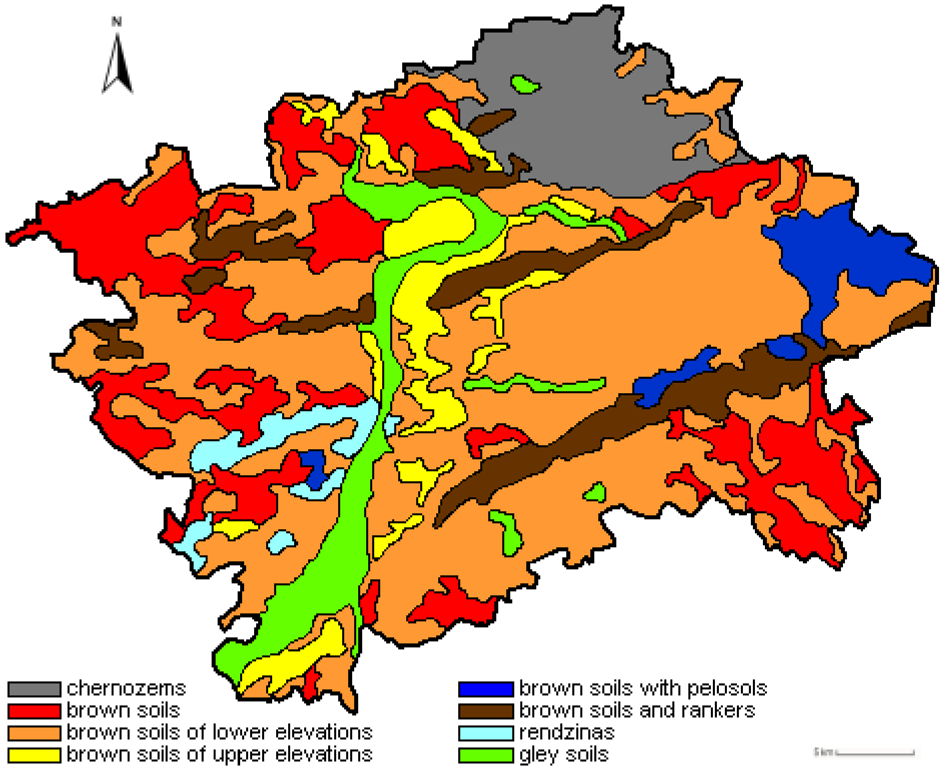

Fig. 5: Pedological map of basin area (geoportal), processed by author.

4.5. Hydrographical

a) Litovecký creek (Strnad pond)

N	1	2	5	10	20	50	100	Tř.
Qn	1,8	3,5	6,1	9	12,5	18,4	23,9	III

N – year values of water flow in cubic meters/s

M	30	60	90	120	150	180	210	240	270	300	330	355	364	Tř.
Qm	239	172	136	112	93	78	65	54	44	34	23	11	2,5	III

M – daily values of flow rate in liters/s

b) **Jenečský tributary**

N	1	2	5	10	20	50	100	Tř.
Qn	1,5	2,7	4,9	7,2	10,1	14,9	19,3	III

N – year values of water flow in cubis meters/s

Tab. 3: Hydrographical parameters: Basin of litovicko – šárecký creek (ČHMÚ)

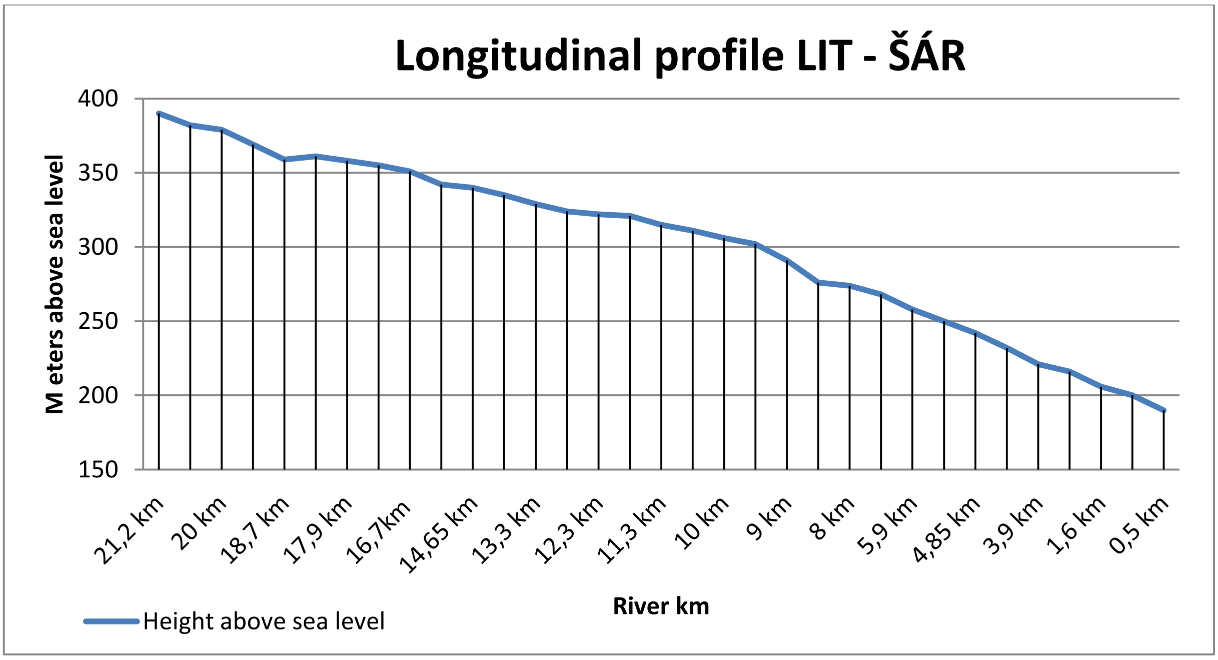

Fig. 6: Longitudinal profile of Litovicko – Šárecký creek (author´s assessment)

Characteristic of Litovicko – Šárecký creek:

- **Catchment area:** 62, 93 km^2
- **No. of hydrological order:** 1-12-01-002, 1-12-01-004, 1-12-01-006
- **Order of stream:** III
- **Total length:** 23,335km
- **Total number of main tributaries:** 4
- **Left sided:** 3
- **Right sided tributaries:** 1
- **Average slant: 0,9 %**

  (lhm)

4.6. Sources of pollution

The upper part of the stream, specifically before reaching the Strnad pond, had been researched in the years 2012 – 2013, and it was found that the water quality in the upper part of the creek was rated as damaged (Class IV), because of high concentrations showing presence of sewage wastewater - NL, BOD5, N - NH4, Pc. Overall, we can say that the surface water is, by all means, long – term polluted by discharges of sewage wastewater into storm drains, including improperly discharged treated water from a nearby sewage treatment plant that is located in municipality of Hostivice. The presence of sewage in surface water in the upper part of Litovicko - Šárecký creek is confirmed by study of cyanobacteria presence done in September 2011 at the Bašta pond and Džbán retention pond (Komínková, 2011). With increasing content of organic matter, nitrogen and phosphorus the quantity of cyanobacteria rises and leads to development of intense algal bloom in Břevský pond and pond Kala. (Šupíková, 2012) Lower part of Šárka creek is ranked as moderately affected (III.), due to high concentrations sewage in the water, according to: NL, BOD5, CODCr, Pc. Litovický - Šárecký stream is in monitored area throughout the longitudinal profile influenced by anthropogenic activities, which reflects negatively on the water quality in the basin.

4.7. Fauna & Flora

Litovický - Šárecký stream is part of Prague's largest natural park Šárka - Lysolaje, which includes eight small protected areas: Baba, Divoká Šárka, Dolní Šárka, Housle, Jenerálka, Nad Mlýnem, Vizerka and Zlatnice. The lower part of the creek is notable for its geological formation and geomorphology. Typical for the area are rocky gorges originated from cobblestones, which bind all sorts of flora and fauna species. Chokecherry and ash trees are rising along the creek. There are very distinctive yellow flowering tuft of alyssum on the rocks in the spring, in canyons occur again *cryophilous* communities of ferns. At some locations, we can also find species - rich communities with the fescue feather grasses, *Koeleria macrantha, Muscari tenuiflorum Tausch* or *Allium senescens L. Gagea Salisb* and *Veronica dillenii* occur on the edges of the rocks. On sunny rocky steppes, there is a home to many species of steppe and forest - steppe molluscs and insects. The vertebrate fauna is also very rich. *Gobio gobio* and *Rutilus rutilus,* several species of amphibians and reptiles, including rare *Vipera berus* live in Šárecký stream. There exists about 80 species of birds, half of which are nesting in the area: *Fringilla coelebs, Parus major, Sylvia atricapilla, Phylloscopus collybita* and *Lanius collurio.* The mammals are represented by abundant hedgehog, there are also minor carnivores and a fox (lesy hl.m.).

4.8. Ponds and retention water bodies

4.8.1. Džbán

Waterworks Džbán had been built between years 1966 - 1971 in the flowpath of Litovicko - Šárecký creek in Prague 6 and was designed as a residential recreational center. Its other function is to ensure a minimum flow below the dam (15 liters/s) and a partial reduction of the effects of floods on Litovicko - Šáreckém creek. Dam of Džbán is also a major fishing spot for sport fishing. In recent years, there was a summer overgrowth of algae, which usually meant a swimming restrictions and lead to its complete ban. This unfavorable situation raises from a number of factors. One of them is the unsatisfactory quality of water flowing from Litovicko - Šárecký creek, that originates mainly from residential units and their wastewater outlets into the creek, beyond the city of Prague, then further mudding of the dam which reaches about 55,000 cubic meters of sediment. Large silting has a substantial effect on the operation of the dam. In 2008, parallel with the repair of sluice gates in the dam water project, stone fortifications of river banks were repaired. To improve the access to the basin from the park, several places with concrete steps, leading to surface of the basin were constructed. On the left bank was built a shallow area for wetland vegetation, which is designed to serve as a shelter and nesting site for waterfowl. The result of the project is a long - term improvement of water quality in the natural swimming pool, ensuring safe operation of the waterworks and the improvement of living conditions for aquatic plants and animals, and thus for sport fishing

4.9.2. Liboc

Based on the historical map plots, it is estimated that the founding of the pond is dated around the end of the 18th century. Historically the pond was and continues to be a source of water supply to the Prague Castle, where the water is used mainly for irrigation. Water is drawn from the pond sampling facility located in the northeastern part of the dam. In the past, the water had been guided to the Prague Castle by a system of open ditches and pipes. Currently the entire water supply leads into the underground. In 1987, the reconstruction of the pond was performed. Mud was removed from the bottom and the pond was fortified along the edges. Nearby Litovický stream was straightened, its riverbed was deepened and fortified the way we see it nowadays. Currently it is mainly used as a fishing pond.

4.8.3. Jíviny

Jíviny retention pool had been built between years 1980 - 1984 on Litovicko - Šárecký creek in Prague 6 district, in order to capture storm water from storm sewers. An extensive network of storm sewers was first diverted into storm settling basin of Dědina and Jívina. The water was there pre - cleaned of coarse materials and proceeded further into a retention pool. Another purpose of the water work Jivina is improvement of waterflow in Litovicko-Šáreckém creek. The main purpose of this project is therefore a flood protection of the bottom part of Litovicko-Šárecký stream. In the years 1998 - 2000 a fortification of upstream side of the dam at normal water levels by wire - concrete mattresses was build to prevent abrasion of the dam. In 2008, it had to be removed as wire baskets completely corroded. The original stone filling baskets were left in place and used as a stone collecting container

4.8.4. Strnad

It is located in the administrative area of Hostivice. It is designed as a flow basin with variety of purposes, such as biological, retentional, landscaping and fishing. It has an area of 8, 3 hectars and the maximum depth is 3 meters. Supply of the pond is provided by Litovický pond and laterally also by Zličínský pond. It is used for extensive fish farming, particularly carp species, pike and tench. Due to unstable state, it was fortified on the edges and additionally the pond got substantial amount of bottom mud removed. All in 2007. Also new trees were planted in a following year. The pond is a home to several bird species.

4.8.5. Litov

Litovický pond is the biggest part of set of ponds in the Hostivice area and it has an a area of 18 hectars. Litovický pond receives water from both Kala pond and Břevský pond. Currently it serves mainly as a fish pond. It is a breeding pond to several fish species such as *Hypophtalmichthys molitrix* and *Perca fluviatilis*. The water in the system of these three ponds has been found strongly eutrophic, thereby increasing the number of green algae, which leaves a visible mark on the water color. The growth of algae is caused by the presence of high content of nitrogen and phosphorus, which receives the water from the surrounding fields and of wastewater discharged. The bad quality water is further enhanced by feeding management for the fishing purposes. In consequence in 2005 and 2007 there have been two accidents of multiple bird dying caused by algae.

4.8.6. Kala

Kala Pond is part ponds system of Hostivice. The total are of the pond is approximately 13 hectares and a maximum depth is 2 meters. It is laterally supplied by Litovický creek and also slightly supplied by a spring that originates in nearby forest. Water is flowing out of the pond trough a safety profile. Half a decade the water have been flowing into a Litovický pond. Formerly it flowed trough drainage ditch along Litovický pond, but this route has been blocked for a few years now. A small outlet is located on the right side of the dam of Kala pond and is designed, if necessary, to supply a nearby wetland called Chobot and preventing it from going dry. Out of Chobot wetland the water can move freely into a drainage ditch round the Litovický pond.

4.8.7 Břev

Břevský pond is situated as the first of the three ponds of municipality of Hostivice. It is 10 ha large and a maximum depth is 2,5 meters. This pond is supplied by Litovický creek. It is supplied by one addtitional source from a small water basin of Břev, that is supplied solely by groundwater source. Water flows in multiple directions from Břevský pond and it is by an overflow in the eastern part of the dam to Kalý pond and also trough a ditch into Litovický pond.

4.8.8. Strahov

Strahov is a pond located in the municipality of Chýně. Its total area is about 1.3 hectares and has a depth mark of 3.5 m. It serves as a recreational pond to residents of Chýně and Hostivice and as a fish pond. There are several species of fish including: carp, tench, grass carp, pike, perch, eel, asp, whitefish seled, chub, bream, catfish according to informational sign posted by the local municipality. Ahead of the pond are located three water basins of smaller scale, used for rearing fish stock. Water flows into the basin from the Bašta pond. There is an outlet of treated wastewater into this pond from wastewater treatment plant of Chýně.

4.8.9. Bašta

Pond Bašta lies on the catastral municipality of Chýně. Its total area is 4 hectares and its maximum depth is around 2.5 meters. It is located as a first of pond systems and is supplied by Litovický creek from West.

Source: lesy hl.m., Magistrat, Generel (2008)& Author´s observation

No.	pond/retention basin	River km	Function	Area (hectars)
1	**Bašta**	22,60	Fish breeding, recreational, fishing,	4
2	**Strahov**	21,75	Fish breeding, biological, fishing, landscape	1,3
3	**Břev**	21,02	Fish breeding, landscape	10
4	**Kala**	20,42	Fish breeding, landscape	13
5	**Litov**	19,91	Fish breeding, landscape	18
6	**Strnad**	16,81	Fish breeding, retention of water, biological	8,3
7	**Jiviny**	15,58	Fish breeding, landscape, recreational	9
8	**Liboc**	12,52	Fish breeding, fishing, landscape, fishing,	2,7
9	**Džbán**	10,27	Recreational, landscape, fishing, retention of water	18

Tab. 4: Comprehensive overview of water bodies

5 Materials and methods

5.1. EcoRivHab

In order to evaluate ecomorphological state of watercourses in the area of interest, EcoRivHab methodology was applied. Assessment using EcoRivHab methodology, as required by the Water Framework Directive, is based on a comparison of the current state of the watercourse and the reference state. The refrence stream reaches are chosen as areas without significant human intervention. The main objective is to evaluate ecomorphological state of a stream with emphasis on the hydromorphological characteristics of riverbed and ecohydrological state of riparian belt and floodplain. Further, it is used to identify anthropogenically influenced sections, which should be revitalized and natural or near - natural sections that need to be protected (Matoušková, 2003, 2007, 2008). First conducted, under the EcoRivHab metodology, is usually a basic reconnaissance of the terrain and determination of the natural flow sections (reference reach of the stream). Stream reaches are divided into sections of heterogeneous length and of homogeneous quality. There are three main parameters that are rated in order to discover qualitative state of each stream´s reach. Monitoring is not only related to the watercourse itself, but to the entire aquatic ecosystem. According to norm EN 14614, the monitoring and evaluation of hydromorphological characteristics should cover these three zones of river environments:

1: streambed,

2: riparian belt,

3: floodplain.

When assessing with methodology of EcoRivHab, it is required to proceed from the source to confluence and to evaluate all 31 parameters. Each individual parameter is assigned with a score ranking from 1 to 5, while one represents the best value and 5 the worst . Some criterias are evaluated verbally. As part of the methodology of EcoRivHab, all parameters have the same weight. The 31 criterias are divided into 8 major groups, that gain a value (1 – 5) based on arithmetic mean (Tab.5). They are further divided into 3 main groups (streambed, riparian belt, floodplain). Arithmetic mean of the 3 main groups provides a value according to which, we then determine the overall ecomorphological grade (ES). Ecomorphological state of a stream is thus characterized as the quality of five classes. They indicate the degree of anthropogenic impact on a stream.

I. - natural condition, near natural condition

II. – low anthropogenic influence,

III. - moderate anthropogenic influence,

IV. - strong anthropogenic influence,

V . - very strong anthropogenic influence.

Legend		
I	Natural, or close to natural status	Dark blue
II	Low anthropogenic influence	Green
III	Moderate anthropogenic influence	Yellow
IV	Strong anthropogenic influence	Orange
V	Very strong anthropogenic influence	Red

Tab.5: EcoRivHab classification (Author).

Main parameters	**Assessed characteristics**	**Type of ranking**
Streambed		
Morfology and water course	Type of streams valley	S
	Degree of curvature	B (1, 3, 5)
	Shape of streambed	B (1, 2, 3, 4, 5)
	Depth of streambed	B (1, 2, 3, 4, 5)
	Linkage with groundwater	B (1, 3, 5)
Longitudinal profile	Presence of terracing	B (1, 2, 3, 4, 5)
	Presence of erosion and accumulation units	B (1, 3, 5)
	Flow characteristics	B (1, 3, 5)
	Riffles and pools	B (1, 2, 3, 4, 5)
	Runoff characteristics	B (1, 3, 5)
Transversal profile	Type and stability of profile	B (1, 2, 3, 4, 5)

	Mean depth of profile	S
	Width variability of profile	B (1, 3, 5)
	Capacity of profile	B (1, 3, 5)
Streambed structure	Type of substrate	S
	Streambed alteration	B (1, 2, 3, 4, 5)
	Microhabitats presence	B (1, 3, 5)
Bank structures	Characteristics of shore vegetation	B (1, 2, 3, 4, 5)
	Structure of shore vegetation	B (1, 2, 3, 4, 5)
	Technical alterations of shore	B (1, 2, 3, 4, 5)
	Mobility of shore	B (1, 2, 3, 4, 5)
Water quality	Hydrochemical properties	B (1, 2, 3, 4, 5)
	Hydrobiological properties	B (1, 2, 3, 4, 5)
	Outlet of wastewater into stream	S
	Streambed vegetation	S
Riparian belts		
Riparian belts	RB presence	B (1, 3, 5)
	Vegetation chracteristics	B (1, 2, 3, 4, 5)
	Land use	B (1, 2, 3, 4, 5)
Floodplain		
Floodplain	Dominant land use	B (1, 2, 3, 4, 5)
	Presence of flood protection	B (1, 3, 5)
	Retention potential	B (1, 3, 5)

* B = Grade ranking S = Verbal ranking

Tab. 6: Ecomorphological evaluation (Matoušková, 2003), processed by author.

The results are thematic maps of various zones and ecomorphological map of overall condition (Matoušková, 2003, 2007, 2008). Methodology of EcoRivHab does not address the evaluation of stagnant water, water basins are therefore excluded. Longer sections placed artificially underground are assigned value of V - very strong anthropogenic infulence. In total: 59 reaches were evaluated for 5 streams in given basin.

5.2. Assessing alterations of stream length, shape and land cover

The most fundamental changes to watercourses in terms of impact on runoff, include shortening of the river´s network as a result of straightening the riverbed´s route, mainly due to the drainage of agricultural land and flood protection, consisting of the fastest possible drainage of water from the landscape. Straightening of the flow tends to increase the rate of water flow in the channel, because the removing of meanders leads to uniformity of distribution of the flow velocity. Water obtains a greater energy and its destructive effects are more pronounced. Consequences of flow straightening is also shortening of the total time of flood wave advance trough territory and reducing of volume capacity of the river channel in the given section. Alterations to land cover along the stream were monitored in order to comapare previous and current state of river´s surroundings, and to monitor changes in land use. To make a comparison between the previous and current state, historical maps dated to 1953 and aerial photos dated to the same year were used (geoportal.cuzk.cz).

5.3. Terrain assessing

5.3.1. Theoretical background

Before individual field trip and terrain data assessing, several informational channels were assessed for easier determination of qualitatively homegeneous stream units. For this purpose important sites locations were acquired using free software vector maps and its GPS coordinates, that were saved for further terrain use. Reaches were pre – examined using cartographic, topographic, water, aerial, geological maps etc.

5.3.2. Terrain assessing of data

Terrain assessing of data was performed in ideal condicitions and for the whole length of examined stream and its tributaries. Ideal conditions are important for multiple field data assessment in different states of vegetation cover and river´s flow rate. It is important to monitor the streambed before full vegetation cover and by low flow rates to be able to record every parameter with certainty. For riparian belt and floodplain monitoring, full vegetation cover is recommended. The object was divided into multiple reaches of heterogeneous length and homogeneous qualitative properties. The length was maintained to oscillate between 150 to 1200 meters per section, with a minor deviation possibility. Each sections border were marked and carried out clearly, along with other ecomorphological properties into a purpose – designed form. Borders between reaches had to be measured clearly using Garmin dakota 10 pro GPS device with vector mapsof Czech Republic (1 : 10 000). Sections were marked with a six digit code starting from the water stream´s spring ending with confluence. Photographs were taken at each stream´s unit, using DSLR camera, with focus on various structures influencing natural state of the creek.

5.4. Hydrochemical analysis

Own ecohydrological assessment was supplemented by measurement and evaluation of water conductivity. According to Volenec (2002), the determination of conductivity is an integral part of each chemical water analysis. It allows instant estimate ion concentration of dissolved solids and total mineralization of water. Along with conductivity measurment and other values as acidity, nitrate amount, water temperature and nitrite concentration, dissolved oxygen etc. we are given set of informations that provides us with a complex information about water quality. According Matoušková (2008) it is important to choose substantial amount of representative profiles and determining enough of samplings for at least 4 measurments (four seasons of a year). As this may be expensive, the EcoRivHab study allows to exclude this measurment from the evaluation methodology. Allthough for this study, conductivity, pH, and dissolved oxygen were measured. Also laboratory measurment was done, allthough the data were from one sampling place only.

5.4.1. Conductivity

Conductivity measurement is used, for example, in monitoring indicators of the quality of drinking water. The electric conductivity is an ability of a solution to conduct an electric current. There is a process when the negatively and positively charged particles in the electric field of the solution are moved to oppositely charged electrodes, wherein the movement of the ions is influenced by the solution characteristics: temperature, viscosity and ionts and also influenced by characteristics of solution, namely by: charge, concetration, size. Changing the temperature by 1 ° C causes a change in conductivity of at least 2 %. Conductivity is therefore usually measured or converted to a temperature of 25 ° C (Horáková, 2003). Every measurement was therefore corrected to 25 °C. There are digital devices called conductometers, used for measurment of conductivity. Basic measurment unit is S/m, but in this research a uS/cm unit was used. For own research a WTW multimeter 350i was used in every reach of LIT – ŠÁR´s creek and at a selected location for Nebušický, Zličinský, Lysolajský and Jenečský creek.

5.4.2.pH

The pH of water is the measure of how acidic or basic the water is on a scale from 0 to 14. It is a measure of hydrogen ion concentration. The usuall pH for river water ranges from 6,5 to 8,0. Water acidity can be increased by acid rains and household waste water outlets into the river, but also can be kept in check by the bedrock composition (limestone). Extremes in pH can make a river inhospitable to life (Herlihy, 1993). Low pH is especially harmful to immature fish and insects. Acidic water also speeds the leaching of heavy metals harmful to fish. Excessively high or low pH levels are often associated with nutrient deficiencies, metal toxicities, or other problems for aquatic life. High pH makes ammonia more toxic (Odén, 1976). As the pH increases with temeprature, a correction to 25°C was made, in order to obtain comparable results. Measurment of pH was carried out by a WTW multimeter 350i. Before and after each measurment, the electrode was rinsed with purified water, to mantain accuracy for following measurments. Calibration was done accoridng to the manual. 2 – way calibration was selected: buffer solution: pH 7.00 and pH 4.00. Measurment was performed in every ecohydrological unit of LIT – ŠÁR stream.For comparative research, one additional measurment was performed in JEN, ZLI,NEB and LYS creek. A mesasurment in whole length of stream can help to identify locations with low pH. Streams located in densely populated areas are often negatively influenced by unwanted wastewater pollution. Further we can observe acidity fluctuation along the flow and in case of further interest focus our interest on specific locations.

5.4.3. Dissolved oxygen

The level of dissolved oxygen in water is on of the most important parameters in determining its quality, because it indirectly provides and insight, whether there is a source of pollution in the stream. The common pollutants in the streams, such as wastewater, originated from households, industrial wastes and for rural areas a runoff from livestock feedlots, directly affect the level of dissolved oxygen in the water. The decrease of dissolved oxygen can cause dying of organisms sensitive to its concentrations. The common level of oxygen in water streams ranges between 6,5 to 16 mg/L. The DO concentrations depend on water temperature, dissolved salts, atmospheric pressure, presence of reducing compounds, suspeneded matter, and living species (Ibanez, 2008). More oxygen can be contained in cold water. With increase of water temperature, the amount of maximum oxygen concentration is decreasing. Minimum oxygen required to support aquatic life in fresh water is in a range between 4,5 to 6 mg/L. Under this value, the water becomes hypoxic for most of the species (Dean, 1999). The aquatic fauna and flora affects the amount of dissolved oxygen in the water. Either by consumption, or produciton (Ibanez, 2008). Dissolved oxygen was measured in every monitored unit of LIT – ŠÁR creek and also one control measurment was performed for Nebušický, Zličinský, Lysolajský and Jenečský creek. As the results need to be comparitive, the oxygen data were corrected to 25°C.

5.4.4. Laboratory measurment

To determine hydrochemical properties of water in fresh streams, several measurments are required, that are hardly acquired due to financial reasons in the field conditions by hand devices. Therefore water samples gathered from a sampling place (Fig. 11) were sent at each of the four year´s seasons to a certified laboratory. Samples were collected at following dates, representing the four year seasons: 30.6. 2015, 30.9. 2015, 16.12. 2015, 9.3. 2016. For this analysis following parameters were measured: dissolved oxygen, conductivity, biochemical oxygen demand, chemical oxygen demand, undissolved substances, temperature, nitrate, ammonum nitrate, phosphorus. BOD is important indicator as it states the degree of pollution based on amount of consumed oxygen in water by organic matter eating bacteria (Davis, 1977). COD on the other hand indicates water pollution by indicating total amount of organic matter in the water that is tested by its oxidization. Amount of reagent consumed in this reaction is recorded (Pisarevsky, 2005).

Fig. 7: Sampling location for laboratory testing below Džbán retention basin (Author).

For the reason of one sampling place only, the results of chemical analysis were not included in EcoRivHab evaluation. The data serves for an informational purpose. Obtained readings were not corrected to a certain temperature gradient in order to provide an overview of seasoning changes in hydrochemical properties.

Legend		Conductivity	Dissolved oxygen	BSK5 (mg/L)	CHSKcr (mg/L)	Undissolved	N - NH4 (mg/L)	N - NO3 (mg/L)	P (mg/L)
Very clean water	I	<400	>7,5	<2	<15	<20	<0,3	<3	<0,05
Moderately clean water	II	<700	>6,5	<4	<25	<40	<0,7	<6	<0,15
Polltued water	III	<1100	>5	<8	<45	<60	<2	<10	<0,4
Very polluted water	IV	<1600	>3	<15	<60	<100	<4	<13	<1
Heavily polluted water	V	_>1600	_<3	_>15	_>60	_>100	_>4	_>13	_>1

Tab. 7: Limits for selected indicators of fresh water (ČSN 75 7221, author´s making

5.5. Data processing

Data were transferred from paper into a digital version using text emulator. Then processed in analytical software. Excel editor. The data were further carried out in a form of maps and tables. Data were processed both for single streams and for basin.

6 Results

6.1. Historical flow pattern of Litovecko – Šárecký creek

By comparing channel flow route in 1953 and the current state in 2015, both observed from aerial photos, it is possible to observe, that several of water bodies on the route of Litovicko – Šárecký creek were not yet present in 1953. Strahovský pond was formerly nearly dried up, and its water mark depended on good climatic conditions. This pond was reconstructed and had been refilled with water in 1999 (Magistrat hl.m.). Another retention basin was not present in 1953 along the direction of flow. Pond Strnad was finsihed in 1958 to become a retention basin to diminish harmful floods. It was built into its present shape, when it changed its destination to a pond in 1969 (Generel, 1998). Nearby rentention basin Jíviny also changed natural flow pattern of the stream, as it had been built from 1980 – 1986. Last significant water body that creates a border between Litovický and Šárecký creek is Džbán (N50°05.425, E014°19´57.0). It had beein built in 1966 – 1971. As we can see on the figure: 1 . and figure: 2., its construction slightly shortened length of the creek, as any other pond creation would. By looking into 1953 maps i didn´t noticed significant change in flow pattern from the spring to t Šárecké valley. There are however few exceptions on the Šárecký stream on GPS coordinates: N50°06´307, E014°22´02.1.a location near Zlatnice, located in mid – part of Šárka waterway a revitaliazation was done in 2013 (Magistrat hl.m.). A meandring streambed was created and the stream length was increased by 650 meters (fig. 3 and fig 4.). In the case of Lysolajský creek, there is no significant change in streambed route alterations. That is mainly given by a fact, that it flows trough an old built – up area, that hadn´t dramatically changed in past 60 years. There is some housing – development, but still far away to reach the streambed. The same conditions are with Nebušický creek. Streambed of Jenečský creek is difficult to recognize with the given photos. Therefore i cannot tell any altertions. In basin area of Zličínský creek, we can see that pond Dolejšák wasn´t yet constructed in 1953.

6.1.2. Historical land cover

Comparison between past and current land cover was assessed by own field assessment and by use of historical and current aerial maps. We can see noticable increase in urban populated areas by 11,6 %. caused by new storage areas, located in the eastern part of Jeneč and by new households located in previously unpopulated gap between Hostivice and Je neč. Another increase in urban areas is caused by new developed houses in north – western part of Hostivice, where the creek flows directly through its gardens. There is 14 % decrease in arable and agricultural landscape composition. Partially new houses were built on the arable land and the rest became afforested. Part of the former fields became a quarry in the south – eastern part of Jeneč. Slight increase in water bodies is caused by construction of a pond.

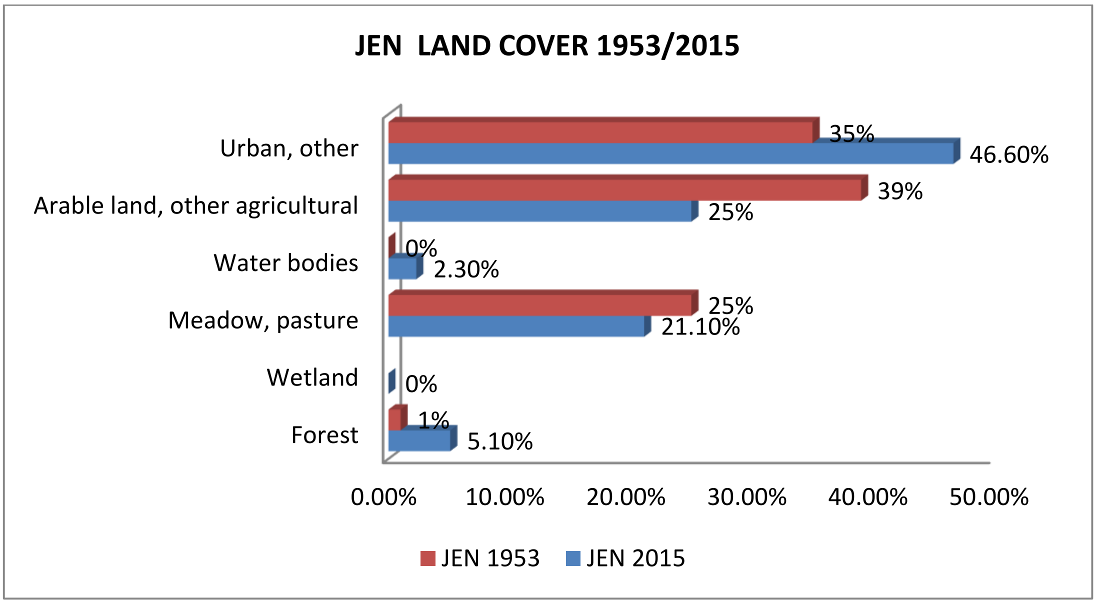

Fig. 8: Land cover along the Jenečský creek – monitoring 1953 and 2015

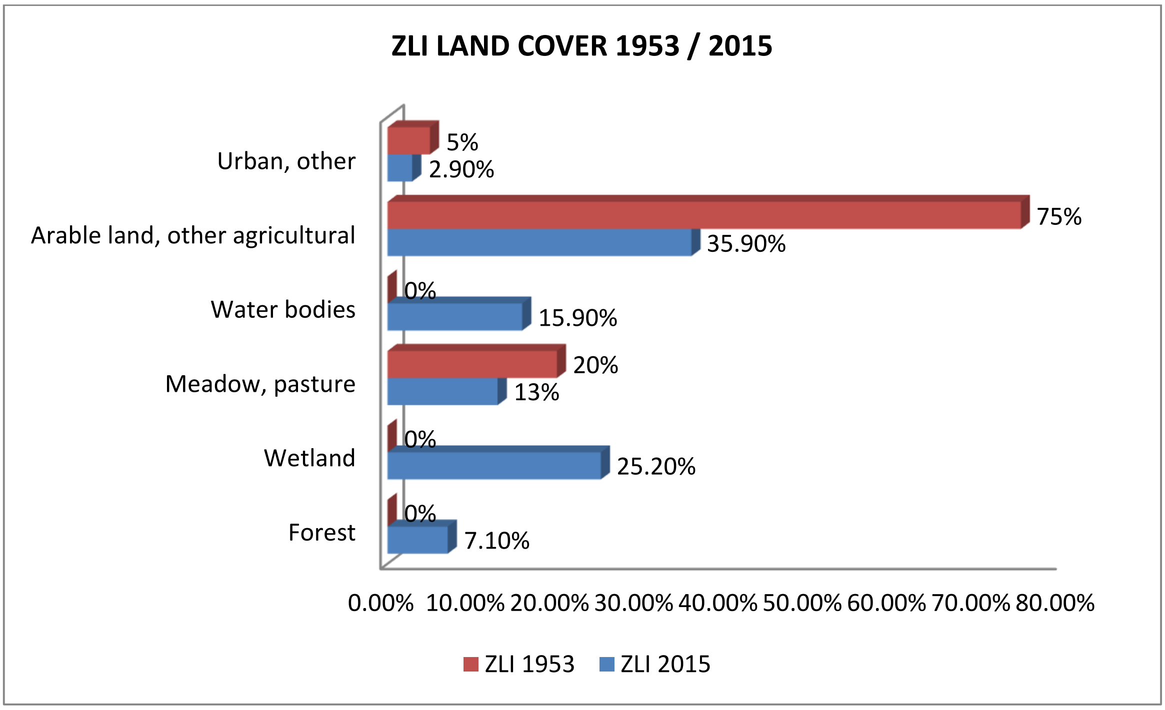

Fig. 9: Land cover along the Zličínský creek – monitoring 1953 and 2015

In 1953, Zličínský stream was mostly surrounded by arable lands (75% in 1953). It decreased to 35, 9%. Arable fields were naturaly transfered wetlands and forests. In 2015, reach ZLI03 became surrounded by a wetland vegetation and forest. This part is often a heaven for dozens of wild boars, as it became a quite area. Increase by 15, 9% in the area is influenced by construction of pond: Dolejšák, Strnad and Peterkův.

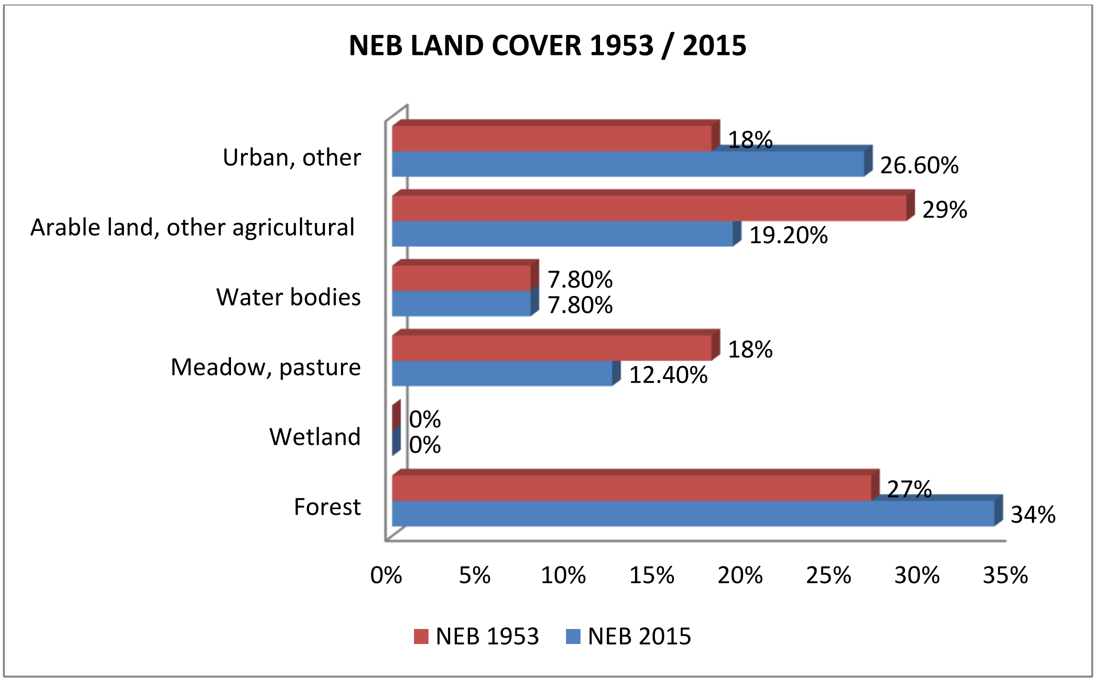

Fig. 10: Land cover along the Nebušický creek – monitoring 1953 and 2015.

8,6 % increase in urban land cover is caused by rapid housing expansion near local forest, that directly neighbours with NEB04. Afforestation by 7 % reduced with the same proportion pastures and arable land.

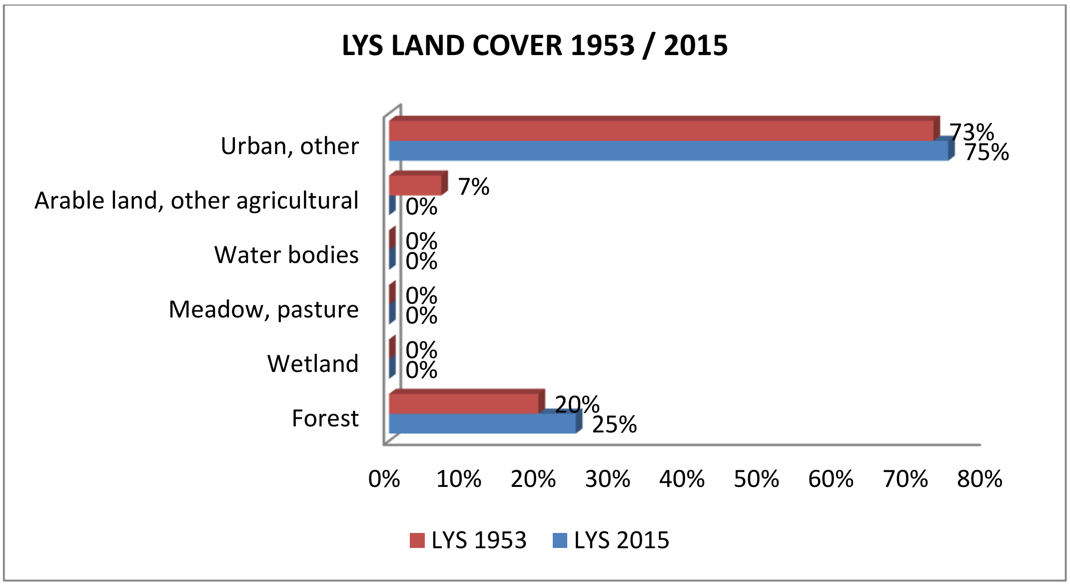

Fig. 11: Land cover along the Lysolajský creek – monitoring 1953 and 2015.

Land cover along Lysolajský creek shows only minor changes. Urban development shows only 2 % increase and 5 % increase in forestal area.

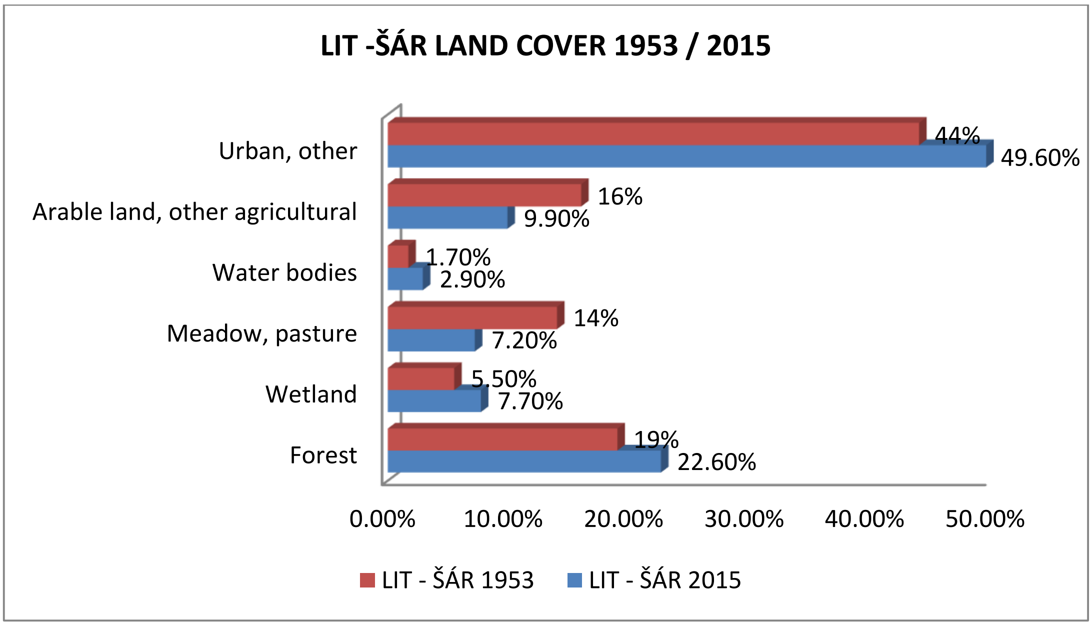

Fig. 12: Land cover along the Litovicko – Šárecký creek – monitoring 1953 and 2015.

Urban density within Litovicko – Šárecký creek slightly increased by 5,6 %. It is relatively stable beacuse along the Šárecký creek, there is either a precious natural park or land market prices are too high, therefore there is little fluctuation in housing . Main increase in urban areas are in Hostivice and Ruzyně. Arable lands and meadows were replaced by forests and urban areas. Slight increase in wetlands by 2,1 % is caused by recent revitalization done in Hostivice pond system. Nowaday areas between those ponds are wetted and provide excellent biological value for many fauna and flora species.

6.1.3 Current land cover

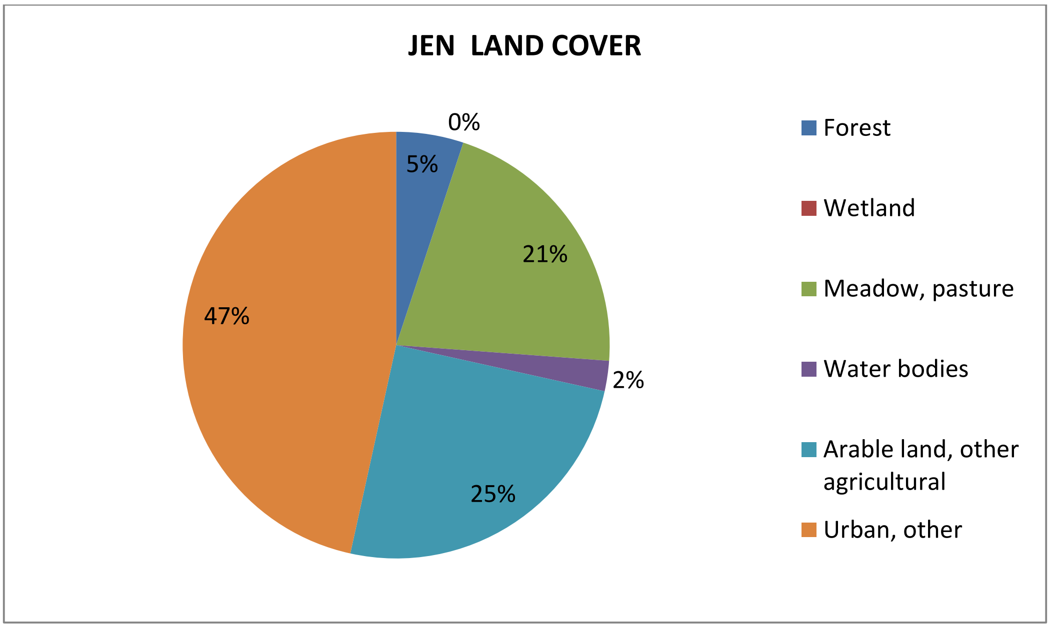

Fig. 13: Current state of land cover along the Jenečský creek.

Current land cover along Jenečský creek shows very high high human influence in are (47 %).

In connection with 25 % of arable lands, it might be noticable source of pollution.

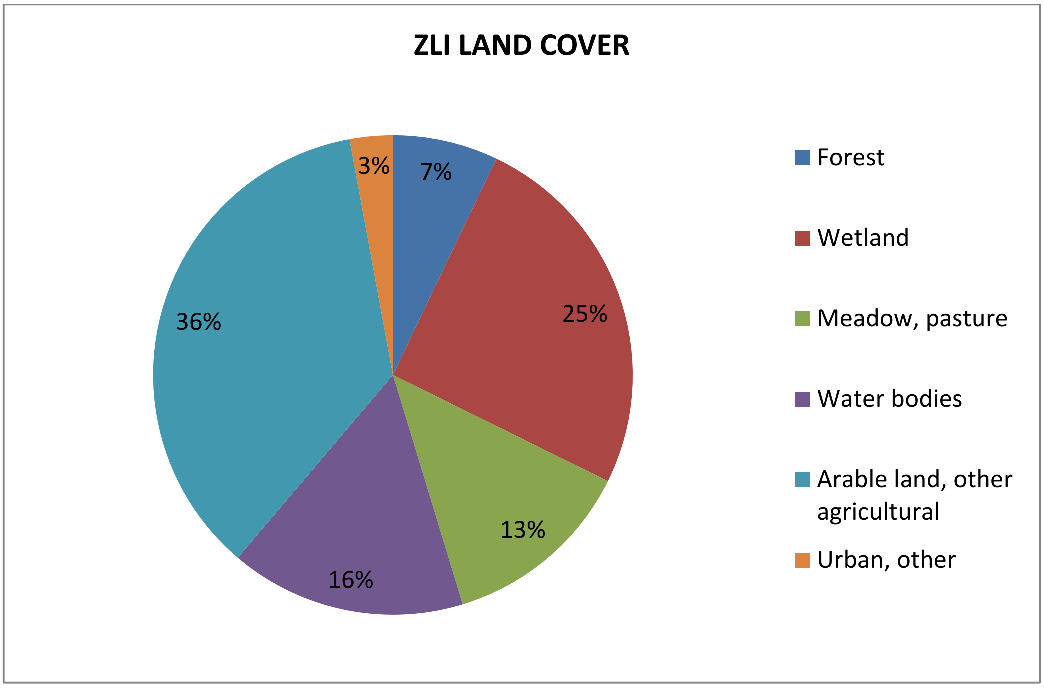

Fig. 14: Current state of land cover along the Zličínský creek.

36 % of land cover is arable land. Possible source of nitrogen pollution. Only 3 % of urban areas is a good qualitative measure. 25 % of wetlands shows good qualitative status of this area.

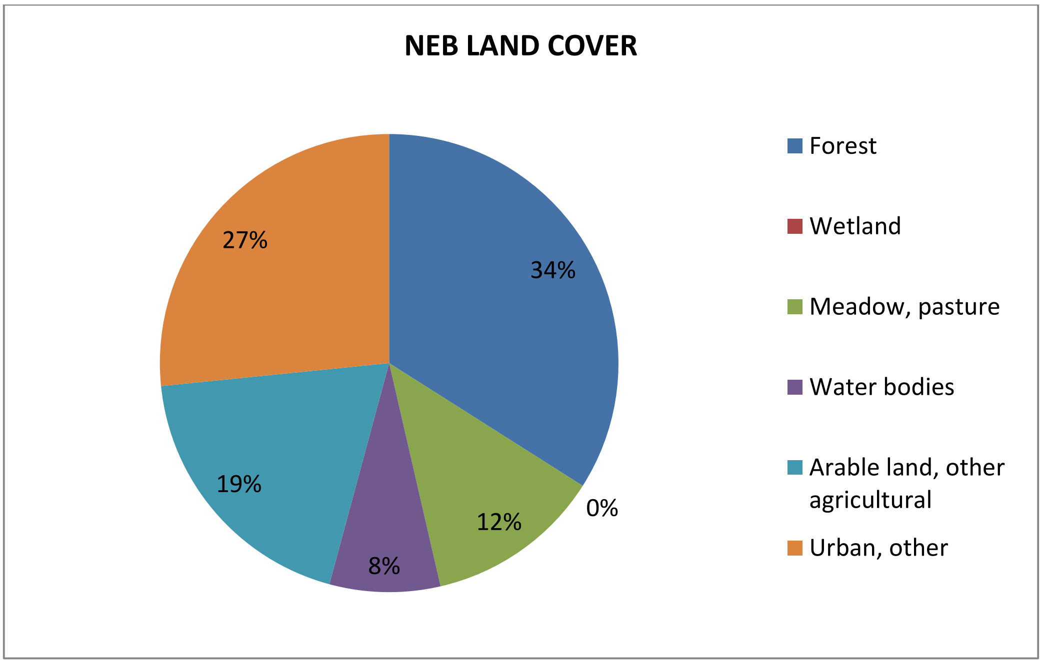

Fig. 15: Current state of land cover along the Nebušický creek.

34% is covered with forest and 12 % with meadow. That is almost a half. On the other hand, urban areas are present at 25 % of the basin.

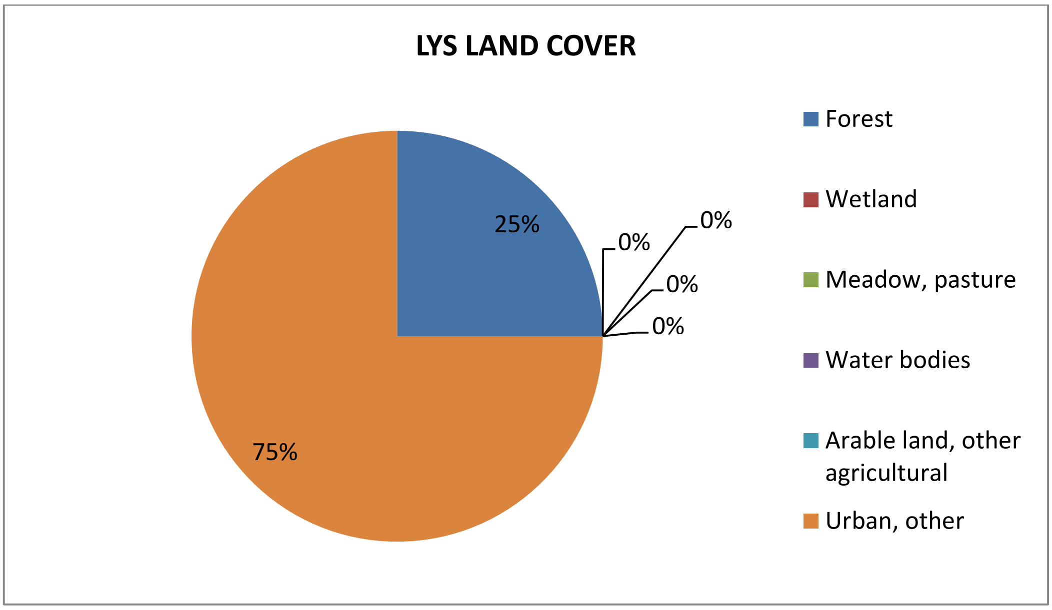

Fig. 16: Current state of land cover along the Lysolajský creek

Basin of lysolajský creek is only covered by forests (25%) and urban areas (75%). It implies bad qualitative status of basin. Most of the stream´s length length is negatively influenced by anthropogenic influence.

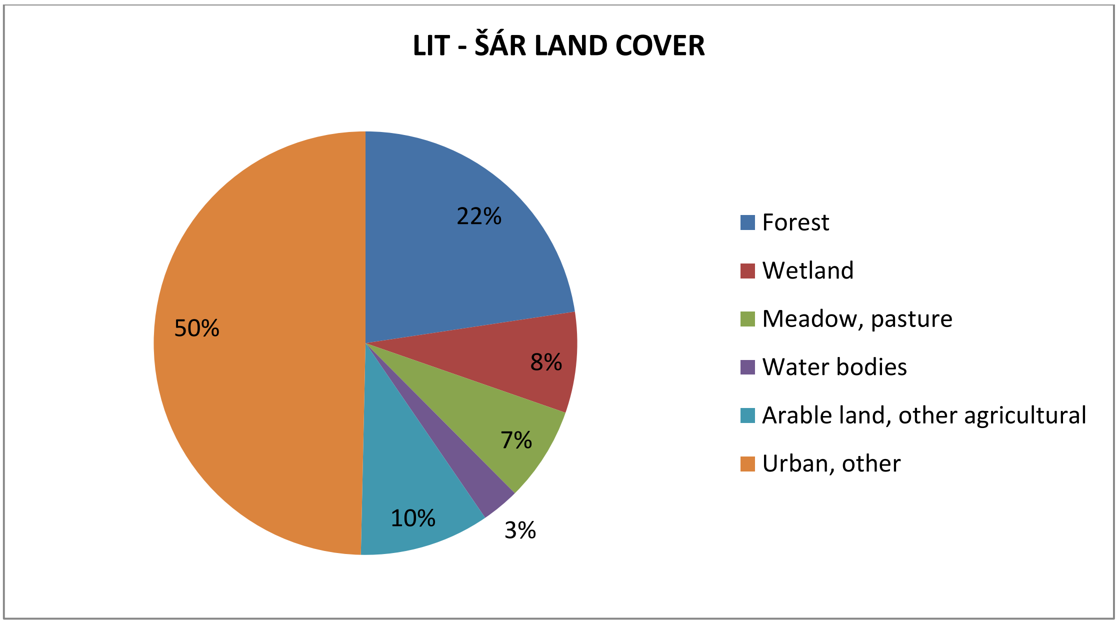

Fig. 17: Current state of land cover along the Litovicko – Šárecký creek.

The longest stream shows unflattering 50 % coverage by urban areas. 22% of the forest mostly belongs to Šárecké Valley. T

6.2. Hydrochemical properties evaluation

6.2.1. pH measurment

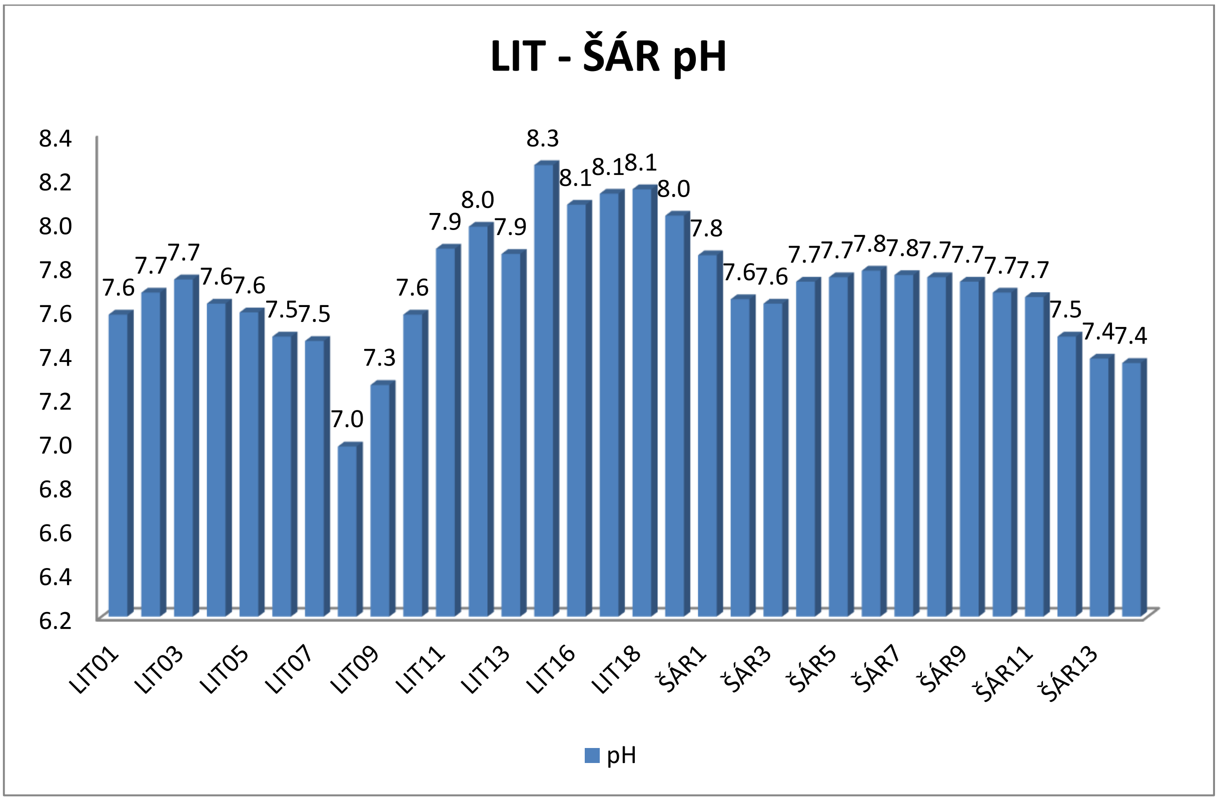

Fig. 18: Complex pH measurment of Litovicko – Šárecký creek.

Acidity results showed some drops in Ph. Namely LIT07 wih pH 7,455 to LIT08 (pH 6, 975 and LIT09 (pH 7,255). It may be caused by inflow of sewage wastewater. Several pipe inflows into the creek are located in LIT08 area. Highest mesaured values are LIT15 with pH 8,255 and the lowest value LIT08 (pH 6,975). Few hundreds meters below the connection with Lysolajský creek are ŠÁR13 and ŠÁR14 (pH 7,375 and pH 7,355). Probably affected by the tributary with acidic water condition (Tab. 10). There is a pattern of decreasing pH, from ŠÁR08 to the confluence with Vltava river. It may be caused by increase in populated areas along with streams progress Some with wastewater outlet into the water The same pattern is visible at LIT04 to LIT09, when the creek is emerging from forest into urban area.

6.2.2. Dissolved oxygen measurment

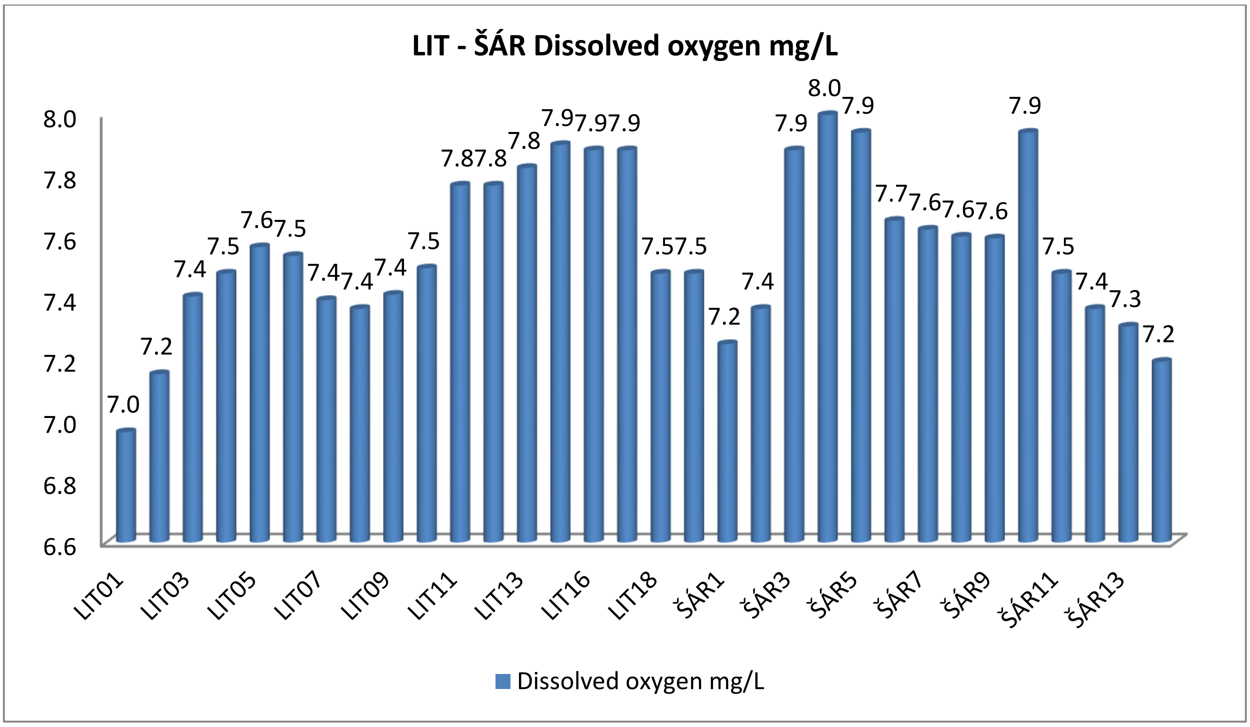

Fig. 19: Complex dissolved oxygen measurment of Litovicko – Šárecký creek.

Average values of dissolved oxygen show at least minimum support for aquatic organism with values over 7 mg/L and therefore the conditions cannot be marked as hypoxic, as they dont fall under 6 mg/L. Lowest value is 6,96 mg/l and is represented by LIT01. It is probably caused by very low fluctuation and stagnant water. Drops can be seen at LIT08, LIT09, where is a possibiltiy of wastewater input. The same situation is visible at decrease of dissolved oxygen from ŠÁR10 gradually to ŠÁR14 (7,94 mg/L to 7,19 mg/l). Relative drop is seen at ŠÁR with 7,25 mg/L, where the sampling place was 100 meters below Džbán retention basin. It is possibly caused by low oxygen stagnant water and by different biochemical conditons in the retention basin. Sections of a relative good ecohydrological quality with high variability of river flow and natural surrounding are.: ŠÁR 4 – 7 with 7, 62 to 8 mg/L. Most of the dissolved oxygen values are in II. class of water quality [>6,5 mg/L].

6.2.3. Conductivity measurment

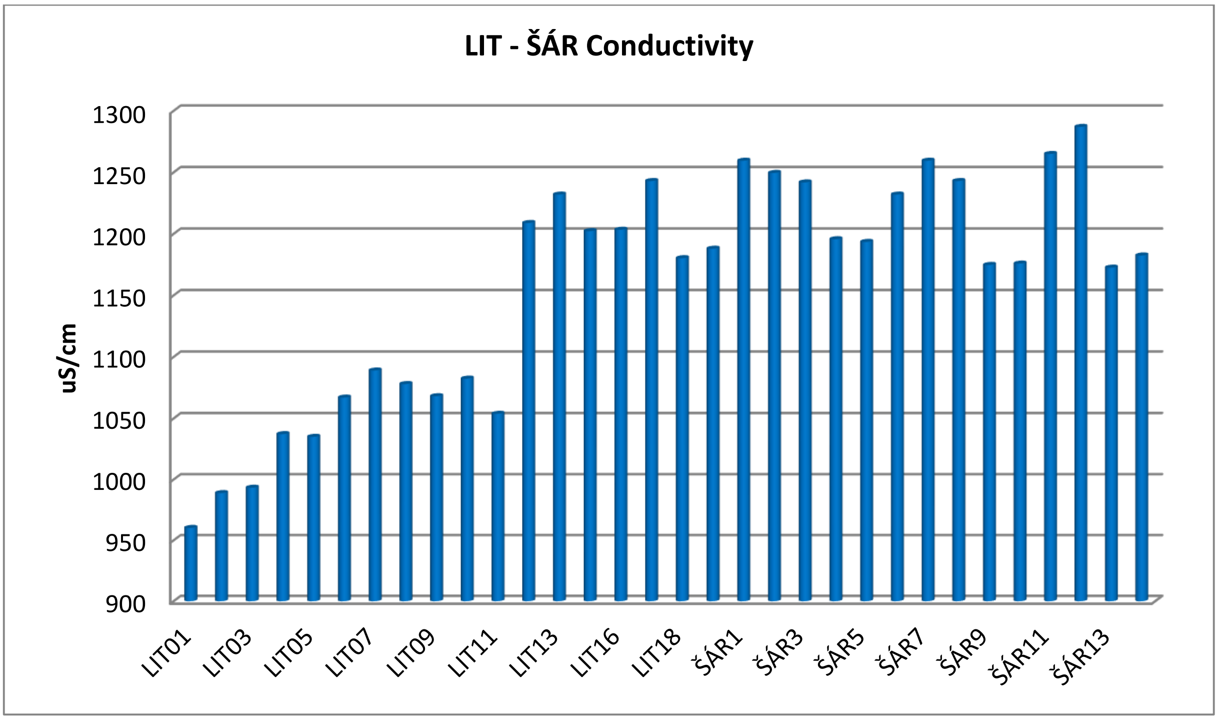

Fig. 20: Complex conductivity measurment of Litovicko – Šárecký creek.

The electric conductivity rises from LIT01 (960, 03 uS/cm) to LIT07 1089 (uS/cm), where the electrical current stagnates. From LIT12, when the creek enters the most populated areas, vaules are at steady and range between 1172 uS/cm (ŠÁR13) and 1287 uS/cm (ŠÁR 12). Allthough the first 33 % of the creek belong to qualitative class III. – moderately polluted [700 – 1100 uS/cm], other 67 % (LIT13 – ŠÁR14) belong qualitative class IV. [1100 – 1600 uS/cm]

	Dissolved oxygen	**pH**	**Conductivity**
JEN	6,79	7,575	1104,4
ZLI	5,58	7,175	1288,1
NEB	6,62	7,805	942,7
LYS	5,90	6,625	1255

Tab. 10: Hydrochemical parameters at each of tributaries.

Another measurment of hydrochemical properties is shown in table 10. Lowest pH 6,625 was measured in Lysolajský creek and it also shows the second lowest amount of dissolved oxygen in the water – 5, 90 mg/L, that is close below hypoxic level for most of the organisms. Also conductivity showing possible presence of wastewater is very high – 1255 uS/cm. Nebušický creek presents loweest conducitvity of the four tributaries (942, 7 uS/cm) and the least acidic water with pH 7,805. Dissolved oxygen is highest, but still qualitatively not high enough, Nebušický and Jenečský creek (6, 62 mg/L and 6,79 mg/L).

6.2.4. Laboratory measurment of hydrochemical properties

Hydrochemical status										
	Water temperature (°C)	pH (0 - 14)	Conductivity (uS/cm)	Dissolved oxygen (mg/L)	BOD5 (mg/L)	CHODKcr (mg/L)	Undissolved substances (mg/L)	N - NH4 (mg/L)	N - NO3 (mg/L)	P (mg/L)
30.6.2015	20,1	8	890	7,2	8,2	31	32	0,76	3,1	0,31
17.9.2015	19,3	8,15	970	8,3	5,9	27	28	0,81	1,1	0,58
16.12.2015	7,8	7,95	1110	10,9	3,8	23	17	0,27	0,9	0,27
9.3.2016	8,1	7,8	1070	10,2	5,2	29	15	0,38	1,3	0,32

Tab. 11: Results of hydrochemical measurments carried out in a professional laboratory

Water sampled underneath the Džbán´s dam was carried out in a professional laboratory to provide an insight on seasonal changes in water quality. The acidity was realtive stable during the year and it oscillated around pH 8. The temeprature during winter is around 8°C. Conductivity was kept mostly under 1100 uS/cm and therefore belongs to II. qualitative class according to table 7. Higher amount of dissolved oxygen is obtained when the water is colder. It is because at lower temperatures the oxygen diffusion is better (16.12. 2015 – 10,9 mg/L) and for comparison 30.6.2015 – 7,2 mg/L. Highest biological oxygen demand was measured in summer: 8,2 mg/L. This is probably caused by Algae bloom. Lowest BOD in winter (3,8 mg/L). This may cause decreasing acitivity of microbes with decresaing temperature. Relative high amounts of N – NH4 and phosphorus in 30.6. 2015 (0,81 mg/L N – NH4 and 0, 58 mg/L P. There might have been fertilizers runoff into the recipient in summer.

Parameters	Inflow	Outflow
pH	7,6 – 8,5	7,5 – 7,8
uS	996 – 2653	996 – 1003
BSK5	510 – 1140	3,4 – 5,3
CHSK	1330 – 1760	34 - 38
NL	456 – 624	7 - 9
N – NH4	12,6 – 39,9	1,4 – 1,8
N – NO3	0,4 – 4,4	-
Pc	13 – 17	0,2 – 5,1

Tab.12: Wasterwater treatment plant of Hostivice - inflow and outflow: hydrochemical values (Generel, 2008).

Cleaning abilities of wastewater treatment plant of Hostivice (Tab. 9) The wastewater treatment plant empties the treated water into Litovický creek. For comaprison, basic hydrochemical measurment was made by author,to compare at least 3 parameters using WTW multimeter 350i. Measurment was performed directly at the treated wastewater outlet into the recipient. Results are shown in Table 10.

Parameters	Results
Conductivity	980 uS/cm
Dissolved oxygen	7, 36 mg/L
pH	7,5

Tab. 10: Hydrochemical properties of treated wastewater from WWTP Hostivice.

Measured conductivity corresponds with WWTP outflow parameters (980 vs 996 – 1003 uS/cm). pH lies at the bottom range, given by the tab.9 (pH 9,5). Table 9. doesn´t provide a measurment of dissolved oxygen. Therefore it won´t be compared.

6.4. Ecohydromorphological evaluation

The ecohydromorphological evaluation of Litovecko – Šárecký creek´s basin was performed in order to obtain detailed assessment of anthropogenic influence. Qualitative scale (I. to V.) was used to describe the degree of human influence. Results are arithmetic means calculated out of 31 parameters. Deatailed data is provided in attachment.

6.4.1. Reference reaches

Fig. 20: LIT02 – Reference state for upper part of the stream.

EcoRivHab methodology requires a reference reach, which has natural or near – natural conditions. Stream reach with overall best ecohydrological scoring is chosen for this purpose. I choose my reference reaches after first field trip taken in June 2015.

For the upper part of the stream i choose reach LIT02 that represents a location with overall best ranking in upper basin of 1,2. Detailed ecohydrological status of LIT02 is provide in table 11. It is located 1 km west of Chýně municipality. It flows through a dense forest consisting of *Fagus Sylvatica* and few solitary *Carpinus Betulus* species. Its streambed and river banks are not in any way altered. Many accumulation units are present in the streambed and its bottom is fully covered by decaying leafes. Flow dynamics changes between mild and stagnant water that creates large pools. Both left and right sides of the stream are lined with natural forest.

Fig. 21: ZLI03 – Reference state for middle part of the stream.

Part of Zličínský creek was chosen as reference reach . ZLI03 has similar natural conditions as LIT02 and is mainly located in wetland conditions. Allthough it is situated on a stream that is otherwise qualitatively moderately infulenced in both directions (III.ES), ZLI03 gained total ecohydrological ranking of 1,022. Its streambed provides great degree of width variability. Streambed has irregular shape with no alterations. Waterflow is fast and gradually changes into slow flowing water passing through wetland, decaying wood and leafes. River bank is firm and shows no erosion.

Fig. 22: ŠÁR04 – Reference state for low part of the stream.

For the lower part i chose a refernce reach ŠÁR04 from Šárecký creek. This stretch represents a reference state for the lower part of the basin. Its streambed and river banks are unaltered. Minor riverbank fortifications are present under a wooden and older concrete bridge. But that is a technical measure, that affects only few meters of total lenght. The flow is diversified with lots of pools and riffles. There are many oxbows along the way. There is medium amount of wooden debree and couple of uprooted treas that provide aditional biological diversity to the habitat. As for the flora, there is *Robinia Pseudoacacia*. It is not native, but introduced and therefore the municipality is currently trying to replace this species with *Quercus Robur*, *Carpinus Betulus* and *Tilia Cordata*.

Location	Stream unit	Length (m)	Streambed	AVP	Floodplain	Total
UP	**LIT02**	237	I	I	I	I
MID	**ZLI03**	598	I	I	I	I
LOW	**ŠÁR04**	1472	I	I	I	I

Tab. 11: Reference stream units - ranking

6.4.2. Ecohydromorphological evaluation of Jenečský creek

The Jenečský creek springs nearby to a franciscan monastery Hájek, close to a district road leading to Jeneč. The spring is almost impossible to find because the water has soaked into the soil in 2/3 of its length. JEN01 measures 1660 meters and is also the longest reach of the Jenečský creek. The streambed is artificially straightened and currently serves as border between two fields. It is artificially deepened. There are no alterations to river bank or streambed. River belts aren´t present and the creek is surrounded by an arable land, currently seeded with *Medicago sativa*. Floodplain consists of field. 300 meters to every direction. This section ends before a disctrict road. The pass through the road is covered with iron bars and there is a 50 cm drop on the other. ES ranking is III. JEN02 continues into the village of Jeneč inside an eroded profile, that is shaded by both sides by approximately 30 years old *Carpinus betulus* species. At the time of the study, there was little water in the profile. Due to urban conditions, floodplain can´t fully develop. This section is strongly infuenced (ES IV.). After 200 meters JEN02 enters urban area with houses and gardens and erosion banks covered by inroduced *Festuca rubra*. Streambed is narrowed and straightened. JEN02 flows freely into a 250 mm pipe into underground. Following reach JEN03 is placed into a counduit for 777 meters and therefore its rating will be V – heavily anthropogenically influenced. JEN04 emerges underneath a industrial center in the south – east of Jeneč with length of 1141 meters. In the time of first field assessment, it was surrounded by an unused area with set of trees slightly shading the stream. River banks were unfortified. When JEN04 flew under a roadbridge, its riverbanks were fortified. Currently, here is a garden park with housing in construction and the area is no longer safely approchable. Rating: II.

JEN05 continues with medium deep riverbed, shifting from 30 – 60 cm of depth. It enters an urban area with large gardens, where the creek runs relatively freely. With longtitude, the creek becomes deeper in the terrain and more twisted. River banks are slightly eroded and covered with potentialy native grasses. Couple of wastewater outlets are pointed into the riverbed and bad odour would confirm an active outlet of wastewater. There are no river belts in the area as they were replaced with seeded grasses for garden purpose. In floodplain´s way, there are several houses and therefore it is rated with V. Overall ranking: III. JEN06 continues with relatively short lenght (223 m). Its riverbanks are covered with grasses of *Carex* species. Profile is relatively stable, with few signs of erosion. Variability of profile´s width is relatively low and profile is probably artificially deepend. It is over 1 meter deep in some areas. Retentional potential is relatively low. Flood wave in JEN06 would only accelerate. ES = II. Part JEN07 is an artificial watercourse with a length of 417 meters. It was bypassed from a set of two fishing ponds on the left side and then diverted into gardens of local housing area. River banks are fortified with large stones, unoriginal in the area. Riverbed lacks any accumulation or erosion units and there is also no existence of microhabitat. Riverbed is paved with cobblestones and covered with thin layer of silt. Inundation area is fractured by houses. Overal ranking of this section is IV. JEN 08 is the last stretch of the stream that is above the ground. It flows along a paved road. Riverbanks are ocasionally reinforced with a quarry stone. There are also quarry stones in streambed to provide more divirsified flow. Inundation areas are still in an urban area. Ranking for this part is III. Subsequent JEN09 is put into conduit till a confluence with Litovecký creek. Therefore it is rated as strongly anthropogenically influenced – V.

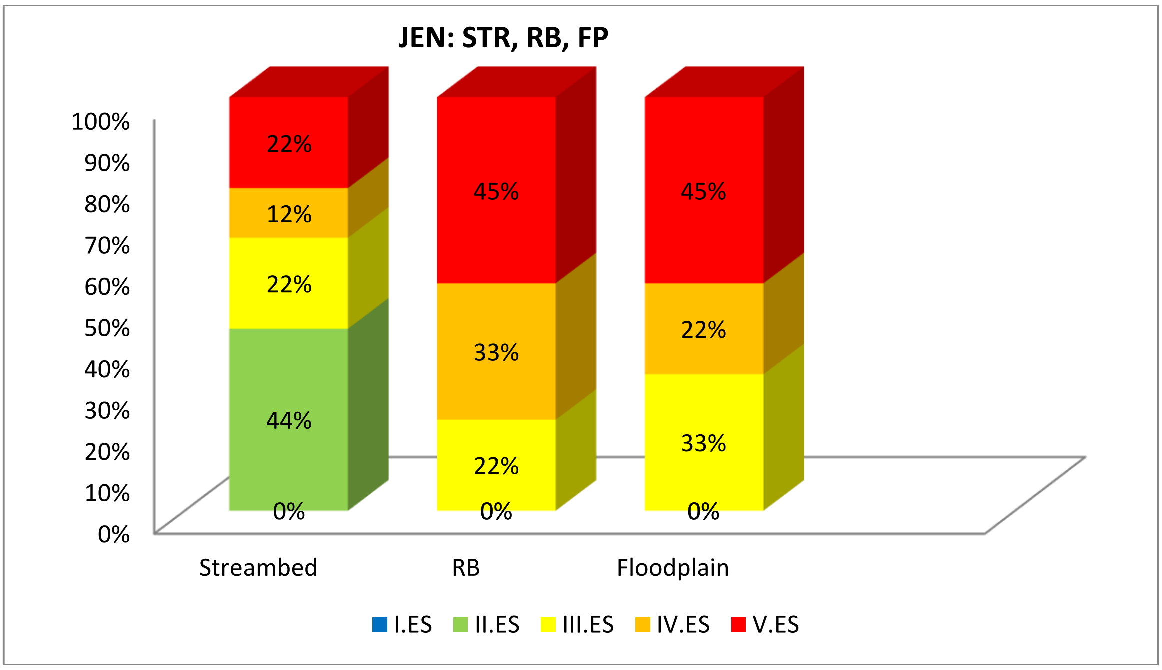

Fig. 23: Ecomorphological state of Jenečský creek – Streambed, Riparian belt, Floodplain

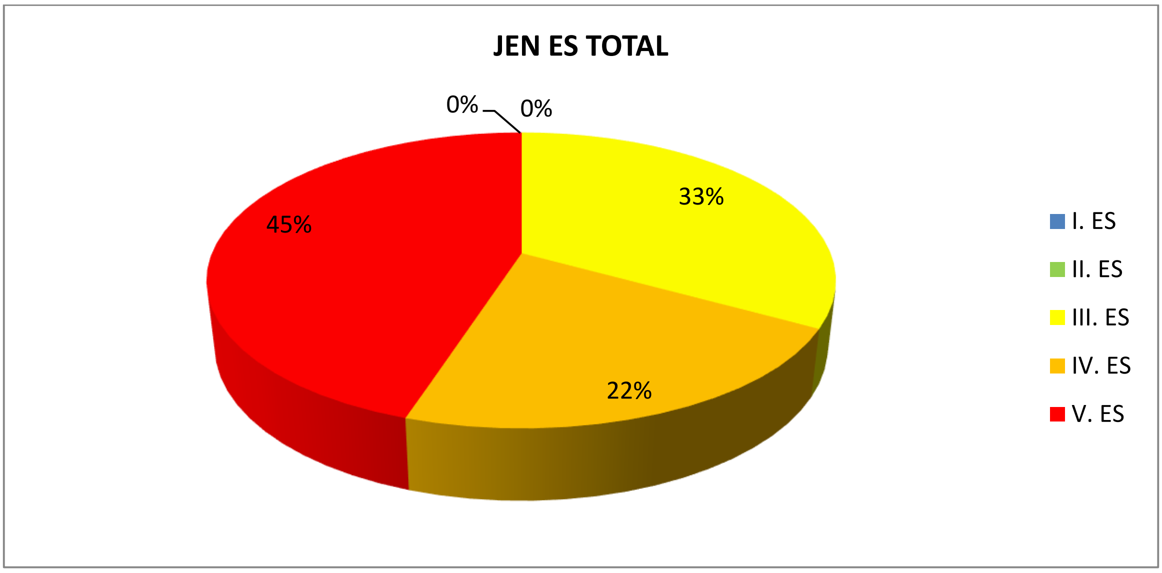

Fig. 24: Ecomorphological state of Jenečský creek – total

6.4.3. Ecomorphological evaluation of Zličínský creek

Zličínský creek springs south of Strnad pond and is 1,5 km long. It is negatively affected by an outlet of wastewater from local wastewater treatment plant Kilo s.r.o. company. Control measurements were done at the wastewater treatment plant´s outlet with results showing high amount of pollution. Sensoric evaluation was rated with very bad odour. Dissolved oxygen: 5,6mg/L, pH: 7,1 Conductivity: 1288 uS/cm ZLI01 flows below a main road into a 800 mm concrete ring, then drops from a 50 cm step. (Pic.7) Stream flows in concrete bowl – shaped streambed that allows only minor connection to groundwater. Left inundation zone consists of field. ES: III. ZLI02 is similar. River banks are covered with vegetational concrete blocks. As well as the bottom. rated as ES: III, (ZLI01: ES 2,8 , ZLI02: ES2,7). ZLI03 is described in chapter 6.4.1. ZLI04 continues in deep riverbed, sheltred by dense shruds. It empties into a fishpond. Riverbank is covered with natural grasses. Both bottom and banks are fortified with vegetational concrete blocks. Streambed is regualar with low variability. ES: III. ZLI05 is 168 meters long and flows between fishpond above ,,Peterkův,, mill and Strnad pond. It partially flows in conduit with concrete cover. Therefore there is no riverbank vegetation.

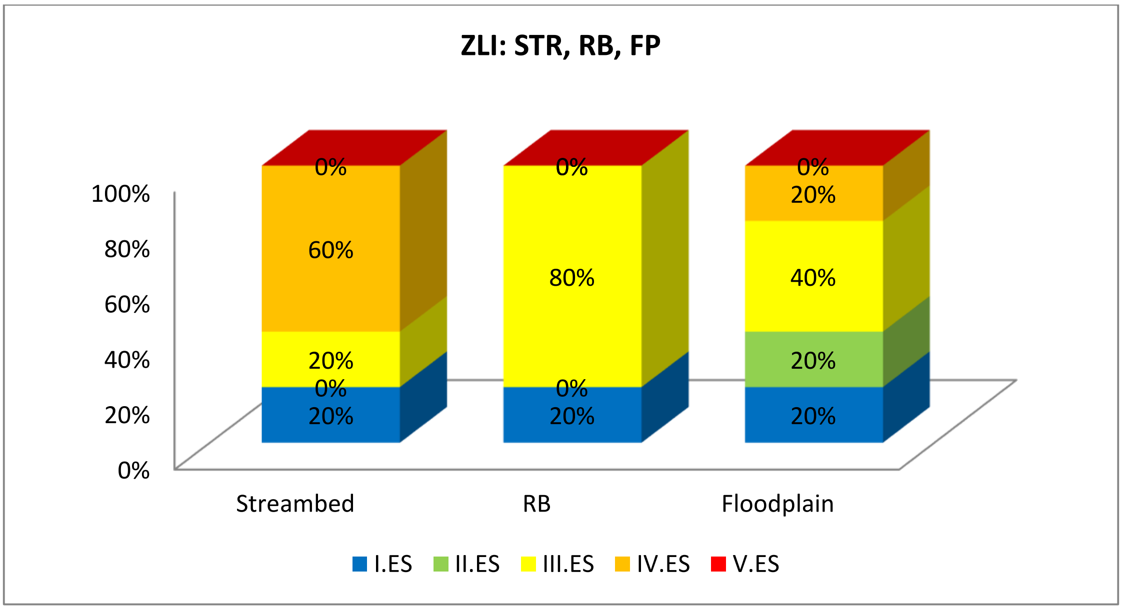

Fig. 25: Ecomorphological state of Zličínský creek – Streambed, Riparian belt, Floodplain

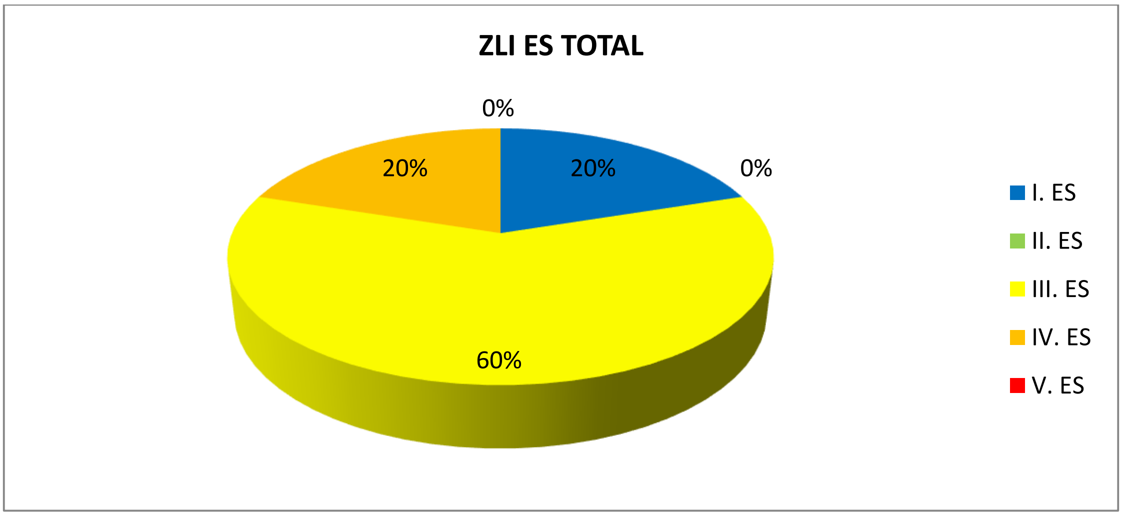

Fig. 26: Ecomorphological state of Zličínský creek - total

6.4.4. Ecohydromorphological evaluation of Nebušický creek

Nebušický creek is approximately 3,5 km long. Its basin area is home to *Anguis Fragilis, Lacerta Agilis* and common *Urtica Dioica.* NEB01 springs in western part of the village and ends in Nebušický pond. Along NEB02 , there is some embakment NEB1 spring is in direct contact with horse breeding on the parcel. NEB02 is partially lead in conduit. NEB03 has a substantially low profile. Highly erodive river banks are unstable and for this reason are fortified in critical spots with freely layed down massive concrete blocks (Pic.7). Otherwise the flow is variable with medium presence of acumuluation units. Strambed has silty layer on the bottom and medium variability of riffles and pools. NEB 01&02 have ecohydrological quality III: moderately infuelnced. and NEB03 II.: low influence. NEB4 is in lined with forest on the left side and with a meadow on the right side. There are herds of sheeps grazing grasses along the creek. There is nicely developed inundation area. No alterations to streambed or riverbanks. ES: I. Natural, or close to natural status. Along NEB05 there is no problem to spot *Bufo Bufo.* This part looks in a good condition. Provides a good variability of flow and enough accumulation units. After leaving the dam of Záveský pond, it continues in a wide developed valley. On the left side extends a natrual forest and on the right side a meadow. This unit measures 837 meters and gained ranking ES: II. For the most part of its track, NEB06 is an artificial watercourse. It is lined with concrete walls and streambed. Streambed is shaped as a rectangle. 180 out 240 meters it flowalong nearby buildings. River banks are poorly covered with vegetation and grassed. Last reach of the creek before confluence with Šárecký creek is in overall good condition. NEB07 provides variable width of profile. It is shallow and river banks are lined with grown trees. Floodplain is relatively wide, but the incline is too steep to hold the water for a lonhtime. ES: II.

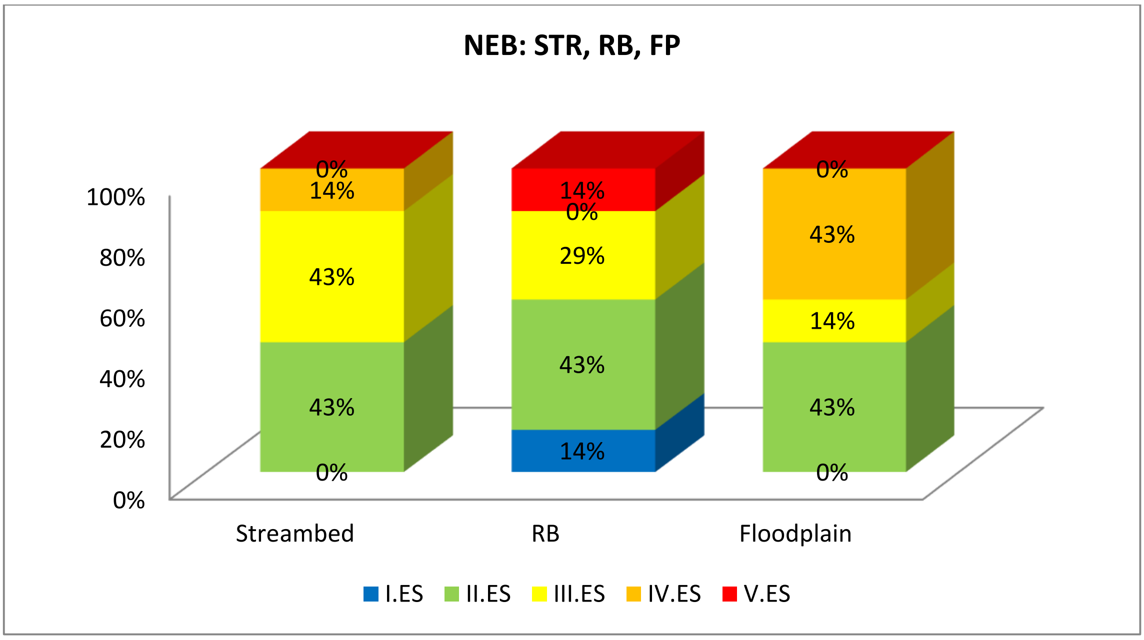

Fig .27: Ecomorphological state of Nebušický creek – Streambed, Riparian belt, Floodplain

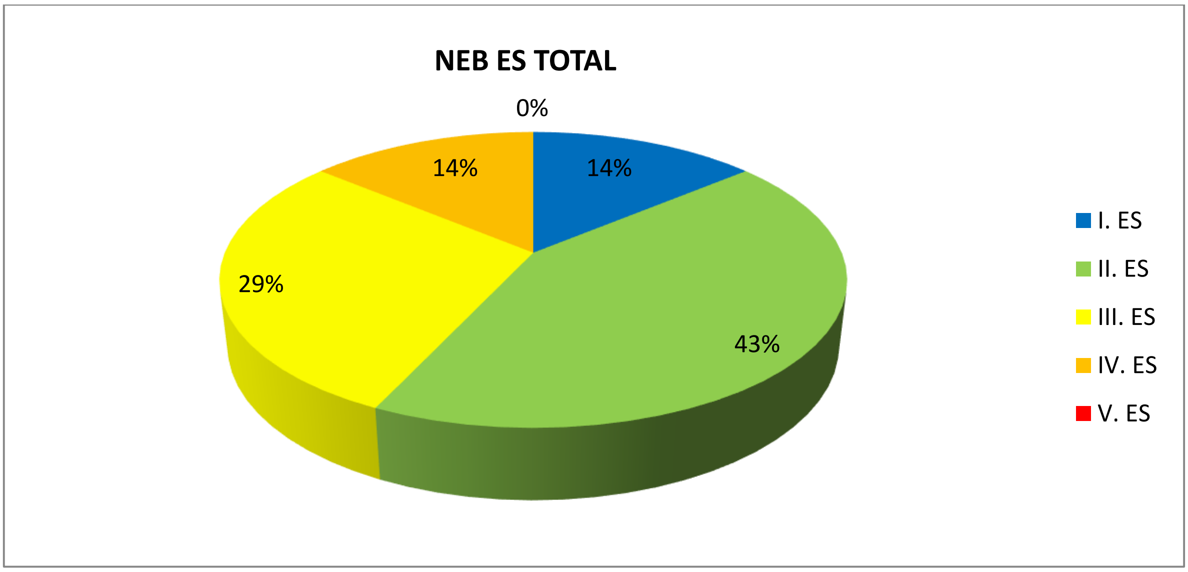

Fig. 28: Ecomorphological state of Nebušický creek: total

6.4.5. Ecohydromorphological evaluation of Lysolajský creek

Lysolajský creek rises in 269 meters above sea level and empties in Šárecký creek in 190 m, after 1,9 kilometers of travel down the hill. It rises from so called Miraculous spring, that has a capacity of 5,5 l/s. First section LYS01 is artifficially influenced (ES: IV). First artificial step is located after 50 meters. After another 50 meters, the creek is blocked by a small water gate. River banks are fortified with an old cover, what might had been solid concrete. Now eroded by grass and moss. Streambed is impermeable and has 1 cm thick layer of silt. Then it flows into a counduit for about 25 meters and ending in what seems to be a retention basin for firefighter´s needs. LYS02 has a artificialy narrowed streambed of a regular shape. It is located in a deep valley. Only single querry stones are put into the streambed. Riverbanks are partially complete and consist of scattered trees on both sides. Flood plain is non existent and the shape of the valley is only going to accelerate incoming stormwater down the flow. LYS2 ends after a >1m drop in a concrete retention basin with iron bars at the outlet. ES: III. LYS03 is lead underground in more than 70% of its length. LYS04 rises from the underground right below a local mill. Then it enters a deep v – shaped valley covered with lot of wood residues, leafes and other organic matter. Right riparian belt consists of a moderately dense young forest, left riparian belt is lined with road and houses. Riverbank is narrowed in less than 10 % and its streambed is only fortified with sandstones. Same rocks are used to fortify its right bank. There are however no erosive patterns. ES: II. LYS05 is the last reach of Lysolajský creek and it is strongly influenced. It is an artificial flow. No vegetation, riparian belt, floodplain. It flows in rectangural shaped streambed. Some of the bridges that overpass the creek have silt deposits and are clodged by plastics and mud. They may have lower capacity to lead water, when flow rate would be higher (Q5).

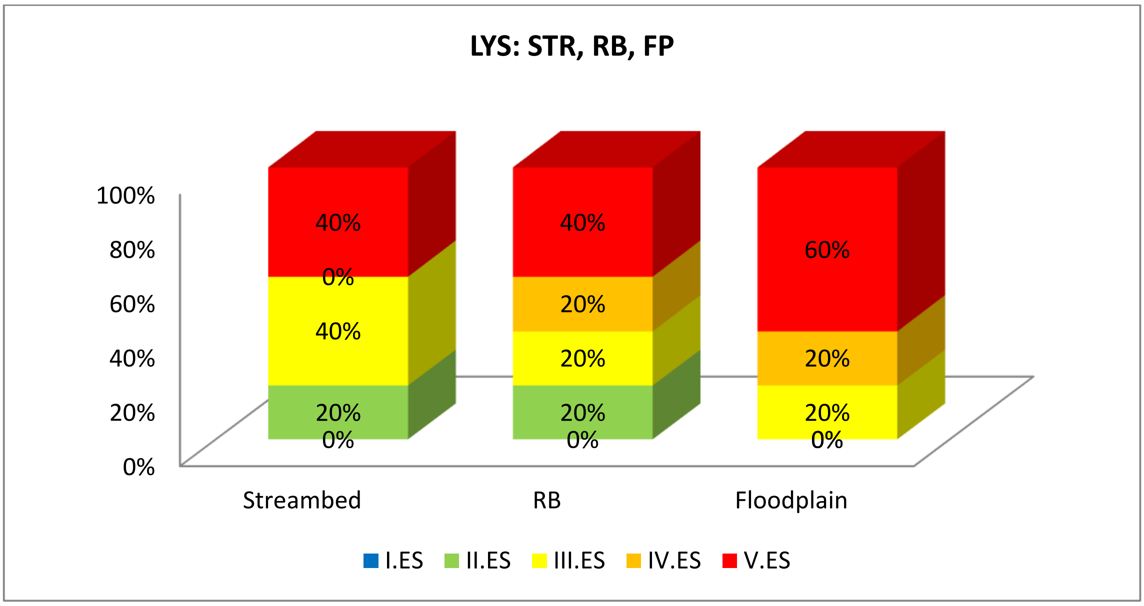

Fig. 29: Ecomorphological state of Lysolajský creek – Streambed, Riparian belt, Floodplain.

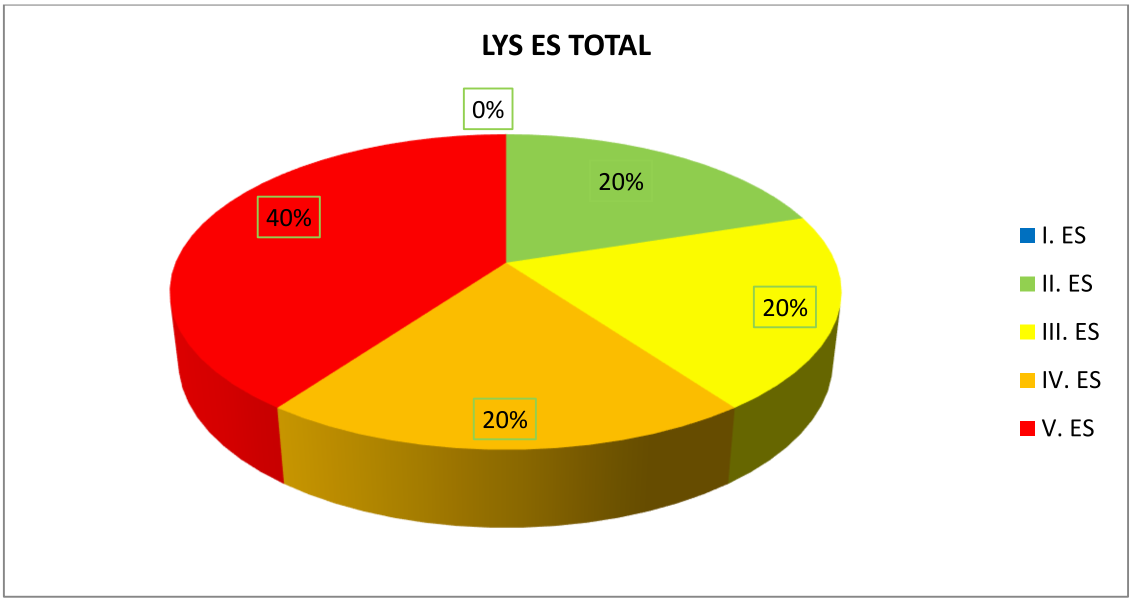

Fig. 30: Ecomorphological state of Lysolajský creek – total

6.4.6. Ecomorphological evaluation of Litovicko – Šárecký creek

Litovicko – Šárecký creek is the longest of all monitored streams in this paper. It measures 23 km. Its basin has an are of 63 km^2 . Its source is located in field 1,2 km west from city of Chýně. The source itself is diffuclt to find and preparatory methods must be used before taking a field trip. LIT01 ends in forest The first reach is clearly separated from surrounding fields. It isn´t in any way reinforced. It is probably straightenend from previous years as it flows straight.It doesn´t seem like a natural state. It is ranked as moderately affected. LIT02 flows into forest, where it has a better natural conditions. It was described in chapter 6.4.1. LIT03 is a streatch of the stream from railway to Bašta Pond. It is obvious that it´s flow pattern is artificial and outflow characteristic had been changed. It has moderately deep profile with low width variability. Flow pattern is consistent. There is a forest surrounding the stream. Meadows on the left side would be used as flodplain. This part is ranked as mildly affected (ES: II). Pond bašta is the first to be excluded from evaluation. According to Matoušková (2008), stagnant waters are excluded from EcoRivHab methodology. LIT04 binds Bašta pond and Strahovský pond. This 592 meters long area is characteristic by being the first to have reinforced banks. It starts with outflow of Bašta pond, followed by a rock slide and <20 cm drop. It contains a lot of wood blockage on the way and the stream is shaded thanks to dense vegetational cover (ES III.). LIT 05 is hidden in overgrowth of *Phragmites.* It forms a wetland with wetland vegetation. Water flow is steady. There are no alterations. It has rather straight shape. (ES II.). LIT06 is rated as category ES I. It has a very well developed floodplain, river banks are not eroded. Soil is rather mushy and it fulfills wetland criteria. LIT07 is copying right bank of Litovický pond. Streambed contains sufficient amount of detritus, leafes etc. Color of the water became yellowish. It could be a result of an intensive decay process in the stagnant water of LIT07. Ranking: ES II. With LIT08, the ecomorphological status is worsened. It begins with rough rock slide to a lower level, where the profile is 1 meter below landscape. Both banks are covered with concrete but few grown trees have disrupted the concrete coverage. Left riparian belt has 7 – 10 meteres and is lined with houses all along the route. Profile is artificial, bowl shaped. The concrete further prevents from rooting of trees in vicinity of riverbank. ES: III). An interesting stretch presents LIT09. This reach of 588 meters had been revitalized during years 2013 – 2015 and now contains several oxbows, riffles and pools and its profile width variablity had been improved. The banks are only grassed, which is qualitatively a bad parameter (App. 9) (ES II). LIT10 was revitalized 12 months later, and during the field assessment, river banks were grassed, unstable and without vegetation. Riparian belts were in form of soil without cover. Nevertheless, channel morphology was in a good shape (ESIII). : LIT 11 is a connection between two retention basins - Strnad and Jíviny. It has slow runoff in the mid section. It flows directly underneath two motorway bridges and its surroundings is highly antrhopogenically influenced. Mostly by asphalt road, parking lot, garbage and pavements. LIT12 contains clearly visible outlets of wastewater. It has a twisty route and its banks are strenghtened with old trees. Banks are slightly eroded at the bottom parts. Riparian area is mostly unused by nature or humans and lies as it is with presence of solitary trees and bushes. Another revitalized area is LIT13, that is only 134 meters long. it ends by bar cells under Ruzyně prison compound. This section has fortified banks with large stones. More stones are randomly put into the streambed and create more diverse flux. As a part of bank vegetation, there are *Carex* species and *Festuca rubra.* 771 meteres long section is put underground. This section is rated as ES V. Reaches 15 – 17 are all rated as moderately influenced. They have different quality of river belts and inundation areas, but they are similar in profile shape and river bank´s modifications. They all have moderate river flux with large stones lining the banks. LIT17, as the only one, has a streambed coverage by cobblestones with poor silt substrate layer. All of those reaches are in third category (ES III). LIT18 proceeds through the middle of gardens. Therefore, it is altered in profile, runoff and vegetation cover. There are only solitary trees along its banks. banks are fully covered by concrete or by supportive concrete blocks. Streambed is covered by cobblestones or concrete. Profile changes its shape from rectangular, to bowl shaped and into V shaped. (ES IV). LIT19 starts with fully concreted lagoon, that is currently emptied and waits for a reconstruction. At the end of the lagoon, there are manually operated water gates. Then the stream continues into a park, where the profile is poor on variability. Banks are fortified and river belt is only on the left side.

ŠÁR01 starts as shallow and wide current. Rocks are put freely in the streambed and at the bottom parts of riverbanks. Šárecký creek becomes to rage and to torrent. It drops around 15 meters. There are plenty of riffles and pools and the flux is more then complex. All of this spectacles takes place in a narrow pass. With ŠÁR01 there also starts a territory of protected area of Šárka´s valley (ES II). ŠÁR02 represents natural conditons (App.8) of the stream, it has a ranking 1,257, however ŠÁR04 which is a reference reach has a ranking of 1,02. The difference is worse ranking in riparian belts for ŠÁR02. ŠÁR03 below iron bars. The creek slides onto slippery rocks and flows through an erosive profile. Left river bank is grassed, as wel as right bank. (ES II). ŠÁR04 is described in chapter 6.4.1. ŠÁR05 is characterized by erodive river banks, that are unstable. Besides that, there are near to natural conditions and it is marked with ES I. ŠÁR06 is rated with ES I, overall good ecohydrological quality. Its streambed is various in width, there are riffles and pools in more than 75% of the length. River banks are slightly eroded. ŠÁR07 is a short part (266 m), ES II. of meandring stream. It is obvious, that there had been made a revitalization in recent past. Less than 10 % of both banks have a quarry stone present for a supportive function in the most stressed areas. Profile is about 40 to 60 centimeters deep. Banks are steep and support large roots of *Carpinus betulus.* Left side of floodplain is limited by a steep slope and finally by a fence. Right side has well developed inundation area. (ES II). ŠÁR08 flows through a mill in a deep artificial profile. River banks are concrete, streambed as well. There are several high steps (>100 cm), close to the Nebušický tributary (ES III). ŠÁR09 (ES IV) is 272 meters long reach, that flows through gardens of villas. It is artificially narrowed in most of its length. Banks are grassed. Floodplain is non – existent and there is a high risk of material damage by Q5. ŠÁR 10 - 12 are all rated as low influence (ES II). ŠÁR10 and ŠÁR12 are recently revitalized. They had been given meandring shape and wetland vegetation. ŠÁR 11 flows straight. All of them have silty bottom layer and no significant erosion of river banks. ŠÁR11 is lined with growing trees, in turns, on right and left bank. ŠÁR10 and ŠÁR12 have banks grown by seeded grasses. Inundation area is more developed with ŠÁR10 and ŠÁR12. ŠÁR11 is often in proximity of roads and fences. ŠÁR13 (ES III) flows along a highlighted road. That means, that its left bank is 2 meters high and made of stone. Right bank and riparian belt consist of meadow, partially overbuilt. ŠÁR14 empties into the Vltava. it has an ecohydrological status

IV, highly affected. At the confluence, where last of the hydrochemical properties measurment was done, the water became smelly and blur.

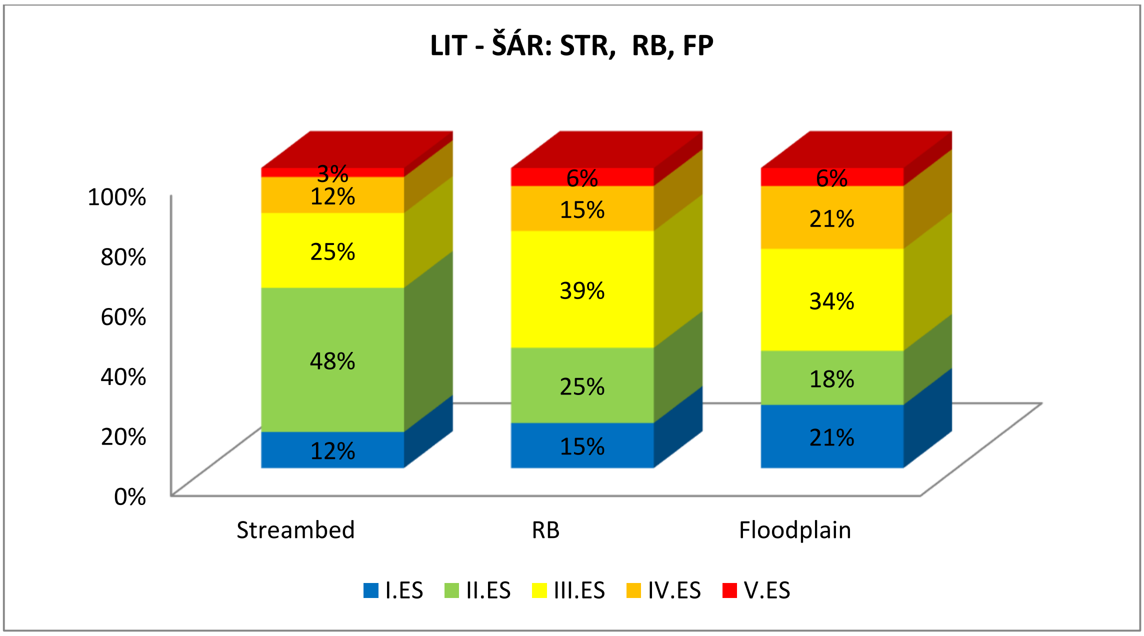

Fig. 31: Ecoomorphological state of Litovicko – Šárecký creek – Streambed, Riparian belt, Floodplain.

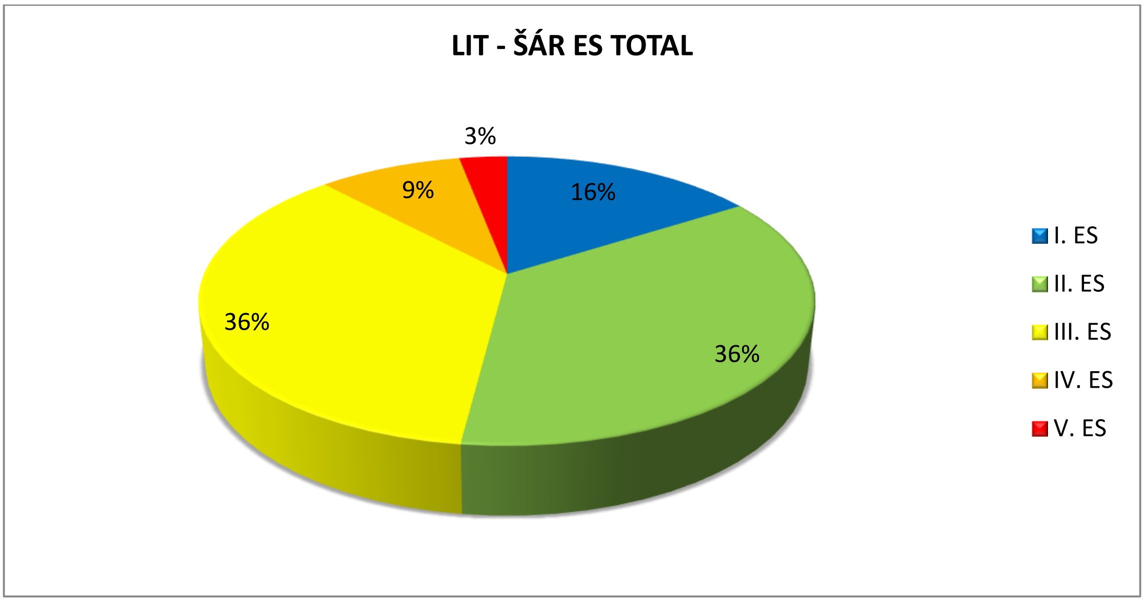

Fig. 32: Ecomorphological state of Litovicko – Šárecký creek - total.

6.4.7. Ecomorphological evaluation for the river´s basin

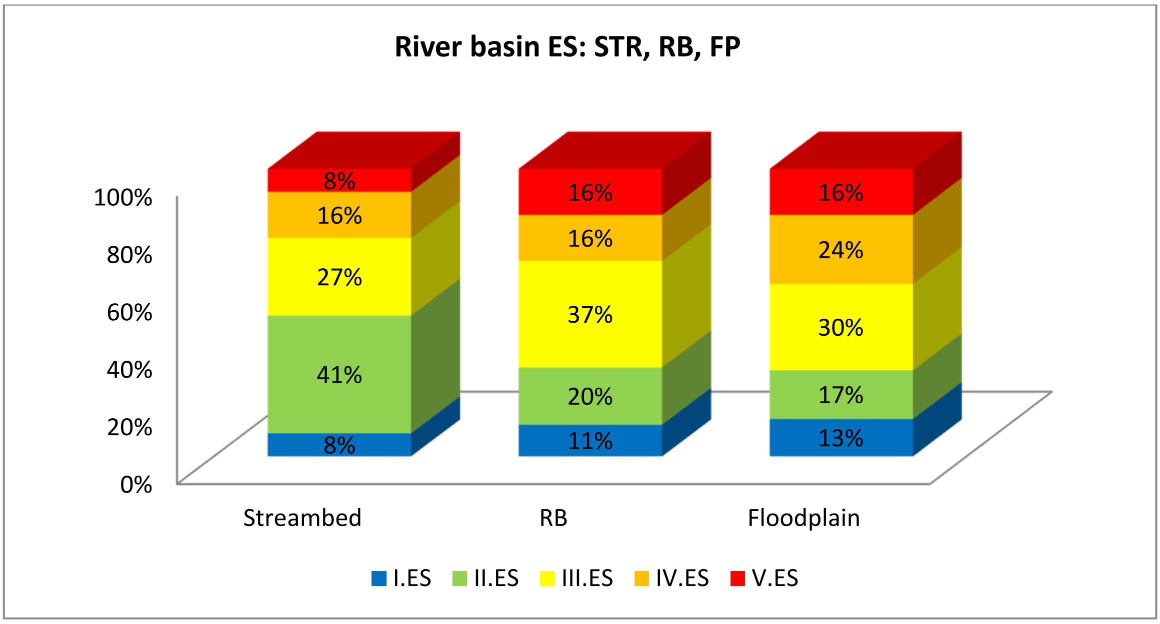

Fig. 33: Ecomorphological state of river´s basin – Streambed, Riparian belt, Floodplain.

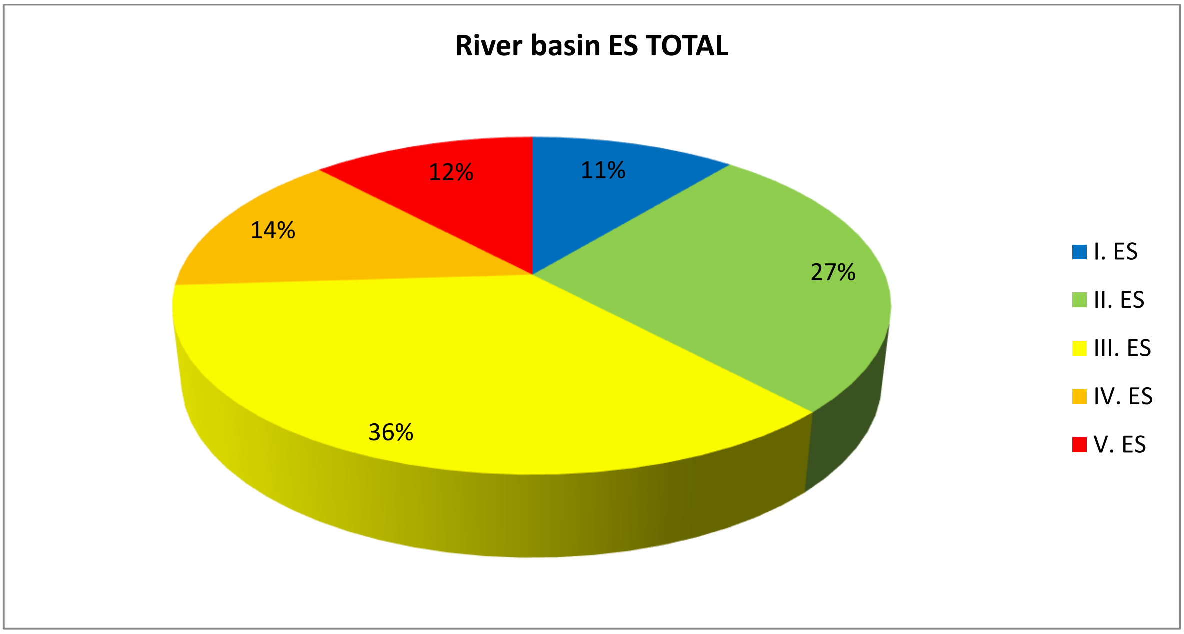

Fig. 34: Ecomorphological status of river´s basin – total.

6.5. Revitalization proposal

The EcoRivHab methodogy encourages, after ecohydrological evaluation, to propose and carry out revitalization measures in highly anthropogenically influenced areas.

Stream	Unit no.	Measure
Zličínský	ZLI01	Removal of flow obstacles
Zličínský	ZLI02	Concrete streambed removal, increase profile variability
Zličínský	ZLI05	Concrete streambed removal, restoration of riparian belts to natural state
Jenečský	JEN06	Concrete streambed removal, increase in streambed capacity
Litovický	LIT08	Removal of bank fortification Restoration of vegetation in riparial belts
Litovický	LIT18	Increase in bank diversity Removal of flow obstacles
Jenečský	JEN06	Support shallower profile , retard its runoff

Tab.11: Revitalization proposal

7 Discussion

7.2.1. Hydrological status of Litovicko – Šárecký creek.

The stream is moderately anthropogenically influenced. 48% of the streams evaluation is III. to V. class. More affected is the floodplain with 70% of negative influence in the basin and followed by riparian belts that have got relaitevely good status in a comparision . It is inegatively influenced by 51%. The bad ranking of flooplains is caused dense urban areas, in which basin is located. Most of bad evaluations on flooplain is in the middle part of Litovický creek and low part of the low of Šárecký creek. Mostly the creek was aligned with houses, streets or pavements, therefore the floodplain could not develop properly. The evaluation on hydrochemical properties was

The streambed is relatively low influenced, 49% are ecohydrologicaly favorable. Streambed was rarely fully covered with concrete or cobblestones. Which show only 8 % of V. grade. that implies presenece of concrete surfaces in streambed. The riparian belts are of similar status as floodplain. They are negatively influenced by 69 %, only 1 % less than floodplain. Part on lower quality of Litovicko – Šárecký creek has LIT014. The 771 meters long reach that was rated V in all kategories, because it was in conduit.

7.1.2 Hydrological status of Jenečský creek

The total hydrological state of Jenečcský creek is very strongly anthropogenically affected. It ´s state is 100% affected in III .to V. class. Riparian belts and flood plain are of similar quality. But still bad. Streambed is in better qualitative status. It has low influence in 44 % of length. The overall bad status of Jenečský creek are because of the two stretches that lead in a conduit JEN03 and JEN09. One 777 meters flowing under Jeneč and second at the confluence with Litovický creek. Overall Jenečský creek flows in densely populated areas.

7.1.2. Hydrological status of Zličínský creek

Zličínský creek has 60% status of III. moderately influenced. But in is not surprising as it contains only from 5 stretches. Relatively best stastus has floodplain. As the creek is far away from civilization for 80% of its flow. ZLI01 is area that has thanks to nearby wastewater treatment bad odour. Moderately anthropogenically influenced and worse than floodplain and riparian belts. Zličinský creek does have a fortified streambed in more than 60 % of its total length. Only exception is ZLI03 that is of natural ecohydrological conditions.

7.1.3. Hydrological status of Nebušický creek

Nebušický creek has a very good status in comaprison with other streams and is low influenced. Best status have riparian belts, that has 57% in ecohydrologically favorable status. Inundation zone and floodplain are both of 43 % of good status. NEB02 has shallow profile to have a flow in between houses. It would deserve more protection of the banks. Streambed and floodplain dont contain V. ES – very strong anthropogical influence as the Nebušický creek never flows in densely populated areas.

7.1.4. Hydrological status of Lysolajský creek

Lysolajský creek flows in valles with land cover of 75 % of urban designated areas and 25 % of forests. It is very strongly antrhopogenically influenced. It´s total ecohydrological state is 80 % between III. to V. category. It is situated in steepy valley and already LYS1 is of of moderately negative influence.

7.1.5. Hydrological status of basin.

Basin is negatively influenced in 62 % of its lentgth.
However for example in Šárka Valley there isn´t a negatively influenced overall reach. Bad infulence rises mostly from the triubataries, that make the little worse in ranking.

8 Conclusion

Ecohydrological evaluation within Litovicko - Šárecký basin was performed in order to determine its ecomorphological state. Biggest flows of the river basin were selected for this study. Litovicko - Šárecký, Jenečský, Zličínský, Nebušický and Lysolajský. As auxiliary study, to more accurately determine the quality of flow, hydrochemical analysis of basic indicators of water quality was conducted throughout the length of the watercourse. For even more accurate results, more samples were sent to undertake professional laboratory testing. Ecohydrological measurements were complemented by mapping of land cover for a better understanding of land use near streams. On the basis of these informations, revitalization measarues were proposed. In terms of ecomorphological rating using EcoRivHab methodolgy it is possible to tell that Litovicko - Šárecký basin is heavily antrphogenically influenced. Grade III - moderate anthropogenic influence to grade V - very strong anthropogenic influence, affects 62 % of the basin. Only 38 % of the basin can be assessed as ecohydrologicaly favorable, which includes grades I and II, that is natural and low anthropogenic influence. Out of streambed, riparian belt and floodplain. It was the floodplain. ,that is negatively influenced within 70 % of the basin.

It is due to the fact that according to research of land cover, there is up to 50% of flows being directly affected by human settlements. There is therefore no place for alluvial plain to develop . Riverbed was the least affected, with positive rating of 49 % of the flow and 51 % the flow were negative.

As a worst anthropogenically influenced flow can be described Jenečský stream, which is within the III. to IV. Grades negatively affected in the entire length of the flow. It recieved the V. degree even in 45 % of reaches. It is due to the fact that its 2 out of 7 sections flow in conduit and are thus rated as very strongly anthropogenically influenced (V. degree). And also the fact that most of its route is located in populated area.

Hydrochemical analysis was able to detect, for example, decrease of acidity in urban areas. When the pH between sections LIT03 and LIT09 decreased from pH 7.73 to pH 7.25. And between section ŠÁR09 pH7,75 to ŠÁR14 pH7,35 which is related to the discharge of waste water into the creek. This also confirmed by increased values in measurement of electrical conductivity LIT 03 and LIT09 993uS/cm to 1068uS/cm and 1174uS/cm to 1182uS cm/cm.

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FIGURES

Geo mapy 1:50 000. *Geologické a geovědní mapy* [online]. Praha, 2015 [cit. 2016-02-04]. Available on the internet: http://www.geologicke-mapy.cz/geologicke-mapy/mapovani/

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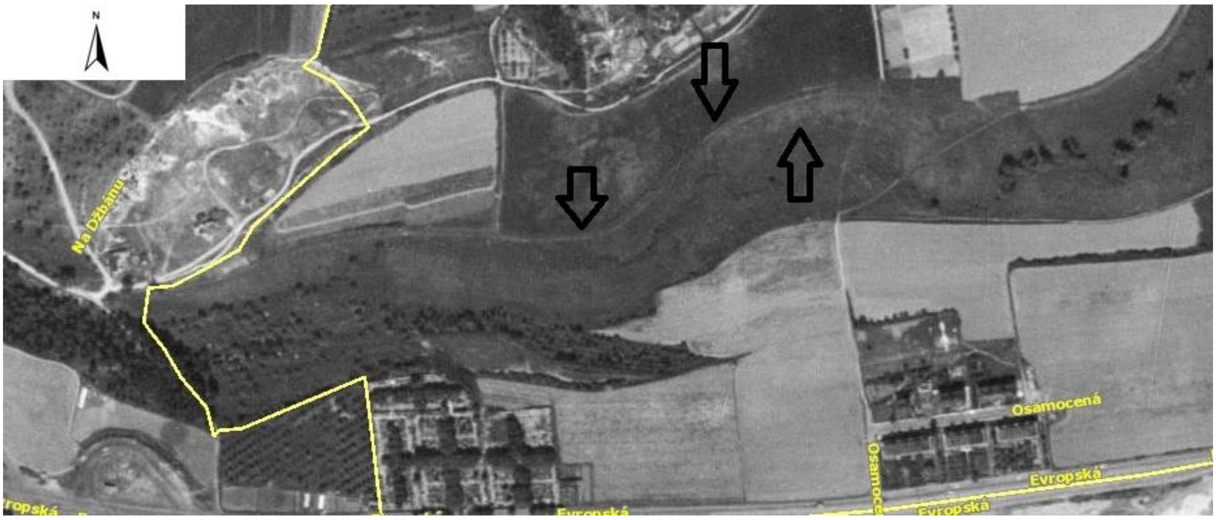
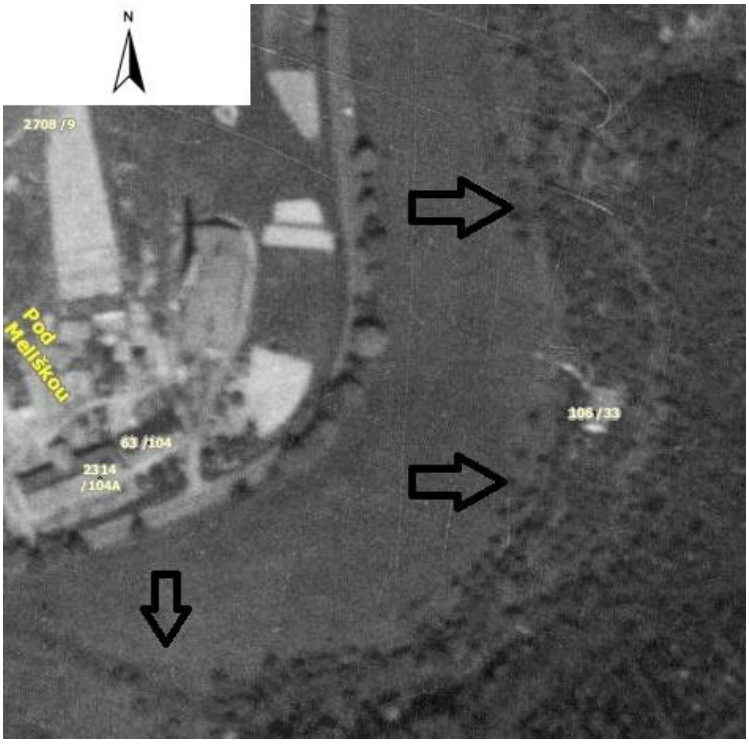
9) Appendixes

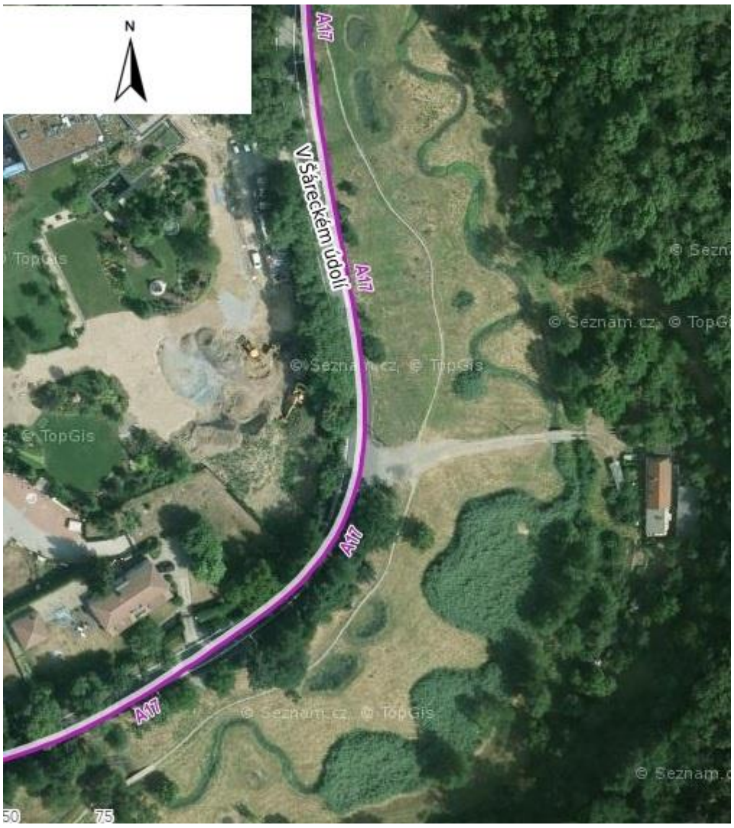


App. 1: Original river flow of Litovicko – Šárecký creek in 1953.

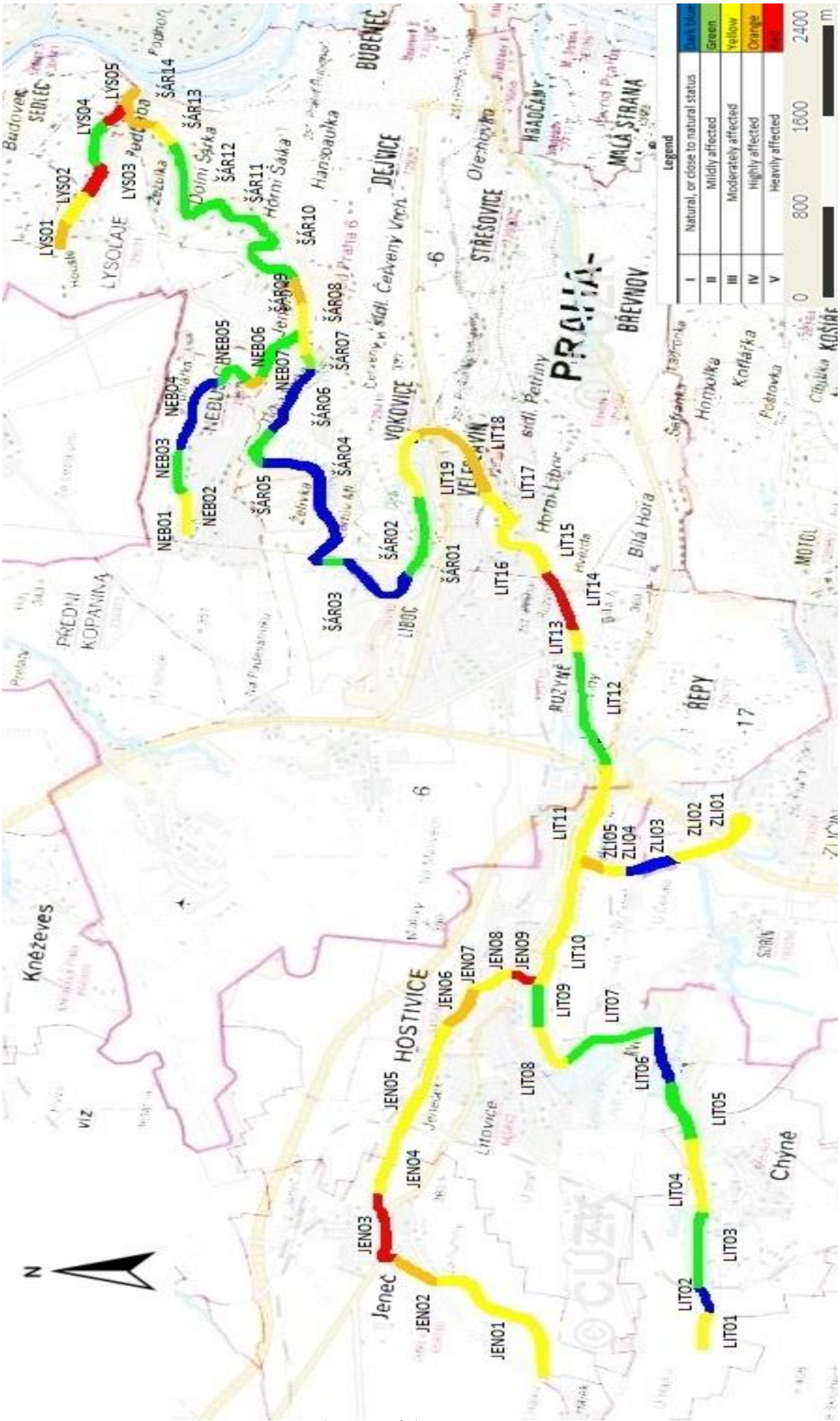
App 2: Current state of retention basin Džbán 2015.



App 3: Original state of Litovicko – Šárecký creek in the location of Kaplanka.



App 4: Current state after revitalization done in 2013 – Kaplanka.



App 5: Ecomorphological state of LIT – SAR basin

Formulář ekomorfologického monitoringu vodních toků

Obecné charakteristiky hodnoceného úseku:

Název vodního toku: ....

Poř. číslo, vymezení úseku ř. km ....

Délka hodnoceného úseku vodního toku: ....(km)

Datum, čas pozorování, mapový list: ....

I) KORYTO VODNÍHO TOKU

1. *Morfologie a průběh trasy koryta*

1.1 typ údolí vodního toku ⇑•

Typ	Označení
soutěska	S
kaňon	K
erozní typu V	V
neckovité	N
úvalovité	U
úvalovité s široce vytvořenou údolní nivou	UN
umělý tok, přeložka	UP

Pozn.: Parametr má pouze dokumentační charakter

1.2 stupeň zakřivení ⇑•

typ	Znač	hodnocení u N, U, ÚN
meandrující	M	plně odpovídá danému úseku vodního toku 1
zakrutový, větvený	ZV	
zakrutový, nevětvený	ZN	mírně pozměněný 3
divočící	D	změněný, neodpovídá danému úseku 5
přímý	P	

1.3 charakter a tvar koryta ⇑•

Přírodní (přírodě blízký)	body	Umělý	body
pravidelný	2	miskový	3
nepravidelný	1	lichoběžníkový	4
		obdélníkový	5
		kruhový - zatrubnění*	5

Pozn. více než 80 % délky úseku, neprovádí se další hodnocení

1.4 zahloubení koryta toku ⊗•

Typ	hodnocení
extrémní	5
značné	4
střední	3
malé	2
žádné	1

Hodnocení se provádí vzhledem k referenčnímu stavu úseku

1.5 přítomnost erozních a akumulačních tvarů ⇑•

stupeň výskytu N, U,UN	hodnocení
vysoký	1
střední	3
žádný	5

2) Podélný profil koryta vodního toku

2.1 typ stavebních úprav (přítomnost umělých stupňů) ⊗•

typ úpravy	hodnocení
žádná, drobné přír. stupně	1
nízký stupeň <10 cm, jez s přirozeným obtokem	1
drsný (kamenitý) skluz s mírným sklonem 1:10 až 1:30	2
stupňovitý jez (jedn. s.<30 cm)	2
hladký skluz s výrazným sklonem 1:30 až 1:50	3
nízký umělý stupeň (jez), výška 10 až 30 cm	3
jez s přechodem pro ryby	3
vysoký stupeň (jez) výška 30-100 cm bez rybího přechodu	4
velmi vysoký stupeň (jez) výška > 100 cm bez rybího přechodu	5

2.2 zatrubnění (délka úseku) ⊗•

délka úseku v %	hodnocení
0 – 5	1
5-25	3
>25	5

2.3 charakter proudění ⇑•

charakter proudění	hodnocení
vysoce diversifikované proudění	1
středně diversifikované proudění	3
málo diversifikované proudění	5

2.4 variabilita hloubek, střídání tůní a peřejnatých úseků (riffles a pools) •

variabilita hloubek	hodnocení
velmi vysoká >75 % úseku	1
vysoká 50-75 % úseku	2
střední25-50 % úseku	3
nízká 5-25 % úseku	4
žádná <5% úseku	5

Pozn. Hodnoceno vzhledem k potenciálně přirozeným poměrům.

Celkové hodnocení oddílu 2

skupina	hodnota
2.1	
2.2	
2.3	
2.4	
2.5	
celkem	
arit. průměr	

2.5 charakter odtoku ⊗•

Odtok	charakteristika	hodnocení
nezměněný	režim odtoku plně odpovídá danému typu vodního toku	1
pozměněný	režim odtoku neodpovídá plně danému typu vodního toku, provedené technické úpravy (napřímení toku, zpevnění břehů, vzdutí, výpusti odp. vod, atd.) mírně pozměnily přírodní charakter odtoku	3
zcela změněný	charakter odtoku neodpovídá přirozenému odtoku, došlo zde k výstavbě umělých nádrží, kanálů, zavlažov. zařízení atd., pomocí nichž je regulován odtok, zcela zásadně se mění velikost a charakter přirozeného odtoku v průběhu roku	5

3) Příčný profil

3.1 typ profilu ⇑•

příčný profil	hodnocení
přírodní, přírodě blízký v rovnováze, stabilní	1
přír. profil, relativně stabilní, drobné projevy eroze	2
přír. erozní profil, nestabilní, nehrozí škody	3
upravený profil umělý, zahloubený, částečně zpev. břehy, významné projevy boční eroze	4
velice silně zahloubený profil (uměle zpevněné břehy)	5

Pozn. záznam projevů nadměrné břehové a hloubkové eroze v mapě

3.2 střední hloubka profilu ⇑•

označení profilu	hloubka
mělký	< 25 cm*
středně hluboký	25-75 cm *
hluboký	> 75 cm *

Pozn. Tento parametr má pouze dokumentační charakter,
** stanovení jednotlivých hloubek, dle ref. stafu*

3.3 variabilita šířek koryta ⇑•

stupeň variability V, N, U, UN	hodnocení
vysoký kv>=1,5	1
střední kv(1,2-1,5)	3
nízký kv<1,2	5

3.4 technické úpravy příčného profilu ⊗•

úpravy koryta	hodnocení
není uměle zúženo/rozšířeno ve 95-100% úseku	1
zúženo/rozšířeno <25% úseku	2
zúženo/rozšířeno <50% úseku	3
zúženo/rozšířeno <75% úseku	4
zúženo/rozšířeno >75% úseku	5

Pozn. vztaženo na prům. šířku koryta vodního toku

Celkové hodnocení oddílu 3

skupina	hodnota
3.1	
3.3	
3.4	
celkem	
arit. průměr	

4). Struktury dna

4.1 typ substrátu dna •

Typ	označení
jílovitý	JI
písčitý	PI
štěrkovitý	ST
kamenitý (kameny, valouny)	KA
balvanitý (bloky, balvany)	BA
skalní	SK
bez pokryvu	BP
aj.	AJ

Pozn. Tento parametr má pouze dokumentační charakter, uvádí se 1-2 dominantní typy

4.2 úpravy dna ⊗•

typ úpravy	> 50% hodnoceného úseku
žádná úprava	1
vložené jedn.volné kameny, vegetační materiály apod.	2
zpevnění kulatinou (dřevem)	2
zpevnění lomovým kamenem (rovnanina)	3
vegetační tvárnice	4
beton. desky/ kamen. dlažba překrytá přírodním substrátem	4
betonové desky/kamen. dlažba bez překryt, souvislý betoní	5
jiný typ úpravy	

4.3 existence mikrohabitatů (diverzita substráty, akumulace detritu, listí, mrtvé dřevo, aj.) ⇑•

stupeň výskytu u V, N, U, UN	hodnocení
vysoký	1
střední	3
žádný	5

Celkové hodnocení oddílu 4

skupina	hodnota
4.2	
4.3	
celkem	
arit. průměr	

5) Břehové struktury

5.1 vegetace břehů •∅

dominantní druh porostu	LB	PB
žádná z důvodu přírodních poměrů	1	1
mokřadní vegetace, poten. přirozené byliny, trávy, K+S	1	1
poten. přirozené byliny, trávy s jedním poten. přír. vegetačním patrem (K/S)	2	2
poten. nepřirozené S/K, invazní druhy, ruderální vegetace	3	3
zatravnění, ruderální vegetace, invazní druhy	4	4
žádná z důvodů úprav koryta, projevů boční eroze apod.	5	5

Vysvětlivky: K keřové patro, S stromové patro

5.2 struktura břehové vegetace (keřové a stromové patro)•

struktura vegetace	hodnocení
žádná z důvodu úpravy břehu	5
solitery (jednotlivé stromy/keře)	4
galeriový pás (souvislý pás LB a PG, zastínění toku)	3
galeriový pás (střídající se stromy LB a PB)	2
souvislý lesní porost	1
žádná z důvodu přírodních poměrů	1

5.3 technické úpravy břehů ⊗•

charakter úpravy	LB >50 %	PB >50 %
žádná	1	1
zatravnění, vrbové plůtky	2	2
zpevnění lomovým kamenem (typ rovnanina, zához, pohoz), přír. pro lokalitu	2	2
opevnění kulatinou, hať oštěrkové válce	3	3
kámen nepřirozený pro danou lokalitu, gabiony	4	4
vegetační tvárnice	4	4
kamenná/betonová dlažba na sucho	4	4
kamenné/betonové zdivo, souvislý beton	5	5

5.4 pohyblivost břehů ⇑•

charakter pohyblivosti	hodnocení
velmi pohyblivé břehy s velkými nátržemi	5
pohyblivé břehy s nátržemi v části břehového svahu	4
mírně pohyblivé břehy s drobnými nátržemi v patách svahu	3
nepohyblivé břehy se stabilizovanými nátržemi	2
stabilní břehy bez nátrží	1

Celkové hodnocení oddílu 5

skupina	hodnota
5.1 LB / PB	
5.2	
5.3 LB / PB	
5.4	
celkem	
arit. průměr	

6) Jakost povrchových vod

6.1 hydrochemické vlastnosti ⊗•

jakostní třída dle ČSN 75 72 21	Hodnocení
I.	1
II.	2
III.	3
IV.	4
V.	5

Pozn. hodnocení se provádí ve vybraných úsecích

6.2 hydrobiologické vlastnosti ⊗•

saprobní index	hodnocení
<1,2	1
<2,2	2
<3,2	3
<3,7	4
>3,7	5

Pozn. hodnocení se provádí ve vybraných úsecích

6.3 výpusti odpadních vod do toku

výpust odpadních vod	ano	ne

Pozn. Tento parametr má pouze dokumentační charakter, je možno zaznamenat počet

Celkové hodnocení oddílu 6

skupina	hodnota
6.1	
6.2	
celkem	
arit. průměr	

II). DOPROVODNÉ VEGETAČNÍ PÁSY (PŘÍBŘEŽNÍ ZÓNA) DVP

7.1 přítomnost DVP (min. šíře 10 m) ⇑•

DVP	LB	PB
existující	1	1
částečně existující	3	3
neexistující	5	5

7.2 vegetace DVP - se zřetelem na stromové patro •∅

typ	LB	PB
les s poten. přirozenou druhovou skladbou, mokřad	1	1
skupinová vegetace / galeriový pás s poten. přirozenou druhovou skladbou s průhledy na koryto	1	1
roztroušená vegetace/ solitery s poten. přirozenou druhovou skladbou	2	2
les s poten. nepřirozenou druhovou skladbou)	3	3
skupinová vegetace / galeriový pás s poten. nepřirozenou druhovou skladbou, zatravnění	3	3
roztroušená vegetace / solitery s poten. nepřirozenou druhovou skladbou	4	4
pouze zatravnění, ruderální veg, invazní druhy.	4	4
žádná vegetace (vyjímka přír. pom.)	5	5
jiný typ		

7.3 využití ploch v doprovodných pásech *±

Typ	>50% LB	>50% PB
les (poten. přiroz. skladba), mokřad	1	1
louky, pastviny, parky	2	2
les (poten. nepřir. druh. skladba)	3	3
plocha ležící ladem, ruderální p.	3	3
zahrady, sady, vinice	3	3
pole, orná půda	4	4
dopravní komunikace, zástavba, umělé povrchy	5	5

Záznam převládajícího typu využití

Celkové hodnocení oddílu 7

skupina	hodnota
7.1	
7.2	
7.3	
celkem	
arit. průměr	

III). Údolní niva

8.1. Dominantní využití ploch

Typ	>50 % LB	> 50 % PB
Les (poten. přiroz. skladba), mokřad	1	1
Louky, pastviny, parky	2	2
Les (poten. nepřir. druh. skladba)	3	3
Plocha ležící ladem, ruderální p.	3	3
Zahrady, sady, vinice	3	3
Pole, orná půda	4	4
Dopravní komunikace, zástavba, umělé povrchy	5	5

8.2. Přítomnost povodňových opatření

Typ	Hodnocení
Žádný, minimální vliv	1
Střední vliv	3
Vysoký vliv	5

8.3. Retenční potenciál

Typ	Hodnocení
Vysoký	1
Střední	3
Malý, žádný	5

App. 6: Evaluation form for EcoEivHab merthodology

App. 7: ZLI01

App. 8: ŠÁR02

App. 9: LIT09