

AQUATIC HABITATS IN PROPOSED INTEGRATED URBAN WATER MANAGEMENT ELEMENTS IN SIBIU (TRANSYLVANIA, ROMANIA)

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ABSTRACT: The necessity for such specific work has appeared from the major concern regarding the accentuated declining quality of lotic systems as providers of important ecologic services. The Cibin River basin in the Sibiu locality area benefited in the last over a century from complex biological and ecological assessment and monitoring studies, a fact which recommends it as a good area for proposal of ecologic management elements regarding the local habitats. The historic qualitative and quantitative dynamic of the riparian vegetation, vegetated islands, macrophytes, habitats, macroinvertebrates and fish allow the existence of a high resolution image about the status of the studied biocoenosis and habitats and highlight the needed ecologic actions for the rehabilitation of their ecologic structures (like restoring: meanders, hydrological and morphological dynamic processes, ecotones, riverine sectors, floodplain sectors, river bed, banks, connection with adjacent wetlands and tributaries) for ecologic functions and services improvement.

KEY WORDS: riparian vegetation, vegetated islands, macrophytes, protected habitats, macroinvertebrates, fish, management.

1. INTRODUCTION

In all the humankind history and everywhere on the planet, water was and still is an inestimable natural resource but almost invariably was used by people with diverging interests, different methods and with significant dissimilar effects. The future modifications in water resources will be more accentuated driven by socio-economics (Alcamo et al., 2007).

Because living in the urban areas bring some obvious opportunities for the human populations beyond the rural potential problems related with gender, age, nationality and/or religion (economic development, fast social integration, attractive contemporary ways of living based on better basic services, better health and education services, etc.) these areas are growing fast worldwide. The humanity just passed a historic turning point, presently more than a half of the world's population live in urban areas and the trend is still an accelerated one in this respect. (Chandler, 1987; Gugler, 1997; Brennan, 1999; Brockherhoff, 2000). In this situation the ecological footprint of this major planetary component should be systematically approached in a sustainable manner on every urban area of the planet!

The human populations which inhabit the urban areas induce more than others ample needs on life-support natural resources and services, and the aquatic habitats are not an exception in the conditions in which providing adequate water supplies for the burgeoning urban populations is both difficult and expensive. In the context in which these habitats are in sustainable ecologic state can offer: important fresh water, self-purification processes, biodiversity maintenance, neighbouring lands irrigation, local and regional climate regulation, educational services, recreational functions, food furnishing, etc. Unfortunately the urban populations induce constantly different combinations of many environmental stressors which lead in different degrees to the environmental stress related both with ecologic structures and functions, including those taking place in aquatic habitats.

The qualitative and quantitative aspects of the functions, resources and services offered by rivers, which decides too the direction of the human settlements and the human society will take in development, were and are still affected a lot in all the Europe and not only (Clebert and Rouyer, 1991; Van Dijk et al., 1994; Angelidis and Athanasiadis, 1995; Kimstach et al., 1998; Grimalt et al., 1999; Amisah and Cowx, 2000; Bucka, 2002; Walsh et al., 2005; Gücker et al., 2006; Tockner et al., 2009). The Olt River basin to which Cibin River watershed belong is not an exception in this wide context (Curtean-Bănăduc et al., 2007).

With Neolithic roots, the Dacian-Roman locality of Cedonia, called Cibinium in the XII century, the city of Sibiu (Transylvania, Romania) is a good example of a city which affected its aquatic habitats along its complex history, a consequence of a various combinations of intensive human population growth, rural-to-urban migration and also the annexation of some adjacent rural areas. All these aquatic habitats were and are related with the Cibin River watershed, situated almost in the middle of Romania (between 45°10' and 46°20' northern latitude and between 23°41' and 24°59' eastern longitude) in the south-west part of Transylvania Depression. The Cibin River has its initial sources in the glacial lakes of Cindrel Mountains (1920 m altitude), a 78 km length, a 2210 km² catchment basin and flow into Olt River, as one of its main tributaries. (Roșu, 1980; Posea, 1982) This river basin constituted early in time a zone where the local high potential for human activities was intensively used. Historically, important human impact presence on the river started in 1200-1300 a. C. (Niedermayer, 1979; Beșliu; 1998, 2001; Curtean-Bănăduc and Bănăduc, 2001), when boulders and sand exploitation, river banks modification, tributaries deviations, floodplain and marshes drainages, and both sewage waste and industrial pollutants discharges get started for more than seven centuries till the present. In the last six decades period the human impact was heavily increased, causing visible degradation in the ecological functioning of the river and its

associated wetlands, research was needed to assess the appeared ecological effects and to predict some aspects of their future dynamic.

The approach taken in this paper examines specific features of aquatic habitats in the Sibiu urban environment and the means of their protection and also sustainable exploitation through eco-sensitive measures, ecosystems management approaches, and strengthening the existing ecosystems self-defence mechanisms.

2. SIBIU HUMAN POPULATIONS ACTIVITIES EFFECTS - RIVER INTERACTIONS, SHORT HISTORY

Historically, the first important human impact presence on the Cibin River was mentioned due to the building and later extension and developing and urbanization of the Sibiu City (154.548 inhabitants in 2009) on its banks. Many drainage works in the river's floodplain, marshes and secondary channels and tributaries deviations were initiated, to build, enlarge and develop this town started with the XII century. Today, the river is drastically affected by such human activities effects, in both terms of biotopes and biocoenosis modification, in its passing through Sibiu on around 20 km long sector. In all this period of time, activities like cutting meanders (the river is actually with over 20% shorter than in the past), embanking of some river sectors and some ponds and wetlands connected with the river drainage, were promoted in order to increase adjacent land surfaces. The upstream of Sibiu Gura Râului Dam construction (due mainly to the significant increasing of Sibiu freshwater demand) and management (the water abstraction and the flow regulation) determine the river hydrologic natural regime modifications and also river bed and channel modifications. Historically, the river has received both sewage waste and industrial pollutants for more than seven centuries, accidental and permanent release of hazardous substances has occurred persistent at least in the last six decades, the human impact being in this period drastically higher from this point of view. Environmental impact also coming from gravel mining activity in the Cibin River, important river bed rocks/boulders and sand exploitation started in the XII century period to supply with construction materials the building of the medieval city of Sibiu. All these human activities continued till the present. (Niedermayer, 1979; Beșliu, 1998, 2001; Curtean-Bănăduc and Bănăduc, 2001).

3. RATIONALE

Since the 1990s, limnological concepts have incorporated a catchment approach to better understand the function of aquatic ecosystems, the ultimate foundation of sound river basin management for the implementation of sustainable use of running waters and the associated habitats (Bloesch, 2005).

In spite of the fact that in the same period of time in Romania were done relatively numerous studies in this respect, including concerning the Cibin River watershed (Șirbu, Curtean and Bănăduc, 1999; Curtean-Bănăduc, 2005), special designed studies for large cities which affect aquatic habitats did not yet represent a scientific trend, in spite of the fact that all the localities, at least with over 100.000 inhabitants, should to readjust drastically their management policy regarding their aquatic and semi-aquatic habitats.

This scientific paper intention is to bring such a needed ecological perspective regarding this category of environmental management concern related to the Sibiu City!

4. RIPARIAN VEGETATION

The vegetation in general, also including the riparian one is a direct effect of the interactions of the abiotic and biotic factors (including the human society activities effects) in any river basin. In this respect the hydrological and morphological dynamics are decisive for the existence, succession and spatial repartition of plant communities and define the characteristics of the floodplain vegetation occurring along any stream or river.

The communities of riparian vegetation provide ecotone habitats with high biodiversity including in terms of abundance and ecologic stability, often higher than in the surrounding habitats (Stauffer and Best, 1980; Knopf, 1985; Knopf and Samson, 1994; Lachavanne and Juge, 1997; Moga and Öllerer, 2007; Schnitzler et al., 2007; Liogchii and Adam, 2010; Schneider-Binder, 2010; Curtean-Bănăduc et al., 2010-2011).

The Cibin River riparian zone due to the human impact in the last few hundred of years changed and impoverished its structure and species composition. On some stretches, in particular around Sibiu and in the town itself, these changes are of high degree, and are related to hydrotechnical works (river bank enforcement, canalization, etc.) which changed the natural hydro-morphodynamics and the water quality.

In a natural and near natural state the riverine vegetation of the Cibin River and its tributaries was represented by gallery-like willow softwood forests (*Salicetum albae-fragilis*), in which the most abundant species were the willows species *Salix alba* and *Salix fragilis*, locally also *Salix triandra* and *Salix viminalis*. In some proportion the Black Alder (*Alnus glutinosa*) was also an important component of the water bordering galleries. In the large floodplain of the river stands with Grey Willow (*Salix cinerea*) of the *Salicion cinerea* alliance were still characteristic near large areas of wet meadows and sedge rich wetlands (Schneider-Binder, 1975, 1976, 1978).

The gallery forests were supposed to periodical floods, i.e. changes between high and low water levels, in particular in spring time after snowmelt in the Cindrel Mountains, and has been influenced by this changing discharge and hydro-morphodynamical processes. Thanks to this dynamic a living and changing ecosystem existed, erosion and deposition processes created new river banks and islands with proto-soil conditions, which allowed the settling of willow seeds and the natural regeneration of willow galleries (Schneider, 2003). At some extent in the past the White Tamarisk (*Myricaria germanica*), a characteristic species for rivers with morphodynamics, was also documented for the town of Sibiu (the plant collection of J. Barth in: Drăgulescu, 2010). Also Grey Alder (*Alnus incana*) on morphodynamic larger grain sized sediments is mentioned for the Sibiu area (Drăgulescu, 2010). Due to the loss of the natural dynamic habitats the White Tamarisk and the Grey Alder disappeared from the Sibiu city area.

Even if many changes occurred along the Cibin River from upstream to downstream, the gallery like softwood forests are still existent upstream and downstream the Sibiu City and with a quite representative species composition. The species number in such willow stands was found with 66 species very high (Schneider, 1998). The high frequency classes V, VI and III are

represented by a number of 19 species, in the lower frequency classes II and I the species number is off 47. Characteristic are not only the tree species, dominant being the White Willow (*Salix alba*), but also willow and other bushes, as well as characteristic lianas for floodplain gallery forests such are Hop (*Humulus lupulus*), Bittersweet Nightshade (*Solanum dulcamara*), the Bindweed (*Calystegia sepium*) and the clambering plant *Cucubalus baccifer*. In the last decades the Wilde Cucumber *Echinocystis lobata* spread more and more in the valley of the Cibin River. These plants form locally thick curtains which offer good nesting places for site typical birds. A high number of indicator species for flooded area (8 species) or general wet area (8 species) are represented as well (Ellenberg et al., 2001) such are: *Mentha aquatica*, *Lycopus europaeus*, *Malachium aquaticum*, *Lysimachia vulgaris*, *Symphytum officinale*, *Lythrum salicaria*, *Polygonum hydropiper*, *Poa palustris*, *Bidens tripartita* and others.

The riverine vegetation structured in many vegetation layers: small and tall herbaceous layers, 1-2 scrub layers to tree layer. These layers all together offer many microhabitats for birds, reptiles, amphibians, insects and other species.

Comparing the species richness of the riverine vegetation upstream and downstream Sibiu, with the water courses in the city, a substantially impoverishment is visible, which can easily be observed by the complete loss of gallery-like willow belts along the river. Only rare willow bushes are present and also locally the ornamental, in majority planted *Salix babylonica*. Site typical herbaceous plants as above mentioned, are also very poor represented. From the number of 64 species in the willow galleries around the town, on the water course in the city are present less than 20. Most of the species are indicators for eutrophication and for ecosystem disturbance. With the disturbance appears more and more weeds and also invasive species, most of them neophytes, replacing the site typical species and characteristics.

Due to this impoverished structure the riparian vegetation zone did not any more offer mainly in the Sibiu City area and the adjacent areas, the natural flood pulse related conditions of permanent and active changes from an aquatic to semi-aquatic and to terrestrial ecosystems, mainly due to hydrotechnical works on the river bed and terraces and the extensions of the building areas.

This situation induced a complex impact on the riparian zones and diminished their too often not understood or disconsidered free of charge ecological functions and services.

The very simplified structure of the actual heavy modified herbal and ligneous vegetation induced: decreasing of the allochthonous POC and nutrients along the river continuum (Vannote et al. 1980); decreasing recruitment of large woody debris; decreasing of the adsorption and buffering of nutrients entering in the river channel, especially from the upstream agricultural lands; decreasing of the pools and undercut banks habitats; decreasing of denitrification process mainly in the old floodplains through the increasing of the excess nitrate in the groundwater and in the river hyporheic zones; naturally regulating the liquid and solid discharge variation; sheltering effects for biodiversity; decreasing the natural sources of debris for the aquatic ecosystems functioning; decreasing the role of herbal, shrubs and trees vegetation to stabilize the river banks, hence to reducing erosion and sediment/soil transportation; decreasing the role of habitats and microhabitats for sheltering, resting, hiding, feeding and breeding, for the aquatic, semiaquatic and some terrestrial biodiversity (birds, fish,

mollusks, ground beetles, etc.); decreasing shadowing effects on the aquatic macroinvertebrates and fish, through water temperature and dissolved oxygen modified dynamic; decreasing the role of shading and reducing irradiance, thereby decreasing ameliorating temperatures extremes; decreasing the role of mitigating the habitat fragmentation; disturbing the upstream (alpine) to lowland (downstream) natural habitats gradient, as a moving and migratory corridor for wild fauna (Curtean-Bănăduc et al., 2010-2011).

Ecological rehabilitation and reconstruction of the riparian vegetation in the needed future river restoration projects requires a lot of quantitative and qualitative elements to be considered as key factors. Necessary for the restoration of the river bank vegetation on a natural way is the existence of hydrological and morphological dynamics, which is the prerequisite for erosion and deposition processes, which create proto soil conditions. These are required, if the objective is, to restore a natural floodplain gallery forests even on a small scale. Species like White Willow, and in general all willow species, as well as the Black Poplar, typical for floodplain softwood forests, can regenerate only, if proto soils created by the river dynamics exists. Also changing water levels and duration of higher water levels are basic conditions for the repartition of species along ecological gradients following their flood tolerance. For natural regeneration processes of site typical species also the longitudinal and lateral connectivity is very important, because only connectivity allows the change of diaspores, reproduction units (rizoms, seeds). They are transported during higher water levels also in the existing riverine areas.

Providing just a small strip of trees (the so called green tubing) may be (relatively) aesthetic in terms of urban landscape but is insufficient with regard to ecosystem functions and services. River restoration needs theoretical and practical knowledge by choosing the site typical species in the case that natural regeneration is functioning only on a small scale and fighting invasive species that can be a great nuisance in a beginning restoration process. Presently they “explode” and suppresses other site typical flora. At present the species *Solidago canadensis*, *Aster lanceolatus*, *Aster novii-belgii*, *Helianthus tuberosus* are larger spread (Drăgulescu, 2010). *Echinocystis echinata*, forming curtains on the willows, is on the way of extension, as well as *Polygonum cuspidatum* and *Impatiens glandulifera*.

Even if restoration of the water network of the Cibin River and its tributaries in the City area can be realized on smaller scale as outside the city, it is of great importance to analyze all possibilities to restore near natural structures and habitats, being the first step for a better ecological status and functioning of the river-floodplain ecosystem complex.

Apart from the ecological value of a sound river ecosystem, the redevelopment of gravel and sandy banks with settling possibilities for different species, have also a high recreation and aesthetical value and increase the quality of life conditions for citizens. Restoration works can be realized, where ever it is possible, taking out the river bank reinforcements and giving a mobility space for the river “to work” (Malavoi et al., 2002; Gautier, 2006). The free room for rivers constitutes the beginning of restoring the site conditions and the exquisite valuable functions of the rivers ecosystem.

The concept “free room for rivers” or “mobility space for the good functioning of the hydrosystem” is ongoing from France more and more accepted all over Europe with good results on

rivers outside an inside of cities. It is very important, to develop concepts and to implement even small projects for morphological dynamisation of the river in an intensively used landscape including urban area.

5. VEGETATED ISLANDS

Vegetated islands are key landscape elements along dynamic river corridors; at the same time they are among the first elements that disappear as a consequence of usual "engineering" river regulation. The remaining islands have high conservation value. Islands provide important ecotonal habitats, and they are on average less disturbed than adjacent floodplain areas. As such, vegetated islands play important stepping stones for aquatic, semiaquatic and even terrestrial floodplain organisms along the river corridor.

The islands in the Cibin River near to Gușterița neighborhood being partially supposed to hydro-morphological dynamics, they presents a various range of macro- and microhabitats, which on their turn offer colonization possibilities for well adapted organism to these specific conditions. In dependence of the grain size of sediments they offer colonization possibilities for different pioneer plant species. Such places are colonized also by site typical ground beetles. Also some birds are choosing these places for constant breeding. On the islands we can found the whole evolution series of vegetation from the pioneer settling to first stages of softwood stands (willow species) and to well develop softwood floodplain group of trees. These islands and other natural river banks are the unique places, where regeneration of willows can take place on a natural way, because willows needs for their regeneration, natural dynamic habitats with proto soils offered by these islands. Being supposed to the river dynamics, the islands can change from one year to the other, but with erosion and deposition processes, the microhabitats eroded in one place, are developed again on new deposits in other place. Important for these islands is the preservation of the processes which maintain the functioning of the ecosystem. The allowing of formation of new such islands in old/destroyed by humans islands sites should be encouraged through needed future ecological restoration projects.

6. MACROPHYTES

Water macrophytes are represented in the the Cibin River system only in the few remained old branches of the river upstream the city of Sibiu and in small tributaries like Ruscior and Strâmb. But in general they are not large spreaded as in centuries before, at the time (17-18th century) that the city was surrounded by a chain of artificial lakes (Schneider-Binder, 1976). The most of the water macrophyte communities are edified by species indicating slowly running or standing eutrophic waters. The community of Water Lens (*Lemna minor*) is represented by populations in standing, but also in very slowly running waters as the downstream part of the canalized Ruscior Stream. In the Cibin River upstream of Sibiu phytocoenoses of *Lemno-Utricularietum* on a very small area were present. The community of *Myriophyllum spicatum* occurred in the Valea Aurie area and macrophyte communities with *Polygonum amphibium* and *Potamogeton natans* can be found in the old branches of Cibin River near locality Cristian upstream Sibiu, in the Dumbrava Forest area and on lake „Lacul lui Binder” in Sibiu. In the slowly running water courses of the canalized Ruscior and Strâmb streams the Hornwort *Ceratophyllum demersum* and Pondweed *Potamogeton crispus* forms locally stands. They indicate eutrophic

waters with tendency to high eutrophication (Schneider, 2009) due to diffuse pollution and poor bank vegetation without any bushes or trees spending shadow. The presence of the *Glyceria maxima* tall grass, also an indicator for middle and high eutrophication (Ellenberg et al., 2001) confirms the quality of these modified water bodies.

7. PROTECTED HABITATS

The former large floodplain area of the Cibin River and its small tributaries was characterized by typical wetland habitats. Due to the human interventions with different hydrotechnical measures such as rectifications, drainage, various types of constructions, and intensification of agriculture, including cutting of the riverine floodplain gallery forests for increasing the agricultural lands surfaces around the city, a large loss of floodplain wetlands took place. This is why nowadays wetland and typical floodplain habitats including the riverine habitats are present and developed only on a very small scale and often in an untypical form with only a part of the habitat characteristic species. Although in the floodplain of the Cibin River and its tributaries still exist relicts of some habitat types which are included in the Annexe I of the EU Flora and Fauna Habitat Directive.

3130 Oligotrophic to mesotrophic standing waters with vegetation of the Litorelletea and/or Isoeto-Nanojuncetea. This habitat type exists only in small patches and in a very unstable form from one year to the other. Frequently they occur only in temporary pools in the river adjacent area on the bank of oxbow lakes (Cibin, Ruscior).

3150 Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation. This habitat type occurs in oxbow lakes/old branches of the Cibin River upstream Sibiu.

3270 Rivers with muddy banks with *Chenopodium rubri* pp. and *Bidention* pp. vegetation. The presence of this habitat type was documented on the Ruscior and Strâmb streams but in a fragmental form and unstable from one year to the other. But the occurrence proves that the diaspore bank is active and an important pool for the perpetuation of this habitat type in the area.

6430 Hydrophilous tall herb fringe communities of plains and of the mountain to alpine levels. In the floodplain of Cibin River and as fringes in some parts of the Ruscior and Strâmb streams tall herbaceous wet fringes occurs. Also on the streams from the piedmont on the foot of the mountains such type of habitats exists.

6440 Alluvial meadows of river valleys of the *Cnidion dubii*. The *Cnidion* type meadows were large spread in the floodplain of Ruscior Stream before drainage measures. Also after these works they persisted in some area and occur also at present on a very small area. They have a high conservation value including some rare species with phytogeographical importance.

6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*). This habitat is larger spread in the area in the floodplain of Cibin River and Ruscior Stream area. But also this larger spread area is in danger as for changes in land use.

91E0 *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*). Along the streams and the river Cibin this habitat type is represented upstream and downstream the city.

In the context of the presence of these all above mentioned habitat types of the EU Flora and Fauna Habitat Directive around the city of Sibiu, the water network of thus locality constitutes an important corridor for maintaining and developing more these habitat types also in the core city area. There repartition also in the city area constitutes an important value which, when it will be further developed, can be a plus value in restoration river/stream stretches not only for conservation, but also for recreation and as an aesthetic value.

8. MACROINVERTEBRATES

The aquatic habitats related macroinvertebrates of the Cibin River, its flood areas and also its main tributaries have been studied for a relatively long period (Bielz 1851, 1853, 1856, 1867, 1888; Bieltz 1843, 1951; Botoșăneanu 1957, 1961; Botoșăneanu and Schneider 1978; Borcea 1958; Ciubuc 1993; Cîrdei and Bulimar 1965; Grossu 1993; Kis 1971, 1974; Marcoci 1957; Mayr 1853; Murgoci 1953; Plattner 1963; Schneider 1973).

More recent studies regarding the Cibin River macroinvertebrates communities, including its middle course where the Sibiu City is localised (Curtean et. al., 1999; Curtean-Bănăduc 2001, 2004, 2005, 2006; Sîrbu et. al., 1999; Szállasy, 1999; Șerban and Busuioc, 1999; Ujvarosi and Chișu, 1999) reveal the presence of a total of over 125 macroinvertebrates species which belong to 67 genera, 42 families, 19 orders and 12 classes. The highest species diversity belong to the Trichoptera (28 species), Oligochaeta (18 sp.), Chironomids (15 sp.), Plecoptera (12 sp.), Ephemeroptera (10 sp.) and Odonata (8 sp.).

The macroinvertebrate species numbers vary along the Cibin River. The trichoptera, plecoptera, ephemeroptera and odonata present a higher specific diversity in the mountainous sector, where the water has a high speed, gravel the lithologic substrate is predominant, and the human impact is insignificant. The chironomids and the oligochaeta have a high number of species in the middle and lower sector, where the reduced slope and the trophic offer (water rich in organic substances) are favourable for these organisms.

Analyzing the dynamic of the macroinvertebrate communities diversity along the river Cibin, we found the fact that the high diversity of these organisms is recorded in the mountain sector upstream from the lake of the Gura Râului, there where the human impact is insignificant, the diversity decreases with the increasing of the anthropogenic pressure, the lowest diversity starting with the Sibiu area. (Curtean-Bănăduc, 2005)

The macroinvertebrates diversity dynamic in the Cibin River did not overlap on the theoretic model of variation of this type of diversity along such a category of river, which show the fact that the diversity increase in parallel with the microhabitats diversity increasing and the increasing of the trophic resources quantity, from upstream to downstream (Smith, 1990).

Comparing our field data with the historical data (bibliography data and the Sibiu Natural History Museum collections data), it was possible to highlight the fact that in the last century a total of 13 species changed their areal of distribution in the Cibin River and also 19 macroinvertebrates species were disappeared (Curtean-Bănăduc, 2004).

The species *Anodonta cygnaea*, *Anodonta anatina* and *Unio crassus* (bivalve molluscs) identified in the Cibin River by Bieltz (1851, 1853, 1867) and Grossu, (1993), in the present is no more here. The *Pisidium casertanum* species (unionid

mollusc) sampled by Kimakowicz in 1884 at Gușterița neighborhood of Sibiu, in present is missing with the exception of a reduced far upper mountainous sector, upstream the Cibin River Gorge. This last species disappearance affected the river water natural self cleaning capacity.

The plecoptera were present in all the Cibin River till around 1950 (Kiss, 1971), but actually is present only in the first upstream 38 km of the river, and their missing is starting at 14 km upstream the Sibiu. Six species were disappeared in the last 50-60 years: *Brachyptera braueri* (identified by Worell in 1948 at Sibiu), *Capnia bifrons* (identified by Müller in 1931 at few km upstream of Sibiu), *Protonemura intricata* (identified by Müller in 1930), *Isoperla minima* (identified also by Müller at the Cibin River confluence with the Olt River in 1930), *Isoperla tripartita* (identified also by Müller in 1922 downstream Sibiu and by Worell in 1948 in the present Turnișor neighbourhood of Sibiu) and *Siphonoperla burmeisteri* (sampled also by Müller in 1922 in Sibiu) (Kiss, 1971). The plecoptera fauna dynamic in the studied period of time reveal the fact that the Cibin River middle and lower course habitats were depreciated, and the influence of some of the Sibiu and its neighbouring localities impacts are the main disturbances factors.

Speaking about the trichoptera species identified in the past in Cibin River 10 were disappeared: *Limnephilus flavicornis* (identified by Worell in 1945 in Sibiu), *Limnephilus griseus* (identified by Czekelius in 1920 in Sibiu - Gușterița, and by Müller in 1931 upstream Sibiu at Cristian), *Limnephilus lunatus* (identified in Sibiu by Müller in 1923 and by Worell in 1948), *Limnephilus rhombicus* (identified by Worell in 1954 in Sibiu), *Limnephilus vittatus* (identified in Sibiu by Müller in 1923 and by Worell in 1948, 1953 and 1954), *Psychomyia pusilla* (identified by Müller in 1922 in Sibiu), *Grammotaulius nigropunctatus* (identified by Worell in Sibiu in 1948, 1953 and 1954) *Stenophylax permistus* (identified by Worell in 1943 in Sibiu), *Ylodes simulans* (identified by Müller in 1922 in Sibiu) (Botoșăneanu and Schneider, 1978), *Athripsodes leucophaeus* (sampled by Murgoci, 1953), *Halesus digitatus* (Ciubuc, 1993). *Goera pilosa* and *Beraea pullata* species which were identified by Hannelheim in 1958 and respectively Müller in 1923 in Sibiu (Botoșăneanu and Schneider, 1978), now can be found only in the far mountainous Cibin River area, upstream the Cibin River Gorge.

The longitudinal dynamic/decline in taxon richness have an obvious high peak in the Sibiu locality area and can be explained by the accentuated decreasing of the habitats heterogeneity and quality due to: morpho-hydrodynamics changes, pollution (including organic pollution), cutting meanders, extirpation of river banks and islands, drastic changes of riverine vegetation, etc.

This situation is serious but not irreversibly if proper management actions will be taken: the river water liquid flow should be assured in correlation with the ecological demands (minimum 1 m³/s under the Gura Râului Dam); ecological rehabilitation of the stressed wetlands of the basin; reconnection of the river with the wetlands from the major river bed; proper management of the waste waters of the riverine localities of the Cibin River and its tributaries, especially of the Sibiu City.

9. FISH

In spite of the fact that the Danube is the most fish species-rich European basin (Kottelat and Freyhof, 2007) there are

numerous tributaries which faced problems in respect of their ichthyofauna status also due to the human impact on the aquatic habitats.

Freshwater fishes are an extremely diverse group that have evolved to occupy a wide range of habitat types, but with some exceptions, the aquatic habitats modifications have obvious negative consequences for fish communities quantitatively and qualitatively aspects and the user groups associated with those communities' deficient aquatic habitats. The Cibin River is such a case. In this lotic system, the ichthyofauna offers reliable criteria for the aquatic habitats human impact assessment (Bănăduc, 2000). The fish species preference for one or many certain biotope conditions of the aquatic habitats, and their different degree of resistance to the different long term human stress factors is the reason for the large modifications in this river ichthyofauna structure along the history. Large differences were noted in the way some species of the same family and even of the same genera (*Gobio*, *Barbus* and *Sabanejewia*) responded to the long-term human impact stress, related mainly to the 1960-actual river regulation and management policy impact on the aquatic habitats. Within each such fish group, there were some species that are adaptable to such type of stress and some which simply disappear due to the habitats modifications like: *Alburnus alburnus* (Linnaeus, 1758), *Romanogobio uranoscopus* (Agassiz, 1828), *Romanogobio kesslerii* (Dybowski, 1862), *Barbus barbus* (Linnaeus, 1758), *Cobitis taenia* Linnaeus, 1758, *Zingel streber* (Siebold, 1863) and *Cottus gobio* Linnaeus, 1758. All these species were directly affected by the loss of some of the services offered by the old natural or at least semi-natural aquatic habitats: migrating culloars, sheltering, recolonisation, feeding, breeding, spawning and nursery areas, wintering grounds, etc.

The migrating species big individuals with high reproductive value hardly or didn't face the important water depth decrease barrier. The accidental and permanent source of pollution created chemical-physical barriers (whose degree of effects varies from one type of pollution to another and from one species to another) for the sensible to this habitat proprieties species in different periods of their life cycles. The problems related with high water temperatures were the result of decrease in shade, decrease in water depth and the presence of different wastewater effluents with higher temperatures and unnatural temperature variation regimes which limited and/or induced the disappearance of some fish species which can not find anymore in their habitat the optimal or at least the minimal range of mean or/and peak water temperatures in all the seasons to can avoid the lethal values for all their life stages.

Excessive and unnatural sediment load dynamic due to the channel modifications, reduction in water flow, partially or totally clearing of riparian vegetation, conversion of upstream lands from forest to agriculture, upstream river substratum overexploitation, increases erosion both in the channel and in the watershed and increased the sediment loads over the turbidity limits of some fish species and also heavily modified the required gravel and larger boulders substrate for breeding, spawning, sheltering, feeding, etc.

The single species which have a widespread distribution pattern in the Cibin River is a well known and not accidentally in this position here "habitat generalists", able to live in various habitat conditions even heavy anthropogenic affected.

Quantitatively and qualitatively changes in the aquatic habitats of this river was reflected also in the negative opportunity of

the appearance and spreading of neobiota fish species like: *Carassius gibelio* (Bloch, 1782), *Lepomis gibbosus* (Linnaeus, 1758), *Pseudorasbora parva* (Temminck and Schlegel, 1846) and *Gymnocephalus cernua* (Linnaeus, 1758).

One of the peaks of the human impact effects on the fish species was registered in the Sibiu City area and is a certain result of the hydromorphological alterations in concert with pollution, land reclamation and the appearance of non-native species, and has affected the Cibin River fish fauna and their habitats.

Due to the human impact on the river aquatic habitats the catch yield has undergone serious cutbacks, the fish biomass of the river decreased with over 70% in the last century (Bănăduc, unpublished data).

Overfishing and illegal fishing in an altered habitat (much easier to be accessed by fishermen and poachers too) affected the fish communities and today the sport fishing activities taxes influx of currency is very low.

The longitudinal decline in taxon richness may be explained mainly by the decreasing of the habitat heterogeneity in concert with increasing pollution. These two factors impacted strongly but not irreversibly yet the habitat requirements, without which a series of species cannot survive over a long term and that species will go locally extinct.

Future needed habitat restoration actions should involve also the target fish species or species assemblage's habitat requirements (Morrow and Fischenich, 2000). If not all the habitats requirement information will be available the remained habitat deficiencies will increasingly imperil the fish fauna too. The best approach in this respect is to attempt to restore the initial natural or at least at semi-natural level the river phisico-chemical parameters. Spatially uniform velocities and temporally unnatural variation of the flow velocity should be avoided because there are detrimental to fish communities and will induce the same present poor fish habitats.

The optimal depth should be restored in dependence with the species life stages dependence

The instream cover maximization through ecologic rehabilitation and management will bring a positive input in the aquatic habitats quality if the mineral and woody debris substrate will be enough heterogeneous and stable to provide: fish food support (invertebrates and bioderma), velocity refuges, hiding places from predators, attachment sites for adhesive fish eggs, etc. It should be stressed the fact that maximizing instream cover increases also the diversity in depth and velocity. More instream cover means better fish habitat.

The natural (upstream-downstream) substrate size variation was affected due to the accentuated sedimentation processes, and replaced the need (for some fish species) substratum with a specific granulometry.

Repeated clearings and "igienisations" of the instream vegetation which in general offered the same benefits as the instream cover should be proper managed in the direction of keeping the microhabitats high diversity.

The connections of the river with the floodplain habitats should be restored in some extent these helping in a better fish fauna reproduction and sheltering in some certain life stages; nutrient and sediments sinks which allow a better water quality for the river biota and the human society, attenuate flows, lessen the magnitude of floods and water receding from floodplains often

contains a substantial amount of food utilized by stream fishes, decreasing the sedimentation and excessive turbidity and excessive nutrient inflows and associated problems with water quality, and reduced reproductive success of some fish species, etc.

A proper applicative know-how to these aquatic and semi-aquatic related habitats can make again as feasible the native fish assemblages' optimum management without costly and inefficient in the actual circumstances stockings and re-stockings!

10. CONCLUSIONS

The Cibin River and some of its tributaries and associated wetlands in the Sibiu area were clearly defined as a very important management target based on the biodiversity regress used as an indicator of the local human impact.

There are a lot of physical features which were affected by the human pressure: flow regime (water depth, flow velocity, flow variability, discharge, flood magnitude, flood frequency, drought frequency), physical habitat structure (habitat diversity, habitat connectivity, channel sinuosity, siltation, sedimentation pattern, banks stability, substrate type, plant cover). Also water other variables were anthropogenic affected here (nutrients, thermal regime, toxins, turbidity, oxygen concentration, pH). The trophic sources suffered modifications (primary production of algae and macrophytes, energy, particulate organic matter, aquatic and terrestrial invertebrates), also the biotic interactions (species structure, invasions of exotic species, threatened species, endangered species, sensitive species, species richness, trophic structure, age and genetic structure, predation, competition).

The future needed sustainable general management of the Cibin River should include specific management measures of the: hydromorphology (hydrological regime, quantity and dynamics of water and sediments flow, connection to groundwater bodies, river continuity, morphological conditions, river depth and width variation, structure and substrate of the river bed, structure of the riparian zone), chemical and physico-chemical elements (temperature, oxygenation, nutrient conditions), human impact elements (pollutants), etc.

The integrated monitoring of the needed management results of the interest area should be based on biological and ecological elements like: composition and abundance of flora and vegetation, macroinvertebrates, fish, etc.

No other hydrotechnical works should be added to those which already exist now without the needed ecological know how to be used!

As much as is possible the Cibin River sectors should be returned to a natural or at least semi-natural condition through proper ecologic restoration projects.

For the impacted sectors ecological restoration, not only the Sibiu area should be integrated in the sustainable management plan but also (at least) the upstream areas. This management plan should include the following elements which should be properly managed: waste water canalizations, river substratum sustainable exploitation, river banks ecological restoration and preservation, fishing, pollution, etc. The increasing status of all this elements will induce associated natural processes supporting the ecosystem services.

Perhaps the most important among the basic habitat characteristics is the flow regime - or, stated differently, the availability of water in adequate time, space and quantity. Indeed, aquatic habitats obviously need water to function, and unless their water requirements are met, their capacity to produce and sustain ecosystem services is seriously impaired.

Conventional urban waste water management has focused mainly the urban human population against hydrological extremes (floods and droughts) and providing some water services. It has come to include water supply, urban drainage and flood protection, wastewater management and, more recently, some form of aquatic ecosystems protection. This, however, often does not address specific features of aquatic habitats, their needs and potentials. In many cases, to minimize drainage costs, urban streams and rivers have been incorporated into major drainage systems and have conveyed various types of municipal effluents, resulting in extreme habitat degradation. Newly emerging paradigms underline the need for water conservation, rational use, reuse and the sustainable integration of different components of urban river systems, including those of a technical and natural character. This tendency creates opportunities for changing attitudes to wetlands and their use for concurrently improving efficiency of urban water management and the quality of human life in cities.

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