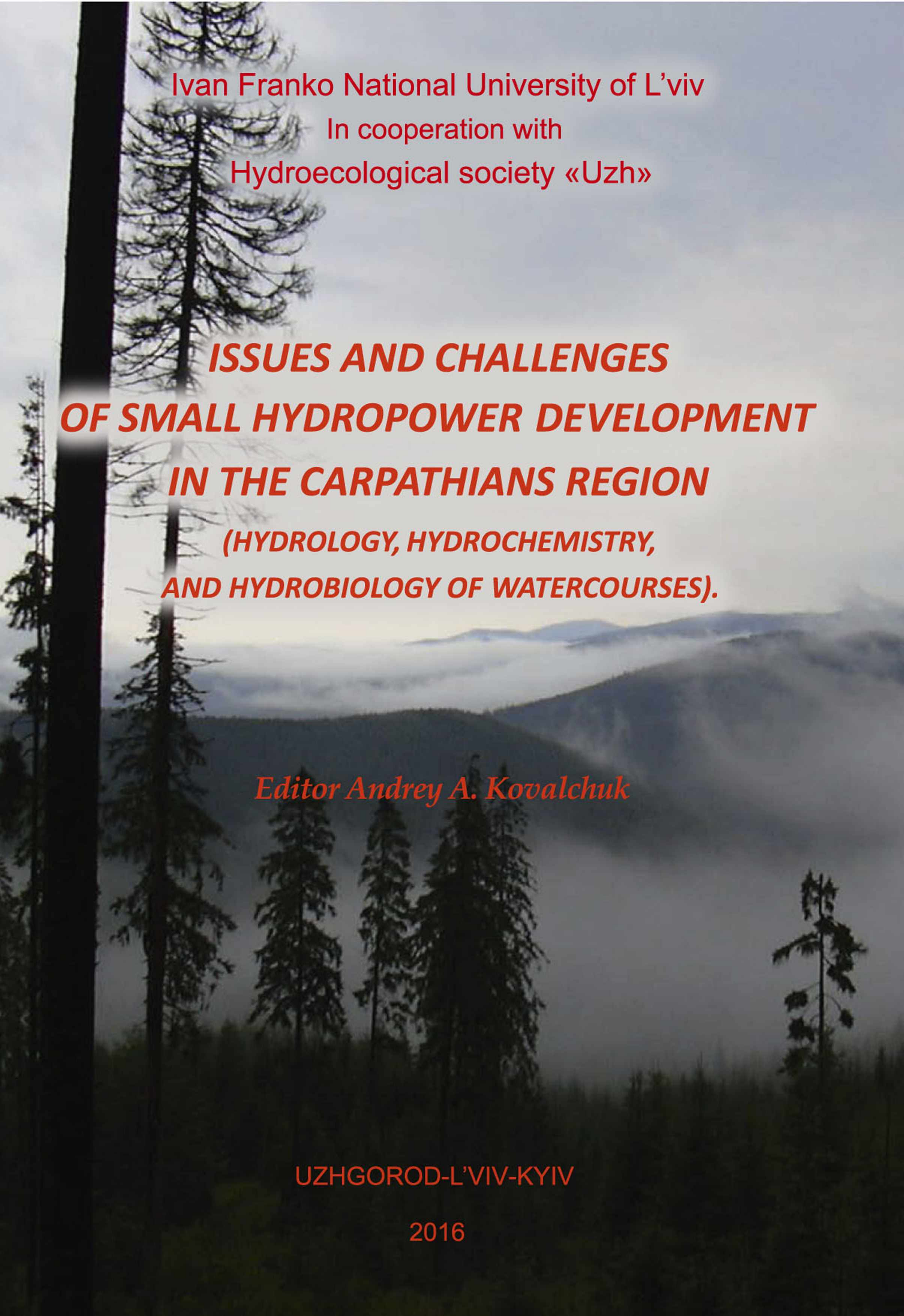

Ivan Franko National University of L'viv

In cooperation with

Hydroecological society «Uzh»

ISSUES AND CHALLENGES OF SMALL HYDROPOWER DEVELOPMENT IN THE CARPATHIANS REGION

(HYDROLOGY, HYDROCHEMISTRY, AND HYDROBIOLOGY OF WATERCOURSES).

Editor Andrey A. Kovalchuk

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This monograph is devoted to the question of development of small-hydroenergy on small rivers in conditions of the Carpathians region, and Transcarpathians with Outer -Carpathians regions. The authors have pay attention both positives and negatives in implementation of modern principles of building of small– mini, and microhydropower plants. Except of the data on hydrology, hydrochemistry and basic legislative approaches it is shown large material on fauna, flora and functionality of aquatic ecosystems. It is consecrated for hydrobiologists, zoologists, algologists and everybody who is interested in acceleration of building renewable hydroenergy sources facilities with a minimum impact against surroundings.

1-st edition (In English).

Page-making, some Chapters translation and final correction of all translated Chapters by the Editor. I apologize for some possible mistakes in the English text, since the language is not native for me, especially grammar, and our budget was quite limited, so I made it both better and completely free of charge...

Photo on front cover by Andrey Kovalchuk: the Black Cheremosh River Valley from the Chornohora Massif, May 08, 2005.

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CONTENT

CONTENT

FOREWORD

In accordance with the development concept of energy independence of Ukraine and Transcarpathians (Zakarpattia) in particular, envisages the construction of small category (small itself, mini and micro) hydropower plants (*HPPs*).

Even in countries that belongs into "developing" group the visible progress was achieved 5-10 years ago (Singh & Upadhyay 2014, Saxena 2007, Rashid et al. 2015 etc.). So, we should effort intensively to have fast results in improvement of actual subject status of renewable hydroenergy.

However, it should be noted that the creation of such hydraulic facilities may result in impacts on the environment of changes in hydrochemical, hydrophysical and hydrological regime of watercourses, and as a result, in hydrobiological regime (Avakyan & Podol'skii 2002). Therefore, appear variations in the composition and structure of benthic, and periphytic communities, begins to form plankton, which is not typical for mountain rivers in general.

Note that the model for these changes is already there, since 50-ies of the last century was built the Tereble-Rikska (Vilshanska) *HPP* on the river Tereblya. The *HPP*, along with a brilliant engineering solution to the problem of diversion from the Tereblya to the Rika river, had some serious negative consequences for ecosystems of both rivers (Kovalchuk 2001).

It is clear that the construction of even small hydropower plants causes a resonance in the society, since practically forever changed natural character of rivers where they are built. Especially fierce debate in the scientific, practical engineering and social plane occurs at the initial stage of such programs, even with their lack of options. This problem caused the need for the widest possible exchange of views, which is possible in the conditions of scientific-practical conference. So, on June 13-16, 2014 in Uzhhorod have take place the conference titled "Problems of the engineering and operation of hydropower plants on small rivers in the conditions of the Carpathians Euroregion". The Conference was attended by 36 participants from the three countries, 15 of whom presented papers, the best of which became the basis for writing this monograph. I sincerely hope that the beginning of an extensive collaboration will be only the first step towards gaining energy independence in the territories belonging to the Carpathians Euroregion.

In the study of the impact on the ecosystem of the rivers in the Carpathians region the construction of small hydropower plants and the creation of ultra-small reservoirs should plan to investigate the fauna of hydrobionts, as the basis for the formation of fish forage base. As well necessary to forecast changes in hydrological an hydrochemical regimes under impact of constructed facilities on environment.

Also important is the assessment of the status of rare and scarce species, especially fish listed in the Red book of Ukraine and international lists of species under threat.

Andrey A. Kovalchuk

1. THE INFLUENCE OF SMALL AND ULTRASMALL RESERVOIRS ON THE ENVIRONMENT.

Abstract. This chapter describe the role of the small category reservoirs and their possible influence on environment.

Key words: small, mini and micro reservoirs, impact on environment, deposition of organic matter.

In accordance with the General classification of the hydropower plants given in M. Majumder & S. Ghosh (2013) they can be divided due to (a) Quantity of water available, (b) Available head, (c) Nature of load. It should be noted that *HPP* classification hardly ever resembles the classification of the reservoirs, as for instance, in statement (a) are included *HPP* without poundage (Photo 1-1). As well frequently enough powerful *HPP* has the very small poundage to store water (Photo 1-2).

As well water regime of some reservoirs is so unstable, that their capacity, especially in flood or monsoon periods, sometimes belongs into large or middle type, and in dry into small (Photo 1-3). Actually, not all artificial reservoirs are connected with the only *HPP* purpose (Photo 1-4). The main uses of reservoirs include 10 statements (Thornton et al. 1992&1996). Therefore for the reservoirs classification is used the term of Full Reservoir Level and Nominal Volume or Capacity that corresponds with the maximum or full capacity.

In small category of reservoirs includes reservoir itself with dam, having a full capacity less than 0.01 km^3 (Avakian et al. 1979, 1987). So, if under this volume we have a basin that is considered to subdivide as small itself, mini and micro. As well, for some reservoirs of such category are sometimes using dams of traditional for the region construction (Photo 1-5).

Important to note, that conflicts based on the perceived needs of humans for fresh water supply versus conservation of life of ecosystems are increasingly seen in the news, especially in cases of forms of natural hazards and catastrophes (Poff et al 2003). Therefore several years ago in some countries (especially, in the USA and Australia) had started activity for returning the natural state of the rivers that leads to destroying of overlap dams (Thompson et al. 2005). But this is giant problem as only in the USA by the end of the 20th century, there were more than 80000 dams higher than 2 m, according to the U.S. National

Photo 1-1. Dam on a stream without poundage for micro *HPP* in the Alps (October 10, 2013, South Tirol, Italy).

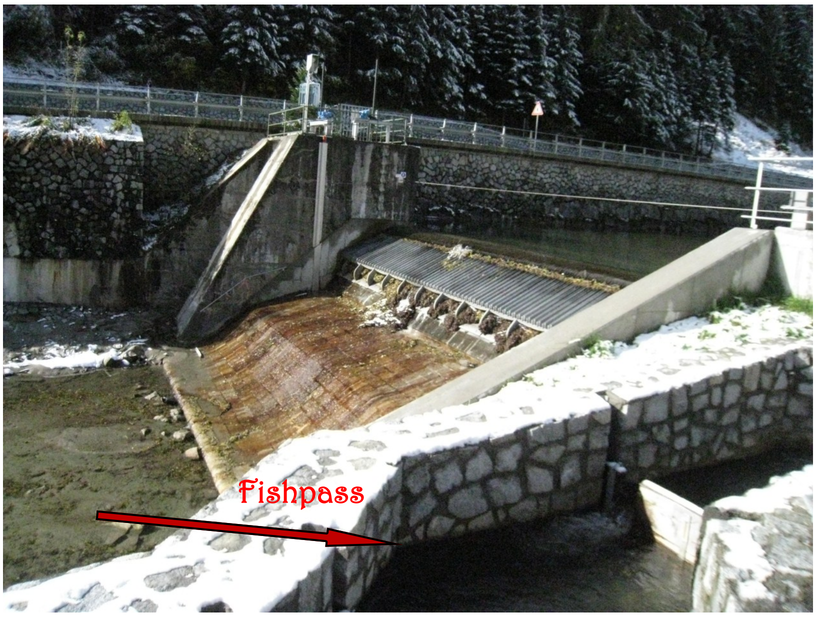


Photo 1-2. Dam on a river with *micro* impoundment for *mini HPP* (20 MW) in the Alps (October 10, 2013, South Tirol, Italy).

Photo 1-3. Low water level in dry season of large the Nam Ngum reservoir (maximum storage is approximately 8.5 billion meters^3) – the largest body of water in Laos PDR (May 6, 2010, Laos).

Inventory of Dams (Graf 2003). Much more dams are not in the inventory lists. That means that official list of impoundments should multiply minimum twice.

It should be noted that the reservoir is highly heterogeneous basin, to a large extent a transition between the river and the lake, so it can be an object of study by Limnology (Marce & Armengol 2010). As a result of dam construction there are significant changes of hydrobiological, hydrological, hydrochemical and hydrophysical regime of the regulated watercourse. One of the negative processes affecting the reservoir and the watercourse on which it is built, is the process of erosion. The scheme of erosion and sedimentation in the typical reservoir is well described by B. Dargahi (2012) – Fig. 1-1.

Also, in the manner that pond which description is given in the Chapter 9 is responded to shallow, since its greatest depth is less than 10 m (only about 3.5 m) and the average depth is less than 3.0 m. The reservoir of this type is related to short-term reg-

Photo 1-4. Author closely near of long time ago formed the mini reservoir in Natural park in Burma (August 23, 2011).

Photo 1-5. Traditional cascade dam from colonial period of the mini reservoir in Natural park in Burma (August 23, 2011).

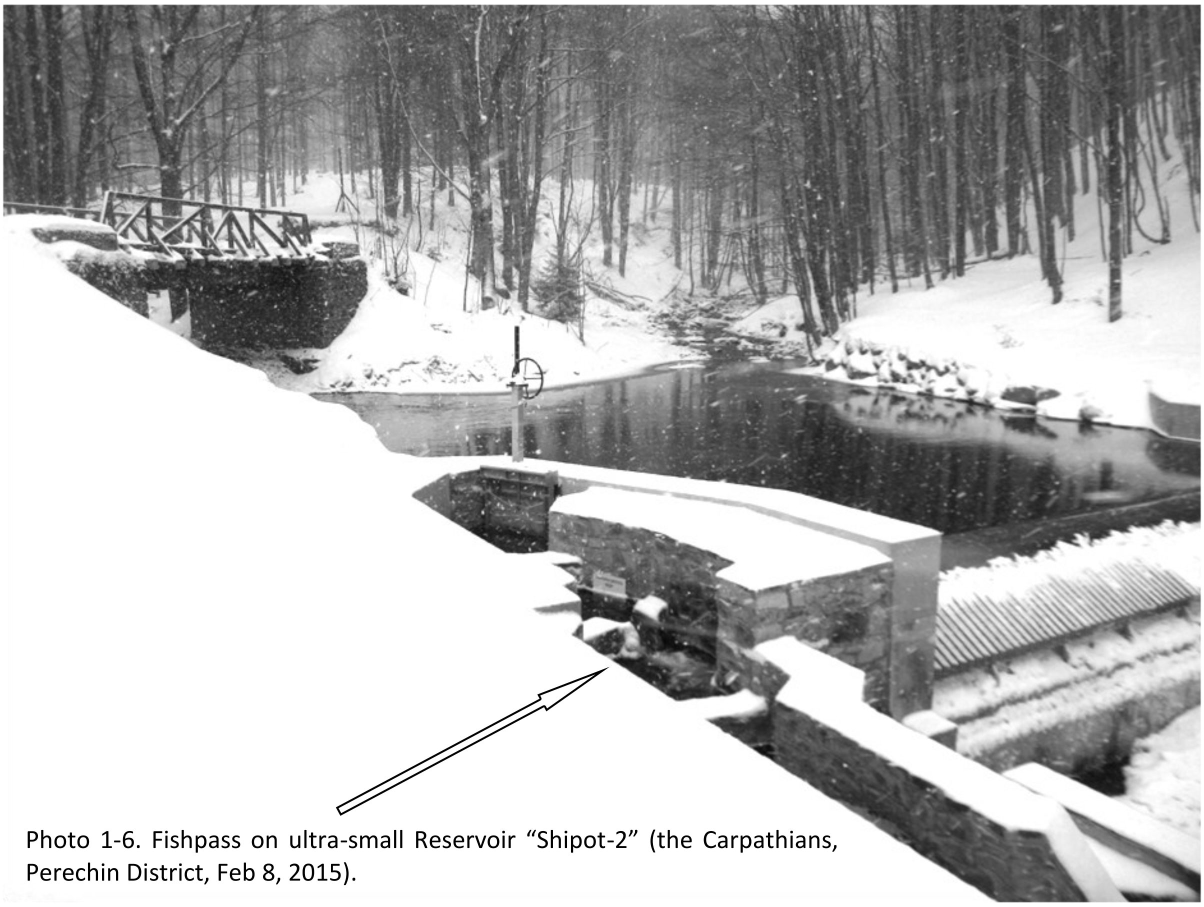


Photo 1-6. Fishpass on ultra-small Reservoir "Shipot-2" (the Carpathians, Perechin District, Feb 8, 2015).

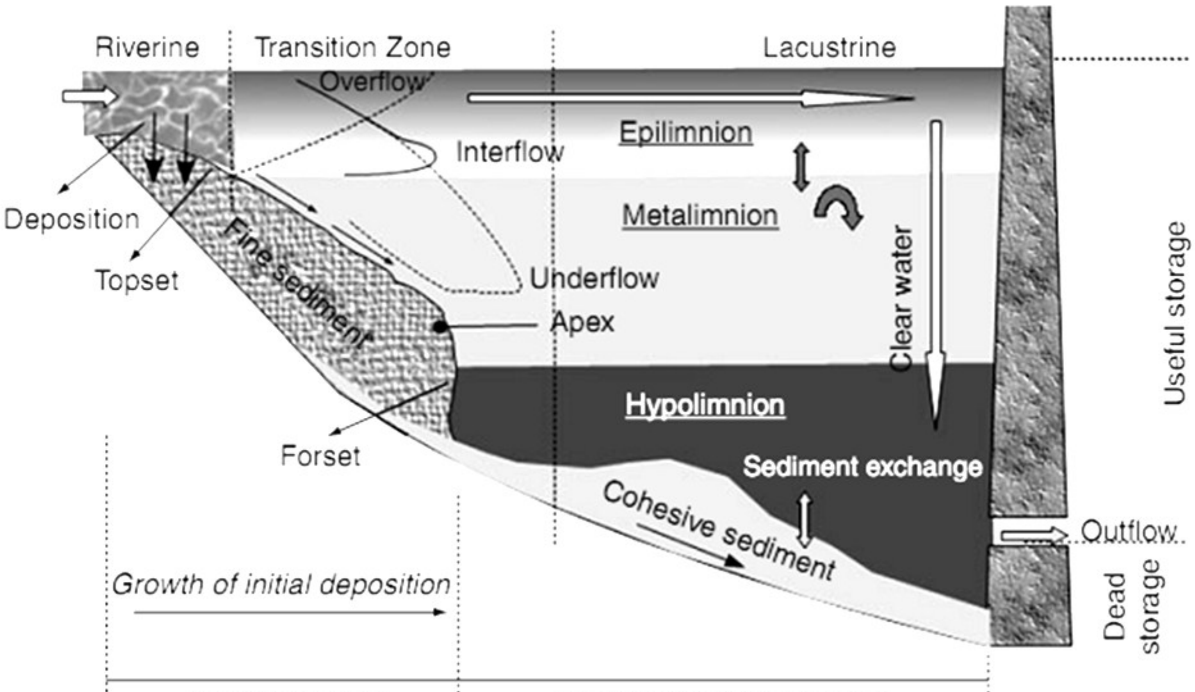


Fig. 1-1. The nature of accumulation of sediments in the reservoir (from B. Dargahi, 2012 – Fig. 3 on page 634 but B&W. Reproduced by courtesy of Dr. B. Dargahi).

ulation of runoff and extraordinary water exchange. The normal hydrological regime of such reservoir is unstable. Its upper riverine zone is not transformed into real lacustrine, and only pseudo-epilimnion exist, as due to total shallowness and fast water flow with even not formed metalimnion (Fig. 1-2). Anyway appear stagnant zone as down sluices is absent or permanently closed due to functioning of derivative canal. Other way of water flowing out of the reservoir basin is a fishpass (Photo 1-2 & 1-6).

The construction of reservoirs of different purpose occurred in ancient times and is still carry on today. They are created for irrigation, water supply, navigation and with anti-flood purpose (Avakian et al., 1979). However, one of the major industries that predetermines creation of reservoirs is hydropower.

Recently, the number of studying reports concerning water quality from *HPP* increased (Bunea et al. 2012). Scientists try to improve water quality, especially level of oxygen. Generally, in small reservoirs the low oxygen level isn't threat due to high exchanging of water. Some influence is caused by organic sediments from the reservoir bottom but it is rapidly compensated. When the decaying organic sediments decompose, they absorb the oxygen from water, producing sulphureted hydrogen, carbon dioxide and methane (in content like greenhouse gas). This pollution can alters the local flora and fauna, even causing total extermination of some aquatic species but in rebuilding ecosystem with large and/or deep reservoirs and giant *HPP*.

Note that a small reservoir for the accumulation of precipitation differs from such typical schemes (Fig. 1-3). Some types of erosion listed above are absent (landslide, shoreline, and other is negligible – channel, meandering (Fig. 1-4). Such scheme is actual for small rivers and creeks of the mountain region of the Carpathians on example mainly of the small Reservoir of *HPP* "Shipot-1" and "Shipot-2".

So, the main factor in the formation of sedimentation into the bottom of the reservoir "Shipot 1" that on the Shipot River (see Chapter 9) may be the waste water from fish ponds, leaf litter, and only then erosion.

One of the effects of created reservoirs on the environment is the increase in intensity of the emission of greenhouse gases, namely CO_2, CH_4 (methane), and N_2O. As a significant component of the global balance of nitrogen emphasize J. A. Harrison et al. (2009)

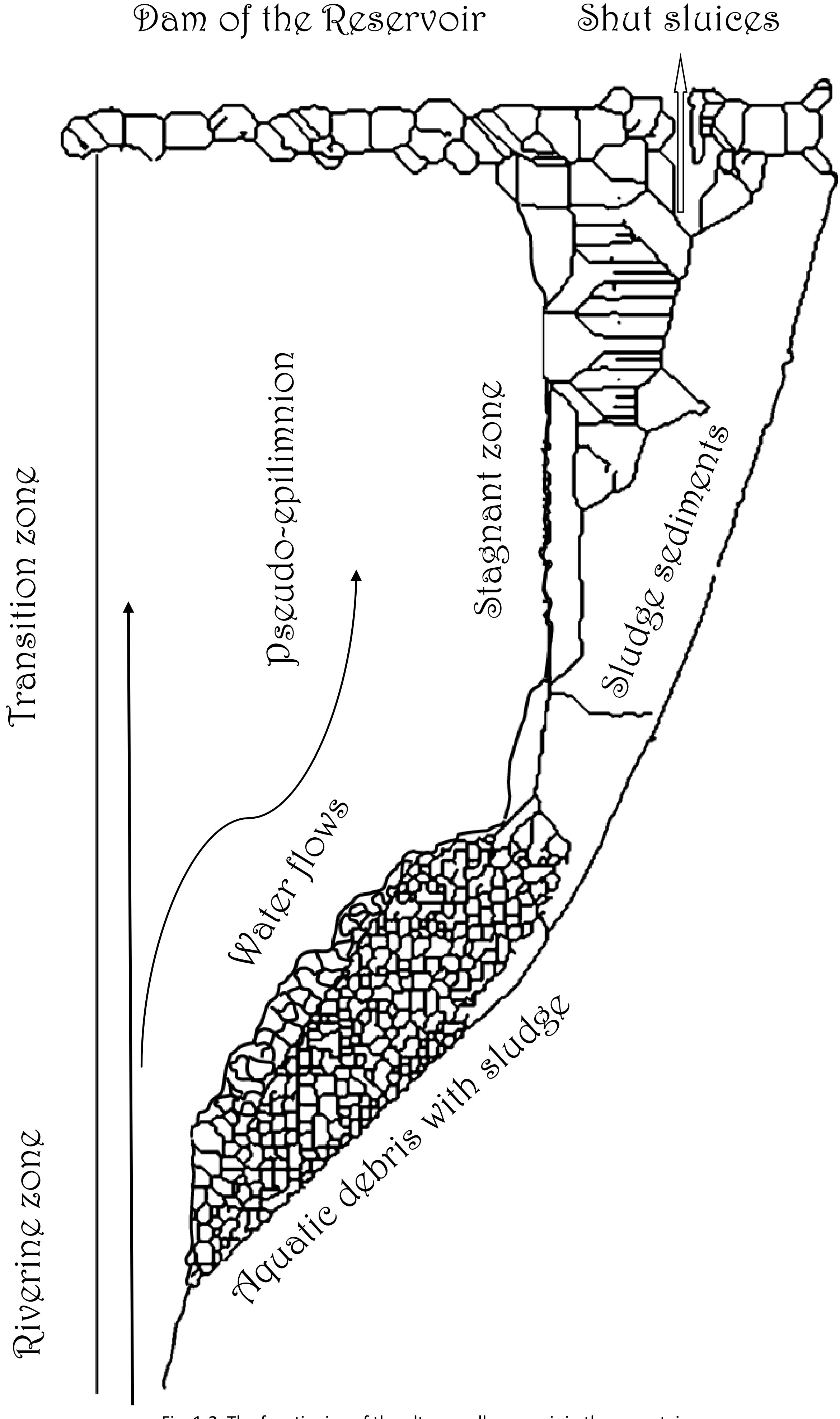


Fig. 1-2. The functioning of the ultra-small reservoir in the mountains area.

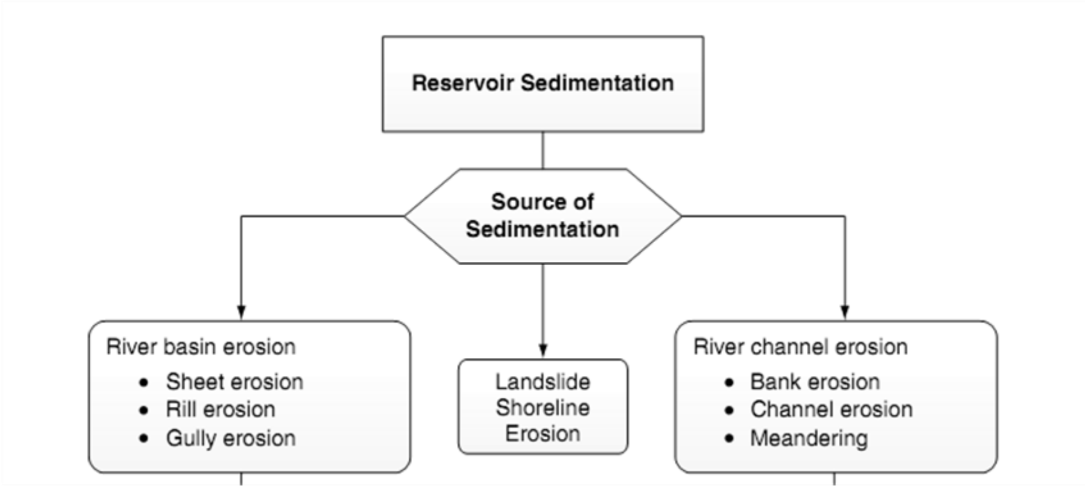


Fig. 1-3. Sedimentation in the reservoir (Dargahi , 2012 – fragment of the figure 1 on page 629. Reproduced by courtesy of Dr. B. Dargahi).

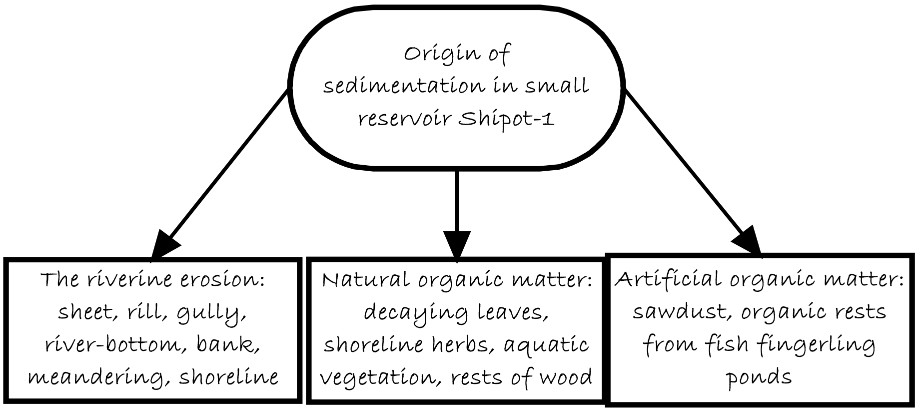


Fig. 1-4. Sedimentation in the reservoir Shipot - 1.

the process of separation of this element from the surface of lakes and reservoirs. Study of small reservoirs in the Alps (Diem et al. 2012) showed that during the day with one square meter of their surface, on average, is allocated 970 ± 340 mg of carbon dioxide and 0.20 ± 0.15 of methane. Should say, that the results of study by C. Tong et al. (2016) confirm methane production is the biogeochemistry process with the hoghest spatial variability in soils of different types.

The greater the rate of discharge N_2O was only observed in lowland reservoirs, where the extraction of this gas is measured in grams. Similar data was obtained by C. J. D. Matthews et al. (2005).

For the three small reservoirs in Ontario (Canada), it was found that the CO_2 production in small reservoirs is not directly related to the amount of deposited in bottom sediments and on the coast of the organic substances of various forms and depends on the season of existence from replenishment of basin. Over time, the amount of formation of carbon decreases from a maximum to a minimum in 797 408 kg of carbon per hectare per season (annual ?). As for methane, its production on the contrary is growing!

It is clear that the reservoirs significantly alter the distribution of fish population – not only in quality but also in quantity. So, V. Draštik et al. (2008) studied the distribution of fish population in cascade and Nakashima reservoirs using hydroacoustic instruments. It turned out that near the dam are holding the larger fish, but the numbers are lower than at sites upstream. Also, there is a difference in available food resources, in particular primary production. Such differences in a small reservoir would be negligible and would not entail significant differences in the fish population, because the depths in the waters are not significant and metalimnion and hypolimnion is actually missing. So, it looks than in mini- and micro-reservoirs the deoxygenation process and zone of thermocline doesn't exist and the riverine smoothly passing into transition zone and then into lacustrine zone that is widespread near the dam.

On the positive side of the existence of the reservoirs can be noted for their recreational value (Elakhovskii 1990). The more close the reservoir prior to human settlements, the higher recreational value. However, you should adhere to the norms of noise pollution as excessive approximation is invalid from the point of view of life comfort of a local population.

It is clear that a redistribution of sedimentation process within the small reservoir will differ from that shown in Fig. 1-1, since in this reservoir due to the small size and depth, is formed only pseudo-epilimnion. In favor of our hypothesis of a significant accumulation in the reservoir Shipot-1 (see Chapter 9) due to the sediments and the products of metabolism from fish ponds, showed a large area of shallow water at the mouth of the wastewater stream in front and along the left bank of the reservoir (sampling sites No 4), which develops a huge number of ciliates and other microinvertebrates.

If the impact of large or medium-sized reservoirs on the environment have been well studied, with ultra-small reservoirs situation is not so simple and their visible impact in the subject of research isn't confirmed (Albergel 2012) . You may agree with the above author that for amphibians and reptiles associated with aquatic environment, a small or ultra-small reservoir is a favorable factor. Also vegetation, both shore and aquatic – which is formed on its banks, is attractive to birds, especially shorebirds and water birds. However, it should also accept his confirmation of the reservoir with a volume of up to 50.000 cubic meters at risk by uncontrolled destruction of the dam, but in most cases the dam is under constant review, because its proper operation depends on the efficiency and, in the end result, the profitability of the object.

Special studies of the impact of small reservoirs on the environment, held in Spain, do not show any significant effect in most cases (Menendez et al. 2012). In particular, did not change pH, conductivity, and oxygen saturation, soluble forms of phosphorus and inorganic nitrogen as well as indices of heterogeneity of benthic groups above and below the reservoirs in the river (Ibid.). However, small reservoirs have a important influence on the decomposition of leaf litter, the intensity of which decreases significantly downstream (ibid.).

An important issue in the functioning of small reservoirs is the distribution of nutrients, in particular nitrogen, phosphorus and associated metals such as iron and manganese. So, M. Martynova (2004) notes the sharp growth of phosphorus in suspension state, iron and manganese in 20 cm layer of bottom water.

D. W. Rodgers et al. (1995) studied the processes of methylation and redistribution of mercury in the reservoirs of hydroelectric power plants and concluded that the accumulation of mercury linked with organic matter, which, in turn, directly affects the release of methane. This is another argument in favor of the need for periodic cleaning of the reservoir.

2. HYDROPOWER IN TRANSCARPATHIANS PROVINCE (ZAKARPATTIA, UKRAINE) AND IN SOUTH TYROL (ITALY).

Abstract. The author trying to compare present state of highly developed sector of hydropower economy of South Tirol in Italy and Transcarpathians province of Ukraine, where are perfect possibilities on building a lot of small– mini-, and micro hydro-electric power plants (HPP). This can help not only Ukrainian regional economy, what is now in the very bad state but will influence positively the ecological state of the region, provide by good paid work for local communities.

Key words: Hydroelectric power plants, South Tirol, Transcarpathians Province, energy consumption, renewable energy.

2-1. Introduction or the main aims to analyze: economical approach.

• Energy consumption by sector in South Tyrol.

• Energy consumption by source in South Tyrol.

• Renewable energy sources and their boundaries.

• Hydropower and its benefits.

• Commercial license of the hydropower plant in South Tyrol.

• Current status of hydropower in South Tyrol.

• The intention of the government of South Tyrol.

• The development potential of hydropower in Transcarpathians.

Energy consumption by sector (A) and by source (B) in South Tyrol.

As it is visible from the Fig. 2-1 the main part of electricity consumption in South Tyrol is covered by hydropower energy. Hydropower energy is comparable with fossil sources and can compete, e.g. with oil and coil.

2-2. Renewable energy sources and their boundaries (Fig. 2-2).

Down are given short characteristics of different types of renewable family:

Geothermic. Positive – Open source, and Negative that it needs a lot of time to implement changes in production.

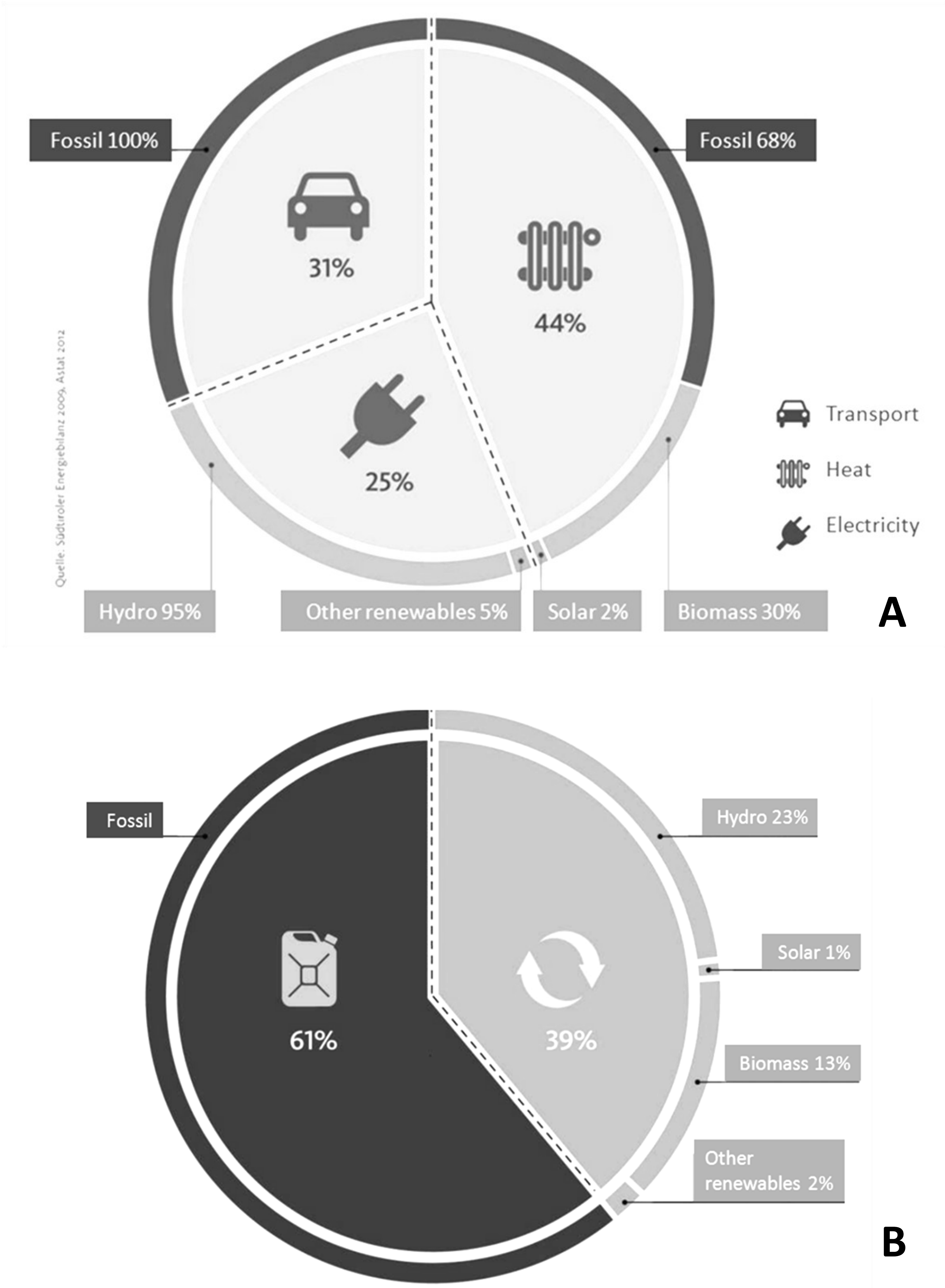


Fig. 2-1. Scheme of energy consumption structure in South Tyrol (A – by sectors of economy, and B – by sources from environment.

Solar. Positive – Open source, and Negative that it is Volatile and unpredictable, and has high costs for waste management.

Wind. Positive – Open source, and Negative that it is Volatile and unpredictable, has Optic impact, and a Negative impact on fertility.

Biomass. Positive – The production of heat and electricity, and The normative and maximum load on the production. Negative – A lot of time to implement changes in production, and Unstable product prices .

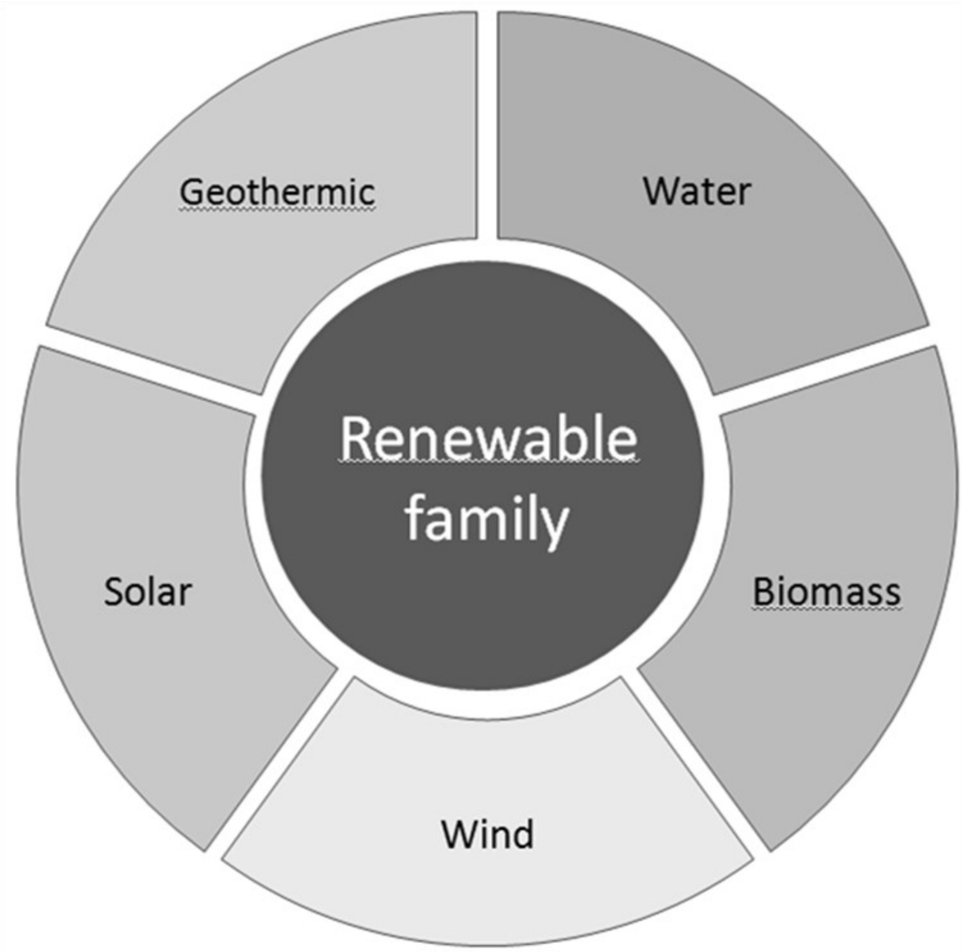


Fig. 2-2. Scheme of renewable family of energy sources.

Water. Positive – Wide range of performance. Flexibility and the ability to store, Very high efficiency, and Low maintenance. Negative – Large investment costs .

2-3. Hydropower and its benefits:

A sustainable solution to climate change.

Advanced technology.

The independence and stability of the system.

More competitive electricity.

The most efficient production of electricity.

Let us to show some peculiarities of the last statement “The most efficient production of electricity”. The efficiency of power generation in General is shown in the Fig. 2-3. From left these are:

- Combined-Cycle Power Plant.
- Brown coal power plant.
- Stone coal power plant.
- Water power plant.
- The Wind power plant.
- Solar cell.
- Burning substance cell.

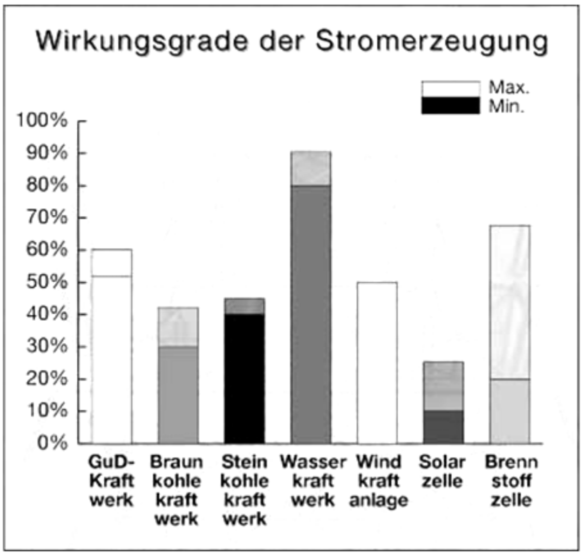


Fig. 2-3. The efficiency of power generation.

So, efficiency of water power plants of modern type is the highest. That’s due to the following features:

High return on energy. During its existence, the hydropower plant produces 200 times more energy than is necessary for its creation, maintenance and operation.

The effectiveness of sources. During the production process water is not consumed. Local pollution and air pollution, and waste from energy production are negligible.

High energy quotient. A simple process of converting mechanical energy into electrical energy, which ensures minimum losses. The storage capacity and flexibility. -It is important to bridge the gap between supply and demand for energy.

Hydroelectric power is more than simply competitive (Fig. 2-4). Its generation is the very low cost, therefore the hydropower production is the most economically advantageous. The process of hydropower energy production is not sensitive to price fluctuations of fuel and has long term profitability. Construction of hydropower plant needs enough high capital costs and approximately long construction period, but the low cost of operation and maintenance. It has an important multiplier effect on local communities. Cannot be underestimated importance or even vitality of Hydroelectric power plants for water supply, irrigation and flood protection, especially in the mountainous regions.

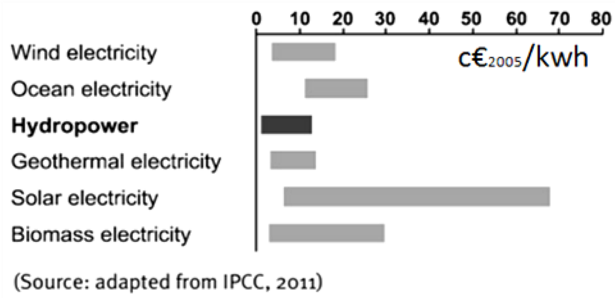


Fig. 2-4. The average cost for electricity generation.

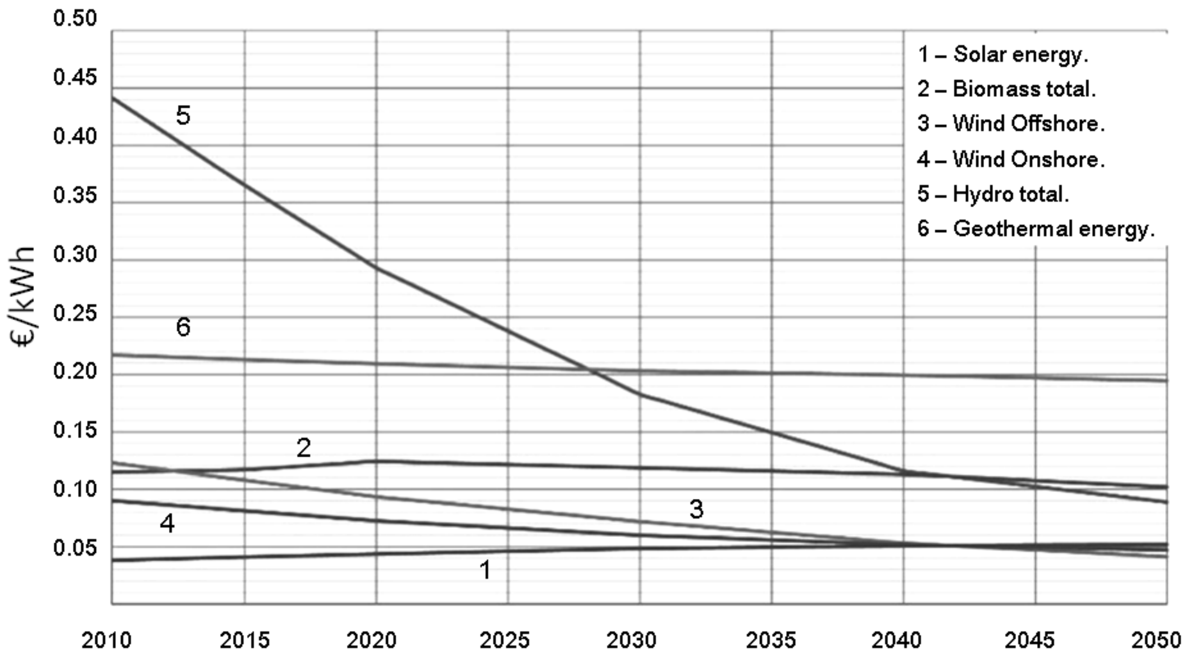


Fig. 2-5. Assumed other costs for the different technologies for use of renewable energy sources by 2050.

The independence and stability of the system of hydropower energy supply. Energy independence and energy self-sufficient is important characteristic of hydropower energy, as well as it is a renewable domestic resource and it increases the number of other possible renewable energy sources that should be developed in connection with storage. Hydropower makes a significant contribution to regional (or local as mini- or micro- *HPPs*) economic and social development. System stability and security of supply means that hydropower is efficient, effective, predictable, controllable, mature, proven and reliable (Fig. 2-5). Moreover, hydropower energy in enough amounts improves the stability and reliability of the electric grid of the area.

Hydropower energy is a sustainable solution to climate change (Fig. 2-6). Low carbon residue means "Low carbon electricity". Hydropower can provide significant amounts of renewable low carbon electricity, as with standard load and at maximum. This can be a key contribution to mitigation of climate change. So, can have global influence on Mankind and Nature.

It should be noted, that hydropower potential in Europe is about half-realized (Fig. 2-7), but when compare different regions the picture can be absolutely difference. Let us look

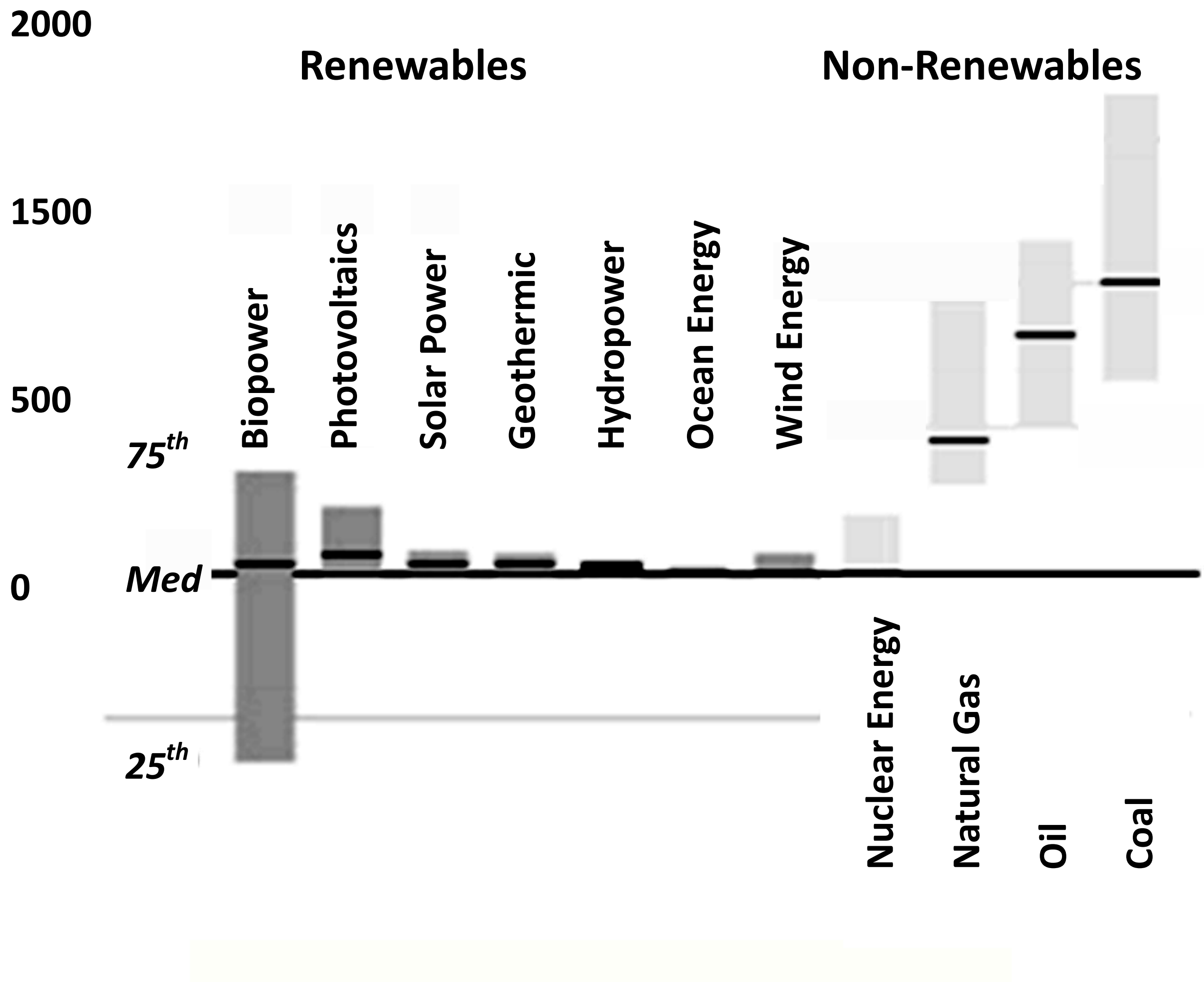


Fig. 2-6. Lifecycle GHG emissions, g CO_2 eq/kWh.

on the situation in South Tyrol (Fig. 2-8), where building of *HPPs* achieved practically its maximum, and the question is not "to built or not to built" but "where to built &" (Table 2-1). Tendency to projects of building the mini- and small *HPPs* is obvious. Let us see the

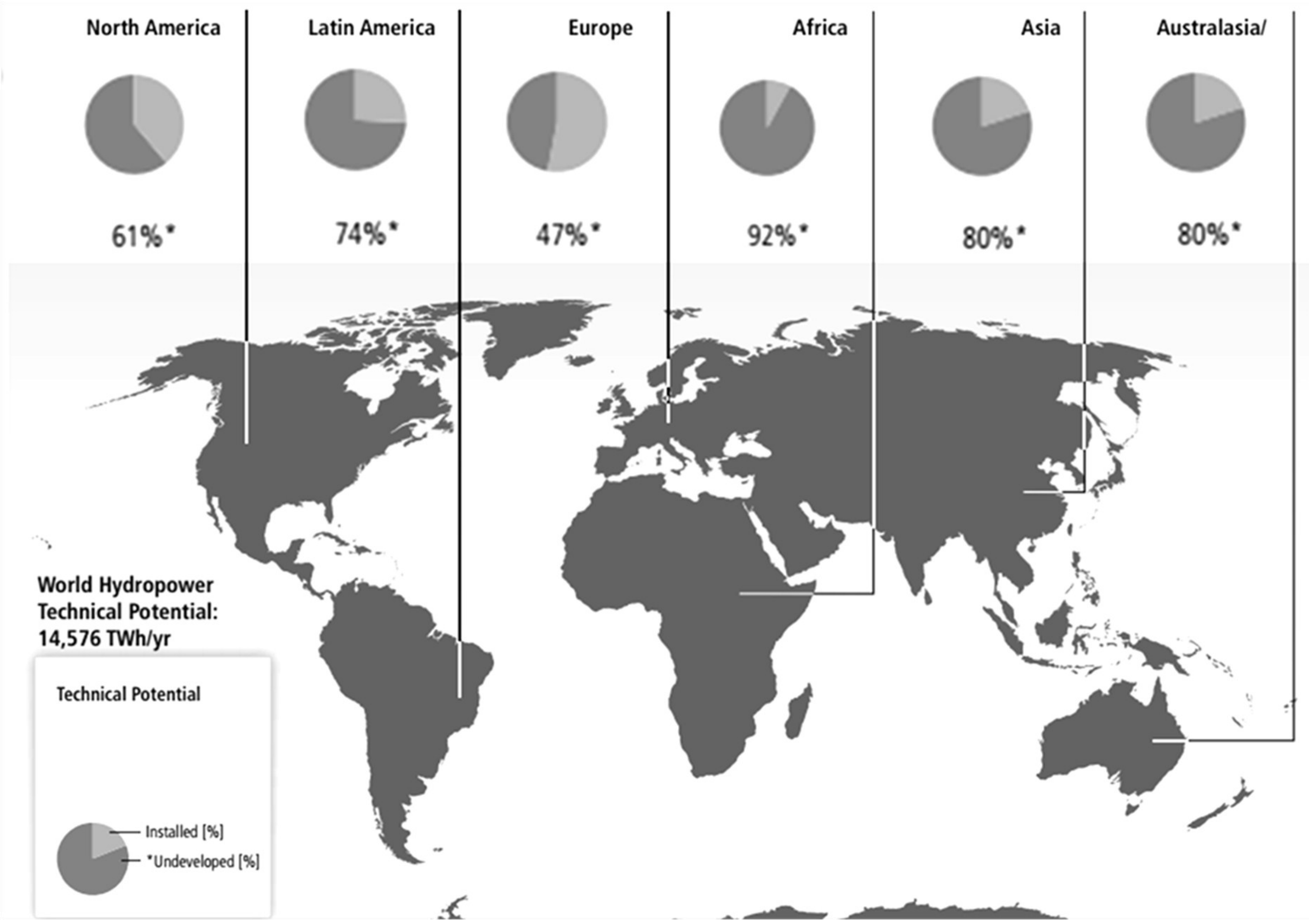


Fig. 1-7. Hydroelectric power potential of the World.

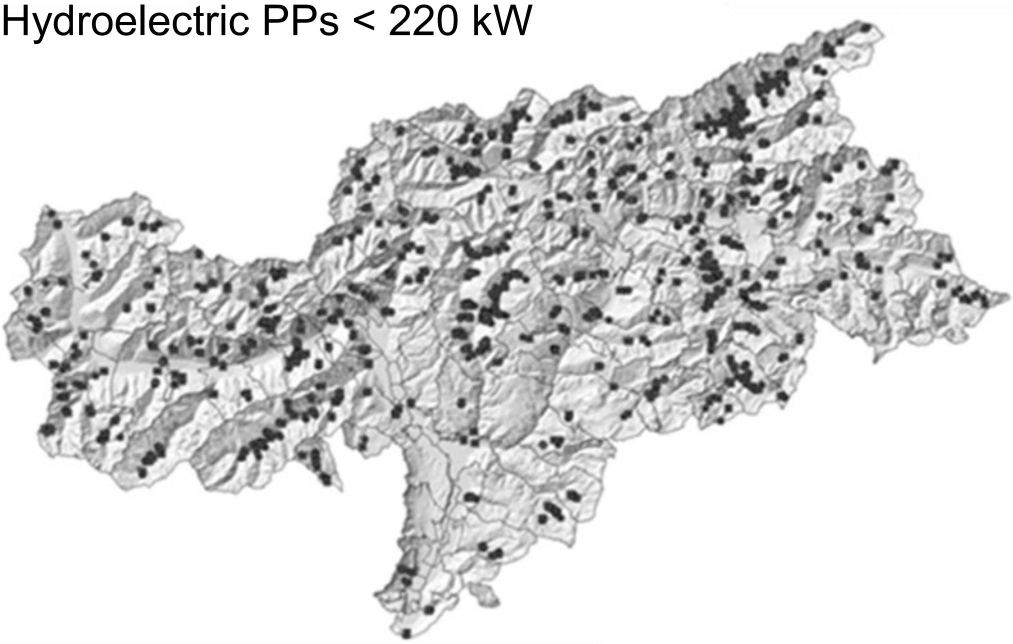
2-1. Commercial licenses hydropower plant in South Tyrol.

Licenses	2009	2010	2011	2012	05/2013
< 200 кВт	12	15	24	12	6
200 > kW < 3000	12	15	7	8	1
kW > 3000	3	0	1	0	0
new	27	30	32	20	7
prolongation+ new	93	94	101	53	16

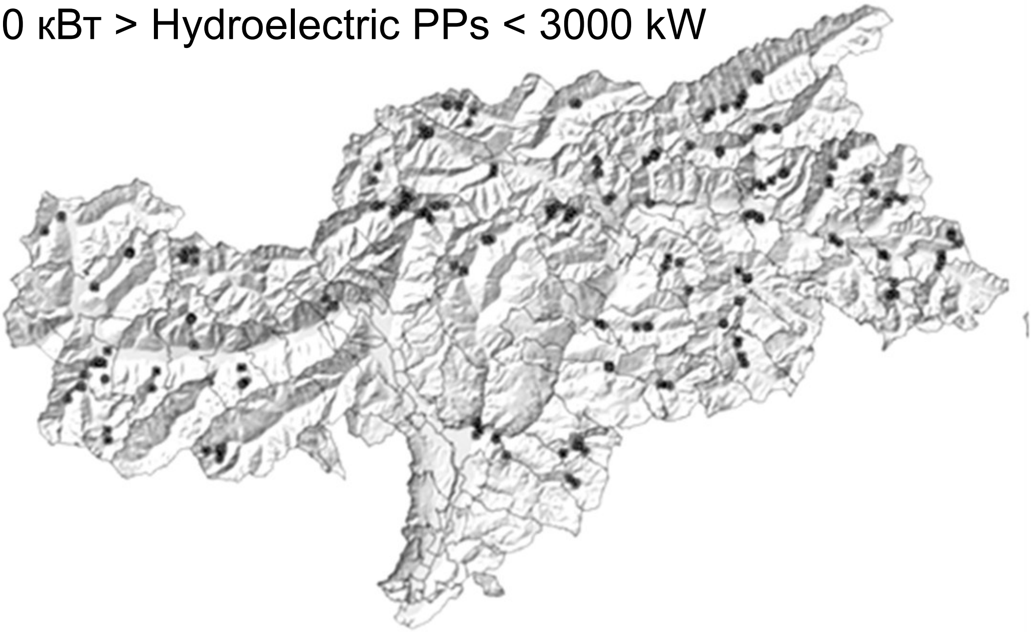
current status of hydropower in South Tyrol (Fig. 2-8). In 2013: 822 HPPs < 220 kW, 144 *HPPs* 220 > kW < 3000, 30 *HPPs* > 3000 kW. In total 996 *HPPs* with power 891 MW and annual productivity 5.5 GW.

The Declaration of the government of South Tyrol from may 2014: 80 applications for hydropower development are such that you can approve. This would bring the total investment volume of EUR 1 billion to the economy, so the approval process of applica-tions needs to be accelerated! Information at the Conference from March 2014, Oslo: In Norway in 2013 issued more than 50 licenses. So, the process goes.

Hydroelectric PPs < 220 kW



220 кВт > Hydroelectric PPs < 3000 kW



Hydroelectric PPs > 3000 kW

Fig. 1-8. *HPPs* location in South Tirol.

European Parliament Decision from 27.01.2014 “A 2030 framework on climate and energy”. It is noted that the stimulation of macrofinance will be a vital element for increasing the share of renewable energy sources and noted that, in connection with this, the decentralized supply of renewable energy can help to reduce the problems faced by electricity networks and reduce the need for new transmission lines and hence the associated costs, as decentralized technologies are much closer to end consumers.

South Tirol		Zakarpattia
512.000	population	1.300.000
7.400 [km²]	area	12.777 [km²]
~42 %	forests	~ 75%

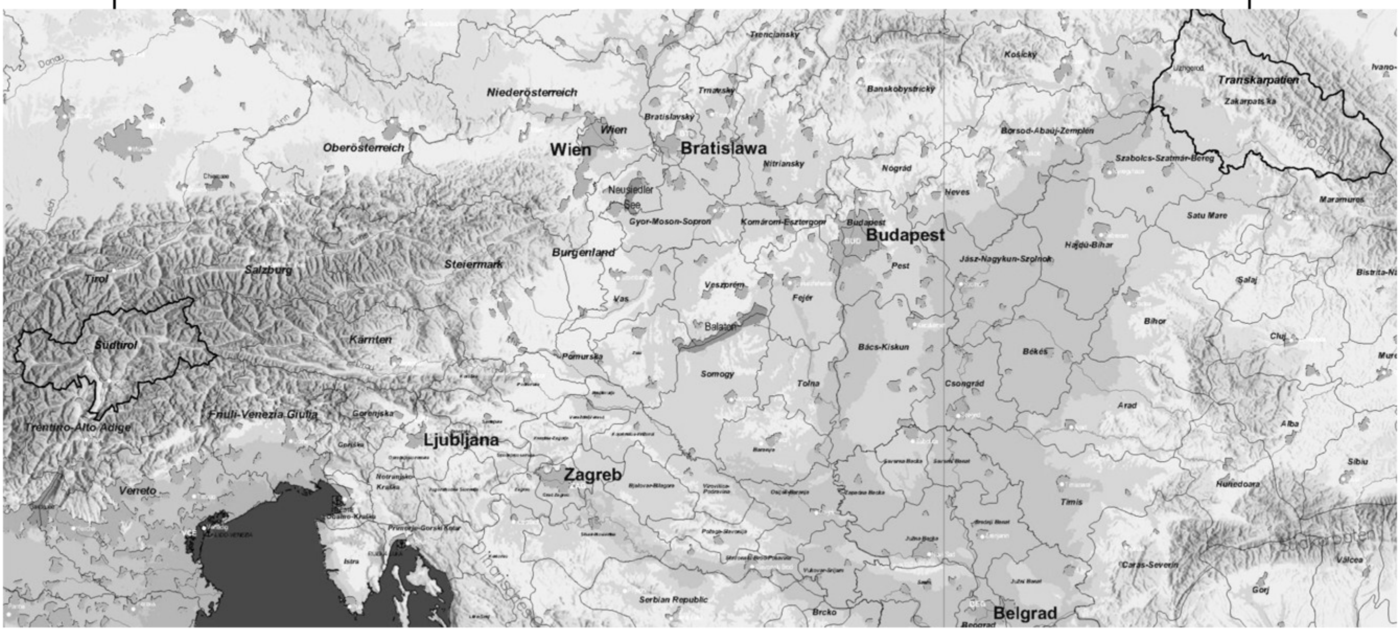


Fig. 2-9. Comparable scheme of South Tyrol and Zakapattia in context of development of hydro-energetics.

2-4. Potential of hydropower development in Zakarpattia (Transcarpathians).

This Province of Ukraine can compare with South Tyrol (Fig. 2-9). Existing hydropower facilities in the Carpathians region: The electrical load of the Transcarpathians region is around 450 MW. Three hydro-power plants (served by Zakarpattyaoblenergo) with a total capacity of 31.55 MW to annually produce 6-9% of the total electricity consumption in the region of the Tereblya-Rika HPP (27,0 MW, commissioned in 1956), Onokovska HPP (2.65 MW, commissioned in 1942) and Uzhhorod HPP (1.9 MW, commissioned in 1942).

The hydrological potential of small rivers in the Transcarpathians province (Fig. 2-10,

2-2. Existing hydropower facilities in the Carpathians region.

River*	Province	Capacity (kW)	Production(GWh/year)
Biliy Cheremosh*	Chernovitska	650	2.73
Bilyn (Tisza basin)	Zakarpattia	630	2.50
Borzhava* (Tisza basen)	Zakarpattia	n/a	n/a
Brusturianka (Tisza basen)	Zakarpattia	n/a	n/a
Bystritsia*	Lvivska	270	1.08
Cheremosh (channel)*	Chernovitska	200	0.64
Cheremosh (channel)*	Chernovitska	100	0.32
Cheremosh (channel)*	Chernovitska	100	0.32
Chorna Tisza*	Zakarpattia	n/a	n/a
Dnister*	Lvivska	250	1.15
Krasnoshurka (Tisza basin)	Zakarpattia	800	3.00
Oriava*	Lvivska	100	0.3
Prut*	Ivano-Frankivska	800	3.04
Shipot (Shipot-1)	Zakarpattia	1094	3.20
Shipot (Shipot-2)	Zakarpattia	1000	3,20
Siret*	Chernovitska	525	2.205
Striy*	Lvivs'ka	500	1.925
Striy*	Lvivs'ka	450	1.44
Tereblia (channel)*	Zakarpattia	360	1.08
Turya	Zakarpattia	n/a	n/a
Uzh*(near Onokovtsi vil.)	Zakarpattia	2650	10.6
Uzh*(near Uzhhorod city)	Zakarpattia	1900	7.6
Velyka Nadvirnianska*	Ivano-Frankivska	320	0.96
Zubrya*	Lvivska	300	0.9

Source: WP2. Existing and prospected small hydro power plants in the Caucasus and Catpathians - Document WP2 Shyca Figure 1. & UKRAINE SUSTAINABLE ENERGY LENDING FACILITY (USELF) + Renewable Energy in Ukraine Technical Report: Small Hydro. Direct information from Statistical Department of state Admin. Of zakarpattia in 2014.

Notes: * Most of these facilities were constructed in the 1950 s.* * Capacity factor calculated from data in table by Black & Veatch.

Fig. 2-10. Geological formations and altitudes in Zakarpattia Province. Possible place for building the mini-HPP is marked by ellipse.

2-11, 2-12).

Small rivers:

- Chorna Tisza (22.84 MW)
- Kosivska (16 MW)
- Bila Tisza (15.54 MW)
- Brusturianka (slightly more than 10 MW),
- Luta (a little more than

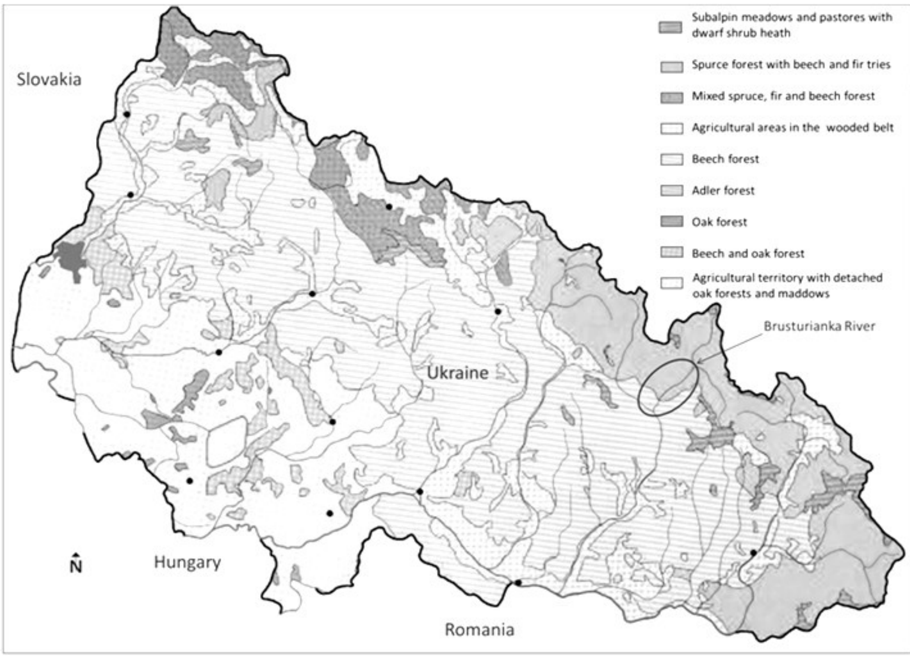


Fig. 2-11. Forest vegetation in Zakarpattia. Possible place for building the mini-*HPPs* is marked by ellipse.

10 MW),

- Mokrianska (slightly more than 10 MW)
- Mala Moshurca (slightly more than 10 MW)
- Vicha (a little more than 10 MW)
- Serednia (slightly more than 10 MW)

Small *HPPs* (served by the “Zakarpattiaoblenergo”):

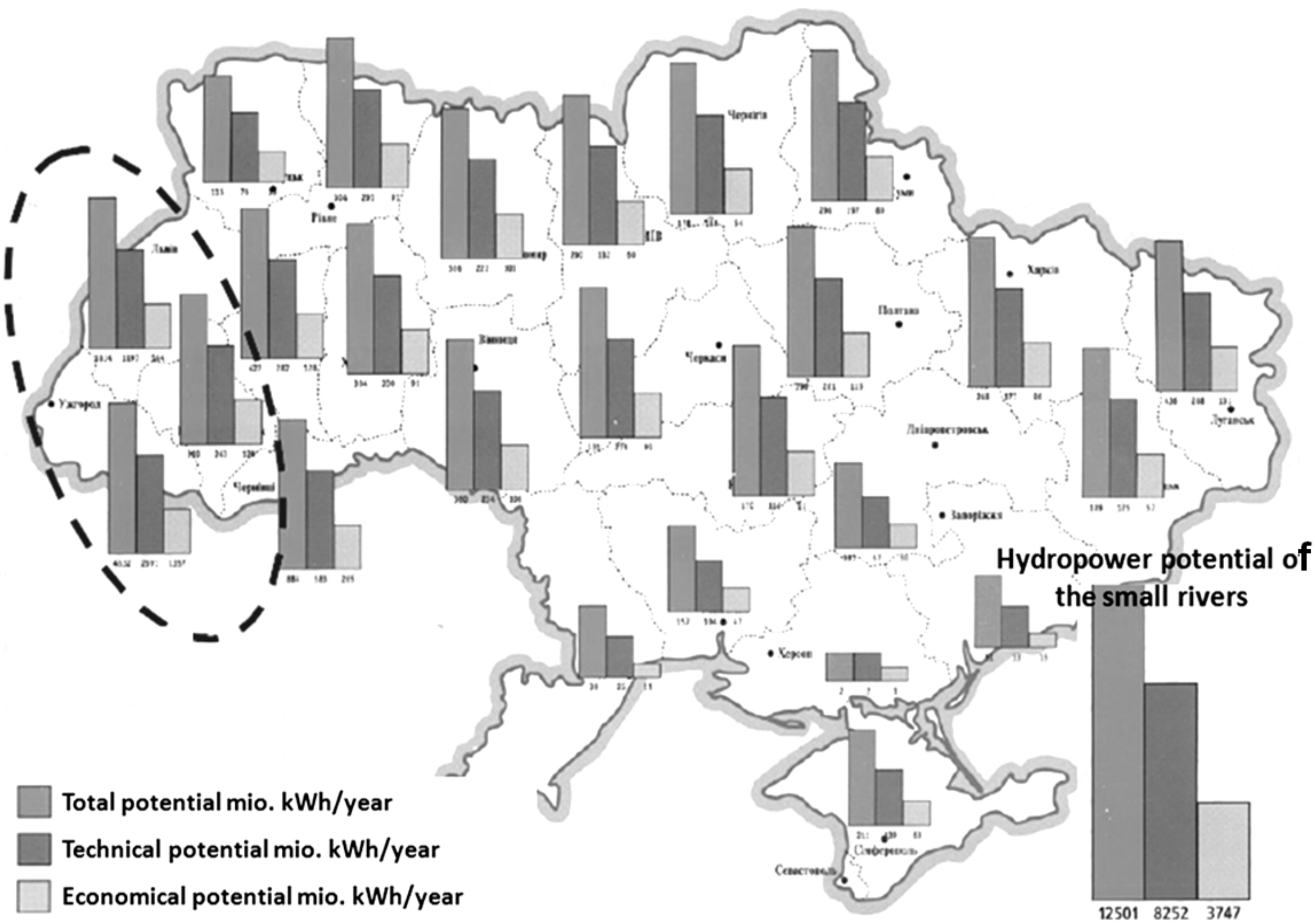


Fig. 2-12. The hydropotential of small rivers of Ukraine. The Carpathians Provinces are marked by ellipse. From: UKRAINE SUSTAINABLE ENERGY LENDING FACILITY (USELF). Renewable Energy in Ukraine Technical Report: small *Hydro PPs*.

- The Tereblia-Rika or the Vilshanska (27 MW) ~ 30 %
- Onokivska (2.65 MW) ~ 50 %
- Uzhhorodska (1.94 MW) ~ 50 %

In General, the production of electricity of ultra-high pressure:

185 million kW & 10 % of electricity consumed.

The energy potential of small rivers:

Economic potential 1357 mln kWh/a, & Technical potential 2991 mln kWh/a.

2-5. Conclusions and Recommendations.

The main objectives of national programs for the development of electricity production of ultra-high pressure (selection of the Western regions):

Reconstruction / upgrade of existing facilities of electricity of ultra-high pressure.

Reconstruction of production of electricity of ultra-high pressure with stored hydro-operations.

Reconstruction temporarily closed production of electricity of ultra-high pressure man-made threat of hydro-operations.

The construction of new production facilities of electricity of ultra-high pressure on the existing reservoirs.

The new decentralized production of electricity of ultra-high pressure on small canals and rivers to supply power to remote regions.

The creation of new industries of electricity of ultra-high pressure on the rivers Tisza and Dniester to solve problems with power supply -Western part and the control of floods in these regions (it is of great importance for the agricultural sector).

The increased maneuvering capabilities of harmonization of Ukrainian and European energy markets and the European Union for the coordination of transmission of electricity (Western power structures have a greater sensitivity to energy import / export energy flows.

The reduction of greenhouse gas emissions, especially in the Western part of operational monitoring of transboundary transfer of harmful substances.

The process of developing a strategy for the production of electricity of ultra-high pressure was based on a detailed study of existing facilities, the design documentation and previous studies of hydropower potential. Strategy development does not include the assessment of specific hydropower projects, especially in selective application that has good chances to become the most economically beneficial use of hydropower.

3. HYDROPOWER OF TRANSCARPATHIA: BETWEEN SCYLLA OF "GREEN TARIFF" AND THE CHARYBDIS OF ENERGY DEPENDENCE.

Abstract. The state of the energy sector and socio-economic aspects of construction and operation of mini hydropower plants (mini-HPPs), usually defined as 100 to 1.000 kW in Zakarpattia (Transcarpathians) is considered. A wide range of issues related to the construction of new hydropower plants and selling electricity by green tariff as well as possible negative impact on the environment is scrutinized.

Keywords: mini-HPPs, energy availability, environmental expertise, "green tariff".

3-1. Introduction

The upsurge of interests in the development of hydropower resources in Transcarpathians region in recent years depends on several factors. The impetus for this was the adoption at the session of the Transcarpathians Regional Council resonance "Program of integrated water resources of Transcarpathians Region" (25/02/2011, №161), as well-developed and adopted in the framework of the Program "Scheme of location of small hydropower plants in the Transcarpathians region "(decision of the council dated 04/11/2011, №310) (The program of integrated water resources 2011).

If deeply look on the merits, it seems the problem of Transcarpathians region energy shot with no agenda. Analysis of electricity consumers in the region indicates an annual growth of its amount. Thus, to consumers of the region during 2013 had been ensured delivery of over 1 750 gigawatt hours (GW) of electricity in the network, thus about 38 GW (over 2%) more than in 2012. There is also increase of electricity consumption by population up to 43 GW or 4.5% if compared to 2012 (Tsvelykh 2014).

Actually, the electricity of hydropower plants for 2013 grew to 123.4 GW and amounted to over 7% of the total electricity consumption in the region. Three solar power plants with total capacity of 18 MW generated 13 GW of energy.

Consequently, actual electricity production in 2013 was almost 137 GW, accounting for nearly 8% of total consumption in comparison with the year 2012 increased by 14 GW (12%). In order to increase its own production of electricity and renewable energy in the region in 2013 in Uzhhorod district was commissioned by solar power plants near Irlyava village with total capacity of 9.6 MW, and near Guta – 3.0 MW (Tsvelykh 2014).

This once again confirms that the Transcarpathians region is almost entirely dependent on the supply of electricity from the power grid of Ukraine, particularly from the Burshtyn PP – or rather, "Burshtyn Energy Island".

3-2. History of Development of mini-*HPPs* in Zakarpattia.

With the independence of Ukraine the institute "Ukrhydroproekt" in 1993 elaborated the program of energy supply of Transcarpathians: "Scheme of water management of the Tisza basin". It involves construction of 33 *HPPs* with capacity from 2 to 28 MW, located in the lower and middle sections of riverbeds of the Tisza River & Teresva River with total capacity of about 400-600 MW with production of about 1.5 GW (Conclusions of public examination program 2011).

When you create a diagram, apart from the use of the hydropower potential was taken into account a flood prevention, which is relevant not only for the field have been written about but also for the Ukrainian Carpathians in General.

Later the branch of the Institute "Lvivprombudproekt" on request of Transcarpathians Province Administration elaborated the alternative "Program of energy saving and energy for the period till 2015", which includes:

1) Construction of 330 (!) small *HPPs* capacities from 0.005 MW to 1.500 MW and a total capacity of 700 MW in almost all settlements along the streams and rivers, starting from the top;

2) Building for them of water storage reservoirs that exceed three times the required volume of flood control drain.

This program – "On the Program of integrated water resources for Transcarpathians" was approved by resolution of the Regional Council No 161. It involves the use of hydro-power potential of the rivers of the region and will increase its own production of electricity up to 75% of the demand by building of mini-*HPPs* facilities.

Due to the activity of certain environmental organizations, planned and organized publications in the media, and despite the opposition of the local population, Commission on environmental, health environmental protection and safety of the Public Council at the Transcarpathians regional state administration was forced to implement in 2012 Public examination "of the Program for complex utilization of water resources of the Transcarpathians region" and "Local and regional schemes of location of small *HPPs* " (Conclusions of public examination program.. 2011).

The verdict was strongly negative, and the idea of mini-*HPPs* in Transcarpathians suffered from an integrated effort from various directions. It was recognized:

1) Today small mini-*HPPs* are not priority of state politics and their electricity is generally considered as renewable energy (unlike the more costly wind and solar, and more economical organic mass of recycled resources);

2) Exist possibility of reducing of energy consumption by 2-5 times (by the way, this mantra on the territory of Post Soviets still widespread ranging from the mid-1970s);

3) Region has no problems with electrical energy supply of local consumes, as they use only 1% of the total amount of electricity produced in Ukraine, and country is a powerful European energy exporter;

The main objection against mass building of proposed *HPPs* was that construction and dam type of mini *HPPs* of derivational type in the upper reaches of mountain rivers can lead to a regional environmental disaster due to changes in the hydrological regime and ruining of hydrofauna communities.

3-3. Results and Discussion.

In advance agree that the environmental component of the problem will be left for the consideration of conservationists and law enforcement officers. In them is a large number of serious justified complaints and comments to the practice of hydropower development in the Silver Land (ethnic name of Transcarpathians Province).

Let's not think about the operation of mini-*HPPs* in the mountainous regions of European countries, as this issue is also controversial, and we are not here to be an arbiter between the positive European experience and tough stance of Greenpeace and the World Wildlife Fund (WWF). For reference, the own production of electricity by small hydropower in Switzerland is 8%, and in Austria 10% only of the total production of electricity.

Let us consider the socio-economic component of the problem.

Now Transcarpathians consumes more electricity than produces. Actually, the hydroelectric power production in 2013 was 123.4 GW that was performed at six *HPPs* (see Table 2-2 & Tsvelykh 2014).

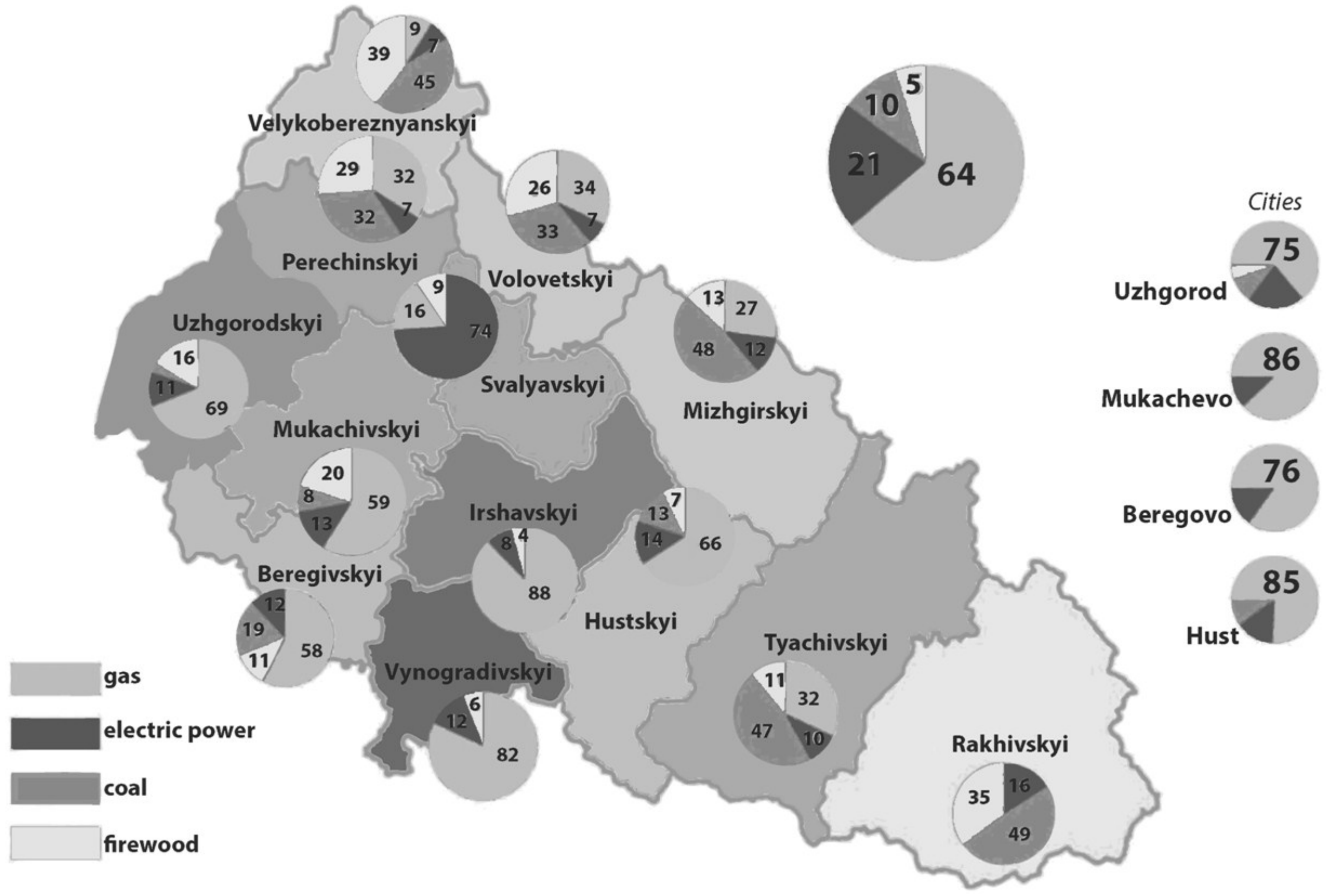


Fig. 3-1. Distribution of consumption of different types of energy in Transcarpathians Province.

So the question arises: is it still needs new hydropower plants in Transcarpathians?

Further analyses of the structure of energy consumption from different sources in Transcarpathians (data for 2010) is in the Fig. 3-1, made on the base of Tab. 1 from E. Tsvelykh (2014).

Consequently, most in manufacturing and in the home use of Transcarpathians regions consumes natural gas. In Ukraine, the more there is no more such places where converged 4 transit and export pipelines, "Dolina – Uzhgorod – State Border-2", "Soyuz", "Urengoy-Pomary-Uzhgorod " and "Progress".

It is from here exported about 80% of the total export of gas to Europe. Uninterrupted operation of all system is ensure by the 4 gas compressor stations with a total capacity of almost 500 MW, with pressure in the pipelines of 75 atmospheres. Therefore, widespread use of natural gas in the region is quite justified.

But now the situation with gas is changing dramatically. Accordingly to the requirements of the European Union and the International Monetary Fund (*IMF*) that increased cost of gas for Ukrainian consumers, political games around the gas problem are continuing.

Russian "Gazprom" is completely unpredictable, and the main task in increasing energy safety of the Transcarpathians region is to reduce the share of natural gas and improve the use of local fuels especially from the renewable energy sources.

Moreover, due to adverse natural conditions and transport logistics, some of Transcarpathians mountainous areas and even the whole Rakhiv district hardly ever get a "blue light" – gas. It is therefore necessary to develop the alternative energy – electricity. Possible solar and wind resources are not enough, so, the development of mini-*HPPs* is inevitable. Even the already mentioned "Public Expertise" was forced to admit that a significant potential of increasing electricity production in our region is amongst following steps:

1) Increasing the capacity of existing Tereble-Ritska, Onokivtsi and Uzhgorod *HPP*;

2) restoration of the once existing mini-*HPPs* that had been constructed in 1950-60's and ruined in the "dashing 90" near Ust-Chorna, Uhlya, Dilove, etc. (Conclusions of public examination program.. 2011).

So, given the situation on the natural gas market and the global trend of price dynamics in the market of fuel and raw materials, Transcarpathians must strengthen its energy security. Along with improving energy efficiency and energy saving, it is necessary to develop a network of mini-hydropower plants in strict compliance with the recommendations of the scientific expertise, legal norms and mandatory involvement of the public.

Another way is orientation of heat and supplies companies and electricity utilities on decreasing of use of natural gas. This is especially true for those regions areas where gas supply is absent or minimal, especially in Velikobereznyanskiy and Rahivskiy districts.

Again, this is a rather cost-effective and environmentally friendly as an alternative to coal (as is also imported from outside, because local brown coal is inefficient), and firewood. By the way, the discussion about the benefits or harm of mini-*HPPs* for some reason completely forgot about the felling in the Carpathians forests – environmental problem no 1 of state level!

3-4. And then Their Majesties – *"green tariffs"…*

The existing interest of Ukrainian and foreign energy companies to establish an uninterrupted supply of electricity to mountain villages and big cities cannot fail to arouse admiration and amazement. However, the picture changes dramatically when we hear the magic word "green" tariff.

Ukraine has decided to support and develop alternative and natural sources of energy. In particular, the Law of Ukraine "On Electricity" Article 17 granted the National Commission for State Regulation of Energy to approve "green" tariff for electricity from generated entities at the power plants that use alternative sources energy. It includes *HPPs* with capacity up to 10 MW. This document stimulates the production of electricity from alternative sources used for each entity within 10 years from the date of its establishment (On electricity 2015).

National Energy and Utilities Regulatory Commission (NEURC) prepared the Decree "On approval of the establishment, review and termination of the "green" tariff for business entities" from 02/11/2012. There for the first time was established the juridical term of "green tariff" – until 01/01/2030 (point 1.3).

The idea is that the state encourages those who produce energy without damage or minimum damage for the environment. The investor is building mini-*HPP*; the state pays for its electricity more than usually. This way the state subsidizes thereby Energy, to be exact - private entrepreneurs. According to the current situation the "green tariff" is the economic incentive for potential investors. In addition, the investor has to provide jobs for the local population to service *HPP*, to invest in the infrastructure development of human settlements, particularly remote.

As for the last two assignments, the available experience shows rather negligible.

To solve the issue of employment the mini hydro power station hardly ever provide stuff with more than 15 job positions. As well a lot of depends on the initiative of local authorities and conscience builders in solving social problems of locals.

NEURC after the date 01/06/2014 by its decision No 772 from 29/05/2014 has set tariffs for "green" energy for electricity producers of mini *HPPs*, particularly in the Transcarpathians province, amounting to 1.8638 UAH/ per 1 kWh (For installation in June 2014... 2014, Public joint-stock company "Zakarpattyaoblenergo" 2016).

In comparison after the same date 01/06/2014 NEURC by its decision No 757 from 27/05/2014 established for retail electricity rates to PHC "Zakarpattyaoblenerho" the amount of 0.8908 UAH/ per 1 kWh.

So feel the difference and consider fantastic economic operation of mini-*HPP*. No wonder the cost recovery of the current power plants is around 5-7 years.

Quite explicitly is the problem of the construction of mini-*HPPs* for the development of tourism in the province. Ecologists blame to workers of the energy sector of distorting the landscape with pipes and changing of water flows, which can theoretically lead to a reduction of tourist attractiveness of the Carpathians region, to the detriment of "green tourism" in the future – for the falling incomes of the local population, which today survives as well due to the development of rural tourism. However, in Europe mini-*HPPs* in the highlands, built, again, with strict observance of environmental standards and regulations of landscape design, on the contrary, are centers of tourism. First, let's be honest, in the Carpathians tourists go especially in the mountains. Secondly, in the world (in Ukraine also) is gaining momentum "industrial tourism" but fancy *HPP* among wild fir, and beech forest is kind of attractiveness. Thirdly, cozy storeroom of mini-*HPPs* with warm water is the ideal refuge for the tourists in the absence of civilization in the Carpathians forests.

3-5. Conclusions.

1) Construction and operation of the mini-*HPPs* in Zakarpattia is a difficult and the very controversial issue, which should be balanced with environmental, social and economic factors. The question is: what is more important for the province uninterrupted power supply or changing the environment?

2) From a socio-economic point of view now, with the gas crisis, the reducing mining of coal amount and deforestation, switching power supply for hydropower is the most optimal way. It recommends a gradual transfer of heating companies step by step on electricity.

3) A wide range of serious environmental problems of the province should start to solute. Therefore involving a wide range of scientific and environmental approaches is necessary.

4. PREDICTION OF POSSIBLE CHANGES IN RIVER FLOWS OF THE CARPATHIANS REGION IN THE XXI CENTURY AND DEVELOPMENT OF HYDROENERGY.

The estimation of possible changes in water flow in the Carpathian region of Ukraine in the XXth century was done. The results of climate change of Ukraine forecasting are on the basis of calculations using the water-balance model and the regional model REMO.

Keywords: water, river flow, water balance model.

The Carpathians region is very important for the economy of Ukraine. Its peculiarity is that here are located the most of the main Carpathians rivers such as the Dniester, Tisza, Siret and Prut, as well as a significant number of mountain tributaries. Water content of rivers in the region is important due to the largest runoff modules in the western area. In average there are over 15 floods per year in the Ukrainian Carpathians. This makes the region a perspective on the development of hydropower energy sources. The objective of present studies is to identify trends in local water resources flow in terms of climate change. Reducing of runoff may indicate to the reducing of water supply and the threat of economic development, while the increasing of flows rate could threaten the overflow of built reservoirs and potential possibility of flooding.

Nowadays the research of stream flow changes under the influence of climatic factors became a subject of many scientific studies worldwide. In Transcarpathians such investigations were undertaken in Rakhiv region on the river Tisza (both the White and Black) by V. O. Balabukh & O.I. Lukianets (2015).

Certain explanation of future changes in water state of Ukraine rivers was given by the works of native scientists as N. S. Loboda & Ye. D. Gopchenko (2003), who provide the assessment of water resources in Ukraine by three alternative scenarios of global warming, which were recommended by the Second World Climate Conference in Geneva from 1990). A. Shereshevskiy (Ukraine and global greenhouse effect, 1998) studied the water runoff of the Dnieper basin by using of several climate change scenarios, based on the settlement of atmospheric general circulation models GFDL, UKMO, MPI (look, e.g., Carril et al., 1997). Other scientists such as: V.V. Grebin' (2014), L.A. Gorbacheva (2014), and V. I. Vishnevsky (2001) also devoted a lot of time and efforts for studying of the problem. But present situation is not fully learned. It requires much deepest studying.

4.1. Methods and Methodology.

To diagnose the impacts of climate change on water resources, we have selected five representative bodies of water, such as rivers as the Prut, Tisza, Uzh, Dnister and Stryj.

To assess the impact of climate change on the water flow of the river basin was used a method of water balance, which is already more than a century belongs to the basic hydrological science research methods. Since the second half of the twentieth century it was successfully used to solve problems related to the assessment of climate impacts on water resources as individual river basins and entire regions, countries and continents (Yates, Strzepek, 1994; Kaczmarek et al., 1996; Strzepek, Yates, 1997).

Common thing to all methods of water balance calculation is the mass of the water balance of the river basin. Present methodology described in detail in numerous scientific publications. For example, J. Dooge (1992) proposed a fundamental theorem of the theory of hydrology, which is a partial form of the continuity equation.

Examining the water balance of a large basin or region for a long period, the condition when the change of water balance is equal to a zero is accepted.

$$P_a = Et_a + Q_a,$$

where P_a – an average amount of precipitation, Et_a – an average amount of evaporation, Q_a – average annual amount of water flow.

J. Dooge (1992) appointed that any assessment of the impact of climate change on water resources depends on the ability of linking the changes in real terms of evaporation with predicted changes of precipitation and potential evaporation.

This article contains the water-balance model of L. Turc (1954), which has been successfully applied by Polish hydrologist Z. Kaczmarek (1996) to assess the changes of water resources of our planet in the preparation of the third report of the Intergovernmental Panel on Climate Change. This technique is very sensitive to changes in precipitation and temperature R. H. Moss (1996) and allowed to obtain quite satisfactory results of forecast for river basins in Europe Z. Kaczmarek et al. (1996).

The mentioned estimated water-balance model designed for usage of average annual data that has been proposed by the French hydrologist L. Turk (1954). He was the first who managed to establish a clear correlation between rainfall, temperature and flow. It was spread for the forecasting of possible changes of water resources in the second half of the twentieth century due to the occurring of a new scientific problem – estimates of future reserves of water in the climate change that caused by global warming.

Convenience of its using is explaining by the fact that all current Atmosphere-Ocean General Circulation Models (*AOGCMs*) designed to calculate the basic parameters of the future planet climate, depending on the particular scenario of development of society, namely, temperature and precipitation. That are precisely the parameters used in the model of L. Turk as input.

Results of present model approbating on river basins of various natural areas and their comparing with the results of US Country Studies Program (Strzepek, Yates, 1997) that assess the changes in water resources of over 40 countries (Turc, 1954). It can be recommending as a basic model for predicting changes in water resources under the influence of climate and conditions in Ukraine.

To calculate the input parameters of water-balance model the published results of forecasting the temperature and rainfall for XXI century were implemented. Those results were accounted by Ukrainian research hydrometeorological Institute and researchers of the Department of Meteorology and Climatology of Taras Shevchenko Kyiv National University who specialize on climate changes, use the *REMO* regional climate model (Max-Planck Institute of Meteorology, Hamburg, Germany) and World Data Center (*WDC*) for Meteorology, Asheville in the USA (Data verification, 2008; Numerical Weather of Ukraine, 2010; Verification of world climatic data center, 2009). Global CO_2 emissions scenario *A1v1-MiniCAM* was taken into consideration.

Forecasted calculations were carrying out with a time step of 20 years. Thus, the predicted values of air temperature and precipitation for 20-year periods of XXI century: 2001-2020 period-round, 2021-2040, 2041-2060, and 2061-2080 period round were considering in our calculations.

4.2. Results and discussion.

The calculation results for the water-carrying model allowed to obtain the predicted value of local characteristics of water flow in the region in the form of a layer of annual runoff. In the Table 1 are representing the flow characteristics as for medium water content years, and for shallow and abundant years.

Analysis of the present Table 4-1 data and their comparing with the average long-term rate of flow makes it possible to estimate the expected changes in water flow medium water content years and in different forecast periods (Table 4-2).

4-1. Results of water runoff forecast for some West-Ukrainian representative rivers in the XXI century (layer flow-mm).

Place of observations	Runoff level	2001-2020	2021-2040	2041-2060	2061-2080
the Uzh-Uzhgorod	Average	465,5	458,4	441,1	440,8
	Min	448,5	438,0	426,8	422,5
	Max	480,4	481,2	458,3	459,6
the Tisza-Vilok	Average	730,9	706,6	652,4	657,6
	Min	699,9	670,2	643,1	624,5
	Max	757,7	748,0	699,3	692,6
the Stryj-Verhne Sinjovydne	Average	618,2	609,4	611,7	602,3
	Min	584,1	566,9	589,3	571,3
	Max	643,0	640,2	634,0	631,4
the Prut-Chernivtsi	Average	302,9	302,2	290,1	282,2
	Min	287,2	292,8	274,5	263,2
	Max	316,9	318,9	302,1	301,3
the Dnister-Zalishchiky	Average	320,1	300,5	277,8	267,1
	Min	297,7	274,1	258,3	242,4
	Max	336,1	323,5	297	284,9

Obtained results show that in the period before 2020 the river water volume of all studied places will be slightly higher than their average long-term norms. Similarly, during the period from 2021 to 2040 year the water content of the Carpathians mountain rivers not undergo significant changes and preferably as well will be somewhat higher than normal. During the next period (2041-2060) water content of mountain rivers also still close to normal, instead of the Dniester near Zalishchiky where it came to decreasing. During the period of

4-2 - Relative changes in water flow compared with the perennial runoff norms of studied rivers flows.

Річка – пункт	Norm of the runoff, mm	Change of runoff in comparing with modern norm of			
		2001-2020	2021-2040	2041-2060	2061-2080
the Uzh-Uzhgorod	445,3	4,5	2,9	-0,9	-1,0
the Tisza-Vilok	690,0	5,9	2,4	-5,5	-4,7
the Stryj-Verhne Sinjovydne	604,9	2,2	0,7	1,1	-0,4
the Prut-Chernivtsi	300,9	0,7	0,4	-3,6	-6,2
the Dnister-Zalishchiky	309,9	3,3	-3,0	-10,7	-13,8

2061-2080 years there is observing insignificant reduction of river flow in Carpathian region, for the Dniester reduction expected to be more significant.

Thus, it can be concluded that during the present century the water content of the Ukrainian Carpathians rivers shouldn`t undergo the significant changes. If during the first half of the XXI century the river runoff in the researched region will slightly exceed the average long-term value, then during the second half the river runoff will be slightly lower than normal. An exception will be only the Dniester, where the predicted water consumption for this period will be less than the rate of 10-15 %. This may be due to certain influences on the water content of the Dniester River by the flat left bank tributaries of the basin at the site of the city Zalishchyky, where the gradually reduce of runoff in the XXI century is predicted to take place.

5. ASSESSMENT OF THE IMPACT OF THE FLOOD CONTROL COMPLEX ON HYDROMORPHOLOGICAL SITUATION IN THE UPPER TISZA RIVER (TO THE BOARDER WITH ROMANIA).

Abstract. Present subchapter discusses the identification, typology and hydromorphology assessment of the water bodies of the Upper Tisza to the border with Romania according to WFD. Also the forecast estimation of water bodies by hydromorphological conditions in accordance with the Program of flood prevention for the rivers of the Upper Tisza basin is fulfilled.

Key words: river basin, identification of rivers, ecological status, typology of rivers, water body; assessment of hydromorphological conditions, flood protection.

Adoption and implementation of any water management measures should take into account the social, economic and environmental factors that cause them. It is important for appropriate water management decisions are optimal combination of these indicators.

The estimation of ecological status and its components (biological, physical-chemical, chemical and hydromorphological) is the basis of a management plan in any river basin, including the Tisza river. Management plan should include measures to maintenance, preservation and improvement of the ecological status of water bodies that is the basis idea of the EU Water Framework Directive 2000/60 / EU implementation (The EU Water Framework Directive ... 2006).

However, for conditions of flood dangerous region, which is the Tisza basin, to the management plan should the flood protection measures territories should be included. In compliance with the EU and Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (2007) the management plans generating flood risks as a part of integrated river basin management.

The present researches subject is the Tisza River through to the state border with Romania and its main confluents – the Chorna and Bila Tisza.

The first step in assessing the ecological status of rivers should be the identification and typology. While the identifying of water bodies within the Ukrainian-Romanian Tisza areas, we relied on the provisions of the *WFD* (EU Water Framework Directive 2000/60/

EC Definitions of Main Terms, 2006) and the regulations of the Joint Strategy (Guidance Document on Implementing the GIS, 2002; River Basins Management Plans, 2005).

As a result of the research were identified six water objects (bodies) within the Upper Tisza basin (Tab. 5-1).

There is the definition of a water body surface when performing the typology. This

5-1. Identification of water bodies (*WB*) and river categories of the Upper Tisza Reaches.

River	Upstream point	Downstream point	Name of *WB*	Length of *WB*, km
Chorna Tizsa	Headstream	River mouth of the Dovzhyna river	Chorna Tisza 1	17
	River mouth of the Dovzhyna river	Confluence with the Bila Tisza river (v. Roztoky)	Chorna Tisza 2	33
Tizsa	Inflowing of the Choma and Bila Tisza	Inflowing of the Visheu river	Tisza 3(1)	28
Bila Tizsa	Headstream	River mouth of the Balzatul river	Bila Tisza 1	8
	River mouth of Balzatul River	Inflowing of the Goverla river (v. Goverla)	Bila Tisza 2	7
	Inflowing of the Goverla river (v. Goverla)	Confluence with the Chor-na Tisza (v. Roztoky)	Bila Tisza 3	19

means that in any case water bodies of different categories cannot be combined into one type. Then all water bodies of each category should be distributed according to the types of system *A* or *B* that are in the *WFD* (Kampa & Hansen 2004, EU Water Framework Directive 2000/60/EC Definitions of Main Terms 2006).

The river typology of Ukrainian part of Upper Tisza basin was executed by the system *B* (Rivers and Lakes 2003, The EU Water Framework Directive ... 2006) with using of four descriptors among which there are three mandatory and one optional, viz. catchment area, average height of catchment area, geology, substrate. Concerning the mandatory descriptors, the authors followed to limits of classes that were offered in the *WFD* using system *A*. The mainstream of bottom sediments was the additional descriptor.

Following the typology performing by four abovementioned descriptors, 4 types of Upper Tisza Basin Rivers, which are listed in Tab. 5-2, can be distinguished.

Thus, have been identified 2 types of small rivers in midlands, one type of medium river, and one type of large river in midlands.

5-2. Typology of the Upper Tisza Rivers Basin in Ukraine.

Code of the type	Type	Ecoregion	Substrate	Example
A. Small rivers				
4A	Small rivers in calcare-ous rocks at midlands	Carpathians	Boulders	Chorna Tisza 1
5A	Small rivers at volcanic rocks at midlands	Carpathians	Pebbles & Boulders	BilaTisza 1
B. Medium rivers				
5B	Medium rivers in rocks on the midlands	Carpathians	Boulders	Chorna Tisza 2, Bila Tisza 3
C. Large rivers				
1C	Large rivers in the cal-careous rock at midlands	Carpathians	Pebbles & Boulders	Tisza 3

The base of hydro-morphological assessment is the principle where the highest grade is achieving by the greatest possible approximation of modern factual hydromorphological conditions to referential.

Researches were performed by uninterrupted or discrete location of exploration areas (*EA*).

Although *WFD* (EU Water Framework Directive 2000/60/EC Definitions of Main Terms, 2006) doesn`t imply an assessment of hydro-morphological characteristics into five classes, but the standard (EN 14614: 2004. Water Quality 2005) recommends to use a classification system basing on five classes (Tab. 5-3).

5-3. Limits of hydromorphological status classes.

Hydromorphological status		Limit value	Colour
1.	Near natural	1.00-1.74	Blue
2.	Slightly altered	1.75-2.54	Green
3.	Moderately altered	2.55-3.44	Yellow
4.	Extensively altered	3.45-4.24	Orange
5.	Severely altered	4.25-5.00	Red

Based on the identification and typology of the river were identified water bodies (Tab. 5-1), for which hydromorphological assessment was performed and hydro-morphological status was determined. Hydromorphological assessment for certain water bodies was executed in accordance with the European standard (EN 14614:2004. Water

Quality 2005). The next categories scores were assessed – the river, internal flow characteristics, banks and the riparian zone, floodplain (The ecological status 2010, Carpathians rivers 2012). General hydromorphological assessment index that is presented by the marks with corresponded colors was counted by matched quantitative measures. Assessment of hydro-morphological status of major water bodies of the Chorna and Bila Tisza rivers and the Tisza River from the confluence of these streams prior to its transboundary part (Dilove village) was performed continuum. Hydromorphological assessment results are given in Tab. 5-4.

The water body No 1 that locates inside the headstream and out to river mouth of the Dovzhyna River (water object – the Chorna Tisza is falling within the `Near Natural` hydro-morphological status. Its general index is 1.41. The water body No 2 that locates inside the mouth river of the Dovzhyna river out to the inflowing with the Bila Tizsa river belongs to the second `Slightly altered` status and its average index is 2.46. General index of water body No 3 that locates inside the inflowing of the Chorna and Bila Tisza river out the state border with Romania (Tisza 3) is 2.57 and corresponds to the third `Moderately altered` hydro-morphological status. In accordance with researches that were done in present work the pointed area of the Tisza river should be fit into the potential candidates to Heavily Modified Water Bodies (*HMWB*).

According to our research, the total length of the hydrotechnical structures inside the headstream of the Chorna Tisza river and Tisza to the state border with Romania consist (on both coasts) 29% of the total length of the river. Most of those river bad regulating structures locating on those areas of researches that are in satisfactory hydromorphological condition. Accordingly with identification of the River Bila Tisza it is representing by three water bodies. Analyzing the first water body inside the headstream out the inflowing the Balzatul River (Bila Tisza 1), it corresponds to excellent "Near natural" hydro-morphological status of the general index – 1.00. An excellent hydro-morphological status has the second water body that extends from the mouth river of the Balzatul to the inflowing of the Hoverla River (Bila Tisza 2). The third water body that extends from the mouth of the Hoverla River to inflowing with the Chorna Tisza (the Bila Tisza 3) has a total range – 2.03 that describes its good or "Slightly altered" hydro-morphological status. The total length of riverbank (on both sides of the abovementioned third water body) is 23.8% of the total length of the water body.

According to the classification of the International Commission for the Protection of the Danube River (ICPDR) and in compliance with Romanian approach to Natural River water bodies should be included the following: the Chorna Tisza 1, the Chorna Tisza 2, the Bila Tisza 1, the Bila Tisza 2, the Bila Tisza 3. Concerning the water body the Tisza 3 (1) (inside the inflowing of the Chorna and Bila Tisza to the confluence with the Visheu River), it can be related to potential member of *HMWB*.

While assessing the hydro-morphological status in general for the Tisza river (up to the confluence with the Visheu River), it should be noted that the worst characteristics are belong to categories `coast` and `banks/riparian zone and floodplain`, and the best characteristics are belong to `internal flow`. It certifies the fact that the changes in a specified section of the river are connected with coast protection, economic development of floodplains, and building capacity are specified into two pointed categories. The internal flow characteristics are the least vulnerable to any changes in comparison with reference conditions. This is attributable to the fact that while having a relatively large slope, water content and capacity of river flow has significant renewable ability, which in some way affects the structure and shape of the riverbed.

In order to predict the future course of events relatively to changes of hydro-morphological status in abovementioned rivers the list of designed flood control facilities should be pointed in a case of full implementation of the program. The list of these objects included:

Section 2 - Bank Protection,

Section 4 - Reconstruction of road structures,

Section 7 - Flood capacity.

Considering the Section 2 - Bank protection program was designed (Programs of the complex...):

• Construction of bank protection in the v. Yassinya with length of 1 km (2012 - 2014)

• Construction of bank protection in the v. Kvasy - v. Trostianets with length of 2 km (2012 - 2015)

• Construction of bank protection in Rakhiv with length of 0.250 km (2009-2010)

• Construction of bank protection in the v. Kostylivka with length of 1.18 km (2012-2014).

Considering Section 4. Reconstruction of road facilities, by present program is offer the following items:

Reconstruction of the road Rakhiv-v. Bogdan-v. Lugy with length of 0.066 km (2008 - 2010);

Reconstruction of the road v. Yassinja – v. Chorna Tisza with length of 0,024 km (2010).

Considering the Section 7. Detention basin, by present program is offering:

Construction of detention basin on the river Chorna Tisza with the length volume of 7.2 million m^3 (start of construction – 2008);

Construction of detention basin on the river Bila Tisza near v. Lugy with volume of 8.1 million m^3 (start of construction – 2008).

All of the pointed designed flood protect facilities were put on the continual hydro-morphological assessment of these rivers. Consequently, hydromorphological prognostic assessment that could become a reality in the implementation of these measures was obtained. These changes apply to all the aforementioned water bodies.

Analysis of the forecasting results shows that in some areas continual examination hydro-morphological condition worsened (Tab. 5-5).

Fig. 5-1 illustrates a hydro-morphological status on examined areas of water bodies within the rivers Chorna and Bila Tisza and in the case of implementing of the Program on flood protection in the Tisza river basin in Transcarpathians region in 2006-2015 years.

The general score of Chorna Tizsa accordingly to designed works rose up to the II `Good` status. Condition of the Chorna Tisza 2 water body is changing to the worse and coming to satisfactory. Condition of the Bila Tizsa is also changing to slightly worse condition and the Bila Tisza 2 – it gets the category of "good" Therefore, the implementation of the designed flood control facilities should not significantly affect the hydro-morphological status of the studied rivers.

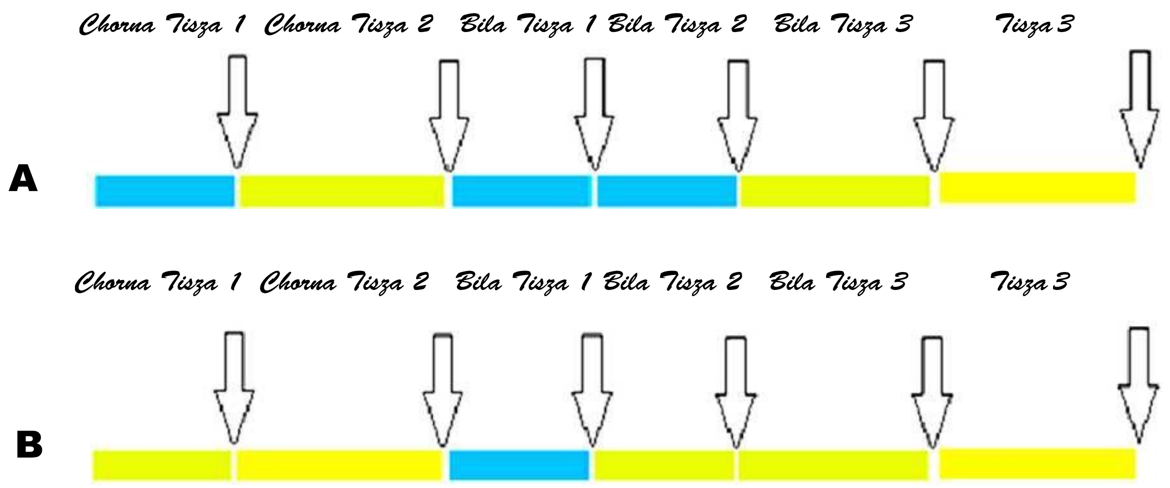


Fig. 5-1. Hydromorphological status of the Tisza river water bodies: **A** as of 2010; **B** after the implementation of flood control complex.

5-4. Hydromorphological assessment results of the river Tisza, Bila Tisza and Chorna Tisza.

Water body	River bed	In-stream characteristics	Bank and riparian zone	Floodplain	Class	Score
Chorna Tisza 1	1.10	1.00	1.62	1.95	1.41	I
Chorna Tisza 2	1.56	1.35	3.2	3.75	2.46	II
Tisza 3	1.67	1.35	3.57	3.68	2.57	III
Bila Tisza 1	1.04	1.04	1.17	1.33	1.14	I
Bila Tisza 2	1.17	1.10	1.67	2.00	1.48	I
Bila Tisza 3	1.33	1.20	2.52	3.08	2.03	II

5-5. Predictable classes of hydromorphological status of the river Tizsa, Bila Tisza and Chorna Tisza.

Water body	River bed	In-stream characteristics	Bank and riparian zone	Floodplain	Class	Score
Chorna Tisza 1	1.33	1.10	2.00	3.00	1.86	II
Chorna Tisza 2	2.17	1.35	3.75	4.00	2.81	III
Tisza 3	2.00	1.58	4.20	3.75	2.88	III
Bila Tisza 1	1.04	1.04	1.17	1.33	1.14	I
Bila Tisza 2	1.33	1.10	2.00	3.00	1.86	II
Bila Tisza 3	1.33	1.20	2.52	3.08	2.03	II

To prevent the deterioration of existing hydro-morphological status in accordance with the requirements of the WFD a program of measures to support the preservation and improvement of the ecological status of water bodies should be developed (The EU Water Framework Directive ... 2006). That action plan is a part of the River Basin Management Plan.

For water bodies the Chorna Tizsa 1, the Bila Tisza 1, the Bila Tizsa 2, Bila Tizsa 3 were established measures to maintain and preserve existing conditions and to prevent its deterioration. This is mostly nature observation measures that can be functionally put on the regulations of the water management depending on location of researched areas. Among the activities, there are the following possible measures:

Systematic (at least once a year, and in the event of active floods, immediately after their passage) examination of the *EA*;

Detecting and fixing of any changes in management (agriculture, construction, etc.) in the riverbed floodplain complex;

Detecting and fixing of the riverbed forms changes;

Fixing of construction the new riverbed regulating and other flood control structures;

Fixing of the lying the new communications in the river bad floodplain complex;

Detecting and fixing of vegetation changes in the river bad floodplain complex.

For such water bodies as the river Chorna Tisza 2 and 3 that corresponds to the third class were established measures to recover or improve their condition as required until at least the second "good" class. To improve significantly the quality class is impossible in present situation because of the priority of flood protection actions that are direct to preventing of safety conditions for human activity and functioning of economic and communication structures.

It caused by the presence of area reclamation and economic usage of the floodplain and riverbank operating on both banks of the river. One of the measures may increase the percentage of natural vegetation in these areas and reduction of cultivated land.

Such actions are effective to prevent banks from erosion and establishing of flood protection. Simultaneously such acts are negative complying to the morphology and certainly lead to deterioration of the whole Tisza river condition.

6. FLOOD PROOF OF THE URBANIZED FLOODPLAIN TERRITORIES ON THE MOUNTAIN RIVERS.

Abstract. Basing on the riverbed processes and natural monitoring researches of riverbed processes in the Tisza River Basin in the Ukrainian Carpathians, a hydromorphological assessment of the riverbed-floodplain complex according to Water Framework Directive of the European Union was done. Procedure for determining the most optimal width of the water supply porthole in the bund areas in the mountain, foot-hill and flatland parts of the river was proposed. As an example the system of regulative decisions concerning new type of controlling the river bad-floodplain complex deformation for the Latoritsa River is presented.

Keywords: hydromorphological condition of river area, the riverbed-floodplain complex, water supply porthole, hydro-morphological monitoring, managing plan.

1-1. Introduction

Nowadays creation of multifunctional flood protective complex for rivers of the Ukrainian Carpathians is one of the most urgent needs. Catastrophic (the river bad destructive) floods caused many problems that concern the safety of people habitation on the floodplain territories. As an example, catastrophic floods in 1998, 2001 and 2008 caused major damages of natural and economic complexes in the basins of the rivers Dniester, Tisza, Prut and Siret. Considering the hydromorphological conditions, occurrence of such floods can lead to transformation of the river bad forms and even modifications of the riverbeds` types. This course of events in the riverbed-floodplain complexes can produce the creation of unstable social and environmental situation, namely, the destruction of the coast and protective regulatory and engineering constructions, excessive accumulation of organic and inorganic origin materials in the river bad, sometimes even complete deterioration of ecological status of a river.

In present work are stated the main findings of researches on adaptation and improvement of assessment methodology of hydromorphological conditions of mountain rivers (Obodovsky, Yaroshevych, 2006). Actual results of hydromorphological conditions assessment of the Uzh and Latoritsa River Basins was published by O. Obodovsky et al. (2012).

1-2. Methods, Results, and Discussion

Cooperation of natural and anthropogenic factors is determining the formation and transportation of the riverbed creating deposits which peculiarly are the present riverbeds of the rivers and define their types by the river`s length.

Together with analysis of the riverbed processes and safety conditions which connected with flood protective measures, the general assessment of ecological status of waterway should be also applied. The most effective way to imply the foregoing is to follow the provisions of The EU Water Framework Directive (The EU Water Framework Directive 2006). According to that Document, there is a great necessity of compliance with provisions of preservation the good or excellent general ecological conditions of the riverbed-floodplain complex operating.

Assessment of the ecological status and its compounds (biological, physicochemical and hydromorphological) is a base of managing plan for any riverbed-floodplain complex. Managing plan should include all of the maintaining measures, preservation and improvement of ecological status for all water objects. According to conditions of floodplane region, especially those of the river Tisza basin, the flood protection measurements of the territories should be included into the plan (Obodovsky et al. 2012) (Fig. 6-1).

In a case when hydromorphological status of checked districts is related to the first `excellent` grade or the second `good` grade, maintaining and preservation actions should be established for saving and non-deterioration of that conditions (The EU Water Framework Directive 2006). Those are mostly the actions of supervision and depending on the location of the tested districts should be functionally delegated to inter-district Water Management Authorities. There can be the next measurements (tasks):

1) systematic river` districts checking (not less than once per year, but when flood occurs a checking should be provided immediately after it) ;
2) detection and fixing of any changes in managing of the riverbed-floodplain complex (agriculture, lands allotted for settlement, construction);
3) detection and fixing of changes in the riverbed forms;
4) fixing of the new riverbed regulating and other flood protective structures;

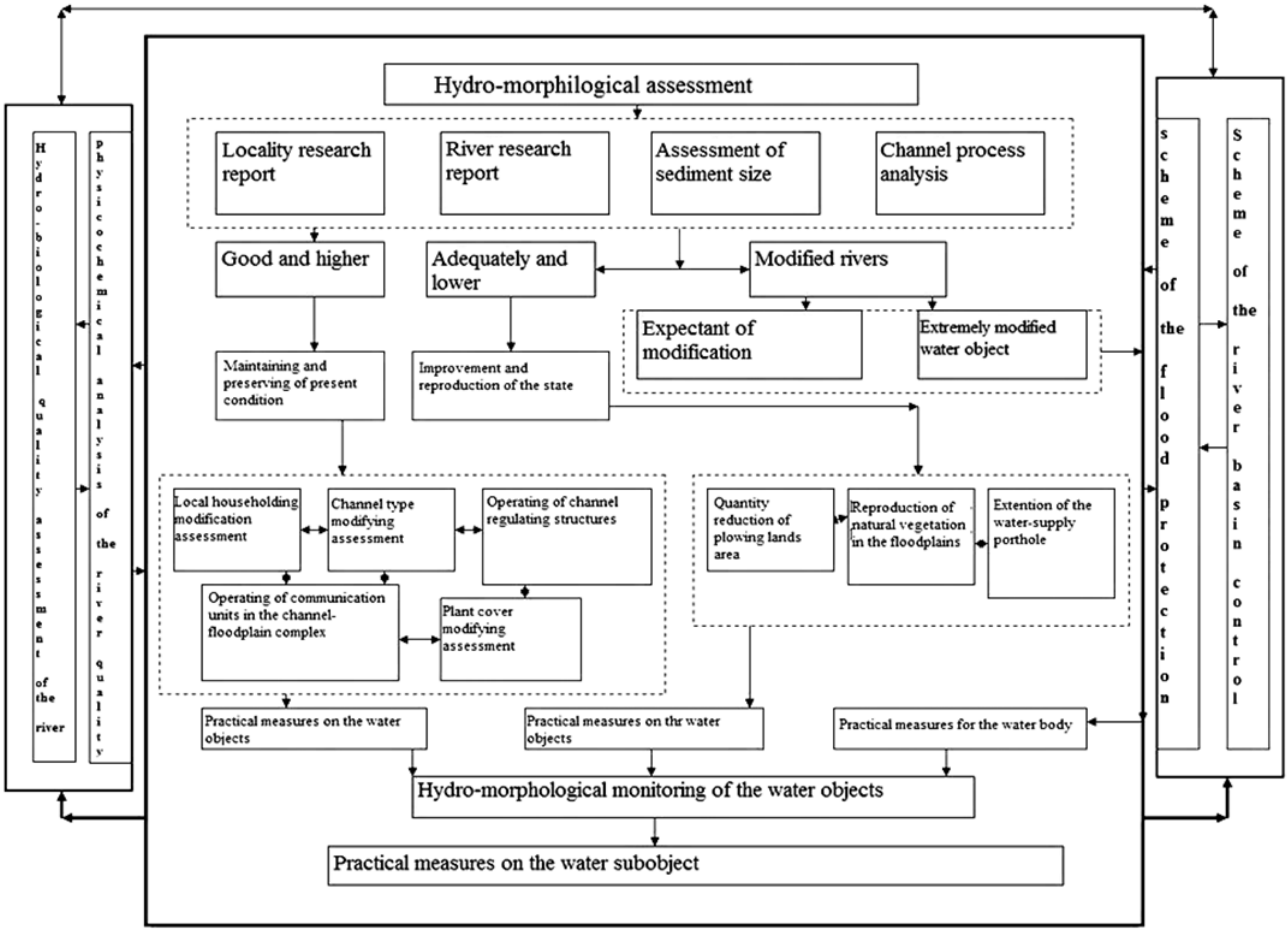


Fig. 6-1. Algorithm of implementation the hydro-morphological status assessment of channel-floodplain complex for making the most effective decision about mountain river conditions.

5) fixing of the laying of new communications in the riverbed-floodplain complex;

6) detection and fixing of the changes in green covering of the riverbed-floodplain complex;

7) detection and fixing of the forms of appearance of gravitational processes on water intakes joining to the river.

If the hydro-morphological status of EA is related to the third `adequate`, to the fourth `marginal` or even to fifth `inadequate` grades , the measurements for improvement and approaching to the second `good` grade should be provided. Modified areas of the riverbed-floodplain complex (bodies of river) should be classified by the next categories: *expectant of modification* and *extremely modified.* The first case is intending to areas of fourth or third status grade. Great efforts should be made to renew or improve such kinds of areas. The second category of areas include the areas that are going beyond of the fifth class category where renewing or improving of hydro-morphological conditions of the rivers is impossible (e.g., on the river costs there are guard installations to protect the railways, highways, or the riverbed that are straightened and carried by embankment).

One of the most important aspects of the practical application of hydromorphological conditions assessment is providing of riverine objects monitoring (bodies of river). Obtained result will permit not only to get full information about the riverbed conditions but also to take another approach of measurements if some changes in morphological indexes of the riverbed-floodplain complex have occur.

Considering the high flood hazard in the rivers of the Ukrainian Carpathians, monitoring researches and developing of new flood-protection action complexes should be done in compliance with government program for particular region (Regional state program of flood control complex 2001). However it is necessarily to determine the impact of already existing flood-protection engineering constructions to hydromorphological status of rivers.

On the example of relevant river the Latoritsa the hydromorphological assessment and complex of flood-protection measurements were realized (Obodovsky et al. 2012). Arising from the geographic zonality position and on the bases of hydromorphological theory of the riverbed processes this river includes 3 main parts: mountainous upper area -hill terrain, middle altitude), foot-hill (middle) and flatland (lower).

Findings of hydro-morphological assessment of *EA* of the Latoritsa and its tributaries shows that in the most cases in the category of the worst class were the following compound elements of the river: banks, riverine zone (riparian) and floodplain. For that parts were established a number of measurements that will preserve, improve and protect the territory complex from the flood.

Concerning the bodies of river (water objects) of the low-hill terrain and foot-hill of the Latoritsa, the great attention should be paid to preservation of the riverbed and banks in its natural state. River is flowing in the narrow lowland, so that any activity on this territory can partially break the optimal state of it. Such situation is obvious for present time.

Installation of some protecting-regulation constructions without any scientific background is not allowed for that parts of river. Building of bank protection structures can be permitted only in the territories of densely inhabited localities in compliance with provision of urbanized territories flood protection program (The associated programme on flood management 2014). The general scientific-methodological approach for regulating the deformation of the riverbed-floodplain complex in the urbanized areas of mountain rivers is observing the conditions of providing the necessary broadness of water supply porthole B_h. In areas of the river Latoritsa the riverbed is often closed to the hillside, and its floodplain is more or less broad. In this case the local embanking is entirely possible. During the river embanking environmental measures for preservation of coastline water protection should be provided. That protection of coastline is necessary for safe flowing when high level catastrophic floods take place.

Any practical use of the territory (turning up the soil, building, etc.) within the area of water supply porthole (on floodplain) is forbidden. Such territories on the Latoritsa are located both in mountainous and sub-mountain parts of the river. Type of the riverbed in these areas is characterized by development of alluvial form depending on the river meandering. Whereon rocks and flow-resistance formations are taking place, structure less sediment transportation is observed. Abovementioned operating plan in the floodplain territories will permit not only to preserve an excellent and good grade of hydromorphological status in the Basin of the Latoritsa but also to organize local improvement actions.

For single-sided flood protection of urbanized floodplain territories is proposing to implement a control under the riverbed flowing process in compliance with “Scheme of the compounding of biological binding within the area of water supply porthole for parts of the river with limited meandering” (Patent of Ukraine № 44478 (a utility model.), 2009). (Fig. 6-2).

Present Scheme contain the system of pre-embanking biological band, where l = 10 m, which are arranging at an angle $\alpha_1 = 20°$ to an axis of the embankment by the flow and system with cross-band of biological binding between the riverbed and flood embankment, that located at 100 m from at an angle approximately $\alpha_2 = 75°$ to an axis of the riverbed flow down a stream. Wood in the bands is proposing to locate over 5 m. Locally spread in the floodplains species of wood can be recommend.

The broadness of water supply porthole B_r is proposed to be rationalized by hydraulic calculation within from $2B_r$ to $5B_b$. In a case of flowage from the mountains, the correlation

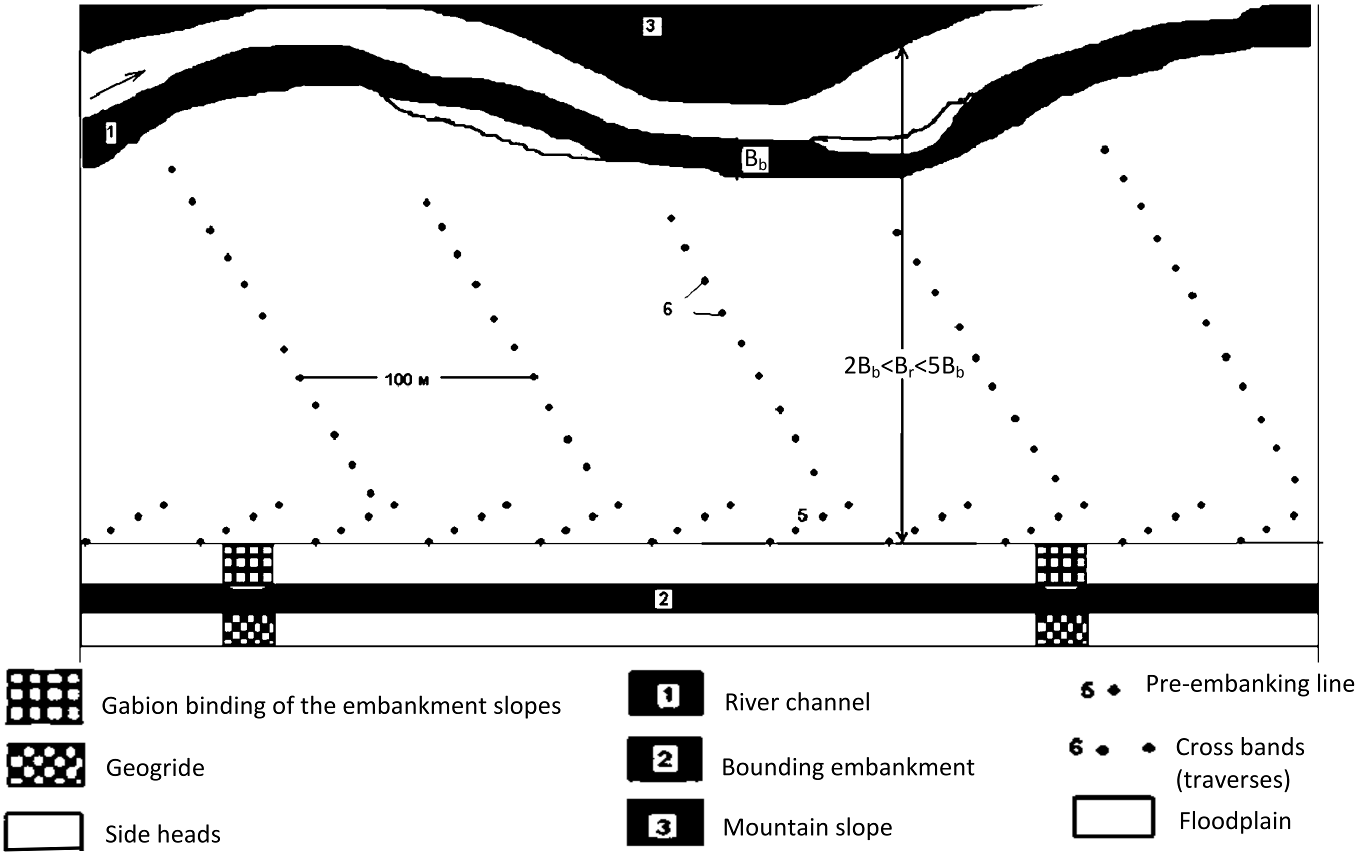


Fig. 6-2. Scheme of the compounding of biological binding within the area of water supply porthole for parts of the river with limited meandering.

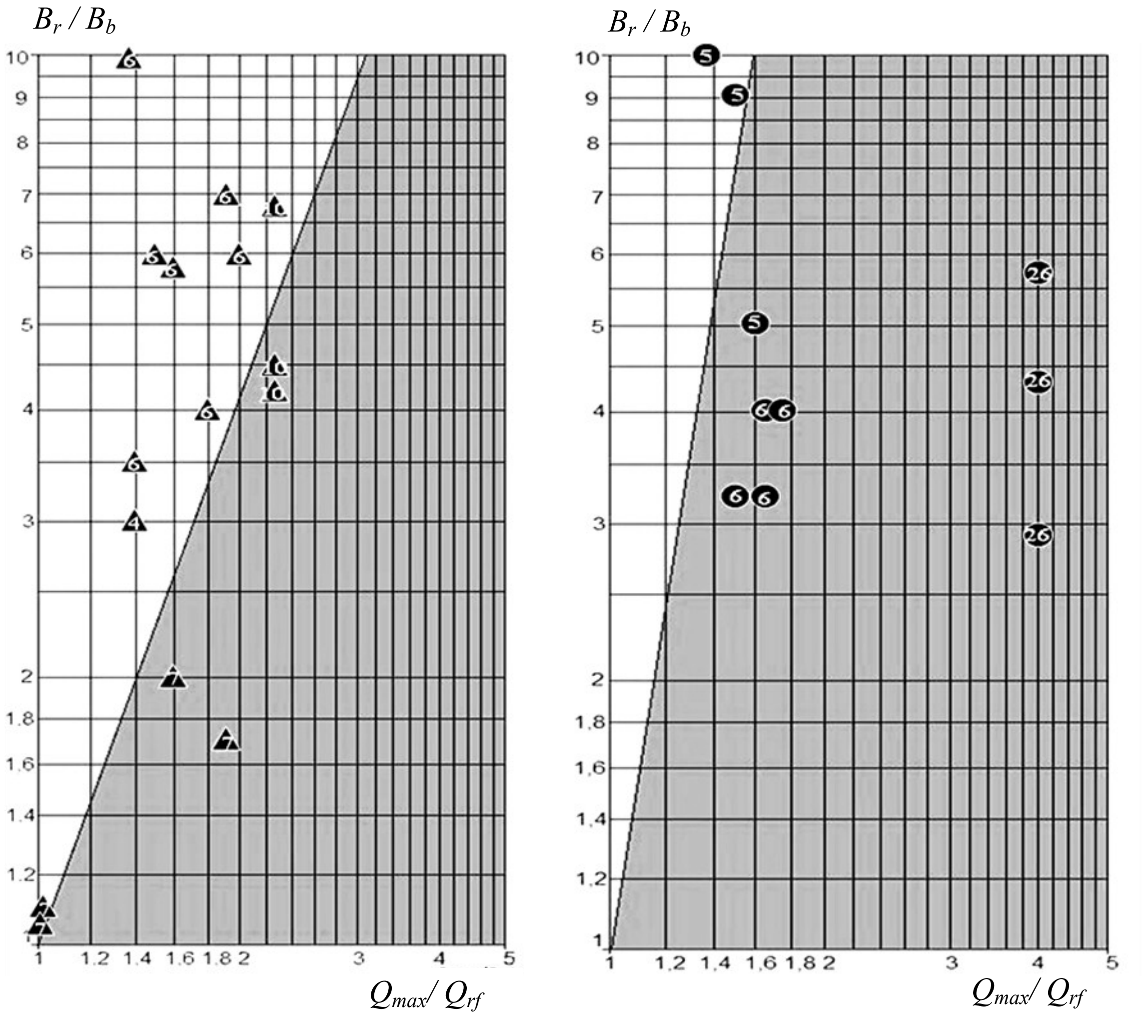


Fig. 6-3. Graphs of the connection $B_r / B_b = f\,(Q_{max}/ Q_{rf})$.

of Q_{max}/Q_{rf} will be approximately 2.2.

On the graph of connection $B_r / B_b = f\,(Q_{max}/ Q_{rf})$ to such regulation is corresponded right line 1 (Fig. 6-3,left) (right line in logarithmic Cartesian coordinates), defined by formula:

$$B_r / B_b = (Q_{max}/ Q_{rf})^2 \qquad (1)$$

For river Latoritsa (mountainous and foothill conditions) hydraulic calculation of water supply porthole could be done basing on the dates of observations in v. Pidpolozzya region. In closely located areas it can get the meaning of $Q_{max} \approx Q_{1\%} = 543$ m^3/sec, $Q_{rf} = 93.0$ m^3/sec, and water wastes in the floodplain at the moment of supplying through porthole will be 450 m^3/sec.

For the foot-hill conditions is recommended to use the next formula :

$$B_r / B_b = (Q_{max}/ Q_{rf})^{3.5}. \qquad (2)$$

At the bodies of river Latoritsa, that located at the lowland $>10B_b$, the broadness of water supply porthole is planning to be $>10B_b$. So that the next empirical dependence should be used :

$$B_r / B_b = (Q_{max}/ Q_{rf})^5, \qquad (3)$$

That corresponds to right line 2 at the Fig. 6-3(right).

For the areas of straightened the riverbed of the Latoritsa, (flatland) is proposing to use the scheme of floodplain embankment arrangement and system of biological binding (Fig. 6 -4). It can permit to provide good hydromorphological conditions for the river in the altered areas (Patent of Ukraine № 44478 – a utility model 2009).

In order to preserve the gained self-organization natural structural level of maximum permissible discharge or artificially created the riverbed leveling line, is proposing to use the system of uninterruptible discrete control over the riverbed-floodplain flow with complex of biological biding within the area of water supply porthole. The system of pre-riverbed bands of biological binding is posited at the angle $\alpha_1 = 15°$ on axis of the riverbed flow downstream. The length of each band is $l_1 = 15\ m$. Placing of the trees – (willow) should be in every band approximately over 5 meter. Condition of meandering can be stabilized and intensive impact of dynamic-kinematic effect can be avoided under arranging of

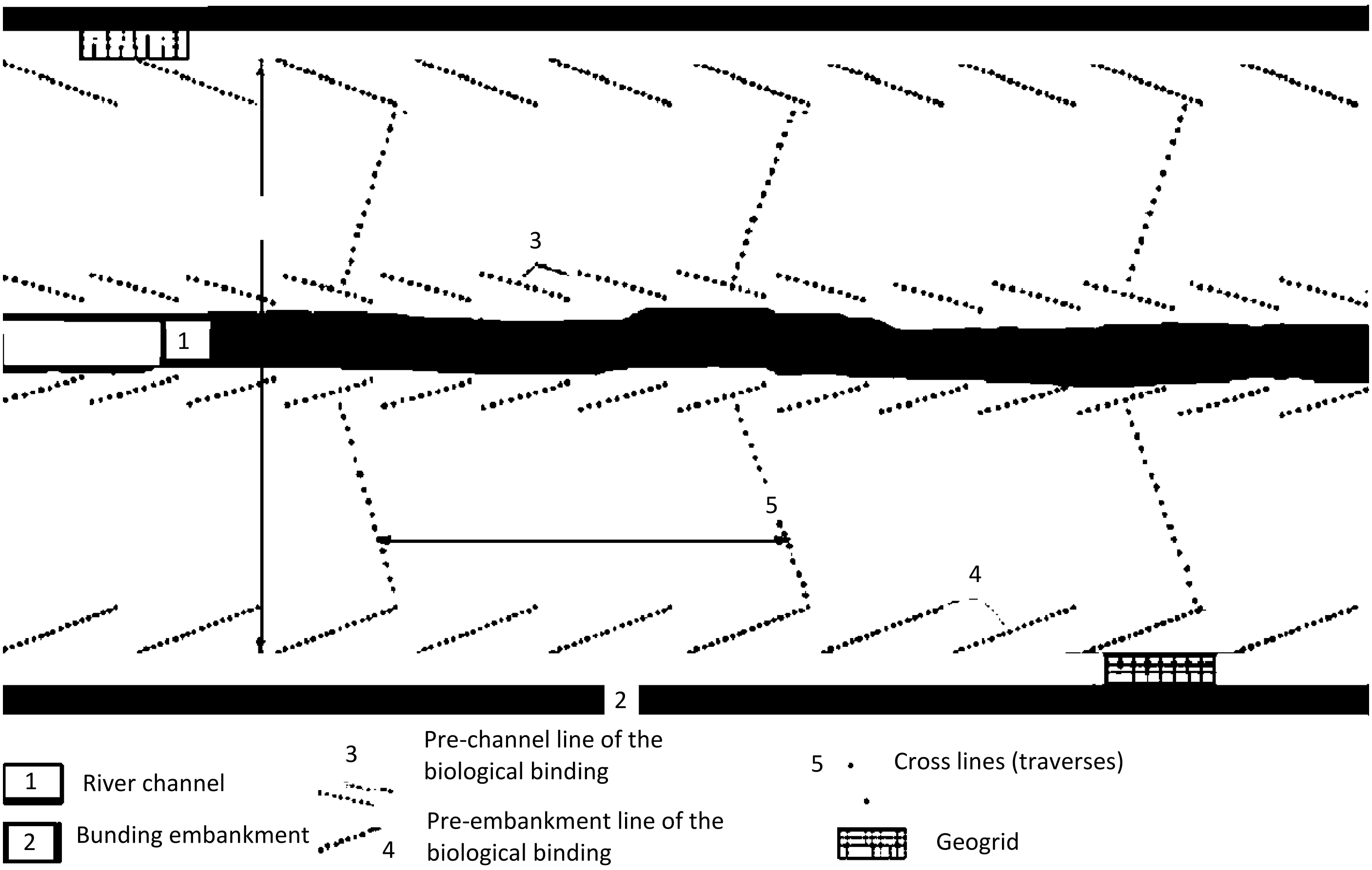


Fig. 6-4. Scheme of biological binding bands arrangement within the areas of water supply porthole for the areas of straightened meander.

Fig. 6-5. Scheme of biological binding bands arranging within the areas of water-supply porthole for the areas of river with free meandering.

6-1. Proposals for determining the optimal width of the corridor culvert on floodplain of urbanized territories on the river Latoritsa.

Location of the researched area, km	Part of the river	The *Baltic system* of heights (BSV), meters	Type of the channel	Wideness of the water supply porthole B_r	Characteristic of the flood protection in the floodplain territories
0-1.20	low-hill terrain	775-535	Rapids-Waterfall	B_b+25m	One-side embanking
1.20-6.20	low-hill terrain	535-402	Channel with non-developed alluvium forms	2 B_b (where $B_b>25$m)	One-side embanking
6.20-9.63	low-hill terrain	402-359	Channel with developed alluvium forms	4 B_b	One-side embanking
9.63-10.05	low-hill terrain	359-348	Channel with developed alluvium forms (branched on the bedrock)	(4-5) B_b	One-side embanking
10.05-26.70	low-hill terrain	348-343	Channel with developed alluvium forms	5 B_b	One-double-side embanking
26.7-36.00	low-hill terrain	343-316	Channel with developed alluvium forms (single branches)	5 B_b	One-double-side embanking
36.00-37.00	low-hill terrain	316-313	Channel with non-developed alluvium forms	(3-5) B_b	One-side embanking
37-50	foot-hill	313-217	Channel with developed alluvium forms at the background of free meandering	5 B_b	double-side embanking
50-60	foot-hill	217-177	Free meandering	10 B_b	double-side embanking
60-75	foot-hill	177-147	Channel with developed alluvium forms at the background of free meandering	(5-8) B_b	One-side embanking
75-88.5	foot-hill	147-120	Channel with developed alluvium forms with single branching	10 B_b	double-side embanking
88.5-143	lowlands	120-99	Free meandering	$B_p \geq 10$ B_b	double-side embanking

this construction of the riverbed band. So that, 3-5 trees should be placed in every pre-riverbed line.

Considering the binding of water supply porthole along the protective embankments, the system of biological binding that is the similar with pre-riverbed line should be used.

Pre-riverbed bands are 20 m long and placed at the angle of $\alpha_2 = 20°$ on axis of flood-breaking embankment and are closed to their footing. It is proposed to establish the cross biological lines for improvement the hydraulic control and for raising an effectiveness of pre-riverbed lines. Those lines should be established in 50 m, at the angle $\alpha_3 \approx 75°$ on the axis of the riverbed flow downstream (Fig. 6-4). Here trees could be placed not less than after 5 m.

For the areas of free meandering areas of river Latoritsa (flat part of the river) is proposing to use a scheme of the riverbed-floodplain flow regulation with the aid of pre-embankment lines complex and cross biological binding system (Regional state program of flood control complex, 2001) (Fig. 6-5). Pre-embankment biological lines are located at the angle $\alpha_1 = 20°$ on axis of embankment downstream and with the length equally to l_1 = 25m. Trees in the pre-embankment bands should be places after 3.5 m depending on the hydro-morphological status of the riverbed-floodplain complex. Trees in the lines (traverse) should be located after 5 m.

Basing on the analysis of results of natural hydromorphological conditions of the Latoritsa from the head to state border, in the tab. 6-1 are listed propositions about determining the most definitive wideness of water supply porthole under the regulation of the riverbed-floodplain complex at the urbanized areas. From the Table 6-1 data it follows that along the river from the head to outflow at the areas of the riverbed-floodplain complex embanking the wideness of water-supply porthole B_r is changing within the measure of 2 up 10 widths of the riverbed in balks B_b. One-sided or double-sided embanking of the riverbed-floodplain complex within the populated locality areas depends on the form of valley, type of the riverbed, rate of the Q_{max}/Q_{rf} correlation, level of the urbanized territories, technical-and-economic objectivities of embankment height, kind of slope embankment binding structures and protective-regulatory structures.

1-3. Conclusions & Recommendations.

1) To improve a hydromorphological status of the riverbed-floodplain complex in Ukrainian part of the Latoritsa river basin it is recommended to comply with provisions of maintaining the water protective zones that should be 25 m in width along the costs of small rivers and 50 m – for rivers of midlevel (Water Code of Ukraine, 2000).

2) In the water object of mountain and foot-hill parts of river water intake in the areas with more or less wide floodplain embanking of the riverbed could be arranging only within populated locality. In foot-hill part of the Latoritsa where are the riverbed with developed alluvium forms on the background of the limited or adapted meandering, the riverbed embankment could be done discretely in relatively short areas (no more than 1 km) with a width of water supply porthole from $B_r = 2B_b$ to $5B_b$ depending on the meaning of correlation Q_{max} / Q_{rf} (where Q_{max} – maximal long-term waste in present hydro-morphological cross section that should be no less than 1% with possibility to overcome the rated consumption relating to the engineering design of flood control structures within populated localities.

3) For approximate calculation the width of between-embankment space should be no less than 10 B_b (Tab. 6-1). On the all specified areas of the Latoritsa in between-embankment water supply porthole plowing should be banned. At all these sites, the river should prohibit the plowing in the culvert between the dam corridor. This measure will protect local excess sediment in the river, stop the development of erosive-accumulative processes in “protected” floodplain and improve its hydro-morphological class.

4) Above proposed measurements for ecological flood protective the riverbed-regulating of the river Latoritsa will not worsen its general hydro-morphological status. Implementation of present measurements will give an opportunity to resist against flood danger more efficiently.

7. HYDROCHEMICAL AND ENVIRONMENTAL MONITORING OF HEAVY METALS, AND RADIATION STATE OF SMALL RIVERS OF TRANSCARPATHIANS.

Abstract. Discusses the distribution and migration of heavy metals and gamma-active radionuclides in the waters and sediments of small rivers in mountain, foothill and lowland regions of the Transcarpathians region. It is established that in relation to heavy metals is the Geochemistry of wear and content of these components in waters and sediments of mountain rivers is lower than in the foothill rivers, and in the last than in the rivers of lowland regions. The content of heavy metals in waters and bottom sediments is proportional to the level of silting of rivers.

Distribution of natural gamma-active radionuclides rows of U-238 and Th-232 in the bottom sediments of small rivers has an opposite character, and in the mountainous regions of the total specific activity of radionuclides is higher, and in low – low. This is due to tectonic deformation in mountain regions and their seismic activity, the result of which can be allocated to Rn-222 and Rn-220, which are the disintegration products of U-238 and Th-232. Proposed radiological labels, which you can judge about the natural specific radioactivity of bottom sediments of small rivers, in particular Bi-214 (a series of U-238) Ac-228, Pb-212 (a series of Th-232). Geochemical wear is typical only for anthropogenic Cs-137, which can be considered an indicator of the processes of soil erosion and the intensity of precipitation.

*Key words: **r**adionuclides, heavy metals, small rivers, sediments, geochemical demolition, radiologic marker.*

1-1. Introduction.

Small rivers of the Carpathians are characterized by fast currents, low degree of siltation and thus the chemical composition of water is largely dependent on geochemical and geomorphologic conditions of the catchment area. So, Zakarpattia (Transcarpathians) region has the highest density of river network (1.7 km / km^2), but hydrochemical and hydrological state of the vast majority of small rivers is almost not studied (Environmental passport of Zakarpattia Region 2013, Report on Environment of Transcarpathians region in 2012 & 2013). Assessment of small rivers and changes caused by natural and men caused factors, should take into account the topographical conditions and geochemical characteristics of the pool, so it is important to find patterns of change hydrochemical and radiological indicators of small rivers in the transition from mountain to foothill and lowland regions (Yatsyk et al. 1991).

Hydrochemical and radiological indicators of water of small rivers do not always reflect the peculiarities of geochemical and geological environmental conditions, so the more informative is the state of these objects sediments (Sukharev et al. 2014). Moreover, the tectonic deformation and seismic activity of the mountain in Transcarpathians region can significantly influence the hydrochemical and radiological parameters of the small rivers. Considering the monitoring parameters of the environment, the most informative is the content of heavy metals (*HM*) and gamma-active radionuclides (*GAR*), because they can take account of both natural geochemical anomalies, and degree of anthropogenic impact on the state of small rivers of Transcarpathians.

The aim of this work is to establish patterns of distribution and migration of *HM* and *GAR* in water and bottom sediments of small rivers of the Transcarpathians region, which is part of the Carpathian Euroregion, depending on topographical and climatic environmental conditions. This allows considering the main hydrological and hydro-chemical problems burden on small rivers of Transcarpathians. To do this, we studied the control areas, enough free from direct men caused influence of river basins that are located within nature conservation areas, like National Nature Park "Synevir" (mountain region in the Gorgany massif ridge), "Uzhansky" (mountain region in the East-Beskidy massif) and "Enchanted Land" (mountain region in the Gutyn volcanic massif).

7-2. Methods.

For the determination of *HM* in the water we applied the sorption-atomic absorption method of analysis. For sorption concentration of *HM* in natural waters, we used a polymeric reagent based on poly-4-allyl-3-(4-pyridyl)-5-tioxo-4,5-dihydro-1H-1,2,4-triazole-1-carbo-ditionic acid (*APTT*) (Sukharev 2012), and the determination of metals was performed by atomic absorption spectroscopy (*AAS*): option electro-thermal (*Cd, Pb, Cu, Zn*) with modifier benzoate sodium salt of pyruvic acid (*BSPA*) (Sukharev 2012) and the method of "cold steam" for determining *Hg*. The definition of *HM* in bottom sediments of small rivers was carried out similarly without a proper concentration. To assess specific activity of *GAR* it was used the method of low-background gamma spectrometry, and measurements were performed on a set of "SBS-40" with Ge(Li) detector with corresponding calibration by standard samples (Švec 2008, Kis et al. 1998).

In Fig. 7-1 shows the dependence of the degree of recovery of a *HM* from an aqueous solution of a polymer reagent in static conditions (mixing only) on *pH*. It is seen that in the range of *pH* ~ of 5.0 possible concentrations (1:1000) of all defined *HM*. The sorption equilibrium at *pH=5.0* is installed within 10 minutes (G=94-99%). During the processing of the sorbent, which has concentrated the metal ions, sulfuric acid solution (1 moll/dm^3) for 10-15 minutes, undergoes the desorption of metals (transition in eluent) and regeneration of the poly-reagent box. Received in eluent determine the content of metals using *AAS*.

This approach allows you to define the content of *Hg (II), Cd (II), Pb (II), Zn (II)* and *Cu (II)* in natural waters at background concentrations. The proposed method of sorption-atomic absorption (*SAA*) determination of *HM* has a limit in the waters definable content (by 3S-test) respectively: *Hg* – 0.005 mg / dm^3, *Cd* – 0.008 mg / dm^3, *Pb* – 0.02 mg / dm^3, *Zn* – 0.005 mg / dm^3, *Cu* – 0.02 g / dm^3.

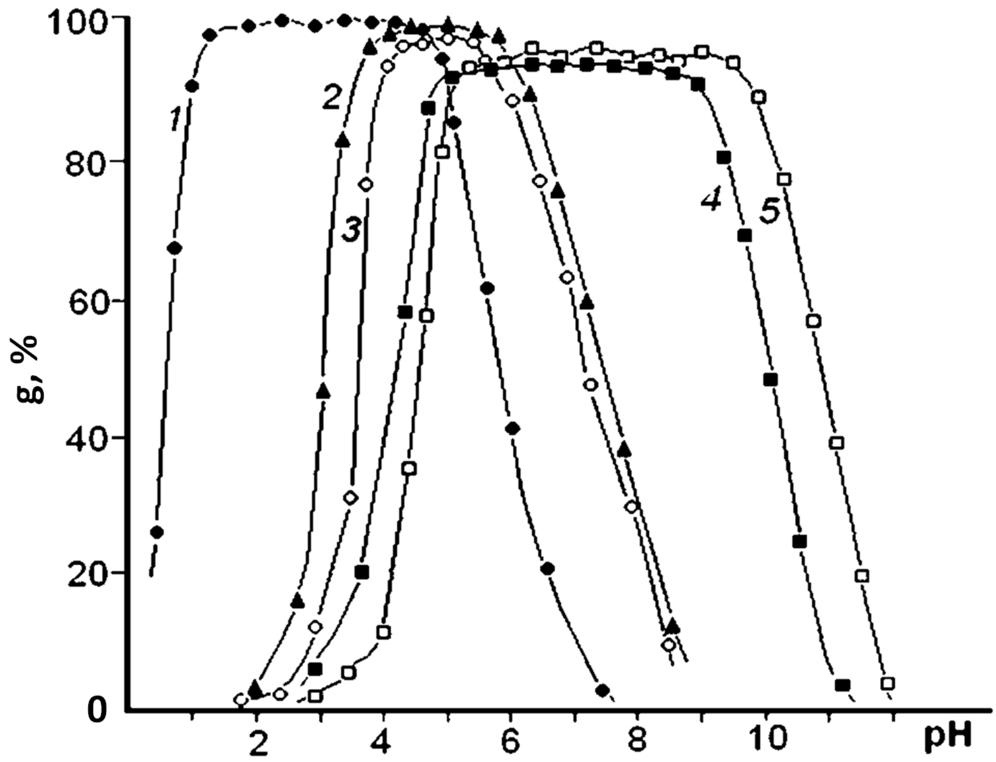


Fig. 7-1. Dependence degree of involvement (D%) with an aqueous solution of metal cations (at their concentration 10 mg/dm^3) of poly-reagent box on the *pH* in static conditions: $m_{poli\text{-}APTT}$ = 0.5 g; V = 500 cm^3; t = 24 h; 1 - *Hg (II)*, 2 - *Cd (II)*, 3 - *Pb (II)*, 4 - *Zn (II)*, 5 - *Cu (II)*.

7-3. Results and Discussion.

Based on the proposed *SAA* determination of *HM* in fluent water of the rivers, and to identify concealed in the bottom sediments of small rivers by *AAS* conducted a systematic study to determine the *HM* in these facilities during the years 2012-2013. Averaged data distribution of *HM* in the fluent water of small rivers of studied areas of Transcarpathians region are presented in Tab. 7-1, and data of distribution of *HM* in the bottom sediments of the rivers – in the Tab. 7-2.

Analysis of the data of Tab. 7-1 shows that the total content of the *HM* in the fluent water of the rivers depends on the topographic conditions of the basin and in mountain rivers the *HM* content is less than in rivers in piedmont regions, and in the last – less than rivers in lowland regions. Thus there is a "geochemical wear" of *HM*, which is reflected in the water of small rivers. The seasonal content of the *HM* in the waters are ± 13-21%, depending on the water level in the rivers. In addition, the *HM* content in the water of small rivers is proportional to the level of their silting. Causes of siltation can be as dynamic features of rivers (meandering), and the construction of reservoirs for hydroelectric power plants. Therefore, the creation of water control facilities (reservoirs) of a significant amount on small rivers of Transcarpathians may contribute to the accumulation of undesirable amounts of heavy metals.

The trend regarding *HM* content in bottom sediments of small rivers (Tab. 7-2) has similar distribution of *HM* in the fluent water of these rivers (Tab. 7-1) and "geochemical wear" of *HM* compounds. The exception is *Cu*, which is obviously due to the geochemical peculiarities of the territory. *HM* content in bottom sediments of small rivers is by 2-3 orders of magnitude higher than in the fluent water of the respective rivers, thus, the bottom sediments, with accumulating properties can be considered as representative objects that reflect the ecological condition of the river basin over the content of the *HM*.

The regularities of distribution and migration of *HM* in the waters and sediments of small rivers of Transcarpathians allow consideration of the geological, topographical and geochemical features of the region. On the basis of generalization of these data have been conducted a mapping of basins of small rivers with the total content of the *HM*. Like example, in Fig. 7-2 is presented map of the distribution of the sum of *HM* in the sediments of the Upper reaches of the River Borzhava with the extrapolation of data on the river basin.

From Fig. 7-2 shows that it is possible to allocate a zone of accumulation of *HM*, this is proportional to the level of silting of the river. The latter is confirmed by the definition of *HM* in the soil horizons of the protected areas, where the most indicative are the data for the humus soil horizon.

7-1. HM in the fluent water of small rivers of Transcarpathians.

River	Heavy metals ($\overline{X} \pm \Delta X$), mg/dm^3				
	Hg(II)	*Cd(II)*	*Pb(II)*	*Zn(II)*	*Cu(II)*
Gorgany Massif					
Sloboda	0,005±0,001	0,011±0,002	0,319±0,052	1,34±0,25	1,62±0,26
Tereblya UR*	0,008±0,002	0,023±0,004	0,471±0,074	8,12±1,28	6,12±1,03
Suhar	< 0,003	< 0,003	0,073±0,014	0,93±0,16	2,36±0,45
Ozeryanka	< 0,003	0,014±0,002	0,081±0,013	5,34±1,02	4,95±0,89
East-Beskydy Massif					
Uzh UR*	0,009±0,002	0,057±0,011	1,180±0,190	14,07±2,24	9,18±1,29
Lubnia	< 0,003	0,013±0,002	0,207±0,031	1,19±0,21	1,49±0,27
Vyhorlat Massif					
Ulichka	0,007±0,001	0,029±0,005	0,636±0,108	1,53±0,28	0,97±0,17
Polonynskiy Massif					
Vyshka	0,005±0,001	0,041±0,007	0,737±0,102	4,77±0,67	2,41±0,39
Gutyn Massif					
Ilnychka	0,008±0,002	0,027±0,005	1,070±0,150	6,89±1,10	4,87±0,88
Irshavka	0,011±0,002	0,034±0,005	1,280±0,220	11,18±1,57	7,66±1,23
Syniavka	0,009±0,002	0,019±0,003	0,841±0,135	8,23±1,39	3,39±0,58
Borzhava UR*	0,039±0,007	0,083±0,015	2,060±0,310	21,37±2,78	10,43±1,46

Note. UR* – upper reaches, <0,003 mg/dm^3 – less than limit of detection methods.

7-2. HM in sediments of small rivers of Transcarpathians.

River	Heavy metals ($\overline{X} \pm \Delta X$), mg/kg (dry sludge)				
	Hg(II)	*Cd(II)*	*Pb(II)*	*Zn(II)*	*Cu(II)*
Gorgany Massif					
Sloboda	0,011±0,002	0,017±0,003	0,079±0,011	0,92±0,13	1,44±0,24
Tereblya UR*	0,019±0,003	0,031±0,005	0,126±0,019	1,82±0,24	2,09±0,33
Suhar	0,005±0,001	0,004±0,001	0,055±0,010	0,74±0,11	1,17±0,18
Ozeryanka	0,007±0,002	0,019±0,003	0,063±0,010	1,16±0,16	1,65±0,26
East-Beskydy Massif					
Uzh UR*	0,011±0,002	0,022±0,004	0,109±0,017	2,26±0,34	1,87±0,26
Lubnia	0,007±0,002	0,012±0,002	0,067±0,012	0,95±0,12	0,93±0,14
Vyhorlat Massif					
Ulichka	0,009±0,002	0,014±0,002	0,084±0,013	1,17±0,16	1,28±0,19
Polonynskiy Massif					
river Vyshka	0,010±0,002	0,019±0,003	0,078±0,012	1,82±0,25	1,62±0,23
Gutyn Massif					
Ilnychka	0,009±0,002	0,019±0,003	0,114±0,017	2,17±0,30	0,91±0,14
Irshavka	0,012±0,002	0,017±0,003	0,117±0,016	2,84±0,41	0,87±0,12
Syniavka	0,007±0,002	0,014±0,002	0,097±0,014	1,78±0,27	0,82±0,13
Borzhava UR*	0,013±0,002	0,022±0,04	0,139±0,021	3,73±0,52	1,13±0,16

The radioecological monitoring within protected areas allows evaluating the distribution of natural and technogenic gamma-active radionuclides (*GAR*). Only bottom sediments of small rivers had been studied, because the specific activity of the fluent water of these rivers is too negligible to obtain reliable data. It is known that the background radiation is the natural form of ^{40}K, ^{238}U *and* ^{232}Th. Due to large periods of half-disintegration of ^{238}U and ^{232}Th and their low specific activity in bottom sediments, it is advisable to assess the amount for the products of their disintegration: in accordance ^{214}Bi and ^{214}Pb (^{238}U series) and ^{228}Ac, and ^{212}Bi, ^{212}Pb (^{232}Th series). The ratio of the activity of individual *GAR* of $^{214}Bi/^{214}Pb$ and $^{212}Pb/^{212}Bi$ is a criterion of balanced natural radioactivity. As the experi-

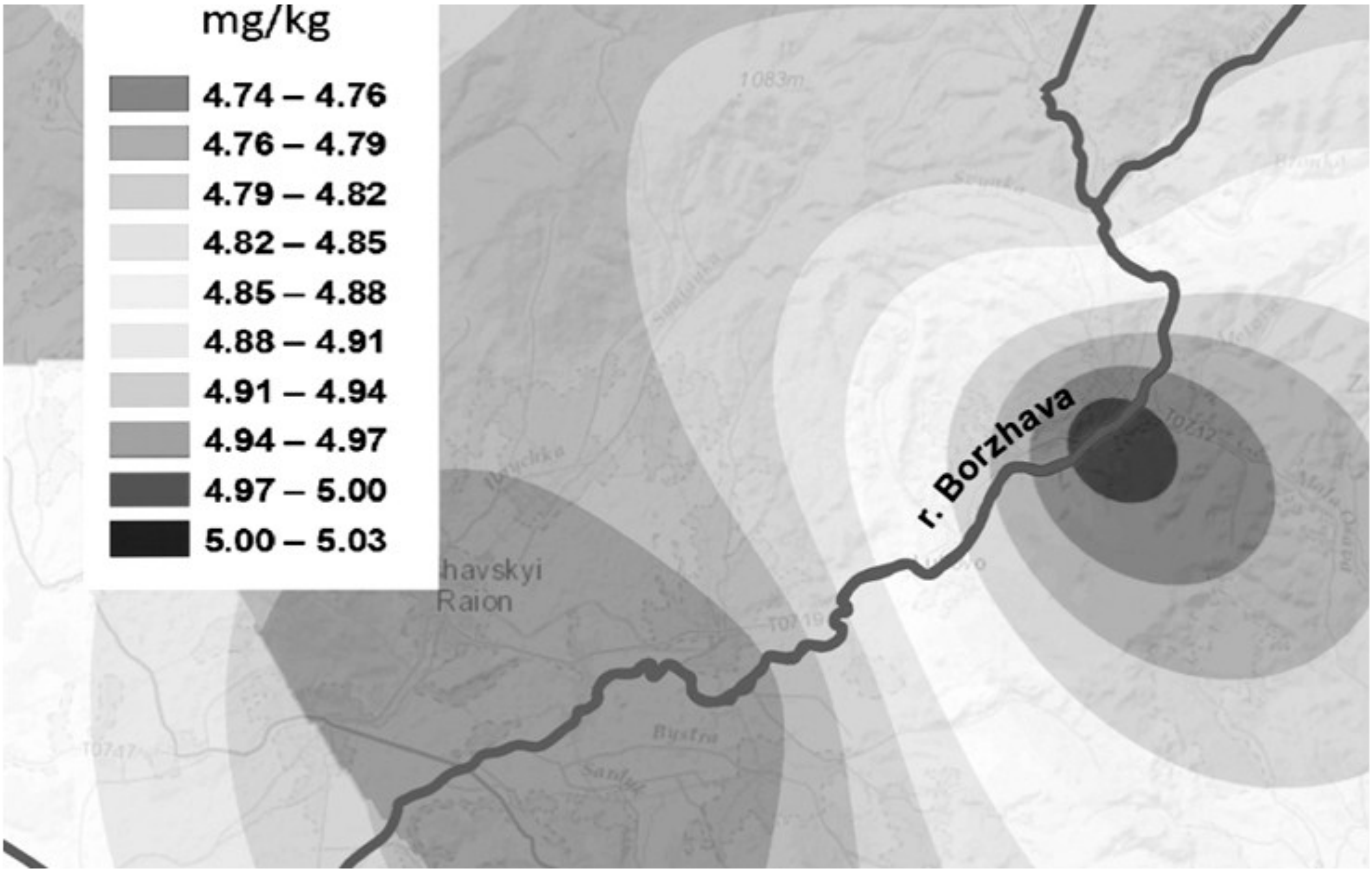


Fig. 7-2. *HM* in bottom sediments of Irshava district (the Borzhava downstream) as extrapolation to the territory of the river basin. Note that growing of levels graduate from left to right accordingly to ascendant of altitudes.

ence of similar studies (Parlah et al., 2013; Symkanich et al., 2012), the most effective radiological markers have ^{214}Bi (^{238}U series) and ^{228}Ac, ^{212}Pb (^{232}Th series) that we used for research.

It is established that the specific activity of the amount of natural *GAR* (excluding ^{40}K, the activity of which is proportional to the gross content of potassium) in the sediments of small rivers has an opposite distribution pattern of *HM*. So, for the river

Borzhava it is exclusive distribution for both *HM* and *GAR* as it is the same ! (Fig. 7-2 & 7-3). The highest specific activity of *GAR* is inherent in bottom sediments of small rivers in higher altitudes, and lower for sediment low-lying regions. This is obviously due to tectonic faults and seismically active mountain regions, resulting in the allocated *Rn-222* and *Rn-220* (are products of disintegration of ^{238}U and ^{232}Th) and form in the disintegration result ^{214}*Pb*, ^{214}*Bi* (^{238}*U series),* and ^{212}*Pb*, ^{212}*Bi* (^{232}*Th series).*

Thus, the average total specific activity of natural *GAR* (excluding ^{40}K) in bottom sediments of small rivers, the basins of which are within the upper reaches is 281±22 Bq/kg, within the middle reaches – 253±19 Bq/kg, and within the down reaches – 167±24 Bq/kg. It should be noted that an averaged specific activity of natural *GAR* in bottom sediments of small rivers reflects the ecological state of the territories of the pool, because it practically coincides with the data for the humus soil horizon for this indicator. Therefore, exploring the bottom sediments of small rivers on the values of specific activity of natural *GAR* can be described by the state of their basin, which greatly saves time for carrying out radio-ecological monitoring. As an example, in Fg. 7-2 & 7-3 shows a map of the distribution of the total specific activity of *GAR* (excluding ^{40}K) in bottom sediments of the

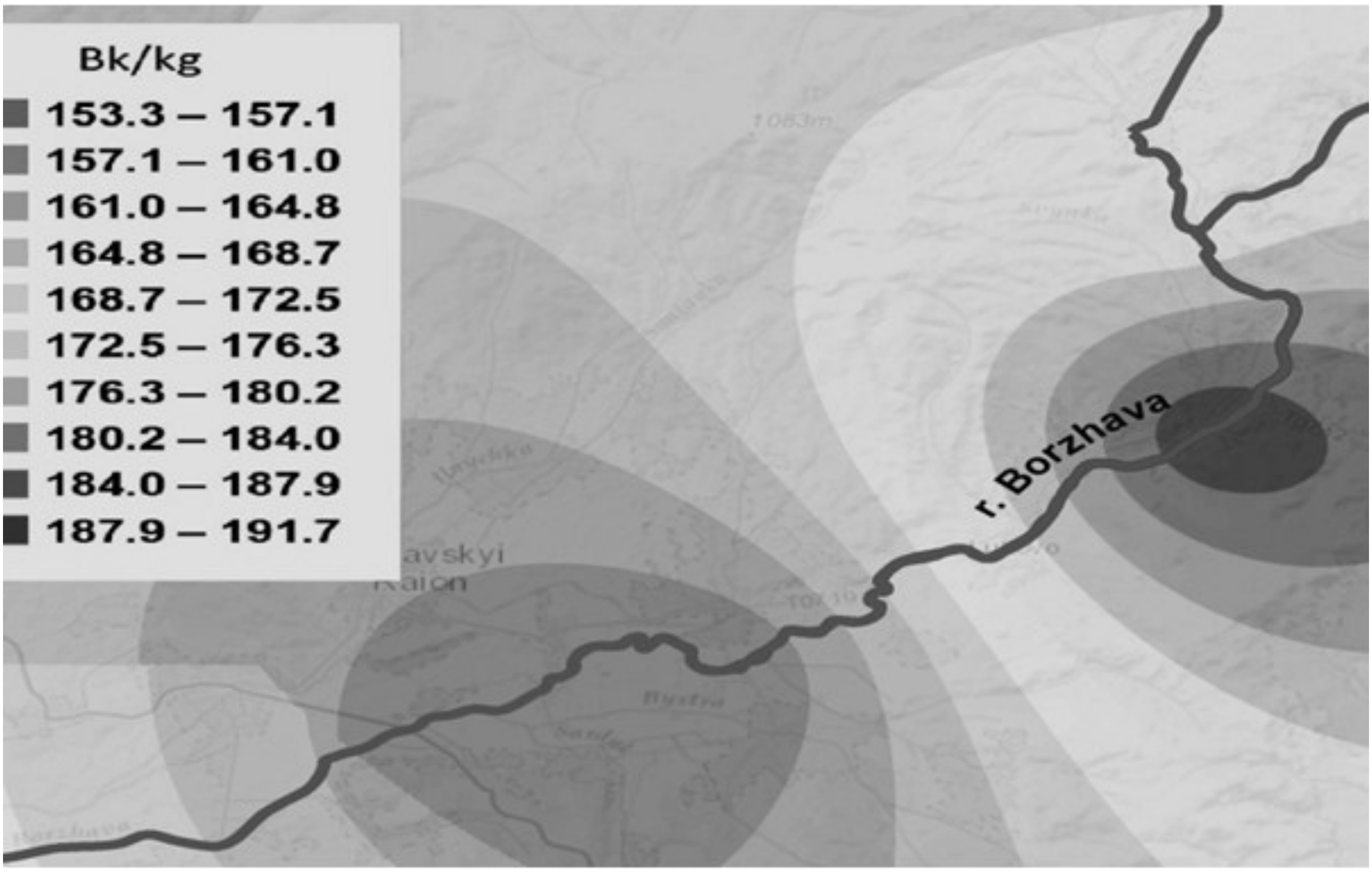


Fig. 7-3. Natural *GAN* (excluding ^{40}K) in bottom sediments of the river Borzhava downstream) as extrapolation to the territory of the river basin. Note that growing of levels graduate from left to right accordingly to ascendant of altitudes.

River Borzhava and in soil horizons in the area of NNP "Enchanted land".

As can be seen from Fig. 7-2 & 7-3, the zones of accumulation of natural *GAR* in the basin of the river Borzhava coincides with the zones of accumulation of natural *GAR* in humus soil horizon (0-20 cm) of the protected area (Sukharev et al., 2014). Similar patterns are obtained for other regions of the Transcarpathians Province.

Such zones of accumulation may be due not only to the morphology of rivers and construction of reservoirs that will contribute to the accumulation of *GAR* and *HM*, and this can lead to undesirable consequences.

It should be noted that the patterns of distribution of natural *GAR*, in particular radiological markers ^{214}Bi and ^{212}Pb, in the bottom sediments of small rivers in space is expressed, thus making it possible to predict the state of these objects.

Unlike natural *GAR*, the artificial *GAR* of ^{137}Cs distribution in bottom sediments of small rivers has the opposite nature and have been observed the process of "geochemical wear". It can be used as an indicator of the processes of soil erosion (deposition in bottom sediments of small rivers) and intensity of deposition. Thus, the average content of ^{137}Cs in bottom sediments of small rivers, the basins of which cover the upper reaches of the rivers is 2.9±0.5 Bq/kg, for middle reaches – 4.6±0.7 Bq/kg, and for rivers lower reaches – 6.3±1.3 Bq/kg.

In General, the content of *HM*, and the specific activity of *GAR* in water and bottom sediments of small rivers of the Transcarpathians region is low and may be taken as background values. This, in turn, allows to use the results of the distribution of *HM* and *GAR* in small rivers of Transcarpathians province as control data for monitoring of the environment.

7-4. Conclusions.

1) Thus, have been established regularities of distribution and migration of heavy metals and gamma-active radionuclides in water and bottom sediments of small rivers of the Transcarpathians province.
2) It was justified reasons of resonating but adverse distribution of heavy metals and radionuclides in the upper, middle, and lower reaches of the rivers (except of the riv-

er Borzhava, where it is synchronic).

3) It has been suggested that the construction of large reservoirs on the rivers is undesirable because, silting within the reservoir contributes to the accumulation of heavy metals and gamma radionuclides. It is difficult to predict forms of these compounds in conditions of bottom sediments, but it could result in future into negative consequences to the river continuum.

8. ECOLOGICAL STATE OF TRANSCARPATHIANS SMALL RIVERS.

Abstract. This subchapter is devoted to ecological state of Transcarpathians small rivers. It was determined that average meanings of ecological index of water quality of small rivers varies from II class (good) to III class (satisfactory). Ecological index was based on nitrate nitrogen concentration and biochemical oxygen consumption by water during 5 days. It is determined that small rivers have high and permanent anthropogenic pollution and hence of that river system is hardly capable of self-purification. The possible measures of improvement of small rivers ecological state are offered.

Key words: Ecological state, small rivers, water quality, tropho-saprobiological indices.

In Transcarpathians region there are 155 rivers that are longer than 10 km. The river network is the most dense in Ukraine, the average density of river network is 1.7 km per 1 km^2 (Water resources … 2007). The rivers belongs to the basin of the Tisza river (a tributary of the Danube), formed on merging of the Bila and Chorna Tisza. Such rivers as the Borzhava, the Tereblya, the Rika, the Teresva, and the Battar flow into the Tizsa within the area of Transcarpathians. The Latorica flows into the Bodrog-Tisza in Hungary, the Uzh – into the Laborets-Latorytsia in Slovakia.

Almost all rivers are rising from the mountains and flow mainly from the Northeast to the Southwest. Water supplying of the rivers come with rains (40% of annual runoff), snow and soil. Floods are significant to the river after heavy rains (8-10 floods per year) (Hutsuliak et al. 2002). Basic information about some of the rivers of Transcarpathians are presented in Tab. 8-1.

Ecological state of small rivers of region determines the stage of transformation of ecosystems from normal (or favourable) satisfactory due to catastrophic, tense pre-crisis, poor and critical. The catastrophic floods that occurred in November 1998 and March 2001 is confirmation of underestimating the objective laws of Nature. The ecological status of rivers stay in functional dependence on the state of ecosystems and natural ingredients from the effects of the technosphere on natural components. Due to the high density of the river network the land area is characterized by erosion and flooding. In terms of geomorphology territory of Transcarpathians depending on altitudes and the nature of the relief is divided into three regions, which are very different in soil and climatic conditions, namely:

8-1. Basic information about the rivers of Transcarpathia.

No	*Name of the river*	*Place of river confluence*	*Side of the bank*	*Length of the river (km)*	*Area of the intake (km^2)*	*Quantity of the tributaries*	*Total length (km)*
263	Uzh	Laborets – Latorytsya river	R	133 107	2750 2010	509	979
272	Turya	Uzh river	L	35	467	135	287
266	Ublya	Uzh river	R	6	26	18	28
252	Verke	Serne river	L	33	–	24	179
251	Serne	Charonda river	R	44	–	50	100
246	Charonda	Latorytsya river	L	28	–	20	39
221	Latorytsya	Bodrog – Tisza river	L	191 144	7860 4900	376	1061
165	Tereblya	Tisza river	R	91	750	472	643
223	Vecha	Latorytsya river	L	38	243	142	248
232	Vyznytse	Latorytsya river	R	30	160	52	71
241	Tsygany	Stara river	R	24	115	11	26
235	Stara	Latorytsya river	R	40	461	25	103
203	Borzhava	Tisza river	R	16	1360	262	456
212	Irshava	Borzhava river	R	48	346	73	143

Note. No – Number from catalogue.

Prytysyanska plain – a zone of potential flooding as local surface runoff water and transit, which comes from the top and flows year. Coastal erosion may take place there.

Foothills – a zone of excessive moisture. Weak aeration and water penetration of soil causes severe flood that washed away the soil on these slopes. Linear soil erosion dominates there.

The mountainous area covers 65% of the regional territory. In this area there are always all kinds of erosion, mudflows and landslides.

Monitoring control was applied to identify the environmental problems of small rivers (The EU Water Framework Directive 2006) the Ublya river (mountain zone), the Turya (foothills), the Verke (Prytysyanska lowland). Sampling was carried out in the same places where samples were taken for the study of hydro-chemical parameters during the program TACIS (The TACIS … 2000). There were defined hydro-chemical indicators from three block codes environmental of assessment of water quality - salt I_s, trofo-sapro-biological I_{ts} and toxicological and ecological calculated integral index (Method of Environmental Assessment … 1998). The results are presented in Tab. 8-2 (Chundak et al. 2010, Trapeznikova et al. 2010 & 2011a,b,c & 2013).

It was established that water quality of the abovementioned rivers by the point of the concentration of nitrate nitrogen (*NO_3-N*) and biochemical oxygen consumption during 5 days (*BOC_5*) (group of tropho-sapro-biological or the ecological and sanitary code) belongs to class No III and V respectively. It shows that the condition of water is very bad, the degree of purity / pollution – very dirty (V class) and the state – satisfactory, the degree of purity / pollution – polluted (III class). The integrated environmental index describes the water quality of the river Turya and Ublya as good (II class), and the Werke –

8-2. Environmental classification of rivers Ublya, Turya, Verke water quality.

Class of water quality	I Blue	II Green		III Yellow		IV Brown	V Red
Category of water quality	1	2	3	4	5	6	7
Name of classes and categories of water quality complying to condition	Excellent	Good		Satisfactory		Bad	Very Bad
	Excellent	Very good	Good	Adequate	Middle	Bad	Very Bad
Name of classes and categories of water quality in compliance with degree of purity (contamination)	Very clean	Clean		Polluted		Dirty	Very Dirty
	Very clean	Clean	Suffic. Clean	Slightly polluted	Temperate polluted	Dirty	Very Dirty
Average value of the salt index of the river Verke, Ublya, Turya	Ublya Turya	Verke	-	-	-	-	-
Average value of the index trophy- saprobity (Its)	-	-	-	Ublya Turya	-	-	Verke
Average value of nitrate nitrogen (NO_3-N)	-	-	-	-	-	-	Ublya Turya Verke
Average value of ammonium (NH_4-N)	-	-	Ublya Turya	-	Verke	-	-
Average value of dissolved oxygen (O_2)	Ublya Turya Verke	-	-	-	-	-	-
Average value of BOD_5	-	-	-	-	Ublya Turya Verke	-	-
Average value of phosphorus phosphate (PO4)	-	Ublya Turya Verke	-	-	-	-	-
Average value of the content of toxic substances action (IT) index	-	Turya Verke	-	-	-	-	Verke
Average value of ecological index (IE)	-	Ublya Turya	-	-	Verke	-	-

Notes. BOD_5 – Biochemical oxygen demand per 5 days. Suffic. – sufficiently.

very bad (V class).

During research monitoring of the rivers the Vecha, the Vyznytsa, the Tsygany there were identified problems with pollutions of the group of trofo-saprobiological indicators, such as nitrate nitrogen and BOC_5, average and maximum values (worst) values of their concentration varies from class III to V, i.e. from satisfactory to very poor condition.

Determined stable tendency of variation of hydrochemical indicators mean the permanent pollution of anthropogenic origin and the consequent inability of river ecosystems for itself purification.

Thus, the most important factors of small rivers pollution include:

a) pollution of river basins caused by accumulation of soil erosion, leaching from the soil surface contamination and mechanical harmful agrochemicals;

b) contamination of rivers due to the dumping of organic and inorganic waste due to lack of sewage purification systems;

c) hydrobiological pollution as the result of entering of nutrients into aquatic surrounding, which leads to intensive development of pathogenic microflora, aquatic vegetation growth, etc.

Comprehensive assessment of water quality of rivers: the Ublya, the Turya, the Vecha and Verke, the Vyznytse, the Tsygany, the Irshava, and Borzhava river led to the following conclusions:

1. Water pollution of human origin in mentioned above rivers can be measured by hydrochemical indicators from the group of trofo-saprobiological index, such as nitrate nitrogen and BOC_5.

2. The content of nitrate nitrogen (NO_3-N) significantly exceeds the maximum allowable concentration (*MAC*) (of sanitary state and in fisheries), which threatens the recreational and commercial use of small rivers in the region.

3. In order to improve the ecological state of small rivers of Transcarpathian region there should be applied the significant increase of the effectiveness of ingoing local administrative environmental measures accordingly with the legislation and ensure the proper use of budget allocated for their implementation.

9. THE PRELIMINARY DATA ON STATE OF THE RIVER SHIPOT ECOSYSTEM AS A RESULT OF HYDROPOWER PLANT BUILDING (THE UZH TRIBUTARY, THE TISZA BASIN).

Abstract. This subchapter describe the preliminary evaluation of situation with the hydrobiological regime of the river Shipot, partially transformed by building of the hydroelectric power plant (HPP) and micro (ultra small) reservoir.

Key words: small hydro-electric power plant, hydro ecosystem, impact on hydro ecosystem, quantitative indicators, gross primary production and total decomposition of organic matter.

9-1. Introduction.

The main aims in the study of changes of the ecosystem of the river as a result of hydraulic engineering:

Assessment of aquatic communities, including microinvertebrates, protozoa and fish.

Assessment of the situation with a rare, a few species, and species that need or are protected.

Changes in the transformation of organic matter in a small reservoir, upstream and downstream.

Evaluation of changes in the structure of the river in the upper reaches of the river Shipot hydro-ecosystems in conditions of building of a small electric power plant “Shipot-2” (not in this Chapter).

Evaluation of the ecological state of water body on microbiological criteria:

A) Dynamics of abundance of aquatic microorganisms depending on the level of anthropogenic load.

B) Assessment of character of microbiological processes in the Shipot ecosystem .

C) Determination of water samples and opportunistic pathogens.

D) Evaluation of the sanitary conditions of the river Shipot on microbiological indices.

Forecast changes and proposals to avoid possible adverse changes in aquatic microbiota, invertebrate, and protozoa communities, and fish.

9-2. The list of symbols, characters, items, abbreviations and terms.

HPP – hydropower plant.

OS – organic substance.

DOS – decomposition (destruction) of *OS*: Is the main indicator to show the process of transformation of OS in water bodies as a whole. Formed by all organisms of one or another ecological group (ecogroup).

GPP – gross primary production: The formation of organic matter in the process of photosynthesis, resulting in significant levels to self-pollution or eutrophication. Formed mostly single-celled algae that inhabit different ecological groups within the reservoir or watercourse. The lack of primary production indicates a low number of single-celled algae, or the poor conditions for the process of photosynthesis – a physiological process that leads to the formation of primary production.

Plankton – aggregate of the water organisms.

Benthos – organisms of bottom sediments.

Periphyton or *biofouling* – aggregate of organisms on other aquatic organisms, or on the rocks (pebbles, boulders or on the cobs) and dams in the aquatic environment but projecting above the bottom sediments.

Spms – spicimens in sumple, usually per square or cubic meter/sometimes gram or liter.

Ecological groups – above mentioned three groupings within habitats.

Zooplankton, zoobenthos, zooperiphyton – animal organisms that make up the relevant ecogroup.

Protista – unicellular organisms many of which are able to form colonies that are part of ecogroups.

The microbiocoenosis (bacterial community) – aggregate of bacterial populations, which is part of various ecogroup.

Fish fauna – fish and fish-shaped (ichthyoids) of a reservoir or watercourse.

Saprobiological characteristics – evaluation of pollution of one or another area: Evaluated by direct or indirect methods by use of bioindicator organisms, i. e. those that can exist in environmental conditions with clear specifications for pollution. There are different indexes that can provide pollution digitally.

Zones of contamination – levels of presence of organic matter: katarobic – OS virtually absent (excellent state of water ecosystem); oligosaprobic – low level of pollution (good state of the water system); β-mesosaprobic – middle level of pollution (acceptable state of water ecosystem); α-mesosaprobic – high level of pollution (unacceptable state of water ecosystem); polysaprobic – the very hogh level of pollution (extremely bad state of aquatic ecosystems, which requires comprehensive measures to bring the system back to normal; hypersaprobic – catastrophic condition, which can be corrected only by means of landscape engineering.

Bacterial indicators – characterize water contamination by pathogenic microorganisms: coli-index – the number of *Escherichia coli* in 1 liter of water; coli-titer – water containing one *E. coli*.

Quantitative indicators of development – structural characteristics of population development: *density* (or *abundance* in the area or at volume) and *biomass*.

Functional indicators of communities – production, consumption and destruction of OS by animals, unicellar organisms and bacteria.

9-3. Materials and methods.

Characteristics of reservoir water volume :

Cubic capacity – 1.500 m^3.

Retaining normal level – of 4.6 m.

Maximum level – 6 m.

Projection surface (area) – 1000 m^2 .

Dam height – 4.6 m.

Width of dam – 36 m.

Depth: maximum – 4.6 m; average – 1.5 m.

Consumption of water : maximum during floods – 140 m^3 of water; minimum – 0.5

m^3.

Microbiological investigations. Microbiological analysis of water has been carried by conventional methods (Chaika 2004, Semenchenko 2004, Methods of hydroecological investigations 2006). Samples of water were collected in a sterile container for all investigated stations. To study carried bacterioplankton a serial dilution of samples were undertaken and at the end they were plated on selective environment. To determine the number of bacterioperiphyton the measuring of the surface area has been made.

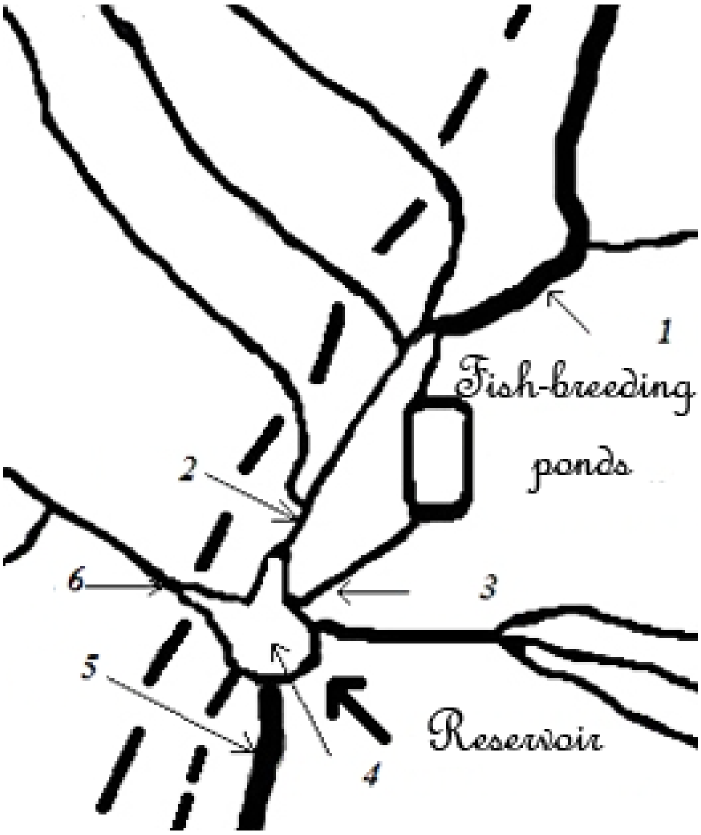


Fig. 9-1. Map of location of upper sampling sites on the Shipot near and in reservoir.

Hydrobiological investigations.

Plankton. Was sampled by the Jedy plankton net and the Ruttner Water Sampler (three horizons – superficial, middle and bottom).

Benthos. For sampling benthos the jars of 200 ml with throat area of 16 cm^2 were used. Sampling was carried out in 2-3 repetitions mainly by neck jars. Samples were treated by the conventional method (Zhadin 1956).

Periphyton. It was sampled by placing stone from pebble (stones up to 10 cm in diameter) in jars of compatible volume. After delivery to the laboratory stones were purified by toothbrush, and their surface area (only active upper plot) was scaled by lined paper.

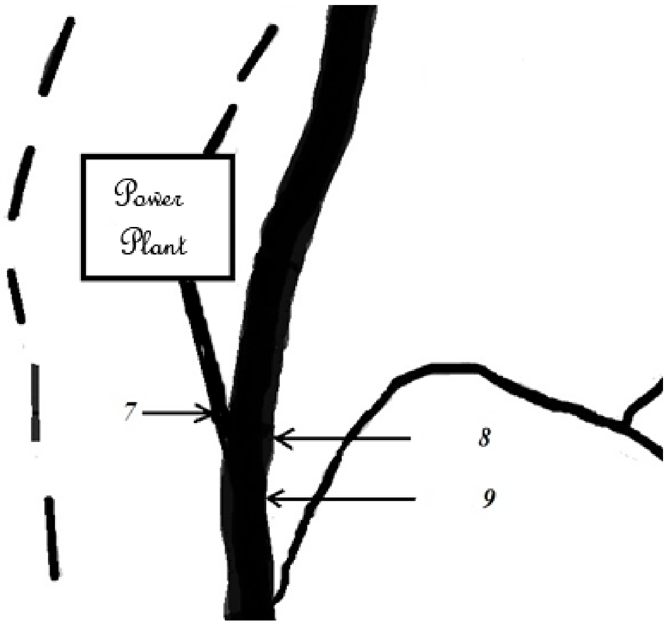


Fig. 9-2. Map of location of down sampling sites on the Shipot near the power plant.

Photo 9-1. The river Shipot sampling site No 1. Upper than fish-ponds.

Photo 9-2. The stream from fish-ponds: site No 3.

Photo 9-3. The Shipot reservoir: site No 4.

Photo 9-4. The stream from fish-ponds: site No 6.

Photo 9-5. The canal from hydropower plant: site No 7.

Photo 9-6. The main watercourse before conjunction with the canal: site No 8.

To determine organisms the specialized keys have been used (Chernovski 1949, Zhadin 1952, Bartoš 1954, Borutskiy 1959, Manuilova 1964, Monchenko 1974, Mazei & Tsiganov 2006, Chertoprud & Chertoprud 2006).

Each taxon of organisms was counted for the total abundance of organisms. The data have been summarized and thus determine the total number of organisms in the sample, and recalculate for the area.

Saprobity was assessed by method of Zelinka and Marvan. For each sampling site the index of Rotshine in I. K. Toderash' modification (Toderash 1980) has been calculated.

Ichthyology. To evaluate the composition of fish fauna a periodical collectioning of ichthyological material have been conducted in accordance with the methodology proposed by I. F. Pravdin (1966).

We used methods that allowed by current legislation of Ukraine and namely: bottom trap with one hook, net and net spider the size of 1m to 1m. A variety of fishing methods used and baits (earthworm, young fish larvae, and larvae of stone-flies), that were used to collect the material allow a fairly detailed picture of the current state of fish fauna of studied watercourse.

Gross primary production and the total decomposition (destruction or mineralization) of *OS* in plankton of the reservoir. Setting of experiments on the determination of *GPP* and the total *DOS* by glass method performed in an oxygen modification accordingly to G. Vinberg (1960). The oxygen content in the experiments was determined by Winkler method.

The material served was fixed by 4% formalin:

4 samples of plankton collected October 26, 2013;

7 samples of benthos, October 26, 2013;

5 samples of plankton collected , November 28, 2013;

5 samples of periphyton, November 28, 2013;

4 samples of microzoobenthos, October 30, 2013;

Also in November 28, 2013 were collected and processed 7 unfixed (alive) samples of protozoa and microinvertebrates.

Material has been collected at nine sites (Fig. 9-1, 9-2; Photos 9-1 to 9-6). Sampling sites were selected during expedition in October 26, 2013, but some were living, other fixed by 4% formalin.

At the reservoir water-intake of mini *HPP* in November 28-30.2013, it was conducted an experiment to determine the *GPP* and the total destruction of *OS*.

Ichthyological material have been collected in 3 zones of the river Shipot:

catching zone 1 – located upstream, above the hydroelectric water-intake and discharge of fish-breeding ponds, is the most close to the natural habitat, with rapids, small waterfalls, the depth of the river bad drops from 0.1 to 1.5 m., and the flow velocity 0.2 to 1.0 m/sec;

catching zone 2 – extends from the discharge of water from the fish-breeding ponds to the reservoir. It is characterized by slow drift (up to 0.2 m \ s) and great depth (up to 4 m.) in the reservoir. The most prominent feature of the site is that due to the process of siltation and accumulation of organic residues, there is methane and hydrogen sulfide.

catching zone number 3 – extending from the exit point of water intake after hydroelectric turbines. Plot length of about 1 km. Characteristic features of the site are: a large number of shallow gravel spits, a small drop from the depths of 0.1-0.6 m, and reaches speeds of 0.2 to 0.8 m /sec.

Analysis of structural parameters was performed using several indexes, the main of which are shown below (Methods of hydroecological investigations …, 2006):

Shannon-Weaver Index:

Modified Simpson diversity index (biodiversity is higher when higher is amount of

$$H = -1.443 \sum_{i=1}^{S} \left(\frac{n_i}{N}\right) ln \left(\frac{n_i}{N}\right)$$

species in community (biocoenosis) and the more they are equitable in terms of significance (abundance, biomass, etc.):

$$S_\lambda = 1 - \sum \left(\frac{n_i}{N}\right)^2$$

where n_i – number of individuals of each species, and N – total amount of individuals of all identified species.

Pielou index of diversity:

$$E = \frac{H}{logN} = \frac{H}{H_{max}}$$

The opportunities to explore near water fauna were very limited, since amphibians and reptiles at a time when the investigation is actually going to work (November, beginning of December) are inactive and to do their accounting is impossible. However, the study of reservoirs of this type (ultra-small) shows the positive impact of such ponds for spawning opportunities and biodiversity of amphibians. That is adverse to large reservoirs were impact on near water animals can be very negative (Hawkes & Wood 2014).

Regarding near the water vertebrates, the experience of water research suggests that certain types martens – otters, ermines, ferrets etc. have the best opportunities to meet food and of survival in the cold winters.

9-4. Results of investigation.

9-4-1. Active water acidity or pH.

9-1. Meanings of pH in the morning at sites of the Shipot and Shipotets.

№ sampling	pH on sampling sites	
	26.10.2013	28.11.2013
1.	-	7.23
2.	7.13	7.18
3.	-	7.09
4.	6.95	6.98
5.	7.01	7.04
6.	7.21	7.26
9.	7.05	7.13

Changes in pH (Tab. 9-1) over measurement points from upper part of the reservoir till down reaches of the river indicate the features of this index within the reservoir. Into acidification of the reservoir results breeding of fish inside and affluent of waste water from fish-breeding ponds that existed closely near (Site 3), which is in favor of substantial amounts of carbon dioxide. However, downstream pH gradually increased, which could be explained by the growing of GPP intensity in periphyton on the pebbles. However, as can be considered normal pH of pure (benchmark) the River Shipotets – 7.26, which is above all other meanings in October, and notably *higher than reservoirs' meanings in November.*

9-4-2. *GPP* and Total decomposition of *OS*.

Because no primary production (both pure, even gross) in plankton of the reservoir

9-2. Decomposition of *OS* in plankton of the reservoir of a ultra-small *HPP* on the river Shipot (Site 4).

No	Date	Depth, m	Temperature	Decomposition OS, J/m^3	Decomposition OS, g/m^3
1	30.11.2013	0.25	2°	31558.924	7.5
2	30.11.2013	0.25	2°	12595.884	3.0
3	30.11.2013	0.75	2°	6228.732	1.4
4	30.11.2013	0.75	2°	4498.528	1.0
5	30.11.2013	1.25	2°	13772.423	3.2
6	30.11.2013	1.25	2°	13495.590	3.1

during the studies is not observed, then the estimates in production glass have been used as repeating of darkened glass for decomposition experiment (Tab. 9-2).

Given in a last column value of 1 g/m^3 *DOS*, presents data that give evidence of significant degradation of the process of *DOS* in water of the reservoir during the day. It should be noted that in the warm season these values can be 3-4 times higher. The lack of primary production indicates that the plankton decompose allohtonic agents, i.e. one that have been formed elsewhere. Also lack of protistoplankton and zooplankton allows you to set that degradation processes in the water reservoir occurs due microflora (bacterial destruction) and probably the destruction of chemical agents (a small percentage).

Partially the process of *DOS* goes in sediments, both through aerobic decomposition (involving oxygen) and anaerobic (without oxygen, which indicate the presence of hydrogen sulfide odor, and bubbles of methane that periodically rise from the bottom).

9-4-3. The bacterial community.

The bacterial community of the reservoir characterizes the intensity of OS decomposition, its pollution and the nature of the processes of transformation of organic matter that occur in it. Therefore microbiologic characteristics of the reservoir is an important addition in assessing the quality of natural water.

All organisms that are indicators of water pollution can be classified accordingly to R. Kolkwitz & R. Marsson (1908) into katarobic and poly-, meso-, and oligosaprobic. Katarobic – microorganisms that live in clean waters. Saprobic – organisms that live in fresh water with different levels of pollution. Quantitative and qualitative value in water biocenoses are not stable and vary depending on the content of organic substances, changes in other conditions that vary depending on saprobity (Antipchuk 1973, Gak 1975).

Saprobity shows all features of reservoirs, have determine the development of relevant microorganisms in water and containing of *OS* in certain concentrations and certain degrees of mineralization. Bacterial indicators as well characterize water contamination by pathogenic microorganisms.

To assess the direction of human impacts on aquatic ecosystems (the Shipot) samples

9-3. The bacterioplankton abundance in the river Shipot.

Place of sampling	MPA (millions CFU/1cm^3)	ENDO AGAR (thousand CFU/1cm^3)	Coli-index	Coli-titer
Site 1	0.0012	0.015	15	66.6600
Site 2	0.0290	0.054	54	18.5100
Site 3	14.0000	260.000	260000	0.0038
Site 4	0.07500	8.600	8600	0.1100
Site 5	0.02300	7.400	7400	0.1300
Site 6	0.02600	0.040	40	2.5000
Site 9	2.5000	2.700	2700	0.3700
LSD_{05}	0.0560	0.044	-	-

Notes. Here and next: *MPA* – meat peptone agar, *CFU* – colony forming units.

of water were taken to determine the abundance of microorganisms of different ecological and trophic groups. The results of the research are presented in the Tab. 9-3.

Most species of microorganisms that are part of bacterioplankton inherent hemo-organo-heterotrofic metabolism. For them, the main source of energy and carbon is organic matter. Under the action of bacteria the transformation of complex organic compounds and their subsequent mineralization, the chemical composition of water, gas treatment, the flow of nutrients have been done. The activity of the bacterial population is one of the key factors that determine the balance of the primary processes of production and decomposition of organic matter, and therefore ecological status of water bodies. Thus, bacterioplankton, its abundance and biomass adequately reflect the overall level of accumulation of organic matter of autochthonous (produced within the system), and allochthonous (external) origin.

To consider the role of trophic, physiological and indicating properties of bacterioplankton, its indices are used to determine trophic status of water (Chaika 2004, Semenchenko 2004, Methods of hydroecological investigations 2006). Research results of bacterioplankton in water were sampled at stations 1 and 2 (Tab. 9-3, Photo 9-1, 9-7) showed that sanitary indicators Coli-index and Coli-titer index of water meets environmental standards and site of the watercourse is characterized as clean.

Characteristics of the water body by bacteriological indicators is (accordingly to O. Oxiuk et al. 2003) as follows: water quality category – 1; water quality category according to their purity – clean; trophic state – oligo-mesotrophic; saprobity – ß-meso-, to oligosaprobic. Studies of water runoff from selected fish-breeding ponds on the Shipot showed significant contamination. On indicators of sanitary condition its water is characterized as highly contaminated, due to the arrival of a significant amount of allochthonous organic matter and xenobiotics. Characteristics of the water body by bacteriological indicators as follows: water quality category – 5; water quality category according to their purity – the very dirty; trophological state – hypereutrophic; saprobity – polysaprobic.

Analysis of bacterioplankton in aquatic ecosystems after hydroelectric power station (Site 9), showed (Tab. 9-3, Photo 9-8) water pollution but much lower than at stations (4, 5, 6), and it should be noted that the total abundance of microorganisms increases and content of *E. coli* reduced. Characteristics of the water body by bacteriological indices were following: water quality category – 3; water quality category according to their purity – moderately polluted; trophic state – meso- to eutrophic; saprobity – ß-mesosaprobic.

Research of bacterioperyphiton correlates (Tab. 9-4) with research of bacterioplankton because, after confluence of waterflows both main and canal after plant (station 9) signifi-

9-4. The bacterioperyphiton abundance in the river Shipot.

Place of sampling	MPA (millions *CFU*/cm^2)	ENDO AGAR (thousand *CFU*/cm^2)
Site 7	1.45	34.00
Site 8	2.67	97.00
Site 9	8.34	265.00
LSD $_{05}$	0.23	0.16

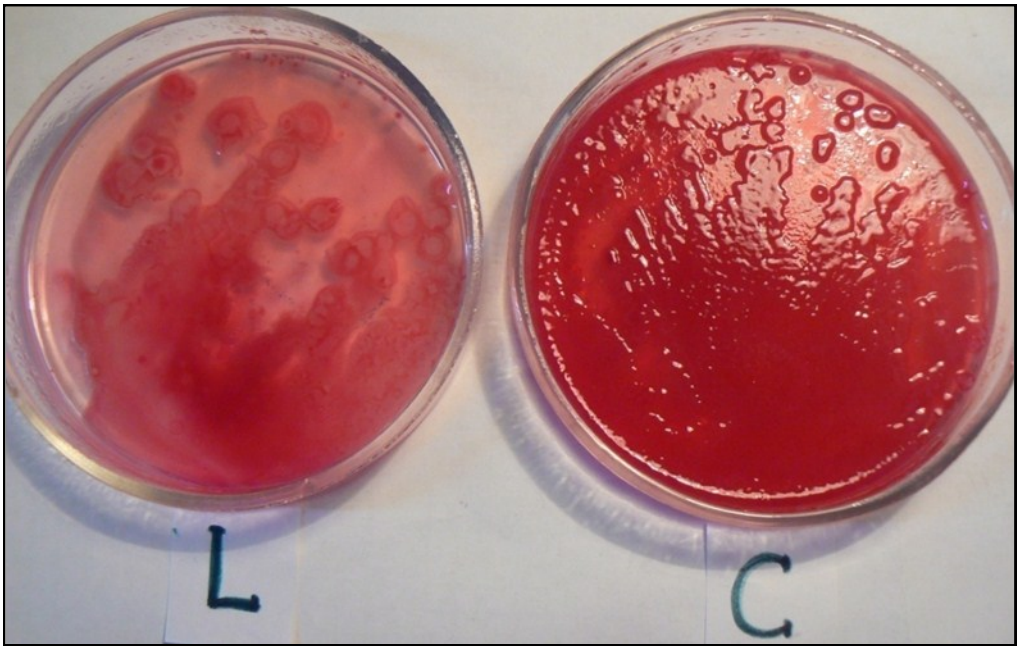


Photo 9-7. Colonies of *E. coli* in plankton of the Shipot: C – fish farm runoff, L – in reservoir.

cantly increased the total amount of bacterioperyphiton and abundance of *E. coli* growing as well.

Characteristics of the water body (Station 9) for bacterioperyphiton indices: water quality category – 5; category of water quality in their degree of purity – moderately polluted; trophic state – eutrophic to hypereutrophic; saprobity – α-mesosaprobic.

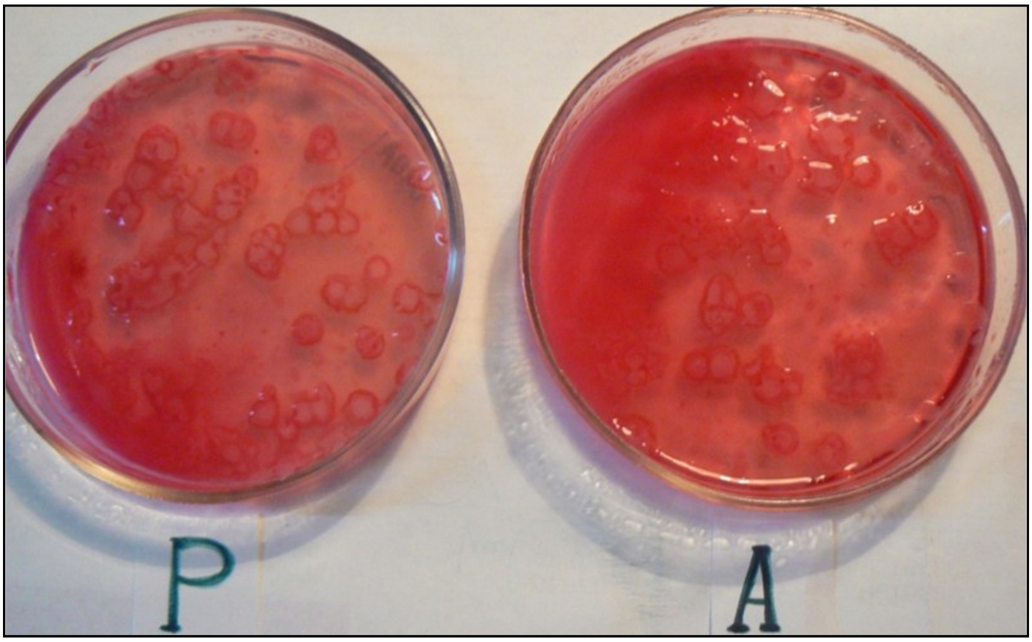


Photo 9-8. Colonies of *E. coli* in plankton of the Shipot: R – canal after hydroelectric power plant, A – after confluence of canal with the main water course.

Thus, the results of microbiological testing of the water body indicate that significant adverse changes in aquatic ecosystem is due to functioning of fisheries farm "Shipot", as evidenced by ecological and sanitary-microbiological indicators. Operation of hydropower plants does not cause a sensitive adverse changes in the biology of aquatic organisms.

When taken into consideration the complex of microbiological research of aquatic ecosystem of the river Shiport on the basic items of anthropogenic influence, we recommend the encourage reconstruction (upgrade) of farm Fishery "Shipot" to minimize environmental impact and prevent dangerous for surrounding and irreversible changes in functioning of aquatic ecosystem of the river Shipot.

9-4-4. Plankton.

When processing samples of plankton (fixed) of the investigated complex of the reservoir no organisms were detected. At samples present particles of sand, detritus and fragments of leaves.

9-4-5. Characterization of benthic fauna and periphyton.

Even short-term studies have revealed a rich protistofauna, including the number of Rhizopoda Testacea species – 17 (Tab. 9-5), and the number free-living ciliates is 45 (Tab. 9-6). Also revealed several representatives from the meiobenthos and macrobenthos, including crustaceans – ostracods, and harpacticoids copepods, worms, rotifers, 5-6 species of gastrotrichs – 2 species of microturbellarians, oligochaetes and larvae of insects, especially

9-5. The testate amoebae of the river Shipot in the autumn 2013.

	Species and sampling sites	1	2	3	4	5	6	9
1.	*Centropyxis aculeata aculeata* Stein			+			+	+
2.	*Centropyxis discoides discoides* Stein	+	+	+			+	+
3.	*Centropyxis ecornis Ehrenberg*		+		+			
4.	*Centropyxis orbicularis Deflandre*			+			+	
5.	*C. sp. 1*						+	
6.	*C. sp. 2*		+					
7.	*C. sp. 3*	+						
8.	*Cyclopyxis kahli* Deflandre		+				+	+
9.	*Cyclopyxis penardi Deflandre*				+			
10.	*Cyphoderia ampulla* Ehrenberg	+				+	+	
11.	*Difflugia oblonga acuminata* Ehrenberg						+	+
12.	*Difflugia oblonga oblonga* Ehrenberg	+	+		+			
13.	*Difflugia bryophyla* Gautier-Lievre						+	
14.	*Difflugia globulosa* Dujardin					+		
15.	*D. mammilaris var. oranensis* G.-Lievre & Thomas, 1958			+				
16.	*Difflugia penardi* Hopkinson				+		+	
17.	*Difflugia viscidula* Penard	+						
18.	*Pontigulasia bigibbosa* Penard	+	+			+		+
19.	*Pontigulasia sp.1*		+					

chironomids, mayflies, stoneflies, caddisflies, and bivalve mollusks. Most species are typical for the foothills of the Carpathians rivers.

9-6. The free-living ciliates of the river Shipot in the autumn 2013.

	Species and sampling sites	3	4	7	8	9
1.	*Anteholosticha monilata* (Kahl)				+	
2.	*Aspidisca cicada* O.F.M.	+	+			
3.	*Carhesium polipinum* (L.)			+	+	
4.	*Chilodonella uncinata* Ehr.				+	+
5.	*Chilodontopsis depressa* Perty			+		
6.	*Cinetochilum margaritaceun* Perty	+	+	+	+	
7.	*Coleps hirtus* Nitzsch.		+			
8.	*Colpidium colpoda* (Losana)					+
9.	*Cristigera minor* Penard	+				
10.	*Cristigera setosa* Kahl		+			+
11.	*Cyclidium glaucoma* O.F.M.		+			
12.	*Cyclidium sp.*	+		+		
13.	*Frontonia acuminata* Ehr.	+			+	
14.	*Glaucoma sp.*	+				
15.	*Halteria grandinella* (O.F.M.)			+		
16.	*Hemiophrys sp.*		+	+	+	+
17.	*Hexotricha caudata* Lackey		+			
18.	*Holophrya ovum* (Ehr.)		+			
19.	*Holosticha pullaster* Müller			+		+
20.	*Lacrymaria olor* O.F.M.					+
21.	*Lacrymaria olor pusilla* Vux.	+	+			
22.	*Lagynophrya simplex* Kahl		+			
23.	*Lembadion magnum* (Stokes)				+	+
24.	*Litonotus fasciola* (O.F.M.)	+		+	+	
25.	*Loxophyllum melegaris* Duj.	+		+		
26.	*Mesodinium acarus* Stein		+			
27.	*Monilicarion monilatus* (Stokes)		+			
28.	*Nassula exigua* Kahl				+	
29.	*Ophryoglena flava* Ehr.			+		+
30.	*Oxytricha cienkowskii* (Kowal.)		+			
31.	*Oxytricha setigera* Stokes				+	
32.	*Paramecium aurelia* Ehr. complex	+	+			
33.	*Pelagostrombidium mirabile* (Penard)					+
34.	*Plagiocampa longis* Kahl		+			
35.	*Pleuronema coronatum* Kent	+	+			
36.	*Rimostrombidium humile* Penard		+			
37.	*Tachysoma pellionellum* (O.F.M.)	+	+	+	+	+
38.	*Tetrahymena pyriformis* (Ehr.)		+	+		
39.	*Tintinnopsis cylindrata* Kof.-Camp.					+
40.	*Uroleptus caudatus* Stokes		+			
41.	*Uronema marinum* Duj.	+	+			
42.	*Urotricha agilis* Stokes	+	+			
43.	*Urotricha armata* Kahl		+		+	
44.	*Urotricha farcta* Cl. Et L.	+	+	+		
45.	*Urotricha sp.*	+				

Quantitative characteristics of "live" (unfixed by formalin), and alive samples differ quite significantly. If the reservoir bottom sediments number of ciliates may be 50-60*10^6 spms/m^2, the lower reaches (downstream), where the soil is pebbles (stones), and the population on its surface can be characterized as periphyton – from 2 to 30*10^6 spms/m^2 , depending on the flow velocity.

If ciliates abundance in the mainstream down of the Shipot reservoir was lower, the protist abundance at site after hydropower plant with increasing the amount of water due to inflow from the canal sharply reduced. In the canal mouth on the broken stones biotope the abundance of ciliates is only 2-3*10^6 spms/m^2.

Biomass of ciliates is also significantly lower at site in the canal than in the mainstream but not to such an extent as abundance.

Functional characteristics of the communities of ciliates in the bottom sediments of the reservoir indicate that mineralization (decomposition, destruction) by them of OS is to 0.2 g/m^2 per day.

If consider that the share of ciliates only occasionally exceeds 10% of total destruction of OS in reservoirs of this type, it can be estimated at approximately 2 g/m^2 per day.

Thus, the main mineralization of organic matter in the reservoir, despite the rather large shallow areas, and even in the absence of zooplankton, takes place in plankton of the reservoir.

Several species of ciliates were good indicators of water quality organic pollution and are widely used to assess the saprobiological status of water bodies (Kolkwitz R., Marsson 1908), which made it possible to calculate indices of saprobity at different sites.

So, everywhere in the reservoir and below it, as well as in the stream that inflows from the fish-breeding ponds the α-mesosaprobic zone of organic pollution is observed, but this is probably associated with the weakening of the self-purification processes in the cold season. The worst situation is observed in the broken stones biotope, which is in the canal below the plant, where organic pollution is in deep α-mesosaprobic zone – 3.23 (below limit of polisaprobic zone is 3.5).

All amount of species of protists and microinvertebrates that have been found in the

Shipot water courses in autumn is well over 100, and the majority of them are of protists. So, it was found 45 species and varieties of the free-living ciliates in the Shipot river system. Most of them are typical for Transcarpathians rivers, but some are even new for the province, like *Hexotricha caudata* Lackey, that is typical for the reservoir. As well in the reservoir several species from the genus *Urotricha* have been found (Tab. 9-6).

Other protists group – *Rhisopoda, Testacea,* is as well enough good represented (Tab. 9-5). It was found 19 species and intraspecies units, mainly from *Centropyxis* and *Difflugia* genera. Some, like *D. mammilaris var. oranensis* G.-Lievre & Thomas, 1958 can be new for the province. The list of species cannot be compared with these from large reservoirs, where sometimes more than 100 taxons of testate amoebae can be found (Davidova et al. 2008), but is enough large for the only short period for the small artificial dam in the mountainous region of the Carpathians.

From other taxonomic groups should point on rotifers – about 6 species, mainly from the genera *Cephalodella*, and Copepoda Crustacea, where more distributed is *Bryocamptus tarnogradskyi* Borutsky, and much more rare *Attheyella crassa* (G.O. Sars), from cladocerans *Alona quadrangularis* (O. F. Muller), and *Candona sp.* from ostracods. Between tardigrades the *Hypsibius dujardini* (Doyère) is enough widespread.

Nematodes are presented practically at all sampling sites, gastrotrichs are middle widespread – enough frequent appear in the reservoir (2 species), as microturbellarians, and water larvae of insects, especially abundant are chironomids. From mollusks typical is bivalve *Pisidium pusillum* (Gmelin).

The greatest number of species of zoobenthos is noted for the site on stream Shypotets. It usually operates by natural mountain stream benthic communities in which the leading role belongs to testate amoebae and harpacticoids crustaceans.

The species (or taxonomic) diversity of a group is an indicator of its ecological state. Favorable conditions are emerging a rich communities of species (or taxa) like biocoenosis that differ in multi-dominance of community, thus by the presence of a large number of species with high amount. An example of favorable conditions – very clean rivers where abundance and biomass of benthic fauna may be low, but evenly distributed between species (so-called equitability of groups that can be characterized using Bray-Curtis index.).

In communities that inhabit habitats with extreme conditions taxonomic diversity are generally declining, and they are mono-dominant, that high abundance and biomass has one, at least two species. Examples of ecosystems that develop in extreme conditions, is ecosystem in highly contaminated areas of the reservoir, where the limiting factor is the amount of organic pollutant from fish-breeding ponds. In such circumstances, a change in patterns of benthic communities takes place that may be expressed by indexes of species diversity.

The higher is the Shannon index – a complex index that characterizes both the equitability and species richness, i.e. the number of species per unit of area, the greater species richness of community and evenness of individual species in abundance (or in other indices). Usually the indices are in the range of 1.5 to 3.5, rarely exceeding 4.5.

9-7. Indices of biodiversity for the testate amoebae communities of the river Shipot in the autumn of 2013.

Site	The values of indices of species diversity and species richness of testate			
	Shannon	Pielou	Simpson	Species amount
1	1.016	0.632	0.017	6
2	0.989	0.561	0.032	7
3	0.981	0.504	0.006	4
4	0.872	0.543	0.007	4
5	0.892	0.532	0.025	3
6	1.438	0.654	0.022	9
9	0.926	0.561	0.045	5

To characterize evenness of species in communities the Pielou index is used, which is calculated based on Shannon index: This value varies from 0 to 1, with E = 1 at equal amounts of all species. The best index among species dominance indices is considered the Simpson index. In Tab. 9-7 are represented some biodiversity indices for testate amoebae communities in the river Shipot sites (in Autumn period).

9-8. Indices of biodiversity for the bottom communities of the river Shipot in the autumn of 2013.

Site	The values of the number of taxa and taxonomic diversity of zoobenthos			
	Shannon	Pielou	Simpson	Species amount
1	1.471	0.932	0.322	8
2	1.355	0.728	0.259	7
3	1.871	0.852	0.342	7
4	0.961	0.693	0.019	7
5	1.855	0.789	0.333	8
6	2.338	0.805	0.185	21
9	0.986	0.866	0.175	14

According to Shannon-Weaver index values listed in Tab. 9-7 and 9-8 natural, "healthy" situation in benthic communities is marked for the Shipotets stream – there are higher Shannon indices: 1.438 and 2.328. The lowest indices are marked for bottom of water reservoir, and downstream.

The hydrological regime of the reservoir has a negative effect on the composition of the autochthonous benthic fauna and its functioning. This is also indicated by the Pielou index value. It is possible to improve the situation in this object, in particular of the oxygen regime. It is necessary to clean the reservoir from the accumulated decaying debris and of compounds of heavy metals and other toxicants immobilized in its benthos .

9-4-6. The ichthyofauna.

The study of the qualitative and quantitative composition of fish fauna was carried out in the framework of the research by A. Kovalchuk et al. (2013), aimed at assessing the impact of anthropogenic factors, namely the engineering (small *HPP*).

Catches were conducted in summer-autumn period, namely from 29 to 31 August 2013, from 13 to 15 September 2013, from 18 to 20 October 2013 and from 28 to 30 November 2013, in consequence of which we have identified the following species (taxonomy is given accordingly to Yu. Movchan 2008-2009):

The Salmon family (Salmonidae Cuvier, 1816) – brook trout (*Salmo trutta morfa fario* Linnaeus, 1758), rainbow trout (*Oncorhynchys mykiss* Walbaum, 1792).

The Grayling family (Thymallidae Gill, 1884) – European grayling (*Thymallus thymallus* Linnaeus, 1758).

The Carp family (Cyprinidae Fleming, 1822) – Riffle dace, Varione (*Telestes souffia* Risso, 1827), European chub (*Squalius cephalus (*Linnaeus, 1758), Common minnow (*Phoxinus phoxinus* (Linnaeus, 1758), Common barbell (*Barbus barbus* (Linnaeus, 1758), Spirlin (*Alburnoides bipunctatus* (Bloch, 1782), Common gudgeon (*Gobio gobio* Linnaeus,1758), Carpathian gudgeon (*Gobio carpathicus* Vladykov 1925).

The River loaches family (Balitoridae Swanson, 1839) – Stone loach (*Barbatula barbatula* Linnaeus, 1758).

The Loaches family (Cobitidae Swanson, 1838) – Golden loach (*Sabanejewia aurata* (De Filippi, 1863).

The Bullheads family (Cottidae Bonaparte, 1831) – Alpine bullhead (*Cottus poeci-*

lopus Heckel, 1837).

So, the result of catching shows that the greatest number of species established within the first zone of the river with the condition of the watercourse as close as possible to natural (Tab. 9-9). In the second zone of catching species tending to slower water flow are observed (european chub and spirlin), and in general these species are much more characteristic to the lower reaches of this river. The appearance of rainbow trout is directly related to the fisheries enterprise, located in the zone of this site. Probably, the presence of rainbow trout is associated with a random flight from fish-breeding ponds, and perhaps with the deliberate release of juveniles of this fish in the river.

9-9. The distribution of species on the fishing zones.

Species / catching zone	1	2	3
Alburnus bipunctatus	+	+	+
Barbatula barbatula	+	-	+
Barbus barbus *	-	-	+
Cobitis montana	+	-	-
Cottus poecilopus	+	-	-
Gobio gobio	+	+	+
Oncorhynchys mykiss	-	+	-
Phoxinus phoxinus	+	+	+
Sabanejewia aurata	+	-	-
Salmo trutta morfa fario	+	-	-
Squalius cephalus	-	+	+
Telestes souffia *	+	-	-
Thymallus thymallus *	-	-	+

Note. By * species from the Red Book of Ukraine are marked.

In the third zone of catch there is an interesting pattern: for it is becoming more common species that inhabit the lower reaches of the Shipot, but there are also grayling that were absent in catches in zones # 1 and # 2. To accurately establish the fact that the dam is for grayling significant barrier is necessary to conduct a more detailed seasonal study.

Also on the lower experimental zone appears Common barbell[1], which is included in the Red book of Ukraine.

The absence of brook trout[1] may indicate a high level of pollution that causes for this species the critical reduction of oxygen content in water (about 4.5 mg/l). It can occur at night warm seasons. It is also possible for the specific role of the dam in reducing the distribution of a trout into the down reaches of the river. And although the dam is now equipped with modern fish pass, however no less favorable spawning grounds and living conditions for trout down the river. It is the result of deceleration of the flow in the main

[1] During preparation this book for publication n 2014-2915 several specimens of Brook trout was caught downstream of the reservoir, and some Common barbells upstream. This may be due to acting of fishpass.

channel and the sedimentation.

The reservoir Shipot-1 of the water intake of a small hydropower plant is located on a mountain river with rapid current, which leads to erosion along the banks. This causes the accumulation in the reservoir sediments (silt). Need to clean the bottom of the reservoir from the sludge, as the sludge reduces the volume of the reservoir, affects the nature of its surface and the hydrochemical regime of the river downstream.

The accumulation of sediment and organic contamination can cause the formation of new biotopes. These biotopes are similar to the complex biotopes of stagnant water, but differ from the natural in the first place the duration of complex formation, stability and sustainability.

Conclusions:

In studied areas 13 species of fish were identified, of which 3 species listed in the Red book of Ukraine.

Among the studied sites of the river Shipot there are differences in the species content of fish. This may be caused by the presence of waterworks and pollution that occurs as a result of fisheries management.

For sites above the reservoir the spawning places of brook trout were observed.

The results of the research indicate a significant influence of anthropogenic activity on the ecosystem of the river Shipot, that has a negative character.

The emergence of invasive rainbow trout probably is a negative factor, because it competes with native species for prey.

9-5. General conclusions.

1) As a result of erection of storage pool intensity of water changing on an area of hydroenergetic use is diminished.
2) There is development of anaerobic processes in the accrued storage pool.
3) The accrued storage pool plays an important role in the processes of self-wiping of water due to sedimentation, bottom destruction of organic matter. From other side, the certain worsening of quality of water takes place for an account deceleration of water changing, phenomena of thermal and oxygen stratification, intensive develop-

ment of biota in the ground sedimentations.

4) Basis of *DOM* in a storage reservoir is a plankton (layer of water), where processes take place due to bacterioflora with intensity from 1 to 7.5 g per cubic meter per day, that, at a middle depth of a 1.5 m shows about 5 g in the column of water.

5) Calculations show that in the bottom sediments are mineralized approximately 2 g per cubic meter of organic matter per day.

6) Taking into account the useful volume of storage pool and area of its surface (1000 square meters) it is possible to bargain that at the end of early November-December in storage pool about 7 kg of *OM* are mineralized per day. In the spring, according to the law of Van' t-Hoff-Arrhenius factor, the rate of chemical and biochemical processes increases by 3-4 times, and consequently *OM* deposited in the sediments are practically all mineralized.

7) Microbiological examination of the water body indicate a significant adverse effects on the aquatic ecosystem due to operation of the fishery ponds "Shipot", which is confirmed both ecological, microbiological and sanitary indicators.

8) Functioning hydroelectric storage pool does not cause significant negative changes in the life of aquatic microorganisms.

9) No organisms were educed in plankton at period of investigations (autumn).

10) In the storage pool of the hydro-electric station on the Shipot, and in the river upper and downstream about 80 species of protists and microinvertebrates are found in content of benthic and periphytic communities.

11) Within the limits of investigational territory 13 species of fishes are determined.

12) Three species of the fishes educed in the Shipot, belonged to the Red book of Ukraine.

13) For two species of fishes there are problems in natural distribution in limits of the river Shipot.

14) Among the studied sites of the Shipot river there are differences in species composition of fishes that can be caused by the presence of waterworks or pollution coming

as a result of activities of fish-breeding economy.

15) Evaluated by benthic ciliates sanitary condition of the river relates in general to β-mesosaprobic zone of organic contamination. In the reservoir in the autumn period it was the worst.

16) The effect of perspective waterworks, the construction of which is planned upstream of the waterfall, on the ecosystem of the watercourse, provided derivative project with the lower intake and the lack of significant capacity of the reservoir will be low.

9-6. Suggestions and recommendations.

1) Water discharge from fish farms must undergo a mechanical and biological filtration, in order to avoid siltation near the intake and to reduce the level of organic remains, but as a consequence of: nitrates, nitrites and phosphates in the water.

2) Taken into consideration the complex of microbiological studies of aquatic ecosystems on the main points of the directional anthropogenic impacts, we recommend the owners to reconstruct (upgrade) the working cycle of the fisheries factory "Shipot" to minimize the negative impact on the environment and prevent irreversible changes in the functioning of aquatic ecosystems of the river.

3) It is necessary to develop a system of sanitary discharges from the reservoir, especially during spawning and a very warm time of the year.

4) To establish a permanent long-term monitoring of aquatic organisms of the river Shipot, due to the increased anthropogenic influence.

5) Use opportunities to enhance the recreational value of the reservoir for both the local population and for tourists. You can build near the reservoir a small recreation zone or camp site.

6) To create an information center for modern energy technologies, based on *HPP* or near the reservoir.

7) Need to clean regularly the bottom of the reservoir from the sludge, as the sludge reduces the volume of the reservoir and often provoke reducing of the surface area. You must plan for storage of these wastes in a specific location that cannot be diluted by rain water with subsequent flushing in the Shipot river or other watercourse.

10. INVESTIGATION OF AQUATIC INVERTEBRATES COMMUNITIES AT PERSPECTIVE PLACE FOR HYDROELECTRIC POWER PLANT (ON EXAMPLE OF THE RIVER RIKA).

Abstract. The overall taxonomic diversity of the upper reaches of the Rika (before impact from the Vilshanske reservoir, previously named as Tereble-Rikske) is three times higher if compare to its lower sites (after the inflow of water from the Vilshanske reservoir), the average density of aquatic invertebrates decreases 11–28 times, and biomass 10–11 times. Parameters of communities of invertebrates of the Rika and Tereblya show the degradation of river ecosystems downstream of the Tereble-Rikske hydroelectric power plant (HPP). The water quality of these rivers decreased downstream from the very clean, or moderately polluted to weakly polluted, or polluted in different periods of the research.

Key words: influence of hydroelectric power plant (HPP), communities of invertebrates, mountain hydroecosystem, the Rika, the Ukrainian Carpathians.

10-1. Introduction.

Hydroecological researches of direct influence of *HPPs* on mountain ecosystems are still poor developed in spite of exploitation a lot of such objects at the area of the Ukrainian Carpathians. Therefore, the main goal of present work is studying of communities of aquatic invertebrates of the river Rika at the area where the Nyzhniobystryanska *HPP* is planning to be built. Key task of the paper is to evaluate the diversity of invertebrates, their content, and qualitative and quantitative development in conditions of potential danger for aquatic ecosystems and to recommend the featured measures that provide the decreasing of negative possible impacts.

10-2. Materials and Methods.

Accordingly to the data published, it had been found 16 species of mayflies, 1 species of dragonflies and 4 species of stoneflies in the river Rika near village Iza (Kovacs, Godunko, 2008). The rotifers, oligochaetes, chironomids and stoneflies are typical for zooplankton and zoosirton of abovementioned river (Parchuk 1995). Chironomids, and caddisflies larvae are dominants at the upper sites of the investigated area (278-302 MASL) in the Ukrainian Carpathians, and the oligochaetes has their notable abundance. The percentage of stoneflies and amphipods is usually reduced at these altitudes to 1 %. (Afanasiev, 2011).

The communities of invertebrates were researched during March-June 2014 on the three sites of the river Rika, two sites of the river Tereblya (in comparison), in the shallow water of the Vilshanske reservoir and in some lentic areas (Fig. 10-1, Photo 9-1 to 9-9). Spring allows us to isolate key areas of development most groups of aquatic organisms, because they are more evenly later inhabit the waters year as a result of drift.

Samples were taken once a month. Sampling and processing have been done by usual hydrobiological methods of (Zhadin 1960, Methodical… 1983 & 1984, Methods…, 2006). In total, there were gathered and processed 32 bottom (benthic and periphytic), 12 of sirton and 15 planktonic samples. Identifying of hydrobionts qualitative content was made for separate groups into species level, for some specimens it was done to higher taxonomic units only (Bartoš 1959, Lepneva 1964 & 1966, Kutykova 1970, Monchenko 1974, Kutykova & Starobogatov 1977, Askew 1988, Stradnychenko 1990 & 2004 et al.).

During the researching period biomass of the invertebrates (Morduhaj-Boltovskyj 1954, Boruckyj 1958, Methods… 2006, Pankratova & Balushkyna 2006 et al.), structure of dominancy (Tischler 1979), saprobe state by bioindicators with Woodiviss index (*TBI*)

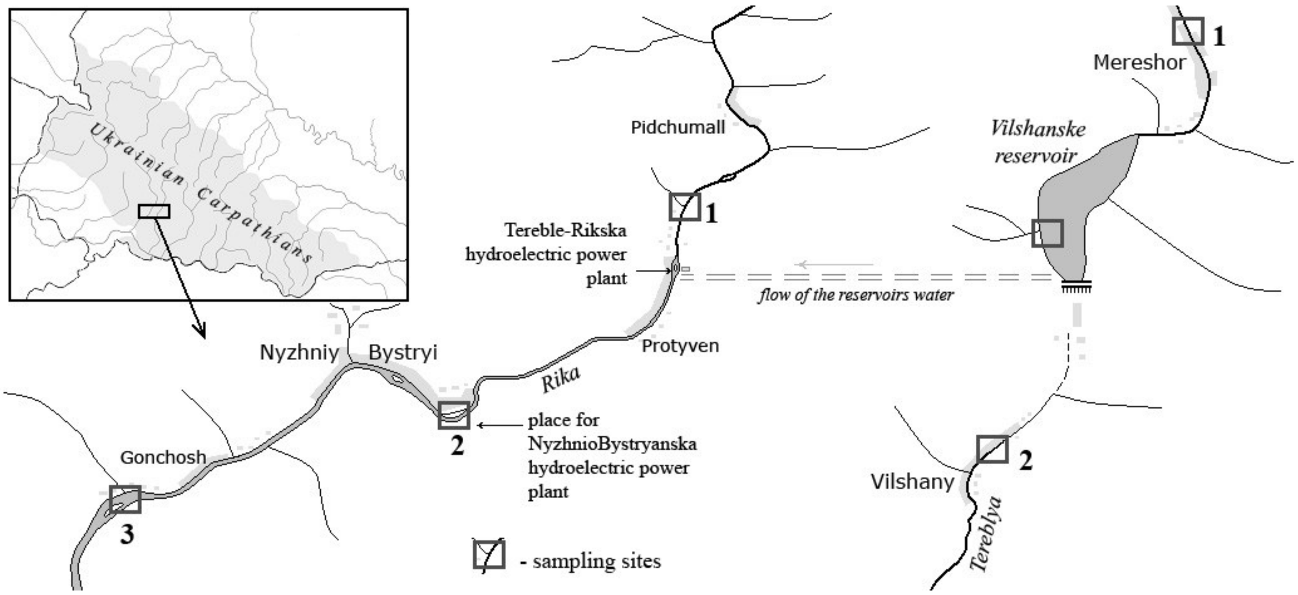


Fig. 10-1. Sampling sites in the area of research in the rivers Rika and Tereblya.

(Woodiwiss 1964) and by saprobe index (S) (Pantle & Buck 1955) are studied. The values of biotic indices have been converted into the categories of water quality that are standard for Ukraine (Oksiuk et al 1993, Method… 1998, Methodic … 2006).

Statistical processing was performed using the Shannon-Weaver index (Shannon 1948), the modified Simpson index (Gibson 1966) and the evenness index of Pielou

(Pielou 1975).

Methods of collection: washed pebbles, washed stones, sandy, clay sediments passaged, while in the plankton net caught all that was carried during sampling by water, sirton was investigated by filtering large water volumes (100 liters or more), plankton – 5, 10, 20 l, depending on the reservoir, plus an active collection and test catching.

Biomass: individual weight of large objects – insect larvae, mollusks, amphipods were solved after drying on an analytical scale, for smaller groups recalculated over linear dimensions and tabular data (Mordukhai-Boltovskoi 1954, Greze 1957, Braginskiy 1957, Borutzky 1958, Pankratova & Balushkina, 2006 et al.). Thus, despite the diversity of the groups used more than a dozen literature sources. Accordingly, in the text and the reference list only some are mentioned.

The temperature measurements (8-22°C) and the value of *pH* of river water (6.8-7.2) were checked.

In the region of investigation some men-caused impacts (negative, for my mind) on hydro-ecosystems have been noted, as: influence of the Vilshanske reservoir on the river Rika, influence of solid waste from Mizhgirska landfill (located 100 m far from the river Rika, with the body of the landfill volume – 95 000 m^3 with the fraction of the plastic waste – 65%). Other impact – urbanization of the upper reaches of the river Rika and Tereblya, recreation, deforestation, contamination of rivers by local population, withdrawal of sediments from the river, and others.

10-3. Results and Discussion.

In the river Rika and Tereblya, and water bodies (catchment area) floodplain waters of the river valley 62 taxa from 49 families were identified, from which 26 to species rank from 23 genera (Tab. 10-1).

The greatest amount of diversity of taxa (44) were noted in the site No 1 of the river Rika. Changes of density in bottom are typical for the area.

The total abundance of benthos on the river littoral is increasing from March (75 ind./m^2) to May (448 ind./m^2). Enchytraidae (44%), and rotifer *Trichocerca* sp. (31%) were eudominants of communities in March, *Trichocerca* sp. (30%) in April, Naididae

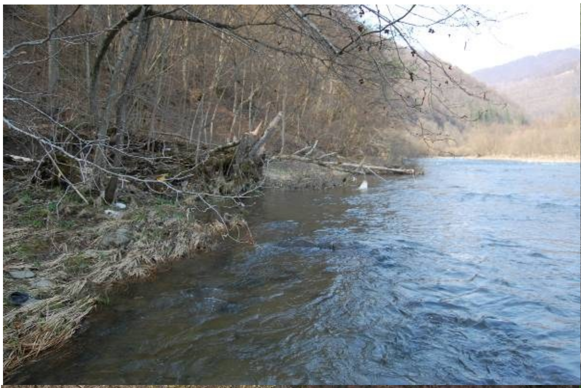



Photo 9-1, 9-2. The river Rika sampling site No 1 (21.03.2014, 22.05.2014).


Photo 10-3, 10-4. The river Rika sampling site No 2 (21.03.2014, 22.05.2014).


Photo 10-5, 10-6. The river Rika sampling site No 3 (21.03.2014, 22.05.2014).


Photo 10-7, 10-8. The river Tereblya sampling site No 1, 2 (27.04.2014).

Photo 10-9. The Vilshanske (Tereble-Rikske) reservoir (27.04.2014).

(30%) and ostracod *Candona* sp. (21%) in May. The total density on the river rapids varied – 237-309 spms/m^2. Chironomids were eudominants in March (46%) and April (74%), mayflies – in May (38%). On the places with an average speed of flow the total density increased from 300 to 463 spms/m^2 during the spring time. Chironomids are permanent eudominants: March – 63%, April – 73%, May – 51%. In streams (April samples) the density of the invertebrate communities are 90 spms/m^2, amphipods are eudominants in the streams (28%).

Chironomids are the dominant group on the site No 1 of the Rika (42% of the average total density). Mayflies (13%, 7% amongst are Baetidae larvae or small minnow mayflies) and caddisflies (11%, 8%). Enough significant is C*heumatopsyche lepida* (Pictet).

The parameters of biomass on the site No 1 are very variable on the different topic places and depends on month (0.1-12.9 g/m^2). The maximum value of the biomass noted on the river littoral by development of the *Lymnaea hartmanni* (Studer) – 98% of the total biomass of the communities. On the river rapids biomass varied in 1.2-3.3 g/m^2, and at the places with an average speed of flow – 1.8-8.4 g/m^2. Total average biomass on site No 1 is 5.4 g/m^2.

On the site No 2 of the river Rika 16 taxa of invertebrates were determined. The density have varied in 4-15 spms/m^2, the biomass haven't exceed 0.1 g/m^2. Chironomids larvae are the dominant group in the riverbed (average 48%).

On the river station No 3 16 taxa there were determined like in previous sampling site. During the spring season period the quantity of benthos organisms in shallow water fluctuated within 11-35 spms/m^2 with trend to increasing from March to May. On the river rapids the resembling value was obtained – 33–50 spms/m^2, and on the deepest areas of the riverbed – 14-28 spms/m^2.

In March the rotifer *Lecane* sp. was eudominant with amount 46% in the shallow water. Later the role of Enchytraidae had grown up (till 73 %).

In rapids the typical eudominant are chironomids (up to 57%). In the places with an average speed of flow the overall eudominant position as well have chironomids (up to 50%). In general the benthos quantity of the lower river site except of the Chironomidae

(37%) and Enchytraidae (22%) appears as important element copepod *Acanthocyclops robustus* (Sars) – 10% of total amount.

Biomass of benthic communities in the shallow water in the site No 3 in March and April didn't exceed 0.1 g/m^2, and in May increased to 2.5 g/m^2 as a result of species *L. hartmanni* appearance.

On the river rapids biomass varied in 0.1-1.0 g/m^2. In places with an average speed of flow – 0.1-0.7 g/m^2. Total average biomass in the site No 3 is 0.6 g/m^2.

Generally, the chironomids larvae dominate in quantity, and gastropods and caddisflies dominate in biomass in benthic communities of the river Rika.

The quantity of taxa in the middle and lower sites of the river Rika is three times smaller than in the upper sampling site. Density is lower 11-28 times, biomass – 10-11

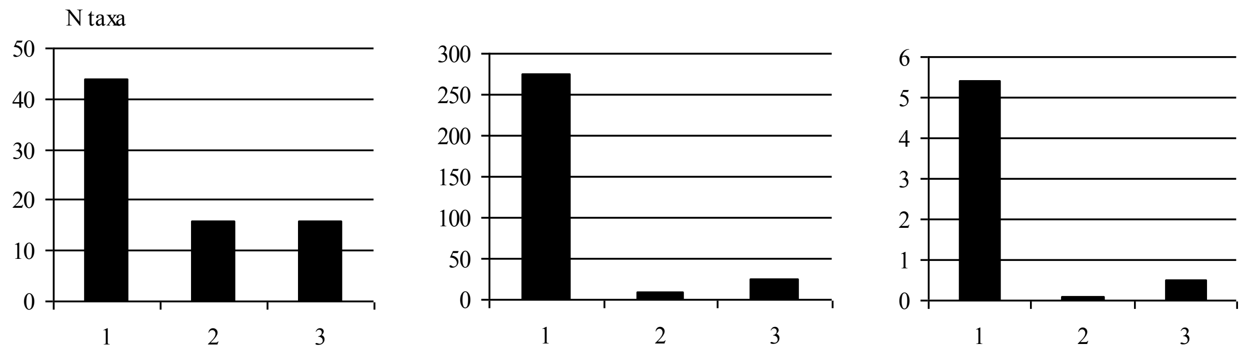


Fig. 10-2. Average parameters of invertebrate communities of the river Rika (1 – upper, 2 – middle, 3 – lower sites): Left – number of taxa, Center – density in spms/m^2, Right – biomass in g/m^2.

times (Fig. 10-2).

The most variable fauna among the lenthic water bodies is locating in old channel of the river near small village Gonchosh where copepod *Acanthocyclops americanus* (Marsh), caddisfly *Nemotaulius punctatolineatus* (Retzius), and gastropod *Bythinella austriaca* (Frauenfeld) within 13 species taxa were determined.

In benthos of the upper sampling area (No 1) of the river Tereblya 9 taxons of invertebrates were determined. An average density of animals was 52 spms/m^2, the greatest value (74%) belongs to chironomids. Biomass of benthos is negligible – 0.2-0.4 g/m^2.

In the area of the river Tereblya in site No 2 it 13 taxa of water invertebrates were determined . Their average density was 54 spms/m^2 with domination of Enchytraidae –56%.

10-1. List of the invertebrates found in the researched water bodies.

Taxa	1R	2R	3R	1T	2T	VR	LWB
Phylum Cnidaria							
Hydra sp.	+	-	-	-	-	-	+
Class Turbellaria							
Planariidae	+	-	+	-	-	-	-
Phylum Nematoda	+	-	-	-	-	-	-
Phylum Rotifera							
Trichocerca sp.	+	+	-	-	-	-	-
Cephalodella sp.	-	-	-	-	+	+	+
Euchlanis sp.	-	+	-	-	-	-	-
Lecane sp.	+	-	+	-	-	-	-
Bdelloidea	-	+	+	-	+	-	+
Phylum Annelida							
Enchytraeidae	+	+	+	+	+	+	+
Naididae	+	-	-	-	-	-	-
Lumbriculidae	+	-	+	-	-	-	-
Lumbricidae	+	-	-	-	-	-	-
Phylum Mollusca							
Ancylus fluviatilis O.F.Mueller	+	-	-	-	-	-	-
Bithynia sp.	+	-	-	-	-	-	-
Bythinella austriaca (Frauenfeld)	-	-	-	-	-	-	+
Lymnaea hartmanni (Studer)	+	-	+	-	+	-	-
Phylum Tardigrada	+	-	-	+	-	-	-
Class Arachnida							
Hydrachnidiae (or Hydracarina)	+	-	-	-	+	-	+
Subphylum Crustacea							
Order Cyclopoida							
Acanthocyclops americanus (Marsh)	-	-	-	-	-	-	+
Acanthocyclops robustus (Sars)	+	+	+	-	-	-	-
Chydorus sphaericus O.F.Mueller	-	-	-	-	-	-	+
Cyclops strenuus Fischer	-	-	-	-	-	+	-
Diacyclops bicuspidatus (Claus)	+	+	-	-	-	+	+
Diacyclops crassicaudis (Sars)	+	-	-	-	-	-	-
Diacyclops languidoides (Lilljeborg)	-	-	-	+	-	-	-
Eucyclops serrulatus (Fich.)	+	-	-	-	-	-	+
Microcyclops varicans (Sars)	+	-	-	-	-	-	-
Order Harpacticoida	-	-	-	-	-	-	+
Class Ostracoda							
Candona sp.	+	+	-	-	+	-	+
Class Malacostraca							
Gammaridae	+	+	+	-	-	-	+
Class Insecta							
Order Trichoptera							
C*heumatopsyche lepida* Pict.	+	+	+	+	-	-	-
Grammotaulis nitidus Mueller	-	-	-	-	+	-	-
Hydropsyche angustipennis Curt.	+	-	-	+	-	-	-
Hydropsyche pellucidula Curt.	+	+	+	+	-	-	-

Continuation of Tab. 10-1.

Taxa	1R	2R	3R	1T	2T	VR	LWB
Oxyethira tristella Klap.	-	-	-	-	+	-	-
Psychomyia pusilla Fabr.	-	-	-	-	+	-	-
Polycentropus flavomaculatus Pict.	+	-	-	-	-	-	-
Rhyacophila nubila Zett.	+	-	+	-	-	-	-
Rhyacophila tristis Pict.	+	-	-	-	-	-	-
Sillo pallipes Fabr.	+	-	-	-	-	-	-
Perlidae							
Perla marginata Panzer	-	-	-	+	-	-	-
Chloroperlidae	+	+	-	-	-	-	+
Heptageniidae	+	-	+	+	-	-	-
Baetidae	+	+	+	-	-	-	-
Caenidae	+	-	-	-	-	-	-
Ephemerellidae	+	-	-	-	-	-	-
Gomphidae							
Onychogomphus forcipatus (L.)	+	-	-	-	+	-	-
Corixidae	+	+	-	-	-	+	+
Gerridae	-	-	-	-	-	-	+
Elmidae	+	+	+	-	-	-	-
Gyrinidae	+	-	-	-	-	-	-
Dryopidae	-	-	-	-	+	-	-
Dytiscidae	-	+	-	-	-	+	-
Agabus sp.	-	+	-	-	-	-	-
Ceratopogonidae	+	-	-	-	-	-	-
Chironomidae	+	+	+	+	+	-	+
Simuliidae	+	-	-	-	+	-	-
Tipulidae	+	-	-	-	-	-	-
Empididae	+	-	-	-	-	-	-
Syrphidae	+	-	-	-	-	-	-

Notes. R & T – the Rika and Tereblya sampling sites; VR – the Vilshanske Reservoir; *LWB* – lenthic water bodies.

An average biomass was 1.7 g/m^2, this index is obtaining mainly due to occurrence of gastropod *L. hartmanni* (88%).

In the river Terebya the quantity indices of the invertebrate communities are similar to the river Rika. The main difference is in content of species and taxa. For example, in the upper site caddisflies are represented mainly by predators and species grazers which are typical for cold mountain waters (*Hydropsyche angustipennis* Curtis, *H. pellucidula* Curtis, C*heumatopsyche lepida* Pictet), in the lower site – detrital feeders and species which are characterized for warm basins (*Psychomyia pusilla* Fabricius, *Grammotaulis nitidus* M?ller, *Oxyethira tristella* Klapalek).

In the coastline zone of the Vilshanky reservoir there were determined only six taxa. The indices of diversity, density and biomass of invertebrates for this reservoir are the lowest among others researched water bodies.

The containing of sirton of the rivers Rika and Tereblya is qualitative and quantitative scanty. There were occurred rotifer *Lecane* sp., copepodite stages of *A. robustus,* larvae of mayflies and chironomids with total amount about 300 ind./m^3.

The data of biotic indices of Shannon, Simpson and Pielou are presented in Tab. 10-2. From these data, the most high is the diversity of the first river station of the River Rika and quantity is the most equitable (due to the largest number of dominant species in approximately the same quantities). The worst situation in state of structure of invertebrates communities (disbalance) is observed in the Vilshanske reservoir.

10-2. Indices of biodiversity of the invertebrate communities of the river Rika and Tereblya in spring 2014.

Site	Shannon	Pielou	Simpson
Rika1	3,207	1,782	0,930
Rika2	2,011	1,670	0,773
Rika3	2,202	1,755	0,833
Tereblya1	2,000	1,745	0,641
Vilshanske reservoir	0,280	1,323	0,997
Tereblya2	1,323	0,465	0,604

The biomass indices of benthic organisms in the upper reaches river station of the river Rika (5.4 g/m^2) are comparable within the average meanings to the other rivers of the Ukrainian Carpathians. The situation is as follows: the Tereblya and Lyutyanka – 3 g/m^2 , Shypit – 9.5 g/m^2, despite of the lowest indices of quantity, e.g., river Rika (the upper site) – 275, river Tereblya – 576, Lyutyanka – 760 and Shypit – 4432 spms/m^2 (Kruzhylina et al. 2012).

Obviously, the invertebrate fauna of the downstream river part from the Tereble-Rikska *HPP* is forming mainly by the drifting specimens.

Among the abovementioned taxa the most important in the nutrition of grayling and Danube salmon are caddisflies, especially *H. pellucidula,* stoneflies and mayflies (Kruzhylina et al. 2012, Krazhan et al. 2012). So, the most suitable conditions for nutrition of threatened salmons formed only in the upper river station of the Rika River. Nutritive base of the river in the lower part is unusually scanty for abovementioned species.

Ecological situation in the researched region can be characterized by biotic indexes. The meanings of *TBI* index (Fig. 10-3) show the great difference of water quality between the sampling sites. Oligo/β-meso saprobic waters (very clean/clean) is significant only for the upper reaches river site of the Rika. In other sites the water quality is harshly changing to β-meso/α-meso saprobic (slightly polluted/polluted water). The quantity of the mayflies (indication group of *TBI*) in the river Rika is harshly reducing when descending from the upper reaches, but the rate of the oligochaetes is increasing. Such trend is also distinctly appreciable in the river Tereblya (Fig. 10-4).

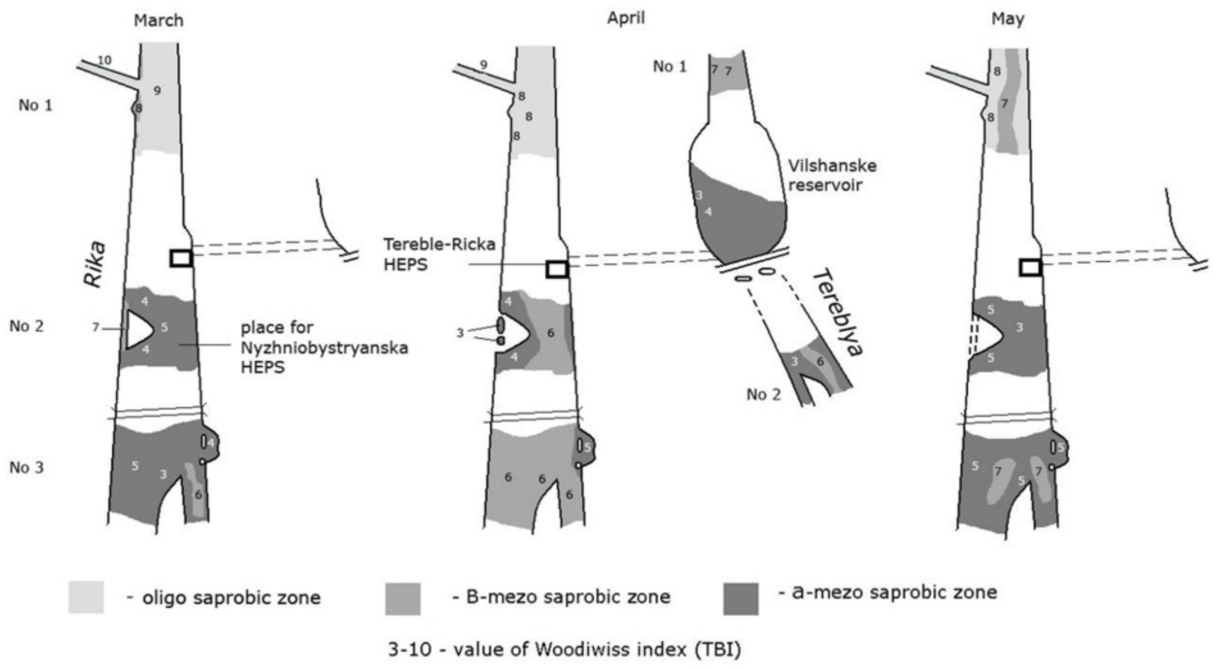


Fig. 10-3. Value of the Woodiwiss index (*TBI*) of the research water bodies.

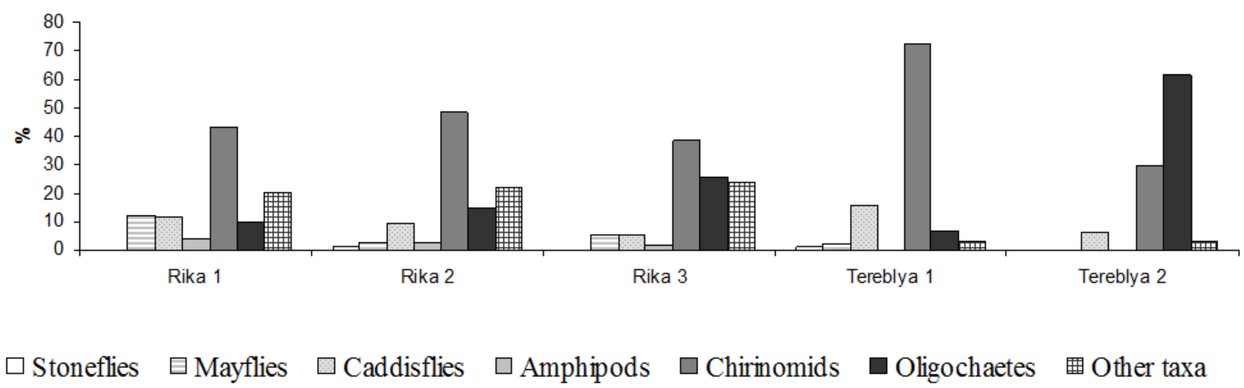


Fig. 10-4. Representation of indicator groups Woodiwiss index (*TBI*) on the sites of rivers Rika and Tereblya.

Saprobity indexes showed more averaged results (Fig. 10-5), where for upper site of the river Rika oligo/β-mesosaprobic (clean/slightly polluted) quality of water is inherent, for the middle and lower river sites – β-mesosaprobic (slightly polluted). For the river Tereblya upper of the Vilshanky Reservoir water is significantly of β-mesosaprobic quality, on the Vilshanske reservoir and on the lower site of the river – β-meso /α-meso saprobic quality (slightly polluted/polluted water).

10-3. Recommendations.

Basing on the results of the executed work for associating the project of Nyzhniobystryanska small-*HPP* (Building… 2014) there were formulated several recommendations (Horban et al. 2014):

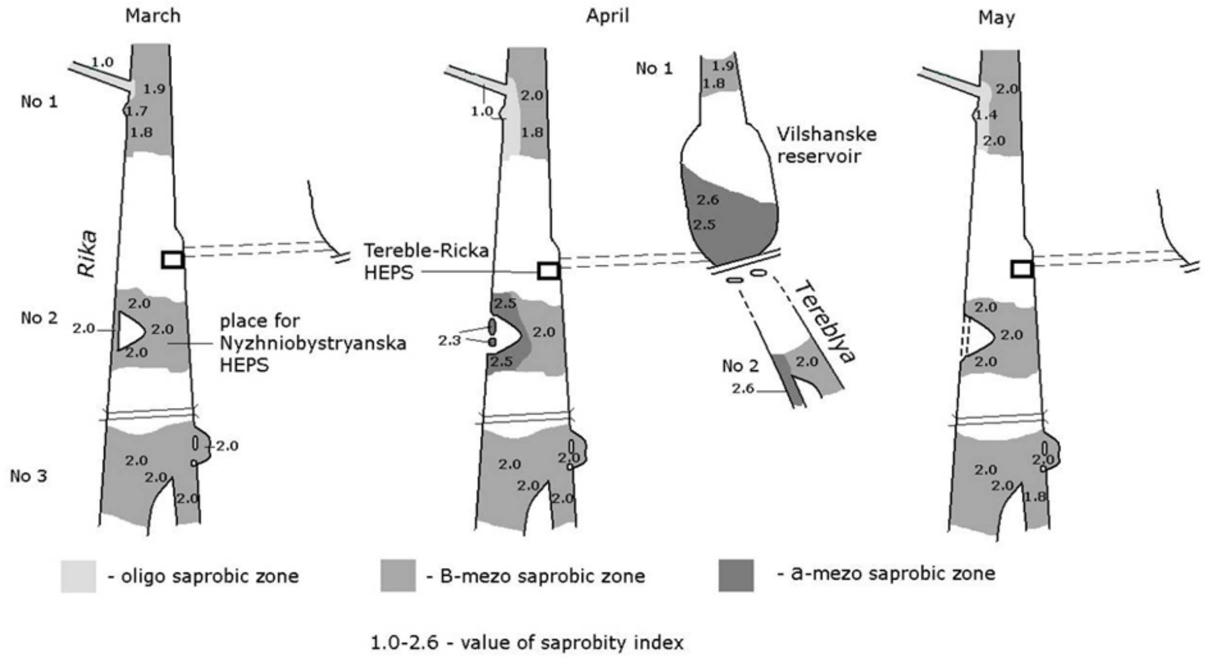


Fig. 10-5. Value of saprobity index of the researched water bodies.

1) Needed to minimize the area of water surface of the reservoirs (maximum 10 hectares) and use modern project of derivative type of HPP with maximum conservation of main channel of the river.
2) Should make modern fishway (fishpass).
3) To provide of water intake ports with equipment for intimidation of fish.
4) To equip the Nyzhniobystryanska small-*HPP* by automatic regulating system for water discharge.
5) To provide permanent monitoring of the hydroecological situation of the area closely near of Nyzhniobystryanska HPP.

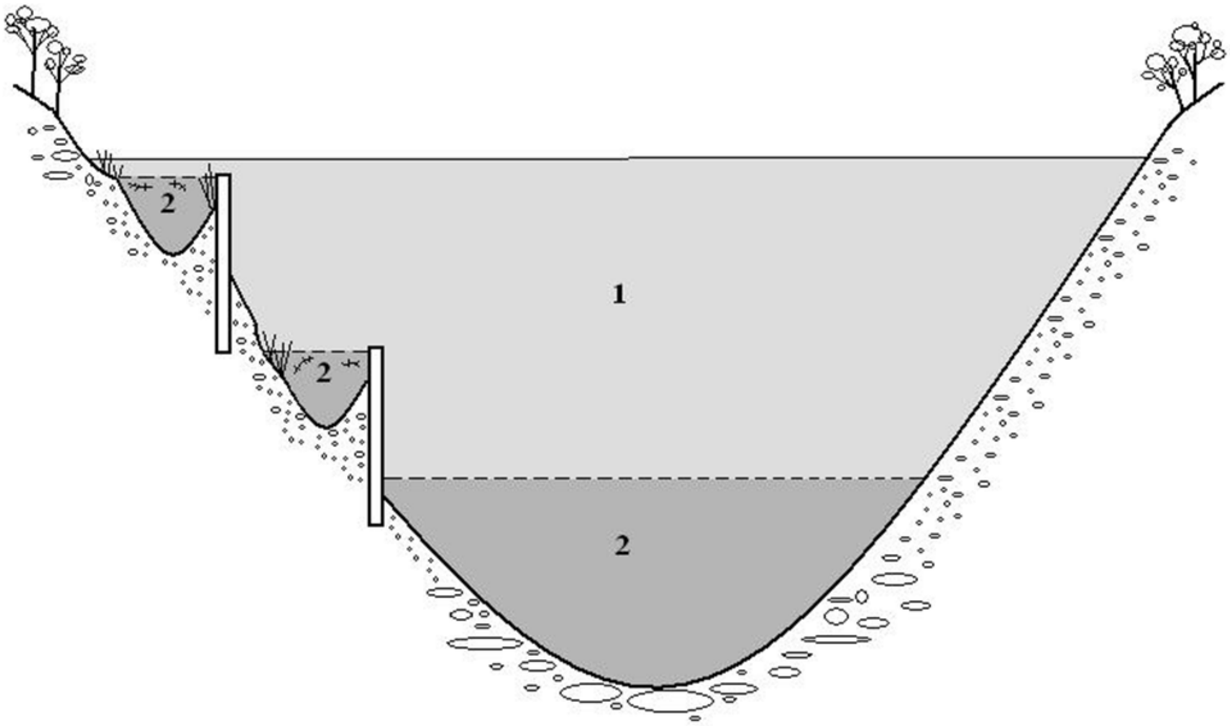


Fig. 9-6. Proposed scheme of possible reclamation of the Vilshanske reservoir: 1 – full level of the reservoir, 2 – minimum water level.

6) Reclamation of the Vilshanke reservoir should be provide with the aim to raise the biological productivity and to normalize the water quality.

7) The main ecological problem of this water basin is a sudden drop of depth as the highest water level appear in spring and during the summer time water is discharging abruptly. So, to smooth the negative influence on biota I propose to create special system of wetlands on the walls of the reservoir in places with the stream mouth (Fig. 10-6).

8) To protect against erosion banks should be strengthen by aquatic and semiaquatic macrophytes, especially by sedges and water-starwort *Callitriche sp.,* because their formations in the Carpathians is followed by the highest development of hydrobionts (Mykitchak et al. 2014).

9) This system can significantly improve the fish forage base and mitigate the negative influence of the reservoir on the River Rika and Tereblya ecosystems.

11. POTENTIAL ECOLOGICAL HAZARDS TO THE CHEREMOSH RIVER POSED BY A DIVERSION HYDROPOWER PLANT (ROZTOKY SETTLEMENT, KOSIV DISTRICT, IVANO-FRANKIVSK REGION, UKRAINE).

Abstract. The paper assesses possible risks to the river ecosystem posed by Small diversion hydropower plant No. 3 on the Cheremosh river (Ivano-Frankivsk region, Ukraine) and defines the ways of their mitigation.

Key-words: ecological hazards, diversion hydropower plant, phytoplankton, phytoperiphyton, macrophytoperiphyton, suspended matter, oxygen content.

11-1. Introduction.

Power generation is an important component of Ukraine's sustainable development, thus energy supply to industry and society constitutes a major and urgent issue.

Along with conventional *HHPs* on large rivers, there is a great energy potential in small *HPPs*, constructed and operated on small rivers in different regions of Ukraine. "Small" hydropower engineering provides an important benefit, because, apart from electricity generation, small *HPPs* perform water-regulating function and protect the adjacent areas from surplus inflow and seasonal floods.

Surveying the distribution of power generators over different regions of Ukraine, one can see that major power complexes (thermal power plants, nuclear power plants, large hydropower plants) are concentrated in central, eastern and southern country regions. By contrast, the Carpathian region is worst provided with generating capacities (Law of Ukraine on Alternative Sources of Energy 2003).

Owing to development of small *HPPs*, it is expected (Present-day state, challenges, prospects… 2014) that the electricity output will reach 3.75–4.20 billion kWh/year by 2030, which will make it possible to save fossil fuel in the amount equivalent to 1.3 billion m^3 of natural gas.

Technogenic disturbances of river ecosystems must be justified from the environmental point of view, and the possible hazards must be mitigated. The truth is that small mountain rivers are very vulnerable, therefore any interference with their natural functioning must be given detailed grounds, and the major attention must be paid to water ecosystem protection, rather than to economical and social issues. First of all, consideration must be taken of qualitative and quantitative diversity of hydrobionts of different trophic levels and ecological groups inhabiting the particular Carpathian river.

The aim of the study is to estimate possible risks to the river ecosystem posed by a small diversion *HPP* No. 3) on the Cheremosh river near Roztoky settlement (Kosiv district, Ivano-Frankivsk region, Ukraine).

11-2. Hydrological characteristics of the Cheremosh river.

The Cheremosh river is a right-bank tributary of the Prut river, which outfalls into the Danube. Within the area of the future *HPP* construction the Cheremosh is a mountain stream, with its bed 30–40 m wide, 0.9–1.2 m deep during the low-water season. The current speed makes up 1.2–1.6 m/s, reaching 3.5 m/s in rapids. The river bed is meandering and characterized by a riffle-pool sequence.

The river's alimentation is formed by surface runoff, with prevailing of rainwater and snow melt (60–70%), as well as ground-water runoff (up to 35%).

Seasonal dynamics of water is a natural factor, which will significantly affect the performance and operating procedure of the future *HPP*. The maximal rate of stream flow is observed in flooded conditions and during the high water period. In the latter case the water level can rise up to 3.5 m 2–3 times a month.

According to seasonal readings of the hydrograph, the highest monthly average water discharge is recorded in March, April, May, and the lowest – in January, February, when the river feeds from ground water inflow.

The maximal, the minimal and the average annual river runoff are the important components of seasonal water dynamics, which will make a significant effect upon the structural safety and economic viability of the *HPP* operation. The maximal discharge of the Cheremosh river, depending upon the water supply, varies between 589 and 2000 m^3/s.

For example, the minimal runoff during the open-water period fluctuates within 7.51–11.40 m^3/s, but is much lower in winter – 4.52–9.83 m^3/s (Small diversion *HPPs*… 2010).

Thus, the highest risk to the river ecosystem, including hydrobionts of different trophic levels and ecological groups, will be observed in winter season, especially when ice cover is formed. It is important to develop a Special schedule of water intake by the diversion canal of the *HPPs* during this period.

11-3. Materials and methods.

In order to receive reliable data, which can fully characterize the present-day ecological state, the diversity of the main abiotic and biotic components of the Cheremosh river near Roztoky settlement, possible risks posed by the Small diversion *HPP* construction and operation, field studies of the river ecosystem were conducted in early September 2015. Taking into account the peculiarities of the river section studied, two diverse sampling sites were chosen, which differed primarily by their hydrological conditions: *sampling site No. 1* – the river pool, *sampling site No. 2* – the riffle located upstream of sampling site No. 1.

The following components of the river ecosystem were studied: oxygen content, temperature conditions, water transparence, qualitative and quantitative composition of suspended matter, qualitative and quantitative diversity of phytoplankton, phytoperiphyton, phytomacroperiphyton.

The generally accepted methods of hydroecological research were applied, precisely described in methodical recommendations (Methods…, 2006). The species forming over 10% of algal number/biomass in a sample were regarded as dominant species, and, respectively, 5% – as subdominant species. The field data were processed with the help of Statistica 6.0 software.

11-4. Present-day ecological state, diversity of the main biotic components of the Cheremosh river and estimation of their possible changes after the *HPP* construction.

<u>*Dissolved oxygen content*</u> is one of the most meaningful indicators of the water-body's ecological state, water quality and living conditions for hydrobionts.

Absolute oxygen content in the pool habitat varied between 8.32 and 8.73 mg O_2/dm^3. Relatively equal values were obtained for the riffle habitat – 8.24–8.40 mg O_2/dm^3. Oxygen saturation in the studied river section fluctuated within narrow limits, making up 90% at an average. (Tab. 11-1).

Proceeding from the "Ecological classification of surface waters and estuaries according to tropho-saprobiological (ecological and sanitary) criteria" (Methods… 2006), according to absolute oxygen content and oxygen saturation the water quality refers to the second class. It allows to state, that dissolved oxygen regime in the area of the future *HPP* is favorable.

<u>*Temperature conditions*</u>. During our studies the water temperature in the area of the future *HPP* varied within 18.0–18.8°C, which fully corresponds to the river conditions in early autumn season. The obtained average values for two habitats – the pool (18.4°C) and the riffle (18.1°C), which differ considerably by their hydrological conditions, make it possible to state that the temperature rise in the newly created run-of-the-river reservoir will be insignificant.

11-1. Dissolved oxygen content in the Cheremosh river in the area the Small diversion HPP future construction.

Sampling site	Samples	Replication	O_2, mg/dm^3	Oxygen saturation, %
1. Pool	1	first	8.40	92%
		second	8.32	
		third	8.36	
		in average	8.36	
	2	first	8.72	
		second	8.71	
		third	8.73	
		in average	8.72	
	Average for the pool		8,54	
2. Riffle	1	first	8.32	89%
		second	8.28	
		third	8.24	
		in average	8.28	
	2	first	8.36	
		second	8.40	
		third	8.32	
		in average	8.36	
	Average for the riffle		8,32	
Average for this section of the river			8.43	90%

<u>*Water transparence*</u>. Water transparence in the river bed measured with a Secchi disk fluctuated within insignificant range and did not exceed 10–15 cm of the water column. We believe that creation of the run-of-the-river reservoir with lower current speed, than in the present-day free-flowing river, will cause a slight increase in the water transparence, which

is explained by large amount of suspended matter and more intense vegetation of phytoplankton, screening the water column.

We consider that creation of the run-of-the-river reservoir with respective temperature rise, increase in water transparence, and, consequently, the photosynthesizing potential, will be favorable for improvement of the dissolved oxygen regime, especially during the period of active phytoplankton photosynthesis, and, therefore, for more intensive self-purification of water.

Suspended matter. Suspended matter consists of a small amount of organic components and the major inorganic part, which comes into water from abrasive banks and bottom deposits.

Granulometric analysis showed the inorganic fraction to be formed by mineral particles within a wide range of sizes – from 10 mm to more than 260 mm in diameter.

In order to analyze mineral suspended particles more precisely we ranked all data massive according to the size[1]. 4 dimensional classes were distinguished (Tab. 11-2), among which a relatively large fraction prevailed. One may state, that during the *HPP* operation large mineral particles will precipitate and can interfere with normal functioning of water-intake facilities and fish-protective devices.

Besides, a gradual deposition of silt is forecasted in the newly created run-of-the-river reservoir, especially in its deep-water part, where the river flow will lose its momentum. Thus, it is necessary to take into account during the *HPP* designing and construction, that after some time of the *HPP* operation there will be considerable silting up of the river bed.

Taxonomic and quantitative diversity of phytoplankton. The leading role in the river biota functioning is played by phytoplankton, however, in the view of intensive water turbulence, benthic or periphytic algae could occur in water column at the moment of sampling as well.

In the pool habitat of the studied Cheremosh river section phytoplankton was rather diverse – 60 species and infraspecific taxa including the nomenclature species type from

[1]Note. The size of suspended particles was measured with a micrometer eyepiece scale in Nageotte chamber with the ocular lens ´7 and the objective lens 40$^{\times}$. The data are given in micrometers (mm).

11-2. Ranking of suspended mineral particles according to their size.

Class	Number of particles (sample)	Size, mm	Percentage of the total number
I	16	< 30	26
II	8	31–70	13
III	14	71–100	22
IV	24	> 101	39

5 divisions. The floristic diversity was dominated by diatoms – 77%, subdominant divisions were represented by green algae – 12% and blue-green algae – 8% (Tab. 11-3).

One might add, that absence of Euglenophyta in water indicates a rather low degree of organic pollution in this section of the Cheremosh river, which is necessary to maintain during the Small diversion *HPP* construction and operation.

11-3. Taxonomic and quantitative diversity of phytoplankton of the Cheremosh river in September 2015.

Taxonomic diversity			Quantitative diversity			
Divisions	Species and infraspecific taxa		Number of cells, thousand cells/m^3		Biomass, mg/m^3	
	pool	riffle	pool	riffle	pool	riffle
Cyanophyta	5/8	2/4	617/15	63/8	0,019/1	0,003/1
Chrysophyta	1/2	–	24/1	–	0,026/1	–
Bacillariophyta	46/77	42/86	1179/29	312/39	1,314/50	0,111/27
Xanthophyta	1/2	1/2	2184/53	405/50	0,577/22	0,107/26
Chlorophyta	7/12	4/8	108/3	27/3	0,681/26	0,194/47

Note. Above the bar – number of species, number of cells, biomass of the particular division; below the bar – percentage of the total number of species, number of cells, biomass in a sample; "–" – species of this divisions were not found.

The total number of phytoplankton cells in the pool made up 4112 thousand cells/m^3, and the biomass – 2.617 mg/m^3. According to the number of cells yellow-green algae dominated – 2184 thousand cells/m^3 (53%). Diatoms – 1179 thousand cells/m^3 (29%) and blue-green algae – 617 thousand cells/m^3 (15%) were subdominants. The biomass was dominated by diatoms – 1.314 mg/m^3 (50%), and green and yellow-green algae were subdominants – 0.681 mg/m^3 (26%) and 0.577 mg/m^3 (22%) respectively (Tab. 11-3).

Phytoplankton in the riffle habitat according to all structural and functional characteristics was less rich than that in the pool habitat (see Tab. 11-3). The taxonomic diversity was formed by 5 divisions and 49 species and infraspecific taxa. The total number of phytoplankton cells in the riffle made up 807 thousand cells/m^3, and the biomass – 0.415 mg/m^3.

So, intensive turbulence of the water flow has a negative effect upon the qualitative and quantitative diversity of the Cheremosh river phytoplankton.

The composition of phytoplankton dominant species in the studied section of the Cheremosh river was formed by diatoms (50%), blue-green algae (20%) and green algae (20%) (Tab. 11-4).

11-4. Composition of dominant phytoplankton species of the Cheremosh river in September 2015.

Species	Number of cells, thousand cells/m^3		Biomass, mg/m^3	
	pool	riffle	pool	riffle
Aphanothece clathrata W. et G.S.West	$\frac{192}{5}$	–	*	–
Lyngbya aerugineo-coerulea (Kütz.) Gom.	$\frac{180}{4}$	–	*	–
Oscillatoria amphibia Ag.	$\frac{221}{5}$	$\frac{63}{8}$	*	*
Achnanthidium minutissima (Kütz.) Czarn.	*	$\frac{93}{12}$	*	*
Aulacoseira italica (Ehr.) Sim.	$\frac{672}{16}$	–	$\frac{1,034}{40}$	–
Gomphonema parvulum Kütz.	*	$\frac{36}{4}$	*	*
Placoneis elginensis (Greg.) Cox f. *exigua* (Greg.) Bukht.	*	$\frac{45}{6}$	*	$\frac{0,017}{4}$
Tribonema affine G.S. West	$\frac{2184}{53}$	$\frac{405}{50}$	$\frac{0,577}{22}$	$\frac{0,107}{26}$
Cosmarium subprotumidum Nordst.	*	*	$\frac{0,662}{25}$	$\frac{0,193}{47}$

Note. Above the bar – number of cells or biomass of a particular dominant species; below the bar – percentage of the total number of cells or biomass of algae in a sample; “–” – the species was not found; “” – the species occurred, but did not dominate.

In the whole one may say that phytoplankton dominant species compositions in the pool and in the riffle are rather similar, though that of the riffle is more diverse.

Taxonomic and quantitative diversity of phytoperiphyton. Phytoperiphyton, that is the assemblage of microscopic algae, attached to the underwater stone substrata, is an important component of the autotrophic link of the Cheremosh river ecosystem.

Compared to phytoplankton, phytoperiphyton shows much lower taxonomic and quantitative diversity (Tab. 11-5).

11-5. Taxonomic and quantitative diversity of phytoperiphyton upon the stone substrata of the Cheremosh river in September 2015.

Taxonomic diversity			Quantitative diversity			
Divisions	Species and infra-specific taxa		Number of cells, thousand cells/10 cm^2		Biomass, mg/10 cm^2	
	pool	riffle	pool	riffle	pool	riffle
Cyanophyta	2/6	5/22	2160/80	8710/97	0,020/3	0,064/43
Bacillariophyta	32/91	17/74	517/19	276/3	0,556/92	0,075/51
Xanthophyta	–	1/4	–	32/*	–	0,008/6
Chlorophyta	1/3	–	11/*	–	0,027/5	–

Note. Above the bar – number of species, number of cells, biomass of the particular division; below the bar – percentage of the total number of species, number of cells, biomass in a sample; "–" – species of this division were not found; "*" – the percentage of this division is less than 1%.

In the pool habitat 35 species and infraspecific taxa were found, out of which 91% belonged to diatoms, while 6 and 3% – to blue-green and green algae respectively.

The total number of cells made up 2688 thousand cells/10 cm^2 and the biomass – 0.603 mg/10 cm^2. The cell number was dominated by blue-green algae (80%) and diatoms (19%), and the biomass – by diatoms (92%).

Phytoperiphyton in the riffle had the following characteristics: 23 species and infraspecific taxa, 9018 cells/10 cm^2 and 0.147 mg/10 cm^2.

The composition of the phytoperiphyton dominant species in the pool and riffle habitats was characterized by similar structure and in total comprised 15 species from diatoms

(50%), blue-green algae (30%) and green algae (20%). It is necessary to note, that there were more dominant species in the pool habitat, than in the riffle habitat, where water turbulence is much more intense (Tab. 11-6).

11-6. Composition of phytoperiphyton dominant species in the Cheremosh river in September 2015.

Species	Number of cells, th. cells/10 cm^2		Biomass, mg/10 cm^2	
	pool	riffle	pool	riffle
Lyngbya aerugineo-coerulea (Kütz.) Gom.		2892 / 32	–	0,017 / 12
Lyngbya kuetzingii (Kütz.) Schmid.	2000 / 74	5500 / 61	*	0,033 / 22
Oscillatoria amphibia Ag.	–	*		0,012 / 8
Achnanthidium minutissima (Kutz.) Czarn.	126 / 5	*	*	0,012 / 8
Cocconeis placentula Ehr.	*	–	0,056 / 9	–
Cymbella cistula (Hemp.in Hemp. et Ehr.) Kitch.	*	–	0,035 / 6	–
Gomphoneis olivaceum (Horn.) Daw. ex Ross et Sims.	*	*	0,039 / 7	*
Gomphonema truncatum Ehr.	–	*	–	0,007 / 5
Gyrosigma spenceri (Quek.) Grif. et Henf.	*	–	0,095 / 16	–
Nitzschia sigmoidea (Nitzsch) W. Sm.	*	–	0,094 / 16	–
Planothidium lanceolata (Bréb. in Kütz.) Round et Bukht.	*	*	*	0,023 / 16
Stauroneis anceps Ehr.	*	–	0,048 / 8	–
Tribonema affine G.S. West	–	*	–	0,009 / 6
Ulothrix zonata Kütz.	*	–	0,027 / 5	–

Note. Above the bar – number of cells or biomass of a particular dominant species; below the bar – percentage of the total number of cells or biomass of algae in a sample; "–" – the species was not found; "" – the species occurred, but did not dominate.

One may predict that in the newly created run-of-the-river reservoir the phytoperiphyton growth will be more abundant, than in the present-day river bed section. That will improve oxygen regime, production potential and self-purification processes in the water column, and will form good forage resource for zooperiphyton, which, in turn, will be a positive factor for fish fauna development.

Phytomacroperiphyton. In the studied pool of the Cheremosh river phytomacroperiphyton was represented by green filamentous algae, mainly *Ulothrix zonata* Kütz., which formed big aggregates up to 0.4-0.6 m long. Usually young filaments are of bright green colour, old filaments – of brown colour, with the average dimensions of one cell about 45´65 mm. The phytomacroperiphyton aggregates also contained a green filamentous alga *Oedogonium sp.*, but its dimensions were much less, than those of *U. zonata.*

Occurrence of green filamentous algae in the pool of the Cheremosh river makes it possible to predict, that if a run-of-the-river reservoir is formed, with less turbulent water flow, than in the unregulated river's pool, filamentous algae might grow abundantly. In the view of biological and ecological features of this species, as well as hydrological parameters of the water flow, we can forecast intensive growth of filamentous algae on a fish-passing facility, which may interfere with its normal functioning. Therefore this possible biological interference to fish migration must be taken into consideration during the fish-passing facility operation.

11-5. Estimation of possible ecological risks for the Cheremosh river from the hydropower complex of the Small diversion *HPP*.

The hydroelectric complex of Small diversion *HPP* No. 3 (Fig. 1) will consist of:

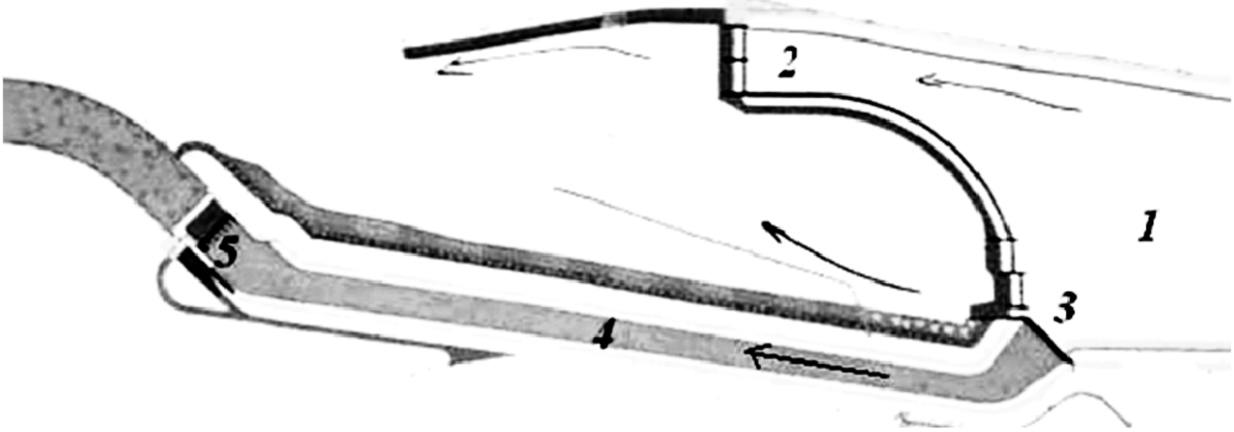


Fig. 11-1. Layout of Small diversion *HPP* No. 3 on the Cheremosh river: 1 – run-of-the-river reservoir, 2 – water-retaining dam of the run-of-the river reservoir and its water intake, 3 – water intake to diversion canal, 4 – diversion canal, 5 – *HPP*. The arrows indicate direction of current in the Cheremosh river and hydroengineering constructions.

- the newly created run-of-the-river reservoir for backwater effect (1);
- the water-retaining dam of the run-of-the river reservoir and its water intake (2);
- the water intake to the diversion canal (3);
- the diversion canal (4);
- the *HPP* with six hydroelectric units (turbines) (5).

Newly created run-of-the-river reservoir. Constructing the hydroelectric complex will require to create a run-of-the-river reservoir with the volume 0.33 m^3, the water area – about 19 ha, the length – 890 m, the maximal depth – 3.5 m, the average depth – 2.0 m (Small diversion *HPP*… 2010 & 2015).

The artificial fragmentation of the Cheremosh river will cause a more lentic subsystem to form within the mountain river, with somewhat different hydrological, hydrophysical, hydrochemical and hydrobiological conditions.

First of all, it will lead to temperature rise, increase in water transparence, slowing down of the current speed and decrease in the water flow turbulence. The river biota will respond to such changes with more intense phytoplankton and periphyton development, which will cause the increase in photosynthetic aeration of water, improvement of oxygen conditions. Development of algae will intensify zooplankton growth, which, in its turn, will contribute to natural forage resources for fish.

It is necessary to state clearly, that local fragmentation of the Cheremosh river, lentic conditions forming with the following biota response, requires performing of the Systemic Hydroecological Monitoring. The monitoring data received will make it possible to assess the effect of the newly created run-of-the-river reservoir upon the ecological state of the river, development of hydrobionts of different trophic levels and ecological groups. The monitoring data will also permit to make more precise operating procedure of the Small *HPP*, to mitigate possible risks to biota development and the river ecological state.

So, the ecological and biological report concerning the river local fragmentation will be given further detail as new data of the Systemic Hydroecological Monitoring become available and the *HPP* operating procedure is amended accordingly.

Water-retaining dam of the run-of-the river reservoir and its water intake. Uninterrupted water pass with a fish-way, optimal for fish migration, is the main requirement for the dam functioning. A fish ladder is the most appropriate fish-way for today, which will ensure passage for salmon and barbel fishes, which form the unique character of the Cheremosh river fish fauna.

It is evident, that the efficiency of the fish-way operation and the level of risks mitigation during fish migration will be specified in course of Monitoring, particularly its ichthyological component.

Water intake to the diversion canal. The main requirement posed to the water intake operation, aimed to mitigate its negative impact upon the biodiversity, consists in installing a reliable fish-protective device, which must render it impossible for any fish to get into the diversion canal.

However, the efficiency of the fish-protective device functioning can be estimated only according to the findings of the Systemic Hydroecological Monitoring.

Diversion canal. We think that in case of efficient functioning of fish-protective device and impossibility for fish to get into the canal, the diversion canal operation will not constitute any substantial risks for the Cheremosh river biodiversity.

HPP with six hydroelectric units (turbines). Analysis of technical specifications of Small diversion *HPP* No. 3 (Small diversion *HPP*… 2010 & 2015) shows that its operation is rather safe, owing to implementation of environmentally safe technologies.

From the point of view of risk mitigation the main requirements include strict observation of the hydroelectric units. Operating procedure depending upon:

Dryness of the year;

Water discharge during the particular season or month, especially in winter;

Prevention of violation of the Cheremosh river sanitary conditions;

The data of Permanent Hydroecological Monitoring concerning mitigation of the possible environmental risks to ecological state and biodiversity of the river ecosystem.

So, the analysis of operation of Small diversion *HPP* No. 3 on the Cheremosh river near Roztoky settlement has made it possible to outline several potential risks to the river ecosystem.

11-6. Practical recommendations for mitigating the risks to ecological situation and biodiversity.

1) It is necessary to conduct the Systemic Hydroecological Monitoring of the main abiotic and biotic components of the river ecosystem within the impact area of the Small diversion HPP.

2) In the view of significant seasonal dynamics of the Cheremosh river's water, alternation of low-water and high-water years, it is necessary that the Operating procedure of the Small diversion HPP should be developed.

3) In order to mitigate ecological risks to hydrobionts, to insure basic sanitary standards in winter condition or during the flood or high-water period, it is necessary to develop a Special schedule of the HPP operation in extreme conditions.

4) It is important to monitor the efficiency of the fish-protective device and the fish-way functioning during fish spawning migration and to introduce constructive changes if needed.

5) To prohibit any building and repair works during fish spawning period.

6) To take into account possible biological interferences with water intake and fish-protective device operation, including the fact, that the major part of mineral suspended matter is represented by large particles.

7) Taking into consideration that in the newly created run-of-the-river reservoir the current speed (kinetic energy) will be much lower compared to the unregulated river, it is important to carry out special monitoring of silt deposition and purification methods. It is obvious that this problem will become more urgent in the years to follow, and will depend upon the frequency of high-water years.

8) When designing and constructing a fish-way it is necessary to foresee, that green fil-

amentous algae might grow intensively and interfere with normal operation thereof.

11-7. Conclusions.

Analysis of field data concerning the abiotic and biotic components of the river ecosystem has made it possible to formulate a positive opinion as to Small diversion *HPP* No. 3 on the Cheremosh river near Roztoky settlement (Kosiv district, Ivano-Frankivsk region). Several critical remarks were expressed as to possible risks to river ecosystem, which can arise during the *HPP* operation.

In general we believe that confirmation by scientific recommendations will make it possible to mitigate the potential ecological hazards on the Cheremosh river by better operating the small *HPP*.

12. THE PRESENT STATE AND POSSIBLE CHANGES OF THE PLANKTON AND DRIFT MICROINVERTEBRATE FAUNA OF THE RIVER TERESVA (THE TISZA BASIN).

Abstract. Results of investigation of the planktonic fauna of the Teresva River (the basin of the Tisza River) investigation during the period of 2007–2010 are presented. Species content, distribution, quantitative development of the planktonic invertebrates of the river, and some satellite basins, especially tributaries in the possible area of construction of HPP are given.

Key words: planktonic fauna, biodiversity, mountainous river, hydro-power plant (HPP).

12-1. Introduction.

Recently development and rational exploitation of water resources in the Carpathians have become the very important reason of investigation. This especially concerns building of *HPPs* that not only produce electric energy but also provide regulation of the river flow, especially during a flood retaining over snow melting (freshet) and heavy precipitations. Mountain relief in Transcarpathians Province (Zakarpattia) provides a possibility to produce significant amount of energy, as potential energy resources of rivers are large.

However, hydropower construction on the river is the most powerful impact on its hydroecosystem. It causes changes of natural hydrological, hydrochemical, and hydrobiological regime of a riverine. Rivers' regulation leads to smoothing of flooding and changes both biota content and functioning of the river ecosystem (Afanasiev 2006, Kharchenko et al. 1999, Afanasyev et al. 2008). Thus, the degree of changes in fauna caused by the river regulation can be judged only after thoroughly analysis of existing species content, seasonal changes and distribution of hydrobionts of a river.

The Teresva River is one of the largest right-banks tributary of the Tisza River within the limits of Ukraine. The length of the Teresva River is 56 km, the catchment area is about 1225 km^2, long- term average discharge at the mouth is 37.1 m^3/sec, the average depth at the mouth of the river, 0.5–2 m, flow rate 0.5-1 m/sec.

Nowadays the flood-protection is realized by embankments which are located within the lower and middle section of the river. The river is not embanked in the upper part and intensive side erosion takes place. Up to date several projects of construction of *HPPs* cascade in the lower reaches of the river were elaborated.

At the stage of documentation design concerning of cascade of *HPPs* construction we have undertake a study of the plankton fauna in the Teresva River basin.

The purpose of this work is to study peculiarities and main characteristics of planktonic fauna of the middle Teresva River, forecast of its changes under the impact of possible construction and operation of *HPPs*.

12-2. Material and Methods.

The upper reaches of the Tersva River are located in high-mountain area of the western slopes of the Gorgany Massif of the Carpathians. In the lower part the valley becomes wider and gets piedmont character. Sediments that were relocated from the upper reaches form rocky spits – rapids. Shallows are occurring in the river bad as a result of stream-flow separation (The rivers of the Carpathians 1999).

Investigation of plankton was carried out over sporadically in 2007-2010 from the upper reaches to the river mouth. Totally 31 quantitative sample of plankton was taken during investigations.

Potentially the area of investigation may be suffered by possible regulation, for example, because of interruption of ways of fish migration. The grid of stations covered directly the area of expected reservoirs and Teresva riverine with its tributaries, such as the river: 1 - Luzhanka, 2 - Mokryanka, 3 - the upper reaches of Teresva, 4 - Teresva above Neresnytsia village, 5 - Teresva above the village of Ternove, 6 - mouth of the river Teresva (Photo 12-1 to 12-7).

More detailed sampling was done in the areas of designed construction of the facilities (area of 7.5 km between villages Neresnytsia and Ternove), and shelf site of the Villshanske (Tereblya–Rikska) reservoir (on the river Tereblia), as a model of typical zooplankton character (No 7). For zooplankton sampling 100/200 l of water were filtered using the plankton Epstein net. Samples were conserved by 4% formaldehyde solution. Organisms were identified and counted using light microscope Carl Zeiss Primo Star. Abundance and biomass were calculated according to the standard hydrobiological methods (Methods of hydroecological researches of surface water, 2006). Other peculiarities of sampling and cameral working are well described in Chapters 9, 10, and 14.

It was stated that zooplankton hardly comprised of typical planktonic organisms. Samples

Photo 12-1, 2, 3, 4, 5, 6, 7. Sampling sites No 1 – the Luzhanka, No 2 – the Mokryanka, No 3 – the upper reaches of Teresva, No 4 – the Teresva above Neresnytsia village, No 5 – the Teresva above the village of Ternove, No 6 – the river mouth of Teresva, No 7 – control sampling site in the shallow middle right shore of the Vilshanske Reservoir (Photo 1-6 by LG, 7 by AK).

12-1. Species content of zooplankton of the river Teresva river basin.

No	Species	Holopl	Dryft	TereM
	Rotifera			
1.	Bdelloidea div. sp.		+	+
2.	*Brachionus quadridentatus* Hermann	+		
3.	*B. nilsoni* Ahlstrom	+		
4.	*B. calyciflorus* Pallas	+		+
5.	*B. angularis* Gosse	+		+
6.	*Cephalodella div. sp.*	+	+	+
7.	*Euchlanis oropha* Gosse		+	
8.	*E. dilatata* Ehrenberg		+	+
9.	*Habrotrocha* sp.		+	+
10.	*Keratella cochlearis* (Gosse)	+		+
11.	*K. quadrata* Müller	+		
12.	*Platyias quadricornis* (Ehrenberg)		+	
13.	*Polyarthra vulgaris* Carlin	+		+
14.	*Rotaria rotatoria* Pallas		+	
	Cladocera			
15.	*Alona affinis* (Leydig)		+	+
16.	*A. rectangula* Sars		+	
17.	*Bosmina longirostris* O.F. Müller	+	+	+
18.	*Camptocercus rectirostris* Schoedler	+		
19.	*Chydorus sphaericus* (O.F. Müller)	+	+	+
20.	*Daphnia longispina* O.F. Müller	+		+
21.	*D. magna* Straus	+		+
22.	*Moina rectirostris* Hellich		+	+
23.	*M. brachiata* (Jurine)		+	
24.	*Peracantha truncata* (O.F. Müller)		+	
25.	*Scapholeberis mucronata* (O.F. Müller)		+	
	Copepoda			
26.	*Acanthocyclops vernalis* (Fischer)	+		+
27.	*A. americanus* (Marsh)	+	+	
28.	*Cyclops strenuus* Fischer	+		+
29.	*C. vicinus* Uljanin	+		+
30.	*Eucyclops serrulatus* (Fischer)	+	+	+
31.	Harpacticoida div. sp.		+	+
32.	*Mesocyclops leuckarti* (Claus)	+		
33.	*Paracyclops fimbriatus* (Fischer)		+	+
	Rhizopoda Testacea			
34.	*Arcella arenaria* Greef		+	+
35.	*Centropixis aculeata* Stein		+	+
36.	*C. discoides* Penard		+	+
37.	*Difflugia elongata* Penard		+	+
38.	*D. fallax* Penard		+	+
	Oligochaeta			+
39.	*Nais barbata* Mueller		+	+
	Chironomidae			+
40.	*Cricotopus sylvestris* (Fabricius)		+	+

Notes. Holopl – Holoplankton species, Dryft – Benthos and Planktobenthos species, TereM – the river mouth of Tereblia.

mainly consist of plankto-benthos (according to V. Polishchuk & I. Garasevych 1986) and syrton (drift organisms – look for example, Yavorskiy & Kovalchuk 2010). Amongst the above mentioned the most frequently occurs aquatic oligochaetes, nematodes, and larvae of insects, as: nonbiting midges or chironomids (Chironomidae), mayflies, stoneflies and caddis flies – Ephemeroptera, Plecoptera and Trichoptera (*EPT*).

12-3. Results and discussion.

Taxonomical richness of holoplanktonic organisms of the Teresva River and its tributaries is not high. Totally 19 taxa (including subspecies level) were registered: rotifers (Rotatoria) – 14, copepods (Cyclopoida, Calanoida and Harpacticoida) – 8, and cladocerans (Cladocera) – 11. In the mouth section of the river 21 taxa were found (Tab. 12-1). In drift was found 26 species. In the river Teresva mouth 29 species of invertebrates have been found, so this place is the most rich in fauna.

The very diverse group of plankton is Rotifera. In quite cold waters of the river occur only a few specimens of cladocerans. Their amount increased only in the lowland reaches.

Copepods are the most widespread group of plankton. It occurs in all types of water bodies (streams, creeks, cutoff meanders or oxbow lakes).

In general, the river basin is inhabited mainly by lacustrine plankton. The most frequent is the rotifer *Euchlanis dilatata,* which is usually periphytic, and cladocerans *Bosmina longirostris,* and *Chydorus sphaericus*. These three species with other listed above in the Tab. 12-1 are typical for plankton fauna of the whole Tisza catchment area (Parchuk 1999, Polischuk & Garasevych 1986).

In the Teresva River large quantity of syrton (or dryft) organisms has been found. Due to high turbulence and sometimes water turbidity (especially during flooding periods) this is quite common for the most of the Carpathians rivers, especially in the upper reaches. Therefore, syrton is the richest and most diverse group whereas holoplankton occurs rare.

The reophilous microinvertebrates dominate in the main stream of the Teresva River. These are: rotifers (*Cephalodella* sp., *Bdelloidea div. sp.)*, harpacticoids, and cladocerans (especially, *Chydorus sphaericus*).

Total amount and biomass of plankton and syrton is quite low: the maximum values registered in summer about $23*10^3$ spms/m^3 (103 spms)/m^3 and 188 mg/m^3, in autumn – $37*10^3$

spms) and 86 mg/m^3. In spring these parameters did not exceed 8*10^3 spms)/m^3 and 22 mg/m^3.

There are several typical benthic and plankto-benthic species in syrton of the Teresva River (Tab. 12-1), such as: different Harpacticoids, *Habrotrocha sp.*, *Arcella arenaria* Greef, *Centropixis aculeata* Stein, *Difflugia elongata* Penard, *Nais barbata* Mueller, *Cricotopus sylvestris* (Fabricius) and other.

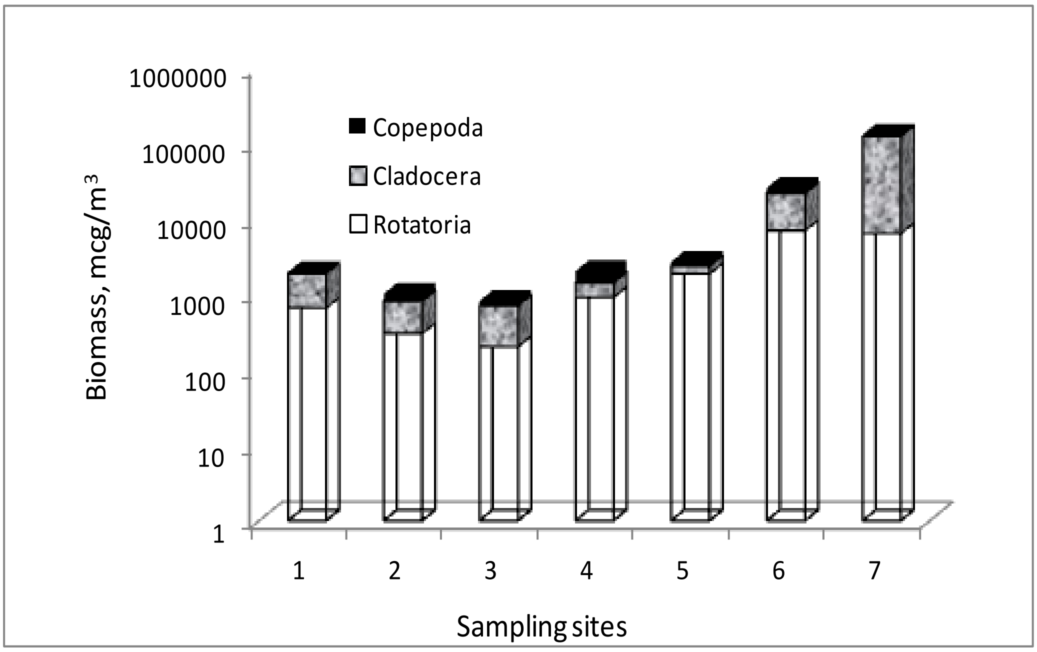


Fig. 12-1. Quantitative development of the main zooplankton groups at the most important sites of investigation (mcg=10^{-3}mg).

Quantitative parameters of zooplankton in the river mouth of the Teresva also indicates its poor development, however amount and biomass (2.2–2.7*10^3 spms)/m^3 and 13.0–25.2 mg/m^3) with percent of holoplankton species here was higher than in other sections (Fig. 12-1, 12-2). Total quantitative parameters of invertebrates depends on drift intensity, which content and abundance varies in wide limits. In the upper reaches such situation occurred due to increase of species associated with hard substrate (benthos Crustacea, like cladoceran *Chydorus sphaericus,* cyclop *Paracyclops fimbriatus*, harpacticoids and ostracods. Variety and quantitative parameters of the holoplanktonic species

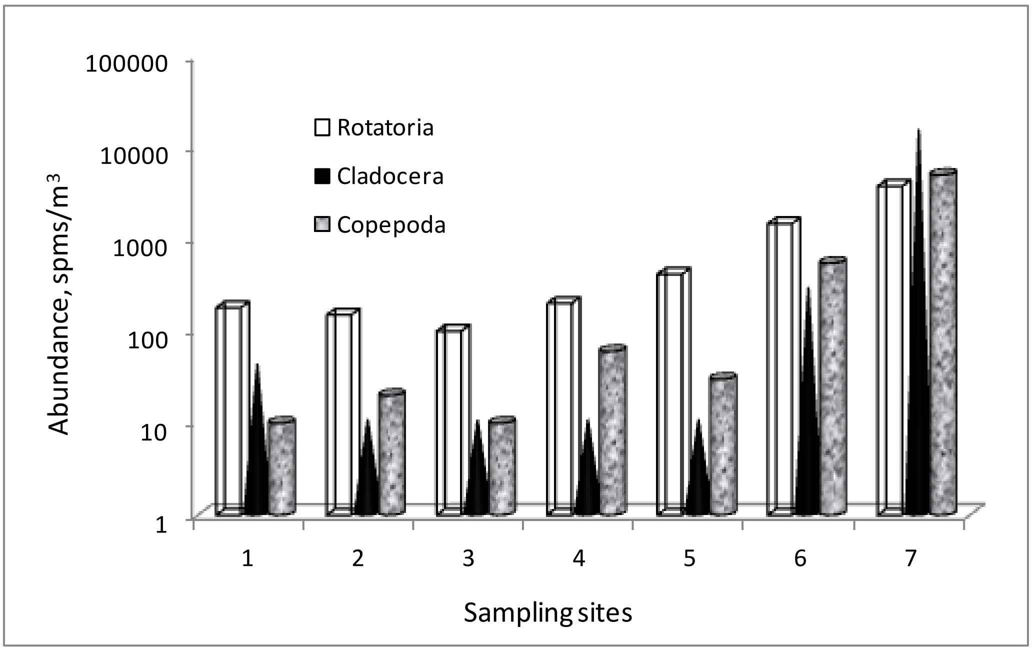


Fig. 12-2. Quantitative development of the main zooplankton groups at the most important sites of investigation.

strongly depends on water flow velocity.

Zooplankton of the Vilshanske reservoir comprised of 15 species. There abundance ($23*10^3$ spms)/m^3 and 123.7 mg/m^3) was comparable with other considered sections, whereas biomass is higher due to development of relatively big crustaceans. Such pattern was determined by peculiarities of hydrological regime of the reservoir as low flow velocity and comparatively high depths. These conditions are much more favorable for crustaceans. In other words, lentic habitats completely modify structure of planktonic communities in compare with typical for the Carpathians river habitats.

Low abundance of organisms and high turbulence of water do not allow effective saprobiological analysis of the Teresva River. Even saprobiological index which is calculated to show the tendencies in changes of the water quality. Nevertheless, it should be noted that species-indicators of saprobiological state belong to oligosaprobes – 18%, oligo-β-mesosaprobes – 20% and β-mesosaprobes – 55%. The other 7% are β-α-mesosaprobic species like *Brachionus calyciflorus or even* α-mesosaprob *Daphnia magna*, or high saprobic *Rotaria rotatoria.*

So, plankton of the considered the river Teresva catchment area is presented by a few holoplankton forms. It comprises mainly by associated with substrate and drifting bottom invertebrates. Its abundance is low. In the mountainous sections holoplanktonic organisms occur in the floodplain pools and well-warmed isolated satellite waters. At the first stage after reservoirs construction quantitative parameters and species number of the planktonic organisms will increase, mainly at the expense of increase of portion of holoplankton and near-bottom species, like *Chydorus sphaericus, Paracyclops fimbriatus*, and decrease a portion of organisms, associated with substrate.

12-4. Conclusion.

In general, in our opinion, construction and operation of the *HPPs* cascade in the river Teresva will lead to negative effects that will result in decreasing of species richness and possible structural degradation of the riverine communities (reduction and exchanging of typical species amount, or even extinction of separate systematic groups, significant fluctuations of quantitative parameters, disturbance of ecological balance and/or evolutionally formed structure of coenosis with all following consequences).

13. POSSIBILITIES FOR IMPROVING OF THE DOMASA RESERVOIR WATER QUALITY BY IMPLEMENTATION OF MODERN BIOTECHNOLOGICAL PRINCIPLES.

Abstract. Based on long term monitoring of physical, chemical and biological properties the water quality of the Domasa reservoir can be significantly affected in the inlet area by appropriate management of river basin. It is possible to improve water quality by limited fishing for predatory fish using the ecological principle of "food web management," which can confine the primary production by the use of planktonic filtrators as consumers of phytoplankton through reducing the amount of planktivorous fish by predatory fish. To increase elimination ability of nutrients in overgrown parts of wooden vegetation in the upper part of the water dam it is necessary to consider the multiple furcation of flow. It is possible over creation of artificial channels in the concerned area, where there were effective elimination of nutrients by accrual flora and fauna. Should also prepare suitable conditions for spawning and fish development.

Key words: Water quality, nutrient elimination, river basin management, food web management.

13-1. Introduction.

The Ondava river is amongst the rivers that provide the greatest amount of suspended sediment in the river mouth in Slovakia. After building the reservoir Veľka (Big) Domasa (Fig. 13-1) this process have cause significant accumulation of sediments in the reservoir bad, and influencing biota. Another notable feature is that the reservoir belongs to the categories of the multiannual filling up by water.

Author addresses a series of tasks designed to assess the impact of sedimentation processes and subsequent events in relation to water quality of the upper part of the Velka Domasa reservoir (Terek 2003, Vološ & Terek 2007). Biological relationship, especially zooplankton and zoobenthos dealt by J. Terek (1987), J. Terek & J. Brazda (1983). Watching ratios and reconciliation of the results from years 1976-1978 (Terek 2007) allow assessing changes, only up to certain extent because of the results of year with extremely poor water level (especially in 2002, 2003).

Pollution in the Ondava river basin was reduced by one third in the last two decades (Terek & Novosad 2010). Influence of environmental factors, especially turbidity with significant impact on the qualitative-quantitative representation of aquatic organisms and con-

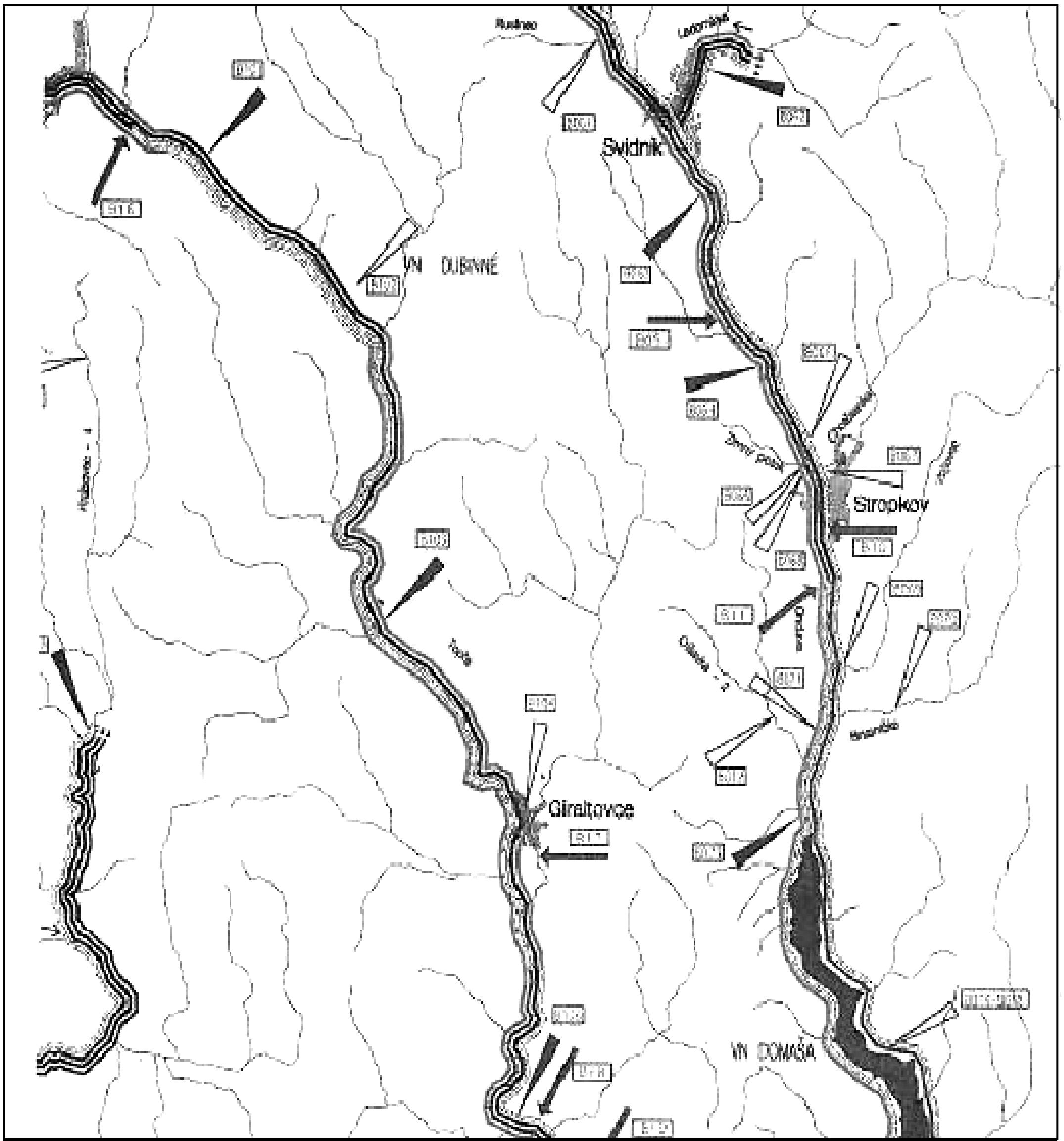


Fig. 13-1. Sketch of the water dam Velka Domasa and its tributary.

sequently on water quality and trophic conditions. Monitoring of these processes in terms of water quality in the dam meant for determining forecasting as well as for subsequent biotechnical measures in the water dam and basin. Given the fact that this ever-expanding area without any apparent care, is to be assessed in terms of protection and utilization of the inundated land, as well as in terms of forestry, fishing, ecotourism and conservation or other considerations.

Insoluble substances are actually one of the factors that affect the self-cleaning process, oxygen water regime, especially after being precipitated in the bottom of the reservoir. Water quality is determined by processes throughout the river basin, and in the reservoir. In terms of water quality, the effect of sedimentation has also some positive impact due to raising transparency, and inactivation of toxic fluids, thereby improving water quality especially in terms of physics. For the reservoir itself, it is undesirable phenomenon, as forest communications, which conducts about 95% of all distracted surface effluent water from forest stands and up to 99% of all soil erosion losses in the forest (Midriak, Zaušková 1997).

Role of suspended sediments is evaluated accordingly to Seszták (1998) who investigated almost all entire area of the Velka Domaša water reservoir. On the total formation of sediment slopes a significantly participation of the processes of aside abrasion of the slopes of banks of the reservoir was noted (Votruba, Broža, 1989).

13-2. Characteristics of the studied object.

The water reservoir Velka Domasa was built on the Ondava River, and was put into operation in 1966. The purpose of the reservoir is: ensuring the flow rate (Q = 5.91 m^3/sec) for industrial, environmental and energy use, to protect the affected area from flooding, to provide water for irrigation of 17000 hectares of agricultural land, for recreation and sports, for farming and fishing.

Accumulation zone of suspended matter, which is largely covered by wooden vegetation or weed, occupies an area of about 2.5-3.0 km^2. The average quantity of transported, and now suspended sediments were estimated by M. Pirkovský (1964) at 23000 m^3/year and can reach up to 140000 m^3/year. Total useful volume of the reservoir is 179.5 million m^3 (accordingly with J. Szesták 1998 it is 187.5 million m^3).

The comparison of the results of the last two measurements, respectively their essays (in 1977 and 1992) shows that the sedimentation volumes coming into the order of the real volume levels. It reasonably should be counted as well as loads of suspended solids and sediment on the eastern rivers. Quantities of established deposit for the last 16 years practically did not affect the net volume of the water dam (0.25 %). There is a loss of the total volume of 0.3 %.

The water dam surface at the maximum level is 15.1 square kilometers; the length of backwater river between 71.57 and 90.54 is nearly 20 km (Abaffy & Lukáč, 1991). Catchment area located in the flysch zone of the Ondavska Highlands occupies 788.3 square kilometers (accordingly with J. Sezsták 829.79 km^2), and forest covers in the basin about 50% of the area.

The water reservoir Veľká Domaša reservoir belongs to a group with a multiannual it inevitably clogging and bottom sediments have a decisive contribution to the development of adverse biochemical processes.

The most important biogenic element we consider phosphorus, which affects the development of cyanobacteria and algae, i.e. water quality. We found the linear relationship between concentration of phosphorus in water before the onset of spring maximum of development of phytoplankton biomass. Such following maximum reached during the subsequent season of growing was noted on large lakes (Sakamoto 1966). Its predictive validity and applicability in the reservoirs of the long terms residence has been amply confirmed.

Different models of utilization of biomass of algae in waters of different types are explained by A. Kovalchuk (2015). The very important mechanism is flow out of organic matter by adult insects with water larvae.

Sources of accumulated sediments are both – products of surface and rill erosion from surface drainage basin produced particularly from arable land, but also from the limited extent of forest land. In the last case the source is a unpaved earth roads, outgoing

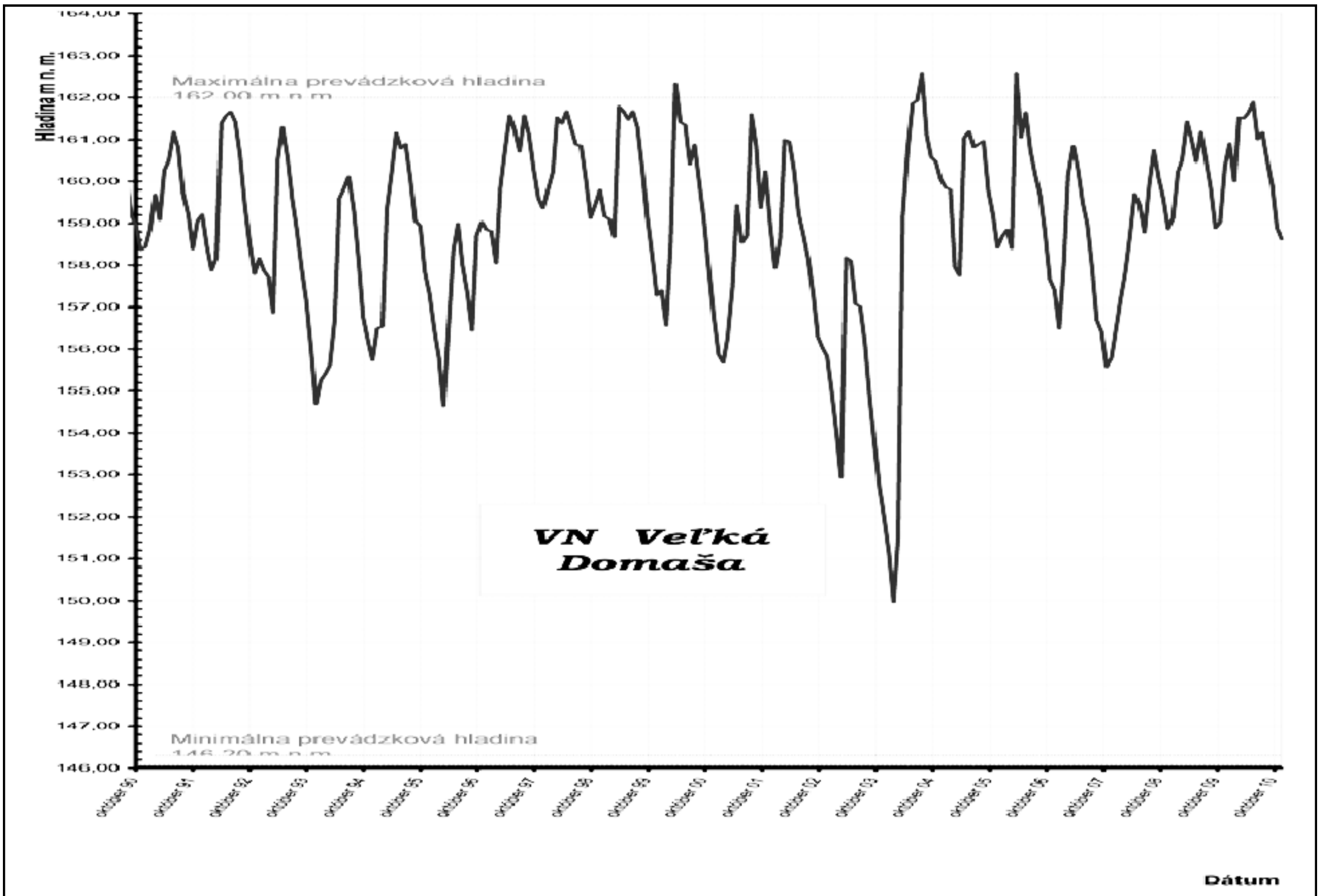


Fig. 13-2. Fluctuation of water level regime.

implementation. The complete filling of the need for several years. The water level is changing, often fluctuates and creates extremely unfavorable conditions for living organisms as well as for recreational use (Fig. 13-2).

13-2. Materials and Methods.

Have been identified:

- hydrological and physical properties of water (level regime, turbidity, conductivity, temperature, transparency, sedimentation);
- chemical properties (oxygen, ammonia, nitrates, nitrites, total phosphorus, soluble and insoluble substances, BOD_5 – Fig. 13-3, 13-4, 13-5, 13-6 in mg/l);
- biotic characteristics of quality - the quantitative ratios of aquatic plants, including plants, zooplankton, zoobenthos, fish.

Sampling was done at the top of the tank, near the bridge to Lomne as well as in the central location near „Zajacia debra“ Hydrobiological Station UPJŠ in Presov.

River basin of Bodrog and Hornad in Kosice, company, Slovak Water Management provided long-term water quality data of water dam Velka Domas at profile Lomne bridge and dam wall.

13-3. Results and discussion.

From the comparison of the results of the last two measurements respectively their years (in 1977 and 1992) it is known that the sedimentation volumes coming into the order of the real volume levels correlate with the focus to be counted as well as loads of suspended solids and sediment on the eastern rivers. Quantities established deposit for the last 16 years practically did not affect the net volume of the tank (0.25 %). There is a loss of the total volume of 0.3%.

Water quality profile Lomne maintains β-mesosaprobity the inclination to α-mesosaprobity. In the central part of the tank occurs and the dam wall there is a slight improvement in water quality between β-mesosaprobity (Terek 2007).

At the top of the tank was determined periphyton in the growth of woody vegetation and showed a high degree of recovery and the dead stems of willow stand. Overall, it was

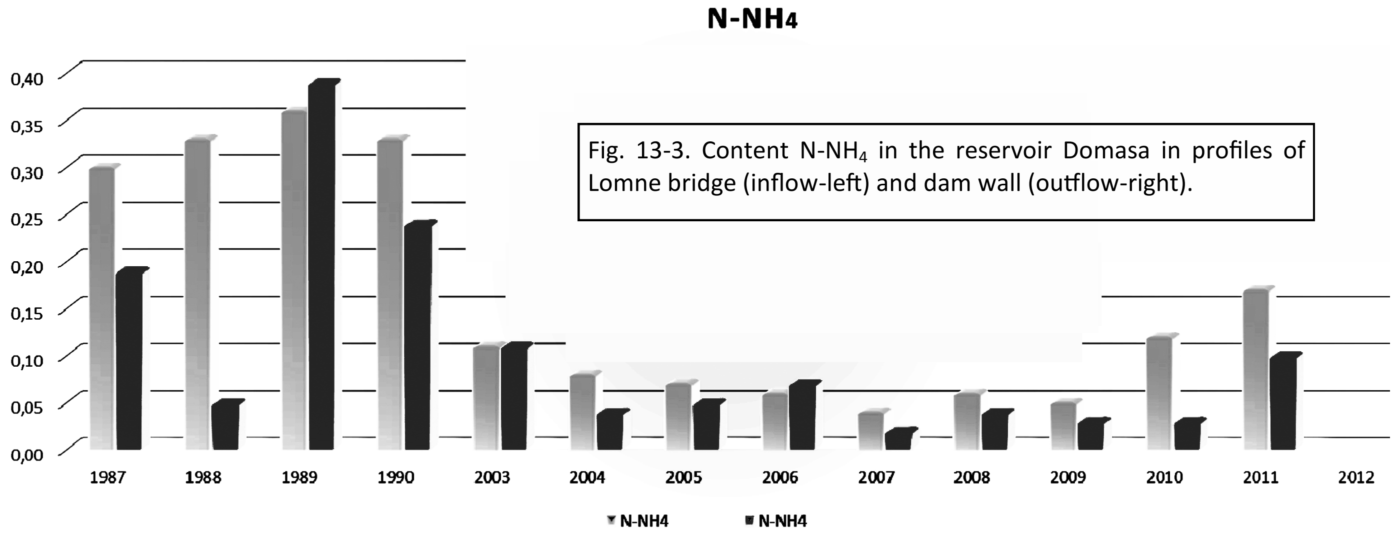


Fig. 13-3. Content N-NH_4 in the reservoir Domasa in profiles of Lomne bridge (inflow-left) and dam wall (outflow-right).

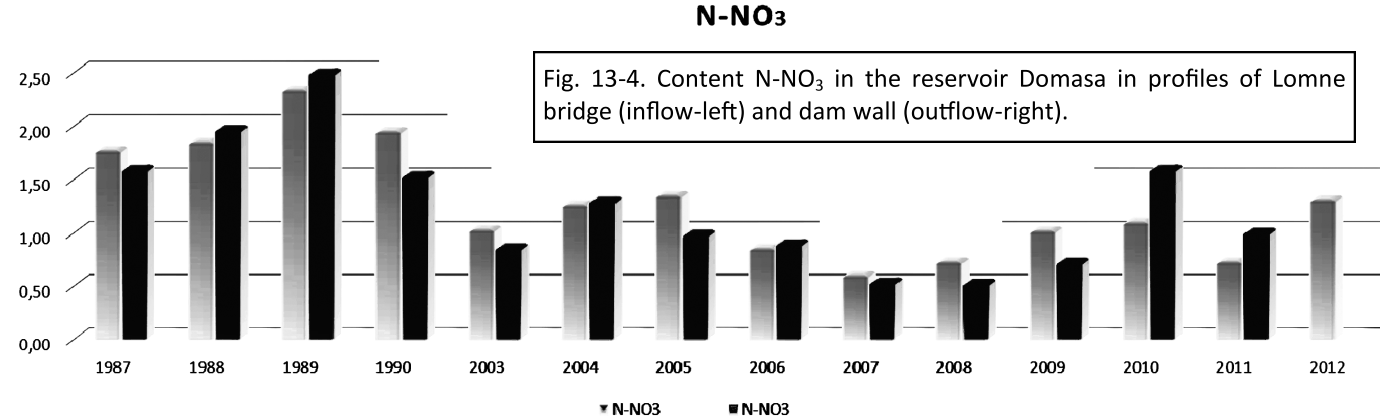
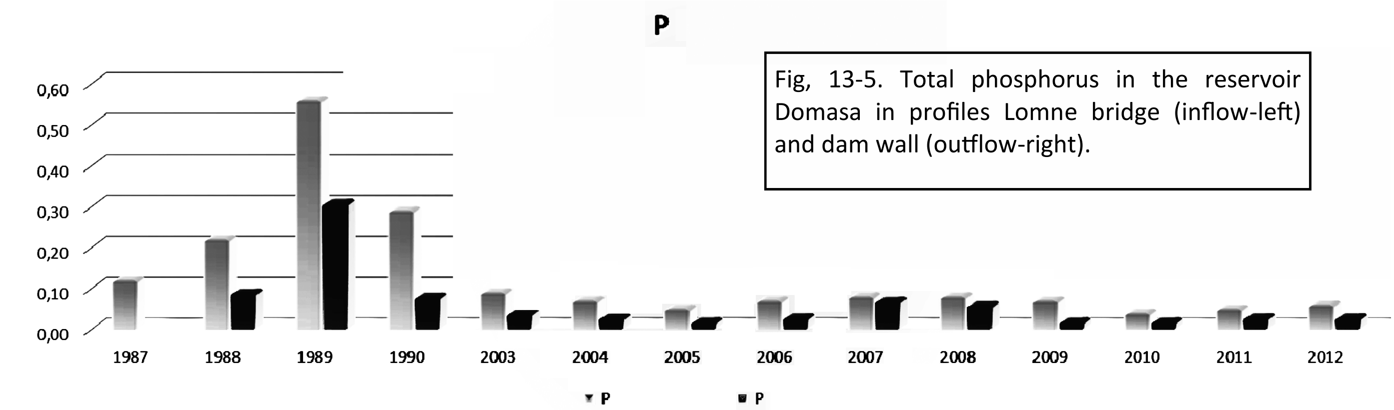


Fig. 13-4. Content N-NO_3 in the reservoir Domasa in profiles of Lomne bridge (inflow-left) and dam wall (outflow-right).



Fig, 13-5. Total phosphorus in the reservoir Domasa in profiles Lomne bridge (inflow-left) and dam wall (outflow-right).

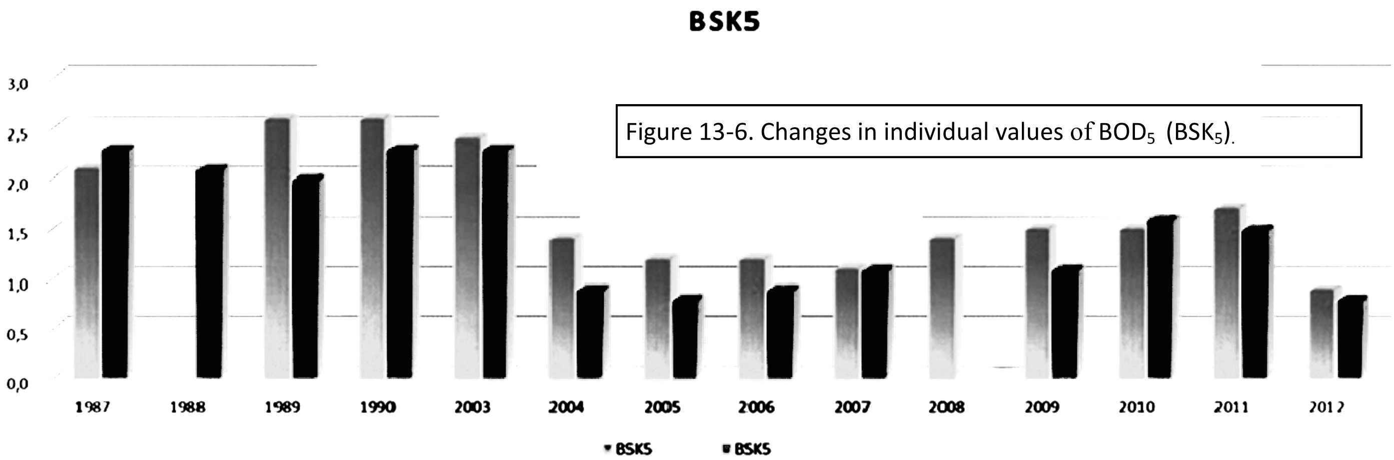


Figure 13-6. Changes in individual values of BOD_5 (BSK_5).

discovered more than 60 taxa of cyanobacteria and algae. Similarly was determined weed and bush vegetation, which showed high species diversity (Terek & Balazs 2013).

In 2004 it was evaluated density of 100 spms of willow bush woodland per m^2, thickness 2 cm, height of 2.5 meters, and the total contact area of 50 m^2 and occupied hypothetical amount of 7.8% of the aquatic environment. In 2007, the number of plants per 1 m^2 of 100 spms thickness of 0.6 cm and 60 cm plant height had contact area 11.3 m^2 and a volume of 1.6% of the aquatic environment.

Over 25 years there has been a major change in the representation of the planktonic, and benthic animals but mostly at a depth of 5, 8, and 12 m where the frequency is reduced from dozen to hundreds of spms per m^2. In some years has been indicated complete absence of the organisms. These ratios relate on the altered substrate conditions.

Both nitrate concentration and especially content of total phosphorus in the longer period of time have the strong impact and is related to the recession farming and more recently the increase of its activities. This was confirmed not only in the reservoir but also in the river Ondava which significantly reduce pollution (Terek & Novosad 2010).

It was prediction of M. Sakamoto (1966) who regarding that the content of phosphorus and cyanobacteria with algae could not be assessed due to large fluctuations in water levels, despite the fact that there are permanent monthly observations.

13-4. Suggestions for troubleshooting.

An essential element for recreational use is stabilizing of the water regime and creation of recreational areas. Among the important measures to improve the current state is changing of water handling code for reservoir operation, with the meaning to reduce the proportion of waste water sewages into the Ondava river.

Increasing of the water quality needs to be considered from multiple furcation flow, i.e. by creating of new arms of the River Ondava at the upper reaches of the reservoir bad, where can be effective elimination of nutrients by physic-chemical and biotic way.

Blooming of microscopic flora is a specific problem. In most of the discussions we talk about blooming as a negative impact, due to bad odor, toxic effect on animals, decaying, destroying of recreational potential etc. Positive influence of algae sometimes remains unnoticed. In average amounts microalgae in compound community of hydrobionts acts as a biological filter, that can improve water quality (self-purification).

The weed vegetation provides suitable spawning grounds for fish and creating conditions for recovery and total enriching of fauna.

The solution is in stimulation of long food chains „filtrators - planktivorous fish - predatory fish". The proportion of predators that will participate in the elimination of planktivorous fish, thereby contributing to increase filtration function, involved to the reduction of the cyanobacteria, should increase. Such approach is named „biomanipulation" through diet. When affected in right way it can decrease the net primary production into suitable level.

So, relating "food web management" can be practical guide for primary production regulation. In practice this means “a ban on hunting predators”. This path can serve as a means for improving water quality.

Removal of cyanobacterial biomass using herbivorous fish is still in the stage of experimentation, but appears as one of the easiest ways to combat overproduction of cyanobacteria and algae in our waters. Fish that have been tested in our waters is the silver carp (*Hypothalmichthys molitrix*) or bighead carp (*Aristichthys nobilis*).

When designing new water dams, it must be addressed individually how to adjust the upper surfaces of the container planting suitable plants. It should include the development of the forest management plan. Especially, it is necessary to change the structure of a homogeneous plant. The major part of the existing stand of willows timber thickness does not exceed 10-15 cm and their removal is problematic. They are particularly under represented alder stands where conditions are right for a production activity.

14. THE IMPACT OF DAMMING AND WATER POUNDAGE ON THE FORMATION AND STRUCTURE OF ZOOPLANKTOCOENOSES IN THE CONDITIONS OF RIVERS IN THE UKRAINIAN ROZTOCZE (THE "OUTER" OR "CHUNK" CARPATHIANS).

*Abstract. We analyzed the features of zooplankton groups of water bodies of Ukrainian Roztocze in conditions of damming impoundments (instream ponds) but not for purpose of hydro-power energy producing. The following indices were taken into account: species content, trophic characteristics, biomass, abundance, Shannon index, the index of Pantle-Bukk, and the index of dominance. The zooplankton fauna consists of 48 species, including 17 species of rotifers, 23 species of cladocerans and of 8 copepods. The maximum zooplankton abundance is 554.3*10^3 spms/m^3, biomass – 4.7 g/m^3. The use of space in habitats occurs through the occupation of different eco -niches by organisms. Only few dominants have play a significant role in the functioning of zooplanktocoenoses along the riverbed. It is shown that species composition of zooplankton has high plasticity.*

Key words: zooplankton fauna, Ukrainian Roztocze, instream ponds, water dams.

14-1. Introduction

Hydraulic engineering is a powerful factor, which determines the peculiarities of formation of the hydrobiological characteristics of running waters. Lotion system, according to the concept of river continuum, is considered as a certain integrity. Changes in the flow go downstream. Thus, in the first place, decreasing the flow increases the width and depth of the river bed, its water retaining. The primary producers, and therefore consumers in these conditions are developing more intensively. As water-mass is carrying downstream the natural changes in the quality of the living environment of hydrobionts have occur. It happens through both influence of environmental factors and by biocoenotic relationships (Begon et al. 1989, Vannote et al. 1980).

Building of instream ponds is widespread near the Carpathians region and has a significant impact on lotic hydroecosystems. The priority in this case is the change of speed of flow-regulated watercourse, which in turn causes changes in the hydrological, chemical, and morphometric parameters of the riverbed and floodplain. In particular, it produces changing in the landscapes of the region, disturbed oxygen regime of watercourses and in some cases lead to the thermal stratification of new born impoundments. Anyway the structure of every ecological group of organisms strictly depends on the communities from the upper reaches in a greater degree.

Optimization of biocoenotic processes in such man-caused altered systems, the proper functioning of the trophic networks are largely determined by developing of zooplankton that usually only rarely appear as important coenotic player in typical shallow rivers of lowlands of the Near Carpathians. As the primary filterers and an intermediate sedimentators zooplankters are a connected link between autotrophs and higher trophic levels that determines its critical role in transformation of matter and energy (Alimov 2000, Ivanets 2003, Kovalchuk A. 1999 & 2015, Kovalchuk N. 1999).

Predatory zooplankton accumulates the energy of small species and make it accessible for fish larvae and water birds.

Zooplankters are subtle indicators of the ecological status of water bodies not only sensitive to negative environmental effects of structural rearrangements of the communities, but also for changes in population characteristics and individual reviews of the organism-environment relations. This makes them important, inter alia, in the system of monitoring in the prediction of trends of changes in surroundings under the influence of man-caused factors (Dokulil et al. 2001, Lampert & Sommer 1993).

Of particular interest from the point of view of influence on the watercourses by hydraulic engineering is transformation of zooplanktocoenoses in conditions of instream ponds. This is due to the fact that in impoundment of this type a complex of plankton communities, both lotic and lentic type is forming. The ponds had been constructed by the cross-damming of the river. Certain sections of these reservoirs are characterized by a pronounced running hydrological regime, however, there are also areas where the flow is weak or absent. The formation of impoundments of this type leads into changes in the structure and dynamics of groups of river continuum, which transforms characteristics of zooplankton.

Differences in the structure of coenoses formed this way, are noted by many authors, for large reservoirs (Zimbalevska et al. 1989, Malarevskaya et al. 1986) However, they are not investigated for small impoundments which are instream ponds.

Therefore, considering the importance of such processes in the formation of energy flow of aquatic ecosystems, such studies are of key importance.

14-2. Materials and Methods.

Zooplankton coenosis of the impoundments that make up the instream system of impoundment ponds of the river Vereshchitsa in the Ukrainian Roztocze have been studied.

The river Vereshchitsa – one of the most heavily regulated by dammed ponds rivers of the Ukrainian Roztocze. The bottom of the channel is relatively leveled, muddy, covered with peat. Average current speed 0.2-0.3 m/sec. (Kovalchuk & Petrovska 2003).

Along the course there are 56 ponds, of which 12 were investigated. The investigated waters are of a cascade type formed by overlapping the river by earthen dams. The ponds are filled with river and spring water, surface water from spring snowmelt and rain waters. There are water sluice facilities in the bodies of the dams separating the ponds. Maximum depth of ponds is typical for near dam area and is 2.0-3.5 m.

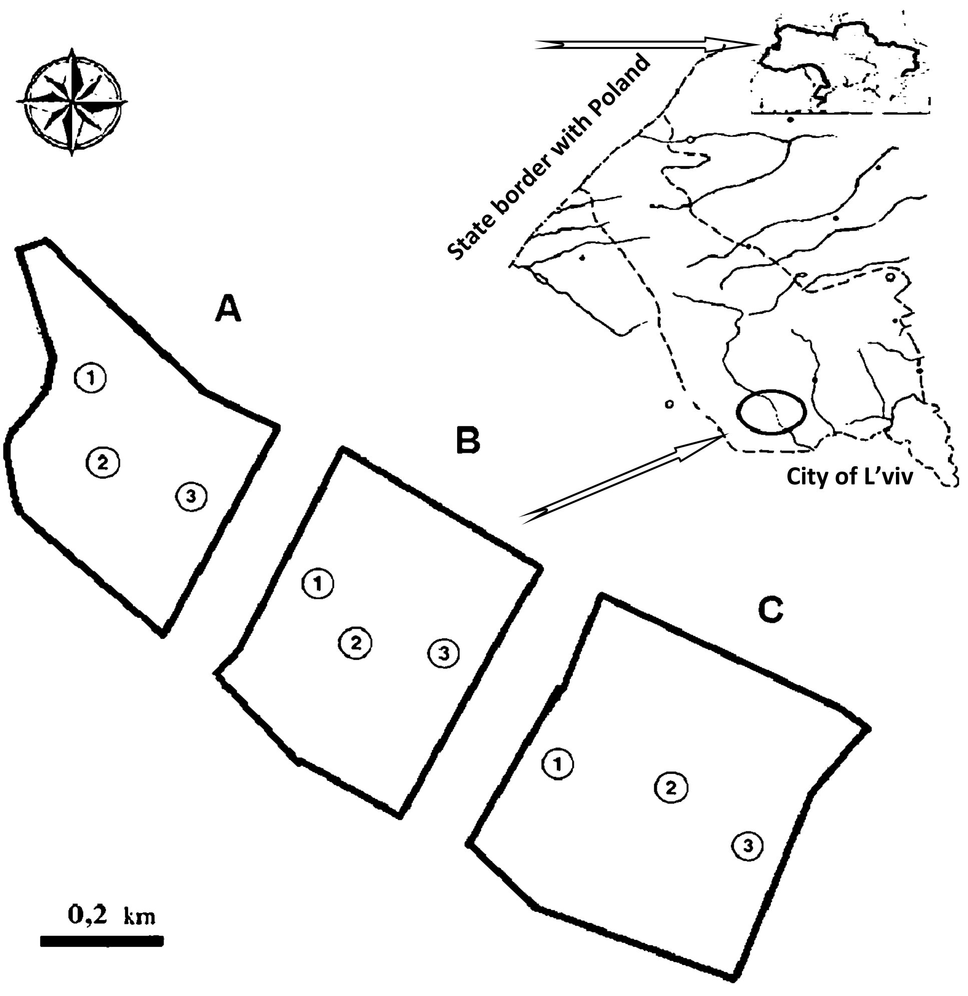


Fig. 14-1. Map of the survey area. A – instream ponds No 1, B – No 2, C – No 3 with sampling sites on the river Vereshchitsa (the Dniester basin).

In the upper reaches and in the coastal zone the ponds bed is overgrown with aquatic vegetation, shrubs and scattered trees. Capacity of bottom sediments is 0.3-0.5 m. Significant cause of siltation of these water bodies are the products of ruination of the coast, wave and wind erosion.

The highest daily values (24-26°C) the water temperature reaches in July and the first half of August.

The data were based on 127 gathered samples, collected in the instream ponds during 2010-2012 usually in three seasons: in spring, summer and autumn. Sampling and processing of samples was carried out by common methods in Hydrobiology (Kisselev 1969, Pesenko 1982, Wetzel & Likens 1979).

For the sampling the Apstein mesh (length of the cone is 55 cm, the diameter of the inlet 25 cm, Cup diameter of 4 cm) had been used. As well for studying the horizons in deep waters the opened-water-sampler of Dr. Franz Ruttner was used. In such cases samples were taken at three horizons of the water column: the surface of the reservoir, middle level, and near bottom level. The collected material was fixed with 4% formaldehyde. For quantitative processing of the samples camera of Bohorov had been used.

Species composition of zooplankton groups were analyzed using the index of species diversity of the Shannon-Weaver (*H* – look Chapter 9).

The following indices were calculated:

• the abundance of separate groups and total abundance,

• biomass,

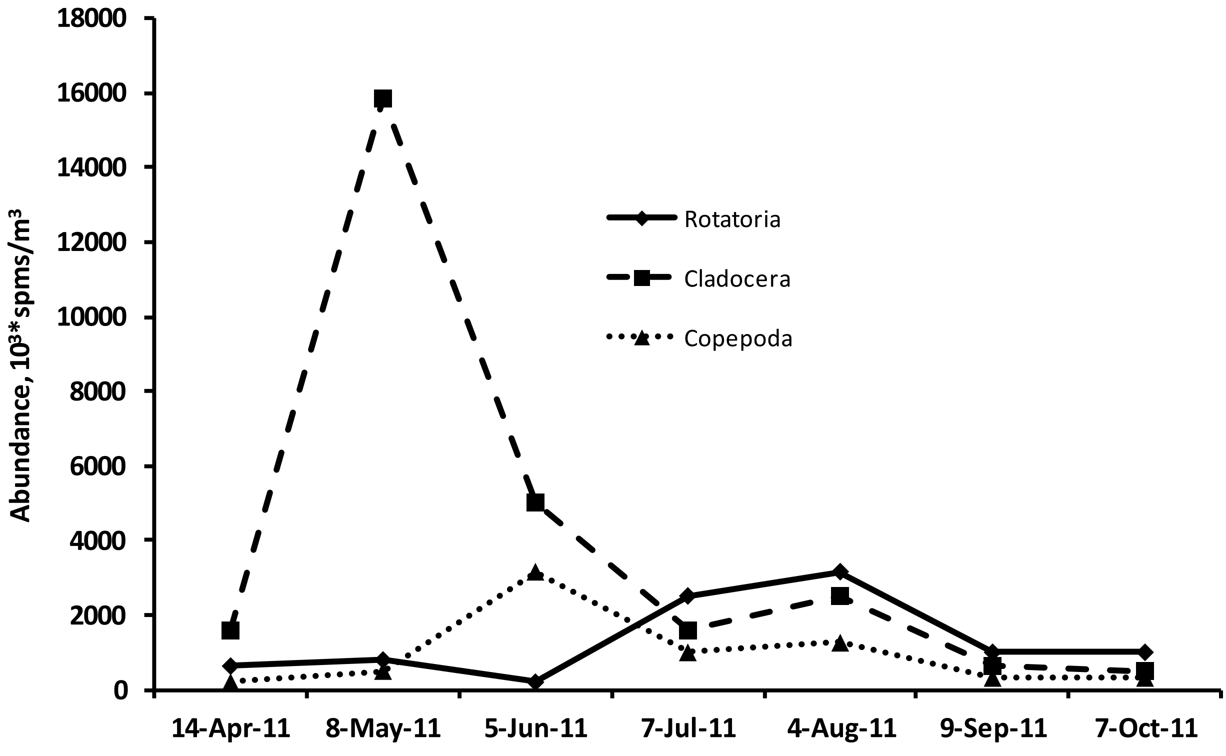


Fig. 14-2. Abundance of zooplankton in pond No. 1 . Note. Average indices for 3 sampling sites.

14-1. The species list of zooplankton of instream ponds of Ukrainian Roztocze.

	Species/Pond	**I**	**I**	**I**	**II**	**II**	**II**	**III**	**III**	**III**
No	**Season** ⟹	***Spr***	***Sum***	***Aut***	***Spr***	***Sum***	***Aut***	***Spr***	***Sum***	***Aut***
	ROTIFERA									
1.	*Asplanchna girodi* Guerne,1888	+	+			+	+		+	+
2.	*A. priodonta* Gosse,1850			+		+		+	+	+
3.	*A. priodonta var. henrietta* Langhaus,1906			+		+		+	+	+
4.	*A. herricki* De Guerne,1888		+	+	+	+		+	+	
5.	*Brachionus angularis angularis* Gosse,1851		+	+		+	+		+	+
6.	*B. angularis bidens* Plate,1851		+		+				+	
7.	*B. calyciflorus* Pallas,1776	+	+			+	+	+	+	
8.	*B. diversicornis* (Daday,1883)			+		+		+		+
9.	*B. quadridentatus* (Barrois&Daday,1894)		+	+		+	+		+	
10.	*Euchlanis lyra* Hudson,1886		+			+	+	+	+	
11.	*Keratella quadrata* (Mueller,1786)	+	+	+	+	+			+	
12.	*K. cochlearis* (Gosse,1851)	+	+	+	+	+	+	+		+
13.	*Lecane luna* (Mueller,1776)		+	+		+		+		
14.	*Platyias quadricornis* (Ehrenberg,1832)		+			+		+	+	
15.	*Polyarthra dolichoptera* Idelson,1925		+	+		+	+		+	+
16.	*P. luminosa* Kutikova,1962	+	+			+		+		
17.	*Trichocerca cylindrica* Imhof,1851	+	+			+	+		+	+
	CLADOCERA									
18.	*Alona guttata* Sars,1862		+	+		+			+	
19.	*A. quadrangularis* (Mueller,1776)	+				+		+		
20.	*A. rectangula* Sars,1862		+				+		+	
21.	*Bosmina (Bosmina) longirostris* (Mueller,1776)	+	+	+		+	+		+	+
22.	*Ceriodaphnia laticaudata* Mueller,1867		+	+		+			+	+
23.	*C. pulchella* Sars,1862	+			+	+			+	
24.	*C. quadrangula* (Mueller,1785)		+		+			+		
25.	*C. reticulata* (Jurine,1820)		+			+	+		+	+
26.	*Chydorus ovalis* Kurz,1875	+	+	+	+			+	+	
27.	*C. sphaericus* (Müller,1776)	+	+			+	+		+	+
28.	*Daphnia (Ctenodaphnia) magna* Straus,1820	+	+		+	+			+	
29.	*D. (s.str.) longispina* (Mueller,1776)	+	+	+		+			+	
30.	*D. (s.str.) pulex* Leydig,1860	+	+	+	+	+		+	+	
31.	*Diaphanosoma brachyurum* (Liévin,1848)	+	+			+	+	+		
32.	*Graproleberis testudinaria* (Fischer,1851)			+		+			+	+
33.	*Moina brachiata* (Jurine,1820)		+			+		+	+	
34.	*M. micrura* Kurz,1875		+		+	+			+	
35.	*Pleuroxus (Peracantha) truncatus* (Mueller,1776)			+		+	+		+	+
36.	*P. (Tylopleuroxus) aduncus* (Jurine,1820)		+	+		+		+		
37.	*Polyphemus pediculus* (Linnaeus,1761)	+				+		+		+
38.	*Scapholeberis mucronata* (Mueller,1776)		+				+	+		
39.	*Sida cryslallina* (Mueller,1776)	+	+			+			+	+
40.	*Simocephalus (s.str.) vetulus* (Mueller,1776)		+	+		+	+	+	+	
	COPEPODA									
41.	*Acanthocyclops languidus* (Sars G. D.,1863)	+	+			+			+	
42.	*A. vernalis* (Fischer,1853)	+		+		+		+		+
43.	*Cyclops strenuus* Fischer,1851	+	+			+	+	+	+	
44.	*Diaptomus gracilis* (Sars G. O.,1863)		+	+			+			+

14-1. The species list of zooplankton of instream ponds of Ukrainian Roztocze.

45.	*D. castor* Jurine,1820	+	+	+		+		+	+	
46.	*Mesocyclops crassus* (Fischer,1853)			+		+		+		+
47.	*M. leuckarti* (Claus,1857)		+	+		+		+	+	
48.	*Microcyclops gracilis* (Lilljeborg,1853)	+	+	+			+	+	+	

•

Notes. I, II, III – Ponds No 1, 2, and 3.

frequency of getting into the net,

• the index of dominance.

The level of organic pollution was determined based on index of saprobity of Pantle & Bukk (*S*).

Taxonomic analysis of zooplankton groups were carried out using several identification keys (Kiefer 1978, Koste 1978, Einsle 1993, Flössner 2000, Dumont & Negrea 2002).

14-3. Results and discussion.

In the zooplankton of the investigated water bodies 48 taxa were identified. Rotifers are represented by 17 taxa, 23 taxa of cladocerans, and 8 taxa of copepods have been found (Tab. 14-1).

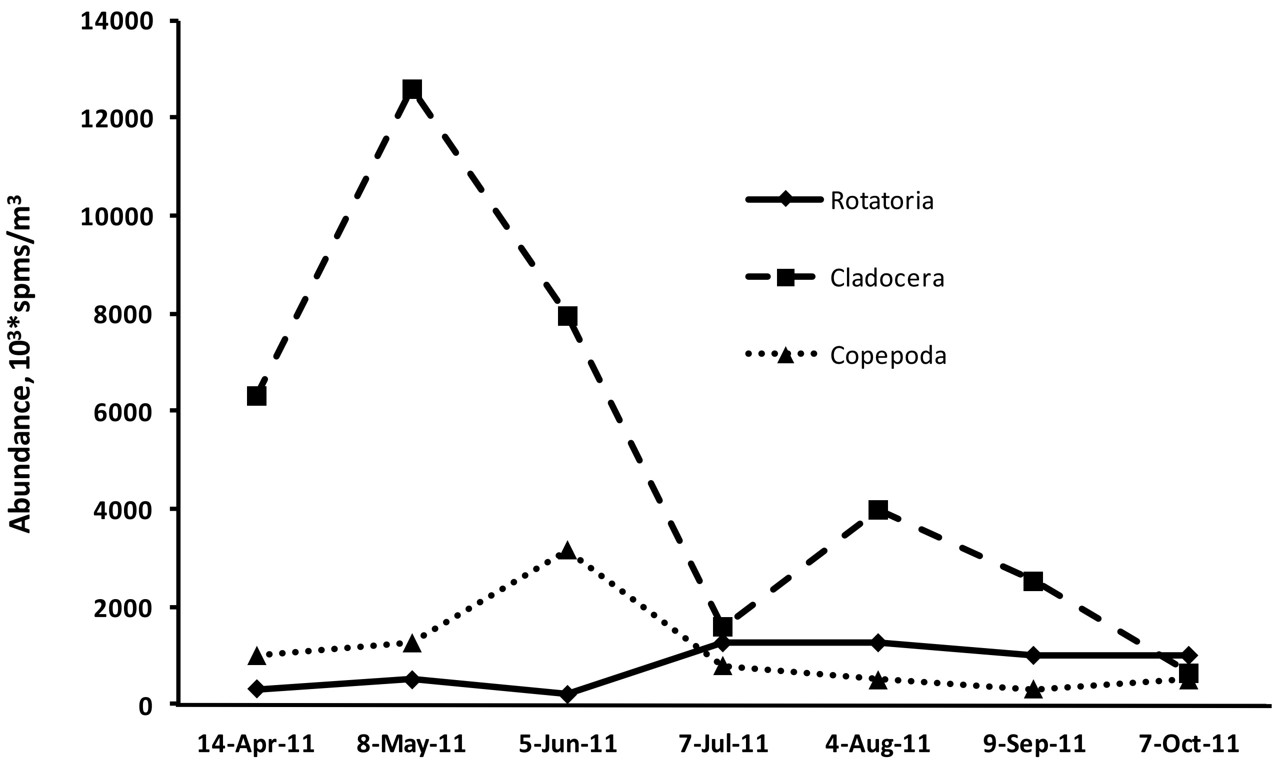


Fig. 14-3. Abundance of zooplankton in pond No. 3. Note. Average indices for 3 sampling sites.

Permanently zooplankton is formed by 17 typical species. The rest species have occur sporadically. A significant role (dominants in abundance) in zooplankton communities plays a small group of species. It rotifers, mainly: *A. priodonta*, *K. cochlearis*, *B. an-*

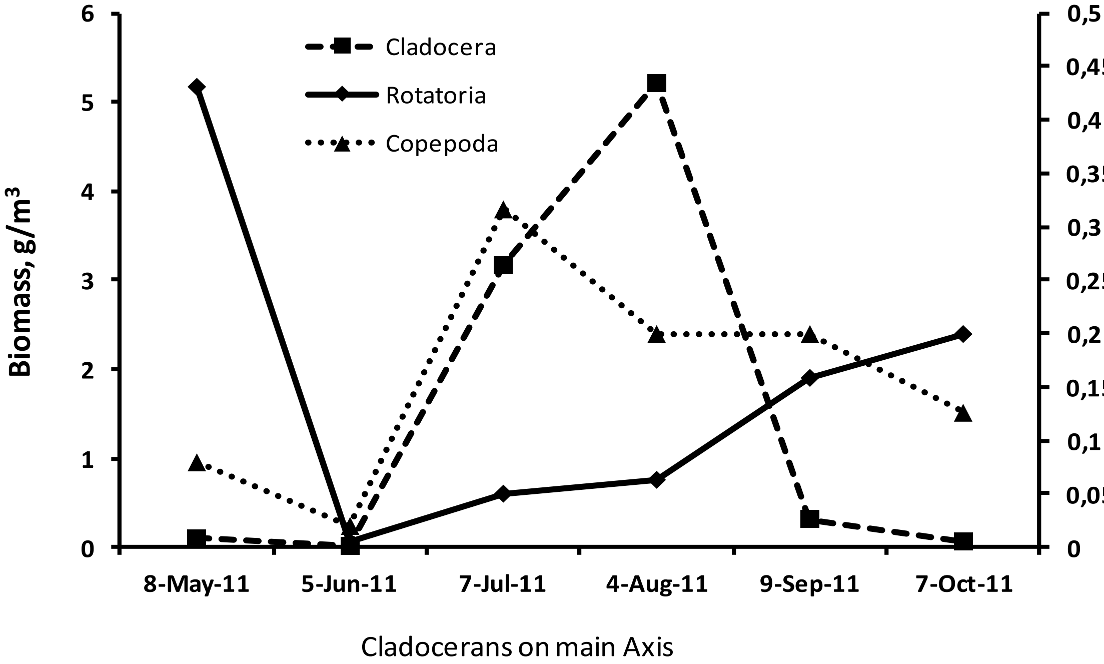


Fig. 14-4. Biomass of zooplankton in pond No. 2. Note. Average indices for 3 sampling sites.

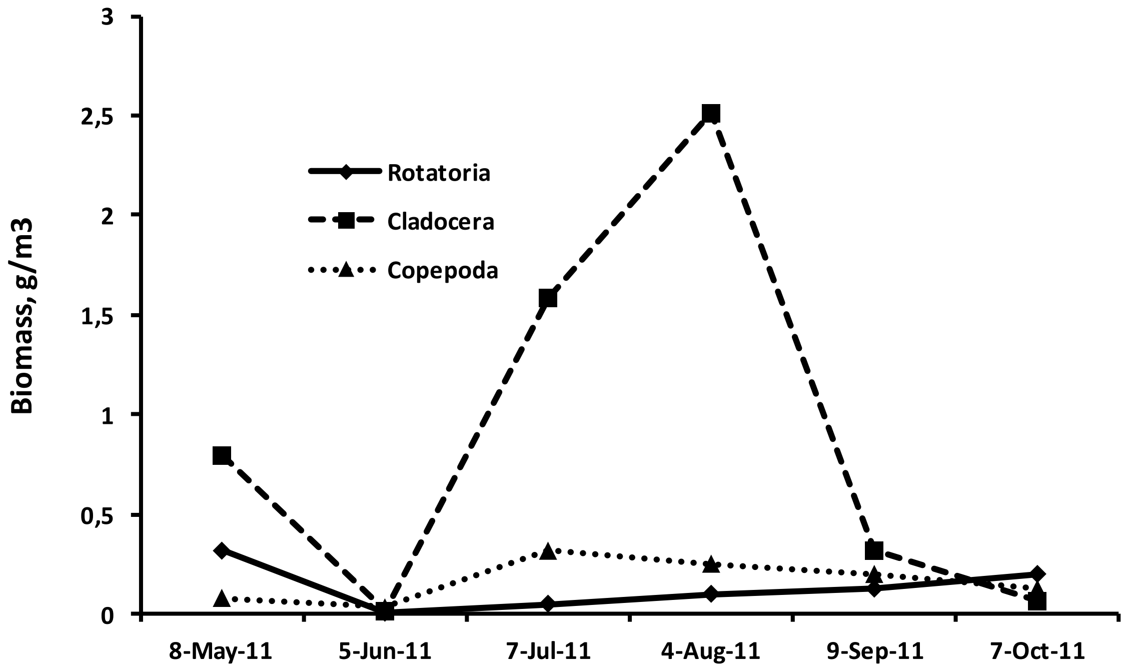


Fig. 14-5. Biomass of zooplankton in pond No. 3. Note. Average indices for 3 sampling sites.

gularis. The second – subdominants are some copepods, as *M. leuckarti* and *A. vernalis*. Cladocerans are less common in species content. Among them are forms having low frequency of catching by net, such as: *S. mucronata*, *P. aduncus*, *G. testudinaria*. These species are characterized by monocyclic reproduction and are sensitive to water pollution. Their presence in the plankton community suggests slight trophic status of these impoundments.

The value of some systematic groups of zooplankton changed with the seasons. In May-June of great importance are the cyclopoids and rotifers. In July and August increases the value of cladocerans, in September guiding the complex of copepods. But all these may appear in natural riverine conditions. After regulation the situation has change and cladocerans have play the most important role in abundance with a maximum in spring or early summer (look, for instance, Fig. 14-2 & 14-3).

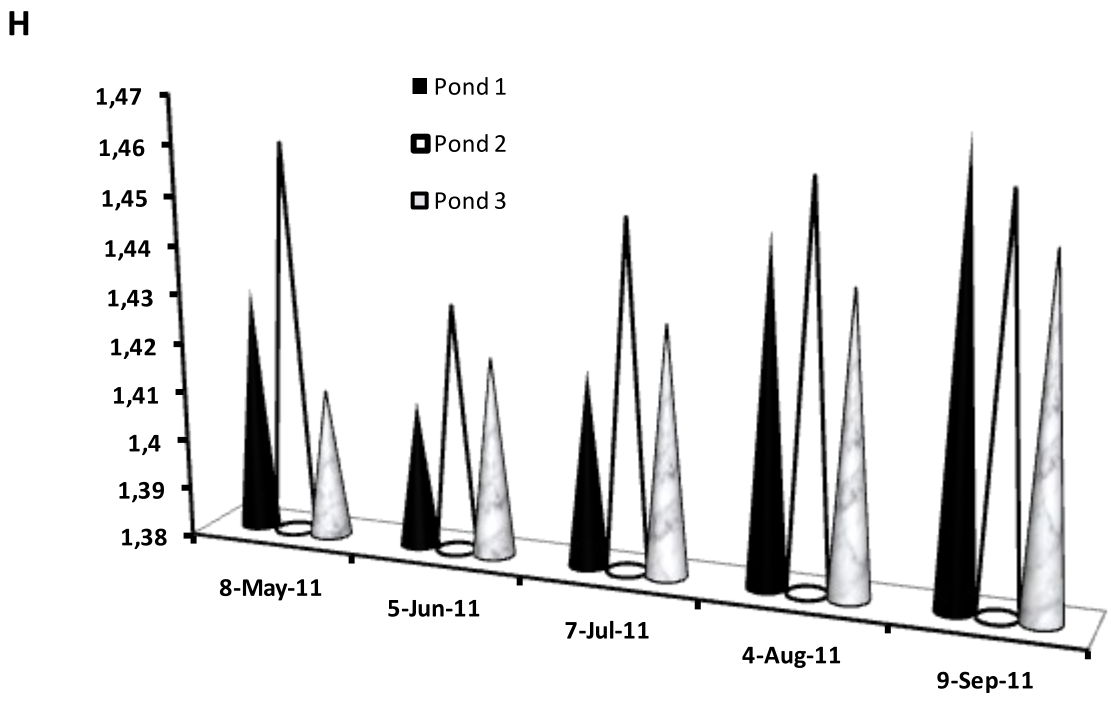


Fig. 14-6. Seasonal changes in the Shannon-Weaver index in three ponds.

Biomass in the impoundment conditions has different seasonal changes when compare with abundance, and is usually characterized by a maximum in late summer due to cladocerans (Fig. 14-4 & 14-5).

The poverty of species content of zooplankton in water bodies depends on low temperature, as water occurs primarily at the expense of spring and ground water.

In the study of the structure and peculiarities of functioning of the biocoenosis, we used a systematic approach, which involves identifying the structure of the object as a set of stable relations. The effectiveness of this approach in biocoenology is especially obvious, since the stability and robustness of biological systems due to various changeable factors (Ivanets & Gorban 1994, Alimov 2000, Ivanets 2011).

Such biocoenotic indices as the frequency of catching, dominance, Shannon-Weaver index (Fig. 14-8) adequately reflect the functional features of zooplanktocoenoses. High values of index of dominance give the species that have a high indices of catchment and significant abundance and biomass. So, in the studied water bodies are forming mainly the planktocoenoses of *S. vetulus*.

Members of the genus *Simocephalus* are occurring primarily in the coastal zone of reservoirs. They are typical representatives of phytophilous planktocoenoses and form an important link in trophic chains. In particular, they consume planktonic algae, detritus, and bacteria in turn are food of fish, and insect aquatic larvae (Orlova-Bienkowskaja 2001).

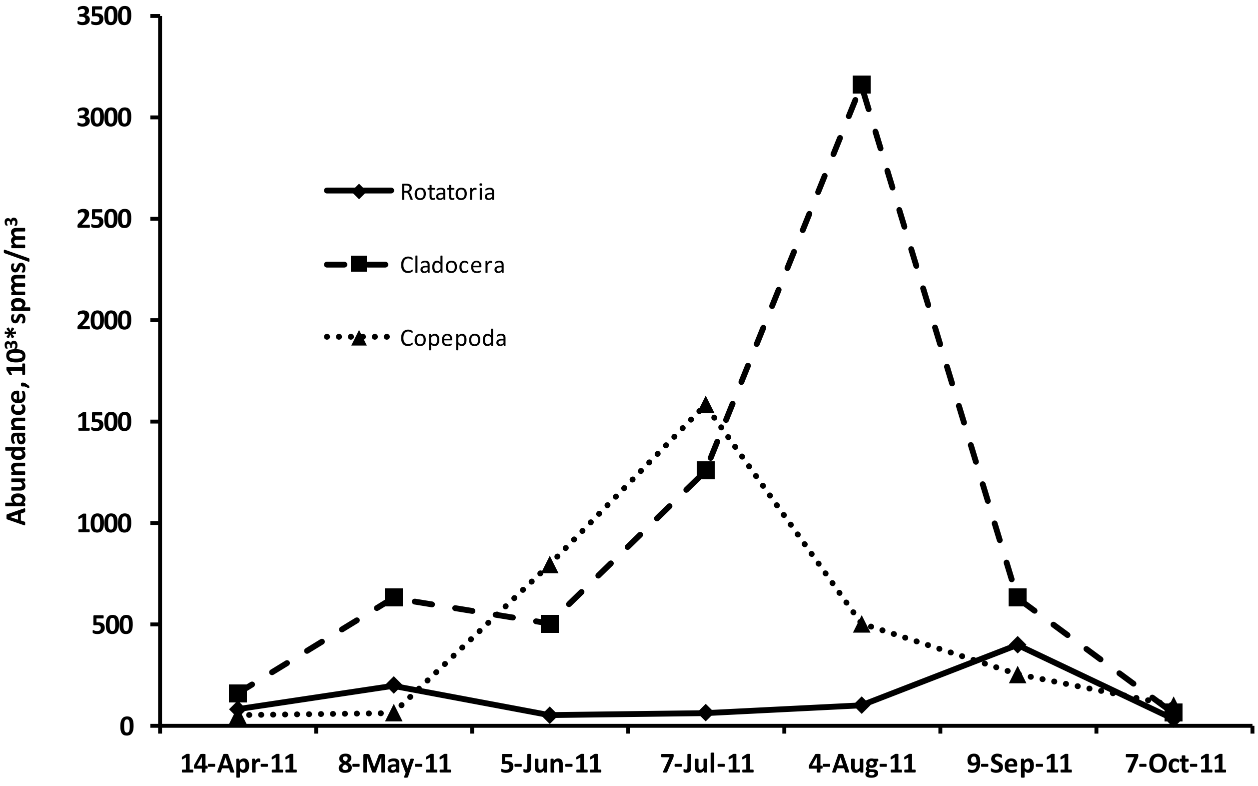


Fig. 14-7. Abundance of zooplankton in pond No. 2. Note. Average indices for 3 sampling sites.

Simocephalus species have a number of adaptations that provide them the best conditions in coastal thickets of submerged vegetation. In particular, the ability to attach to the substrate allows the crayfish to remain inconspicuous to predators whose abundances in littoral is quite high. Growths and spikes on the scallops obviously also play a protective function. *Simocephalus* is also a perfect filterer of water that ensures an optimal assimilation of

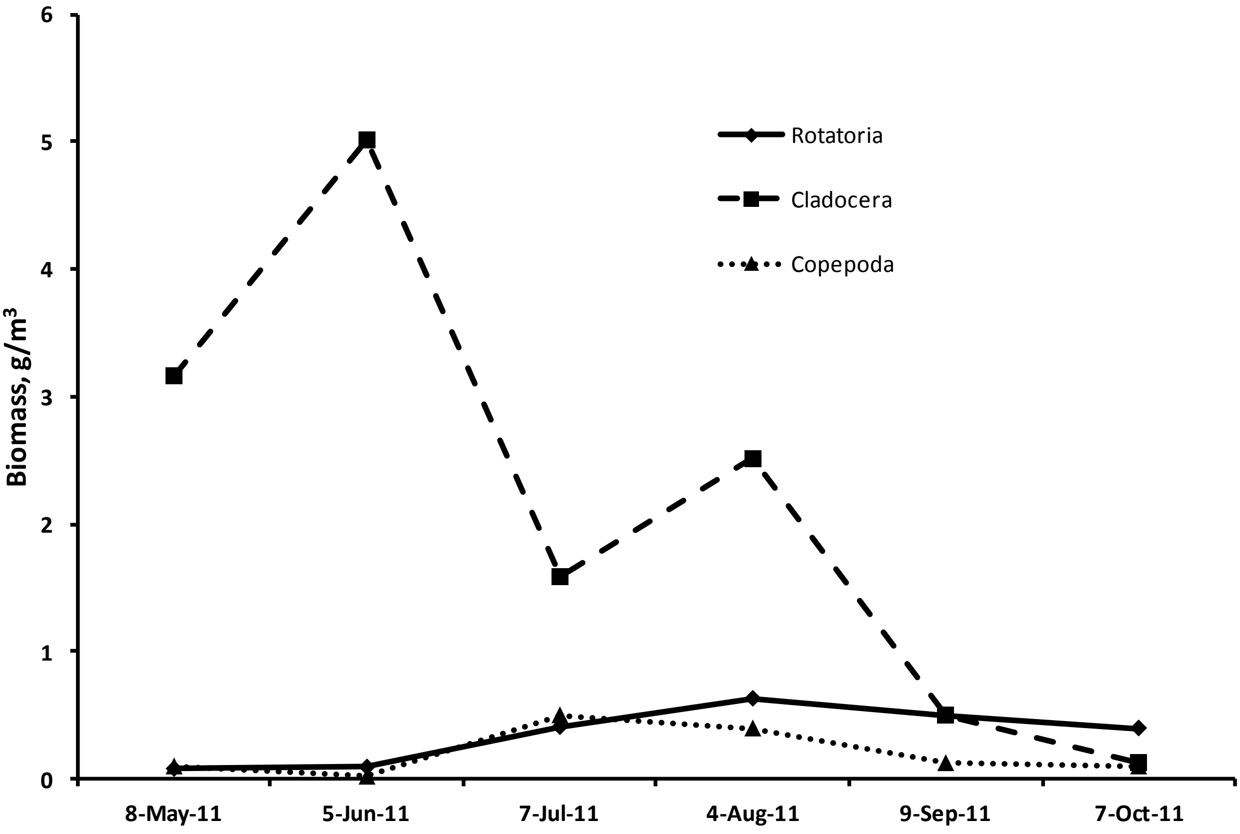


Fig. 14-8 Biomass of zooplankton in pond No. 1. Note. Average indices for 3 sampling sites.

a large number of suspended particles in the coastal zone (Orlova-Bienkowskaja 2001, Sharma et al. 2009, Shuh-Sen et al. 2012).

In the formation of zooplankton communities the important place is occupied by species with a predatory type of feeding. Among subdominants that have a significant functional role in plankton, there are several predator species, as: *P. pediculus* and wheel animalcules of the genus *Asplanchna*, in particular: *A. herricki*, *A. henrietta*, *A. priodonta*, *A. girodi*. For our opinion some anomalous and atypical features in a seasonal development of zooplankton (Fig. 14-7 & 14-8) can happen due to selectivity of raptors of different taxonomic groups as conditions of surroundings for all impoundments of the river Vereshchitsa are practically the same.

Such organisms are implementing in the process of plankton functioning in complicated communities like regulative mechanism by the unused part of the space and adapt to each other through resizing. Better utilization of ecological niches is due to the interaction with each other by different organisms. This, for species of the same trophic group, is a high priority. Such regularity allows to use the diversity of food resources in accordance with the body size of consumer.

Thus, self regulation allows planktonic species to develop appropriate mechanisms of adaptive linkages that allow the system to adapt to changing of environmental factors. The foundation for these adaptations is based on the interaction of organisms with different dimensional characteristics, based on the peculiarities of trophic relations. This also leads to reformation of the spatial structure of groups.

In the case of close values of the index of dominance of species of one trophic group organisms differ in size, which prevents competition for food resources. In reservoirs neighborhood is common for species with different types of feeding. Such a relationship between different populations with the lack of trophic competition is a type of “neutralism”.

Among subdominants in the investigated water bodies an important role are playing eurytopic forms like *M. brachiata*, and *B. longirostris*. They quickly adapt to changing conditions.

M. brachiata is the plankter that are characterized by *r*-strategy of life cycle. For such species, the ratio of propagation energy to the energy used for the maintenance of the main vital functions of the body is prearranged by the size of the organism, the nature of its life cycle, density of population and the capacity of the environment.

In unsaturated environments, the selective pressure favors for species that have high reproductive potential. The beginning of reproduction of such species accounts for the early periods of the life cycle, thereby increasing fertility. Thus, most of the flow of energy is directed to reproduction (Begon et al. 1989). Species with high biotic potential are selected in unsaturated or in an unstable environment which is exposed to periodic stresses (ibid.).

In Moinidae an important adaptation to stress factors has become a closed brood pouch, which completely isolates the embryo from the environment and protects them from adverse factors.

The advantage of a closed brood chamber in Moinidae is the fact that they are characterized by a special type of gestation when the embryos receive nutrition from the mother's body. This eliminated the need for the production of eggs with lots of yolk and have the opportunity to oviposit more small eggs. The eggs increased during embryogenesis in the brood pouch, which has the ability to stretch.

Moinidae are also sufficiently perfect eggs ephippium that is well protected from adverse conditions. They tolerate desiccation, being easily transferred by wind and birds (Dumont & Negrea 2002, Flössner 2000).

Members of the genus *Bosmina* are characterized by significant polymorphism in body shape, length of flattened leaf-like leg, and antennae form. This suggests that the process of speciation, which provides the adaptation to a planktonic lifestyle is quite active in this group up to date. Obviously, an important role in this process is interspecific hybridization. This group is of great interest for further research (ibid.).

Both species are characterized by sizes of the same order, and belong to the same trophic group. In a list ranked by total index of dominance of a number of the next closely related species with similar requirements to the environmental conditions is the result of a temporary barrier.

Their biomass maxima are alternating in seasonal aspect. So, rhythms of seasonal development of these species quench a possible increase of the competition.

The development of planktonic populations of organisms is limited, in particular, by the press of predators and scarcity of food. Moreover, the influence of environmental factors does not depend significantly on the density of populations. A great influence on the dynamics of these indices has a man-caused influence. Indices of abundance and biomass of the studied reservoirs vary within considerable limits: from 0.7 to $554.3*10^3$ spms/m^3 and 0.003-4.7 g/m^3.

Limits of quantitative development are significant. This is primarily due to the fact that the ponds are comparatively small and the very shallow. In this case, even small changes in the start can produce tremendous differences in future, especially in case with the observed rapid changes in the abundance of small organisms with high intrinsic rates of natural increase. In seasonal aspect biocoenotic balance, as a basis for sustainability, is provided, in particular, by variability of species content.

An important integral characteristic of the community that reflects the concept of dominance, and naturally correlated with total biomass and abundance is the Shannon-

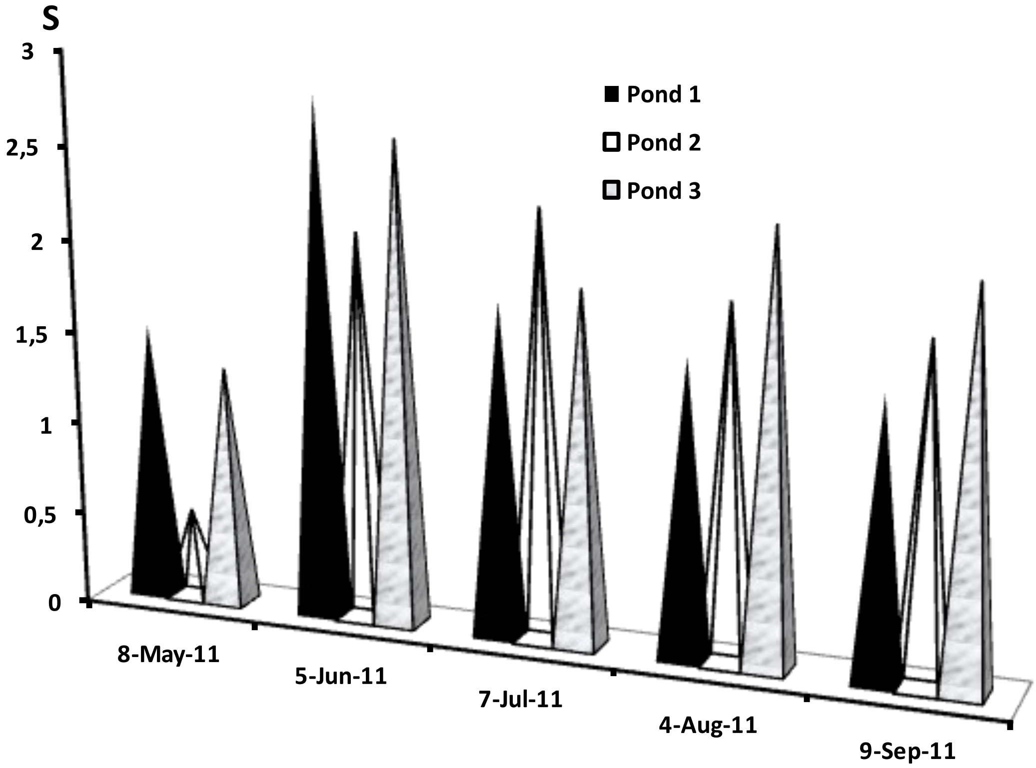


Fig. 14-9. Seasonal changes in the saprobity index in three ponds.

Weaver index (*H*). Its value in the studied impoundments varies from 1.41 to 1.47 (Fig. 14 -6). Interestingly, that this structural index is changing more smooth and is maximal in June that is opposite to abundance and biomass and is the base of structural stability of plankton community.

Further, with the heating of water, pollution of water bodies increases gradually and reaches a maximum in June. The value of the index of saprobes varies from 2.3 to 2.8 that corresponds to β-mesosaprobic and α-mesosaprobic conditions (Fig. 14-9). The increase in water temperature in the summer accelerates the processes of destruction and creates favorable conditions for anthropogenic eutrophication. In the autumn the indicators of pollution are characterized by β-mezosaprobic area.

14-4. Conclusions.

1) Thus, the basis for the formation of plankton in instream ponds of the Ukrainian Roztocze is primarily trophic relationships of the components are limnoplankton representatives.
2) Structural and associated functional changes in groups of zooplankton are characterized by a reduction in food chains, replacement polycyclic species by

monocyclic and bicyclic.

3) The abundance and biomass at the ecosystem level is determined by the population of dominant species with a survival strategy. Secondary and rare species play an important role in the overall strategy of preserving the stability of planktons, in adaptation to new environment conditions.

4) At the regulation of watercourses and the formation of instream ponds of the Ukrainian Roztocze the cladocerans with predominance of *S. vetulus* have guiding role in zooplankton communities.

15. ON THE VERTEBRATE THREATENED FAUNA IN THE AREA OF CONSTRUCTION OF SMALL HPP NEAR VILLAGE OF HOLOSHYNO (IVANO-FRANKIVSK PROVINCE).

Abstract. In summer 2012 we conducted research on the composition of terrestrial fauna – mammals, birds, reptiles, amphibians – which are under protection (included in the Red Book of Ukraine) in the area of possible construction of small HPP (vil. Holoshino).

Keywords: the Carpathians, small HPP, Holoshyno, fauna, the Red Book species.

15-1. Information sources.

Field study (conducted by us in July - August 2012), project documentation, including assessment of the impact on the environment (AIE), materials from Regional Museum in v. Verkhovyna, available materials from forestry's (including herbariums, accounting etc.), a survey of local people, forestry workers, hunters, local historians, existing publications.

15-2. Introduction.

The Ukrainian Carpathians is the richest region in the country's biodiversity and natural systems, which significantly affects the adjacent territory of neighboring countries and all Europe. Framework Convention on the Protection and Sustainable Development of the Carpathians (2004) provides for cooperation in development of ecological network in the Carpathians as a structural part of the Pan-European Ecological Network. It found many species of flora and fauna listed in the Red Book of Ukraine and European Red List, Bern Convention list on the protection of species of flora and fauna in Europe, the Red Book of the International Union for Conservation of Nature (IUCN) (Solodkiy 2008, Red Book of Ukraine: Flora & Fauna 2009).

Plants communities have 39 species of vascular flora listed in the Red Book of Ukraine. The number of species that are subject to state protection, together with the species listed in the European Red List, is 54 (one third of the "red" species of Ukrainian Carpathians). There are: *Arnika Montana* L., *Astrantia major* L., *Botrychium lunaria* L. Sw., *Leucorchis albida* L. E. Mey., *Gentiana acaulis* L., *Lilium martagon* L., *Listera ovata* L. R. Br., *L. cordata.* L. R. Br., *Gymnadenia conopsea* L. R. Br., *Lycopodium annotium* L., *Traunsteinera globasa* L. and others.

As well here exist the high degree of saturation by endemic flora species, that include 42 species (The provisions of NPP "Cheremoskyy" 2011, Red Book of Ukraine: Flora &

Fauna 2009).

Natural vertical placement of vegetation is significantly disturbed by human activities on the slopes of the mountains, where are often cultivated and engaged agricultural cultures. As a result of grazing in the mountains, forests disappeared, in their place is developed the meadows, which are now not only on slopes but also on the tops of gently sloping ridges and are used for pasture and hayfields. A significant change has been in the natural forests, greater attention is paid to the cultivation of spruce.

Fauna is also rich. Here are known about 5 thousands species of invertebrates, 121 species of terrestrial vertebrates (Shcherbak & Shcherban 1980, Mishchenko 1994, Krochko 1992 & 1993, Godovanets 2003, Bokotey & Dzyubenko 2005, Pisanets 2007 et al.) belonging to 52 families, 20 oders and 4 classes. This territory is inhabited by 23 species of the red Book of Ukraine and by 16 species from European red list. The area is also an important center for the preservation of a significant number of rare representatives. Among them – the weasel (*Meles erminea* L.), badger (*M. meles* L.), river otter (*Lutra lutra* L.), wild cat (*Felis silvestris* Schreber), lynx (*Lynx lynx* L.), alpine shrew (*Sorex alpinus* Schinz), common shrew (*S. araneus* L.), water shrew (*Neomys anomalus* Cabrera), Short-toed snake eagle (*Circaetus gallicus* Gm.), the lesser spotted eagle (*Aquila pomarina* C. L. Brehm), golden eagle (*A. chrysaetos* L.), western capercaillie (*Tetrao urogallus* L.), boreal owl (*Aegolius funereus* L.), eurasian pygmy owl (*Glaucidium passerinum* L.) and many others (The provisions of NPP "Cheremoskyy" 2011, Red Book of Ukraine: Flora & Fauna 2009).

15-3. Flora and fauna of the region of investigation.

The list of rare fauna and flora of Cheremosky NNP significantly exceeds that of other natural protected areas of the Ukrainian Carpathians (Solodkiy 2008).

Near the building of Holoshinska HPP dominates *Picea excelsa*, *Abies alba*, *Pinus silvestris*, *Facus silvatica*, *Acer pseudoplatanus*, *Betula verrucosa*, *Larix europaea*, *Populus tremula*, *Alnus incana*, *Padus serotina*, *Salix fragilis*, *Salix caprea*, *Corylus avellana*, *Sorbus aucuparia*, *Sambucus racemosa*, and *Ulmus caprea*.

As well, surrounding areas are inhabited by amphibians, reptiles, birds and mammals.

Amphibians (Class Amphibia).

Yellow-bellied toad (*Bombina (Bombina) variegata* (Linnaeus, 1758) – Order tailless amphibians (Anura), Family (Bombinatoridae). Conservation status: the Book (the category of "vulnerable species"). Appendix II of the Convention on the Conservation of Wildlife and Natural Habitats in Europe (category "Species subject to special protection"), Vertebrate Red Book of the International Union for Conservation of Nature (IUCN). The abundance is associated with the transformation of habitats, decreased breeding places and their pollution. Daily conservation of populations is realized in protected areas in general conditions, special protection measures are not available. Recorded in the area of construction.

Spotted salamander (*Salamandra salamandra* (Linnaeus, 1758) – order Tailed amphibians (Caudata), Salamander family (Salamandridae). Conservation status (category "vulnerable species"), Appendix III of the Convention on the Conservation of Wildlife and Natural Habitats in Europe (category "Species to be protected") and vertebrates Red Book of the International Union for Conservation of Nature (IUCN). In the Carpathians density adults and larvae – from 12-80 to 45-50 ind./km^2, in Chernivtsi Province 8.2? and in Ivano-Frankivsk Province 4.9-6.3 ind./m^2 of water (larvae). Reducing of abundance is associated with changes in habitat and trapping. Daily conservation of populations is realized in protected areas in general conditions, special protection measures are not available. Recorded in the area of construction.

Carpathians newt (*Lissotriton montandoni* (Boulenger, 1880) – order Tailed amphibians (Caudata), Salamander family (Salamandridae). Conservation status: Entered in the Red Book (the category of "vulnerable species"). Appendix II of the Convention on the Conservation of Wildlife and Natural Habitats in Europe (category "Species subject to special protection"), the Red Book of International Union Union for Conservation of Nature (IUCN). Carpathians endemics have been found in the mountains and foothills of Chernivtsi, Ivano-Frankivsk, Lviv and Zakarpattia provinces. The abundance and causes of change: In Ivano-Frankivsk Province – from 1.8-2.0 to 14.3 spms/m^2 in Chernivtsi – from 4.6 to 19.6 spms/m^2 of water area. Abundance decreases with habitat transformation, and killing by vehicles when used puddles in the country roads for spawning. Daily conservation of populations is realized in protected areas in general conditions, special protection measures are not available. Recorded in the area of construction.

Alpine newt (*Ichthyosaura alpestris* (Laurenti, 1768) – order Tailed amphibians

(Caudata), Salamander family (Salamandridae). Conservation status: the Red Book (the category of "vulnerable species"); Appendix III of the Convention on the Conservation of Wildlife and Natural Habitats in Europe (category "Species to be protected") Vertebrate Red Book of the International Union for Conservation of Nature (IUCN). The abundance and causes of change: In the Carpathians region – 3-7 spms/m^2 of water surface. Killed by vehicles in reproduction period in small-basins in country roads. Contamination of water, extraction for commercial purposes and the introduction of alien species reduce the number and diversity. Daily conservation of populations is realized in protected areas in general conditions, special protection measures are not available, but necessary to protect against direct catching. May be recorded in the area of construction.

Reptiles (Class Reptilia).

Aesculapian snake (*Zamenis longissimus* (Laurenti, 1768) – order Snakes (Serpentes). One of the five species of the genus, one of two species of the genus in the fauna of Ukraine. By 2002 considered a part of the genus *Elaphe* Fitzinger, 1832. Conservation status: Threatend. Distribution: South-West Ukraine and Central Europe, North half of Asia Minor, the Caucasus. Enough rare. The reasons for changing the abundance: man-caused transformation of habitats, direct killing by people and vehicles. This species is under special guardianship of the Berne Convention (Annex II). Protected in the Carpathians Biosphere Reserve, Uzhansky NNP and others. Recorded in the area of construction.

Birds (Class Aves).

Black Stork (*Ciconia nigra* (Linnaeus, 1758) – order Ciconiiformes, a family of storks (Ciconiidae). One of the 5 species of the genus, one of 2 species of Ukraine fauna. Conservation status: Rare.

Abundance and causes of change. In Ukraine the total abundance reaches not more than 400-450 breeding pairs of birds. In Europe reaches 7.8-12.0 thousand pairs with trend to growing. Reasons for changes in the population: the degradation of nesting sites through deforestation, trouble factor. Daily conservation of populations and measures of protection. Listed in Appendix II of the Bern Convention, Appendix II of the Bonn Convention, Annex Agreement AEWA (*Annex* 2 – Waterbird Species) , the category III of Species of European Conservation Concern (SPECs), in Appendix II of Convention on International Trade in

Endangered Species of Wild Fauna and Flora (CITES) . Protected in reservations in the areas of the Carpathians and Polissya provinces. Recorded not far from the area of construction.

Black grouse (*Lyrurus tetrix* (Linnaeus, 1758) – order Galliformes), black grouse family (Tetraonidae). One of 2 (some classifications of 4-5) species of the genus, the only species in Ukraine. Conservation status: Endangered.

Areal of the species and its distribution in Ukraine. Forest and forest-steppe zone. In the Western and Central Europe is now most often found in mountain forests and on heathland, where area usually has a distinct island character. In Ukraine, distributed in Polesie region, in the Carpathians and in Northern of the forest-steppe zone.

Abundance and causes of change. At the beginning of 1970 in Ukraine totaled about $66.6*10^3$ spms, in 1980 – $20.8*10^3$ spms, in 2007 – $13.3*10^3$ spms. The largest number of species is in Zhytomyr region – 3426 spms. Reducing of abundance is caused by changes in habitats, forestry activities, degradation of wetland systems, grazing, poaching, factor of trouble, especially during mating and nesting. Daily conservation of populations and measures of included in Appendix III of the Bern Convention. It should prohibit gathering berries, construction of tourist routes and grazing in breeding places. Should regulate the abundance of stray dogs and cats. Recorded in the area of construction.

Grouse (*Tetrao urogallus rudolfi* Dombrowski) – order Galliformes, family (Tetraonidae). Subspecies from the Carpathians. Conservation status: endangered. The population density in the Carpathians – 0.3-0.9 spms/thousand ha. Reducing of the abundance cause: deforestation, poaching, the impact of stray dogs and cats. Entered in the Red Book (1994), Appendix II of the Bern Convention. Protected in Carpathians BR "Gorgany", Cheremoshsky, Vyzhnytsky, and other NNP of the Carpathians. Recorded in the area of construction.

Eurasian eagle-owl (*Bubo bubo bubo* (Linnaeus, 1758) – order Strigiformes, family of True owls (Strigidae). In the Carpathians this nominative subspecies. In Ukraine are about 200 pairs, of which at least 110 pairs in the east. Persecution from human is the most dangerous. Daily conservation of populations and measures of CITES, Appendix II of the Bern Convention, Appendix II. The Red Book (1994). Protected for breeding in the Carpathian and forest reserves. To save the species must strengthen control over shooting of illegal hunting by poachers. Propagation and cultivation in specially created conditions multiplied in Kyiv and Odessa zoos. It occurs in the area of construction.

Mammals (Class Mammalia).

Wild cat *Felis sylvestris* Schreber, 1777 – order Carnivora, cats family (Felidae). One of the 5 species of the genus, one species of the genus in the fauna of Ukraine. Conservation status of species: vulnerable.

The abundance and reasons of its change: can be estimated at 400-500 spms. The majority of recorded animals had the Zakarpattia (Transcarpathians) Province. The reasons for the changes in the population: the reduction in the area of old deciduous forests, especially oak forests, hunting of animals during the implementation of the population control of stray and domestic cats during a hunt, a death in trap poaching and by hunting dogs, recreational, and economic pressures on forest and swamp areas.

Conservation of populations: in the Red Book (1994), the IUCN Red List, CITES, and as a species subject to special protection of the Bern Convention. The very dangerous is mixed breeding with domestic cats. In the investigated area is noted once per 10 years.

Ermine (*Mustela erminea* (Linnaeus, 1758) a number of prey (Carnivora), marten family (Mustelidae). One of the 20 species of the genus, one of the 6 species of Ukrainian fauna. Conservation status types: invaluable. In the Carpathians widespread everywhere. Reasons for changing abundance: transformation of different wetlands and persecution by home and stray dogs. Daily conservation of populations and measures of protection: entered in the second edition of the Red Book, and the IUCN Red List as a species to be protected, the Bern Convention. Recorded in the area of construction.

River otter (*Lutra lutra* Linnaeus, 1758) – order Carnivora, martens family (Mustelidae). One of the 12 species of the genus, one species in the fauna of Ukraine. Conservation status: invaluable. Daily conservation of populations and measures of protection: included to the second edition of the Red Book. As a species, whose state is close to threatening, listed in the IUCN Red List, Annex I to CITES, as well as species subject to special protection of the Bern Convention. Can be recorded in the area of construction.

Northern birch mouse (*Sicista betulina* (Pallas, 1779) - order Rodentia, family (Sminthidae). One of the 23 species of the genus; one of the 4 species of fauna in Ukraine.

Conservation status species: Rare and Least Concern. Natural habitat type and its distribution in Ukraine - the Carpathians. Spread requires clarification. The abundance and causes of change: In typical biotopes share of the catch does not exceed 2.6%, in pellet of birds of pray (casting) reaches 6%.

Daily conservation of populations and measures of protection: Entered in the IUCN List and as a species subject to special protection, included in the Berne Convention. Requires the identification and conservation of habitats. Recorded in the area of construction.

With the creation of the National Park "Cheremosky" the Bukovina Carpathians have become a testing ground for scientific research of rare plants and animal species (The provisions of NNP "Cheremosky" 2011).

Up to date, the data for conservation of flora and fauna of NNP were systematized with idea to follow the principles of ecologically sustainable natural resource management in accordance with the requirements of the Protocol on conservation and sustainable use of biological and landscape diversity to the framework Convention on the protection and sustainable development of the Carpathians, signed in Kiev on 22 may 2003, and with the development of the Carpathian network of protected areas, and implementation of international conventions and agreements (Law of Ukraine On Ratification of the Protocol on Conservation and Sustainable Use … 2009, Solodkiy & Lavrov 2008).

The guarantee of preserving unique and typical natural landscapes as the basic element of ecologically balanced socio-economic development of the Carpathian region is Cheremosky NNP. The foundations of nature conservation in the Carpathians of Bukovina has already been laid – as up to date, the natural reserve Fund area is 101.5 thousand hectares (12.5% of the province territory) (Solodkiy 2008). The establishment of NNP Cheremosky and its expansion in the long term increases the area of the nature reserve Fund territories by unique Chornodil physical-geographical sub-areas (The provisions of NNP "Cheremoshkiy" 2011, Solodkiy 2012).

15-4. Conclusions

1) As a result of our field research in the area of construction Holoshynska HPP and adjacent areas detected 16 species of vertebrates (4 species of amphibians, 1 species of reptiles, 5 birds and 6 mammal species), listed in the Red Book of Ukraine. Another 3

species (black stork, lynx, wild cat) is very rare in adjacent areas (according to the materials of local history Museum and Gostivetsky forestry).

2) Expected changes in terrestrial ecosystems caused by potential construction Holoshinska *HPP* related, primarily, to changes in the hydrological regime, leading to minor changes in the extent of flooding of terrestrial habitats. Partially changes in the hydrological regime can be compensated by periodic powerful indigenous water discharges through the riverbed. For terrestrial fauna in General are not expected to a sensitive adverse effect. The expected changes will not significantly affect terrestrial fauna, including species listed in the Red book of Ukraine.

3) For avifauna, primarily owls and gallinaceous is the main potential source of risk – power lines (Peskov 1982).

16. ASSESSMENT OF ENVIRONMENTAL IMPACTS OF CONSTRUCTION AND OPERATION OF SMALL AND MINI HYDROPOWER PLANTS OF DERIVATIVE TYPE.

Abstract. The assessment of the environmental impacts of construction and operation of small and mini hydropower plants has been made. Using the software calculations of dispersion of pollutants in the surface layers of the atmosphere, calculated risks to human health and the impact on the environmental, social and technogenic areas have been calculated.

Key words: small hydropower, pollution, hydroelectric of derivational type, water intake, risk, environment.

Actuality. The usage of fossil energy sources – coal, oil, gas – leads to a reduction of reserves, which in turn threatens the future existence of the chemical industry. In addition, absolutely unacceptable is the use of fossil energy to produce electric current, which leads to an increase of greenhouse gases emissions in the atmosphere, bringing humanity to the environmental disaster. Government of Ukraine adopted a series of laws to support alternative energy and initiated energy saving programs aimed at reducing of energy dependence on states, neighboring Ukraine, cheaper of electricity, raising of environmental welfare of the citizens of Ukraine and the removal of social tensions.

One of the important directions of reducing the use of fossil energy sources – gas, coal and oil – is the widespread use of alternative (renewable) energy sources which include solar, hydro, wind, thermal and biogas plants. As for alternative energy sources, the most promising for Transcarpathians there are two types – hydro and solar. For other sources, they needs some development infrastructure.

To ensure the environmental safety requirements in Ukraine, according to current environmental legislation and regulatory and technical documents, for any new construction or reconstruction of existing enhanced technological processes, impact assessment (IAs) is performed (Water Code of Ukraine 1995, LU "On Wildlife" 2001, LU "On environmental expertise" 1995, LU "On ensuring sanitary and epidemiological welfare of population" 1994, LU "On Public Appeals" 1996, LU "On Local Government in Ukraine" 1997, LU "On Environmental Protection" 1991, LU "On Nature Reserve Fund of Ukraine" 1992, "On Flora" 1999, "On Alternative Energy Sources" 2015, Convention on Access to Information 1999). Moreover, according to (The composition and content of impact assessment 2004 & 2010) IAs scheme investment in the construction process should take place in 4 stages:

Stage 1. Researches before investment. The development of the *IAs* as a part of the feasibility study.

Stage 2. The stage of designing. Implementation of IAs in full. Ecological expertise of *IAs* materials in the complex state expertise, coordination of materials according to current legislation.

Stage 3. Stage of construction. The submitting of declaration of construction. Implementation of measures according to *IAs*.

Stage 4. Operation. Evaluation of effectiveness of environmental and protective measures according to the *IAs, IAs* specification and post-project analysis.

By the criteria of the general requirements (On an increased risk objects 2001) and according to the Law of Ukraine "On regulation of urban development", Order of reference of objects to IV -V complexity Construction of small and mini hydroelectric plants of derivational type belongs to the class effects (liability) CC 3 and has a V category of complexity of the construction, and development of the *IAs* as part of project documentation is mandatory. However, despite the almost perfectly developed road map of *IAs* (The composition and content of impact assessment 2004 & 2010), an obvious positive impact on social and man-made elements of the environment, development of *IAs* for small *HPP* associated with solving a number of specific issues inherent in this type of business, the main of which are:

1. Slight lasting effect on the fauna and flora of the hydrosphere. Only database of long-term targeted biological research can give a real picture of the impact of small *HPPs* on its condition.

2. The uncertainty of impact on the natural landscape exactly the derivative hydraulic components. This uncertainty can be solved only by modeling the natural topography of land, which is scheduled to construction of derivative structures.

3. The impact of unpredictable flooding and high waters, typical to the Carpathians, and more recently hurricanes and possible earthquakes.

4. Social factors and political situation. Incitement population.

Possibility of predicting of uncharacteristic events, typical for the region, the probability of which is extremely small, will prevent the ravages of natural cataclysms and related disasters.

Terms. Primary *IAs* Directive (85/337 / EEC), which entered into force in 1985, applies to a wide range of subjects of industrial and economic activity, regardless of forms of ownership. Mandatory *IAs* in all EU countries is carried out for all projects that are considered as such, which may have at least some negative impact on the environment.

Assessing the impact on the environment is one of the elements of scientific reasoning of environmental safety and forecasting of social and environmental impacts of construction and operation of engineering facilities of different type and purpose, is an instrument of removing of social tension. (On Public Appeal 1996, On Local Government in Ukrain 1994, Convention on Access to Information 1999).

IAs is based on three factors: first – matching the projected activities and the working draft to existing legal regulations and technical documents; second – basic scientific research and engineering technical research; third – consideration by designers predictable and unpredictable consequences, that may follow from the results of research and engineering research.

The need for carrying out of *IAs* for the construction of hydropower and hydraulic structures is established and governed by the laws of Ukraine (Water Code of Ukraine, 1995, State building norms of Ukraine 1997, LU On Wildlife 2001 et al. LU) and (Convention on the protection of wild flora and fauna 1996, The composition and content of impact assessment 2004 & 2010).

According to (The composition and content of impact assessment, 2004) the purpose of the *IAs* is to determine the feasibility and acceptability of planned activities and justification of economic, technical, organizational, sanitary, state – legal and other measures to ensure environmental safety.

The main *IAs* objectives are:

General description of the existing state of territory of the planned building and activities;

Assessment of environmental, social and technological factors, sanitary and epidemiological situation, competitive possible alternatives of planned activity and rationale of the selected alternatives and variants of location;

Establishing a list of possible environmentally hazardous impacts and areas of impacts of the proposed activity on the environment;

Determination of the scopes and levels of impact of the proposed activity on the environment;

Forecast of changes of environment according to the list impacts;

Determination of package of measures to prevent or minimize effects of the proposed activity on the environment;

Determination of susceptibility of residual impacts on the environment that may be provided by realization of all anticipated activities;

Drawing up Statement of environmental effects.

One of the important stages of *IAs* is public participation in the discussion of the project. For this customer of the planned activity provides on time:

Informing the public about the discussions about planned activities;

Public discussion of the project;

Providing project materials to members of public according to the statement of intent.

Under current legislation adjusting the *IAs* by the results of public consultations carried out by decision of the customer and the general designer. Motives of disregard certain decisions, if necessary, sent to the interested public.

Materials of *IAs* are developed on the basis of environmental engineering, sanitary - hygienic and engineering - technical researches. Urban conditions and restrictions, provided by local authorities and bodies of regional management architecture, provides a list of organizations and authorized government entities (which delegated the activity), which issue the appropriate permits, restrictions and technical conditions for the adoption of certain design decisions, which compliance is mandatory.

In developing project documentation and *IAs* is mandatory:

Technical assignment.

The decision of the session of the local government (if the land planned activities within the locality);

City-planning conditions and restrictions of building land, issued by the district department of architecture and urban planning;

Specifications of joint-stock company (*JSC*) "Zakarpattyaoblenergo";

Climatic conditions and background concentrations, issued by Hydrometeocentre; Materials of Engineering – geodetic researches;

Materials of Engineering – hydrological researches;

Report "River fishery characteristics";

Geological engineering researches;

Letter from the State service for emergency situations (*SSES*);

Specifications of the Road Service in Transcarpathians region;

Public joint-stock company (*PJSC*) “Ukrtelecom” technical specifications;

Basin water resources of the Tisza River, technical specifications;

Office of the *SSES* of Ukraine in Transcarpathians region, *JSC* "Zakarpattyaoblenergo", specifications on passing electric power;

Management of protection, use and reproduction of aquatic biological resources and regulation of fishing in the Transcarpathians region (Transcarpathians fish-protection), specifications;

Office of the *SSES* of Ukraine in Transcarpathians region.

The challenge to develop engineering section of civilian protection as part of project documentation.

Technical solutions. Small (micro and mini) *HPPs* use the energy of water, they are clean, their aggregates have a very high maneuverability, that can quickly change the power in accordance with changes in water content without noticeable deterioration in its operating performance.

In hydropower there are three main hydraulic circuits:

dam scheme in which all the pressure on hydro-aggregates created by the dam;

derivative scheme which creates pressure using derivational tract;

mixed dam – derivative scheme in which water from the pool, propped by dam, dispose into derivational hydroelectric truck.

Dam scheme inevitably leads to the flooding of coasts in the upper pool of dam and HPPs with high power – to change the established microclimate, characteristic to the area. Considering the lack of land in Transcarpathians and zone seismicity, they are not acceptable.

At derivative scheme the height of the dam is not significant. Its role is limited to disposing water into derivational track, which formed also a pressure on hydraulic units. Dam in most cases does not play a role of forming pressure facility.

Derivative scheme has advantage in great river slopes and relatively low cost, that is mainly in the mountains. For mountain conditions of construction of hydroelectric complex of *HPP* is the optimal when implement the derivative scheme of hydropower plant. The structure of the mini (small) *HPP* includes complex of hydraulic structures: water-intake tower, fish-passing facility, two-chamber settler, pressure pool, upstream pipeline, closed machine building of *HPP*.

Facilities of derivative *HPP*. By location and purpose are divided into main (water-intake) node, derivation pipeline with structures on its track and station node (*HPP* building).

Assembly of derivative *HPP* depends on topographical and geological conditions, on the characteristics of the river. In most cases pressure derivation is accepted. This is due to the nature of the terrain, variable water levels in the river throughout the year and provides an opportunity to bring water to the station by the shortest route.

Intake unit. To collect into a derivation the estimated cost of water inlet should have an appropriate cross section, and its threshold should be located considering fluctuations in water level (below the minimum water level in the river).

Derivation. Pressure derivation at longitudinal profiles can be laid without some bias, in the form of a broken line, is only required that in the derivative pipeline along its entire length was excessive internal pressure in any mode hydro.

Station node. Station node includes a service platform, building of mini hydroelectric power plant, transformer substation, turbine conduit, devices against water hammer, discharge pipe emptying of derivational pipeline and the outlet channel.

Space planning solution. The main purpose is to justify the construction of hydropower plans, the choice of optimal variant layout.

The design of the water intake.

Location of water intake, its design are determine by the surface topography and slope angle of flow on this part of the channel. In the case of complex terrain and slight slope often offer a combined water intake structure, side surface water intake with the surface segment gate and movable valve. The gate in use position forms the lockup and ensures a steady selection of water to the water intake structure. Surface water intake with the segment gate and movable flap has a width of 14.25 m and height in working position 2.2 m. Gate movement occurs through hydraulic servo, which is located on both sides of the dam. To maintain a stable level of water in the outlet arrangement an automated control systems of differential water level, water points and automated gauge rails are provided.

Electrogradient fish protection device type EHRZ-M. The device is designed to implement a method for protecting fish and their young from falling into the water intake buildings of consumers of drinking water and water of industrial use. The device implements the requirements of fish barriers, that specified in building regulations 172.06.08-87 "Retaining wall and fish-protective facilities" and in a number of regulations of Ukrrybvoda (Kyiv).

The unit performs generation of biologically adequate electrical impulses and their subsequent distribution by elements of the electrode system to produce water pulsed electric field around the perimeter of the protected water intake.

Fish-passing facility. Sanitary water consumption. The project provides the fish-passing construction equipped with automatic flow of constant (fixed) water consumption through the sluice-regulator hole in the upper pool, equal to sanitary water consumption.

The rate of water fall on the lips should be large enough to return the fish to the road, but it should not be so great to wash it back downstream or throw it to the point where it can not continue its way up the flow. Modern design decision fish-passing facility is as close to a natural performance and has a width of 4.4 m. Sizes of fish-passing facilities are selected based on experience of previously implemented projects, based on the density of fish going to spawn. Overall length of fish-way is selected in such way to allow to arrange a number of rest pools. Pools are separated by rough stones and filled with a layer of gravel 0.2 m to imitate the natural environment. Barrier stones with a diameter of 0.4 to 0.9 m is planned to place in such way to ensure the flow of water around, but not on top. Great waterway and the slope of barrier stones in the direction of flow reduces the risk of blocking by floating debris and provides energy dissipation of water.

The maximum water consumption. As a result of passing of maximal water consumption through the turbine, which is 7650 l/sec, energy output is up to 1000 kW. Thus there are the most favorable conditions to maximize energy.

Gate before pressure pipe. This gate shall be closed by its own weight without electricity in case of pipeline damage. Roller gate has approximate dimensions: width 3.60 m, height 3.70 m.

Pressure pipeline. Pressure pipeline starts after discharge pool. Pressure pipeline expected to perform from environmentally friendly fiberglass pipes which have lower hydraulic hammer effect compared to using other materials such as steel.

The impact of the planned activity on the environment. Air environment. During the exploitation of mini *HPP* is no air pollution because emissions of pollutants are not implemented. During the construction pollutants are ground for welding and cutting of metal structures, vehicles – cars for transportation of goods, special machinery – bulldozers, cement agitators, truck cranes, dump trucks, tractors.

During carrying out of welding works and from the vehicles following substances will be emitted: iron and its compounds, manganese and its compounds, substances in the form of suspended particulate matter (micro-particles and fibers), nitrogen oxides (converted to nitrogen dioxide [$NO + NO_2$]), sulfur dioxide, carbon dioxin, saturated hydrocarbons.

Characterization of sources of pollutants in the atmosphere:

Sourse 1 – ground for welding, not stationary and unorganized sources. There is a welding of metal constructions, which are used in construction welding machine designed for welding steel, using electrodes type ANO-5 (1,865 t), fund of working time is 9042 hours / year, the pollutants, which are released into the atmosphere – iron oxide, manganese oxide.

Sourse 2 – mobile sources – vehicles (cars, vans, trucks) and heavy equipment (bulldozers, dump trucks, excavators, brush cutters, tractors) only 24 pieces in all. The fuel is gasoline A-92, A-95, AC.

Methods of calculation. The calculations were carried out using the method of calculation software "Welding 2005". The results obtained are given in the Tab. 16-1.

Emissions from mobile sources were calculated according to (Tishchenko 1991, A collection of methods for calculation of pollutant emissions … 1994).

When operating, vehicles (cars, tractors and bulldozers) released into the atmosphere: carbon dioxide 0.1425 tons / year, nitrogen oxides (converted to nitrogen dioxide [NO + NO_2]) 0.065 tons / year, non-methane volatile organic compounds (NMVOCs) – 0.0193 tons/year, Sulphur dioxide – 0.0097 tons / year, the substances in the form of suspended solids – 0.0135 tons/year.

Calculations of dispersion of pollutants in the atmosphere carried out under the program "EOL+" from Design office of Private Enterprise "Topaz" (Kyiv).

All sources of pollutant emissions are unorganized.

16-1. Characterization of sources of pollutants in the atmosphere.

Pollutant		g/s	tons / year
Code	Name		
Source 0001 AHO-5			
123	Iron oxide (converted to iron)	0.00071	0.023
143	Manganese and its compounds converted to manganese)	0.00092	0.003

Note. g/s – grams per second.

Noise impact. The main source of industrial noise and vibration in operational period is the turbine. Regulatory noise at the workplaces is 80 dB. The main sources of noise are located in the middle of the building and shielded by building construction and structures.

Biologically harmful and dangerous manufacturing factors, including objects, which are employed to cause injury and disease, are absent.

The level of noise impact on the environment outside the building of HPP is within permissible Construction Norms and Regulations and not exceed 35 dB.

The aquatic environment. The purpose of water use of HPP are production needs (electricity generation) and ensure of domestic needs of employees. For drinking purposes planned use of imported drinking water. For technological processes during construction surface water intake (making of building mixes, flushing pipeline, hydraulic of tests piping and for the work of turbine) will be used. For efficient use of fish-passing facilities project provides flow of constant (fixed) water consumption through the sluice-regulator hole in the upper pool, equal to sanitary water flow, what is 640 l/s.

To work of *HPP* the water intake is located downstream from the village. Water supply of power will take place by pressure pipe.

Monitoring the quality and quantity of water.

When functioning derivative HPP water pollution is not made. Background concentrations are unchanged.

To maintain normal biological conditions of the watercourse must be sanitary minimum, taken as 75% of the minimum average monthly water consumption of 95% provision. Namely, sanitary water consumption in control dam site in accordance is 0.64 m^3/sec.

Sewerage. Sewerage of household waste will take place in the cesspool that is set in the yard. Cleaning septic tank will occur as the accumulation by specialized enterprise (Tab. 16-2).

The impact on land resources, soils. Contamination of soil is impossible in strict compliance with technical conditions of construction and operation of projected object.

The impact on the geological environment. The negative impact on the geological environment is absent.

The assessment of impact on aquatic ecosystems. Hydro-building on the rivers – is a factor of the impact on aquatic ecosystems (aquatic microbiota, groups of invertebrates, and fish), the effect of which can manifested in changes in biotic and abiotic factors of existing fish fauna. This problem applies to rivers, which serve as migration routes to spawning for anadromous and semianadromous species. Impact of economic activities on

16-2. Standards for disposal of sewage during the operation of mini-*HPP*.

Directions of use	Sewerage	
	m^3/day	м^3/year
household needs	0.054	14.040
All	0.054	14.040
Damsite		
electricity production	660960.00	241250400.00
building	6782.40	10173.60
All	667742.40	241260573.60
TOTAL	667742.45	241260587.64

fish fauna reservoirs are not reflected in the decreasing number of fodder and its diversity, there is no violation of natural living conditions and the loss of forage organisms.

The analysis of scientific literature and studies of small river ecosystem in the construction of hydraulic structures (in our case the mini HPP), conducted by Prof. of Uzhgorod National University Andrey Kovalchuk and colleagues (look Chapter 9), showed that some changes may be expected in the case of construction of small and medium-sized reservoirs, which are highly heterogeneous system. Special studies on the impact of small reservoirs on the environment, held in Spain, did not show a significant influence. In particular, pH, conductivity, oxygen saturation, the content of soluble forms of inorganic nitrogen and phosphorus, as well as indices of heterogeneity benthic groups above and downstream were not change. Mini reservoirs significantly affect the decomposition of tree waste, its intensity is significantly reduced downstream. However, given the design of the water intake system, the availability of fish ladder and ensuring of sanitary spending, comparing our hydro building with the structure of mini hydro reservoirs, that are highly heterogeneous reservoirs, are not unambiguous.

Main research results: pH 7.08-7.15, destruction of organic matter depends on the depth of plankton, microflora – within the characteristic of small mountain rivers of

Transcarpathians, for most species of microorganisms that are the part of bacterioplankton inherent hemoorganoheterotrophic metabolism.

Given the results of studies of Prof. Andrey Kovalchuk and colleagues, there were made the following conclusions and recommendations:

In the bottom sediments approximately 2 g/m^2 organic matter per day is mineralized.

Effect of construction of derivative mini HPP in the absence of capacity of reservoirs on the ecosystem of the watercourse will be negligible.

For most types of microorganisms that are the part of bacterioplankton hemoorgano-heterotrophic metabolism is inherent.

Characteristics of the water body by bacteriological indices is following: water quality category – 3; water quality category according to their purity – moderately polluted, trophicity – meso- till eutrophic; saprobity – β-mesosaprobic.

In order to maximize the preservation of water live resources and their habitats during the performance of projected work the following measures must be taken:

Commercial (construction) works carried out at the maximum allowable distance from the waters;

During the work to minimize the noise factor to prevent negative impacts on fish migration processes;

To committed to the technology of the work with the obligatory consideration the conclusions of the maximum distance from the water of the river;

To exclude the possibility of getting sewage, industrial and household waste, fuel and lubricants into the water in the river, on vegetation and on soil;

Do not wash vehicles, containers of chemicals and substances that can harm to water living resources or their habitats;

Violate environmental requirements provided by law for the protection of coastal protection zones and water protection zones;

Work performed in the period of low-flow water levels in the river;

After completion of works area in which they were carried out should be reclaimed (scrapping and cleared of debris and, if necessary, brought fertile soil);

Do not turn (moving) vehicles and mechanisms through water of river channel.

These measures are aimed to prevent damage to Ukraine's fisheries during the execution of the projected works, provides inviolability of spawning grounds, wintering, feeding grounds of valuable species of fish and other places that are particularly valuable for their preservation reconstitution.

Assesment of impact on the social environment. The projected *HPPs* will be located outside the village. Generated electricity will be transferred to the existing electricity network of Zakarpattyaoblenergo.

As a part of the cooperation agreement, signed between the village community and the investor of building of hydroelectric derivative *HPP* in benefit of the community is planned to do:

Conducting of channel regulated (if required) works;

Coast firming (if required) works;

Rebuilding of waterproof dam.

Assessment of impact on the population, particularly the negative – is missing.

Assessment of impact on technogenic environment. Building and exploiting of HPP does not damage public and industrial facilities, i.e., existing technogenic environment.

Risk assessment of the planned activity on health is carrying out in accordance with Help annex (The composition and content of impact assessment 2010) estimated risk of developing of non-carcinogenic and carcinogenic effects.

The risk of non-carcinogenic effects is determined by calculation of the index of hazards risk (*HRI*): $HRI = \Sigma HQ_i$

where NQ_i – hazard ratios for individual substances, which are determined by the formula: C_i – the estimated annual average concentration of the i-substance on the verge of residential buildings, mg/m^3; $R_f \bullet S_i$ – reference (safe) concentration of the *i*-substance, mg/m^3; $NO_i = 1$ – threshold adopted value of risk. The risk of development of individual carcinogenic effects (ISR_i) from substances, which have carcinogenic effect, calculated as follows: $ICR_i = C_i \cdot UR_i$, where UR_i single carcinogenic risk of *i*-substance, mg/m^3. Carcinogenic risk in case of the combined action of several carcinogenic substances polluting (CR_a) defined as: $SR_a = \Sigma\ IRS_i$, where IRS_i – carcinogenic risk of *i*-substance. Taking into count that emissions of pollutants into the air are carried by mobile sources of pollution (vehicles, welding machines) which under Decree №7 from 10.02.1995 and RD 52.04-85 (Section 4.1), options of pollution sources are submitted partially, the average concentration of pollutants are not calculated, carcinogens (list of pollutants emitted into the atmosphere) are presented in the table in this section, according to the order No 7 of 13.01.2006 and the order No 309 dated 27.06.2006, – absent.

Spending of assessment of risk of planned exposure of *HPPs* on public health is not appropriate.

Risk Assessment of social impacts of the planned activities of mini-HPP of derivational type. Social risk of activities planned is determined as the risk for group of people, which may be affected by the implementation of economic activity, taking into account features of natural and technogenic system.

Estimated value of social risk (R_s) is given by:

$$R_s = CR_a * V_u * N * (1-N_p)/T,$$

where R_s – social risk, person/year; CR_a – carcinogenic risk of combined effect of several carcinogens, polluting the atmosphere, which was adopted as $CR_a = 1 \cdot 10^{-6}$, dimensionless; V_u – vulnerability of areas;. N – population; T – average life expectancy; $N_p = \Delta N_p / N$, where ΔN_p – number of additional working places – 5.

Due to absence of pollutant emissions of carcinogenic constituents in composition we accept that carcinogenic risk of the combined action is equal $1 \cdot 10^{-6}$ and is dimensionless.

Estimation of level of social risk of planning activities carried out under social risk classification levels (The composition and content of impact assessment 2010). The value of social risk of planned activity of derivational type *HPP* is $4.08 \cdot 10^{-8}$, which is two orders less than 10^{-6}. Based on the value of social risk making a decision on the admissibility of proposed activities.

Conclusions:

Risk assessment of proposed activities on the environmental impact "Construction of mini (or small) HPP" showed that during the construction and operation of the facility negative impact on the environment as pollution of air, water, geological environment – is minimum. Impact on environment in the process of construction – inside normative. Objects of research – are ambient environment (atmosphere, hydrosphere, soil), social environment, and technogenic environment. The level of risk for the investigated object refers to certainly acceptable by all three components.

Along with absence or minimal negative impact on the environment should be mentioned main unit of positivity of small hydroenergetics:

1. Energetical.

1.1. Regulation of active and passive components of capacity for needs of electricity network.

1.2. Adjusting the frequency and voltage while working on a allocated network.

1.3. Maintenance of level of generation in cause of system emergency and transition of work of "island" (on a allocated network).

1.4. The introduction of the “black start" (without external voltage for own needs), in cause of extinction of voltage of electricity grid – blackout.

1.5. Mini hydropower plants – is the source of the electricity grid restoration.

1.6. Source of power supply to vital consumers consumers in case of emergency electricity grid.

2. Aspects of Nature protection (green).

2.1. The absence of environmental pollution.

2.2. The absence of violations of thermal, hydraulic and climatic condition of the area.

2.3. Cleaning and proper maintenance of river channels (small river will has a host).

2.4. Regular compensational stocking with fish.

2.5. Regular monitoring of hydroecological systems. Reproduction of biodiversity.

2.6. Adjusting the flow level, which in turn will stabilize the water regime of rivers and groundwater level.

2.7. Elements of preventing of catastrophic consequences in the event of floods and flooding.

3. Socio-economic aspect.

3.1. Rural development.

3.2. New jobs in rural areas.

3.3. Expansion of tourism and recreation network, creating an recreation areas.

4. Saving of fossil energy resources.

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ISSUES AND CHALLENGES OF SMALL HYDROPOWER DEVELOPMENT IN THE CARPATHIANS REGION (HYDROLOGY, HYDROCHEMISTRY, AND HYDROBIOLOGY OF WATERCOURSES)

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This book preparation & publication had been subsidized by the well-known Ukrainian hydrobiologist Prof. Andrey A. Kovalchuk. Born Dec 30, 1954. Worked Inst. Hydrobiology and Geography Ac. Sci. of Ukraine, and Uzhgorod National University. Visited more than 50 countries of the World. He is the author or co-author of 20 books and in total of about 300 sci. papers. Now due to catastrophic situation in Ukrainian science in general, and extra high corruption in Uzhhorod National University doesn't exist any possibility to go on with sci. researches. So, he is living now with his family in Bangkok (Thailand) where trying to develop hydrobiological investigations. In RG score version of sci. achievements Prof. Andrey A. Kovalchuk is in the first 30-40 scientists of Ukraine.

In Photo:
Prof. Andrey A. Kovalchuk with his wife Namphueng in Synevyr N.P. (Ukraine, the Carpathians) - June 9, 2011.

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