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Common borders. Common solutions.

Creating a system of innovative transboundary monitoring of the transformations of the Black Sea river ecosystems under the impact of hydropower development and climate change

BSB 165 HydroEcoNex

CROSS BORDER COOPERATION

Project background

Aquatic ecosystems are valuable resources, which offer a range of services both for maintaining the quality of the environment and the human development. The alarming rate of depletion and degradation of riparian aquatic ecosystems is of a national and international concern.

Currently, numerous hydropower plants (HPP) exist or are planned to be constructed practically on most main Black Sea rivers. Hydropower developments can have adverse effects on aquatic ecosystems, influencing hydrological regime, water quality, production and destruction of organic matter, aquatic and terrestrial biodiversity, which also have a direct impact on the quality of human life.

The operation of mean capacity HPP on the Prut river has no significant impact on the total water discharge downstream, however with seasonal modifications of the river's streamflow, which makes it possible to combine energy, economic and environmental requirements in a river basin. At the same time, the construction and operation of the hydropower complex on the Dniester River have generated difficult problems related to environmental, economic and social issues.

Continuing the extension of the hydro-technical construction on the Upper Dniester can further aggravate the status of the middle and lower Dniester, especially in the context of climate change. The functioning of the Dniester was considerable deteriorated, due to a decrease of water level and speed, deterioration of self-purification capacity, adsorption and sedimentation processes, correlation between suspended matter and dissolved oxygen, of the minerational and water use, circuit of substances or changes in the resistance of organisms to toxic substances. These changes can be show that considerable changes are taking place at the functional level of Dniester ecosystems and can have considerable consequences on quality of life of the people living in the Dniester basin area.

Dniester river is the main source of drinking water, as approximately 80% of the population of the Republic of Moldova is supplied from Dniester river. The ecological status and water quality of Dniester

river are also important for Ukraine, including the wetland area "Tuzlovskie plavni" and zone supplying with water from Dniester river (e.g Chernivtsi and Odessa).

The need for the Hydroeconex project was based on the common challenges of the partner countries caused by the operation of hydrotechnical constructions and modifications of the water level in transboundary aquatic ecosystems (Romania-Moldova, Ukraine-Moldova), particularly under the conditions of intensification of the drought conditions during the last years. Both the Dniester River, shared by Ukraine and Moldova, and the Prut River, shared by Romania and Moldova, as other European rivers, are affected by hydropower development and climate change, and the joint efforts for ensuring a sustainable usage of water resources are needed.

A decrease in the negative effects of the Dniester and Prut river ecosystems requires consolidation of the efforts of various groups of actors, including research institutions, NGOs, and decision-makers. The HydroEcoNex project contributes to this by developing a unified system of monitoring system and a common set of indicators for impact assessment for Dniester and Prut cross-border rivers and identifying problems related to their implementation. By applying the most promising environmental monitoring and assessment practices downstream of hydroelectric dams of these rivers, combined with an economic analysis of lost ecosystem services and historical information on climate change and water level of these rivers, a transboundary monitoring system innovative ecosystems of the Black Sea basin is established. This system was incorporated into a bilateral co-operation strategy on joint monitoring of cross-border rivers affected by hydropower.

The main goal of the HydroEcoNex project is the development of a unified system of innovative environmental monitoring for the provision with data and information essential in the transboundary and sustainable long-term monitoring of observed transformations in Black Sea Basin's river ecosystems, caused by hydropower operation under climate change.

The following objectives were set in order to achieve the project main goal:

1. to elaborate a system of the monitoring of the influence of hydropower engineering on environment state and ecosystem services delivered by rivers of the Black Sea Basin;
2. to develop the policy instruments and enhance human capacities for integrated water resource management in light of impacts caused from hydropower and climate change;
3. to manage and disseminate the knowledge towards strengthening the transboundary cooperation on integrated monitoring of the impact of hydropower and climate change on river ecosystems.

Despite the increasing concern of the impact of the construction of hydropower plants on the river and riverane ecosystems, the hydropower became the largest source of renewable energy (RES) used for electricity production in the world, due to some advantages, including availability, in comparison with other RES – wind energy, solar energy, biomass and geothermal energy. The growth of share of RES in production of energy is regulatory and financially supported by the international and European bodies, national Governments as a tool to reduce the greenhouse gas emissions. For example, the European Union targeted a share of electricity produced from RES in the national gross final energy consumption of 20% for 2020 (Nastase et al., 2017).

Projects of different scale receive solid investments – from pumped storage HPP to micro HPP (with installed capacity of less than 10 MW). All this will only lead to the increase of the number of HPP, that why the problems addressed by HydroEcoNex project and the obtained results will not lose their importance in the near future.

Project area

The project is carried out in the basins of two transboundary rivers – the Dniester and Prut. The environmental impact of the Dnestrovsk hydropower complex (DHPC), formed by two hydropower plants (HPP-1 and HPP-2), Dnestrovsk pumped-storage hydropower plant – large plants located not far from the Ukrainian-Moldovan border, Dubasari hydropower plant, located on the Dniester River on the Moldovan territory, and Costeti-Stinca hydropower plant, located on the Prut River, was considered.

Period of implementation

The project started in September 2018 and will last until September 2021 (36 months).

Project partners

Institute of Zoology, the Republic of Moldova
The institute conducts fundamental and applied research t is focused on the research of structural and functional organization, dynamics and evolution of animal populations and communities, elaboration of methods of conservation and sustainable use of animal world. http://www.zoology.asm.md/

International Environmental Association of River Keepers Eco-Tiras, the Republic of Moldova
Eco-Tiras is a transboundary association of Moldovan and Ukrainian environmental NGOs, located and working in the Dniester River basin. www.eco-tiras.org

"Dunarea de Jos" University of Galati, Romania
The university is a public higher education institution founded in 1974, which prepares specialists in various domains, including ecology and environmental protection, environmental engineering, environmental chemistry, agriculture, pisciculture, etc. www.ugal.ro

Ukrainian Scientific Center of Ecology of the Sea
The center has multiple tasks on ecological monitoring within the Black and Azov Seas. In accordance with the Strategic Action Plan for Rehabilitation and Protection of the Black Sea. http://www.sea.gov.ua/

Hydrometeorological Center for Black and Azov Seas, Ukraine
The main directions of activity are the provision of population and organizations of all types of ownership with hydrometeorological information, environmental monitoring data, warning and notification on dangerous natural phenomena, and the development of hydrometeorological forecasts.

1. RESEARCH FINDINGS ON THE INFLUENCE OF HYDROPOWER ON THE ECOLOGICAL STATE OF RIVER ECOSYSTEMS

Fig. 1. *The team of the Institute of Zoology during the winter field trip on the Dniester River, Naslavcea (downstream the dam of HPP 2), February 2020*

Dniester and Prut rivers are important transboundary rivers of the Republic of Moldova, which basins are covering 67% and 24% of the territory. In order to ensure a long-term provision of these services, the decision makers need to know the status of these ecosystems and the ecological value they can provide for reducing the impact of the hydropower on the constant flow of ecosystem services. In order to assess the status of river ecosystems, an overview of the historical data in a pre-disturbance phase (before the construction and operation of Hydropower Plant (HPP) was made in comparison to after the HPP commissioning - the changes occurred in river characteristics, which include the newly-gathered data collected during BSB165 project field work.

Changes in the water quality

The water temperature in the Dniester River was considerable influenced after the construction of the Dniestrovsk Hydropower Complex (DHPC). Therefore, in the sector Naslavcea-Valcinet, located downstream of the buffer reservoir of HPP 2, the water temperature decreased by 4-8 °C in spring, in comparison to the background level, and by 10-15 °C - in summer. Obviously, sudden fluctuations of oxygen concentrations indicate a low ecosystem resilience and its inability to withstand hydropower impact and significant changes in the water level in the Dniester River.

During summer the oxygen regime was most unstable. Two critical zones in regard to concentrations of dissolved oxygen were identified:

1st critical zone: Dniester sector at Naslavcea station – in accordance to oxygen saturation, during summer, water were classified to the IIIrd quality class and during autumn – to the IVth class; 2nd critical zone – Dniester sector downstream Soroca - increased temperature during summer coupled with the discharge of untreated municipal wastewaters creates an oxygen deficit of <4mg/L, 42.6% saturation, with a water quality class of IVth class.

The sum of the main ions was also affected by the hydropower plant. Research carried out in 1950s, before the construction of Dubasari reservoir, demonstrated a clear inverse correlation between the salinity (also called mineralization or sum of main ions) and water flow in the Dniester River on the territory of Moldova. Some elements of this dependency were also observed in the first years after the construction of the DHPC, even up to 1980-1990s. Thus, during spring or summer-autumn floods the concentrations of main ions were significantly lower than in the periods with low waters. Nowadays, the salinity is the lowest in summer and the highest - in spring, with the exception of 2013, when the autumn concentrations were somewhat higher than during spring. These changes are indicator of irreversible and unpredicatable processes occurring in the Dniester basin area, of the river changing its water replenishment potential and deterioration of the link between surface and groundwater. The changes in mineralization dynamics indicates that the reprlenishment of water in the Dniester river takes place from the groundwater and springs. This may lead to gradual desertification of the Dniester river basin. An extreme decrease in the water level, may also change the ratio of dissolved elements, particularly metals and the tolerance of organisms to toxic elements.

The hydropower development on the Dniester River lead to radical changes of the amount and the size of suspended particles in the water. Sand, sand-pebble and sand-silt sediments predominated in the Dniester River and Dubasari reservoir in 1970-1980s. Black and gray clay silts were noted only in places with wastewater discharge, for example, downstream the treatment facilities of Ribnitsa, Goieni river banks zones with slow flow, near Iagorlik with slow water flow and in a small area downstream the confluence of the Byk tributary. Nowadays, the gray and black silt sediments are spread all over,

starting from the village of Valcinet, on Unguri-Golosnitsa sector, all along the Dubasari reservoir and in the lower sector of the Dniester River – Bender -Palanka. Small patches of sand deposits can be still found at Camenca - up to Unguri, at Vadul lui Voda – upstream of Varnita and near Tiraspol and Slobozia.

The dynamics of suspended particles in the Dniester water suffered tremendous changes. Thus, before the construction of Dubasari reservoir (1951-1954) the average concentration of suspended particles was approximately of 350 mg/L, with an average annual water runoff of 6.97 km^3. The annual runoff of suspended particles near Bender was of 4000-5005 thousand tons in 1951-1953, but it decreased to 2711 thousand tons in 1954, which was almost 2 times lower. Construction and exploitation of DHPC contributed to the reduction of the amount of suspended particles in 1983-1987 in the Lower Dniester – it ranged 17-100 mg/L in more than 90% of cases at Bender station. At a relatively high water runoff (8.11 km^3) in 1983, the annual runoff of suspended particles decreased to less than 700 thousand tons, and in 1986-1985 - to less than 267-403 tons/year. In the last 10 years, in more than 80% of cases, the content of suspended particles in the water of the Dniester River within the territory of the Republic of Moldova has not exceeded 10 mg/L (Zubcov et al., 2019b).

Another important finding in the chemistry of the Dniester water was the consistent decrease in the concentration of silicates by half compared with the 1950s (Goncharov, Denga, 2019). One of the factors that might have contributed to this is the deposition of silicon together with the sedimentation in the reservoirs and because of the slowdown of the flow, as well as due to the consumption by diatom phytoplankton.

2. RIVER BIODIVERSITY

Phytoplankton

The low water level and water speed lead to intensification of eutrophication in the Middle Dniester and Dubasari reservoir.

Investigations carried out on phytoplankton revealed that during 2017-2018 in Dubasari reservoir, depending on the season, biomass varied within 1.6-15.8 g/m^3, which in most cases characterizes the reservoir as an eutrophic (periodically polytrophic) water body. (Tumanova, Ungureanu, 2019).

In the Lower Dniester, Mayaki station, in autumn 2018 a decrease of the biomass of microalgae comparing with 1970s was recorded, which can be the result of decreasing of phosphorus concentration to pre-eutrophication values. The more abundant development of phytoplankton in winter 2019 may be due to higher winter temperatures and absence of a stable ice cover (Grandova et al., 2019).

Zooplankton

It was expected that the construction of Dubasari reservoir will influence positively the formation of zooplankton in the Lower Dniester. In fact, about 1/3 of total number of forms of zooplankton, which are discharged from reservoir (mainly, the lacustric complex), does not resist and dyes along the first 20-30 km of the river sector or occupyes a secondary role in the componence of the river zooplankton. Among the species of this complex *Daphnia cucullata, Daphnia longispina, Ceriodaphnia reticulate, Filinia longiseta, Pompholyx complanata* are worth to be mentioned (Climenco, 2003)

Fig. 2. *The team of the Institute of Zoology during sample collection on Dniester river, spring 2019.*

The construction of Dnestrovsk reservoir did not favor the development of zooplankton in the Middle Dniester. Most of lacustric species, which are discharged from Dnestrovsk reservoir, do not resist to river conditions and disappear from the structure of zoocenoses already at Otaci (Climenco, Naberejnâi, 2006), 45-50 km downstream of the dam.

The highest densities of zooplankton – of up to 212.4 thousand ind./m^3 – were recorded in the first years of operation of Dubasari reservoir (1955-1959), which is typical for newly built reservoirs. Later, a continuous decrease took place – till 16.2 thousand ind./m^3 in 1995 and 3.7 thousand ind./m^3 in 2000-2003 (Climenco, 2003).

Fig. 3. *Joint field trip for sample collection fom Dniester river organized by IZ in cooperation with UkrSCES and HMC BAS*

The contribution of main groups of zooplankton did not changed significantly in Dubasari reservoir and the Dniester River. Thus, the share of rotifers exceeded 70% in both the taxonomic structure and density of zooplankton. Nowadays, the share of inferior crustaceans in the formation of density of zooplankton in Dubasari reservoir is a small one, even this group dominated in some years, e.g. in 1995.

Zooplankton of the Dniester delta is represented rather by poor species diversity and low quantitative parameters. The comparison of data on the structure of zooplankton at Mayaki station from 2016-2019 with that from 1970s revealed the absence of significant changes, but the average biomass of zooplankton in 2018, when samples were collected in all four seasons, was higher (Nabokin, Kovalishina, 2019). Joint field trip organized by IZ in cooperation with UkrSCES and HMC BAS

The data on the development of zooplankton in Costesti-Stanca reservoir are quite sporadec. However, the impact of HPP can be observed in the development of zooplankton communities. The Middle Prut is characterized by a greater specific diversity than the reservoir (Lebedenco et al., 2017), but the values of the quantitative parameters are much lower. For example, in 2016 the density of zooplankton in the Middle Prut was of 20.5 thousand ind./m^3, which was 6 times lower than in reservoir.

The species diversity of zooplankton in Costesti-Stinca reservoir, as in the Prut River is dominanted by rotifers.

Zoobenthos

In 1946-1954 period, 193 taxa of macrobenthos were found near Camenca city, most of them being reophilic. Later, in 1955–1959, a slight decrease in the diversity of zoobenthos was observed at this site — 179 taxa. To compare, only 92 taxa of benthic invertebrates were recorded in 2015-2018, which is twice less than before the construction of Dubasari HPP. Most probable, the rapid development of the thickets of macrophytes and filamentous algae, as well as siltation of the rocky-sandy bottom area contributed to a decrease in macrobenthos diversity

Fig. 4. *Joint collection of zoobenthos samples by IZ and UkrSCES*

Significant changes in the structure of macrobenthos occurred not only upstream of Dubasari reservoir, but also in the reservoir itself. For example, the representatives of *Plecoptera, Ephemeroptera* and *Trichoptera,* which are sensitive to negative environmental changes, disappeared or their density obviously decreased.

Theodoxus transversalis (*Gastropoda*) and *Unio crassus* (*Bivalvia*) almost completely disappeared.

The last is found currently only in the upper part of the Dubasari reservoir. On the opposite, such species as *Viviparus viviparus (Gastropoda)* reached a higher density (1000 ind./m^2) and biomass (2555 g/m^2), which is most probably related to the intense development of a muddy bottom and accumulation of gray and black silts in this area.

In the Lower Dniester, 218 taxa of macroinvertebrates were recorded in 1946–1947, this number decreased to 142 in 1981–1985, and it remained unchanged until 2015–2018, when 139 taxa were collected in Vadul lui Voda – Palanca river sector (Munjiu, 2019).

Fish

Fig. 5. *Primary processing of fish samples by the project team of the Institute of Zoology, downstream the dam of Dubasari reservoir.*

In the Middle Dniester, sector Naslavcea-Camenca, 42 species of fish were identified between 1996 and 2000. At the first site, the diversity was high, the number of species being less or more similar to that recorded before the construction of Dubasari HPP. However, a cardinal change in the species composition occurred, in comparison to 1950-1959. More exactly, all sturgeon and rare fish species, as *Beluga Huso huso*, sturgeon *Acipenser gueldenstaedti*, stellate sturgeon *Acipenser stellatus*, herring *Alosa kessleri pontica*, European trout *Salmo trutta fario*, grayling *Thymallus thymallus*, dace *Leuciscus borysthenicus*, tench *Tinca tinca*, burbot Lota lota, *Abramis ballerus bluefin*, gudgeon of the river *Gobio kessleri* practically disappeared on this sector of the Dniester river.

The Dniester damming affected largely the fish reproduction. Thus, in the river sector Naslavcea-Camenca, 75% of European roach females and 80% of perch females, already at the 3rd stage of gonad development were not able to reproduce, due to a deep and prolonged resorption of gonads, caused by unnatural thermal conditions, extended until October-November.

In addition, hydropeaking and the absence of normal spring floods, especially in the last 4-7 years, do not allow the passage of fish for their successful spawning, not only on this section of the river, but also in Dubasari reservoir and in the lower part of the river. As a result, the current state of fish stocks in the river is critical, despite the annual restocking of the Dubasari reservoir and the prohibition of industrial fishing on the territory of the Republic of Moldova (Bulat et al., 2018).

The sudden short-term variations in the water level caused by the exploitation of HPP have the highest impact on the fish species with one time reproduction mode, for example, pike perch, which entire generation can be compromised (Bulat et al., 2019). In the whole Middle Dniester, including Dubasari reservoir, commercially valuable fish species were largely replaced by low valuable and short-cycled species, which total share reached around 70%.Ichthyofauna of the Prut River also suffered from the construction of the dam. The main change in the fish fauna of Costesti-Stinca reservoir consists of the losses of rheophilic species (barbell or chub) and development of species with a mixed profile (Vartolomei et al., 2011).

In addition to the native species present at the time of the dam construction (*Squalius cephalus, Barbus barbus, Silurus glani*s, etc.), a number of species of high economic value have been introduced through population, such as *Hypophthalmichtys molitrix* and *Hypophthalmichtys nobilis*. To these species, there were gradually added the invasive species *Neogobius fluviatilis* and *Perccottus glenii,* that benefited from the conditions created by human intervention (Davideanu et al., 2015).

It is important to mention that even there is a general tendency of reduction of the specific indigenous diversity and an increase tendency of the numerical abundance of the eurytopic, generalists and highly competitive species, the Prut River has a significant number of fish species with various level of rarity, especially in its lower part. There, from the confluence with its tributary, the Elan River, from the right side, to the confluence with the Danube River, on both sides of the Prut River, in the mirror, there are protected areas at national, European and world level.

Climate and river hydrology

Climate change and variability, causing usually a shrink in water supplies, have dramatic impacts by threatening ecosystems health, weakening economies and decreasing the quality of human life. In the case of the Dniester and Prut River basins, it was found that, in comparison with 1961-1990, in the last three decades a sharp

increase of air temperature took place, which amounted to about 0.4-0.6°C, 0.6-0.8°C and 0.8-0.9°C per decade for minimal, mean and maximal temperatures, respectively. A slightly more intense warming was observed in the Prut basin.

Fig. 6. *Collection and systematization of hydrological data by project partners from Ukraine*

For 1961-1990 period, a negative trend of precipitation was observed in the Upper Dniester, Prut (about -2 mm/year) and Lower Dniester basins (about -0.2 mm/year). Later, in 1991-2018 period, the trend slightly weakened in the Upper Dniester and Prut basins (to -1.2 and -0.6 mm/year, respectively), but slightly increase (up to 0.5 mm/year) in the Lower Dniester. The observed changes in precipitation were very insignificant both in their magnitude and in direction to be really taken into account for practical purposes.

There is clearly seen a warmer, but also more arid, regional climate in the Lower Dniester; the Prut basin downstream the Costesti-Stinca HPP, by its temperature and humidity conditions, is somewhat closer to the Upper Dniester, but with lower maximum temperatures (Corobov et al., 2019a).

On the whole, the observed and expected increase of air temperatures, which are not compensated by a corresponding increase of annual precipitation, will contribute to the increase of aridity. Thus, the tendency of the regional climate change in the Moldovan parts of the Dniester and Prut basins should be considered as unfavorable for their ecosystems functioning.

In order to assess the modification of the Dniester runoff, the data collected at three hydrological posts were used - Zalishchyky, Mogilev-

Podolsky (Ukraine) and Bender (Moldova). To note that hydrological post Zalishchyky is located 60 km from the end of Dnestrovsk reservoir, and as such it records the Dniester flow in the upper part of its basin, being undisturbed by the construction of the Dnestrovsk Hydropower Complex (DHPC). Such its position allows assessing the possible contribution of global warming to runoff change. The post in Mogilev-Podolsky is the closest to the Dnestrovsk reservoir; the post in Bender records the water discharge in the Lower Dniester, or practically the total flow from the river catchment. Data revealed that in all seasons, a gradual increase in the Dniester annual runoff is clearly visible from the river source to its mouth: from 7.0 km^3 at Zalishchyky and 10.2 km^3 at Bender in 1951-1980 to 7.3 and 9.1 km^3, respectively, in 1991-2015. The observed decrease of annual runoff in 1991-2015 downstream the DHPC by 0.6 km^3 at Mogilev-Podolsky and 1.1 km^3 at Bendery can be attributed to the influence of DHPC.

In particular, the DHPC has also changed the contribution of individual parts of the Dniester catchment to its total runoff. For example, if in 1951-1980 period, which characterizes the river flow before filling of Dnestrovsk reservoir, about two-third (68.6%) of the Dniester's annual flow formed in the upper part of its basin, then after the dams construction this share increased by 11.6%, and now it is already four-fifth.

Moreover, 9% of the flow entering the Dnestrovsk reservoir is regulated by the functioning of its hydropower complex. Such regulation of the water release in the interests of hydropower has caused its seasonal redistribution. In particular, in spring, with a slight increase of runoff in Zalishchyky in 1991-2015, its sharp decrease was observed downstream the dams of DHPC: by 2.9 km^3 at Mogilev-Podolsky and by 3.9 km^3 at Bender. In summer, in comparison with 0.5 km^3 runoff decrease in the upper Dniester, the decrease at Bender was of 1.5 km^3 (Corobov et al., 2019b). Altogether, the water regulation has led to its decrease downstream the DHHC during a warm season, which is especially important for natural and social systems wellbeing.

Acquaintance of data on the Dniester annual runoff at mouth sector meets lots difficulties, due to frequent modification in configuration

Fig. 7. *Members from the Hydrometeorological Centre of the Black and Azov Seas*

of its ducts and numerous lakes, significant change in the water level because of wind direction and intensity. In order to get more accurate data, the data on daily water flow at Bender hydrological post, on daily water level at Troitskoye and Nezavertaylovka posts on the Turunchuk tributary, Olanesti and Mayaki posts on the Dniester River, as well as the slope of the water surface on the river section between Nezavertylovka and Mayaki, were taken in account. Calculations covered the period from 1985 to 2018. In the end, a tendency of reduction of the average annual runoff was put in evidence for Mayaki station. The magnitude of the decrease in runoff for the period under review is about 1%, which in absolute terms shows a decrease in the average annual volume of river runoff by 90 million m^3 over the last 30 years.

There were also identified two conditionally complete water cycles: from 1985 to 2010 (26 years) and from 1995 to 2018 (24 years). For the period from 1985 to 2010, the Dniester average annual volume at Mayaki was of 9,22 km^3, for the period from 1995 to 2018 – 9,15 km^3 (Onishchenko et al., 2019). Hydrometeorological Centre for Black and Azov Seas identified also an important indicator for the changes at ecosystem level – the content of the organic carbon in the sediments.

The review of Romanian authors on the impact of Costesti-Stinca HPP on the Prut morphology and hydrology showed that upstream of the reservoir the sinuosity index (SI) of the riverbed decreased

from 2 to almost 1 (from meandering to sinuous). Downstream of the reservoir the sinuosity index of the Prut river basin shows an upward trend up to SI = 3.3 due to the decrease of the solid material flow by over 65% after 1970 (Grămadă et al., 2015). A slight tendency of diminishing the Prut water flow was observed upstream of Stinca-Costesti reservoir, a phenomenon that downstream is greatly attenuated due to the regularization of the water release by the dam operator. Suspension alluvial flows differ greatly upstream and downstream - from 55 kg/s to 2.28 kg/s (Rădoane et al., 2008)

3. ENLARGING OPPORTUNITIES FOR MONITORING OF AQUATIC ECOSYSTEMS – ACQUIRING NEW RESEARCH EQUIPMENT

In order to update the technical base and enforce the capacity of the institutions for aquatic monitoring of hydropower impact, new equipment were purchased by HydroEcoNex partners.

a b

Fig. 8. *Measuring Instrument with H_2S-micro-sensor and pH/temperature-sensor (a), OxyGuard CO_2 Portable Analyzer in a complete set (b)*

The Institute of Zoology purchased a multi-sensor measuring instrument, which allows determining of both dissolved H_2S/total sulphide in water sample under pH and temperature control and of dissolved oxygen in water samples and soft sediments, directly in the field.

a b c

Fig. 9. *Cooled Incubator FOC 120E (a), BOD EVO Sensor System 6 (b,c)*

Fig. 10. *Wireless transfer data from the BOD EVO Sensor System 6 to the BOD EVO Wireless DataBox with creating an analysis database to PC*

Another recently procured field tool is the OxyGuard CO_2 Portable Analyzer - a reliable and easy to use instrument that measures the free dissolved carbon dioxide concentration directly in the water. The monitoring of the concentration of CO_2 in water is important, as its significant concentrations can affect fish and other aquatic organisms.

For determination of the biochemical oxygen demand (BOD) under laboratory conditions, a VELP Scientifica Cooled Incubator FOC 120E with sets of VELP Scientifica Wireless BOD EVO Sensor System were purchased. This hydrochemical parameter shows the amount of dissolved oxygen consumed by aerobic microorganisms in water, and the BOD-test is widely used as an indicator of organic water pollution.

The BOD EVO Sensor System allows obtaining the reliable results, collecting them with the Wireless DataBox and managing of this data with the BODSoft.

The "Dunarea de Jos" University of Galati has procured in 2019 the equipment for direct analysis of solid samples through high-resolution continuum source atomic absorption spectrometry (HR CS AAS), graphite furnace technique (GF-AAS) (Fig.15), which allows the faster analysis of trace elements in different environmental samples (soils, silts, hydrobionts, etc.) at lower sensitivities. The accessory SSA 600 is used for direct solid sample analysis by using the ContrAA 700 spectrometer, avoiding in this way the need for preliminary sample preparation, which is time costly. Typical sample quantity is usually between 100 µg and 10 mg. The actual sample weight depends on the sample matrix and the concentrations to be determined. The sample is weighed onto a microbalance and brought to the graphite furnace.

After the analysis is complete, the sample carrier may be reused. In the direct solids analysis, the decomposition of the sample matrix by means of an acid digestion is replaced by the temperature program of the graphite furnace. Combined with a powerful background correction, the interference-free and precise determination

of almost all elements in numerous materials is possible. The graphite furnace technique is subject to few interferences caused by the sample matrix. Therefore, even liquid calibration standards may be used in most cases. A calibration with solid matrix reference materials, which are expensive and often not available in the correct composition, is usually not necessary.

The equipment was included in the INPOLDE research center strategic infrastructure.

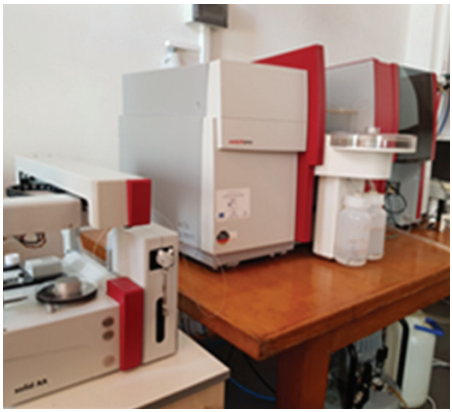

Fig. 11. *Direct solid samples analyser SSA 600 (Analytik Jena, Germany) (on left) coupled to the ContrAA 700 spectrometer (on right) of INPOLDE research center of Multidiciplinary Research Platform at "Dunarea de Jos" University of Galati, Romania*

a b

Fig. 12. *The integrated microbalance (a) and autosampler (a, b) of the direct solid samples analyser through GF-AAS*

4. BUILDING OF THE TRANSBOUNDARY COOPERATION IN THE JOINT MONITORING OF THE IMPACT OF HYDROPOWER DEVELOPMENT IN THE DNIESTER AND PRUT RIVER BASINS

HydroEcoNex project, as part of the Black Sea Basin Programme, it is expected to improve contacts between different beneficiaries in the programme area, to establish sustainable networks, capable to address common challenges in environment. As the project aims to provide a real contribution to the improvement of joint environmental monitoring (Priority 2.1 of the programme), it includes a range of joint events.

Joint research trips

On 2019-2021, the project team members from the Institute of Zoology, the Ukrainian Scientific Centre of the Ecology of Sea and the Hydrometeorological Centre of Black and Azov Seas made a joint field trip for collecting hydrobiological and hydrochemical samples from the Dniester River. The trip brought valuable experience to participants, as they had the chance to exchange their knolwedge and skills on sampling methodology, equipment and sample processing in the field (filtration, preliminary processing of bacterioplankton, phytoplankton, zooplankton and zoobenthos samples).

Fig. 13. *Participants in the joint sampling near Palanca, Lower Dniester, August 2019*

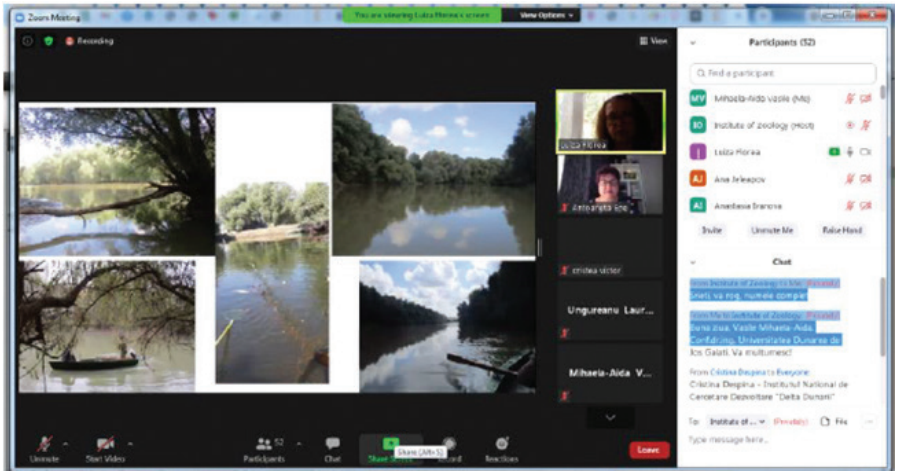

Fig. 14. *A printscreen from a presentation within the knowledge transfer workshop organized online by University Dunarea de Jos Galati*

Knowledge transfer workshop: „The impact of hydropower constructions and climate change on biodiversity"

The workshop was organized online by the University of the Dunarea de Jos Galati on July 1, 2021. The target groups were teachers, researchers, students, specialists in fish farming and aquaculture. The workshop reflected on the key issues and environmental challenges in the Prut River Basin, data on the state of biodiversity of the Prut River Basin, assessment of the impact of hydrotechnical constructions on fish infestation with parasites.

Knowledge transfer workshop: „Aquatic ecosystems under the impact of hydropower construction and climate change"

On 27 March 2021, within the project BSB165 "Creating a system of innovative transboundary monitoring of the Black Sea river ecosystems transformation under impacts of hydropower development and climate change" – HydroEcoNex, the Institute of Zoology in partnership with University Dunarea de Jos of Galati and State University Aleco Russo of Balti, organised the knowledge

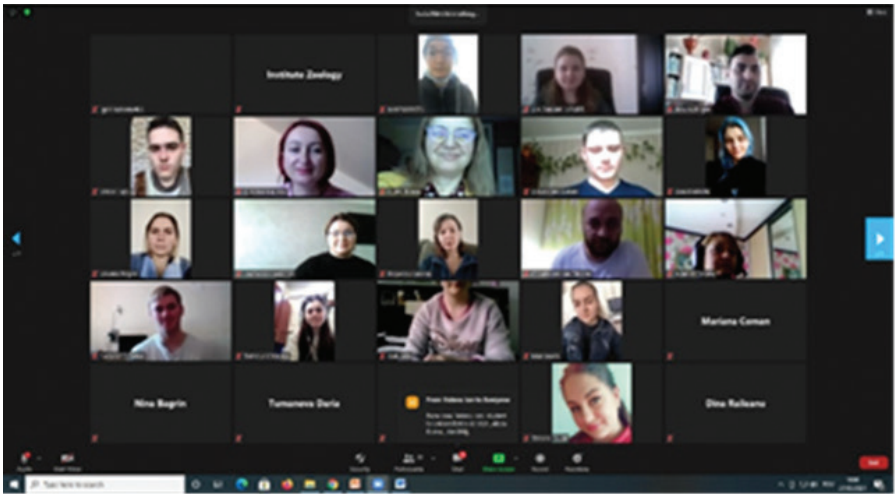

Fig. 15. *Participants of the online event*

transfer workshop ”Modifications of the functioning of aquatic ecosystems under the impact of hydropower construction and climate change”.

The event, which was held online, brought together more than 90 participants, mostly didactic staff, undergraduate, master and doctoral students of the Aleco Russo State University from Balti and the Dunărea de Jos University from Galati, but also teachers and students of the Elena Doamna College of Food Industry from Galati, Dumitru Moțoc Lyceum of Tourism and Food Industry from Galati.

The participants learned that functioning of Dniestrovsk hydropower constructions led to deterioration of important functional processes of the Dniester river such as the considerable decrease in suspended matter with significant reduction in autopurification and buffer capacity of the river, intensification of production and destruction processes and secondary pollution. Also the major changes of hydropower construction on Prut river were presented, including the hydromorphological changes (water flow, sediment transport and sinuosity index) which had negative consequences on biodiversity, particularly migratory species of fish.

Another contribution from the presenters was about the provisions of the European legislation for the prevention and reduction of the impact of hydropower and climate change and how are these followed in the case of Dniester river. Also the global trends and capacity for hydroenergy as well as the social and ecological consequences of hydropower. resentation

The participants were informed about the increased rate of biodiversity loss, particularly species sensitive to hydromorphological changes (e.g. macrozoobenthos and fish), replacing of native species with alien species, spreading of parasite species among fish populations, modifications in the physiological and ecological conditions of fish, with the most destructive effect on migratory and reophylous species.

Knowledge transfer workshop „Reduction of freshwater flow in the Black Sea under the impact of hydropower constructions and climate change"

The workshop took place in Odessa on 12-14 December 2019 and was organised by the Ukrainian Scientific Centre of the Ecology of Sea (UkrSCES).

The participants of the event were members of HydroEcoNex team (Institute of Zoology, International Association of River Keepers „Eco-Tiras" and Hydrometeorological Centre of Black and Azov Sea), as well as representatives from other institutions (Odessa regional administration, Odessa State Environmental University, Odessa National University, Lower Dniester National Nature Park, Biotiks South, Union of Morenists).

The workshop was focused on the reduction of freshwater flow in the Black Sea under the effect of hydropower constructions and climate change. The participants shared historic and recent data on the water quality based on the physico-chemical parameters and relationship between water flow and water surface slope in the Lower Dniester, modification of the Dniester flow as result of building of hydroenergetic complexes, which include large water

Fig. 16. *Participants in the first knowledge transfer workshop, Odessa, 12 December 2019*

reservoirs. Representatives of the Hydrometeorological Centre of Black and Azov Sea demonstrated the electronic database on hydrometeorological observations on rapid assessments, average daily and average annual values of the parameters of atmosphere and the Dniester River from the moment of the station's operation to the present. The database will support the assessment of the hydropower impact on local climate. Also, an overview on existing computer programs on processing of data related to the water quality and modelling on freshwater ecosystems was presented by hosts.

An important point of workshop agenda was the discussion of the first draft of the Strategy of bilateral cooperation on joint monitoring of transboundary rivers affected by hydropower, which is developed within the HydroEcoNex project and is foreseen to be delivered to the decision makers.

Study visits to Dubasari Hydropower Plant and „Aquatir" sturgeon complex

Both study visits were carried out in the frame of the first meeting on the project Steering Committee, which was organised by the International Association of River Keepers Eco-Tiras and held on 16-17 January 2019 in Chisinau and Tiraspol cities.

Fig. 17. *Study visit to „Aquatir" sturgeon complex, Tiraspol, 17 January 2019*

Beside the project members, the regional ministry of agriculture and natural resources, director of the Iagorlic State Reserve, lecturers from the Taras Shevchenko Transnistria State University, representatives of the regional hydrometeorologic service, as well as of youth environmental educational structures and local NGOs took part in the visit. The chief engineer of Dubasari HPP revealed the main technical aspects of the functioning of the power plant. Despite the very cold weather, the participants from Moldova, Ukraine and Romania were very much interested in the discussion, particularly as regarding the water regulation by HPP, water flow, the impact on biodiversity and measures taken to facilitate fish migration and reproduction.

The „Aquatir" Joint Stock Company is a modern company for sturgeon breeding in recirculated system. The complex includes large indoor pools with fishes of different species, age, sex, and reproduction stage. As all large dams affect the fish migration in rivers, the visit was of high interest for the Steering Committee members, as they could learn about the possibility to restore the populations of sturgeons through release of fish, mostly at the stage of fry, brought up in artificial conditions. Thus, this is one of the potential ways of compensation of the HPPs negative impact on biodiversity of river ecosystem.

International conferences

The International Conference "Hydropower Impact on River Ecosystem Functioning" was held in Tiraspol, Moldova on 8-9 October 2019, being organised by the International Association of River Keepers Eco-TIRAS in cooperation with Institute of Zoology and the Taras Shevchenko Transnistria State University.

Fig. 18. *Opening ceremony of the International Conference "Hydropower Impact on River Ecosystem Functioning", Tiraspol, 8 October 2019.*

The conference was an opportunity to bring together 120 participants – representatives of NGOs, research institutions, universities, international organizations (UNDP, OSCE) and independent consultants from Romania, Ukraine, Russian Federation, Sweden - to share the current knowledge regarding the impact of hydropower on ecosystem functioning of transboundary ecosystems of the Dniester and Prut rivers.

The program of the conference included both plenary lectures and communications in sections, which covered three main issues: the impact of hydropower development, climate change and other main factor influencing the functionality of river ecosystems (i), integrated approach to transboundary river basin cooperation – a sustainable solution for shared waters (ii), and the environmental technologies and innovative methodologies for restoration and management of aquatic ecosystems (iii).

The participants of the conference approved a resolution, which expresses their opinion on the current condition of the Dniester River and measures to be undertaken by decision-making bodies of the Republic of Moldova and Ukraine, in order to alleviate some of the effects of human activity in the riverbed and basin. Eco-Tiras, the organizer of the conference, published the proceedings of the conference – print and on-line version on http://eco-tiras.org/.

Session of the X International Conference on Zoology "Rationalization and protection of animal diversification in the context of climate change"

The Xth International Conference of Zoologists is organized by the Institute of Zoology on September 16-17, 2021. Session of the title "Monitoring of the complex in the middle of the fluorescent ecosystem in the context of climate change" includes a series of articles of art. Other projects based on Monitox project, completed in the framework of the Black Sea Basin Program 2014-2020 under the completed project in the JOP Romania-Republic of Moldova. In this case, the Hydroeconex project will be added, the articles with axat on the principle of realization of the project, economic evaluation of the ecosystem service, hydrochemical parameters and water quality in Nistru, the principle of the main group of groups. structure without physical-chemical parameters (for example, salinity, dissolved oxygen and turbidity). More about this source textSource text required for additional translation information.

Fig. 19. *HydroEcoNex team – participants in the International Conference "Hydropower Impact on River Ecosystem Functioning", Tiraspol, 9 October 2019*

Youth summer school

One of the largest activities organized by the NGO Eco-Tiras within the HydroEcoNex project was carried out between the 4th and 15th July of 2019 – the youth summer school Dniester 2019, which aimed to raise youth awareness on the need of integrated management of water resources in the Dniester river basin. The school was held in a summer camp in Molovata Noua village, Moldova, which is located on the left bank of the Dniester River, upstream of the Dubasari dam. Seventy-seven youngsters from Moldova, Ukraine and Romania were selected as participants of the summer school.

The lectures on various topics, such as hydrotechnical constructions on the Dniester and their impact on ecosystems, global warming and its negative effect, aquatic fauna of the Dniester river, assessment of the water quality based on hydrochemical and hydrobiological indices, and the current state of the upper sector of the Dniester River have been held during the resting stops. By hiking, the young people had the opportunity to learn about the peculiarities of landscape, terrestrial flora, and life of the inhabitants of the Dniester valley.

Scientific researchers, teachers from higher education institutions, international project managers and, in general, well-known persons from Moldova, Ukraine and Romania were engaged as experts in the activity of the summer school.

The summer school program included lessons, discussions, simulation exercises on holding the press conferences and public debates, trips, focused, on the whole, on the integrated use and protection of water resources and biodiversity of the Dniester, the influence of rivers on the Black Sea, international cooperation in the management of transboundary waters, climate change, international and European institutions in the fields of environment and democratic development, but also natural and human history in the Dniester basin, interethnic tolerance, etc.

The summer school ended with the Dniester Festival, an event attended by about 150 people, including representatives of central

and local public authorities, international organizations (OSCE, UNECE, GEF), environmental NGOs and mass media. The extensive program of the event also included a boat trip, during which the festival guests had the opportunity to learn about the lower part of Dubasari reservoir.

5. KNOWLEDGE DISSEMINATION

The communication to the public of HydroEcoNex objectives and results is one of the pillar of its successful implementation. Different informational means are used for this purpose – print and online media, radio and TV broadcasting, promotional materials, as leaflets and brochures, public events etc.

Fig. 20. *Project launching in Chisinau, the Meeting Hall of Governmental House, 12 November 2018*

Fig. 21. *Project launching in Odessa, organized by Ukrainian Scientific Centre of Ecology of the Sea, 6 December 2018*

Fig. 22. *The first HydroEcoNex press conference, 13 November 2018, Chisinau*

With the aim to make visible the beginning of the project, launching conferences were organised in each of those three countries – Moldova, Romania and Ukraine, with invitation of relevant decision makers, researchers, university staff, students, NGOs, media and the general public. The events were widely mediated, as the project inspired lots interest, grateful to its burning issue - the synergistic

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Fig. 23. *Interviewed in Chisinau, 12 November 2018 (A) and in Odessa, 6 December, 2018*

Fig. 24. *Participation of the Institute of Zoology to the fair devoted to the Science Day, Chisinau, 9 November 2019*

impact of both hydropower and climate change. The interest of decision bodies to the problems addressed by the project was proved by the fact, that the launching of project in Chisinau was attended by the State Secretary of the Ministry of Education, Culture and Research of the Republic of Moldova Elena Belei, the launching event in Odessa – by the representatives of the city administration.

The HydroEcoNex team put in discussion the major environmental problems addressed by the project in radio and TV broadcasts in Moldova (Moldova 1 TV, TVR Moldova, RTR Moldova, Sputnik Moldova, Radio Europa Libera Moldova) and Ukraine (Odessa channel 1 Pervii Gorodskoi, Odessa 7 News channel).

Such issues of public interest, as current ecological state of the Dniester River, development of hydropower on the Upper Dniester, in Ukraine, damming of the rivers, importance of spring floods for river ecosystems, and the role of internationals project in the study of the Black Sea were raised up.

Among printed already promotional materials, the HydroEcoNex calendar for 2019 is worth to be mentioned. It was elaborated by Eco-Tiras and included a brief introduction to project and short description of documents related to the project topic, as the Water Framework Directive, Water Convention, Espoo Convention, Ramsar Convention, Rio Declaration on Environment and Development, Convention on Biodiversity Conservation, Aarhus Convention, Protocol on Strategic Environment Assessment, Intergovernmental Panel on Climate Change, Dniester Treaty 2012, Prut Agreement 2010 and key elements of the Integrated River Basin Management.

Due to its professional content and design, the calendar was highly appreciated by the specialists in the field of environmental protection.

The project website hydroeconex.com became an important tool for ensuring the visibility of the project, as it contains lots information on the project design and a range of the project deliverables.

For the convenience of beneficiaries, the website was designed in three languages – English, Romanian and Russian. It was launched officially within the project International Conference “Hydropower impact on river ecosystem functioning” in October 2019.

AFTERWORD

As the project will run till March 2021, lots work still shall be done. The monitoring of the state of ecosystems downstream the hydropower dams on the Dniester and Prut rivers will be continued. The new gathered data will help to finalise the protocol of monitoring the impact of HPP on river ecosystems and create data sets for the Dniester and Prut Rivers.

Also, a report on valuation of lost ecosystems services will be published. The need and tools of joint monitoring of transboundary rivers affected by hydropower will be described in a special strategy and a methodological guide.

The project results will be disseminated by scientific reports, papers, presentation at the scientific and public events. The validation of indicators of monitoring the impact of HPP will be done within an international workshop. More knowledge transfer workshops will be organised for specialists in the field in Moldova, Romania and Ukraine. Moreover, public seminars in the communities located in the Lower Dniester and Prut basins will be held, as part of project communication and visibility plan.

Dear readers, if you are interested to get updated information, please, follow us on the project website hydroeconex.com and the project page in Facebook https://www.facebook.com/projectbsb165.

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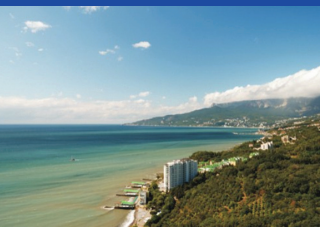

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