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Hydro EcoNex

Black Sea
CROSS BORDER
COOPERATION

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HYDROLOGICAL INVESTIGATIONS IN THE DNIESTER RIVER ECOSYSTEMS

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

On the front cover of brochure - vil. Chobruch, the beginning of the branch Turunchuk

On the back of the brochure cover - hydrological observations on the Dniester River, vil. Olonesti

Recommended for publication by the Technical Council of the Hydrometeorological Centre for Black and Azo v Seas 08/28/2021

BSB 165 - HydroEcoNex

This brochure presents the Project *"**Creating a system of innovative trans-boundary monitoring of the transformation of the Black Sea river ecosys-tems under the impact of hydropower development and climate change**"* **(Acronym: *HydroEcoNex*)**.

This project is realized under the "Joint Operational Programme Black Sea Basin 2014-2020", which is one of the four maritime programmes, estab-lished in the framework of the European Neighborhood Instrument (ENI) 2014-2020 — the Programming document for EU support of ENI Cross-Border Cooperation (CBC). Such cooperation on the EU external borders is a key priority in the European Neighborhood Policy (ENP) and contributes to the ENI overall objective of the progress towards shared prosperity and good neighborliness between EU Member States and their neighbors.

Joint Operational Programme BLACK SEA BASIN 2014-2020
Implementation period: **21.09.2018-20.09.2021** (36 months).
The total budget of the project is 896,865.00 EURO.

The main goal of the HydroEcoNex project is the development of the unified system of innovative environmental monitoring for the provision of the data and the information essential for the transboundary and sustainable long-term assessment of the observed environmental changes in the Black Sea Basin's river ecosystem, impacted by the changes in the hydropower operation due to the effects of the climate change.

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

1. to elaborate the system of monitoring an influence of the hydropower on state of the environment and the services delivered by the ecosystem of the Black Sea Basin Rivers;
2. to develop the policy instruments and to enhance humans capacities for integrated water resource management in light of impacts caused by the hydropower and climate changes;
3. to manage, to broadcast and to disseminate the knowledge towards strengthening of the transboundary cooperation in monitoring the impact of hydropower and climate changes on the rivers' ecosystems.

PROJECT OVERALL OBJECTIVE -

Development of the unified innovative system for an environmental assessment with aim to provide data and information essential for the monitoring of changes in the Black Sea basin ecosystem, caused by the impact of the hydropower and long-term effect of the global climate change.

PROJECT AREA

The project is implemented for the area in the basins of two transboundary rivers — r. Dniester and r. Prut.
Assessment of the environmental impact was considered for:

- the Dnestrovsk hydropower complex (DHPC) — (left, Fig.1), 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 (right, Fig.1), located on the Dniester River on the Moldovan territory,
- and Costeti-Stinca hydropower plant, located on the Prut River.

Fig. 1. Ukrainian hydroelectric power plants on the Dniester River

THE 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.
http://www.hmcbas.od.ua/

Hydrometeorological Centre for Black and Azov Seas (HMCBAS) was founded in 1865 on the base of Novorossiysk University of Odessa. The main directions of its activity are the provision of population and all type ownership organizations with hydrometeorological information and environmental monitoring data, the warning and notification on dangerous natural phenomena and hydrometeorological forecasts. Currently, HMCBAS offers information and forecasting services: synoptic forecasts and hydrological forecasts of the state of rivers in the South of Ukraine, preparing operational forecasts on the state of the sea water area in the Ukrainian part of the Azov and Black Seas basins.

The nowadays network of sea meteorological observations is part of a terrestrial subsystem for obtaining the hydrometeorological data in coastal zone, including stations and posts located in the river estuaries of Ukraine. At some of them the observations on atmosphere and sea water parameters have been carried for more than 200 years. The unique sets of such multiyear data, obtained during coastal hydrometeorological observations, are of great scientific value for the study and prediction of global and regional climate change. HMCBAS also has the ability to analyse the entire hydrometeorological information of the Dniester River basin over the last 50-100 years. It has production units on the whole territory of Southern Ukraine, performing a permanent monitoring of sea environment (hydrology, hydrochemistry), air (temperature, humidity, precipitations, wind speed, visibility, pollution, actinometrical) and river hydrology (streamflow, water level, ice, temperature, hydrochemistry), etc.

The organization structure of HMCBAS in-clouds: Department of hydrometeorological service and maintenance; Department of meteorological forecasts; Department of sea and river hydro-logical forecasts; Department of agricultural meteorology; Department of meteorology; Certified hydrochemical laboratory for analysis of sea water and soil; Laboratory of air pollution observations, and Observing network of marine and river hydro-meteorological stations. HMCBAS is also an executants of the oceanographic part of the National Antarctic Centre programme at the Ukrainian Antarctic Station “Academic Vernadsky” where its main role is investigation and analysis of peculiarities of sea water regime and variability of its parameters as well as observation and study of hydrometeorological conditions here.

Since 2006, HMCBAS has been publishing the Bulletin of Hydro-meteorological Centre for Black and Azov Seas. Its employees are the authors of scientific publications for climate change in the northern Black Sea region and its influence on possible changes in the social conditions of the region. One of the last and important works is the monograph “North-western part of the Black Sea: the structure and climatic variability of oceanological fields” [1]. The HMCBAS's employees were involved as experts in the field of hydrology, oceanology and climatology in different Ukrainian and international projects.

In the HydroEcoNex project, HMCBAS in cooperation with UkrSCES, will contribute to the analysis of historical data and collection of recent relevant

data on ecosystem changes under the impact of hydropower and climate changes. Within the framework of the project, the HMCBAS will model also the changes in basic climatic parameters of the atmosphere (temperature and precipitation) throughout the Dniester River basin for the period up to 2050. The results will be used as a basis for modelling the changes of certain hydrobiological parameters of the Dniester ecosystems that will be taken into account for developing recommendations for an optimal use of the Dniester River's resources by all countries of the region. HMCBAS will organize and actively participate in seminars for the exchange of information and research results with interested organizations. Based on these activities, HMCBAS will con-tribute to the development of a strategy for bilateral water cooperation on joint ecological monitoring of transboundary rivers affected by hydropower and climate change. The results of HMCBAS activity will be presented at the Project's final International conference and disseminated to riparian Dniester communities both close to the hydro-power plants and those located in the Low Dniester and its estuary.

Steering Committee of HydroEcoNex project (fig. 2)

Institute of Zoology: cor. member of ASM, prof. Dr. Hab., *Elena Zubcov*, project manager, email: elzubcov@mail.ru, Phone: +37379638311

International Association of River Keepers Eco-Tiras: Dr. *Ilya Trombitsky*, email: ilyatrom@mail.ru, Phones: +37369121726, +37322225615

University Dunarea de Jos Galati: Prof. Dr. Habil, *Antoaneta Ene*, email: antoaneta.ene@ugal.ro, Phone: +40336130255

Ukrainian Scientific Centre of Ecology of the Sea: Dr., Assoc.profess., Svetlana Kovalishina, email: svetakovalish@gmail.com, Phone: +380974708795

Hydrometeorological Centre for Black and Azov Seas: Dr. Alexander Matygin, email: acm32alex@gmail.com, Phone: +380503953295

Fig. 2. Steering Committee of HydroEcoNex project:
Dr. *Ilya Trombitsky*, Prof. Dr. Habil, *Antoaneta Ene*, cor. member of ASM, prof. Dr. Hab., *Elena Zubcov*, Dr., Assoc.profess., *Svetlana Kovalishina*, Dr. *Alexander Matygin*

1. 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 was purchased by HydroEcoNex partners.

Hydrometeorological Centre for Black and Azov Seas purchased a multiparameter instrument — the hydrological sonde EXO1 that collects water quality data (Fig.3). Figure 4 shows all types of hydrometeorological observations that are carried out by employees of the GMC CHAM in expeditionary work.

The sonde collects the data with up to four user replaceable sensors and an integral pressure transducer. Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes its type. Depending upon user-defined settings, the EXO1 will collect data and store it on board the sonde, transfer the data to a data collection platform

The sonde is designed for high-precision determination of hydrological, hydrochemical and hydrobiological parameters of river and sea waters: immersion depth of sensors, temperature, electrical conductivity (salinity), dissolved oxygen content, turbidity, fluorescent dissolved organic matter, ammonium, nitrate, chloride, pH, Rhodamine, total algae. Not only will these sensors provide the most accurate and fastest response temperature data, but it will also provide the best data for the use in temperature compensation for the other EXO probes.

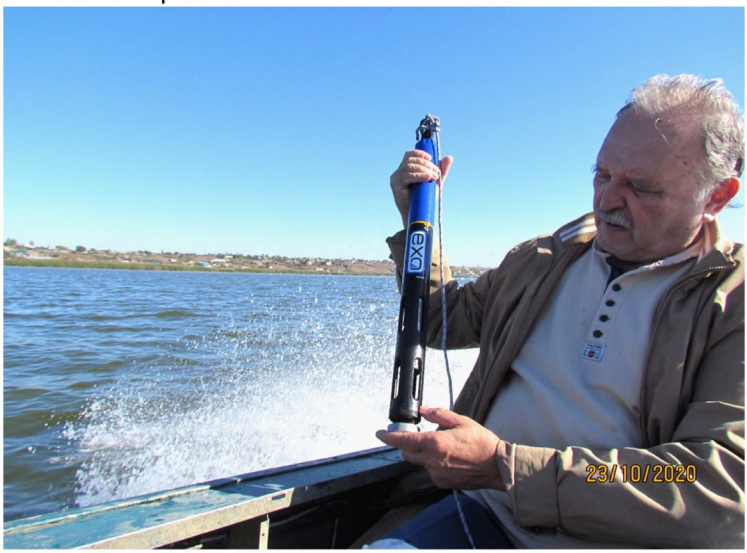

Fig. 3. Multiparameter hydrological sonde EXO1 that collects water quality data

The principle of operation of the EXO optical dissolved oxygen sensor is based on the well-documented concept that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with a carefully chosen chemical dye.

Turbidity is the indirect measurement of the suspended solid concentration in water and is typically determined by shining a light beam into the sample solution and then measuring the light that is scattered off of the suspended particles. Turbidity is an important water quality parameter and is a fundamental tool for monitoring environmental changes due to events like weather-induced runoff or illicit discharges. The source of the suspended solids varies (examples include silt, clay, sand, algae, and organic matter) but all particles will impact light transmittance and result in a turbidity signal.

The EXO Turbidity sensor employs a near-infrared light source and has been characterized as a nephelometric near-IR, nonratiometric sensor in accordance with ASTM Method D7315-07a.1 This method calls for this sensor type to report values in formazin nephelometric units (FNU), which is the default calibration unit for the EXO sensor.

2. 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

In 2019-2021, members of the project team from the Institute of Zoology, the Ukrainian Scientific Centre for Marine Ecology and the Hydrometeorological Centre for Black and Azov Seas, as well as employees of the Lower Dniester National Park, Odessa I. Mechnikov National University and Odessa State Ecological University (fig. 5) made joint production trips to obtain hydrological information and for the collection of hydrobiological and hydrochemical samples from the Dniester River. The trips provided the participants with valuable experience, as they had the opportunity to exchange knowledge and skills on sampling methodology, equipment and sample processing in the field (filtration, pre-processing of bacterioplankton, phytoplankton, zooplankton and zoobenthos samples).

Fig. 5. Participants in joint sampling near Palanca, Lower Dniester, August 2019 (left); LP, PB4, PB5 team during summer industrial practice on the Dniester river and vil.. Chobruch, June and July 2021

More than 20 expeditions along the Dniester were conducted, of which 5 were joint with LP and PB5, and 23 jointly with the Lower Dniester National Park, Odessa National University and Odessa State Ecological University. In total HMC BAS, within the framework of expeditionary studies under the project HYDROECONEX, carried out more than half a million measurements of the parameters of the waters of the Dniester River, Turunchuk River, Beloe and Pogoreloe Lakes and Dniester Estuary.

3. Hydrological investigations in the Dniester River ecosystems

The impact of a hydropower development on the hydrological and ecological regime of rivers is multiple and extremely complex due to the interaction of various factors and the possibility of hard-to-predict consequences, especially if taking into account the recent decades' climate changes. Unfortunately, hydropower activity has not only positive effect, but, if mismanaged, it could lead to such significant negative consequences with such substantial impact, that damages to the aquatic ecosystem could be sometimes irreversible and irreparable.

In this aspect, it is hugely important to monitor the change in the hydrological and ecological regime and its distribution in time and space. In particular, it is essential to carry on the representative screening of the flow rate, temperature, salinity, turbidity of river waters, the concentration of dissolved oxygen, the content of nutrients, the rate of production processes, destruction of organic matter and hydrobionts, and, as a consequence, deterioration of river water quality and biological productivity of aquatic ecosystems.

Zoning of the Dniester basin

Natural mechanisms investigations and river runoff formation conditions investigations in a specific separate river basin, the hydrological situation impact on the ecosystems of the river itself and the ecosystems of the entire water basin require an identification of areas within which the natural conditions and the degree of their impact on ecosystems are sufficiently homogeneous.

Dniester River basin could be zoned into three parts (Fig. 6) accordingly to the, water regime, water supply sources, physical and geographical features:

- Upper “Carpathian” (from the from the very river source to Nizhnee village at the river Tlumach mouth, 296 km length);
- Middle “Podolsky” (from Nizhnee village to the Dubossary HPP, 715 km length);
- Lower (from the Dubossary Hydro Power Plant (HPP) dam to the Dniester mouth, 351 km length).

Also, the Dniester basin can be divided into three parts: Carpathian (before the confluence of the Bystritsa river with the Dniester river); Volyno-Podolskaya part (to the villages of Kamenka-Senatovka, 473 km upper the mouth); Southern (from Kamenka village to the Dniester river estuary) according to its climatic and orographic features.

The Dniester reservoir and the Dniester HPS, which were built and put into operation in the period from 1975 to 1983, significantly changed the hydrological and ecological situation in the Dniester basin. From this point of view, the hydrotechnical complex can be considered as a new basin zoning border, which divides the catchment into two sections, the upper one with an area of 40,500 km^2 and the middle and lower ones with a total area of 31,600 km^2.

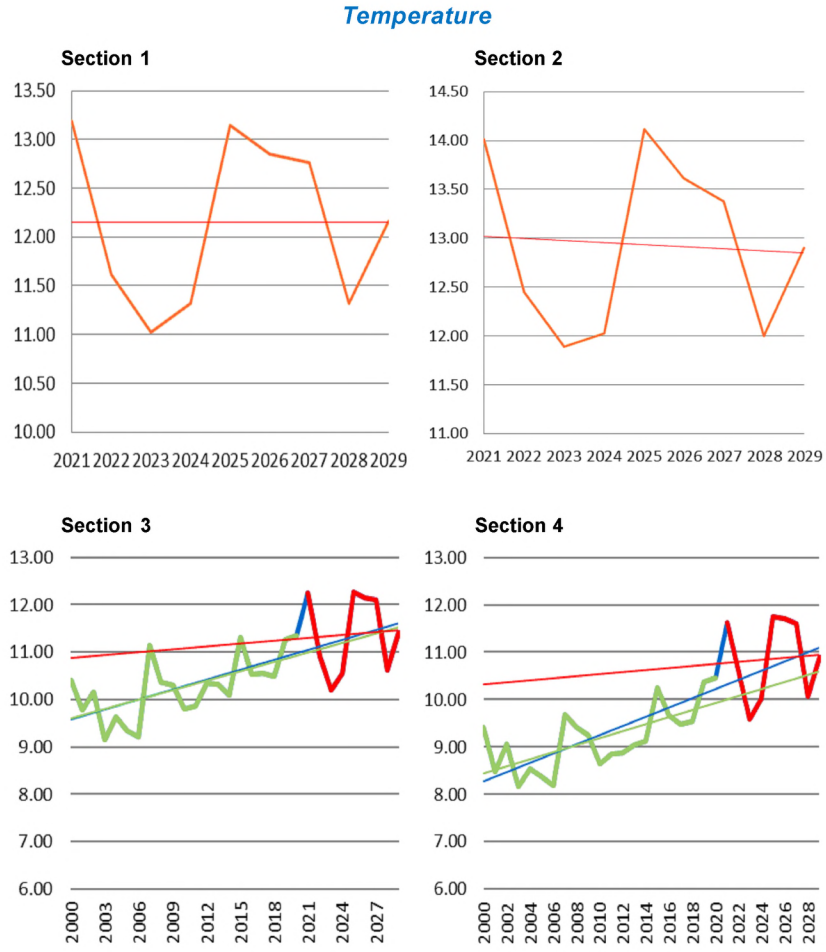

Fig. 23. Average annual values of air temperature in the watershed areas of the Dniester River

The main feature of changes in air temperature over the analyzed periods (Fig. 23) is a decrease in the growth rate of the average annual temperature (the slope of the red line is less than that of the blue and green lines); we also note that in sector 2 the trend has a negative value for the forecast period 2021-2029.

The amount of precipitation on an average annual scale will decrease for all modeling sites (Fig. 24). Note that the positive trend of the first two decades, indicating an increase in precipitation in sectors 1 and 2, is reversed.

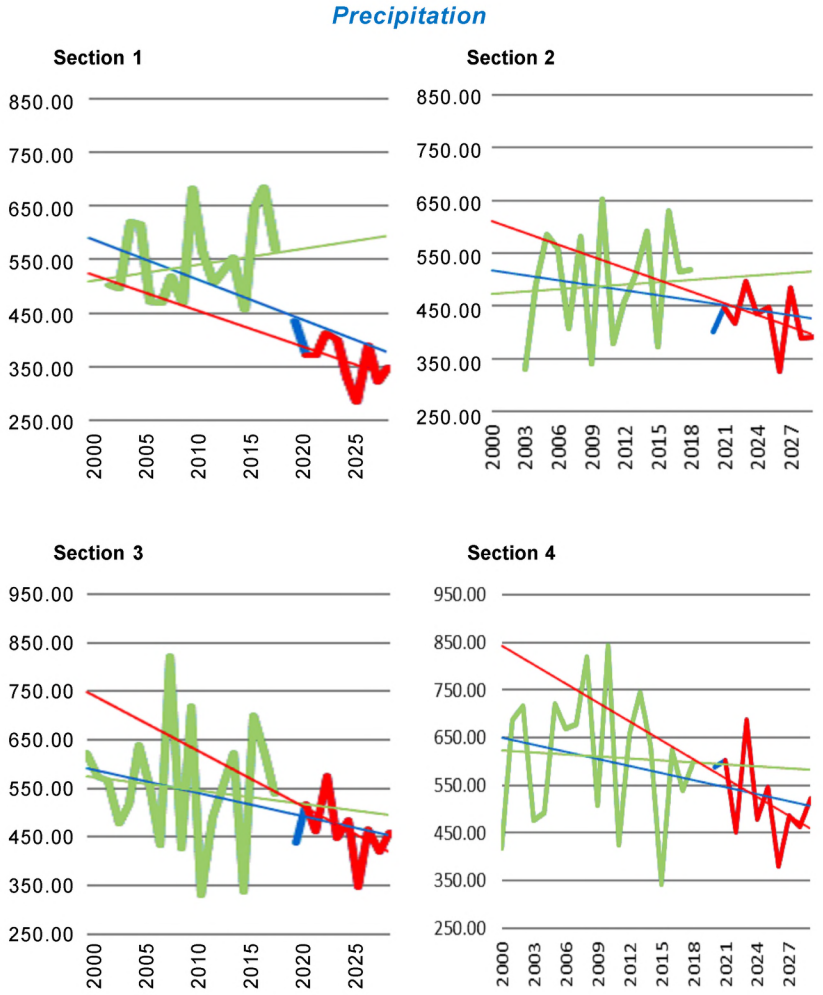

Fig. 24. Average annual values of the precipitation in the watershed areas of the Dniester River

Analysis of the graphs of changes in the average seasonal values of air temperature (Fig. 25) indicates a tendency for its increase, with the exception of the summer months. The temperature growth rate is highest in the winter season, but in spring and autumn it tends to decrease compared to the period 2000-2020.

Changes in the amount of precipitation (Fig. 26) in these areas indicate a further decrease. Note that a characteristic feature of the trends is a significant decrease in precipitation in the winter season with a gradual slowdown in the rate of decrease in the spring and summer seasons, and even their increase is predicted in the autumn season.

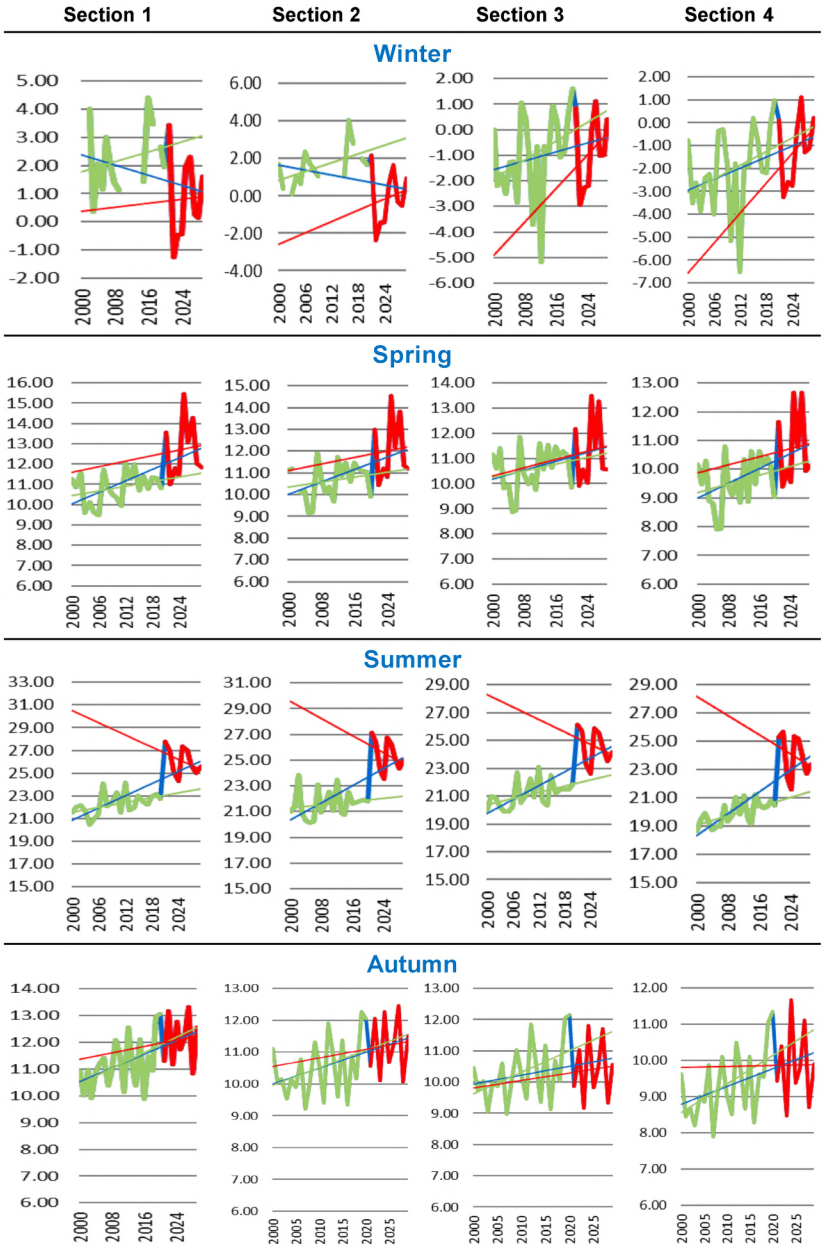

Fig. 25 Observed and prognostic seasonal variability and air temperature trends for sections of the middle and lower Dniester 2000-2029

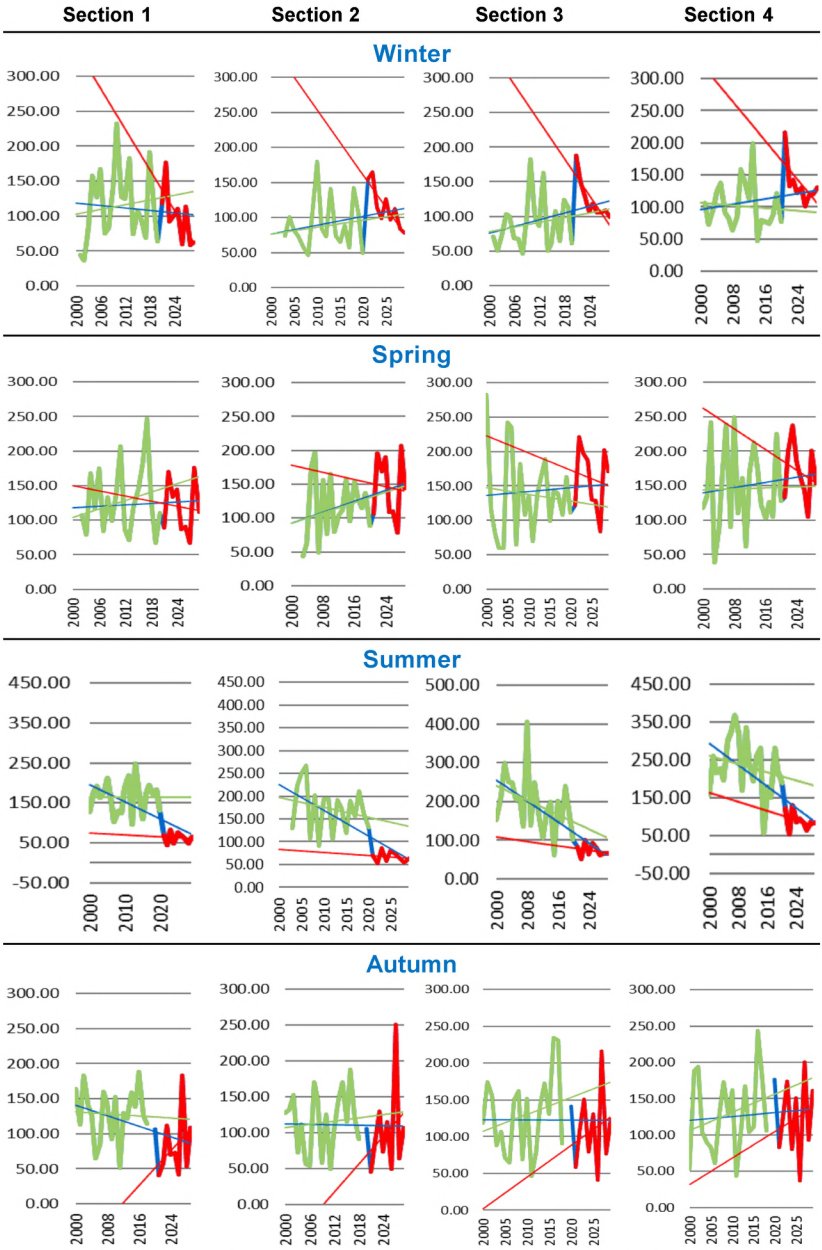

Fig. 26. Observed and predicted seasonal variability and precipitation trends for the middle and lower Dniester regions 2000-2029

5. Knowledge dissemination (broadcast)

Public awareness about the importance of the HydroEcoNex objectives and its' results is the one of the pillar for the Project successful implementation.

Broadcasting and dissemination of the Project objectives usually done through the press and science publications, online media, radio and TV, promotional materials, such as leaflets and brochures and public events.

Fig. 27. Project launching in Chisinau, November, 12 (left) and in Odessa, December, 12, 2018

With the aim to attract the public attention and to highlight the beginning of the Project, the launching conferences were organised in three neighbouring countries: Moldova, Romania and Ukraine.

Invitation were sent to the relevant decision makers, scientists, researchers, university staff, students, NGOs, media and the general public.

The events were widely broadcasted, as the Project had inspired lots of interest, due to its very urgent and important issues — the synergistic impact of both hydropower and climate change on ecosystems of the rivers r. Dniester and r. Prut.

The fact that our public, local government and administration feel very strongly about the environmental issues, was proven by the noticeable and consistent interest of decision making bodies to the problems addressed by the Project and its Launching conferences, such as:

- The State Secretary of the Ministry of Education, Culture and Research of the Republic of Moldova Elena Belei has attended the launching of Project events in Chisinau and

- The Senior Members of Odessa City Administration took part in launching the Project and have attended the conference.

Fig. 28. The first HydroEcoNex press conference, 2018, Chisinau

On agenda were the discussion of the major issues of public interest, such as: current ecological state of the Dniester River, development of the Upper Dniester hydropower complex in Ukraine, building and managing the dams along the course of our rivers, highlighting the importance of spring floods for the river ecosystems, and the role of internationals projects in the study of the Black Sea.

The HydroEcoNex team have discussed major environmental problems, raised by the Project and widely broadcasted it on Moldova and Ukrainian Radio and TV (Moldova 1 TV, TVR Moldova, RTR Moldova, Sputnik Moldova, Radio Europa Libera Moldova) and (Odessa channel 1 Pervii Gorodskoi, Odessa 7 News channel).

On the 22 May 2021, the day of biodiversity, UkrSCES and HMC BAS held two public seminars based on the results of the project BSB165.

The first seminar was organized for schoolchildren in the school of the Maiaky village. The seminar was held as a part of the Ecological Forum “Children of the Dniester”, organized by the Lower Dniester National Park. The public seminar was attended by more than 100 schoolchildren aged 12-14 from 7 schools of 5 localities of Odessa region (Maiaky, Bilyaevka, Yasky, Yosypivka, Nadlymanske).

At the seminar, schoolchildren had opportunity to listen to the reports and to have an open discussion there with three Project leading environmental scientists: Svitlana Kovalyshyna (Project coordinator PB4 BSB165), Elena Zubcov (Project Manager BSB 165 LP) and Alexander Matygin (Project coordinator PB5 BSB165).

In return, as a part of the forum, children have presented their own or their school team ecological projects, put on display their drawings and took part in the competition and quizzes on the topic of the river Dniester ecology.

The second public seminar was held on the 22nd of May 2021, and was organized for the 3rd year students of The Odessa State Ecological University (OSEU), specialty “Ecology”.

Twenty three OSEU students took active part in this public seminar and further discussion of the reports, presented by of Svitlana Kovalyshyna, Elena Zubcov, Alexander Matygin.

On the 2nd of September, 2021,the Project team from Ukraine took part in an open seminar in Romania, organized by Partner — University Dunarea de Jos Galati.

The member of the seminar discussed in details the problems of the ecosystem of the river Prut and river Dniester in content with the HydroEcoNex Project.

Fig. 29. HydroEcoNex Team — Participants in an open workshop in Romania on September 2, 2021

6. Knowledge Transfer Workshop

The workshop “Decline in discharge of the freshwater flow into the Black Sea due to the impact of the hydropower management and climate change” took place in Odessa during period if three days: 12-14 December 2019 and was organised by the Ukrainian Scientific Centre of the Ecology of Sea.

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, such as The Odessa Regional Administration and The Odessa State Environmental department.

The workshop discussion was focused on the issue of the decline in discharge of the freshwater flow into the Black Sea due to the effect of the hydropower management regime and its recent development and the global climate changes. The participants shared historic and recent data on the water quality, based on the physicochemical parameters. 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 the atmosphere and the river Dniester for the period from the beginning of the observational station's operation till the present time.

Fig. 30. HydroEcoNex team participants in the first knowledge transfer workshop, Odessa, December, 13, 2019

An important item on the agenda of the seminar was — the discussion of the first draft of the Strategy for bilateral cooperation on the joint monitoring of the transboundary rivers, affected by the hydropower, which will be reported and delivered to the decision-makers.

On the 26-27 August 2021, HMC BAS held the Knowledge Transfer Workshop and Steering Committee Meeting, where the results of the research

within the framework of the HydroEcoNex were presented by team researching scientists from UkrSCES, Institute of Zoology Republic of Moldova, “Eco-Tiras”, Lower Dniester National Park and Odessa National University I. Mechnikov.

Fig. 31. HydroEcoNex Team Participants in an open workshop in Odessa on August, 26-27, 2021.

At that Seminar the Conclusive Results were presented, that described the summary of the changes in the ecosystems of the rivers r. Prut and r. Dniester, due to the impact of the construction of hydroelectric power plants and climate change.

The conclusive estimates of the oxygen regime in the reservoirs of the lower Dniester were presented, as well as the estimates of the climatic changes in atmospheric parameters (air temperature and precipitation) before 2030 in the area of the River Dniester watershed [8].

7. International conferences

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

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

The participants of the conference jointly accepted and have approved the resolution, which expresses their opinion on the current condition of the River Dniester and recommends the 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 the River Dniester Basin.

Fig. 32. Opening ceremony of the International Conference “Hydropower Impact on River Ecosystem Functioning”, Tiraspol, 8 October 2019 (left); Plenary talk by Alexander Matygin; HydroEcoNex team — participants in the Conference

EcoTiras, — the organizer of the conference, have published the proceedings of the conference — print and on-line version on http://eco-tiras.org [2, 3].

In October 17-18, 2019, the participants of the HydroEcoNex HMC BAS and Eco-Tiras took part in the work of the All-Ukrainian scientific-practical conference “River and estuaries of the Black Sea at the beginning of the XXI century” (Odesa State Environmental University. Ukraine) [9].

The original and innovative method was presented there, that allowed to extend the data and to improve the calculation of the values the river discharge for the river Dniester, by using the correlation formulas and the historical data on the level of water from respected r. Dniester Estuary stations, such as Mayaki station.

The HMC BAS team, in collaboration with other partners in the HydroEcoNex Project, also took an active part in the international environmental conferences, such as:

- “EU Integration and Management of the Dniester River Basin” (October 8-9, 2020. Chisinau, Moldova) [10-12];
- Academician Leo Berg - 145 (Bendery, Moldova — 2021) [7];
- The X-th International Conference of Zoologists “Sustainable use and protection of animal world in the context of climate change” that was organized by the Institute of Zoology (Republic Moldova) on September 16-17, 2021 [4, 13];
- The Geological Society of America. GSA Connects 2021. Portland, Oregon, USA/ GSA Topical Session, “T137. From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary (INQUA IFG POCAS, IGCP 610)” [14, 15].

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