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Pollutants and biodiversity in the Dniester River

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

BSB165-HydroEcoNex

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, of which the contribution of European Union (92%) is 825,115.80 EURO.

PROJECT OVERALL OBJECTIVE

Developing an innovative unified environmental assessment system to provide data and information essential for monitoring changes in the Black Sea basin ecosystems caused by the impact of hydropower constructions and the long-term influence of transboundary climate changes.

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.

SPECIFIC OBJECTIVES

- Elaboration of a system of monitoring on the evaluation of the influence of hydropower engineering and climate change on environmental state and ecosystem services offered by Black Sea rivers, Dniester and Prut;
- Elaboration of the policy instruments on integrative management of aquatic resources;
- Strengthening of human potential on integrative management of water resources;
- Dissemination of knowledge on the impact of hydropower engineering and climate change on transboundary river ecosystems.

RESEARCH DIRECTIONS
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/

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

The Dniester is the largest river in the Western Ukraine and Republic of Moldova. The total length of the Dniester is 1362 km. Ukraine owns the upper reaches of the Dniester and its estuarine part with a total length of 705 km, a section of the river 220 km long is adjacent to Ukraine and Moldova, and a part of the river 437 km long is located on the territory of Moldova. The area of its basin is 72100 km^2, 26.4% of which is located on the territory of the Republic of Moldova, 0.6% in Poland, and 73% in Ukraine.

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.

Fig. 1. The team of the LP, PB4, PB5 during the summer field trip on the Dniester River, June and July 2021 (Boots for entering the water purchased as part of the project BSB165).

More than 50 expeditions along the Dniester were carried out, of which 5 were joint with the LP and PB5.The team of the UkrSCES during the research period from 2018 to 2021, water and bottom sediment and biological samples were taken in the lower Dniester at two stations: near Palanka village (51 km highway or 27 km of the Dniester from the confluence of the Dniester estuary; 46.419 N 30.17389 E), at a distance of 324 km from Dubossary hydropower plant and near Maiaky village (46.4128 N 30.2627 E) at a distance 15 km from Dniester estuary. Sampling for plankton and hydrochemical studies was carried out in flowing waters; in the presence of a boat, samples were taken from the central part of the river, in the absence of a boat, samples were taken entering the river using a throw-in container for taking a sample from flowing water, at a distance of at least 4 m from the coastline. Water column samples for biological (phyto- and zooplankton) and hydrochemical analyses were taken monthly, the total number of samples was 58 for each parameter. Bottom sediments for zoobenthos and pollution were sampled in the coastal part at depths of no more than 0.8-1.5 m. Zoobenthos samples and samples of water and bottom sediments for metal concentration were taken seasonally, the total number of samples was 24.

Fig. 2. The team of the LP, PB4, PB5 during the summer field trip on the Dniester River, August 2019.

Fig. 3. The team of the PB4 during the winter, field trip on the Dniester River, February 2020 (outerwear purchased as part of the project BSB165).

River biodiversity

Phytoplankton

During the period of study, in the Lower Dniester, Maiaky station we found 264 taxa of microalgae which belong to 11 classes: Bacillariophyceae (111), Chlorophyceae (58), Trebouxiophyceae (21), Ulvophyceae (1), Conjugatophyceae (1), Euglenoidea (20), Chrysophyceae (4), Cyanophyceae (34), Dinophyceae (12), and Imbricatea (1), and uncertain taxa of flagellate (1). The contribution of different classes in the total phytoplankton diversity is shown. The basis of taxonomic diversity was formed by diatoms, green algae and cyanobacteria, which is usual for freshwater phytoplankton.

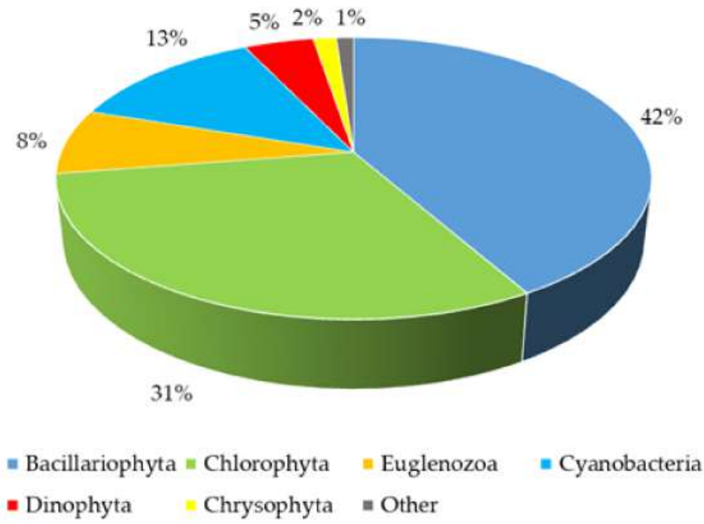

Fig. 4. Taxonomic structure of phytoplankton of lower Dniester (2018-2021)

Comparing with the previous studies of the regulated period (1970-1972 and 1986), we noticed the evident decrease of phytoplankton biomass. However, for most of the year, phytoplankton biomass was higher than in the pre-regulated period. Almost all year round, diatoms are dominated by biomass. Comparing with 1970-1972, the role of Cyanobacteria in total phytoplankton biomass of lower Dniester in the autumn and winter period had decreased, and in summer period increased, and the share of Bacillariophyta in spring increased, and in summer decreased. No constant difference in quantitative characteristics between surface and bottom layers and between sites was shown, but in the summer period, the share diatoms in the bottom layer was higher.

Zooplankton

During the period of study (2016-2021), 47 taxa of planktonic invertebrates were identified. The most diverse were Rotifera (25 taxa), 8 taxa belonged to Cladocera, 4 taxa to Copepoda, 10 taxa were assigned to the group Varia (other organisms). Over the studied period, the most common taxa ranged by their frequency were Brachionus calyciflorus Pallas, 1776, Acanthocyclops vernalis (Fischer, 1853), Chydorus sphaericus (O. F. Muller, 1776), Aplanchna priodonta Gosse, 1850, Brahionus plicatilis Müller, 1786, Brachionus diversicornis (Daday, 1883), Brachionus quadridentatus Hermann, 1783, and Lecane lunaris (Ehrenberg, 1832).

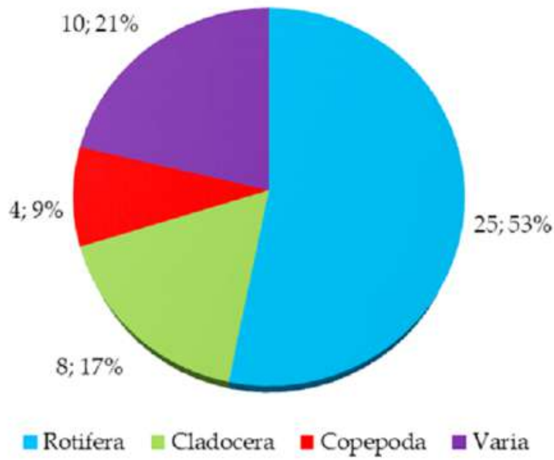

Fig. 5. Taxonomic diversity of zooplankton in the lower Dniester during 2016-2020

Fig. 6. Sampling of zooplankton from the lower Dniester (Palanka, October, 2020)

The role of Rotifera in the community decrease, but there was no evident correlation with the Dniester runoff. Due to the changes in water temperature, the maximum abundance shifted from summer to spring, abundance and biomass over the autumn and winter lower than the natural flow period.

Macrozoobenthos

Macrozoobenthos communities could be characterised as oligomixed ones (Shannon index did not exceed 1.5), but ß-diversity was relatively high and comparable with the historical data. 108 taxa were identified to the lowest possible rank, among them Diptera (23), Gastropoda (22), Oligochaeta (18). Compared to the period before the regulation of the Dniester flow, there is a decrease in the role of macrozoobenthos species in the communities of the Ponto-Caspian species and the loss of sensitive groups - Ephemeroptera and Trichoptera. Viviparus spp. with different co-dominants covered all the biotopes. Average values of abundance of 14500 $\pm$ 3500 ind$\cdot$m^{-2} and biomass of 0.8 $\pm$ 0.2 kg$\cdot$m^{-2} for the community is common for polytrophic water bodies.

Fig. 7. Sampling of Macrozoobenthos from the lower Dniester (Palanka, summer, 2019 and 2020)

Saprobity index calculated both for macrozoobenthos (2.25 ± 0.06) characterised the Lower Dniester waters as moderately polluted waters during 2018-2021. Comparing benthic biotic indexes (BMWP, BBI and PTI) computed on natural flow period and modern period both times described the environmental state as low. The range of the LIFE index increased, but it was not significantly different from 1950th and was common for low current velocity ecosystems. DSFI is not applicable for the Low Dniester because of the lack of indicator groups both in modern and historical data and suggests the adaptation for big lowland rivers of the Black Sea basin.

The state of pollution of waters and bottom sediments in the lower reaches of the Dniester river

According to historical observations, the largest amount of pollutants in wastewater enters the river Dniester from water management areas, which are located in the upper part of the basin (from the source of the river to the Dniester reservoir), where there are many industrial and communal enterprises of Lviv, Ivano-Frankivsk and Ternopil regions. On the territory of Lviv and Ivano-Frankivsk regions there are 4 powerful mining and chemical enterprises (Rozdolsk GGHP "Sera", Stebnitskoe GGHP "Polimineral", GGRP "Podorozhnensky Rudnik", SE "Potash Plant", OJSC "Oriana"), which negatively affect ecological state of the river. Dniester.

The middle-Podolsk part of the Dniester, along with pollutants coming from its upper reaches, is under anthropogenic pressure as a result of the construction and operation of energy complexes and channel reservoirs of the Dniester cascade HPP-1, PSP and HPP-2 (since 1983) and the reservoir of Dubossary HPP (since 1954), as well as from industrial and municipal enterprises of the cities of Mogilev-Podolsky, Yampol, food and light industry enterprises and irrigation systems, which are located within the basin on the territory of the Vinnytsia region.

In the lower reaches of the Dniester, the most polluted section of the river is between the cities of Dubossary and Bender. Most of the pollutants enter this section with the runoff of the Reut and Byk rivers, in the basins of which the bulk of Moldavian industrial and communal enterprises are located, and where the largest number of water users.

The Ukrainian part of the lower reaches of the Dniester is polluted by industrial and municipal enterprises of the Odessa region, as well as food industry enterprises. Irrigation systems are also a significant pollutant, the largest of which is the Dniester irrigation system with a high concentration of organic matter in its waters.

Assessment of the state and variability of water and bottom sediment pollution by pollutants and toxic substances in the Dniester estuarine part is an important indicator of the integral transboundary load from the entire basin on the ecosystems of the flooded estuarine part of the river, the Dniester estuary and the Dniester region of the Black Sea. The main sources of chemical pollution with hazardous and specific substances are: the energy complex, municipal and industrial discharges, rainwater runoff, pesticides and other chemicals used in agriculture, and of emergency pollution. Hazardous substances include metals, oil and its derivatives, endocrine products and pharmaceuticals, and others.

The list of priority hazardous substances is specified in Directive 2008/105/EC and in the order of the Ministry of Natural Resources of Ukraine dated 06.02.2017 No. 45 "On approval of the list of pollutants for determining the chemical state of surface and groundwater bodies and the ecological potential of artificial or low surface class. waters" and includes 45 substances (for surface waters). In the Republic of Moldova, the list of hazardous substances includes 41 substances (Appendix No. 2 to the Decree of the Government of the Republic of Moldova No. 950 dated November 25, 2013 "On approval of requirements for the collection, treatment and discharge of wastewater into the urban rural settlements systems".

Table 1 - The list of the indicators of the pollutants, their main sources and areas of application

№	Reduction	Class and name of the substance	Scope / source
	OCPs	**Organochlorine Pesticides**	Mainly in agricultural production (insecticides, fungicides, herbicides), in sanitation, industry, trade (insecticides, zoocides - for chemical disinfection, disinsection and deratization of warehouses,industrial and residential premises, public buildings, means of transport, terrain treatment for the destruction of disease vectors and harmful insects, etc.).
1	HCHa	α – hexachlorocyclohexane isomer	
2	HCHb	β – hexachlorocyclohexane isomer	
3	HCHg	γ – hexachlorocyclohexane isomer (Lindane)	
4	DDE	Dichlorodiphenyldichloroethene	
5	DDD	Dichlorodiphenyldichloroethane	
6	DDT	Dichlorodiphenyltrichloroethane	
7	HC	Heptachlor	
8	HCB	Hexachlorobenzene	
9	AD	Aldrin	
10	DED	Dieldrin	
	PCBs	**Polychlorinated biphenyls (and their decay products)**	More than 200 substances, mainly used in electrical and hydraulic equipment in various industries; insulating liquid in transformers; cables; plasticizers; additives to paints and lubricants; hydraulic fluids; combustion by-products.
11	Ar-1254	Arochlor 1254	
12	Ar-1260	Arochlor 1260	
13 . . . 41	PCBn	Individual PCBs (29 PCB congeners with numbers according to IUPAC: 8, 18, 28, 31, 44, 49, 52, 66, 77, 101, 105, 110, 118, 126, 128, 138, 149, 153, 170, 174, 177, 180, 183, 187, 194, 196, 199, 206,209)	

№	Reduction	Class and name of the substance	Scope / source
	PAHs	**Polycyclic aromatic hydrocarbons**	They are mainly used in the production of stable dyes, diluents for wood preservatives, for chemical synthesis, in the production of synthetic fibers, plastics, dyes, coumaroneindene resins to obtain corrosion-resistant coatings for protecting pipelines, underwater parts of ships, etc. Natural sources: volcanic eruptions; fossil fuels, crude oil, coal; Forest fires. The main anthropogenic sources are associated with the combustion of fossil fuels: - metallurgical, coke-chemical, pulp and paper and petrochemical enterprises; - thermal power plants, centralized heating stations; - railway, road and water transport, aviation, agricultural machinery.
42	FNT	Phenanthrene	
43	ATC	Anthracene	
44	CS	**Chrysen**	
45	FR	**Fluoren**	
46	FRT	Fluorantin	
47	PR	**Pyrene**	
48	B**b**FRT	Benzo (b) fluoranthene	
49	B**k**FRT	Benzo (k) fluoranthene	
50	B**a**ATC	Benzo (a) anthracene	
51	B**a**PR	Benzo (a) pyrene	
52	NPT	Naphthalene	
53	B**ghi**PRL	Benzo (ghi) perylene	
54	I**123cd**PR	Indeno (1,2,3-cd) pyrene	
55	DB**ah**ATC	Dibenzo (ah) anthracene	
56	ACNPT	Acenaphthene	
57	ACNPTL	Acenaphthylene	
	HMs	**Heavy metals**	They are widely used in various industries. Many potential sources such as combustion by-products, industrial processes, water treatment sludge, batteries, dyes, anti-fouling coatings, zinc and cadmium from car tires, mercury in dental amalgam, nickel from diesel fuel, cadmium from phosphate fertilizers, arsenic, copper and chromium from wood preservatives
58	Cd	Cadmium	
59	Cr	Chromium	
60	Cu	Copper	
61	As	Arsenic	
62	Hg	Mercury	
63	Pb	Lead	
64	Zn	Zinc	
65	Fe	Iron	
66	Ni	Nickel	
67	Co	Cobalt	
68	Al	Aluminum (in bottom sediments)	
	PPs	**Petroleum products**	Used in a wide area: - fuel industry, energy, transport; - chemical industry, production of synthetic fibers, plastics, pipelines, synthetic rubber; - medicine, antibiotics, various antiseptics, cosmetics; and in other areas of production . Natural combustible substance from a complex mixture of hydrocarbons, lying at depths from several meters to 5-6 km, deposits are confined mainly to sedimentary rocks.
69	**TPHs**	**The amount of petroleum hydrocarbons**	

№	Reduction	Class and name of the substance	Scope / source
	Ps	**Phenols**	The main areas of modern application of phenols: the production of synthetic fibers, nylon, phenol-formaldehyde resins, some dyes, perfumery products, plasticizers for polymers, plant protection products, is an antiseptic and is used in the production of medicines. Under natural conditions, phenols are formed in the metabolic processes of aquatic organisms, during the biochemical decomposition of organic substances flowing both in the water column and in bottom sediments. In industry, synthetic production methods are used.
70	TPs	The amount of phenols	
	OC	**Organic carbon**	It is used in the oil refining industry, gasoline and diesel fuel are produced from organic carbon compounds, it is used in the synthesis of organic compounds, it is widely used in medicine to create various drugs of an organic nature, in water purification systems. Organic carbon compounds are involved in almost all biochemical processes in the construction of all tissues of living nature. Plants, animals, humans, fossil fuels, atmospheric carbon dioxide take an active part in the natural cycle. A significant amount of it is found in fossil fuels (natural gas, oil, coal, oil shale). TOC is one of the most important summary parameters that characterize the organic pollution of water and bottom sediments.
71	TOC	Total organic carbon	

Organochlorine pesticides (OCPs)

Organochlorine pesticides (OCPs) are a group of synthetic poisons designed primarily for insect control. A number of organochlorine pesticides (α, ß and γ are isomers of HCH, DDT and its metabolites DDE, DDD, aldrin, dieldrin, heptachlor, hexachlorobenzene, etc.) belong to the dangerous group of persistent organic pollutants (POPs - persistent organic pollutants). The most toxic of this group of OCPs are dichlorodiphenyltrichloroethane DDT and HCH (Lindane), which ranked first in terms of production and use in agriculture until the 1980s.

The widespread use of OCPs in agriculture and other industries in the last century led to the accumulation of these drugs in the natural environment in water bodies and soils and their migration along the food chain from the lower to the higher levels of the ecosystem. In aquatic ecosystems, there is a sorption of organochlorine compounds by suspensions, their sedimentation and burial in the composition of suspended organic material in bottom sediments.

During the observation period, the content of the γ-isomer HCH (Lindane) in water was noted in all samples. Its concentrations were in the range of 0.17-2.12 $ng \cdot L^{-1}$. The lindane content averaged 0.60 $ng \cdot L^{-1}$. Concentrations of the ß-isomer of HCH varied from analytical zero <0.05 $ng \cdot L^{-1}$ to 1.55 $nng \cdot L^{-1}$, the average value was 0.55 $ng \cdot L^{-1}$. The α-isomer of HCH was not detected in all water samples. The presence of DDT Dichlorodiphenyltrichloroethane was observed in all water samples taken. Its concentration varied within the range of 3.15-17.95 $ng \cdot L^{-1}$.

The transfer of organochlorine compounds to bottom sediments is largely due to biosedimentation - accumulation with suspended organic material. In bottom sediments in the lower reaches of the Dniester, the concentration of the γ-isomer HCH (Lindane) was 0.25 $mkg \cdot kg^{-1}$ in March 2019, 0.35 $mkg \cdot kg^{-1}$ in June 2019. In bottom sediments from the group of pesticides POPs (aldrin, dieldrin, heptachlor, hexachlorobenzene), dieldrin and heptachlor were detected in June at concentrations of 5.4 $mkg \cdot kg^{-1}$ and 6.13 $mkg \cdot kg^{-1}$.

Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are a group of stable chlorinated aromatic hydrocarbons and are classified as a hazardous group of persistent organic pollutants (POPs). PCBs are unique substances that have excellent thermal and electrical insulation characteristics, high temperature resistance, inertness towards acids and alkalis, fire resistance, good solubility in fats, oils and organic solvents, high compatibility with resins, excellent adhesion. These properties of PCBs have contributed to their widespread use in many industries as dielectrics in transformers and capacitors, hydraulic fluids, heat transfer fluids and refrigerants, lubricating oils, paint components, varnishes and adhesives, plasticizers and fillers in plastics, flame retardants and solvents.

The production of PCBs was banned back in the 70s. XX century. However, despite the widespread ban on use, some PCB-containing materials and equipment are still in operation and are a potential source of environmental pollution.

The industrial end-product of PCBs is a mixture of large quantities of individual PCBs formed during the chlorination of biphenyl and differing in the number of chlorine atoms and their arrangement in aromatic nuclei called congeners. These regulated mixtures are known under various brand names - in the USA Arochlor (Ar-1221, Ar-1232, Ar-1242, Ar-1248, Ar-1254, Ar-1260), in Germany - Chlorfen, in France and Italy - Fenochlor et al.

In total, there are 209 individual PCB congeners, of which 12 are numbered 77, 81, 126, 169, 105, 114, 118, 123, 156, 157, 167, 189 in the IUPAC (International Union of Theoretical and Applied Chemistry) system in 1997 was recognized by the World Health Organization (WHO) as very dangerous, similar to the effects of dioxins.

The total concentration of PCBs in water in the composition of Ar-1254 in the lower reaches of the Dniester varied during the observation period in the range of 6.14-107.0 $ng \cdot L^{-1}$. Concentrations of individual PCBn in bottom sediments ranged from analytical zero <0.05 $mkg \cdot kg^{-1}$ to 19.59 $mkg \cdot kg^{-1}$.

Polycyclic aromatic hydrocarbons (PAHs)

Along with OCPs and PCBs, polycyclic aromatic hydrocarbons (PAHs, polyarenes) also belong to the dangerous group of persistent organic pollutant compounds (POPs). They are a group of organic pollutants from benzene compounds, which are characterized by the presence in the chemical structure of two or more condensed benzene rings, which are usually formed as a result of incomplete combustion or pyrolysis. There are at least 10,000 different PAHs, of which more than 100 polyorenes are found in environmental objects and food. Depending on the physicochemical characteristics, polyarenes are divided into two groups: low molecular weight (light), containing three or fewer aromatic rings in the chemical structure, and high molecular weight (heavy), containing more than three aromatic rings.

The US Environmental Protection Agency (US EPA) has identified 16 PAHs as priority pollutants: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo (a) anthracene, benzo (k) fluoranthene, benzo (b) fluoranthene, benzo (a) pyrene, dibenz (a, h) anthracene, indeno (123-c, d) pyrene, benzo (g, h, i) perylene, the presence of which should rationed and controlled in environmental objects.

The "light" PAHs conditionally include: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo (a) anthracene, which can be of natural and man-made origin, which depends on the specific object of research. The group of "heavy" polyorenes includes: benzo (b) fluoranthene, benzo (a) pyrene, indeno (123-c, d) pyrene, dibenz (a, h) anthracene, benzo (g, h, i) perylene, which are characterized by as more dangerous carcinogenic compounds of technogenic origin.

According to the World Health Organization (WHO), dibenz (a, h) anthracene and benzo (a) pyrene are the most toxic polyarenes, which are respectively assigned to category 2A (highly likely carcinogenic to humans) and 1 (carcinogenic to humans) according to (IARC classification of PAH, 2015). In the composition of the "light" priority pollutants PAHs, most of them are assigned, according to this classification, to category 3 (not classified as carcinogenic to humans), and naphthalene, benz (a) anthracene, benz (b) fluoranthene, indeno (123 - c, d) pyrene are categorized as 2B (probably carcinogenic to humans.

Concentrations of polyaromatic hydrocarbons PAHs in water, which are among the priority pollutants, varied in the lower reaches of the Dniester in the aisles from analytical zero <0.05 $ng \cdot L^{-1}$ to 0.30 $ng \cdot L^{-1}$. In bottom sediments, the concentrations of the priority pollutants PAHs ranged from analytical zero <0.05 $mkg \cdot kg^{-1}$ to 16.6 $mkg \cdot kg^{-1}$.

Heavy metals (HMs)

Along with hydrocarbons, the most dangerous pollutants are heavy metals, which atomic weight is more than 50 amu. They are included in products of both natural and anthropogenic origin, and come into ecosystems as components of industrial and domestic waste with atmospheric, sewage, slope and river flows.

Unlike organic substances, heavy metals do not degrade but only migrate between different compounds and accumulate in the natural ecosystem in hydrobionts of various trophic levels. In water, metals are present mainly in three forms: dissolved, suspended and colloidal, in bottom sediments, in water-soluble (chlorides, sulfates, complexes with organic compounds), ion-exchange and weakly adsorbed forms. In these forms, the metals are actively involved in the metabolism of living organisms and can accumulate in them. Heavy metals, when excessively released into the environment, behave as toxicants and ecotoxicants. Toxicants are elements and compounds that have a harmful effect on an individual organism or a group of organisms, and ecotoxicants are elements or compounds that negatively affect not only individual organisms, but also the ecosystem as a whole. Therefore, heavy metals are important for their high toxicity to living organisms at relatively low concentrations, as well as an ability to bioaccumulate.

When monitoring waters and bottom sediments in the lower Dniester, the concentration of heavy metals was analyzed for 10 elements: Pb, Cu, Zn, Ni, Cd, Co, Hg, Cr, As, Fe. The concentration of heavy metals in water varied from analytical zero to 44.0 $\mu g \cdot L^{-1}$.

According to the highest value of the registered concentrations, the elements are arranged in the following sequence: Fe > Pb > Cu > As > Cr >

Cd > Ni > Hg, and according to the ratio of the concentration to the ecological quality standard (EQS), in the sequence: Cu > Cd > Pb > Hg > Fe > Cr > As > Ni. In bottom sediments, the concentration of heavy metals varied within the range of 0.17-83.7 mg per kg of dry weight. According to the highest concentrations in bottom sediments, heavy metals are arranged in the following sequence: Zn > Cr > Ni > Fe > Cu > Pb > Co > As > Cd > Hg, and according to the ratio of the concentration to the ecological quality standard (EQS), in the sequence: Ni > Cu > Cr > Hg > Zn > Cd > Co > Fe > As > Pb.

Petroleum Products (PPs)

Petroleum products are among the most common and hazardous substances that pollute surface water and bottom sediments. Oil components have different migration forms a dissolved, emulsified, adsorbed on the solids suspensions and sediment, as a film on the water surface.

The spread of oil components and oil products in water bodies, their active participation in the ongoing physicochemical and biochemical processes, as well as their interaction with aquatic organisms necessitates regular observations of the concentration of oil components in assessing the state of aquatic ecosystems. Oil and oil products are included in the list of priority indicators subject to systematic monitoring and control within the framework of national and international programs for environmental protection. In sanitary-chemical control, as a rule, the amount of petroleum hydrocarbons (TPHs), dissolved, emulsified and sorbed forms of oil is determined .

The concentration of the amount of petroleum hydrocarbons in the waters of the lower reaches of the Dniester near Maiaky village varied in the range from 0.01 $mg \cdot L^{-1}$ to 0.59 $mg \cdot L^{-1}$. Concentrations of total petroleum hydrocarbons (TPHs) in bottom sediments in March and June 2019 were respectively 30.0 and 44.0 $mg \cdot kg^{-1}$ of dry weight.

Phenols (Ps)

Phenols are among the most important priority air, water and soil pollution. The high toxicity of phenols led to their inclusion in the lists of priority pollutants in almost all countries of the world [33]. The toxic properties of phenol are expressed in dysfunction of the nervous system, respiration, blood circulation, in irritation of the mucous membrane of the respiratory tract and eyes.

Under natural conditions, phenols are formed in the metabolic processes of aquatic organisms, during the biochemical decay and transformation of organic substances that occur both in the water column and in bottom sediments. They are one of the most common anthropogenic pollutants entering surface waters with industrial and municipal wastewater during waste incineration with effluents from oil refining, oil shale processing, wood-chemical, coke-chemical, aniline-paint industries, etc.

Concentrations of the sum of phenols TPs during in March and June 2019 were respectively 1.21 and 1.80 mg•kg^{-1} of dry weight and exceeded the value of the ecological quality standard (EQS = 0.05 mg/l) in March 24 times and in June - 36 times. A significant excess of the value of the ecological quality standard EQS for phenols in bottom sediments may indicate pollution of the Dniester waters.

Organic carbon (OC)

Organic carbon is the most reliable indicator of the total content of organic matter in natural waters; it accounts for an average of about 50% of the mass of organic matter. Total organic carbon (TOC - Total Organic Carbon) is one of the most important total parameters characterizing the organic pollution of water and bottom sediments. The content of organic carbon in bottom sediments is one of the main geochemical characteristics that affect the state of the aquatic ecosystem.

The concentration of total organic carbon in the Dniester waters changed during the observation period in the range of 3.09-5.81 mg•L^{-1} and averaged 3.89 mg•L^{-1}. In bottom sediments, the mass fraction of TOC was estimated at 2.01 % in March 2019 and, during the period of maximum runoff of the Dniester waters, in June 2019, 1.42 %.

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 13 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 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.

Fig. 8. HydroEcoNex team - participants in the first knowledge transfer workshop, Odessa, 13 December 2019

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.

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.

Fig. 9. Study visit to "Aquatir" sturgeon complex, Tiraspol, 17 January 2019

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. 10. HydroEcoNex team - participants in the International Conference "Hydropower Impact on River Ecosystem Functioning", Tiraspol, 9 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.

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 broad-casting, promotional materials, as leaflets and brochures, public events, etc.

Fig. 11. Project launching in Chisinau, the Meeting Hall of Governmental House, organized by LP, 12 November 2018

Fig. 12. Project launching in Odessa, organized by Ukrainian Scientific Centre of Ecology of the Sea, 6 December 2018

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 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.

Fig. 13. Interviewed in Chisinau, 12 November 2018 (left) and in Odessa, 6 December, 2018

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 and News channel).

Fig. 14. The first HydroEcoNex press conference, 2018, Chisinau

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.

On 22 May 2021, the day of biodiversity, UkrSCES held 2 public seminars about the results of the project BSB165. One seminar was organized for schoolchildren in the school of the Mayaki 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 (Mayaki, Bilyaevka, Yasky, Yosypivka, Nadlymanske) of Odessa region. During the seminar, there were presented the reports of Svitlana Kovalyshyna (Project coordinator PB4 BSB165), Elena Zubcov (Project Manager BSB 165 LP) and Alexandr Matygin (Project coordinator PB5 BSB165). Within the forum, the presentations of each school team, as well as drawing contests and quiz on the topic of the Dniester ecology were held.

Fig.15. Public Seminar in Odessa, organized by Ukrainian Scientific Centre of Ecology of the Sea, 22 May 2021

The second public seminar on May 22, 2021 was organized for 3rd year students of Odessa State Ecological University (OSEU), specialty "Ecology". 23 OSEU students took part in this seminar. During the public seminar, the reports of Svitlana Kovalyshyna (Project coordinator PB4 BSB165), Elena Zubcov (Project Manager BSB 165 LP), Alexandr Matygin (Project coordinator PB5 BSB165). Tetyana Chuzhekova (Researcher PB4 BSB165), Mykhailo Nabokyn (Researcher PB4 BSB165) were presented.

A team from Ukraine took part in a public Seminar in Romania organized by Partner 3, September 2, 2021.

Fig. 16. HydroEcoNex team - participants in a public Seminar in Romania organized by Partner 3, September 2, 2021

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.

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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