

DEPÓSITO LEGAL ZU2020000153

ISSN 0041-8811

E-ISSN 2665-0428

# Revista de la Universidad del Zulia

Fundada en 1947  
por el Dr. Jesús Enrique Lossada



**Ciencias del**  
**Agro,**  
**Ingeniería**  
**y Tecnología**

**Año 15 N° 42**

**Enero - Abril 2024**

**Tercera Época**

**Maracaibo-Venezuela**

## Environmental Consequences of the Explosion of the Kahovsky Hydroelectric Plant on Biodiversity

Oleksandr Nepsha\*

Svitlana Hryshko\*\*

Larysa Prokhorova\*\*\*

Tetiana Zavyalova\*\*\*\*

Valeriy Lysenko\*\*\*\*\*

### ABSTRACT

The purpose of this article is to determine the ecological consequences of the explosion of the Kakhovka hydroelectric plant (southern Ukraine) on the biological diversity of the region. The main research methods were: theoretical generalization and system-functional approach, analysis, synthesis, expedition method. The ecological consequences of the destruction of a hydroelectric dam are divided into two types: drainage and flooding. As a result of the flooding, 48 objects of the nature reserve fund, with a total area of 120 thousand hectares, were affected. Aquatic biotopes and biotopes characteristic of overmoistened areas were the most affected by drainage. 38 rare types of biotopes, which are under the protection of the Bern Convention, were affected by the ecological disaster; wetlands of international importance (so-called Ramsar) with an area of 33,000 hectares in the Dnipro delta and seven objects of the Emerald network. Prospects for further research are related to the study of biotope restoration after an ecological disaster.

KEYWORDS: Kakhovka hydroelectric power station, Kakhovka reservoir, Biodiversity, Nature conservation areas, Ecological consequences.

\*Bohdan Khmelnytsky Melitopol State Pedagogical University, Melitopol, Ukraine. ORCID: <https://orcid.org/0000-0003-3929-9946>. E-mail: nepsha\_aleks@ukr.net

\*\* Bohdan Khmelnytsky Melitopol State Pedagogical University, Melitopol, Ukraine. ORCID: <https://orcid.org/0000-0002-5054-3893>. E-mail: gryshko245@gmail.com

\*\*\*Bohdan Khmelnytsky Melitopol State Pedagogical University, Melitopol, Ukraine. ORCID: <https://orcid.org/0000-0001-7693-1897>. E-mail: laripr@ukr.net

\*\*\*\* Bohdan Khmelnytsky Melitopol State Pedagogical University, Melitopol, Ukraine. ORCID: <https://orcid.org/0000-0002-0040-2611>. E-mail: zavyalova\_tatyana@ukr.net

\*\*\*\*\*Melitopol Institute of Ecology and Social Technologies, University of «Ukraine», Melitopol, Ukraine. ORCID: <https://orcid.org/0000-0002-3453-1331>. E-mail: lysenko-valeriy@ukr.net

Recibido: 05/09/2023

Aceptado: 01/11/2023

## Consecuencias ambientales de la explosión de la Central Hidroeléctrica Kahovsky sobre la Biodiversidad

### RESUMEN

El objetivo de este artículo es determinar las consecuencias ecológicas de la explosión de la central hidroeléctrica de Kakhovskaya (sur de Ucrania) para la diversidad biológica de la región. Los principales métodos de investigación fueron: generalización teórica y enfoque sistémico-funcional, análisis, síntesis, método de expedición. Las consecuencias ecológicas de la destrucción de la presa de la central hidroeléctrica se dividen en dos tipos: drenaje e inundación. Como resultado de las inundaciones, se vieron afectados 48 objetos del fondo de reserva natural, con una superficie total de 120 mil hectáreas. Los biotopos acuáticos y los biotopos característicos de zonas sobrehumedecidas fueron los más afectados por el drenaje. 38 especies raras de biotopos protegidos por el Convenio de Berna se vieron afectados por el desastre ecológico; humedales de importancia internacional (los llamados Ramsar) con una superficie de 33.000 hectáreas en el delta del Dniéper y siete objetos de la red Esmeralda. Las perspectivas de futuras investigaciones están relacionadas con el estudio de la restauración de biotopos después de un desastre ecológico.

**PALABRAS CLAVE:** Central Hidroeléctrica de Kakhovka, embalse de Kakhovka, biodiversidad, áreas de conservación natural, consecuencias ecológicas.

### Introduction

Ukraine's natural environment is a Russian aggression victim. The war affected every environmental component the – animal and plant life, water, air, soil. The negative impact consequences will be long-term and will have not only a local, but also global character.

The Russian Federation, in addition to the environmental legislation of Ukraine, grossly violates the International Convention of the EEC (European Economic Commission) of the United Nations «On the Protection and Use of Transboundary Watercourses and International Lakes», the Convention on Wetlands of International Importance (Ramsar Convention). According to the data of the State Environmental Inspection, as of January 2023, during the 11 months of military aggression of the Russian Federation, damages to the ecology of the environment of Ukraine amount to more than 1 trillion 743 billion hryvnias, or more than 47.6 billion dollars (Belousova, 2023; Pylypiv, 2023). And with every day of the war, the amount of damage increases significantly.

Therefore, it is important to take care of an effective monitoring state system of the natural environment today. State authorities, the public, and scientists should record the real extent of the damage and involve the international community to prove the fact of ecocide in Ukraine. All this will be absolutely necessary for the case of compensation for damage to the environment at the aggressor country expense.

## 1. Literature review

Issues of environmental protection at the regional and global levels were considered in many scientific publications of researchers, namely the problems of protection and greening of forest use (Gulac et al., 2022; Gulac et al., 2022), the relationship between man and nature (Voronkova et al., 2023; Bondarets et al., 2014), an ecological approach to the problem of nature use in tourism (Oleksenko et al., 2021; Verkhovod et al., 2022), the ecological state of water resources (Demchenko et al., 2015; Nepsha & Hryshko, 2020) and soil resources as a result of anthropogenic stress (Zavialova, 2021) etc.

The hostilities that have been taking place in Ukraine since 2014 and escalated in 2023 pose an ecological and man-made threat to the environment. The state of nature reserves in the occupied territories is also critical. These issues were considered in the following works.

Roman L.Y. (2022) notes that as a result of active hostilities, as of April 2022, 900 protected areas of Ukraine have already suffered significant environmental and economic damage. The total area of damaged protected areas of Ukraine is 1.2 million hectares.

In the research of Ivaniuta S. (2022), the complex of new threats to environmental and nuclear security because of Russian military aggression against Ukraine is analyzed. A set of measures to mitigate threats to environmental and nuclear security due to Russian military aggression against Ukraine are offered.

In another publication, Ivaniuta S. (2023), current problems of the formation of new threats to ecological security in the conditions of Russian military aggression against Ukraine are analyzed. The priority directions for countering threats to the environment in the context of Russian military aggression against Ukraine have been identified.

Mykulets V. (2022) it is shown at the theoretical level of the study the shortcomings of the Ukrainian legal position concerning the provision of compensation for environmental damage due to Russian aggression. It is proposed to define the concepts of

«environmental damage» and «environmental damage during the war» at the level of the relevant Law. The validity of reflecting the position at the level of the law is defended.

In the studies of K. M. Prodan et al. (2023), the impact of military actions in Ukraine on the ecological state of the atmospheric air, soil cover, water resources and identified threats to the territories of the natural fund objects was analyzed.

Angurets O. et al. in 2022 prepared the report "Ukraine, damage to the environment, environmental consequences of war". This report is the results of the research into impacts of Russia's military aggression on the environment of Ukraine. It highlights and analyses the damage that Russian occupiers have caused to the environment during 9 months since the wide invasion of the war, which started in 2014. Historical examples of how environment has been affected by the wars and damage compensation mechanisms are outlined and reviewed in the report.

Albakjaji M. (2022), found that the Russian aggression against the Ukrainian territory has caused severe environmental damages, which cannot go unpunished. Although traditional international law may be insufficient to punish Russia, customary law, warfare law, and international environmental law include rules that may be used to raise the Russian responsibility for these damages.

The article (Terebukh, 2023) outlines the current issues of environmental security in the context of the escalation of the Russian-Ukrainian war.

Researcher Boychenko S. (2023) extensively analyzed the profound direct and indirect environmental effects of the war in Ukraine. These effects can be attributed to changes in the optical characteristics of the atmosphere, atmospheric pollution caused by the emission of missile and shell detonation products, and the increasing release of greenhouse gases and gas-aerosol impurities.

The article (Hrynevych et al., 2023) examines the current economic and ecological state of Ukraine, considering the influence of such drastic external factors as a military invasion with the aim of determining the prerequisites for the formation of an effective social and environmental policy and developing approaches to the improvement and stabilization of the national economy.

## 2. Materials and Methods

### 2.1. Materials

To write the article, materials from state institutions of Ukraine, such as the Ministry of Environmental Protection and Natural Resources of Ukraine, the State Institution «Institute of World History of the National Academy of Sciences in Ukraine», the State Ukrainian Environmental Inspectorate, PJSC «Ukrhydroenergo» and non-governmental organizations - «Ukrainian Nature Conservation Group», analytical center were used «Ukrainian Institute of the Future». Also, the materials for writing this work were personal field observations of the authors in nature-reserved territories within the controlled territories of Ukraine in the Zaporizhzhia and Kherson regions.

## 2.2. Methods

To study the negative biodiversity consequences after Kakhovskaya HPP explosion, we used the following scientific research methods: analysis, synthesis, theoretical generalization and system-functional analysis allowed us to summarize the existing information about the ecological consequences of Kakhovskaya HPP explosion dam and the scale of the ecological disaster; the expedition method made it possible to determine the actual ecological consequences for biodiversity in drained and flooded areas in the controlled Ukrainian territories.

## 3. Result

Kakhovskaya HPP named after Petro Naporozhny is the last (lower) rung of the Dnipro cascade of hydroelectric power plants. It is located in the south of Ukraine, 0.5 km from the city of Nova Kakhovka, Kherson region. The Kakhovka HPP provided annual regulation of the Dnipro flow for power supply, irrigation and water supply in the arid regions in southern Ukraine. The characteristic features of the Kakhovsky hydraulic unit were the direct location of a 30 m high earthen dam on the silt, as well as a closed distribution device. The construction of the Kakhovsky hydraulic unit raised the water level in the Dnipro River to 16 meters and formed the Kakhovsky Reservoir. Completed during 1955-1958. The length of the reservoir is 230 km, the averagely width is 9.4 km (maximum – 24 km). The area was 2155 km<sup>2</sup>, the water volume was 18.19 km<sup>3</sup>. The coastline length is 896 km. The maximum depth is 34 m, the average depth is 8.4 m. The shores are mostly steep, dissected by deep beams, only in some areas they are gentle and sandy. There are many islands (Tomiltseva et al., 2017).

On June 6, 2023, Russian troops blew up the dam of the Kakhovka hydroelectric power station. As of June 14, 2023, about 72% of the water volume, or 14,395 km<sup>3</sup>, has been lost from the Kakhov reservoir (Figure 1) (Feshchenko, 2023).

Figure 1. Drained sections of the Kakhov reservoir, as a result of the dam explosion of the Kakhov hydroelectric plant



As the scientists of the public organization "Ukrainian Nature Conservation Group" note, all the consequences of the destruction of the dam can be divided into two types: the consequences of draining the Kahovsky Reservoir and the consequences of flooding (Moisiienko et al., 2023).

Based on previous studies, scientists have identified the following groups of catastrophic impacts on nature:

Ecological draining consequences of the Kakhov reservoir bottom and water leakage from it:

a) *Impact on fish fauna.* At the time of the terrorist attack, there were no less than 43 species of fish in the Kakhovsky Reservoir alone, of which 20 species are of industrial

importance (annual catch was up to 2.6 thousand tons). It will take at least 7-10 years to restore such reserves. All spawning grounds and the main volume of water, which is the habitat of fish, have been destroyed (Moisiienko et al., 2023; Gilova, 2023).

b) *Impact on amphibians and reptiles.* Amphibians and reptiles are the poorest of all vertebrate classes in terms of species composition. Approximately 15-18 species have been directly or indirectly affected by the draining of the reservoir. The consequences of the drainage are ambiguous. Amphibians were at risk due to the destruction of habitats and spawning waters. It was at this time that larval development was taking place and they were expected to leave the water bodies. For most reptile species, drained areas can theoretically become places for settlement and further changes in the population structure. At the same time, species that depend on aquatic habitats were under pressure and could die or move with water masses to other areas due to the rapid decline in water.

c) *Impact on birds.* Due to the almost complete Kakhovsky Reservoir disappearance, a number of bird species that nest in these places will disappear in this area (particularly, martins, terns, etc.) (Moisiienko et al., 2023).

d) *Impact on bottom fauna (benthos).* A large number of living organisms inhabiting water bodies live in bottom mud in the coastal zone - ripali - part of the stream where there is vegetation and sunlight. Together with the information about the death of the fish population, it can be stated that the vast majority of all living organisms that inhabited the Kakhov reservoir have already died or will die in the nearest future. Particularly, a number of invertebrates that make up the main animal biomass of the reservoir, primarily molluscs (for example, bivalve molluscs), various species of dipterans (*Chironomus*, subfamily *Culicinae*), which serve as a food base for fish, birds, amphibians, etc. (Moisiienko et al., 2023).

e) *Impact on plant life.* As a result of a sharp drop in the water level in the reservoir, aquatic and coastal-aquatic plants of the Kakhovsky Reservoir will disappear. In general, the exposed bottom zone of the reservoir will become the largest breeding ground for dangerous invasive species in the region (At the bottom ...,2023; Gilova, 2023; Moisiienko et al., 2022).

f) *Impact on rare biotopes/habitats types.* All living organisms coexist in nature and form biotopes (natural habitats), a kind of "variety of nature", which are also rare and protected at the pan-European level, because they are important for natural purification and



maintenance of water balance in the ecosystem. In general, 38 such rare types of habitats, which are under the protection of the Berne Convention, were found in the territory affected by the ecological disaster. It was for their protection that the territories of the Emerald Network were created in Ukraine. Aquatic biotopes and biotopes characteristic of overmoistened areas will suffer the most from drainage. (Moisiienko et al., 2023).

g) *Impact on the territory of the nature reserve fund.* Above the dam of the Kakhovka HPP, as a result of drainage, a number of nature conservation areas will also be affected, including at least 11 objects of the nature reserve fund (Moisiienko et al., 2023; Gilova, 2023).

h) *Impact on environmental protection objects of international importance.* In addition, there are nature conservation areas of international importance on this territory. The consequences of the terrorist attack will have a negative impact on the territory of the Emerald Network UA0000106 Kakhovske Reservoir (218119 hectares) and Velykyi Luh National Nature Park (SiteCode: UA0000037) (16755.00 hectares), wetlands of international importance of the Velyki and Mali Kuchugury Archipelago (7740.0 hectares), Sim Maiakiv Floodplain (2140.0 ha). (Moisiienko et al., 2023; Gilova, 2023).

Ecological consequences of flooding the territories below the destroyed dam:

a) *Impact on terrestrial fauna.* The almost instantaneous rise of the water level in the low-lying areas and, even more so, on the islands, left no chance for most terrestrial animals (mammals, reptiles, insects, etc.) and colonies of most bird species. Thus, 70% of the world population of the Nordmann's birch mouse (*Sicista loriger*) was flooded, which may lead to its disappearance in the future. Up to 50% of the population of the sandy blind mole-rat (*Spalax arenarius*), up to 50% of the population of the Falz-Fein's thick-tailed jerboa (*Stylodipus telum falzfeini*) were destroyed. These animals, as well as the steppe viper (*Vipera renardi*), the Caspian whipsnake (*Dolichophis caspius*), have no chance to escape in a stormy stream (Moisiienko et al., 2023).

The Dnipro population of the Danube newt (*Triturus dobrogicus*) is theoretically extinct. More than 200 individuals of the species, which is listed in the Red Book of Ukraine and was considered very rare, ended up in the Black Sea off the coast of Odesa Oblast in the first days after the flooding. Some of them were saved, but most died (More victims ..., 2023).

b) *Impact on nesting colonies of birds.* Important nesting sites of wetland and coastal waterfowl were destroyed in the flood zone. These are tens of thousands of individuals. It is in the floodplains of the lower Dnipro that the largest colonies of herons and other colonial birds in the region are concentrated (Moisiienko et al., 2023).

c) *Impact on plant life.* The flooded territory is a distribution place of specific flora, among which there are many species that have a very local distribution in this region, particularly, they are endemic to the Lower Dnipro sands. It is expected that as a flooding result, hundred thousands of individuals in these plants will die, which is a significant part of their total number. As a flooding result, most likely, part of the birch and oak forests will die, particularly, one of the largest giant oaks of the Kherson region, located in the Zburiiv Forest near the Dnipro banks. In addition, the flooding will lead to a significant rise in the groundwater level in the entire southern Ukrainian region. This will mean not only an increase in moisture in the soil, but also salinization, which is harmful to vegetation. As a result, both relict natural forest remnants (the legendary Gilea) and artificial forests created in the past on the Dnipro sands may finally disappear (this circumstance may be happened in the future expand the zone of negative influence of flooding by another 15-20 thousand hectares) (Moisiienko et al., 2023).

d) *Impact on rare biotopes.* Sandy biotopes, both coastal and continental, with their unique flora and fauna, will suffer mostly from flooding. In addition, water biotopes will be greatly affected due to water pollution. The shallow water bodies that will remain after the water level recedes will actually be a mixture with a large number of pollutants, including thousands tens of toilets that are now flooded in cottages and cities (Moisiienko et al., 2023).

e) *Impact on the territory of the nature reserve fund.* The vast majority of all natural territories located in the flood zone are included in the nature reserve fund. As a result of flooding, 48 objects of the nature reserve fund will be completely or partially affected, including: 1 biosphere reserve; 3 national natural parks, 1 regional landscape park, 16 natural reserves, 3 protected tracts, 22 natural monuments, 2 parks-monuments of garden and park art. It should be noted that the territory of the Black Sea Biosphere Reserve has been protected since 1927, and it itself is part of the worldwide network of UNESCO World Network of Biosphere Reserves. The total area of flooded protected areas may

exceed 120,000 hectares. Another 22 territories of the nature reserve fund in the flood zone are in the process of being created (Moisiienko et al., 2023).

f) *Impact on the Emerald Network territory.* The flooded territory fully or partially includes 9 Emerald Network sites, created by the decisions of the Council of Europe from 2009 to 2020. The loss of the natural features of these territories endangers Ukraine's fulfillment of its obligations to preserve these territories for the whole Europe (Moisiienko et al., 2023). In addition, the Cossack Islands with an area 1,000 hectares are classified as important for bird conservation (IBA) (7 main ... 2023)/

g) *Impact on wetlands of international importance.* The Dnipro delta with an area 33,630 hectares is included in the list of protected international important areas according to the Ramsar Convention (wetland 3UA009). In addition, desalination of the northern Black Sea part may negatively affect 4 more Ramsar wetlands in the region. However, this issue is completely unexplored, so we cannot say this with certainty (Moisiienko et al., 2023).

#### 4. Discussion

As for the environmental explosion consequences of the Kakhovka hydroelectric power station dam, they should be called an ecological disaster, a tragedy of a global scale (ecocide). The area affected by this tragedy covers at least 5 thousand km<sup>2</sup>, which were flooded or drained. About 72% of the water volume, or 14,395 km<sup>3</sup>, was lost from the Kakhovka reservoir (Feshchenko, 2023). According to the calculations of the Ministry of Environmental Protection and Natural Resources in Ukraine, estimated damage amount to the environment due to Kakhovskaya HPP explosion dam already amounts to more than 55 billion hryvnias (Barsukova, 2023; Bespyatov, 2023).

According to the Ministry of Environmental Protection and Natural Resources in Ukraine, 333 animal and plant species with different conservation status and 25 habitat types were threatened with destruction after Kakhovka hydroelectric plant explosion. Due to this catastrophe, Ukraine may lose some ecosystems forever, particularly, in the National Parks " Nizhnyodniprovsky", "Velykyi Luh", "Kamianska Sich" and "Biloberezhja Svyatoslava", Kinburn Spit Regional Landscape Park, Black Sea Biosphere Reserve. The Oleshky Sands National Park was indirectly affected (Barsukova, 2023; Bespyatov, 2023).

In the first days after the blow-up of the HPP dam, the Nizhnyodniprovsky National Park was flooded: the water level near the islands rose by 3 meters on an area of more than

77,000 hectares. On the territory of the park, there are landslides, water transport of products of destruction of rocks, buildings and equipment of the national park suffer. Damages to the national park amount to 46 billion hryvnias (Barsukova, 2023; Bespyatov, 2023).

The flooding affected Emerald Network and Ramsar sites lands, which are of world importance due to their unique biodiversity, Nizhnyodneprovsk flora and fauna National Nature Park – 120 valuable protected species. On the territory of the national park, not only the fauna is disappearing, but also its habitats and reproduction (Barsukova, 2023; Bespyatov, 2023).

Flooding affected areas where typical and rare floodplain forest groups, swamps, meadows, sandy steppes, steppe slopes of the Dnipro and streams, and rock outcrops have been preserved.

One of the main migration bird routes - the Dnipro River - passes through the territory of the Nizhnyodneprovsk National Park, and the stopping places are very important for the feeding and rest of migratory birds. In general, 60 species of birds that are subject to protection live on the territory of the national nature park, which has more than 80 thousand hectares of nature conservation lands (Barsukova, 2023; Bespyatov, 2023).

The Dnipro floodplains have a rich batrachoherpetofauna. The Lower Dnipro is known for its refugia, isolated local populations of forest species refugia, isolated local populations of forest species. Rare and endangered species are found here, as well as amphibian population systems unique to the south (Suriadna & Mykytynets, 2018; Suriadna et al., 2020). All of this was destroyed during the dam subversion. Directions and methods of restoration will still need to be developed, but the consequences need to be recorded today for a scientifically sound calculation of damage.

On the other hand, in the occupied Velikiy Lug national park in the Zaporizhzhia region, due to the decrease in the water level of the Kakhovsky reservoir, on the contrary, the wetlands of the "Big and Small Kuchugury Archipelago" are becoming shallow 54 species of fish, 5 species of amphibians, 10 species of reptiles and 156 species of birds that live on the islands of the archipelago will be under threat due to changes in the ecosystem. As of June 7, 2023, shallowing of 1.7 meters was recorded, the water moved 17 meters from the shore, despite the fact that 8 meters is considered a critical indicator (Bespyatov, 2023).

The Seven Beacons Floodplain archipelago on the territory of the Velikiy Lug National Nature Park will shallow by approximately 50% when the water level drops by 9 meters, and complete shallowing is expected when the water level drops by 14 meters. So, 47 species of fish will disappear there, and there are risks for 137 fish species (Bespyatov, 2023).

Some populations of amphibians and reptiles within the Velykyi Luh National Nature Park are of great evolutionary importance in terms of current trends in speciation and spatial distribution in southern Ukraine.

According to the Academician observations of the National Science Academy in Ukraine, Yakiv Didukh, plant seedlings have already appeared on the drained territory of the reservoir a month after the dam destruction. Among which are grasses and seedlings of trees and shrubs, the vast majority of species are adventive (alien), very durable and capable of active spread (invasive) (At the bottom ..., 2023)

Specialists of the State Environmental Inspection record that the salinity Black Sea level near Odessa is almost three times lower than normal. Such changes can irreversibly affected entire ecosystem, lead to mass Black Sea flora and fauna death representatives.

## Conclusion

On June 6, 2023, Russian troops blew up the dam of the Kakhovka hydroelectric power station, which is located in the southern steppe of Ukraine. As a result of the detonation of the dam, there was a water overflow from the Kakhovsky Reservoir and flooding 5,000 km<sup>2</sup> of lower hypsometric level territories, which caused an ecological disaster for biodiversity. All the ecological destruction consequences of the dam can be divided into two types: the ecological drainage consequences of the Kakhovsky Reservoir and the ecological flooding ones.

As a result of the reservoir drainage, the vast majority of all living organisms that inhabited the Kakhov reservoir have already died or will die in the nearest future. Particularly, these invertebrate number of that make up the main animal reservoir biomass, primarily molluscs, various species of dipterans, which serve as a food base for fish, birds, amphibians, etc. As a result of a sharp decrease in the water level in the reservoir, aquatic and coastal aquatic plants of the reservoir will disappear. In general, the exposed zone of the reservoir bottom will become the largest breeding ground for dangerous invasive

species in the region. Aquatic biotopes and biotopes characteristic of overmoistened areas will suffer the most from drainage. In general, there are 38 rarely protected biotopes by the Bern Convention in the territory affected by the ecological disaster. The terrorist attack consequences will have a negative impact on 243,800 Emerald Network hectares, Kakhovske Reservoir and Velykyi Luh National Nature Park, wetlands of international importance, the Great and Small Kuchugury Archipelago, and the Seven Lighthouses Floodplain. As a result of drainage, 11 objects of the nature reserve fund were damaged.

As a result of the flooding, 48 objects of the nature reserve fund, with a total area 120 thousand hectares, were affected. Including the Black Sea Biosphere Reserve, three national nature parks – Nizhnyodneprovsk, Whiteshore of Svyatoslav, and Oleshkivsky Pisky. A large number of small objects are also in trouble: sanctuaries, monuments of nature and garden and park art, regional landscape park "Kinbournska spit". Flooded areas have many different international statuses. Particularly, wetlands of international importance (so-called Ramsar) with an area of 33,000 hectares in the Dnipro delta fell into the disaster zone. Seven objects of the Emerald network were also affected. This area has the status of Important Bird and Biodiversity Area (IBA), which is necessary for the preservation of bird populations.

The undermining of the Kakhovskaya HPP will have unprecedented consequences not only directly for the south of Ukraine, but also for the entire country. Moreover, the change in the salinity level and the increase in Black Sea pollution affects the ecosystem of the entire Black Sea region, which means the ecological situation of a number of Black Sea countries. So this ecocide act takes on international proportions. First, fresh water fish will get into the sea and die there. Second, the dam collapse led to the release of a large fuel and lubricant amount into the water (at least 150 tons on the first day alone), which are toxic.

As a result of the hydroelectric power plant rupture, populated areas were flooded, and with them various sources of pollution, for example, cesspools, sludge dumps, landfills, cemeteries, landfills, warehouses with toxic chemicals - all this will also enter the river systems and the Black Sea and affect living organisms.

Ecosystem destruction, soil and water space pollution, biodiversity reduction, pest's number increase in forests is far from a complete list of environmental problems that Ukraine will face after the end of the war. It can be assumed that the future ecological disaster in Ukraine will have not only a local, but also a regional character, since the

contamination of water and marine ecosystems, groundwater with possible radiation, chemical or toxic waste will have a cross-border impact on some European countries.

## References

7 main questions and answers after Kakhovskaya HPP explosion (2023). Retrieved from: <https://uifuture.org/publications/7-golovnyh-pytan-i-vidpovidej-pislya-pidryvu-kahovskoyi-ges%E2%80%9C%E2%80%9C/>

Albakjaji, M. (2022). The Responsibility for Environmental Damages during Armed Conflicts: The Case of the War between Russia and Ukraine. *Special Issue Access to Justice in Eastern Europe*, 4-2 (17), 82-101. <https://doi.org/10.33327/AJEE-18-5.4-a000444>

Angurets, O., Khazan, P., Kolesnikova, K., Kushch, M., Černochova, M., & Havránek, M. (2022). Ukraine, damage to the environment, environmental consequences of war. Retrieved from: <https://cleanair.org.ua/wp-content/uploads/2023/03/cleanair.org.ua-environmental-consequences-of-russian-war-in-ukraine-war-damages-en-version.pdf>

At the bottom of the Kahovsky Reservoir, takyrns have formed and foreign species of plants-academician – prevail. (2023). Retrieved from: <https://nikopol.nikopolnews.net/ukraina/kakhovskoho-vodoskhovyshcha-6/>

Barsukova, O. (2023). «The situation in the national parks is critical.» 30% of Kherson Oblast reserves are under threat. Retrieved from: <https://life.pravda.com.ua/society/2023/06/10/254781/>

Belousova, K. (2023). In Ukraine, satellites recorded large-scale environmental war consequences. Photo before and after shelling. Retrieved from: <https://ecopolitic.com.ua/ua/news/v-ukraini-suputniki-zafiksuvali-masshtabni-ekonaslidki-vijni-foto-do-i-pislya-obstriliv/>

Bespyatov, T. (2023) 333 animal and plant species are under threat: what is the situation after the Kakhovskaya HPP explosion in the national parks downstream and upstream (2023). Retrieved from: <https://delo.ua/incidents/pid-zagrozoyu-333-vidi-tvarin-i-roslin-yaka-situaciya-pislya-pidryvu-kaxovskoyi-ges-v-nacparkax-nizce-ta-vishhe-za-tecijeyu-418847/>

Bondarets, D. S., Stetsishin, N. N., Prokhorova, L. A. Zavyalova T. V. (2014) Methods of Improving Effectiveness of Agrolandscape Utilization in Zaporizhia Oblast (Ukraine). *Geography and Natural Resources*, 2 (35), 188-192. <https://doi.org/10.1134/S1875372814020115>

Boychenko, S., Kuchma T., & Karamushka V. (2023). Integrating research in ecological and climate change educational process: assessment of atmospheric pollution over Ukraine due to military actions. *EGUsphere*. <https://doi.org/10.5194/egusphere-2023-1503>

Demchenko, V.O., Vinokurova, S.V., Chernichko, I.I. & Vorovka, V.P. (2015). Hydrological regime of Molochnyi Liman under anthropogenic and natural drivers as a basis for management decision-making. *Environmental Science and Policy*, 46, 37-47. <http://dx.doi.org/10.1016/j.envsci.2014.08.015>

Feshchenko, A. (2023). The disaster at the Kakhovskaya HPP: what are the consequences for ecology and agriculture. Retrieved from: <https://glavcom.ua/country/incidents/katastrofa-na-kakhovskij-hes-jaki-naslidki-dlja-ekolohiji-ta-silskoho-hospodarstva-934419.html>

Gilova, A. (2023). How the Kakhovskaya HPP explosion will affect wildlife. Retrieved from: <https://speka.media/yak-vpline-pidriv-kaxovskoyi-ges-na-diku-prirodu-p0xngp>

Gulac, O., Marchenko, O., Kapitanenko, N., Kuris, Y., Oleksenko, R. (2022). State environmental policy on the issue of legal regulation of fire safety in the forests of Ukraine. *Cuestiones Políticas*, 40 (74), 195-206. <https://doi.org/10.46398/cuestpol.4074.10>

Gulac, O., Oleksenko, R., Kaluha, V., Kravchenko, O. Yukhymenko, N. (2022). Overcoming the environmental crisis in the forestry sector of Ukraine in the context of the ecocentric paradigm. *Revista de la Universidad del Zulia*, 13(38), 59-71. <http://dx.doi.org/10.46925//rdluz.38.04>

Hrynevych, O., Miguel, Blanco Canto & Mercedes, Jiménez García. (2023). The war effect: a macro view of the economic and environmental situation of Ukraine. *Applied Economics*. <https://doi.org/10.1080/00036846.2023.2212975>

Ivaniuta, S. (2022). New threats to environmental and nuclear security due to russian military aggression against Ukraine. *Scientific Collection «InterConf+»*, 22(113), 366-372. <https://doi.org/10.51582/interconf.19-20.06.2022.037>

Ivaniuta, S. (2023). Assessment of countermeasures against threats to the environment from Russian military aggression. *Scientific Collection «InterConf+»*, 29(139), 209-215. <https://doi.org/10.51582/interconf.19-20.01.2023.022>

Moisiienko I.I., Khodosovtsev O. Ye., Vasyliuk O.V., Parkhomenko V.V., Viter S.G., Kuzemko A.A., ... Artamonov V.A. (2023). What are the consequences of the Russian terrorist attack on the Kakhovka hydroelectric plant for wildlife? Retrieved from <https://uncg.org.ua/iakymy-ie-naslidky-rosijskoho-teraktu-na-kakhovskij-hes-dlia-dyko-pryrody/>

More victims of the Russian terrorist attack on the Kakhovka HPP: employees of the Tuzly Estuaries National Park rescued 55 newts overnight. (2023). Retrieved from. <https://mepr.gov.ua/cherгови-zhertvy-rosijskogo-teraktu-na-kahovskij-ges-pratsivnyky-npp-tuzlivski-lymany-za-dobu-vryatuvaly-55-trytoniv/>

Mykulets, V (2022). Legal aspects of compensation requirements of environmental damage as a result of the war of the Russian Federation in Ukraine. *Legal Bulletin*. 2 (63), 23-29. <https://doi.org/10.18372/2307-9061.63.16705>

Nepsha, O. & Htyshko, S. Current hydroecological condition of the North-Western Pryazovie rivers. *20<sup>th</sup> International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management* (Vol. 20, pp. 95-101). 8-11 December, 2020, Vienna. Austria: STEF92 Technology. <https://doi.org/10.5593/sgem2020V1.3/s02.12>

Oleksenko, R., Bilohur, S., Rybalchenko, N., Verkhovod, I., Harbar, H. (2021). The ecological component of agrotourism development under the COVID-19 pandemic. *Cuestiones Políticas*, 39(69), 870-881. <https://doi.org/10.46398/cuestpol.3969.53>



Prodan, K. M., Khomin, D. R. & Andrushko, S. V. (2023). Crimes against Ukraine's environmental security caused by Russia's armed aggression. *Scientific Notes of Lviv University of Business and Law. The series is economical. Legal series*, 38, 24-28. <http://dx.doi.org/10.5281/zenodo.8220189>

Pylypiv, I. (2023). The Russian Federation caused damage to the ecology of Ukraine in the amount of 2 trillion - Ministry of Ecology. Retrieved from: <https://www.epravda.com.ua/news/2023/03/5/697693/>

Roman, L.Y. (2022). Analysis of environmental threats of NRF facilities of Ukraine during the war period. *Environmental sciences*. 3(42), 84-88. <https://doi.org/10.32846/2306-9716/2022.eco.3-42.13>

Suriadna, N. & Mykytynets, G. (2018). Distribution and new findings of newts (*Triturus* and *Lissotriton*) in the Lower Dnipro river area. *GEO&BIO*, 16, 73-78. <https://doi.org/10.15407/gb.2018.16.083>.

Suriadna, N. M., Mykytynets, G. I., Pupinš, M. & Gasso, V. Y. (2020). Population systems of Eurasian water frogs (*Pelophylax*) in the south of Ukraine. *Biosystems Diversity*, 28(2), 154-162. <https://doi.org/10.15421/012021>

Terebukh, A., Pankiv, N., Roik, O. (2023). Integral Assessment of the Impact on Ukraine's Environment of Military Actions in the Conditions of Russian Aggression *Ecological Engineering & Environmental Technology*, 24(3), 90-98 <https://doi.org/10.12912/27197050/157569>.

Tomiltseva, A.I., Mykhailenko, L.E., Baranovska, V.E., Kurilyuk, M.S., Ovcharenko, I.I., Yatsyk, A.V. ... Yurechko, Y.O. (2017). Kyiv: Institute of Ecological Management and Balanced Nature Management.

Verkhovod, I., Donetc, I., Arsenenko, I., Donchenko, L., Havrylova, O. (2022). Philosophical reflections on the relationship between tourism, economic growth and sustainable development in the 21st century. *Cuestiones Políticas*, 40(75), 16-25. <https://doi.org/10.46398/cuestpol.4075.00>

Voronkova, V., Nikitenko, V., Oleksenko, R., Andriukaitiene, R., Polysaiev, O. (2023). Environmental crisis overcoming as a factor for achieving economic sustainability in the context of the European green course. *Cuestiones políticas*, 41(77), 612-629. <https://doi.org/10.46398/cuestpol.4177.41>

Zavialova, T. Ecological condition and problems of using the soil cover of Zaporizhzhia region (south of Ukraine). *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management* (Vol. 21, pp.67-76). 16-22 August, 2021, Albena. Bulgaria: STEF92 Technology <https://doi.org/10.5593/sgem2021/5.1/s20.017>