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Indexed in
INDEXCOPERNICUS
(ICV: 87.25)
GOOGLESCHOLAR

SWorld Journal

Issue №18
Part 2
March 2023

Published by:
SWorld & D.A. Tsenov Academy of Economics, Svishtov, Bulgaria

UDC 08
LBC 94

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UDC 08
LBC 94
DOI: 10.30888/2663-5712.2023-18-02

Published by:
SWorld &
D.A. Tsenov Academy of Economics
Svishtov, Bulgaria
e-mail: editor@sworldjournal.com



UDC 556.53:547.5 (282.247.32)

ASSESSMENT OF THE KEY FACTORS OF THE EXPECTED DETERIORATION OF THE ECOLOGICAL CONDITION OF THE LOWER DNIEPER IN THE MODERN PERIOD DUE TO THE VIOLATION OF THE REGULATED RIVER WATERS FLOW REGIME

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Abstract. *In the article, an assessment of the potential negative ecological consequences for the territory of the Lower Dnieper and the Dnieper-Buh mouth region, which should be expected in the coming years under the influence of man-made disruption of the regime of regulated river water inflow and a significant decrease in the water level in the water system of the studied region, was carried out. The impact of a decrease in the water level, an increase in its salinity, the arrival of a significant amount of pollutants from the Kakhovka Reservoir and a number of other abiotic factors on the future development of the water ecosystem of the region was analyzed. On the basis of the analyzed materials, the main ways of avoiding the deepening of negative ecological consequences caused by the violation of the water regime on the Lower Dnieper were determined.*

Key words: *water regime, water level drop, hydrobionts, ecological hydrology, Kakhovska HEPS, Lower Dnieper, Dnieper-Buh mouth region*

Introduction. Since the middle of the last century, the flow of Dnieper waters to the lower Dnieper section takes place by regulated discharge of certain volumes of them through the dam of the Kakhovska HEPS [9, 20].

The mode of water inflow is a very important factor in the existence of the water ecosystem not only in lower Dnieper section, but also in the entire Dnieper-Buh mouth region [5], since it depends on the inflow of fresh water to all elements of the hydrographic network of the region with a total area 1440 km² [6, 7, 10, 11].

Since the beginning of the full-scale invasion of Russian troops on the territory of Ukraine, the Kakhovska HEPS was one of the first objects of state infrastructure that came under the control of the aggressor country. If in the first months of the temporary occupation of the hydroelectric station, the usual regime of water inflow to lower Dnieper section was mostly not disturbed, then from the beginning of 2023, due to hostilities in the Kherson region, a significant hole was formed in the body of the HEPS dam (Fig. 1).

As a result of this regulation, the inflow of Dnieper waters to the mouth of the river was completely impossible. At the present time, this has already led to a number of negative ecological and socio-economic consequences in the study region, and in the near future we can predict an even greater deterioration of the state of aquatic ecosystems and their biological diversity, which has been formed here for centuries.

Research results and their discussion. The main negative situation caused by the hole in the body of the Kakhovska HEPS dam was a sharp drop in the water level in the Kakhovka Reservoir (Fig. 2) to historical minimum values since its foundation and, subsequently, in the lower Dnieper section.

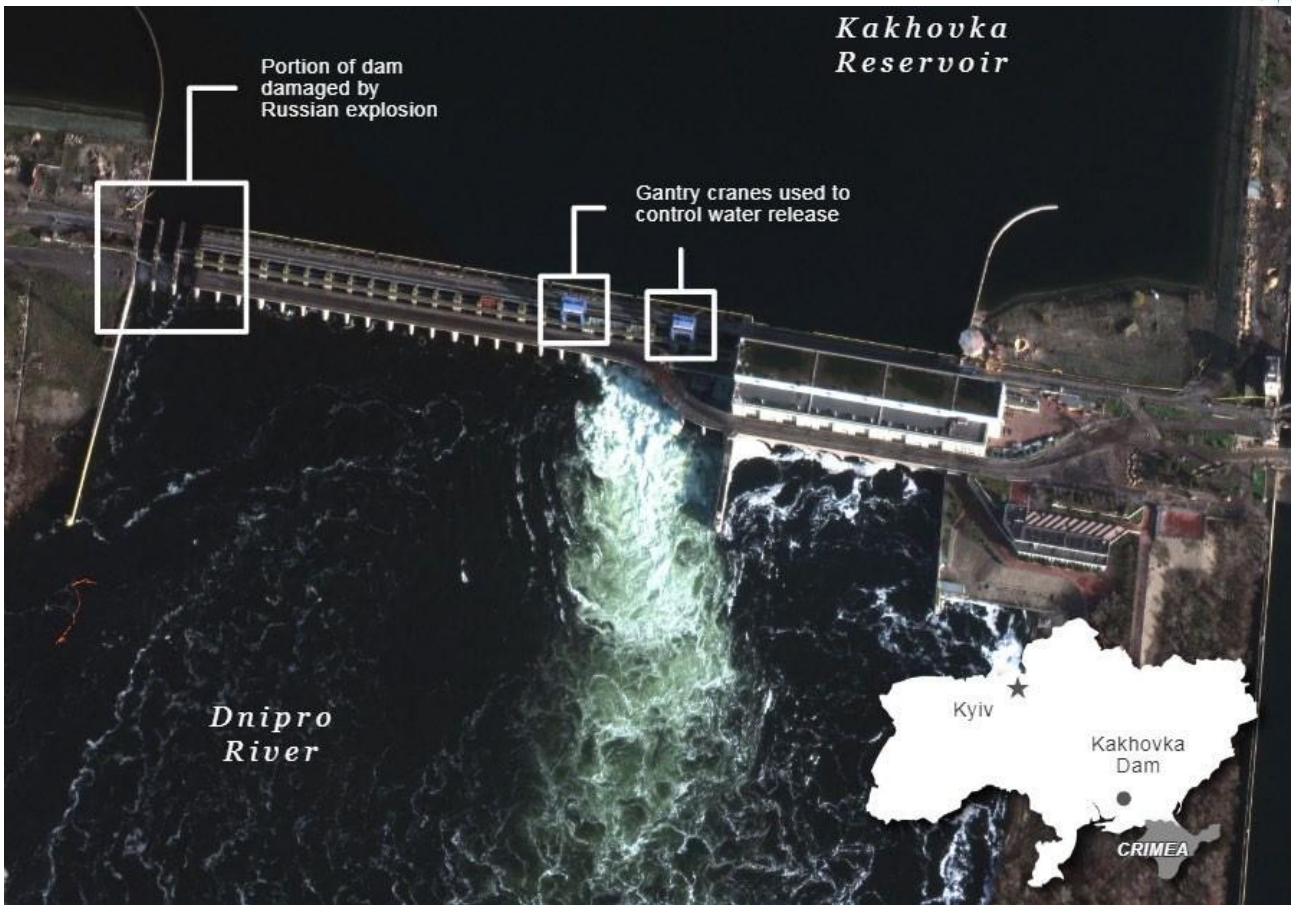


Figure 1 – Satellite image from Jan. 2, 2023. ©2023 Maxar Technologies. Credit: Connie Hanzhang Jin/NPR [18]

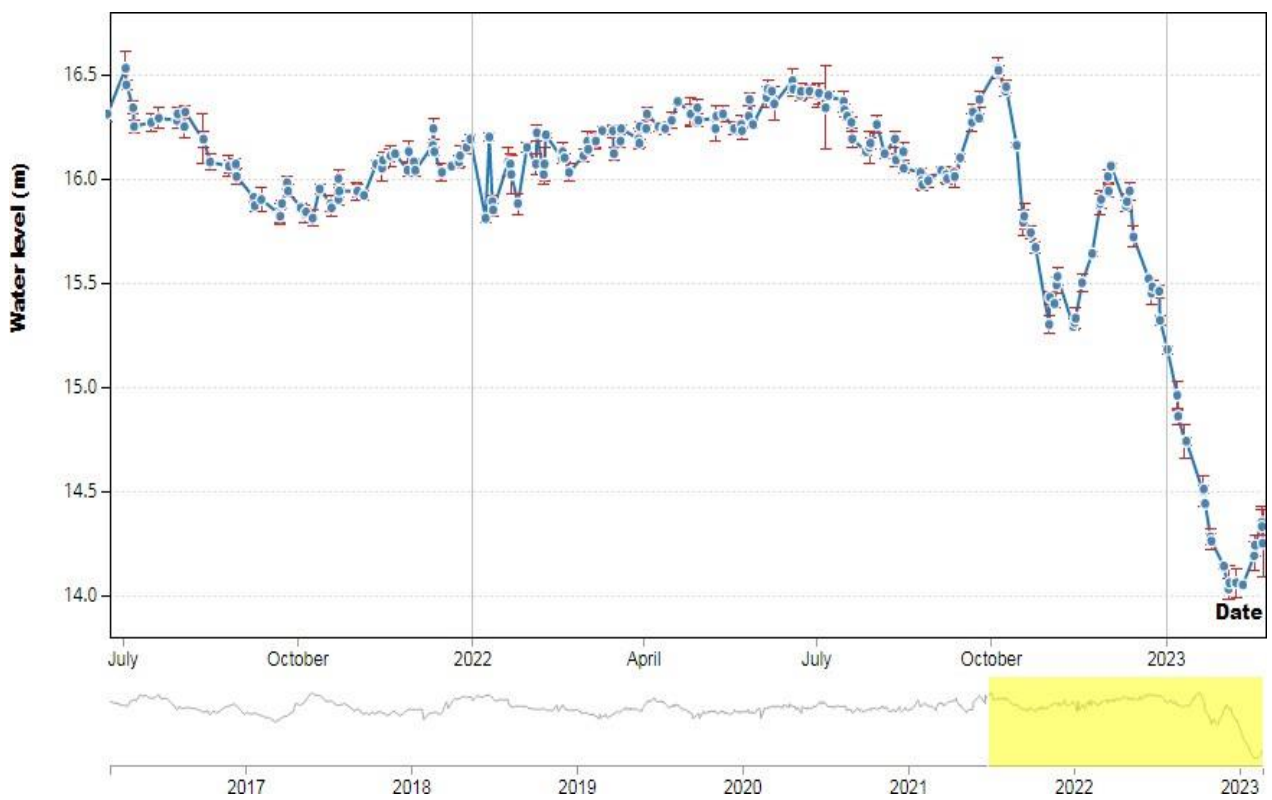


Figure 2 – The course of the water level in the Kakhovka Reservoir from July 2022 to February 2023 [17]



Thus, in the Kakhovka Reservoir in January-February, the water level was lower than the seasonal long-term values by 2.2-2.8 m, in the lower Dnieper section the water level was lower than the normal values by 1.6-1.8 m. As a result of this in the reservoir, significant areas of silty soils accumulated here since the 1950 year were exposed (Fig. 3), floodplains and watercourses below the Dnieper were almost completely dewatered (Fig. 4, 5).



Figure 3 – A fragment of the exposed coastline of the Kakhovka Reservoir with garbage and remains of aquatic plants [18]



Figure 4 – Shallowed part of a typical floodplain below the lower Dnieper section (February 2023) [8]



Figure 5 – Dead mollusk *Sphaerium sp.* and roots of aquatic plants *Nuphar lutea* on the bare coast of one of the typical reservoirs of the lower Dnieper section (February 2023) [8]

According to the results of our observations, low levels of water in the water system below the lower Dnieper section remained for almost the entire last decade of January 2023. Then the lack of water in the water system was compensated by the inflow of salty (sea) water from the Dnieper-Buh estuary. At the beginning of February, the water level rose again to average values, but not due to the restoration of the inflow of fresh water from the Kakhovka Reservoir, but due to the inflow of sea water from the coastal areas of the Black Sea.

From the presented material, it can be concluded that the main negative environmental consequences caused by the violation of the regulated water inflow to the lower Dnieper section, which should be expected in the near future in this region, will mainly be associated with two key factors for this situation:

- arrival of a significant amount of allochthonous biogenic and organic substances containing the products of decomposition of long-term silt deposits from the Kakhovka Reservoir in the spring-summer period of 2023;
- a sharp increase in water salinity in the freshwater hydroecosystems of the estuary of the Dnieper and the Dnieper-Buh estuary.

In the coming months, the damage to aquatic ecosystems will occur mainly due to the contamination of the waters of the listed water areas with allochthonous biogenic and organic substances formed in the silted, dehydrated areas of the Kakhovka Reservoir. According to our calculations, at the present time, more than 90 km² of the exposed bed of the reservoir remains dehydrated, on which, under the influence of sunlight and positive air temperatures, the remains of aquatic animals, plants, organic substances of silt decompose.



The spring water level rise in the Lower Dnieper water system, which can be expected already in the coming months, will cause significant volumes of water contaminated with bacteria and disease-causing microorganisms to enter the estuary of the river, which have managed to multiply on the bare silty substrate of the higher reaches of the river. Such processes will not only further worsen the ecological situation of the Dnieper-Buh mouth region, but will also lead to a violation of the sanitary-epidemiological situation in reservoirs, watercourses below the Dnieper and the Dnieper-Buh estuary.

The second largest consequence for the lower Dnieper section is the inflow of salty (sea) water from the Dnieper-Buh estuary caused by the shortage of fresh Dnieper waters. According to our observations, the water salinity values in the Dnieper near the city of Kherson at the beginning of February in the surface layer varied between 1.2-1.8‰ (with normal seasonal values of 0.2-0.4‰ [3, 15]).

Our numerous studies demonstrate that the flora and fauna of the region, especially freshwater, reacts very sensitively to changes in the abiotic factors of the water environment [1, 2, 10, 12, 13, 16, 19, 20]. Species listed in the Red Book of Ukraine and other regional and international nature protection lists are particularly vulnerable in this sense [4, 7, 14]. Under such conditions, we can expect the disappearance of most aboriginal freshwater species of hydrobionts in the next six months. In the future, natural disturbances of trophic relationships in the water ecosystem below will lead to the inevitable death of a significant number of representatives of aboriginal and red book species of freshwater flora and fauna.

Changes in the hydrological and hydrochemical conditions of the existence of hydrobionts of the Lower Dnieper, which we are currently observing, in the absence of the implementation of appropriate specially developed scientifically based methods of regulating the state of aquatic ecosystems, will inevitably lead to the total degradation of the unique aquatic ecosystem below the lower Dnieper section. First of all, the general degradation of the water ecosystem in the coming years will inevitably be reflected in the total overgrowth of the Dnieper floodplain with higher aquatic vegetation, the increase in the duration and frequency of water blooms, the increase in the number of fish and other hydrobionts, the shallowing of reservoirs and watercourses with their subsequent siltation and complete drying out.

In view of the above materials, we have identified four key directions for the development of urgent practical methods aimed at avoiding the deepening of negative environmental consequences caused by the violation of the water regime on the Lower Dnieper:

- 1) cleaning of exposed areas of the bed of the Kakhovka Reservoir from organically saturated silt deposits and the remains of aquatic plants and animals;
- 2) development and implementation of an ecologically sound system of water releases through the Dniprovsk and Kakhovsk HEPS dams, which will take into account both the volume of water inflow and the amplitude of water level fluctuations in the water body;
- 3) repair of damage to the body of the Kakhovsk HEPS dam caused by the actions of Russian troops;
- 4) development and implementation of methods for regulating the state of water



ecosystems in the affected area by regulating the hydrological and hydrochemical regime of local water bodies.

Conclusions. In the article, a preliminary assessment of the damage caused to nature was carried out due to the violation of the regulated regime of the flow of river waters to the lower reaches of the lower Dnieper section. Based on the analysis of changes in hydrological and hydrochemical regimes, a forecast of possible negative environmental consequences in the Dnieper-Buh mouth region that can be expected in the coming years has been made.

Among the main predictors that can cause a significant deterioration of the ecological situation in the region, we have highlighted the following: a decrease in the inflow of Dnieper waters, a violation of their regulated inflow regime through the Kakhovska HEPS dam, a significant shallowing of the bed of the Kakhovka Reservoir and floodplains below the lower Dnieper section, the inflow of salt water into the river's freshwater areas, increasing the amount of organic and biogenic substances in the water ecosystem of the river.

As suggestions for avoiding the total degradation of the water ecosystem of the Dnieper-Buh mouth region, it is proposed to develop and implement a complex of practical scientifically based methods of active influence on the water ecosystem of the region, which should be specially developed for the situation that has developed at the present time.

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Article sent: 09.03.2023.

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Scientific publication

International periodic scientific journal

Scientific World Journal

Issue №18
Part 2
March 2023

Indexed in
INDEX COPERNICUS
high impact factor (ICV: 89.14)

Articles published in the author's edition

*Academy of Economics named after D.A. Tsenov
Bulgaria jointly with SWorld*

Signed: March 30, 2023

e-mail: editor@sworldjournal.com

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