ГЛАВА 5.[5] ВОДОХРАНИЛИЩА И ОКРУЖАЮЩАЯ СРЕДА: ИЗМЕНЕНИЯ ЛАНДШАФТОВ В КАНЕВСКОМ ВОДОХРАНИЛИЩЕ НА РЕКЕ ДНЕПР, УКРАИНА

ВОДОСХОВИЩА І ДОВКІЛЛЯ: ЗМІНИ ЛАНДШАФТІВ У КАНІВСЬКОМУ ВОДОСХОВИЩІ НА РІЧЦІ ДНІПРО, УКРАЇНА

DAMS AND ENVIRONMENT: LANDSCAPES CHANGE IN THE KANIV RESERVOIR ON THE DNIEPER RIVER, UKRAINE

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Introduction.

The impact of reservoirs on the environment and on the living conditions of the population in river basins with regulated runoff is attracting more and more attention all over the world. There is a desperate struggle of proponents of economic development by creating large (and even giant) reservoirs for electricity production, land irrigation, industrial and municipal water supply and other purposes, on the one hand, and proponents of nature protection, preservation of rivers inpristine condition, limiting water use, on the other. The need for the former is quite clear, because the nations and states that have lagged behind in a certain historical period in socio-economic development are trying to overcome this backlog at the expense of hydropower in the first place. For example, Ethiopia and Sudan are working to build huge reservoirs on the Blue Nile in recent years. The position of ecologists is no less clear, as reservoirs and their cascades have a significant impacton nature, flooding nearby lands, destroying shores, deteriorating water quality, and so on. Even the intensification of seismic activity is observed in the creation of giant reservoirs.

But the most formidable consequence of the cascades of reservoirs creation and the intensification of river water use is the redistribution of water resources in the basins of the so-called transboundary rivers from their source to the lower reaches. If the states in the upper reaches of rivers use water through reservoirs and canals with almost no restrictions, then in the lower reaches there is less and less water, and its quality is getting worse. The tense situation is developing in many basins of the world's great rivers, and it will intensify every year in the face of climate change, population growth, and economic development. And in some basins it is already catastrophic. Thus, excessive use of river water in the upper and middle parts of the Syr Darya and Amu Darya river basins has led to the desertification and salinization of millions of hectares of soil in their deltas and the drying up of the Aral Sea. And between the states of these basins (Kyrgyzstan, Uzbekistan, Tajikistan, Kazakhstan, Turkmenistan, Afghanistan) there is a rather fierce competition for water for irrigation and water supply. Fierce (so far peaceful) competition for the Colorado river water continues between the United States and Mexico, for the Euphrates River

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between Turkey and Syria and Iraq, and for the Jordan River between the Middle East states. Intense interstate negotiations on the rational distribution of river water resources are taking place in Southeast Asia and South America, that is, practically globally.

Attention should be paid to the consequences of large reservoirs creating, such as flooding large areas of land in river valleys, resettlement of people from flooded settlements, as well as the loss of historical, cultural and spiritual heritage of peoples who lived in the area not just before the creation of artificial reservoirs, but also thosepeoples who lived there in the historical past. Architectural and spiritual monuments, which are cherished by peoples who once left these lands as a result of wars or other historical processes, are often flooded. Such facts are often simply ignored when designing reservoirs, and sometimes (unfortunately) such actions are carried outdeliberately to "erase" the real historical memory of peoples.

What can be the solution to such heated debates? Real life shows that in each casethe decision is made on the basis of the balance of interests and losses, based on a strategic assessment of the needs of the region at a particular historical moment. That is why new large reservoirs are being built, outdated projects are being reconstructed or liquidated, more and more attention is paid to environmental measures in the operation of artificial reservoirs. And under no circumstances should we forget that fresh water is a strategic resource of nations and states, the price of which will increase immeasurably. It is from this angle that we try to consider the problems of the Dnieper reservoirs [10-14].

All this variety of problems caused by the creation of large reservoirs deserves significant attention of our scientists, for which it is planned to create in NULES (initially on a voluntary basis) popular science center "Reservoirs and Environment" ("Dams and Environment"), making the object of scientists-ecologists attention artificial reservoirs of both Ukraine and other regions of the world. And this paper examines the problems of spatio-temporal dynamics of hydromorphic landscapes, coastal erosion, overgrowing of reservoir water area with vegetation, coastal development in the Kaniv Reservoir – the second in the Dnieper Cascade (Fig. 1). After all, the impact of reservoirs on the landscapes of adjacent areas is sufficiently covered by the example of reservoirs of different natural zones, including in our publications [9, 16, and 17]. Some attention is paid to the study of landscape changes in the littoral of the Kaniv reservoir and its islands, including those that are created in the reservoir [11, 12, 18, and 19]. It is important to note that certain changes, in particular the overgrowing of the reservoir after its creation, were predicted by well-known Ukrainian scientists, including in publications [6, 8]. And the task is to study the real dynamics of newly created landscapes in this reservoir during its operation. Considerable attention is paid to the processes of abrasion and erosion of shores, dredging of new lands within the reservoir, the threat of flooding and submergence of adjacent areas, including the southern outskirts of Kyiv, during extreme floods. In preparing this section, we used the materials of our long (albeit periodic) research, including the implementation of a joint Ukrainian-Czech project, which were partially published in a number of articles [13, 14] listed in the bibliography.

Fig. 1. Dnieper cascade of reservoirs (1-Kyiv, 2-Kaniv, 3-Kremenchuk, 4-Kamyanske, 5-Dnieper, 6-Kakhovka) and space image of Kaniv reservoir (Landsat-8)

Object of research.

Kaniv Reservoir is the second in the unique Dnieper cascade [2, 3], consisting of Kyiv, Kaniv, Kremenchuk, Kamyanske (under the old name – Dniprodzerzhynsk), Dnieper and Kakhovka reservoirs. The idea of the Dnieper flow regulating originated in the last (XIX) century, first from the need for water transport in the Dnieper rapids. Later, the needs of energy, industrial and municipal water supply, and later irrigation became relevant. Finally, in 1932, the dam construction and the filling of the first reservoir of the Dnieper HPP were completed. The Kaniv reservoir was created at the latest in the cascade. Construction of the Kaniv Dam began in 1963, the Dnieper was blocked with the dam and the reservoir began to be filled in 1972, and the filling to the normal water level (NWL) was completed in 1976. The design area of the water surface at the NWL 91.5 m was 581 km^2, the volume – 2.50 km^3 (later increased to 2.62 km^3), at the level of dead volume (LDV) 91.0 m the volume was 2,20 km^3, the so-called “working” volume between the NWL and the LDV was 0.30 km^3 (now it is slightly smaller). The lengthof the reservoir is 123 km, the maximum width is 8 km, the average width is 5.5 km, the average depth is 3.9 m, and the largest is 21 m [2]. It is important to take into account that the hydro-morphological characteristics change during the operation of the reservoir. Its area is gradually decreasing due to the dredging of new lands for country houses along the left-bank and right-bank dams, as well as due to overgrowing and siltation of shallow waters and increasing the area of islands. Although this trend is partially offset by the

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abrasion of high shores.

Subject and research methods.

The subject of research is: 1) the dynamics of hydromorphic landscapes formation in the Kaniv Reservoir in time and space during the period of its operation in 1976-2020; 2) features of reshaping the shores of the Kaniv Reservoir under the influence of hydro-morphological processes, measures to protect the coast from erosion, deepening the channel and dredging of new land (mainly in the upper part of the reservoir), arrangement of fisheries, hunting and recreational facilities. The research of the Kaniv Reservoir lasted (albeit sporadically) for a long time, so the research methods changed significantly at different stages.

First of all, the long-term experience of studying the interaction of reservoirs and the environment in different natural areas was comprehensively analyzed, published in scientific journals, as well as obtained by the authors themselves [9,16,17]. Direct research on the reservoirs of the Dnieper cascade, including Kaniv, we began in 1993-1997 [10, 16, and 17]. Standard methods of soil science were used to study the impact of the reservoir on the coastal soils, primarily on flooding, waterlogging and soil erosion. Since 2010, we started more detailed route (terrestrial and aquatic) studies of the reservoir overgrowth by hydrophytic and hygrophytic vegetation with the formation of hydromorphic soils on the islands of the reservoir and its coast [7,10, 11]. For the first time, methods of remote sensing of the Earth were used by analyzing a series of space images Landsat-2, 4-5 and 7 to study the temporal and spatial changes of landscapes, as well as geospatial positioning of observation points with GPS GARMIN. The obtained results were widely used by the Dnieper Basin Department of Water Resources and the State Agency of Water Resources of Ukraine. At the last stage in 2020-2021, the study of the Kaniv Reservoir shores transformation was conducted using a Phantom-4-Pro quadcopter and analysis ofLandsat-8 space images and digital terrain maps (Fig. 2) SRTM and GDEM with our “CzechGlobe” partners (Czech Republic).

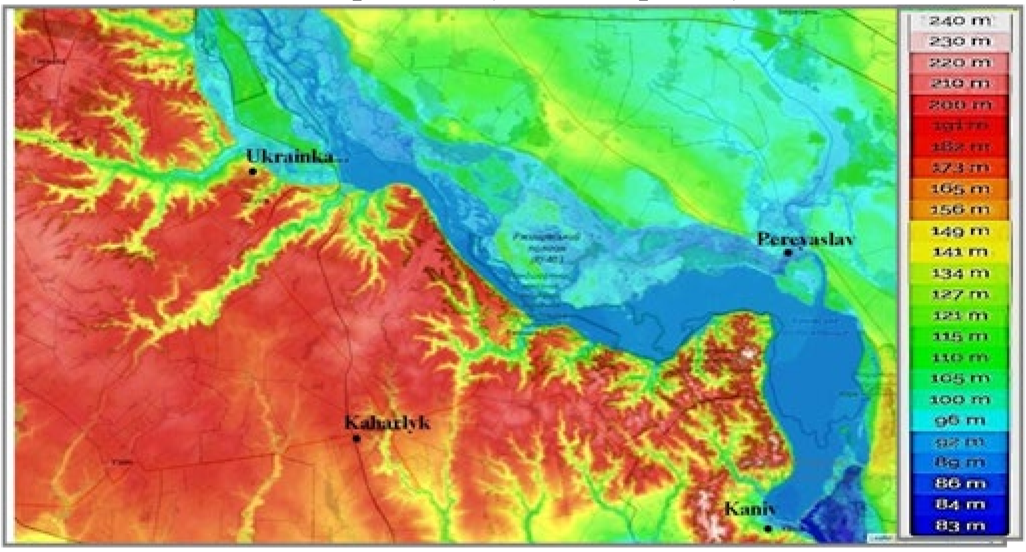

Fig. 2. Digital relief model of Kaniv Reservoir

Results and discussion.

Kaniv Reservoir was filled in 1976 and performs the functions of daily and weekly regulation of the Dnieper runoff to generate electricity mainly during "peak" periods. Thus, its levels fluctuate in a small range of only 20-30cm (Fig. 3). Only in 2010, due to the threat of severe floods [12] and possible flooding of cottages in Koncha-Zaspa, its level was reduced by almost 1 m. The hydro-morphological characteristics of the object change significantly during its operation. In particular, the water surface area [3] and the regulatory capacity of the reservoir decreases due to the accumulation of silt on the bottom, which researchers estimate up to 1 m thick, although the main channel is periodically washed, shallow waters overgrown with macrophytes, island area increases. An important role is played by the hydro-alluvium (dredging) of new lands for country house and cottage development along the left-bank and right-bank dams in the upper part of the reservoir, the area of which we have estimated at more than 1,100 hectares. The formation of hydromorphic landscapes in the reservoir is significantly influenced by geomorphological features of the territory, as both shores of the upper (river) part of the reservoir are lowland, and in the middle and lower (lake) parts the right bank is high and steep (Fig. 4). At the same time, it is in the area of the high right bank that coastal abrasion and erosion occur most strongly, i.e. the banks are transformed (or “reworked” as it is called), and we will discuss this process in detail in Section **«Features of bank transformation in Kaniv Reservoir».**

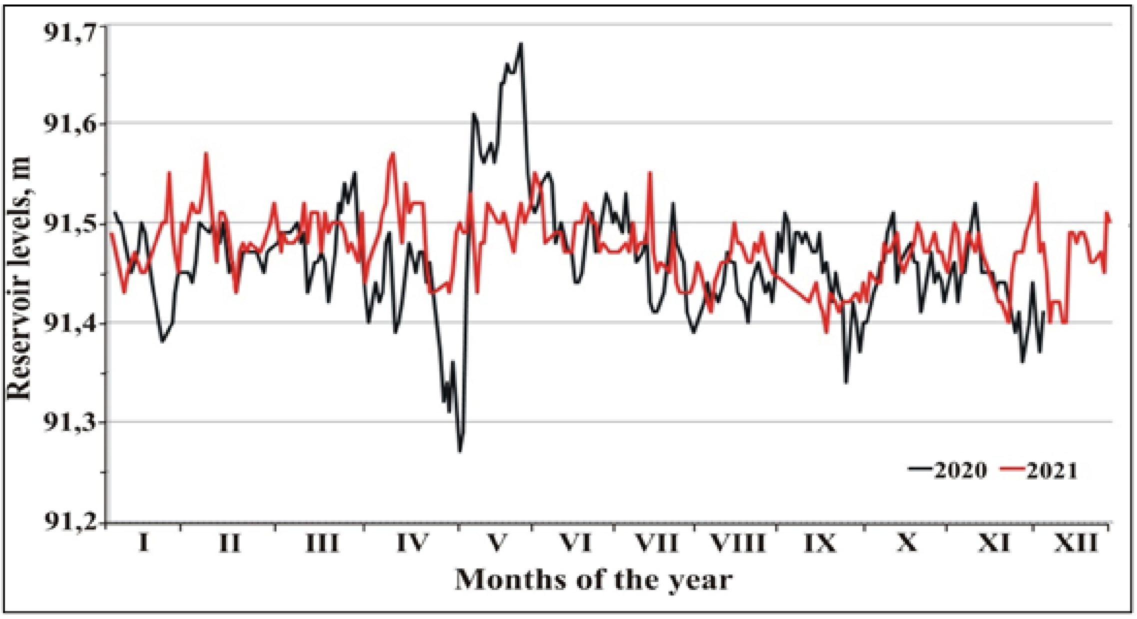

Fig. 3. Fluctuations in reservoir levels in 2020 and 2021

Formation of hydromorphic landscapes in the Kaniv Reservoir.

We use the term "hydromorphic landscapes" as a working name for a set of landscapes formed in reservoirs on hydromorphic soils and shallow sediments under the influence of hydro-morphological, biotic and abiotic processes. And although this term is considered debatable [5], this approach allows us to consider the diversity of

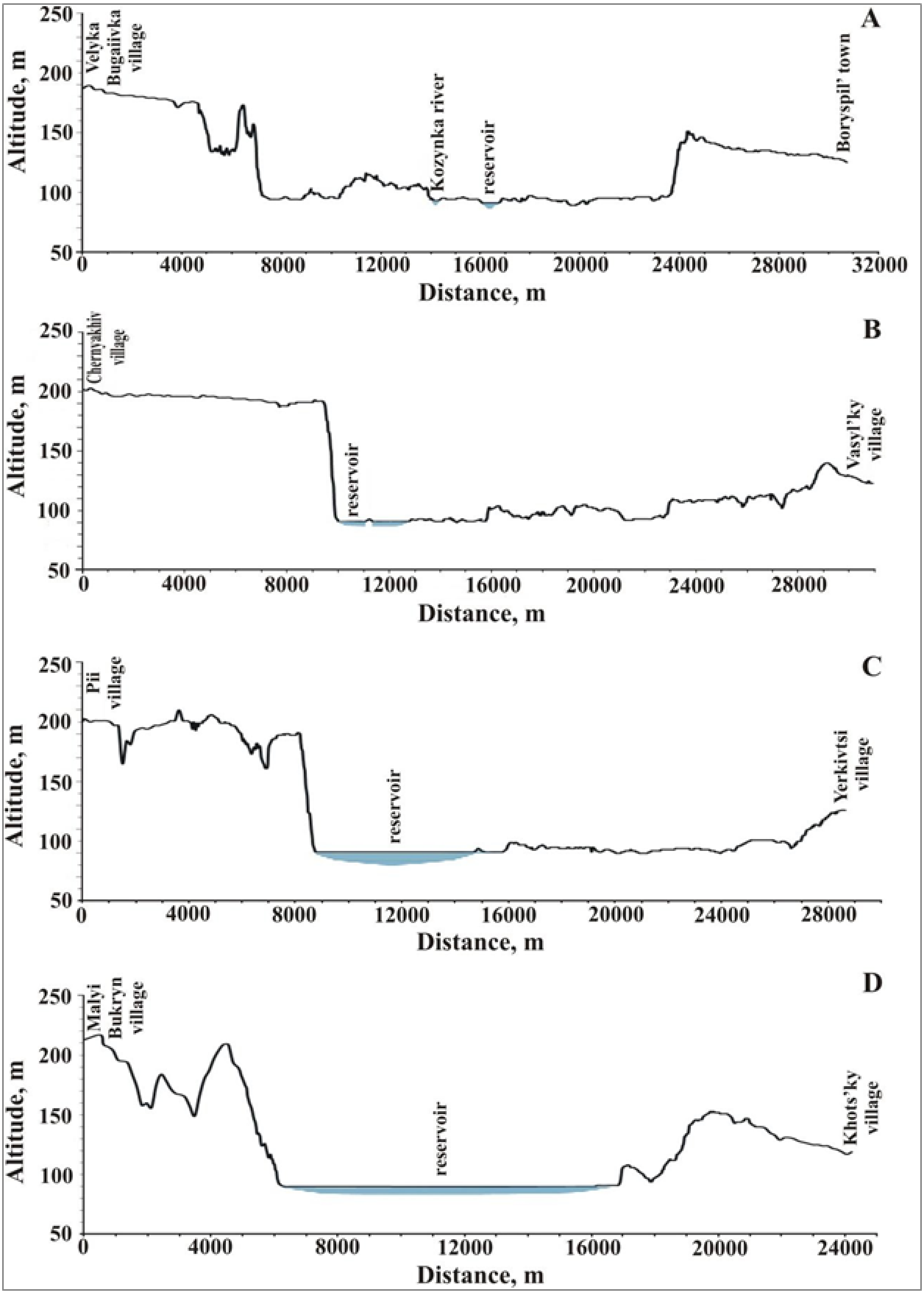

Fig. 4. Transverse profile in the upper (A), middle (B + C) and lower (D) parts of the reservoir

new landscapes formation processes or changes in their existing under the influence of surface water and groundwater of reservoirs in large groups, both littoral and dry land.

In this publication we emphasize first of all the results of remote sensing of the Kaniv Reservoir region, emphasizing the change of water surface areas and, accordingly, the areas of hydromorphic landscapes as a result of their development or destruction, as well as the interaction of water bodies with the coast (banks transformation). If in the first stage of research (at the turn of the last century) mostly field routes were performed on the coast and in winter on the islands (Fig. 5), since 2010 NASA space images – MSS, Landsat- 2, 4-5, 7 and 8 have been actively used to assess landscape changes in time and space, and field water routes were carried out with the support of the Dnieper Basin Management of Water Resources, to which the research results were transferred for implementation.

Fig.5. The first stage of field research

At the first stage, more attention was paid to the study of hydromorphic soils formed under conditions of waterlogging or periodic flooding on existing and newly formed islands, mainly in the upper part of the reservoir (Fig. 6). Among them, sod soils of various degrees of gleying, as well as meadow, meadow-swamp and swamp soils predominated. It is important to note that the formation of soils as a biotope basis of hydromorphic landscapes occurs differently on the "frontal" (mostly northern) part of the islands and on the rear (mostly southern) part of them according to hydro-morphological features and patterns of litho-morphogenesis. In the first case, sandy or sandy-loam layered alluvium is deposited by currents, which is gradually overgrown by meadow and later by shrub and woody vegetation. Here sod and soddy-gley low-humus soils with weakly differentiated profile are predominantly formed. In the rear part of the islands, where the current is smaller, coastal-aquatic and aquatic vegetation is actively developing in shallow water. Dead organic matter, often with layers of silt, gradually accumulates at the bottom of the shallow water and the soil profile is formed from the bottom up. Swamp and meadow-swamp soils with little decomposed organic matter in the upper horizon are formed.

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Fig. 6. Soil profiles on the islands of the reservoir: sod (left), soddy-gley(center) and meadow-swamp soils (right)

Coastal-aquatic and aquatic vegetation, its distribution and successions have been studied around the islands and in shallow water, which are more thoroughly describedin numerous works of botanists, in particular in publications [6, 7, 15]. As part of the very diverse and well-studied vegetation of the reservoir, attention was paid to the active spread (expansion) in its upper part in the shallows of floating water nut (Trapanatans L.) and yellow jugs (Nuphar lutea) listed in the Green Book of Ukraine(2009). Shallow waters with coastal-water and shrub-tree vegetation are overgrown rapidly (Figs. 7 and 8).

Fig. 7. Aquatic vegetation in the reservoir shallow waters

In the middle part of the reservoir, the formation of hydromorphic landscapes is characteristic of shallow waters with numerous islands, distributed along the coast near the Rzhyshchiv military range, where the village of Gusyntsi and its agricultural lands were flooded (Fig. 9). And along the high right bank in the middle and lower (lake-like) parts of the reservoir fragments of hydromorphic landscapes, which we studied using a quadcopter [13], are formed mainly in landslides, talus from high cliffs and outcrops of ravines into the reservoir (Fig. 10).

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Fig. 8. Overgrowth of shallow waters and islands of the Kaniv Reservoir with coastal-aquatic and terrestrial vegetation

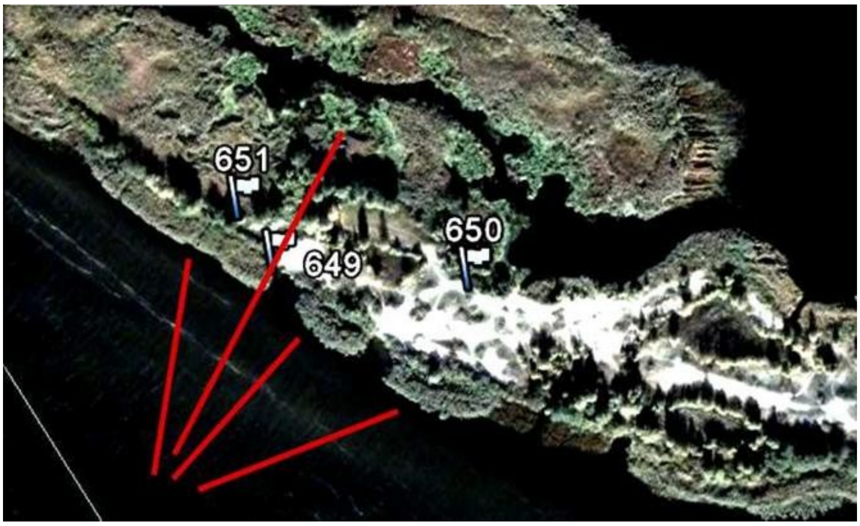

Fig. 9. Fragments of coastal-aquatic vegetation adjacent to the islands nearthe Rzhyshchiv military range (with GPS-points)

Fig. 10. Fragments of hydromorphic landscapes along the high right bank at the foot of marl cliffs

In general, the processes of shallow water overgrowth and the formation of new hydromorphic landscapes in the Kaniv Reservoir are influenced primarily by the influx of large amounts of nutrients from the Dnieper and Pripyat Rivers, which accumulates in the Kiev Reservoir, and Desna River water, which is enriched with dissolved organic matter in swamps of their basins. The wastewater of the Bortnychy system, which purifies the waters of the Kyiv metropolis, also plays a significant role in the inflow of nutrients. We should also take into account the role of hydraulic alluvium lands (dredged lands) creation along the right bank with the formation of non-flowing "Venice" canals to elite cottages, clearly visible from space, where the Dnieper water stagnates, pollutes and "blooms" (Fig. 11, 12).

Fig. 11. Non-flowing canals to elite buildings (left) and private islands on hydraulic alluvium lands (right)

The movement of Dnieper River water in the reservoir and infrastructural objects of the left-bank country massifs are slowed down. The hydraulic alluvium new lands formation, together with the intensive construction of the territories adjacent to the upper part of the Kaniv Reservoir, significantly threatens the possibility of passing extreme floods on the Dnieper River and flooding the southern part of Kyiv [4,12,13].

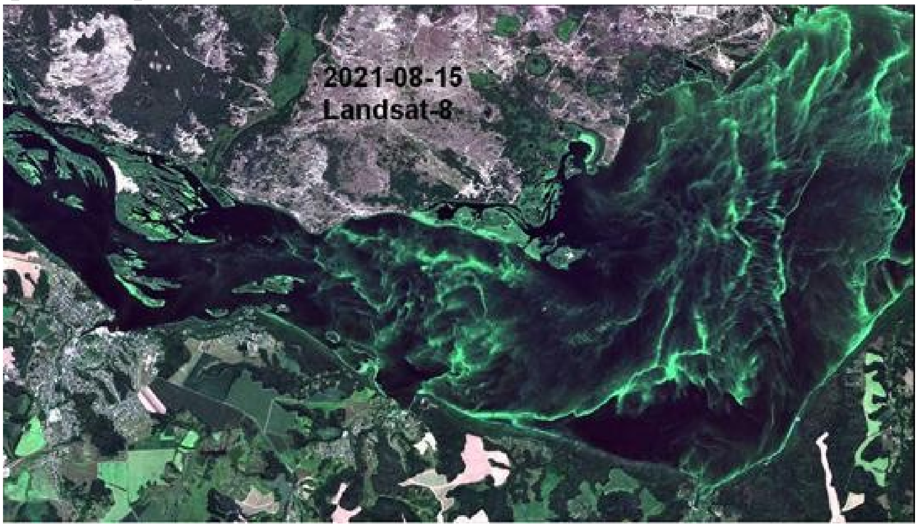

Fig. 12. "Blooming" of water in the middle part of the reservoir (Landsat-8,2021-08-15)

After the first attempts to display the spatio-temporal dynamics of landscapes on topographic maps based on the content of MSS and Landsat-2 space images, which became available to us from the NASA archives [11,12,18], we began to systematically use image visualization Landsat-2, 4-5, 7, 8 in a computer program (Isodata algorithm). The series of images (Fig. 13) of the reservoir upper part (between the protective dams) shows the area before filling the reservoir (1975), and then the time series until 2018 and an example of images classification with 6 classes of surface (deep water, shallow water with vegetation, aquatic vegetation floating, coastal-water and meadow vegetation, shrub-forest vegetation, dry land). To compare the areas, late summer images were used, when the vegetation was maximally developed [19]. In addition, the seasonal dynamics of hydromorphic landscapes from the flood period to the stage of maximum development of aquatic and coastal-aquatic vegetation was detected, as well as its gradual extinction until winter (if, of course, high-quality cloudless images were collected). A strikingly large increase in the area of such landscapes in one season was in the hottest 2010. The development of vegetation in the Kaniv Reservoir is also facilitated by the long-term increase in water temperature during the growing season of about 0.65° C for decades [3]. In recent years, Sentinel-2a and 2b images have been used to study spatio-temporal dynamics.

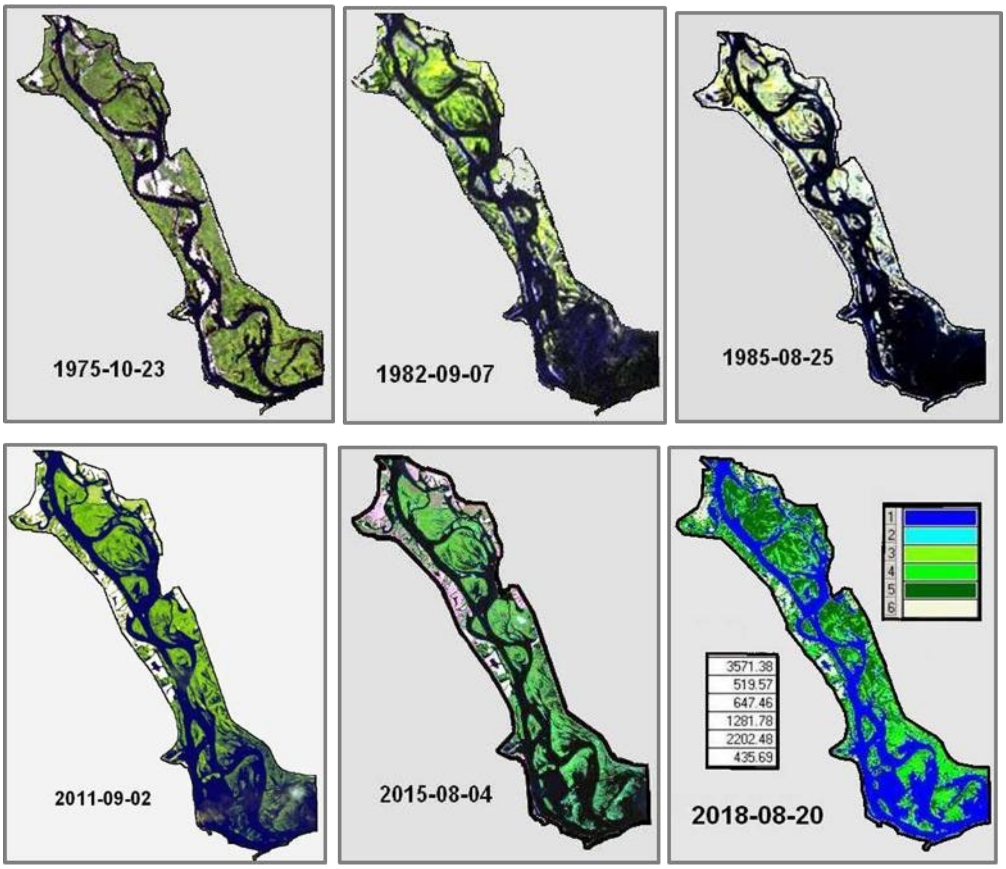

Fig. 13. Spatio-temporal dynamics of landscapes in the upper part of the reservoir according to the satellites Landsat-2, 4-5, 8 and an example of the space image classification. In 1975, the area was not flooded yet

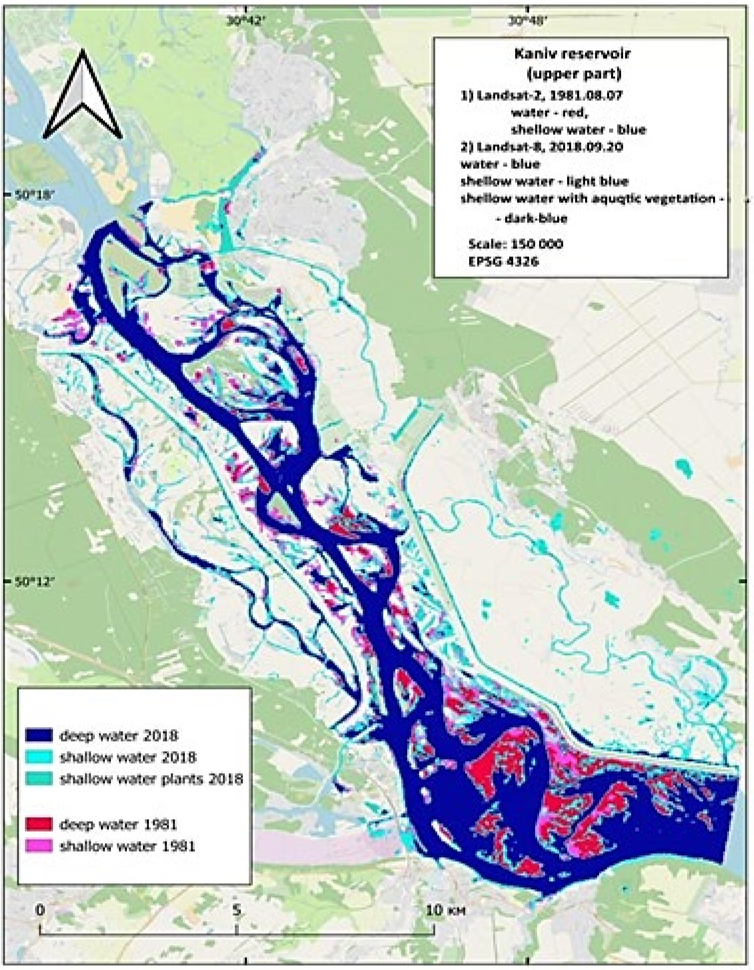

Fig. 14. Assessment of landscapes changes in the upper part of the reservoir for the period 1981-2018

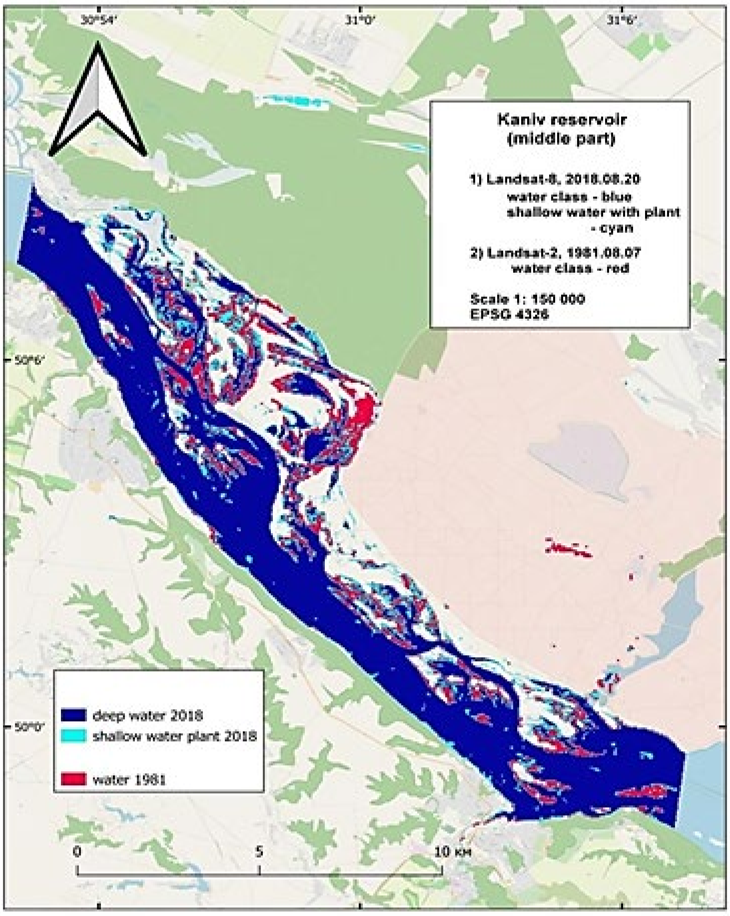

Fig. 15. Assessment of landscape changes in the middle part of the reservoir for the period 1981-2018

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Quantitative assessment of changes in landscapes is carried out by comparing (overlapping) classified images (operation "change detection") for the period of observations. An example of such an assessment for the Kaniv Reservoir for the period from 1981 to 2018, carried out in the program QGIS-3.2.0, is shown in Fig. 14-16.

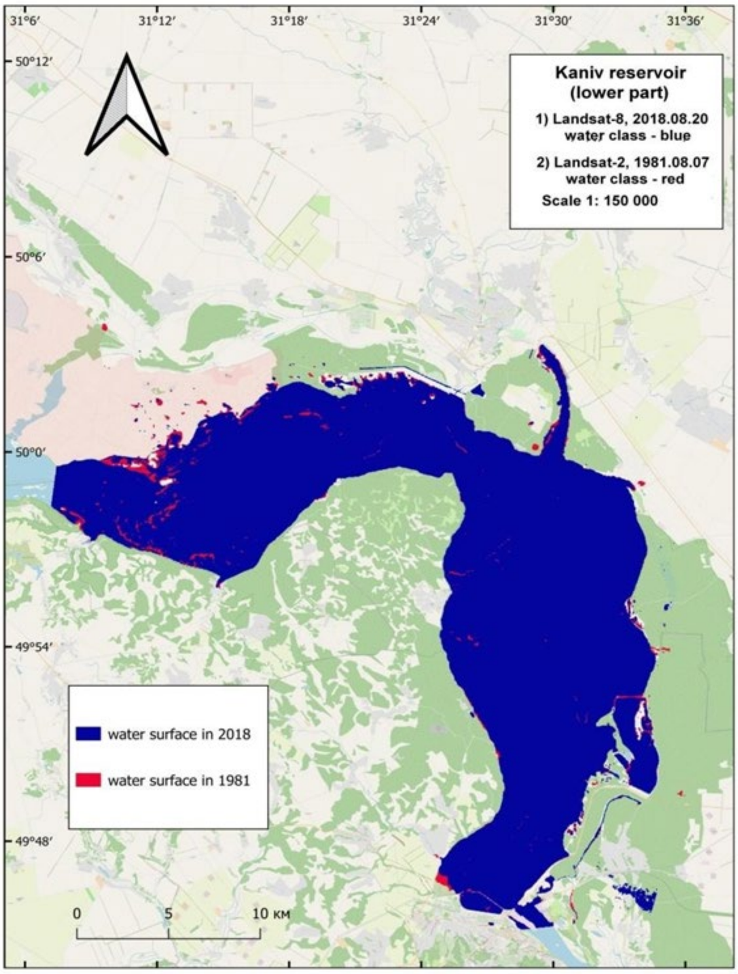

Fig. 16. Assessment of landscapes changes in the lowerpart of the reservoir for the period 1981-2018

Features of bank transformation in Kaniv Reservoir.

The geological structure of the Dnieper river valley in this area involves layers of different ages – from Paleozoic to Cenozoic. The contours of the reservoir water table(675 km^2 with a total volume of 2.62 km^3) are determined by the features of reliefand geological structure (Fig. 2, 4). Soil-forming rocks on the high right bank are mainly coarse-grained light-loam loess. They are underlain by layered Neogene and Paleogene sediments of different mechanical composition (particle size distribution), and at the height of the normal water level (NWL) of the reservoir there are marl clays, which significantly weaken the processes of shore abrasion. On the low left bank there are alluvial sands of the “pine” terrace, which are further overlain to the east by loess-like loams. Soil cover of the high coast is dark-gray podzolic soils and chernozem (typical and podzolic) of varying degrees of erosion. Hydromorphic and semi-hydromorphic soils are widespread on the low shores, and on the “pine” terrace along the left bank there are sod-podzolic soils, more typical for Polissya, occupied by forest vegetation.

Features of the geological structure of the region, relief and soil and vegetation significantly affect the bank transformation during long-term operation of the reservoir under the influence of hydro-morphological processes, measures to protect the coast from erosion, channel deepening and hydraulic alluvium of new land by dredging (mostly in upper part of the reservoir), arrangement of fishery, hunting and recreational facilities. The relief of the territory adjacent to the Kaniv Reservoir differs significantly in its upper river part from the middle and lower - lake-like (Figs. 2, 4). The shores of the upper part of the reservoir are low and sloping, sometimes even below the level of the reservoir. Therefore, the area is protected by dams and needs protection from waterlogging. And in the middle and lower parts of the reservoir the right bank is high and steep, often with vertical cliffs to the reservoir. Accordingly, this part of the shore exposed to waves and currents, especially when the level fluctuates due to runoff regulation. And the shores themselves are subject to planar and strong ravine erosion. The left bank is very low and swampy from the village of Kyiliv to the town of Pereyaslav, further south is a gentle “pine” terrace.

The bank transformation in the upper part of the reservoir began when it was built, when the low banks were separated by dams from potential flooding when filling the reservoir, and pumping stations were built in the area of Plyuty and Kyiliv villages to drain filtration water and water from the small rivers Kozynka and Pavlivka. However, significant changes began when within the water area of the reservoir hydraulic alluvium of new lands began to create by dredgers during the deepening of the main channel and take them for development by country societies (“dachas”) and private estates. The thickness of the accumulated ("washed") sand did not exceed 1-3 m above the NWL, which did not provide such buildings from inundation during high floods, non-flowing canals between individual building blocks were built, in which water became stagnated and "bloomed", as shown earlier (Fig. 11, 12), access of the population to the reservoir was stopped.

Already in 2010, the area of hydraulic alluvium of lands by dredging exceeded 1,100 hectares, much of which has been developed by the owners and is no longer diagnosed in space images. It is extremely important to inform that such construction significantly hinders the possibility of passing extremely high floods in this part of the Dnieper River and threatens flooding and waterlogging of the southern part of Kyiv and adjacent to the reservoir settlements [12]. After our appeal in 2013 to the Ecological Prosecutor's Office of Ukraine with such information, the alluvium of lands within the reservoir water area was stopped for several years. However, in recent years it has been actively renewed (Fig. 17. 18), so this problem needs to be addressed at the state level.


Fig. 17. Hydraulic alluvium of new lands by dredgers in the Kaniv Reservoir: on the left – accumulated (“washed”) areas in the upper part of the reservoir (shown by arrows), on the right - closed access to the reservoir by buildings

Fig. 18. Active restoration of alluvium lands by dredging and a construction development in the former water areas in 2021

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As already mentioned, large-scale (to some extent unique) measures have been taken at the Kaniv Reservoir to engineering the protection of low-lying shores and to create so-called “polder” systems here. Almost 80 km of embankment dams, 7 pumping stations with a capacity of 159.2 m^3 / sec, and 75 km of drainage canals were built to protect the coastal soils from inundation and waterlogging. In total, 45.6 thousand hectares of land were protected from flooding, including 25.2 thousand hectares of agricultural land, as well as the city of Pereyaslav (formerly Pereyaslav-Khmelnytsky). It should be noted, however, that the operation of pumping stations has become an extremely acute problem in recent decades due to the significant increase in the cost of electricity. Under such conditions, the shutdown of pumping stations will lead to inundation and waterlogging of protected areas, including elite houses and cottages that were built on these lands. A particularly dangerous situation will develop on the western outskirts of Pereyaslav [12]. The massif "Protection of floodplains of the rivers Trubizh and Karan" 45 km long and 4 to 12 km wide is located near the town of Pereyaslav. The area of 30 thousand hectares is protected, including reclaimed lands along the Karan and Trubizh rivers (11 thousand hectares), the outskirts of Pereyaslav, as well as a number of villages along the Karan River. Protection is provided by three dams, a drainage channel and a powerful pumping station. This station, which has 8 pumps, annually pumps 300-400 million m^3 of water from the Trubizh River and the drainage canal. To eliminate siltation of the channel near the pumping station, about 10 thousand m^3 of sediments are removed annually. Operating costs for these works have increased significantly in recent decades due to rising electricity prices and the cost of the work itself. However, it is not possible to stop pumping river and drainage water into the reservoir, as protected areas will be flooded. This is how a complex engineering decision on land protection has become a burden on the state budget.

Of particular note is the erosion of the high banks along the middle and lower part of the Kaniv Reservoir (from the village of Khalepya to the Kaniv town). Soil-forming rocks on the high right bank – mostly loamy, quite susceptible to water erosion. And they are underlain mainly by layered Neogene and Paleogene deposits of different particle size distribution. It is extremely important that the territory is highly dissected (Kaniv dislocations, Fig. 4), the slopes to the Dnieper are mostly steep and sloping, of various shapes and granulometric composition (“texture”), directly to the reservoir water's edge they often end in vertical steep cliffs of marl clays up to 20-25 m. There are also cliffs of the same height at a considerable distance from the reservoir, mostly loess, as a result of past tectonic movements (for example, near the village of Grebeni). The territory is also divided by ravines (Figs. 2, 21, 24), in which the vertical loess exposure also reach 19-20 m. The total height of the loess height above the reservoir level is more than 100 m. Shores with cliffs of marl clays stretch (Figs. 20, 21, 25) in a continuous strip from the town of Rzhyshchiv to the village of Khodoriv and continue almost to the Trakhtemyriv village. They are quite resistant to erosion by running water and waves of the reservoir, but still subject to physical and biological weathering in the upper layer (including the roots of woody vegetation). There are collapses of the rock in whole blocks, including trees (Fig. 20).

Fig. 19. Protected valley of the Trubizh River (above), cottages in the area of possible flooding (in the middle), Trubizh pumping station (below)

In general, the transformation of the shores here occurs both under the action of currents and waves of the reservoir, and under the influence of surface runoff, which is concentrated in small and large ravines and destroys marl clays (Fig. 21). Hydromorphic landscapes are formed in fragments at the outlets of ravines [13] during the development of coastal-aquatic and aquatic vegetation on ravine sediments.

Fig. 20. The shore near the village of Balyko-Shchuchynka (left) and anexample of marl clays destruction (right)

Fig. 21. Transformation of shores by ravines with outputs of marl clays: 1-deep ravine; 2- shallow ravines; 3-fragments of hydromorphic landscapes created by coastal-aquatic and aquatic vegetation on ravine sediments

In some parts of the right bank there are high loess cliffs at a considerable distance from the water's edge (Fig. 22), which is typical for Kaniv dislocations. And the area between the cliffs and the reservoir is densely overgrown with woody vegetation and quite resistant to erosion. The most eroded parts of the coast were studied in detail by Panasyuk I.V. with colleagues [7]. And the average intensity of transformation of shores on the basis of long-term monitoring is estimated from 0.1 to 6.87 m with a long-term average of 0.46 m [1]. In general, researchers believe that the rate of erosion over the past 20 years has decreased significantly, except for some areas.

It is worth noting that to combat coastal erosion on the most valuable parts of the coast, such as the famous Monument of Glory in honor of the Great Patriotic War in Balyko-Shchuchynka – protection is provided by a stone dump (Fig. 23).

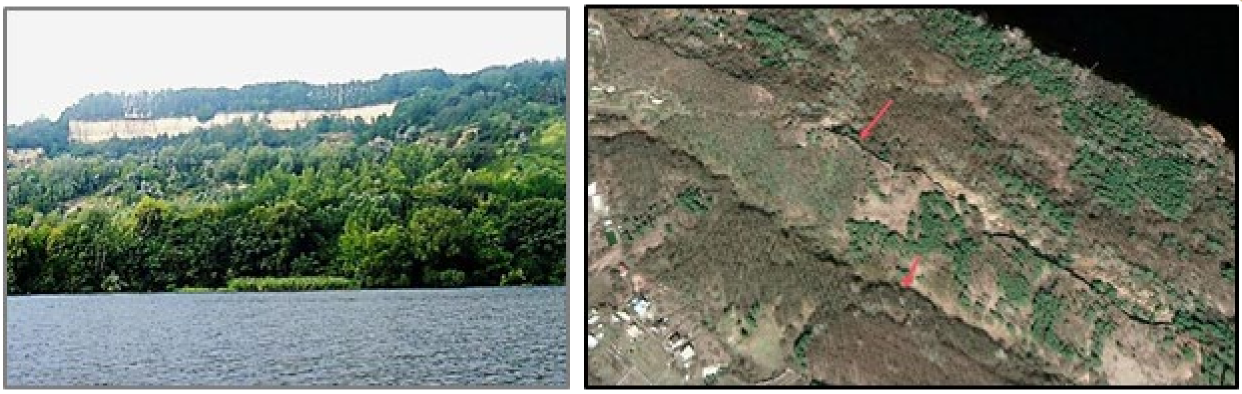

Fig. 22. Loess exposures (cliffs) near the village of Grebeni: on the left - view from the reservoir, on the right – view from above (arrows show cliffs)

Fig. 23. The Monument of Glory in Balyko-Shchuchynka protection against erosion by the stone dump

Actively growing deep ravines remain a great danger for the landscapes of the right bank (Fig. 24). Although they are mostly forested, the lack of earthen ramparts around their tops leads to the ravines advance on arable land and infrastructure.

Fig. 24. A deep active ravine north of Rzhyshchiv advances on arable land

Fig. 25. General view of the steep cliffs on the right bank from the Balyko-Shchuchynka village to the town of Rzhyshchiv (left) and to the village of Trakhtemyriv (right)

Recreational role of Kaniv Reservoir.

Although a number of negative ecological processes take place on the coast, islands and water area of the Dnieper Reservoirs, including the Kaniv Reservoir, their recreational role is very large. After all, a large number of cities and villages of Ukraine are concentrated along the Dnieper and the cascade of reservoirs. Many recreation centers, yacht clubs and other recreational facilities have been established in the upper ("river") part of the Kaniv Reservoir. On many islands in the summer there are many natural recreation centers, where sanitary conditions are not always optimal. And the mountains of garbage after such "vacationers" do not improve the ecological situation here, which is clearly seen in the block of our photos (Fig. 26). But the real evil for the recreational use of the Kaniv Reservoir was the inaccessibility of the shores for local citizens. Huge fences, barriers, security separate locals from the shores and water for tens of kilometers along both the right and left banks from Kyiv to the town of Ukrainka or the village of Kyiliv. However, luxury villas are located downstream directly in the coastal protection zone near the water, increasing water pollution and "blooming" of water.

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Fig. 26. Examples of organized and unorganized recreation on the islands of the Kaniv Reservoir

Conclusions

1) Our research has shown that the increase in the area of hydromorphic landscapes in the Kaniv Reservoir in 1981-2000 averaged 49 ha / year, in 2001-2018 – 86 ha / year, and the average increase for the whole period was 70.5 ha / year. The total area of these landscapes growth was 2680 hectares, with the largest increase in the upper and middle part of the reservoir.

2) As part of the diverse and well-studied vegetation of the reservoir, it is advisable to emphasize the spread (expansion) of floating water nut (Trapa natans L.) and yellow jugs (Nuphar lutea), listed in the Green Book of Ukraine (2009), in shallow water of the reservoir upper part due to inflow of organic matter with wastewater and high summer temperatures.

3) The soil cover of the islands is formed according to the litho-morphogenesis of their different parts. On the anterior (relative to the current) parts of the islands, silty- sandy and loamy-sandy layered sediments are deposited, on which meadow and shrubby-woody vegetation settles and sod soils of various degrees of hydromorphism (and even podzolization) forming with light granulometric composition (texture), low-humus content, and with poorly differentiated profile. The rear shallow part of the islands is dominated by cattail-reed vegetation; the soil profile is formed from the bottom up by accumulating organic matter of dead plants with layers of alluvium. It is dominated by swampy and meadow-swamp strongly gleyed soils with a layer of poorly decomposed (or weakly peat) organic matter on the surface.

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4) Intensive increase in the area of hydromorphic landscapes is observed and forecasted in the rear (relative to the current) part of large islands in the upper (river) part of the reservoir, along the left bank of the dam to the village of Kyiliv, in the area of wetlands between the Kyiliv village and Rzhyshchiv military range. Active overgrowing with aquatic vegetation (with floating leaves) continues in the summer throughout the territory between the town of Ukrainka and the village of Kyiliv. Fragmentary formation of hydromorphic landscapes continues along the high coast (marl cliffs) of the right bank on landslides deposits.

5) The role of non-flowing canals to individual and country buildings on dredged lands in strengthening the "blooming" of water due to the reduction of flow rate and household pollution was detected.

6) In the methodological plan at the hydromorphic landscapes analysis on space images it is expedient to specify: a) diagnostics of territories with submerged aquatic vegetation distribution; b) the correctness of the proposed by us classification of the earth's surface types in addition to the standard use; c) the reliability of the method of assessing the possible flooding of territories during extreme floods because of building development intensification in recent years and overgrowing with woody vegetation.

7) The problem of the coast transformation on the high right bank due to erosion and other exogenous processes remains relevant, although the rate of erosion has decreased significantly over the past 20 years, except in some areas. The average intensity of shores transformation on the basis of long-term monitoring is estimated from 0.1 to 6.87 m per year with an average long-term value of 0.46 m / year [1]. There is still a need for quality care of forest plantations, which protect the shores from erosion and landslides, the earthen ramparts around the active ravines tops , reducing the area of arable land adjacent to the slopes. And the most valuable areas of the coast need engineering protection, as it has already been done near the famous monument in Balyko-Shchuchynka, river ports, etc. We consider it inexpedient to recommend the State Administration for Tourism Development of Ukraine to resume the use of “Raketa” vessels on this reservoir for water transport due to high waves, which increase the shores abrasion.

8) We consider the problems of assessing their recreational suitability and environmental value, prospects for fishery use, radioactive contamination, as well as the loss of historical, cultural and spiritual heritage due to the construction of the reservoir and the resettlement of people from flooded settlements to be priority for further study of the Kaniv Reservoir landscapes.

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