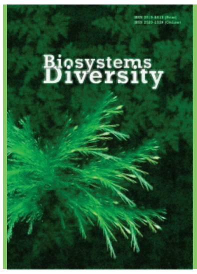

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Complex characteristics of landscape components affected by the disaster at the Kahovka Hydropower Plant

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The paper provides an in-detail analysis of the flooding in Kherson and Mykolaiv oblasts as a result of the explosion at the Kahovka Hydropower Plant (HPP). We considered the possibility of using a combined analysis of the data of on-ground and remote monitoring of the course and consequences of the flooding. Based on the materials of the Ukrainian Hydometeorological Center of the State Service of Ukraine, we determined control points of chronology of the events and the dynamics of the main hydrometric indicators. The flooding began on 05/06/2023, the water returning back to the regular levels on average on 26/06/2023. The highest levels of water were observed in the period between June 7 and June 9, 2023. The synchronicity of the satellite surveillance of the territory during this time is representative. Based on the parameters of spatio-temporal resolution and degree of cloud cover, we chose the satellite images from Landsat 9 as the basic materials for our study. Using a modified normalized water index, we identified changes in the water area in the indicated time period. Using a digital model of the territory's relief, we elaborated the zone of spread of the water surface in areas with dense vegetative cover. We found flooded zones where the water was much higher than the maximal levels recorded at the hydrological-monitoring checkpoints. The elucidation of estimations of the flooding zone revealed the components of natural landscapes that have been affected by the techogenic catastrophe. The flooding pummeled the azonal landscape complexes and complexes of above-floodplain terraces and coastal plains. The results of our study are an important step towards assessing the degradation of the downstream-Dnipro ecosystem. They will lay the groundwork for designing plans to liquidate the aftermath of the emergency and adaptation measures in the conditions of increasing risk of devastating technogenic events.

Keywords: flooding; remote monitoring; normalized water index; landscape complexes; flood surge; Ukraine.

Introduction

The pollution of Ukrainian territory as a result of the disastrous ruination of the Kahovka HPP became an international problem. Therefore, crop and animal farming, as well as the forestry in the basin of the Dnipro underwent hydrological changes. At the same time, not only are soil fauna and vegetative cover in the adjacent territories are at risk, but also aquatic areas at a large distance from the ruined Kahovka HPP, the threat increasing every day.

The explosion at the dam disrupted the food chains in the natural ecosystems and agrocoenoses, and also caused active migration and accumulation of toxic compounds in the environment (Strokal & Kovpak, 2022; Martyukhin & Voloshina, 2023). The explosion at the Kahovka Hydropower Plant in 2023 led to an ecological disaster, submerging a large area. As a result, unique natural ecosystems have been destroyed and the environment has been contaminated, inflicting serious damage (Sanina & Lyuta, 2023). The floodwater drifted myriad contaminants from the benthic deposits of the Kahovka Reservoir into the sea, and also washed out a part of deposits from the flooded downstream-Dnipro areas, which accounted for over 2,000 ha (Tuchkovenko & Stepanenko, 2023; Tuchkovenko et al., 2023).

Ruination of the Kahovka HPP dam became a disaster for aquatic organisms and 42 species of fish, including 20 species of industrial fish (Novitskyi et al., 2024). According to the researchers, over 11 thousand tons of fish were lost just in first days of the catastrophe as a result of destruction of almost all their spawning and feeding sites.

The large amount of water pouring from the breached dam not only has caused a spread of toxic compounds, but also dangerous biological objects that pose threat to wild and domestic animals on land and hydrobionts of the Black-Sea region (Tukalo et al., 2023). Destruction of the dam can have negative implications not only for Ukraine: it will hamper obtaining clean water and endanger sanitary safety in the neighboring countries, and also increase the risk to food safety (Shumilova et al., 2023).

Changes in the quality of water of the Dnipro-Bug Liman near villages of Mykolaiv Oblast right after the disaster in June, 2023, were described by Trokhymenko et al. (2023). In this period, deterioration of the sanitary-chemical and microbiological parameters was found. In the same period, there was observed a dangerous level of pollution of the Inhulets River, where water surged as well, causing flooding of civic infrastructure. The reason for this pollution was wastewater from ruined cattle-burial sites and rubbish swept from the flooded territories.

Trokhymenko et al. (2023) also researched the quality of marine water by the shores near the Odessa Agglomeration. Those authors tallied excesses above the threshold concentrations in marine water for ammonium nitrogen, oil products, toxic metals (zinc, cadmium, and rat poison), and chlorine-organic compounds. In June, 2023, causative agents of infectious diseases were recorded: *Salmonella*, rota- and astroviruses. At the same time, recorded excess above the normative requirements for the index of lactose-positive *Escherichia coli*, and also the presence of *Vibrio cholera* were recorded. As for parasites – the marine water was found to contain eggs and larvae of helminths of animals and people.

According to the Government of Ukraine, discharge of wastewater and manure into the aquatic ecosystems and drinking water poses risks of microbiological contamination. The basin of the river and the Black Sea (CDC, 2023) contained lactose-positive *E. coli*, cholera pathogen, *Amoeba*, *Giardia*, *Enterococcus*, rotaviruses, *Salmonella*, astroviruses, *Cryptosporidium*, causative agents of trichocephalosis, toxocariasis, strongyloidiases, ascaridosis of people, and *Staphylococcus*. The exact source of those pathogens was unknown, but the data of the Ministry of Environment suggest freshwater organisms that had died due to the dam's breach and had drifted to the shore near Odessa (Ukraine, MEPNR, https://ecozagroza.gov.ua/en/news/121). This could have stimulated algal bloom.

Nowadays, it is relevant to study the zones of accumulation of contaminants, comprehensively assess them, including sampling in and analysis of high-risk zones, identifying contaminants of soil deposits, and discharges of chemical compounds. Therefore, researchers are sampling soil in the flooded area (downstream the dam), performing agrochemical surveys of agricultural lands and gardens that have been flooded, and perhaps contaminated, and assessing danger levels of food products. According to various researchers, monitoring quality of the surface must be continued. However, monitoring of biological and chemical contaminations in samples of biota right after the disaster is impossible, since bioaccumulation requires some time (Rapid Environmental Assessment of Kakhovka Dam Breach Ukraine, http://doi.org/10.59117/20.500.11822/43696). The objective of this paper was to designate zones below the Kahovka HPP and provide a general characteristic of natural components of the landscapes affected by the flooding.

Material and methods

Flooding of the territories (Fig. 1) of Kherson and partially Mykolaiv oblasts began on 6/05/2023.

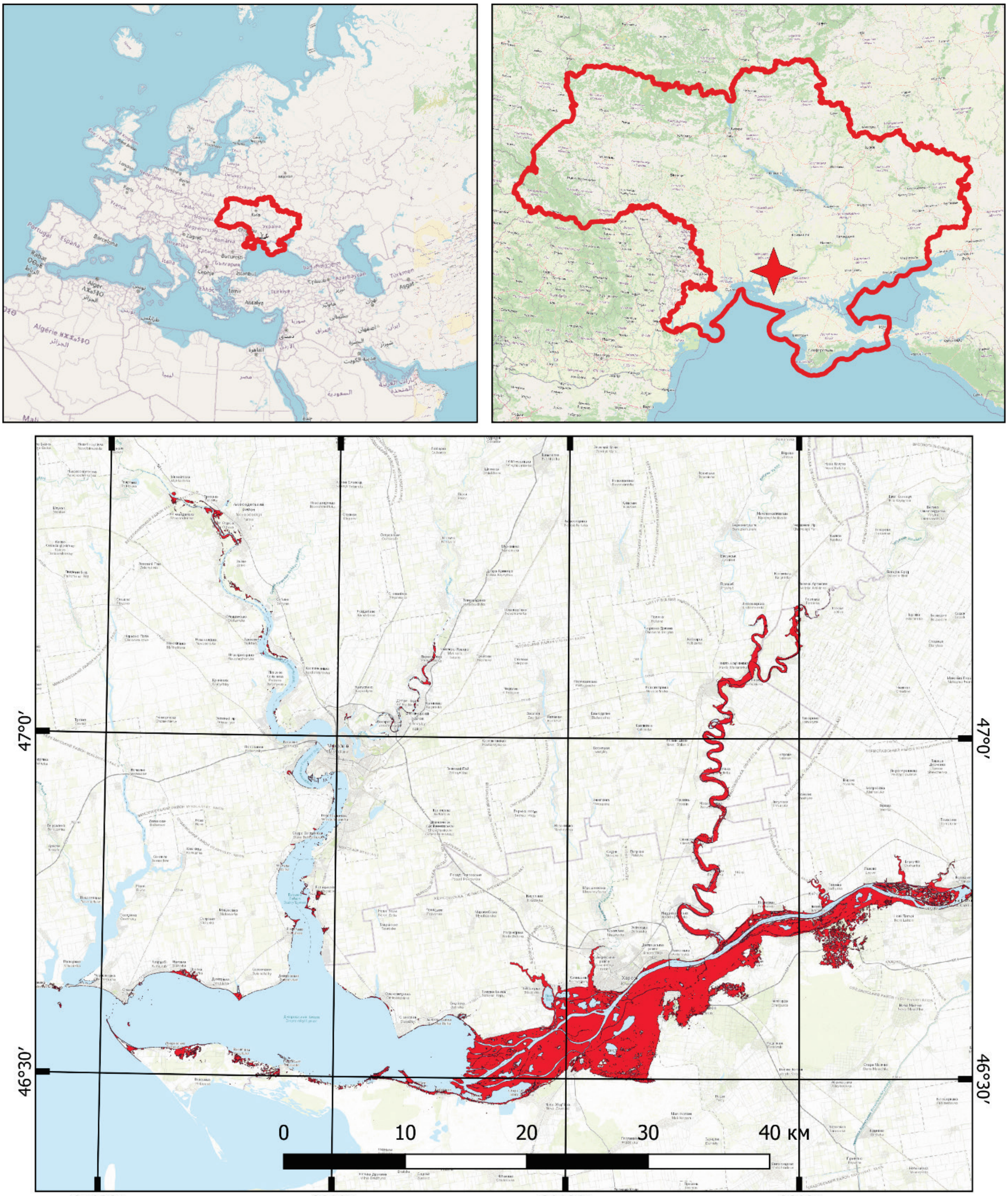

Fig. 1. The area of the technogenic disaster

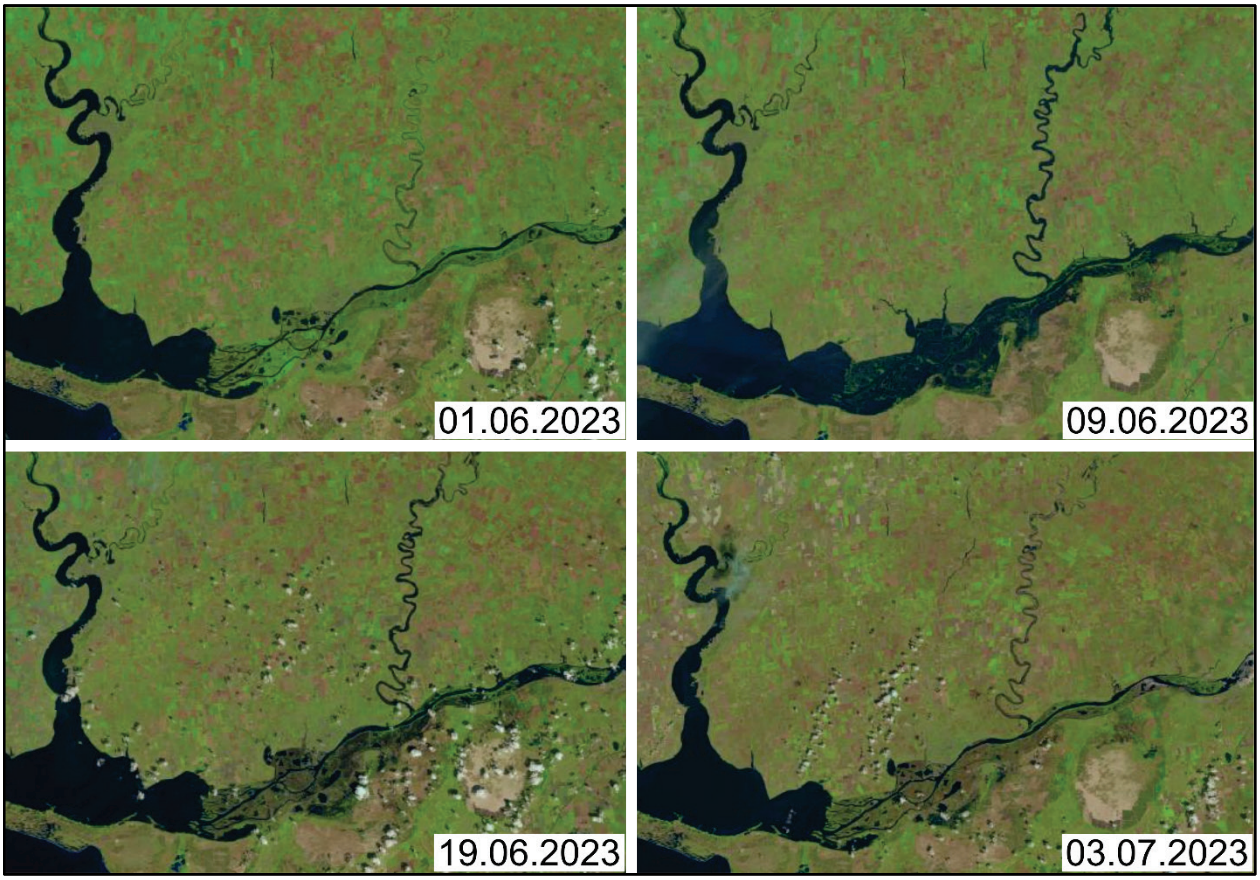

Fig. 2. Dynamics of the flooding (Landsat 9 satellite images)

The water level peaked (5.68 m) on 07.06–09.06.2023 (Magas et al., 2023; Vyshnevskyi et al., 2023; www.meteo.gov.ua/ua/Misyachnii-ohlyad). Since June, 9, the water level declined, with the dynamic of 1–8 cm per h. Finally, the situation normalized in early July, 2023. Visually, the dynamics of the event can be seen on Figure 2. To create a temporal sequence, we used Landsat 9 satellite images.

The flooding zones were designated using a combined method. On the first stage, we used satellite images. This allowed us to identify the general zone of spread of the water surface prior to and after the flooding. For this purpose, we analyzed the satellite images of the area for the period between January 1 and June 9, 2023.

While selecting the satellite images, we considered the following criteria: the resolution of images of no less than 30 m, coverage of the study area by minimum amount of images; frequency of taking pictures of the area no less often than twice a month; the level of cloudiness of the image extent >10%.

We chose the images of the Landsat 9 sensor; product type – OLI_TIRS_L1TP. All the images were borrowed from an online tool of the Geological Service of the US GloVis (Global Visualization Viewer, www. usgs.gov). Landsat 9 has an optical beneficial loading with visible, near infrared and shortwave infrared sensors, comprising 11 spectral ranges: 8 ranges with 30 m resolution, 1 panchromatic spectrum with 15 m^2 resolution, and thermal spectra of 60 m resolution, with 185 km swath width (at nadir) (European Satelite Agency URL:ESA – Sentinel-2 overview).

Preliminary analysis of the images was performed using SCP module (semi-automatic classification plugin), integrated into QGIS. Analysis of the images included standard procedures of calibration and atmosphere correction, according to the recommendations (Semi-Automatic Classification Plugin Documentation – Semi-Automatic Classification Plugin 7.9.7.1 documentation (semiautomaticclassificationmanual.readthedocs.io)). The water surface was identified using the normalized water index MNDWI (modified normal difference water index) (Xu, 2006).

$$\text{MNDWI} = (\text{Green} - \text{SWIR}) / (\text{Green} + \text{SWIR}) \qquad (1)$$

where Green is the spectrum of visible green color (0.53–0.59 μm); SWIR – near infrared spectrum (1.57–1.65 μm).

To identify the vegetative cover, we assessed the normalized vegetative index NDVI (normalized difference vegetation index, https://earthobservatory.nasa.gov/features/MeasuringVegetation/measuring_vegetation_2.php):

$$NDVI = \frac{NIR - RED}{NIR + RED} \qquad (2)$$

where NIR is the coefficient of reflection in the near infrared spectrum; RED – coefficient of reflection in the red spectrum.

For some shallow-water areas with vegetative cover, MNDWI acquired the value ranging –0.30 to 0.15. Therefore, to improve the identification of flooded zones with a shallow water layer or flooded zones with lush vegetation, we estimated difference between MNDWI as of June 6 and June 9, 2023 (Fig. 3).

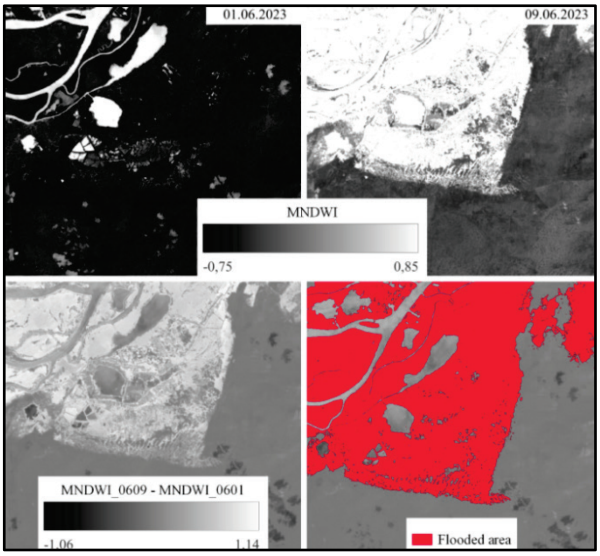

Fig. 3. Example of designation of flooded areas

The values of differences between MNDWI that approached 0 corresponded to the permanent conditions of the area. The positive values of the indicator suggested a change in the conditions of moisture in the territories during a certain period.

In flooded areas and islets with dense vegetation (mostly those were forestlands with broad-leaved and coniferous trees), designation of the flooding zone was carried out using a digital model of the area relief (DMR). The basis for the DMR of the study area was Copernicus DEM (Copernicus DEM – Global and European Digital Elevation Model (COP-DEM), https://link.dataspace.copernicus.eu/bie). The resolution of this model of relief accounted for 30 m, which completely corresponded to the resolution of the images from Landsat 9.

The landscape structure, vegetation, and soil cover of the flooded zone within Kherson Oblast are presented using cartographic materials (Grunty Khersons′koyi oblasti, 1966; Didukh & Shelyag-Sosonko, 2007; Marynych et al., 2007; Geoinformaciynyy Portal Khersonskoyi oblasti, https://bit.ly/3A3c0HK) and scientific sources (Marinich et al., 1985; Baydikov, 2017). Soils of the flooded zone were classified according to the World Reference Base for Soil Resources 2022 (IUSS Working Group of World Reference Base for Soil Resources, 2022), based on the available materials. Identification of the types of soil textures was limited due to a large diversity of texture of most reference groups of soils in the study area and absence of comprehensive data regarding some soils presented in the study.

Results

Using zonal statistics, according to the preliminary MNDWI-assessed layer of the flooding zone, the maximum absolute height of the flooded area was identified, which accounted for 21 m. The territory with those absolute values is southeast of the Krynky village (Fig. 4). The most likely explanation of this is that the wave that had formed in the first minutes after the explosion at the dam overcame the streambed natural levee on the left bank and reached the high floodplain in the area of the Korsunka village, and then, following the inertia, moved almost 8 km deeper into the territory. The shape of this flooding zone can be explained by the area's complex relief and high absorbing ability of the local soils.

The final variant of the flooded zone was produced using the standard overlying operations. The general area of the flooding accounted for 665.5 km^2. The flood has had most severe impacts on the territory of Kherson and Mykolaiv oblasts. In general, the flooding occurred in the floodplain areas of the Dnipro, Inhulets, Southern Bug, and Inhul (Fig. 5).

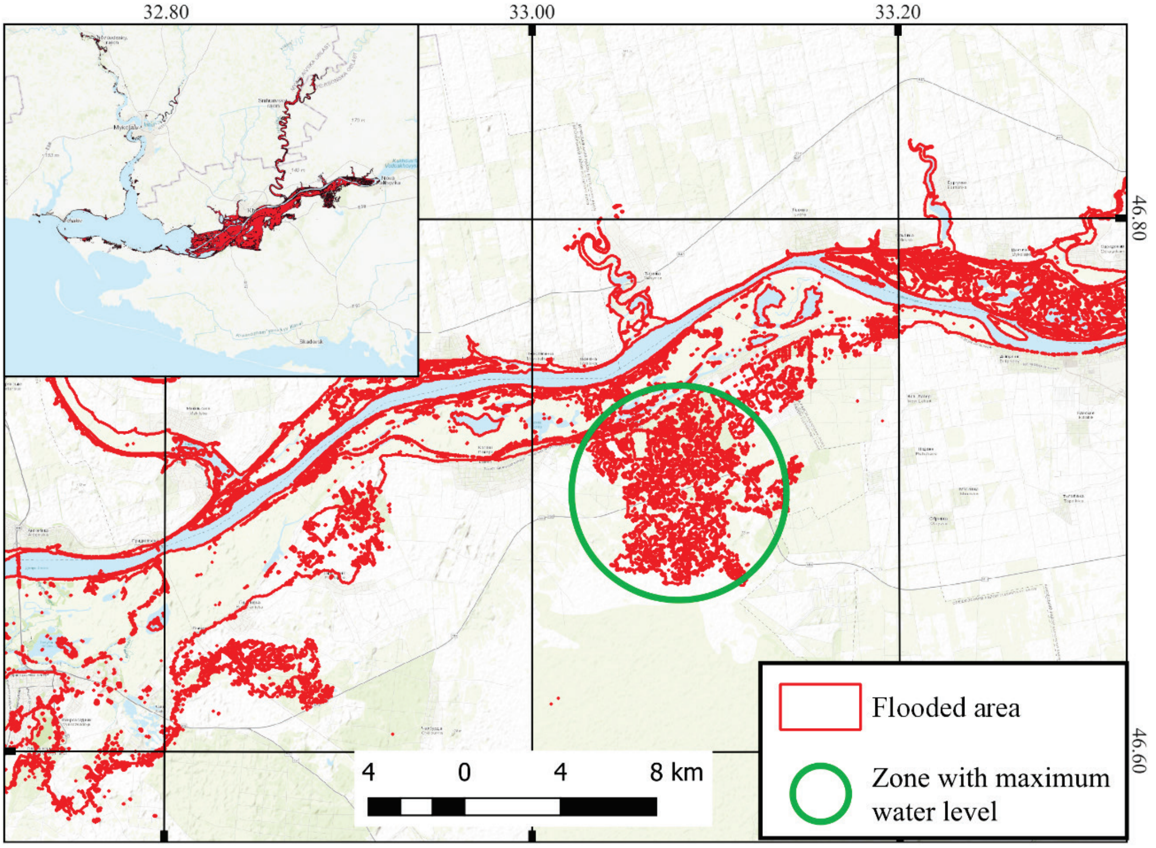

Fig. 4. Territory with highest water levels during the first wave

The flood affected azonal landscale complexes, landscape complexes of the above-floodplain terraces, and shoreline plains (Table 1, Fig. 6). The azonal landscape complexes are represented by floodplains of the Dnipro and tributaries and gully-ravine network, associated with banks of the rivers. The soil cover in the floodplains is mostly formed by gleysols and arenosols, and also common are phaeozems. The natural vegetation, depending on water regime of the territory, is represented by wetland meadows of long-flooded floodplains (reed beds) and broad-leaved forests. The soil cover of the gully-ravine network has been mostly formed by chernozems, kastanozems, with participation of phaeozems. The natural vegetation is represented by dry steppe associations *Festuca-Stipa*, southern xerophytic steppes, and ravine broad-leaved forests. The landscapes of the above-floodplain forest terraces are characterized by a diverse relief, and therefore the soil and vegetative coverage there are complex.

The soil over was formed by chernozems, kastanozems, phaeozems, and gleysols of various degrees of gumboization, carbonate content, solonization, and solodization. The vegetation in the above-floodplain terraces is represented by agrophytocoenoses and fragmentally natural dry-steppe associations *Festuca-Stipa*, forbes-grasses steppified and poorly saline meadows, southern xerophytes steppe, and ravine broad-leaved forests. Peculiarities of the relief, Quaternary deposits, and hydrological conditions of the left-bank valley of the Dnipro influenced the peculiarities of the soil and vegetative cover of the fluvial-delta coastal landscapes. The soil cover of the flooded territories comprises mostly arenosols, gleysols, and histosols. Also, there are areas of kastanozems and solonetz. The vegetation is represented by agrophytocoenoses, lower-Dnipro psammophyte forbes-*Festuca-Stipa* steppe, wetland meadows, *Festuca-Stipa* dry steppes, hemipsammophyte forbes-*Festuca-Stipa capillata* and poor forbes-*Festuca-*

Stipa capillata lower-Dnipro terrace steppe, pine, and broad-leaved-pine steppe forests.

The structure of soil cover in the flooded territories corresponded to the landscape structure of Kherson Oblast (Fig. 6). Important factors to the soil cover were thickness of the water layer and duration of flooding. They were determined by the specifics of the relief, properties of soil and parent rocks, distance from the streambed of the Dnipro, vegetation pattern, and peculiarities of the economic use of the territories that had been flooded. The areas of the flooded soils ranged from small areas (less than 1 km^2) to dozens and hundreds of km^2.

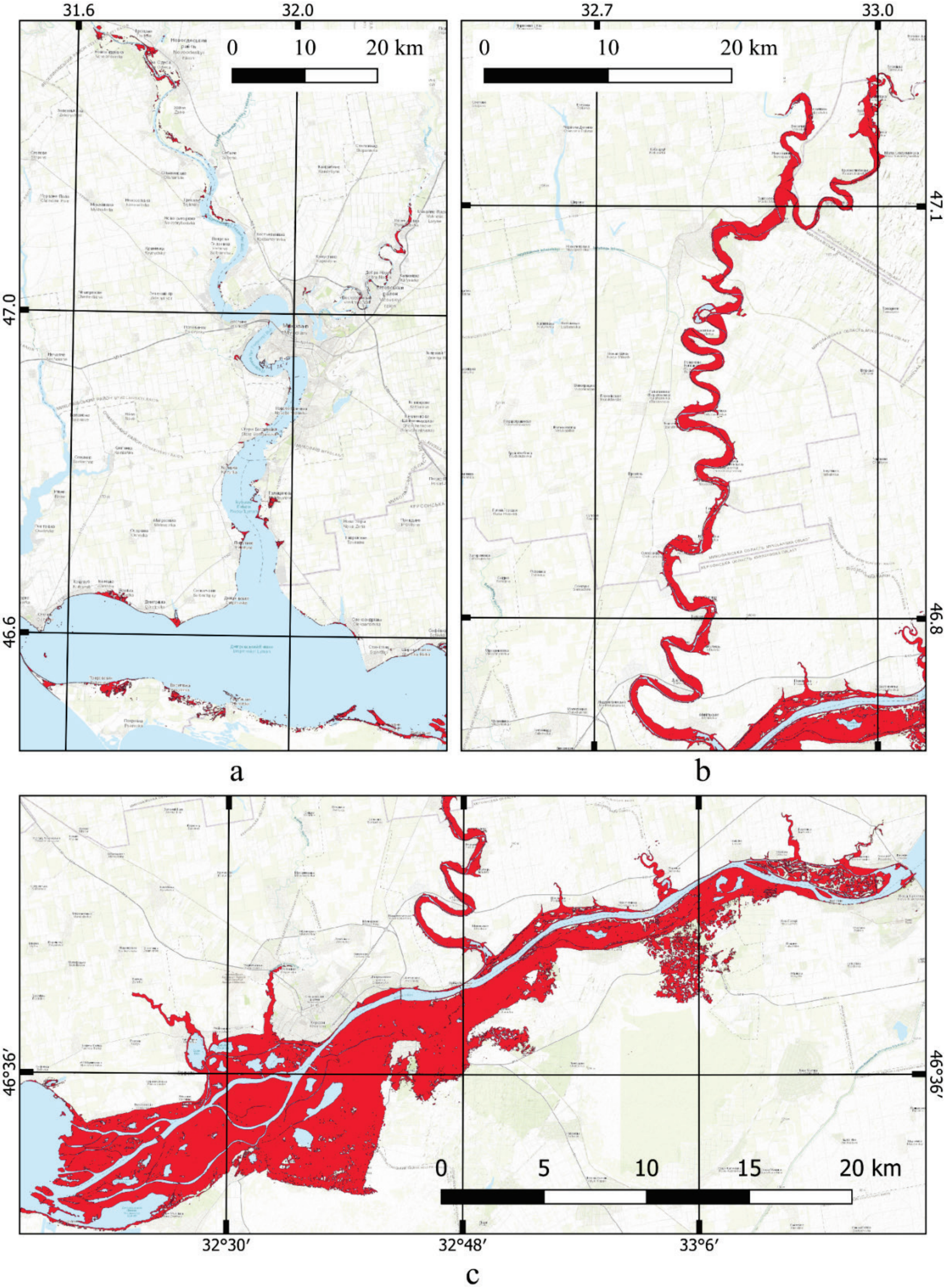

Fig. 5. Flooded zones: *a* – Kinburn Spit and the lower reach of the Southern Bug; *b* – lower reach of the Inhulets River; *c* – mouth area of the Dnipro (from the Kahovka HPP dam down to the Dnipro Bay)

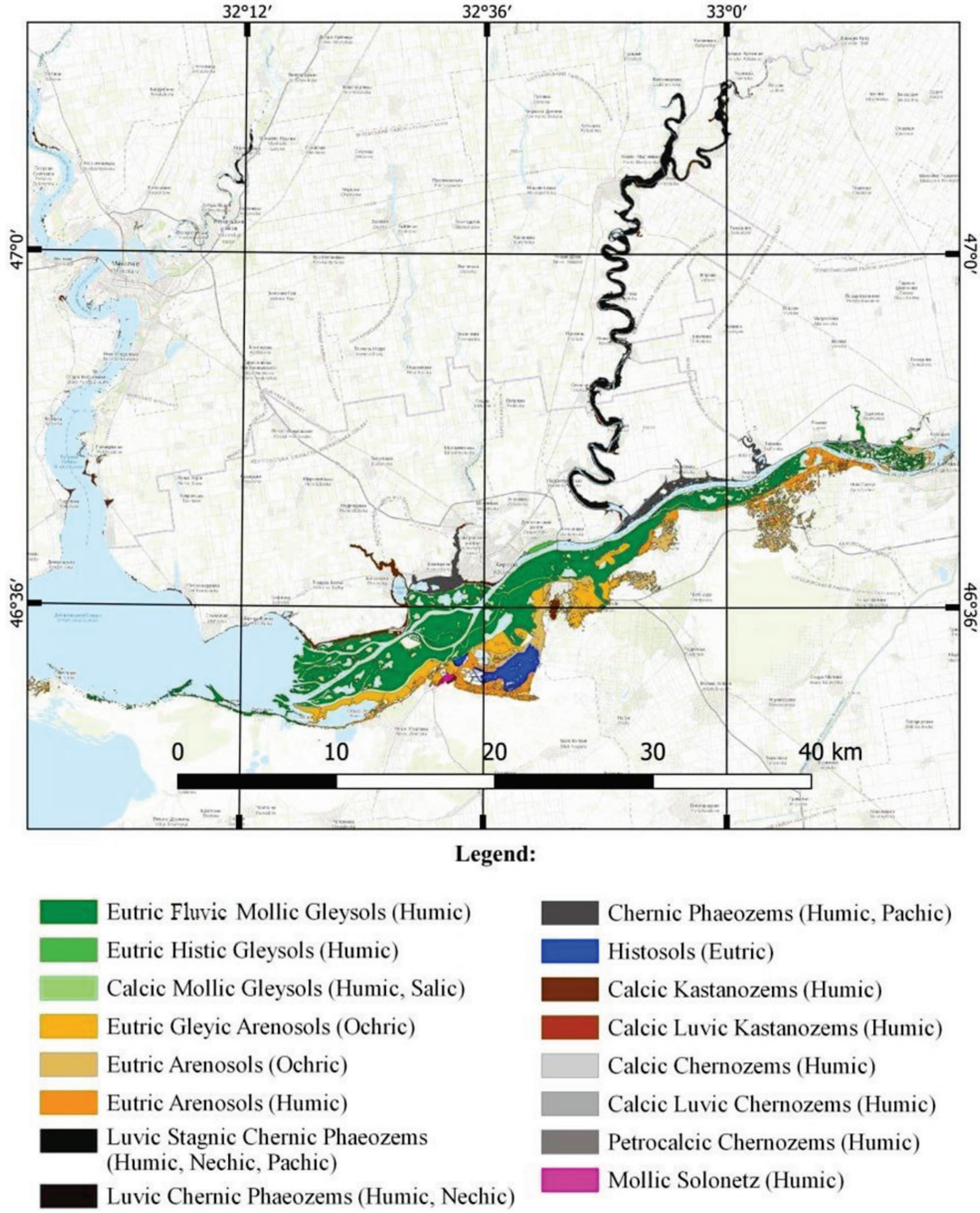

Fig. 6. Soil cover of the flooded areas

The largest areas of flooded soils were recorded within the azonal landscape complexes of floodplains of the Dnipro and Inhulets, and also the fluvial-delta lowlands of the left-bank Dnipro (Table 2): eutric fluvic mollic gleysols (humic) – the flooded area accounted for 261.653 km^2; eutric gleyic arenosols (ochric), eutric arenosols (ochric) and eutric arenosols (humic) – the overall flooded area was 169.013 km^2; luvic stagnic chernic phaeozems (humic, nechic, pachic) – the flooded area measured 69.099 km^2; histosols (eutric) – the area of flooding was 19.880 km^2. Smaller areas of flooding were recorded for chernozems, kastanozems, phaeozems, and gleysols of the above-floodplain river terraces and the gully-ravine network, associated with the banks of the Dnipro and its tributaries.

Discussion

Since the catastrophe at the Kahovka HPP in 2023, Ukrainian researchers have been able to stage-by-stage reflect the consequences of the ruination of the HPP and the dam, which have been associated with change in the water level of the Dnipro downstream the hydroconstruction, and also with increase in pollution of water of the Dnipro, flooded areas, the Dnipro-Bug liman, and Odessa Bay of the Black Sea. According to the data of Vyshnevskyi et al. (2023), the general water surge reached 5.37 m, the maximum being 5.68 m on June 8, 2023. This led to flooding of villages and cities on both banks of the Dnipro (Nova Kahovka, Oleshky, Hola Prystan, and Kherson). Researchers indicate that the highest flood surge occurred in the city of Nova Kahovka. The water level there reached 12.50 m above sea level. The highest water level in the Odesa Sea Port was observed June 10, 2023, being 5–10 cm higher than before the ruination of the Kahovka HPP dam.

According to the official data, the direct impact of the technogenic disaster encompassed 80 settlements in four oblasts of Ukraine: Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhia (Post-Disaster Needs Assessment: 2023 Kakhovka Dam Disaster, Ukraine, http://doi.org/10.18356/9789210029308; Ukrainian scientists tally the grave environmental consequences of the Kakhovka Dam disaster, http://doi.org/10.1126/science.zbde496; Hapich & Onopriienko, 2024). In Kherson Oblast, 48 settlements were flooded, and 23 in Mykolaiv (Stelmakh et al., 2023).

Table 1
Landscapes of Kherson Oblast that were flooded

Geomorphology	Vegetation	Soil (national classification)	Soil (WRB, 2022)
Azonal landscape complexes			
Floodplains of the Dnipro and its tributaries	Floodplain broad-leaved forests	Meadow-wetland soils	Gleysols
	Wetland meadows of long-flooded flodplains (reedbeds)	Wetland soils	
		Soddy gumbied sandy and clayey-sandy soils	Arenosols
		Soddy thin sandy and clayey-sandy soils	
		Poorly sodified low-humus sands and non-sodified soils	
		Meadow soils	Phaeozems
Gullies and ravines	*Festuca-Stipa* dry steppes	Southern low-humus dusty average-loamy chernozems	Chernozems
	Hollow broad-leaved forests	Carbonaceous chernozems on eluvial dense carbonaceous dusty-average-loamy rocks	
	Southern xerophytic steppes	Dark-kastanozem residual-poorly and average-solonets soils	Kastanozems
		Dark-kastonozem residual-solonets soils	
		Meadow soils	Phaeozems
Landscape complexes of above-floodplain terraces			
Above-floodplain loess terraces	Agrophytocoenoses	Carbonaceous chernozems on eluvium of dense carbonaceous dusty-average-loamy rocks	Chernozems
	Festuca-Stipa dry steppes	Southern low-humus dusty-average-loamy chernozems	
	Forbes-grasses stepified poorly saline meadows	Solodized soils	
		Dark-kastanozem residual-poorly and dusty-average-loamy soils	Kastanozems
	Hollow broad-leaved forests	Dark-kastanozem residual-solonets soils	
	Southern xerophytic steppes	Meadow-chernozem solodized soils	Phaeozems
		Meadow and chernozem-meadow deeply solonets soils	
		Meadow soils	
		Meadow superficial-poorly-solonets soils	Gleysols
Landscape complexes of coastal plains			
Fluvial-delta coastal lowlands	Agrophytocoenoses	Thick soddy clay-sandy soils	Arenosols
	Low-Dnipro psammophytic foerbes-*Festuca-Stipa* steppes	Thin soddy sandy and clayey-sandy soils	
		Thin low-humus and non-humus sands	
	Wetland meadows	Soddy gleyed sandy and clayey-sandy soils	
	Hemipsammophyte forbes- *Festuca-Stipa capillata* steppes	Dark-kastanozem residual-poorly and average-solonets soils	Kastanozems
		Dark-kastanozem residual-solonets soils	
	Pine and broad-leaved-pine steppe forests	Meadow dark-kastanozem gleyed solonetzifying- solodized soils	
		Meadow-wetland soils	Gleysols
		Peatifying wetland soils	Histosols
		Peatland-wetland soils	
		Meadow-steppe solonetzes	Solonetz

Table 2
Area and thickness of the flooded soils

Soil classification according to WRB (2022)	Water level, m	Area of flooded soils, km^2
Gleysols		
Eutric Fluvic Mollic Gleysols (Humic)	1.56	261.653
Eutric Histic Gleysols (Humic)	1.93	2.343
Calcic Mollic Gleysols (Humic, Salic)	2.54	0.286
Arenosols		
Eutric Gleyic Arenosols (Ochric)	2.88	66.491
Eutric Arenosols (Ochric)	7.89	57.907
Eutric Arenosols (Humic)	5.05	44.615
Phaeozems		
Luvic Stagnic Chernic Phaeozems (Humic, Nechic, Pachic)	2.60	69.099
Chernic Phaeozems (Humic, Pachic)	2.43	27.781
Luvic Chernic Phaeozems (Humic, Nechic)	0.27	2.135
Histosols		
Histosols (Eutric)	3.61	19.88
Kastanozems		
Calcic Kastanozems (Humic)	3.21	31.208
Calcic Luvic Kastanozems (Humic)	2.95	0.179
Chernozems		
Calcic Chernozems (Humic)	4.39	1.158
Calcic Luvic Chernozems (Humic)	2.85	0.789
Petrocalcic Chernozems (Humic)	3.67	0.555
Solonetz		
Mollic Solonetz (Humic)	2.46	1.147

The water level rose in the rivers Dnipro, Inhulets, and Southern Bug, and also the Bug Liman. The flood affected large territories in the south of Ukraine (Magas et al., 2023). Besides infrastructural objects, ecological damage was also inflicted on objects of natural landscapes. Considering the identified area of the flooding, we designated and characterized the soil cover in the flooded territories, which were distinct by non-homogeneity and diversity (http://issar.com.ua/karti-2). Those harmed the most have been the valleys of the Dnipro, Inhulets, and other tributaries, as well as gully-ravine networks, connected with the river banks.

The spatial structure of the soil cover of the Dnipro valley is closely associated with the geomorphological structure of the river valley (Gritsan et al., 2019; Tutova et al., 2023). Properties of the Quaternary deposits of the valley had significantly determined the diversity of soils on both levels of their classification positions (Yakovenko et al., 2023). The properties of soils have been also greatly affected by vegetation (Belova & Travleev, 1999; Gritsan, 2019; Kunakh et al., 2022), which in the valley the Dnipro is represented by agrophytocoenoses, natural (wetland, meadow, psammophytic, forest), and anthropogenically altered associations.

The largest areas of flooding were identified for gleysols and phaeozems in the floodplains and arenosols in the valley of the Dnipro. Alluvial soils of the floodplains have been significant for agriculture and forestland economy because of peculiarities of their locations in the river valleys, aquatic regime, and high quality parameters (Kabała, 2022; Kunakh et al., 2023; Yakovenko et al., 2024). The level of flood surge was sufficient to flood the above-floodplain terraces of the Dnipro tributaries, and gullies and ravines, connected with the river banks. As a result, the damage was imposed on the territories with productive kastanozems, chernozems, and phaeozems within those landscapes.

As for the area of flooding, none of the researchers gave exact numbers. Only the studies of Stelmakh et al. (2023) provided approximate flooded areas: 650 km^2 after incomplete ruination of the dam and 920 km^2 after complete ruination of the dam. According to the results of combined analysis of satellite images and DMS, the general flooded area was identified as 665.5 km^2.

The dam destruction was also a devastating blow to the animal population. Vertebrates that can migrate (fly, swim) likely did not suffer great losses. Most species that are typical in floodplain biotopes and river banks are well adapted to long and short floods (Belova & Travleev, 1999). As with analysis of groups of invertebrates, the greatest harm in the flooded area was inflicted on groups of wingless invertebrates living on or in the upper layers of the soil, for example, millipedes (Svyrydchenko & Brygadyrenko, 2014) and coleopterans that are unable to fly, including numerous rare and endangered species (Putchkov & Brygadyrenko, 2022). The severest impact had been likely caused on non-flying invertebrates of pine forests, including very rare taxonomic groups (Brygadyrenko, 2014, 2016). By contrast, populations of floodplain bank and meadow species almost completely survived thanks to the ability of many species to fly (Brygadyrenko, 2015b; Putchkov et al., 2019, 2020). The flooding had little effect on the species composition of invertebrates of agrocoenoses and windbreaks, because most species in those ecosystems can fly (Brygadyrenko, 2015a; Langraf et al., 2022).

Conclusion

Ukrainian researchers have thoroughly reported the implications of the 2023 disaster at the Kahovka HPP, including flooding of the territories, water contamination, and also the impact on the natural landscape. The catastrophe entailed a significant water surge, reaching 5.37 m, with the highest point of 5.68 m, submerging many settlements (Nova Kahovka, Oleshky, Hola Prystan, and Kherson). In particular, the city of Nova Kahovka was seriously affected, where the water level reached 12.50 m above sea level.

A raised water level was seen in sea ports (particularly in the Odessa port, where the water rose 5–10 cm after the catastrophe at the Kahovka HPP dam). The catastrophe affected 80 settlements in four oblasts of Ukraine, flooding large areas in Kherson and Mykolaiv oblasts. The water level rose in the rivers Dnipro, Inhulets, and Southern Bug, and also their tributaries, thus flooding large territories of Southern Ukraine. The flood affected soils in the river valleys, which were valuable assets in the agriculture and forestland economy. Despite the available data of the water-level monitoring, no literature source reported the exact area of the flooding. Instead, there are studies that modelled the flood.

At the moment of our studies, the archives of European and American space agencies have amassed a substantial amount of satellite images, which allowed us to elucidate the assessments of the flooded area. All the requirements were met by images from the Landsat 9 multispectral sensor. We were able to select images, synchronize them with the key hydrological events of the technogenic catastrophe. To analyze the territories with dense vegetative cover, the results of deciphering were elaborated using a digital model of the relief. As a diagnostic sign of change in the state of the surface, we used normalized water and vegetation indices. The overall flooded area accounted for 665.5 km^2. It has to be noted that the flooding also affected territories higher than (21 m) the recorded water-level marks. Those are territories south of the Krynky village. This was attributed to rush of the flood surge, formed right after the explosion at the dam. Its height and inertia were powerful enough to overcome the streambed natural levee and reach the floodplain in the area of Krynky village.

The identified area of the technogenic disaster allowed the natural landscapes to be localized that have been affected by the flood. Those include complexes of coastal plains and above-floodplain terraces, and also azonal landscape complexes. Within those landscapes, we designated 7 types of soils (gleysols, arenosols, phaeozems, histosols, kastanozems, chernozems, solonetz) and 12 types of vegetative groups (floodplain broad-leaved forests, wetland meadows of long-flooded floodplains (reedbeds), *Festuca-Stipa* dry steppes, ravine broad-leaved forests, southern xerophytic steppe, agrophytocoenoses, forbes-grasses steppified poorly Saline meadows, lower-Dnipro psammophyte forbes-*Festuca-Stipa* steppe, wetland meadows, hemipsammophyte-*Festuca-Stipa-capillata* steppe, pine and broad-leaved-pine steppe forests). In order to differentiate a possible level of degradation of flooded components of the landscape, we assessed the average depth of the water thickness that covered this area. It was found that in some areas, the water layer reached 8 m. The smallest identified depth of the flood equaled a little more than 20 cm. The mean parameter of the water level equaled 3.14 m.

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