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Analysis and assessment of the environmental situation within Muromets Island (Kyiv)

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Abstract. The environmental situation within Muromets floodplain island, which is considered one of the oldest and largest islands of the Kyiv metropolis was studied. This sandy island was formed due to fluvial migration and numerous alluvial deposits since the Holocene. The island is located in the modern Dnipro floodplain, bordering Trukhaniv

Island from the south. The environmental state of the island's plants, landscapes, water bodies, soils and rocks was analyzed. The environmental protection objects of the territory were also characterized. Satellite images of the Earth's surface over the past 37 years were analyzed to study modern changes in the island outline and hydrography within the Dnipro floodplain near Kyiv. Changes in the shoreline of Muromets Island were assessed. Using our field research data, cartographic schemes, space photographs and scientific publications of various years, we characterized the island's geological environment, presented the dynamics of shoreline development, analyzed the ecological situation, and identified environmental problems. We found that the island's environmental condition correlates with the influence of both natural and anthropogenic factors. The degree and severity of impact of the above-mentioned factors on the island's geological environment was established. It was shown that intense changes in this territory occur due to the geological work of surface water and the work of the wind, which are intensified by anthropogenic actions. The land shoreline has been migrating for a long time as a result of active water erosion by the Dnipro, Desna and Chortoryi (Desenka) rivers and their tributaries. New straits, peninsulas and individual small islands are formed. The results indicate significant natural dynamics of the Dnipro floodplain development, which occurs against the background of anthropogenic influence, the pressure of which is constantly increasing. The complex of anthropogenic and natural factors lead to the active development of invasive plants, eutrophication of water bodies, shoreline erosion, and significant loss of water and land resources of Muromets Island. The conclusions substantiated in the article are of general geological, ecological and practical significance. They are the beginning of environmental monitoring on this issue, expand knowledge about the peculiarities of the geological structure of Kyiv and the Dnipro floodplain, and update data on the development and ecological situation of this territory. This provides an opportunity to predict and determine the direction of development of negative environmental changes in advance, to make early decisions regarding agents of negative influence and pressure on the geological environment, and to respond in time to their localization or termination. The obtained data can also be used in the arrangement of geological and engineering works related to the preservation of the Dnipro floodplain and the shoreline of the dry land, as well as in the planning of environmental protection measures.

Keywords: Dnipro floodplain, Muromets Island, nature protection objects, hydrography, geological environment.

Аналіз та оцінка екологічної ситуації в межах острова Муромець (м. Київ)

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Анотація. Досліджено екологічну ситуацію в межах заплавної острова Муромець, який вважається одним з найстарших та найбільших островів Київського мегаполісу Муромець. Він є піщаним островом і утворився в результаті руслової міграції та численних алювіальних наливів, починаючи з голоцену. Острів знаходиться у сучасній заплаві Дніпра, з півдня межує

з Трухановим островом. Проаналізовано екологічний стан рослин, ландшафтів, водойм, ґрунтів та гірських порід даної території, а також надано характеристику природоохоронним об'єктам території. Для дослідження сучасних змін земної поверхні і гідрографії в межах заплави Дніпра поблизу Києва, було проаналізовано супутникові знімки поверхні Землі за останні 37 років, оцінено зміни берегової лінії острова Муромець. З використанням даних власних польових досліджень, картографічних схем, космічних знімків та наукових публікацій різних років, нами охарактеризовано геологічне середовище острова, представлено динаміку розвитку узбережжя та проаналізовано екологічну ситуацію, встановлено екологічні проблеми. Визначено, що екологічна ситуація місцевості острова корелюється як з природними так і з антропогенними чинниками. Встановлено ступінь та гостроту впливу на геологічне середовище острова названих чинників. Встановлено, що інтенсивні зміни абрису даної території відбуваються, за рахунок геологічної роботи поверхневих вод, роботи вітру та посилюються антропогенними діями. Берегова лінія суходолу протягом тривалого часу мігрує внаслідок активного водно-ерозійного розмиву річками Дніпро, Десна, Чорторий (Десенка) та їх приток; формуються нові протоки, півострови і окремі маленькі островці. Отримані результати вказують на значну природну динаміку розвитку заплави Дніпра, яка протікає на фоні антропогенного впливу, тиск якого постійно посилюється. Саме у комплексі, антропогенні і природні чинники призводять до активного розвитку інвазійних рослин, евтрофікації водойм, розмиву узбережжя і значної втрати водних і земельних ресурсів острова Муромець. Обґрунтовані в статті висновки, мають загально-геологічне, екологічне та практичне значення. Вони є початком екологічного моніторингу з цього питання, розширюють знання про особливості геологічної будови Києва та заплави Дніпра, оновлюють дані стосовно розвитку та екологічної ситуації даної території. Це надає можливість заздалегідь прогнозувати і визначати напрямки розвитку негативних екологічних змін, завчасного приймати рішення стосовно агентів негативного впливу і тиску на геологічне середовище та вчасно реагувати на їх локалізацію чи припинення. Отримані дані також можуть бути використані при проектуванні геолого-інженерних робіт стосовно збереження заплави Дніпра і берегової лінії суходолу, а також при плануванні природоохоронних заходів.

Ключові слова: заплава Дніпра, острів Муромець, природоохоронні об'єкти, гідрографія, геологічне середовище.

Introduction.

The study and monitoring of the ecological condition of the Dnipro basin and its floodplain today remains one of the priorities of natural environment preservation and resource rational use. The topic is relevant, as it falls within the field of the Law of Ukraine "On Strategic Environmental Assessment" (Zakon Ukrainy..., 2018) and corresponds to the Kyiv development plan till 2025, which was approved by the decision of Kyiv City Council on 15.12.2011. This plan is also the basis for the annual programs of socio-economic development of the capital for 2021-2023 (p. 26. «Development of the concept of preservation and development of landscapes of Kyiv»), as well as the Kyiv city target programme for the organisation of the green zone landscaping and the water fund lands for 2022-2025.

More than 30 islands and islets have been formed in the Dnipro floodplain within Kyiv, which are located between the left and right banks. Trukhaniv, Olzhyn, Zhukiv, Halernyi, Kozatskyi, Muromets, Venetianskyi, Velykyi and Dolobetskyi islands and others are among them (Bondar et al., 2018; Regional report..., 2018). All the preserved areas of the Dnipro floodplain, islands and floodplains within Kyiv are planned to be converted into the Dnipro Islands National Nature Park by 2025 according to Kyiv development plane till 2025 (Kyiv in ..., 2015).

An analysis of a significant array of scientific works, the subject of which was the study of the Dnieper floodplain islands, is shown in the scientific publication of A.-O. Yu. Pozharska (Pozharska, 2020).

According to this work, Venetianskyi and Trukhaniv islands are the most frequently researched objects, while Muromets, Velykyi and Zhukiv islands receive much less attention. The main fields of research on the islands are biological, to a lesser extent – environmental and landscape studies, and the least – regional studies, soil studies, and geomorphology. Environmental studies of Muromets Island are presented in the works of I. Parnikoza, A. Honchar and O. Bondar and others (Parnikoza, 2012; Honchar, 2017; Bondar et al., 2018).

Over the past 20 years, the active urbanisation of the suburbs has significantly affected one of the largest islands in the Kyiv region – Muromets Island. This island formerly was named Muravets and since 2004, Muromets has been part of the Regional Landscape Park «Dnipro Islands» (Fig. 1).

Muromets is a sandy island formed due to channel migration and numerous alluvial alluvium since the Holocene. The island is located in the Dnipro floodplain. It borders Trukhaniv Island located to the south (Ostriv Muromets ...). The border between the islands runs near the North Bridge. After blocking the Desenka (old name – Chortoryi) riverbed, in the late twentieth century, the island became a peninsula and today is located between two residential areas of Kyiv (Obolon and Troieschyna). Muromets is bounded on the west by the Dnipro, in the north – Desna river, in the east – Desenka river, and in the south – the North Bridge. The border between Kyiv city and Kyiv region runs through the middle of the island. The current island area is about 7.7 km². The maximum its length is 7.5 km, the perimeter is about 20 km, and the maximum width is 2 km.

The southern part of Muromets Island (excluding the southwestern part) and the northern edge of Trukhaniv Island and Lopukhovatyi Island are parts of the Muromets-Lopukhovate Landscape Reserve of local significance, which is a part of «The Dnipro Islands» Regional Landscape Park. The area of this Landscape Reserve is 2.17 km². There are about ten natural lakes and several swamps on Muromets Island. Bobrivnia, Hlyboke, Lopukh, Muravka, Staryi, Shchytetske, Kilnishche lakes are known from historical times on the island (Ostriv Muromets...). Depend-

ing on the season, the total area of lakes and swamps can reach about 63 hectares. The old Bobrivnia stream bed crosses the island from southeast to northwest and divides it into two almost equal parts. The territory of the Bobrivnia riverbed is swampy, overgrown with shrubs and mire vegetation, and partly dries up in summer. Both negative landforms (ravines, gullies, forms shaped by military action/constructions) and positive ones (hills, dunes, accumulative shorelineo-astal terraces, etc.) are found on the island (Stetsiuk, Kovalchuk, 2016).

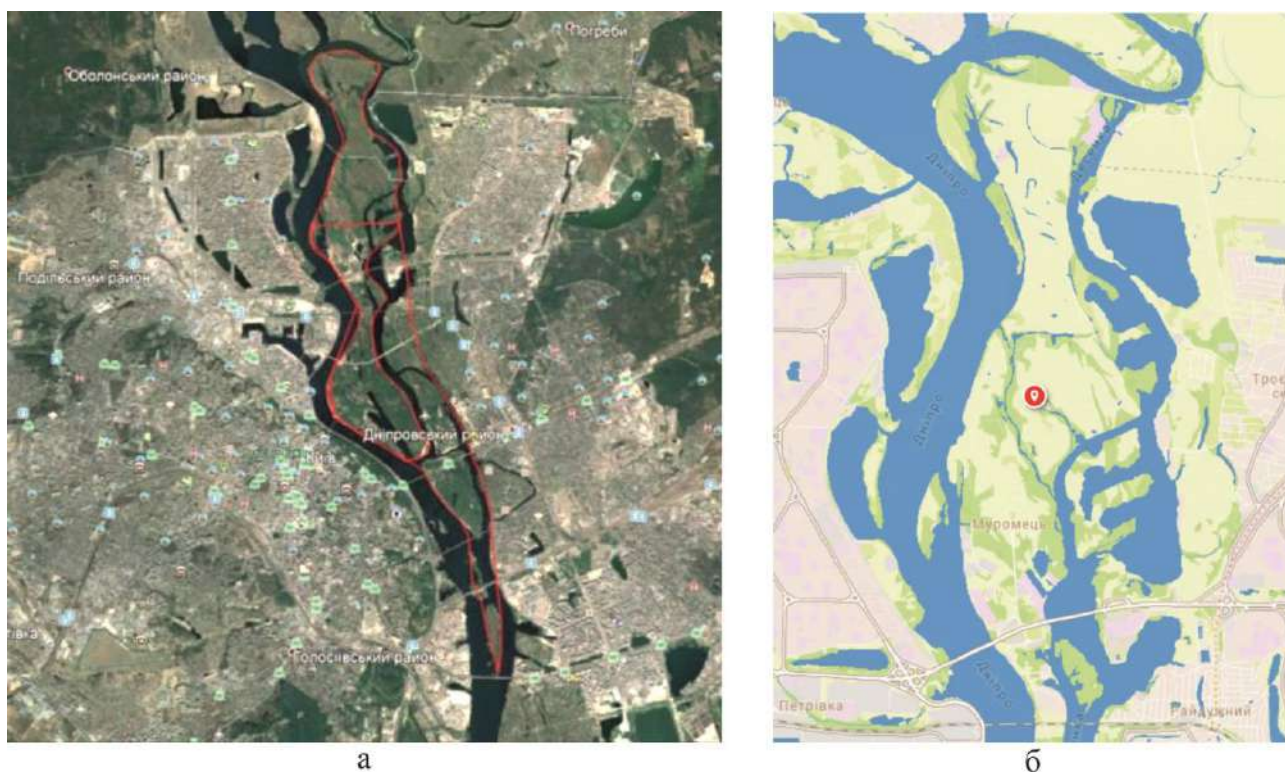


Fig. 1. Schematic map of the Muromets Island area on the Dnipro (a) and modern general view of the island (b) (by <https://maps.visi-com.ua/c/30.53701,50.51714,13/f/POI9VMPPNH/m/u8vwt1371m?lang=uk>) Photo (a) shows a group of islands and islets of different configurations, with a total area of about 2 thousand hectares.

Currently, a large part of Muromets Island is built up (recreation centres, restaurants, bike trails, massive entertainment complexes, etc.). So the unique natural objects of this area and objects of the Nature Reserve Fund of Ukraine are in danger of extinction.

In this work we aimed to analyse and assess the current environmental situation and problems of Muromets Island.

The novelty of the work lies in the comparison of cartographic data (using: <https://earthengine.google.com/timelapse/>) from 1986 to 2021 on the outlines and images of the shoreline of Muromets Island. The fact of significant changes in its outline due to the combined effects of natural and anthropogenic factors was established.

It is known that the geological environment is considered to be the upper part of the lithosphere, which includes water bodies, soils, rocks and minerals, and bottom sediments (Sergeev, 1979). Interacting with elements of the landscape, atmosphere, biosphere and hydrosphere, the geological environment is affected by both natural and anthropogenic influences. Its pollution from anthropogenic sources leads to transformation, significant changes and even disappearance or transition to another state. The impact of human activities on the environment can be partially levelled off naturally, but this is not fast and not in full. That is why any transformation of the geological environment over time is reflected in the environmental changes and, usually contributes to the overall Earth history.

So, today we actually study a natural-anthropogenic system, which develops as a result of two main factors (Dovgiy et al., 2016; Derevska et al., 2021).

General characteristics and features of the Dnipro floodplain geological and geomorphological structure.

The research area is located at the junction of three large structures: parts of the Dnipro Upland (Kyiv Plateau), Polissia and Dnipro Lowlands. The geological structure involves ancient crystalline rocks and thick sedimentary complexes (Barshchevsky, 1993). This territory is diverse in relief forms, initially formed due to natural factors. The landforms are directly related to the composition of the rock and the climate, which had the most notable effect during the Cenozoic. The territory of the modern Dnipro valley began to form in the Paleogene during tropical, subtropical and constantly humid climates. At the end of the Neogene, it became moderately warm with changing humidity, which led to the appearance of the steppe zone in an extensive area of modern northern and central Ukraine. Signs of aridization appear from the Middle Pliocene (5-3 million years, (Derzhavna heolohichna..., 2001)). The deepest incision of rivers occurs in the Quaternary period due to the Dnipro glaciation. Data on the history of the Dnipro valley geological development in the Quaternary period (Derzhavna heolohichna..., 2001) show that during the approach of the Dnipro Glacier exaration destroyed sufficiently thick strata of sedimentary rocks formed in the Pliocene and Pleistocene. After the glacier retreat, a cover of fluvioglacial deposits remained and levelled the early Pleistocene relief. Then, with global climate change, a river network is formed, which is relatively wider than the previous one. The Dnipro Valley gradually moved to the west and finally acquired its modern outlines.

The Dnipro floodplain is characterised by a parallel-maned asymmetric relief, typical for large rivers with a wide valley and an accumulative structure. It was formed in the Holocene (about 12 thousand years ago) with a gradual decrease in water flows and the formation of the first floodplain terrace on the left and partly right banks of the Dnipro River with individual islands in the floodplain (Derzhavna heolohichna..., 2001). The floodplain is distinguished by a low level of altitude up to 4 m and a height above sea level from 89 to 96 m. Its width does not exceed 4 km near Kyiv. The Dnipro floodplain consists of alluvial deposits: multi-grained sandstones, loams, peat and silt. The total thickness of the sedimentary formations of the floodplain does not exceed 25 m. The floodplain surface is uneven, cut by straits and former riverbeds. The islands of the first floodplain terrace can be traced.

Sedimentary rocks within Muromets Island are represented by Quaternary deposits (Holocene sands, loess and alluvial loams), which lie on Precambrian rocks. The total thickness of the island's sediments is about 20 m. Crystalline rocks, mainly granitoids, occur at a depth of 12-15 m from the Dnipro water's edge. Quaternary deposits of the first floodplain terrace are represented by quartz sands, grey, light grey with greenish and yellowish hues, predominantly fine-grained with lenses and layers of former riverbeds loam (Derzhavna heolohichna..., 2001). Geomorphological analysis of the island surface profile shows that the island has a flat or slightly undulating relief. The fluctuations in relative heights do not exceed 10 m, and the transition between high and low areas is gradual. The hypsometric level of the modern surface of the area is from 89.0-96.0 m to 120.0-140.0 m, respectively (Fig. 2). The island relief is slowly being transformed under the influence of exogenous and anthropogenic factors.

The soil cover of the island is heterogeneous. The most common types of soils are meadows and swamps on ancient alluvial, water-glacial deposits and loess-like rocks. The island soils are low-fertile and extremely low-fertile (Rehionalna dovid... 2018; Map of soils...; Kyiv..., 1981).

Presenting main material.

Muromets Island can be divided into three parts with maximum, average and minimum anthropogenic influence. The first part is the shoreline, which is currently predominantly used for recreational, entertainment, sports and public purposes. The second one is the southern and partly eastern part of the island. This territory is used for rest homes, facilities for physical culture and sports, health, houses of fishermen and hunters, children's tourist stations, sports camps and other similar facilities. Muromets Park, with hiking trails and park pathways with lighting, planting areas and some nature reserve fund objects, are located in the third central part of the island (Fig. 1).

Below we present the characteristics of protected areas according to published sources (Ostrovy Kyieva...; Rehionalna dovid..., 2018; Tsukanova et al., 2002; Ostriv Muromets...) and our own data.

The Kyiv City Council established the *Muromets-Lopukhovatyi Landscape Reserve* in 2002 to protect the Lopukhovatyi Floodplain ecosystems and part of Muromets Island, which are situated on the north of Lopukhovatyi Island via Chortoryi (Fig. 3). The Reserve includes the Chortory tract, a historic site on the island between the main channel of the Dnipro and the Desenka Strait.

The General Zoological Reserve of Local Importance «Urochysche Bobrovnia» was established by the Kyiv City Council decision, dated 02.12.99 № 147/649 on Muromets Island (30.0 hectares) to protect the typical complex of psammophyte meadows and treasures of the Dnieper Strait – Bobrovnia (Fig. 4). There is a residential area of Kyiv – Troieschyna on the left bank. The Nebyshivka River begins here and flows into the

Desenka River in 4 km (just above the Podilsk bridge). This river also has a preservation status. The Reserve territory is a fragment of Muromets Island on the north of Muromets Park, including a small fragment of the Bobrovnia Strait. The territory of the Reserve has a rectangle form, oriented to the north of the central square, and the left corner goes beyond Bobrovnia. The Reserve is a typical floodplain ecosystem.



Fig. 2. Geomorphological cross-section of the island (from North to South and from West to East) http://geoinf.kiev.ua/wp/w/Viewer.php?pr=1&ump=m36-13&fmp=kv_m36-13_1.pdf

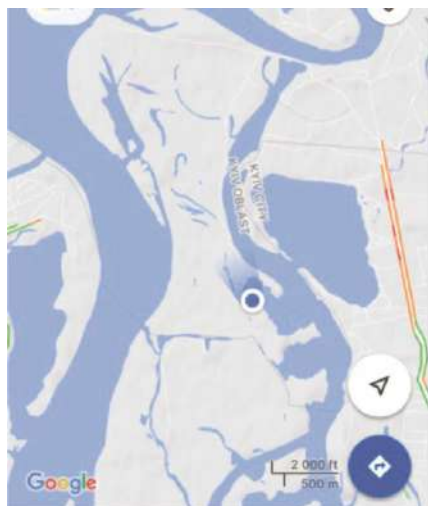


Fig. 3. Chortoryi tract, a bay with steep shores composed of alluvial sands.



Fig. 4. Bobrovnia (beaver) tract. Bobrovnia Strait on Muromets Island.

We present below a brief description of the shore area of Muromets Island and its development dynamics in different historical periods using scientific publications and published graphic material (Ostrov Kyryeva ...; Rehionalna dovid ... 2018; Tsukanova et al., 2002; Ostriv Muromets ...) . Since the first descriptions from the 12th century, the island has undergone significant changes (Figs. 5, 6). The Chortoryi River (modern name – Desenka River) had already formed in 1100, the name of which can be seen on old maps and schemes (Ostrov Kyryeva ...; Parnikoza, 2021 (a,b)). The uneven bottom of the Dnieper caused the turbulent movement of water and the erosion of river

banks and shoals, which contributed to the formation of washed-out strips of land and beaches, and greatly hindered shipping. From time to time, the island joined the left bank of the Dnieper, then retreated again, forming a sizeable elongated island or diverged into two large ones, forming a strait.

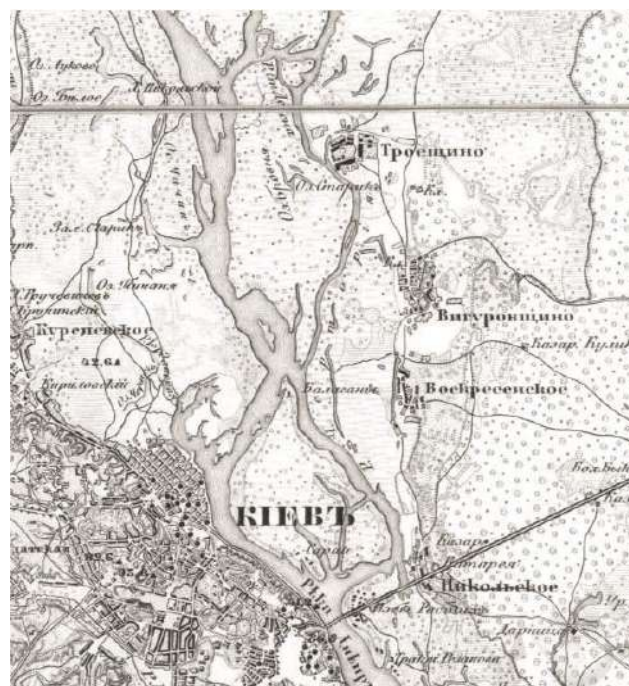


Fig. 5. Left bank of the Dnipro River, the Bobrivnia Island (now Muromets), the scheme of 1800 (according to (Parnikoza, 2021(b), *Voyenno-topograficheskiye karty...*, 1846–1863)).

At the beginning of the XVII century, Muromets and Trukhaniv islands formed one island, which covered an area of more than 3,000 hectares. After the dam construction which blocked the Chortory River mouth in 1851, Muromets Island was reunited with

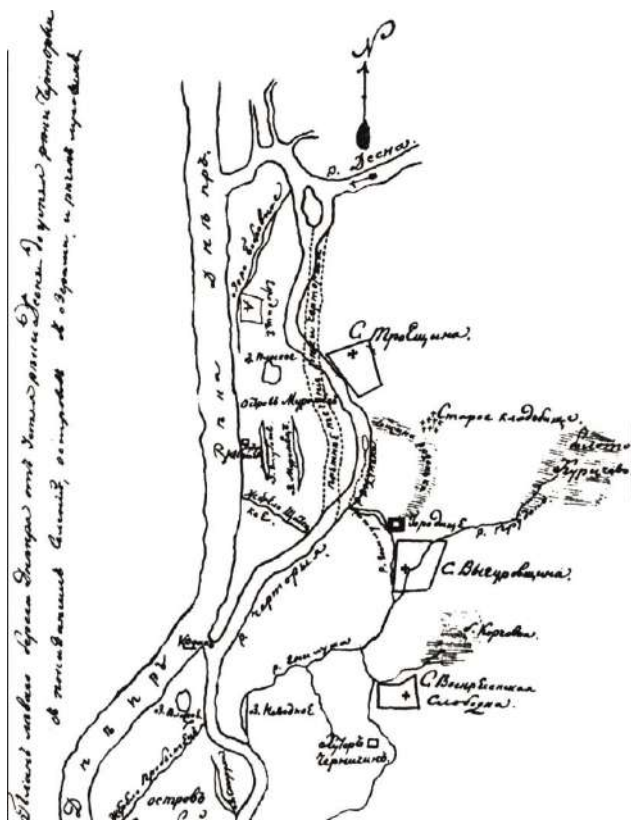


Fig. 6. Plan of the Dnipro River left bank from the Desna River mouth to the Chortory River mouth, compiled by land surveyor Snovskiy in 1912 (according to (Parnikoza, 2021 (b)))

Trukhaniv Island. Due to the Dnipro regulating process on the Muromets Island banks, a dam was built in 1880 just behind the mouth of the Desna River. The island's territory continued to be used for haymaking in the second half of the XIX – early XX centuries.

In the 1920s and 1930s, according to cartographic data, Muromets Island was permeated by the branched bay Bobrovnia (Ostrovy Kyveva...; Parnikoza, 2021 (a, b)). The modern area of Lopukhovatyi Island and the tract of Zapisochchia (as of 1931-1941) was a separate island (scheme of 1923, Fig. 7) or a peninsula of Muromets. The dam system was built on the isthmus between the Muromets and Trukhaniv islands to protect against erosion, and the island branch of the Desna River is marked as Desenka on some maps. The «General Plan» map of 1936 shows the coastal protection along the shores of the isthmus between the Trukhanov and Muromets islands. On the German map of 1941, the island is shown as one with the modern Mizhmostovyi Island, and the bay between them is designated as Chortory (Fig. 8, Ostriv Muromets u G.). The modern Kyiv map shows that Muromets Island is connected with the left bank of the spit near the Desna River, which began to form at the beginning of the XXI century.



Fig. 7. Muromets Island on the map of 1923: 1 – the Desna River mouth, 2 – floodplain lakes on Muromets, 3 – the area of the Strait of Bobrovnia and the modern Mizhmostnyi Island, 4 – the area of the modern Lopukhovatyi Island as a separate island (Parnikoza, 2021 (b))

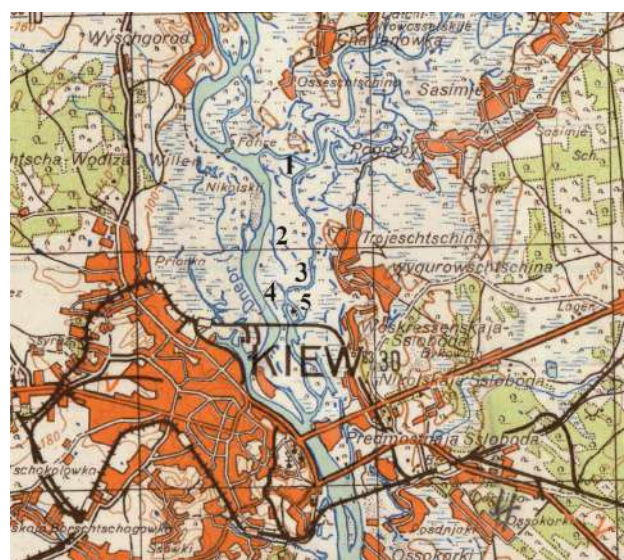


Fig. 8. Muromets Island on the Kyiv map in 1941: 1 – Kilnyshche tract, 2 – Bobrovnia Bay, 3 – modern Lopukhovatyi Island – in 1941, a fragment of Muromets Island, 4 – modern park of Friendship of Peoples with the Nebyshevska Strait, 5 – modern Mizhmostnyi Island (according to (Deutsche Heereskarte..., 1941))

Satellite images of the Earth's surface since 1984 were analysed to study current changes in the surface and hydrography within the study area. Intensive changes were recorded, indicating the transformation of the environment, mainly due to the operation of

surface waters. Over time, the island's shoreline has undergone significant water-erosion and the impact of the Dnipro and Desna rivers. The ravines, straits, and individual small islands or peninsulas were formed (Fig. 9, the most noticeable changes are marked in red).

The total area of Muromets Island in 1981 was 11.25 km² (Kyiv..., 1981). By 2021, its area had shrunk to 7.7 km². In 40 years, the island had shrunk by 3.5 km². This decrease was due to the erosion of both the coastline and the expansion of inland waters

and the mouths of small rivers, tributaries and bays of the island, mainly in the northern, northwestern and eastern parts. Since 2016 (World Map Base...), the number of wetlands and floodplains has increased by 13 hectares; gradually elongated land areas in the west and east with an area of 10.3 hectares, 14 hectares, 3.5 hectares, 2.4 hectares have separated from the shore. In addition, beach areas in the southern and northern parts of the island are slowly eroding. In general, the island has not only decreased in size over the last 40 years but also significantly changed its configuration.

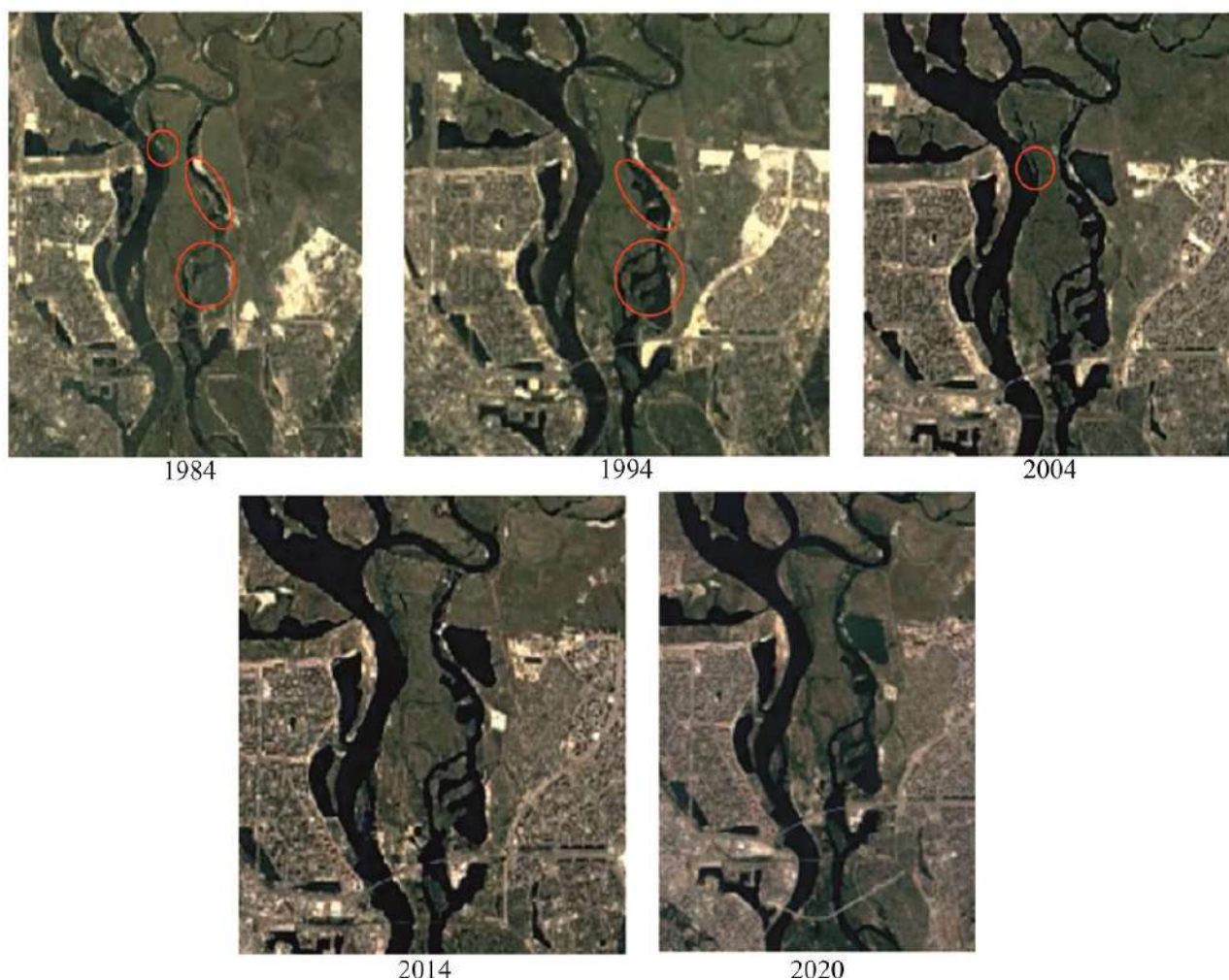


Fig. 9. Geomorphological changes of Muromets Island over time, based on satellite pictures. Source: <https://earthengine.google.com/timelapse/>

Discussion of research results.

Analysis of the environmental situation of Muromets Island. As is known, the ecological situation should be understood as the environment's particular state caused by the nature-human interaction. Among the factors influencing the state of the environment of Muromets Island, both natural and anthropogenic factors can be distinguished, which are interdepen-

dent and, in current conditions of intensive farming, are practically inseparable. This signifies that pure influence factors no longer exist in the natural environment since one action entails others, increasing the importance, risks and consequences.

According to the modern classification of anthropogenic impact on the geological environment, developed by V.T. Trofimov, the following groups of influence were distinguished: 1) physical; 2) physi-

cochemical; 3) chemical; 4) biological (Trofimov et al., 1995). This classification also includes the characteristics of human impact on the geological environment and, consequently, the result of ecological effects of anthropogenesis on human life and biogeodiversity.

Anthropogenic anomalies are formed in the geological environment, which are areas of negative environmental impact and the accumulation of various pollutants. In this case, the spread of pollution occurs at different speeds, depending on the territory's geological structure and soil composition (Malisheva, 1988; Saet Yu.E et al., 1982; Mishchenko, 2003).

The main natural factors include the work of exogenous geological processes, such as the work of surface water and wind. According to cartographic data for the last 13 years, their intensity has increased significantly, leading to the intensification of erosion

and soil erosion, land waterlogging, and incursion of invasive plants into the territory.

The load on the geological environment of Muromet's Island for a long time contributed to significant anthropogenic soil damage. The biggest threat is anthropogenic soil erosion, characterised by its speed (10-30 years). There is also a natural longer term soil erosion (by wind, snow, water). Deflation of sandy soils in the central part of the island is determined, where soil erosion is up to 1%. Large areas are degraded due to the violation of the Earth's surface integrity, weathering, erosion by surface waters, as well as pollution by emissions and debris, open-cast construction, etc. Thus, since 2009, the anthropogenic load and urbanisation of the island have increased sharply. Currently, the southern and northern parts are built up – 4 recreation centres, massive entertainment and sports complexes (X-Park), restaurants, car and bicycle rental, bike tracks, and baseball fields (Fig. 10, 11).

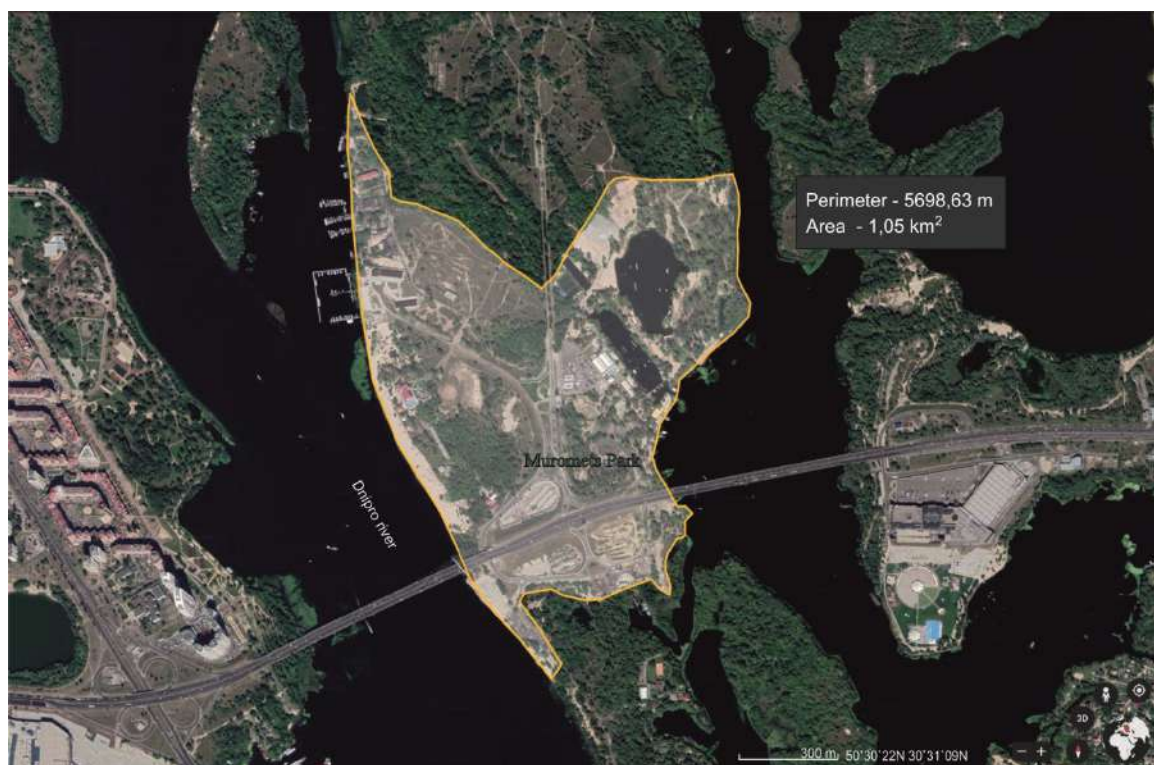


Fig. 10. The level of urbanization, southern area, 105 hectares

The total area for entertainment and tourist complexes and long-term construction is 1.5 km². Asphalt roads or soil roads up to 7-8 m wide have a total area of up to 2 km². Together, these areas of active urbanisation take up 26% of the island.

One of the most critical assessments of the environmental state of the territory is the fertility of soils, the fertility indicator of which is the content of organic matter. It is known that humus determines the

level of fertility, the range of mineral elements in plants and the physicochemical properties of the soil. Marker plants are one of the indicators of soil condition. Floristic indicators are of the most significant importance because they are specific, have different resistance to natural and artificial changes, are most sensitive to soil conditions and fix areas of environmental disturbance (Regional report... 2018, Tsukanova et al. 2002). The complete list of flora spe-



Fig. 11. The level of urbanization, northern area, 15 hectares

cies discovered on Muromets Island was presented in the work of Parnikoz I.Yu. «List of flora of vascular plants of the islands and floodplains of the Dnipro, Kyiv» (Parnikoza, 2021 (c)).

The conducted floristic analysis shows that among the significant phytodiversity, there are species common on poor sandy soils (Fig. 12). There are *Sedum acre* L., *Pinus sylvestris* L. Hydrophytes are also present. Among them, *Caragana frutex* (L.) Koch, *Geranium pratense* L., *Agrostis stolonifera* L., species of the genus *Salix* (L.) are identified. Lichens (*Physcia pulverulenta* (Schreb.) Hampe, *Xanthoria parietina* (L.) Tr.Fr.) and bryophytes of the genus *Polytrichum Hedw* (Bryopsida), which are widespread on the island, testify to a low level of atmospheric air pollution but at the same time indicate the poverty of the soil.

Thus, the soil analysis shows that Muromets Island has sandy, poor soils, weakly turfed sandy areas, and areas with high humidity. The following zones were distinguished: forest and forest-steppe zones; dry, floodplain moisture or swampy meadows; swamps. Wild forest edges characterise the east coast, whereas the western one is mainly marked by the spread of dry sandy areas.

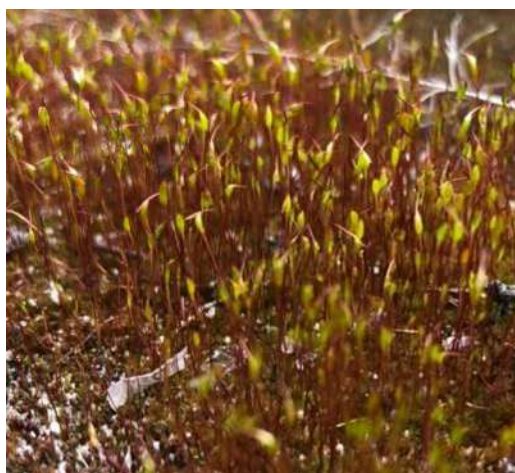
Human economic activity, as a factor in the transformation of the terrain, has changed the natural appearance of the island's surface: there are artificial hills, dumps; disturbed soils for the extraction of sand for local construction; berths, platforms, observation

decks are arranged for entertainment and recreational purposes; built roads and hiking trails, canals, dams; planted gardens, tree alleys, etc. To preserve the banks near the mouth of the Desna, breakwaters and stone embankments were built.

According to the results and analysis of our geological environment monitoring of Muromets Island, several levels of ecological status and areas of negative impact on the environment were identified:

1) The stress zone is determined by the initial stage of violation of the geological environment – soil erosion, salinisation, soil waterlogging, the absence of higher plants, and active invasion of ornamental plants. This area is located in the northwestern part of the island and occupies around 23% of the island. Human influence in this part is limited to the presence of straits, small lakes and rivers that impede easy movement. Though this area is protected, it does not prevent the construction of bicycle paths and tracks and destruction of the soil. To avoid and improve this situation, it is necessary to restrict the movement of any vehicles, inform the population about the protected areas and the importance of soil conservation, to arrange information boards with the corresponding demonstration of objects of the nature reserve fund.

2) The critical state zone of the geological environment is characterised by the destruction of the island's shoreline due to severe impact: a) natural exogenous processes (surface water, wind, natural

*Geranium pratense**Polytrichales**Bryopsida**Xanthoria parietina***Fig. 12.** Soil indicator plants of Muromets Island

development of the Dnipro and Desna valleys, local climate change); b) anthropogenic processes (consequences of economic activity, lack of engineering structures, littering with household waste, car parks, etc.). This area stands out along the entire shoreline of the island (up to 20 km in length and up to 100 m in width), especially around beaches, natural spaces used for parking cars, unauthorised campsites near water, campfires and more. The area of 1 km² in the northeast, captured for recreation, is located on the banks of the River Desenka, which is currently connected to the Desna through two pipes and heavily silted up.

It is almost impossible to avoid the negative impact of natural processes on the geological environment except to slow them down by strengthening the island's entire shoreline. The soil erosion, desertifica-

tion of certain areas, and dust transfer occurred due to the effect of the wind. As a result, this all leads to siltation and eutrophication of water bodies. The anthropogenic effect can be reduced by strict control approaches and penalties for violating protected areas. The critical zone reaches 32% of the island area.

3) The zone of crisis condition (with severe or harmful consequences) is characterised by: a lack of vegetation; mixing and destruction of soils is associated with human activities (sand mining, deforestation, road construction, etc.); pollution or poisoning by industrial and household waste; intense recreational and tourist activities and uncontrolled construction.

The main disaster spot of this zone is near the North Bridge. It is almost entirely built up, illegally littered with construction and household waste, and construction sites have undergone a significant trans-

formation, felling and heavy industrial load. This site belongs to the area subject to severe consequences for the geological environment, associated with the intensive development of recreational activities, construction and industry. Technogenic loads negatively affect the soils and aquatic environment of the island and can lead to its distortion and transformation into a semi-desert, completely built-up area and zone of garbage pollution. Currently, there is a question of control over the content of toxic elements in natural and wastewater, as all liquid waste and petroleum products are released into Dnipro. There is also no work in this area to preserve the shoreline. This, together with the complex anthropogenic and natural loads on the geological environment, can lead to erosion of the coast and significant loss of land and water resources on Muromets Island. The total area of the crisis condition is currently 45% of the island.

The analysis conducted of the environmental condition and the study of cartographic material indicate the Dnipro floodplain dynamics, which are reworked by natural processes leading to changes in relief, the development of the hydrographic system of Muromets in general, soil erosion under the influence of both natural and anthropogenic factors (Derevska et al., 2021; Dovgiy et al., 2016; Zorin, 2006; Korolev, 1995).

The set of measures for the preservation and protection of the Dnieper floodplain islands includes: environmental monitoring; creation of protective engineering structures, and carrying out various measures to preserve the land shoreline; ensuring the prevention of landslides; prevention of harmful effects of karst and other exogenous processes; avoid erosion or destruction of soil cover, flooding, waterlogging, and salinisation of soils. All these measures are necessary in order to preserve land resources.

Conclusions.

The results show the natural dynamics of the Dnipro floodplain development, which is converted

by natural processes under the influence of intensive anthropogenesis. The conducted field study and analysis of publications and cartographic material (from 1984 to 2021) allowed us to draw the following conclusions:

1. From 1984 to 2021, the island's geological environment has significantly changed. The rivers, lakes, bays and straits formed on the island have turned it into an area of islands and peninsulas, which are occasionally connected by a sandy spit.

2. The shore of Muromets Island is collapsing. Its central part is becoming higher than the shoreline, constantly separated by land. From the northwest, part of the island is eroded in the area of the Desna River mouth. For the last 20 years, the spit was formed from the northeast, strengthened by concrete construction. This connected the island with the left bank of the Dnieper, temporarily turning the island into a peninsula. The source of the Desenka River was channelled into pipes.

3. There are several levels of ecological status and areas of negative impact on the geological environment at Muromets Island: the zone of stress is distinguished by the initial stage of violation of the geological environment and covers 23% of the island; the zone of the critical state of the geological environment is characterised by the destruction of the shoreline of the island due to the influence of natural and anthropogenic processes and is 32%; the zone of crisis condition has signs of environmental problems which will be difficult to reverse and has reached 45%.

4. It is shown that anthropogenic load negatively affects the geological environment of the island and can lead to its distortion and transformation into a semi-desert, completely built-up zone, and area of garbage pollution. Complexes of anthropogenic and natural loads which the geological environment of the island has been subjected to for over 30 years can lead to intensive shoreline erosion and significant loss of land resources.

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