

**GeoTerrace-2023-007****Elements of assessment of the anthropogenic impact of a coal mining mine on the site of the Emerald Network using methods of remote sensing of the Earth**

**\*O. Masiuk** (*Oles Honchar Dnipro National University*), **R. Novitskyi**, **H. Hapich**, **Ye. Chubchenko** (*Dnipro State Agrarian and Economic University*)

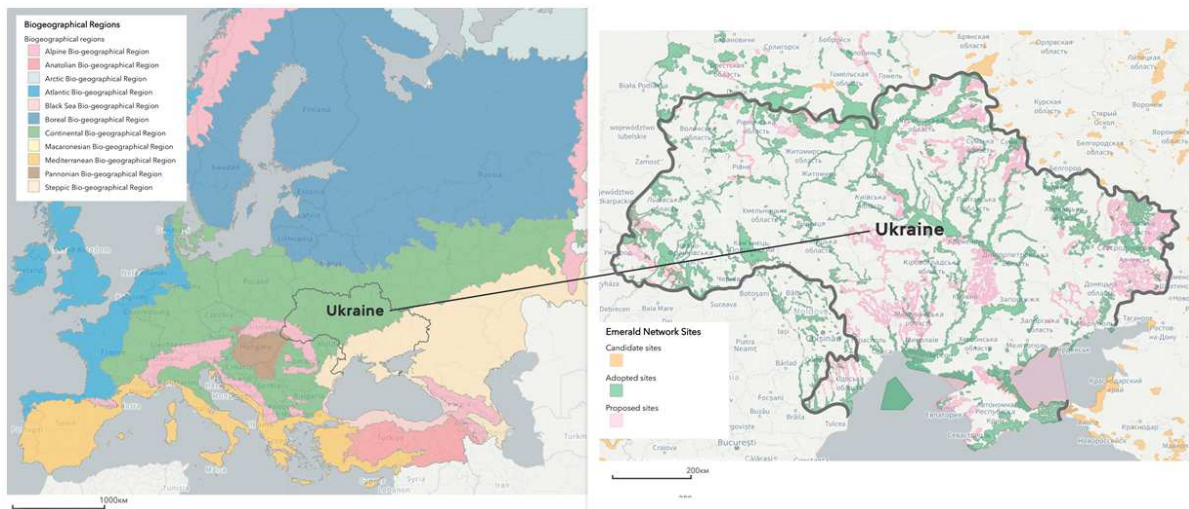
**SUMMARY**

The study presents a preliminary assessment of anthropogenic impact on a part of the object of the Emerald Network "Samarskyi Lis - UA0000212" (Ukraine) as a result of coal mining with the use of geoinformation systems. A complex of standardized field, chamber, laboratory and statistical research methods was used during the study of aquatic and terrestrial vegetation. In order to compare the data of visual observations and obtain representative and reliable research results, the object was additionally monitored using methods of remote sensing of the Earth. A satellite observation tool is used, which allows searching, processing and obtaining information from satellite data according to various indices: WRI, NDWI, MNDWI, NDSI. It has been established that long-term inundation and flooding of landscapes leads to a change in the species composition of the tree stand, the death of the understory and grass layer, and the complete destruction of the existing plant and animal communities. Research results are an important element of comparing the design indicators of the impact of planned activities with the real anthropogenic load on ecosystems in order to ensure the appropriate level of requirements of environmental and nature protection legislation. An important element of monitoring is the substantiation of the further need for protection and expansion of protected areas and water areas, restoration and protection of ecosystems of natural landscapes of the Samara forests. Consolidation of cadastral boundaries and further monitoring of such territories using remote sensing geoinformation systems are priority areas of development in the conditions of martial law and limited free access to such objects and insufficient use of direct geodetic and hydrogeological measurements.

*Keywords:* Emerald Network, Natura 2000, flooding of the territory, remote sensing Earth, natural ecosystem

## Introduction

Emerald Network, according to the Ukrainian Nature Conservation Group (UNCG, 2023) is being developed in Ukraine as part of the implementation of the Berne Convention (Convention on wild species of flora and fauna and habitats in Europe, 1979), as well as within the framework of fulfilling the requirements of the Association Agreement between Ukraine and the European Union (Bevz, 2018). Organization Emerald Network takes place in non-EU countries, but it fully meets the requirements of the Natura 2000 network, which is an analogue in EU countries. First of all, the Berne Convention approved lists of species (plants and animals) and habitats that require protection at the level of the whole of Europe, determined according to uniform criteria (Fig. 1). In Ukraine, the creation of the Emerald Network began in 2009, and its main elements were the existing territories of the nature reserve fund of national importance, which already had a protective status. Currently, the network consists of 271 territories, and its area is only 10% of the area of Ukraine (UNCG, 2023). While the average indicator among EU countries reaches 18% of the area of the states.



**Figure 1** A sample of the map representation of the Emerald Network of Europe and Ukraine according to the data of open GIS portals (<https://emerald.eea.europa.eu/>)

One of the objects of the Emerald Network is "Samarskyi Lis - UA0000212" - an important area of special environmental interest. It is located in the middle of the Oril-Samara River floristic sub-district, which has the most favorable natural conditions within the Dnipropetrovsk region of Ukraine. Accordingly, within the boundaries of the Samara Forest there is the greatest phytodiversity and there are 61 species of plants that are protected by international legislation and the Red Book of Ukraine (Solomakha et al., 2020; Masiuk et al., 2021).

Ensuring the cadastral boundaries of nature protection territories at the legislative level also requires geodetic fixing of protected areas on the ground. An important element of the development of Emerald Network is the development of various cartographic materials based on modern geographic information systems (GIS). General control over the geocological condition and specialized monitoring observations of individual elements of ecosystems of protected areas is impossible without the use of remote sensing of the Earth (RSE).

Since the Emerald Network is currently a planning project, some of them are constantly under anthropogenic influence. Production activity within nature protection limits leads not only to the deterioration of the general state of ecosystems, but also, in some cases, to their complete loss.

Thus, this work presents an element of the study of the negative impact of the coal mining industry (Masiuk et al., 2020) on the example of a section of the Emerald Network territory "Samarskyi Lis - UA0000212" using GIS technologies of the RSE.

## Method and Theory

The object of the study was the area of the earth's surface, within which underground coal mining takes place at the "Ternivska" mine (Ternivka, Dnipropetrovsk region, Ukraine) and the adjacent water areas of the "Samarskyi Lis" Emerald Network facility - UA0000212. A complex of traditional field and camera methods was used to study the flora of the 340-hectare area affected by the mine. When identifying plants, methods of collection, herbarium and species identification were used. Species names are given according to modern Ukrainian nomenclature publications (Mosyakin & Fedoronchuk, 1999).

Remote monitoring of the research object was carried out using EOSDA LandViewer. It is an open access satellite observation tool that enables you to search, process and obtain information from satellite data to solve various geological problems (<https://eos.com/products/landviewer/>). Fragments are taken from satellite data Landsat 8. During the processing and interpretation of the results, the following water indices were used: WRI, NDWI, MNDWI, NDSI.

## Results

According to the project decisions, during 2020-2025, it is planned to extract 3.7 million tons of coal in the cutting area of the "Ternivska" mine. The projected impact of the mine's production activities includes the possibility of deformation of the earth's surface in the form of subsidence up to 0.9 m and a change in the hydrogeological regime of the territory on an area of 340 hectares. 90 hectares are in the risk zone directly (complete inundation and inundation) or indirectly (temporary inundation and inundation), on which there are settlements formed by aquatic, coastal, meadow and forest vegetation.

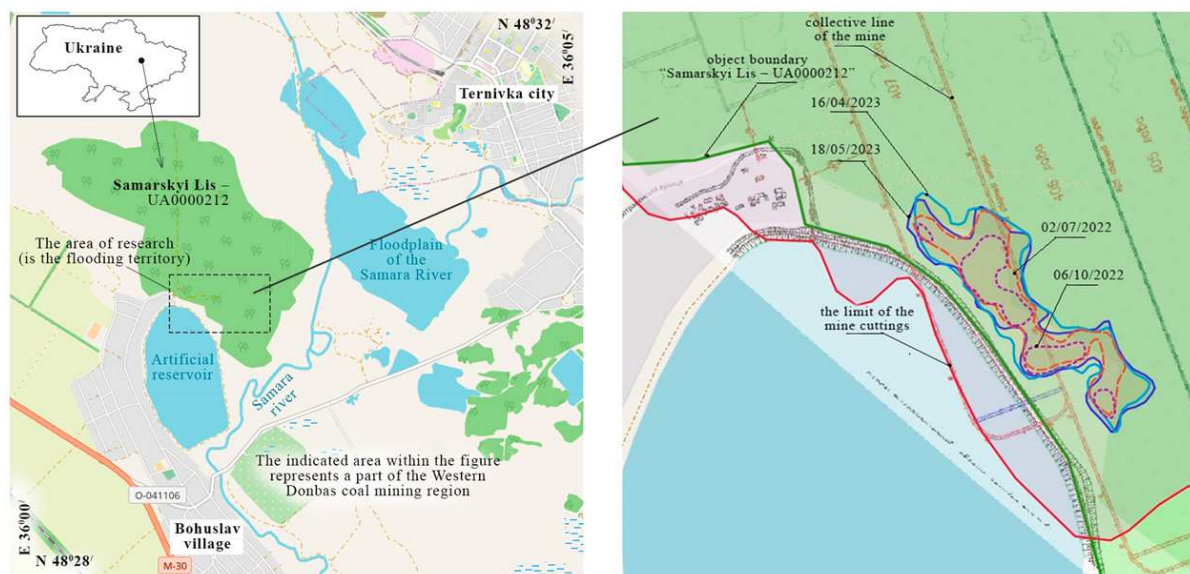
The initial survey of the studied area was carried out in 2020. Seven types of dwellings were identified (Kuzemko et al., 2017): C1.67, C3.5133, E1.2F, E3.4, G1.36, G3.4232, X35. Monitoring of the composition and changes in the diversity of flora and fauna took place during regular four-time expedition trips in April, June, August, November in the period from 2021 to 2023.

According to the results of field floristic studies, 233 species of higher vascular plants (from 168 genera and 62 families) were found in the study area, which have important environmental significance both at the regional and state, and at the international level. We discovered plants listed in the Red Book of Ukraine: *Allium savranicum* Besser, *Stipa borysthena* Klok. ex Prokud., *Pulsatilla nigricans* Storck, *Tulipa quercetorum* Klok. et Zoz, *Ornithogalum boucheanum* (Kunth) Aschers; regionally rare species: *Allium paniculatum* L., *Polygonatum odoratum* (Mill.) Druce, *Ornithogallum kochii* Pare, *Scilla siberica* Haw. *Scilla bifolia* L., *Berberis vulgaris* L.; to the lists of the International Union for Conservation of Nature (IUCN) – *Agropyron dasyanthum* Ledeb; to the Berne Convention – *Jurinea cyanoides* (L.) Rchb and other.

Two types of environmental changes were recorded in the studied area. The first is related to surface subsidence, in stands of Scots pine in the arena and in meadows with steppe elements of flora, which is probably caused by coal mining in the past years (2020–2021). In addition, repeated field studies established the further development of negative engineering and geological processes on the surface of the earth at the end of 2022 and the beginning of 2023. The formation of cracks, suffusion and subsidence occurs to a depth of 40–80 cm (in some places up to 1 meter), which does not yet affect the flora and fauna in these stations. The second type of changes is associated with a change in the hydrological regime of part of the studied territory in the form of long-term inundation, which led to the death and loss of stands due to the flooding of significant forest masses, undergrowth and grassy layer on the border areas in the floodplain part and in the arena part of the landscape within dirt road and a small part of the territory adjacent to it. The nature of the inundation may be related to working out or carrying out work in coal mines, because in 2022 there was a slight rise of water and its localization almost within the natural state. But in the spring, the dam of the "Storm" pond subsided, which led to the leakage of water from it, flooding of the adjacent territories and, as a result, to the transformation of water, coastal, forest and meadow ecosystems with the potential destruction of

habitats of background and conservation plant species. Observations in April, May and early June 2023 indicate the presence of long-term water bodies up to 50–100 cm deep in those parts of the landscape where they were last year.

Note that the limited access to the research object during wartime does not allow direct geodetic measurements and hydrogeological searches to be carried out in full. Therefore, geoinformation systems of remote sensing of the Earth (RSE) are a promising and well-founded element of the study of territories under the influence of technogenic influence. Modern GIS allows monitoring the situation over time and forecasting possible changes in further anthropogenic impact on the environment. A comprehensive analysis of the RSE data made it possible to separate the flooded territory of the Emerald Network "Samarskyi Lis - UA0000212" from the dry land (Fig. 2) and establish the area of the flooded territory in different observation periods.



**Figure 2** The location of the research area and the summarized results of the monitoring of the flooding of the lands of the Emerald Network "Samarskyi Lis – UA0000212" (indices NDSI and WRI)

The analysis of the received data shows that the area of the flooded territory increased from 1.2 hectares in 2021 by almost 5 times to 6.2 hectares in 2023. In addition, the negative impact is also increasing in the water areas of river ecosystems due to the deterioration of the quality of water resources (Hapich et al., 2022) and discharge of mine waters (Kovrov et al., 2023).

## Conclusions

A complex of field research and the use of modern geoinformation systems for remote sensing of the Earth allowed us to identify a number of negative signs of anthropogenic impact of a coal mining mine on one of the elements of the Emerald Network "Samarskyi Lis - UA0000212". The main negative factors of influence are: inundation and flooding of large areas due to subsidence of the earth's surface; the threat of extinction of a significant number of rare and endangered plant species that are of scientific interest for conservation at the national and international levels.

Based on the results of comparison of various satellite data indices (WRI, NDWI, MNDWI, NDSI) of the RSE, the dynamics of the flooding process of the studied territory was determined. It was established that as a result of underground coal mining, a long-term (several years) flooding and inundation of landscapes was formed, which led to a change in the species composition of the tree stand on the surface, the death of the understory and grass layer. Predicted long-term flooding can lead to the complete destruction of the existing plant and animal communities in the element of the Emerald Network "Samarskyi Lis - UA0000212" and will make it impossible for terrestrial invertebrate species that lived in the studied biotopes to develop.

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