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Use of the LandViewer Application for Monitoring Catchment Urbanization and the Ecological Status of Lake Basiv Kut

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SUMMARY

This article examines the relevance of using the LandViewer application to monitor the impact of urbanization pressure on water bodies (using Lake Basiv Kut as a case study). False-color satellite composites of urbanized areas were employed as a tool for detecting systematic violations of the water protection zone regime. Using satellite imagery and the LandViewer software service, a retrospective analysis was carried out of the transformation of the areas located in the immediate vicinity of Lake Basiv Kut and of water quality over the period 2017–2026. The false-color composite is regarded here not merely as a means of visualizing satellite data, but primarily as an effective analytical instrument for the comprehensive investigation of the lake's pollution problem. The results obtained may be used both for scientific analysis and for the formulation of recommendations aimed at improving the ecological status of water bodies, as well as serving as objective evidentiary information in the consideration of matters relating to compliance with the land-use regime of water protection zones.

Keywords: LandViewer; Monitoring; Urbanization processes; Water quality

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Introduction

The assessment of the status of water bodies using geographic information systems (GIS) and remote sensing of the Earth (RS) is becoming a key method in contemporary research on the sustainable management and protection of water resources (Likho et al., 2026; Plichko et al., 2026).

Conventional hydrochemical and sanitary-microbiological monitoring based on point sampling makes it possible to assess the condition of the aquatic environment and to detect pollution, but it is limited in identifying the spatial sources of that pollution. In urbanized areas, surface runoff constitutes a major pathway for the entry of pollutants into water bodies. Therefore, alongside the assessment of the consequences of pollution, a spatial analysis of the factors contributing to its formation is required.

The aim of the study is to substantiate the potential of using satellite imagery and the LandViewer software service for monitoring the impact of urbanization pressure on water bodies, using Lake Basiv Kut in the city of Rivne as a case study.

Intensive and uneven urbanization is a pressing problem of environmental management. Satellite remote sensing data, in particular from the Landsat and Sentinel missions, together with specialized indices, enable effective analysis of the dynamics of built-up areas, thereby expanding the capabilities of environmental monitoring and the identification of zones requiring detailed investigation. According to Sekertekin et al. (2018), accounting for the spatial dynamics of landscapes is an essential prerequisite for sound management and environmentally balanced territorial development.

A study of the influence of different types of residential development on the formation of surface runoff, conducted using the i-Tree Canopy method on the basis of high-resolution aerial imagery, was carried out in the city of Munich, Germany (Xu et al., 2020). It was established that, compared with low-density residential settlements, high-density residential areas tend to generate a greater volume of polluted surface runoff within the district.

A study by Baltodano et al. (2022) demonstrated that the expansion of urbanized areas has a substantial effect on the water quality of Lake Titicaca. Spatiotemporal changes in water quality associated with changes in land cover complicate the management of water resources. Using remote sensing data, a close relationship was established between urbanization of the Katari River basin (Bolivian Andes) and the deterioration of river and lake water quality, which confirms the promise of remote sensing for investigating these processes.

Methods and Theory

The study is based on an integrated spatiotemporal approach involving the application of remote sensing methods to detect and analyze changes in the land-use structure of areas situated within the water protection zone and in the vicinity of Lake Basiv Kut. The transformation of these areas is considered one of the potentially significant factors of anthropogenic impact on the condition of the aquatic ecosystem.

The theoretical basis of the study is the conception of the water protection zone and the coastal protective strip as spatial environmental elements performing barrier and regulatory functions. Their intensive economic development or built-up use may disrupt the natural mechanisms governing the functioning of coastal ecosystems and, consequently, intensify the anthropogenic pressure on the water body (Water Code of Ukraine, 1995).

The choice of the LandViewer platform and the application of the False Color Urban composite, generated from bands B12, B11, and B4 of Sentinel-2 Level-2A satellite data, is determined by the objectives of spatial environmental monitoring. The use of shortwave infrared (SWIR) bands, in particular B12 and B11, makes it possible to enhance the contrast between individual land cover types and facilitates the identification of anthropogenic features in satellite imagery.

The use of false-color composites should be regarded not only as a means of visually presenting satellite information, but also as an analytical instrument for the comprehensive investigation of the ecological status of lake ecosystems. The application of this approach creates opportunities for detecting and spatially documenting changes in development and land use within water protection areas, for assessing the intensity and dynamics of urbanization processes within the catchment, and for the subsequent analysis of their possible relationships with water quality indicators.

Results

Lake Basiv Kut is an artificial in-channel reservoir on the Ustia River within the city of Rivne. The surface area of the lake is 91.28 ha, the mean depth is 2 m, and the maximum depth is 3.1 m. Regulation of the water level in the lake is provided by a dam equipped with an in-channel regulating sluice. Lake Basiv Kut belongs to the category of regulated water bodies, which are characterized by a limited self-purification capacity owing to weak flow-through conditions and increased sensitivity to anthropogenic factors, as compared with lakes of natural origin.

The principal factors capable of exerting a substantial influence on the ecological status of Lake Basiv Kut include the absence of a centralized wastewater disposal system in the Basiv Kut residential district, as well as the intensive development of the areas adjoining the water body, in particular within the water protection zone and the coastal protective strip. Such changes in the pattern of land use require separate analysis with respect to their compliance with the requirements of the current water protection legislation of Ukraine.

Lake Basiv Kut performs important recreational functions and is used for recreational fishing, which necessitates the systematic monitoring of its ecological and sanitary condition. Monitoring of the water quality of the reservoir with respect to compliance with hygienic standards is carried out by the Rivne Regional Center for Disease Control and Prevention.

Analysis of water quality observation data for Lake Basiv Kut over the period 2022–2026 revealed considerable microbiological contamination of the aquatic environment. In particular, the maximum value of the LPEC (lactose-positive Escherichia coli) index, which characterizes the level of bacterial contamination and may indicate fecal pollution of the water, reached 240,000 CFU/dm³ against a standard value of no more than 5,000 CFU/dm³. The number of coliphages amounted to 266 per 1 dm³ against a permissible value of up to 100 per 1 dm³. In addition, cholera-like vibrio and Giardia cysts were detected in the water samples, which further characterizes the unfavorable sanitary and microbiological condition of the water body.

At the same time, Lake Basiv Kut is an established aquatic ecosystem whose functioning depends directly on the quality of the aquatic environment and its suitability for the existence of aquatic organisms. In view of this, it is advisable to assess water quality not only against hygienic indicators, but also with regard to the regulatory requirements established for water bodies of fishery significance. Figure 1 presents a diagram showing the ratio of the maximum actual values of selected water quality indicators obtained over the period 2022–2026 to the corresponding maximum permissible concentrations (MPCs) for fishery water bodies.

It should be noted that the combination of high BOD_5 with exceedances of ammonium nitrogen and nitrites is a typical marker of the inflow of untreated sewage. This, in turn, is attributable to the absence of a sewerage system in certain sections of the area adjoining the lake, in particular in the Basiv Kut residential district.

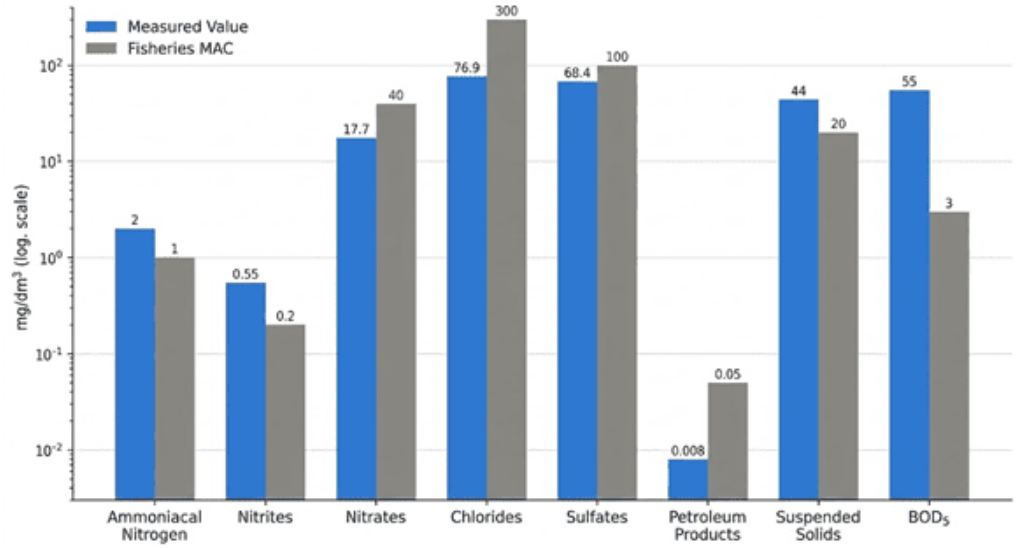

Figure 1. *Ratio of the actual maximum values of water quality indicators to the corresponding fishery MPCs for the period 2022–2026*

The analysis of satellite imagery for 2017, 2022, and 2026 (Figure 2) made it possible to identify a trend toward the progressive intensification of urban development of the areas adjoining the water body. In 2017, the coastal zone was characterized by a moderate level of urbanization: urban development bordered the lake directly mainly on the northern side, whereas the other adjoining areas retained a predominantly agricultural and natural character. Over the period 2022–2026, the intensity of urbanization increased substantially, and development spread across a significant portion of the areas surrounding the lake.

27.08.2017 *21.08.2022* *15.08.2026*

Figure 2. *Image fragments of the area in the vicinity of Lake Basiv Kut for 2017, 2022, and 2026. Satellite: Sentinel-2 L2A, False Color (urban)*

A comparative analysis of satellite images from different time periods visually confirms the trend toward the densification and spatial expansion of development in the area adjoining the lake, which may be regarded as one of the significant factors contributing to the intensification of anthropogenic pressure on the aquatic ecosystem. The use of the LandViewer application allows not only for the visualization of satellite data, but also constitutes an analytical instrument for the comprehensive investigation of lake pollution problems.

The integrated comparison of the results of hydrochemical investigations with the data of the spatial analysis of satellite imagery makes it possible to substantiate a cause-and-effect relationship between

anthropogenic pressure and the degradation processes of Lake Basiv Kut. Considerable exceedances of the standard values for BOD_5, reaching up to 18-fold, as well as high values of the LPEC index - up to 240,000 CFU/dm³ — may indicate the inflow into the water body of insufficiently treated or untreated domestic wastewater.

The analysis of satellite composites for 2017–2026, performed using the LandViewer platform, demonstrates a substantial densification of residential development in the immediate vicinity of the lake shoreline over the period in question. Given the absence of a centralized wastewater disposal system in this residential district, remote sensing materials may serve as spatial confirmation of the potential location of sources of diffuse fecal and nutrient pollution. Consequently, the areas exhibiting the most intensive manifestations of urban development, identified from satellite imagery, spatially coincide with the zones of probable greatest inflow of pollutants into the aquatic environment.

Conclusions

The results of the study demonstrated that the application of GIS technologies and the capabilities of the LandViewer platform substantially expands the functional use of satellite imagery, transforming it from a means of visually representing a territory into an important source of spatial information for the scientific substantiation of management decisions by local self-government bodies.

The proposed approach also creates the preconditions for enhancing the effectiveness of the conventional environmental monitoring system. The use of satellite data makes it possible to preliminarily localize areas with an elevated level of anthropogenic pressure and potential environmental risk, which allows for a more substantiated determination of priority sites for field surveys and water sampling.

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