DOI: 10.25140/2411-5363-2024-1(35)-337-345
UDC 528.946

***Andrii Brydun*[1], *Andrii Sohor*[2], *Mykhailo Fys*[3], *Yurii Hubar*[4]**

[1]PhD in Physical and Mathematical Sciences,
Associate Professor of the Department of Cartography and Geospatial Modelling
Lviv Polytechnic National University (Lviv, Ukraine)
E-mail: andrii.m.brydun@lpnu.ua. **ORCID:** https://orcid.org/0000-0001-5634-0512
ResearcherID: AAC-1271-2020. **Scopus Author ID:** 57212560353

[2]PhD in Technical Sciences, Associate Professor of the Department of Cartography and Geospatial Modelling
Lviv Polytechnic National University (Lviv, Ukraine)
E-mail: andrii.r.sohor@lpnu.ua. **ORCID:** https://orcid.org/0000-0002-0084-9552.
ResearcherID: ABI-6288-2020. **Scopus Author ID:** 57224950613

[3]Doctor of Technical Sciences, Professor of the Department of Cartography and Geospatial Modelling
Lviv Polytechnic National University (Lviv, Ukraine)
E-mail: mykhailo.m.fys@lpnu.ua **ORCID:** https://orcid.org/0000-0001-8956-2293
ResearcherID: AAB-9528-2020.C **Scopus Author ID:** 36091174500

[4]Doctor of Technical Sciences, Head of the Department of Cadastre of Territory
Lviv Polytechnic National University (Lviv, Ukraine)
E-mail: yurii.p.hubar@lpnu.ua **ORCID:** http://orcid.org/0000-0003-2538-0727
ResearcherID: ABZ-0251-2022. **Scopus Author ID:** 57224950139

WEB MAPPING OF SURFACE WATER POLLUTION IN LVIV REGION BY MEANS OF GIS AND REMOTE SENSING

The ecological state of surface waters in Lviv region is affected by various factors: soil and air pollution, technogenic load on the territory, inefficient operation of sewage treatment plants in settlements, pollution and littering of rivers with household and other waste. Another important problem leading to surface water pollution in the region is the absence of water protection zones and coastal protective strips. The lack of cartographic materials and the undefined boundaries of water protection zones and coastal protection strips result in violations of land and water legislation. Currently, the state of water bodies in Lviv region is unsatisfactory. The main problems in this area lie in the growing negative impact on the environment and human health. The main purpose of this paper is to create a web map of surface water pollution in Lviv region, in particular, using remote sensing data.

To this end, we have collected and systematized geospatial statistical cartographic materials on the ecological state of surface waters. In addition to statistical data, remote sensing (RS) data obtained from various sources have been used to assess the state of surface waters. The necessary software for the development of such a web map has been identified. An algorithm for uploading geospatial data to the created web resource has been developed. Thus, the web maps of surface water pollution in Lviv region have been created in ArcGIS Online, a software environment.

Keywords: *geospatial data; GIS; remote sensing; ecological cartography; surface water pollution; interactive map.*
Fig.: 4. References: 25.

Introduction. As a result of long-term operation without the necessary maintenance of water supply and sewerage systems, most of the water supply and sewerage facilities in Lviv region are in unsatisfactory technical condition, with some of them being in the abnormal one. The situation is being worsened by the discharge of untreated and insufficiently treated municipal and industrial wastewater, due to physical deterioration and functional depreciation of sewage treatment facilities and lack of funds for construction.

Over 1.5 million tons of sewage have accumulated on the sludge fields near the treatment facilities of the city of Lviv, which are operated by Lvivvodokanal, a municipally owned enterprise. The sites with a total area of 22 hectares are daily replenished with 3 thousand m3 of sludge, which leads to the aggravation of the environmental situation and violation of the technological regime. Lvivvodokanal belongs to the business entities included in the "List of 100 objects that are the largest environmental polluters in Ukraine" [1; 2].

To date, water zones and coastal strips of water in the territory of Lviv region have not been demarcated, which violates the favorable environmental protection regime of water bodies and leads to their pollution and contamination. Given the state of pollution of surface water bodies, the priority issues are the expansion of sludge sites, sludge disposal, and wastewater disinfection at

sewage treatment plants (STP) in Lviv; construction of sewage treatment plants for the urban settlement of Slavske and for the cities of Rava-Ruska, Morshyn, construction of a collector sewer in Bryukhovychi, STPs in Chervonohrad, Dobromyl, Bibrka, Zhydachiv and Novoyavorivsk [3].

Review of recent scientific publications. The analysis of modern scientific publications showed that considerable attention should be paid to the problem of surface water pollution. If such a problem exists in the future, it will have negative consequences for the environment. Ecological mapping is the only way to visually display the ecological quality of surface waters. The issues in question have been addressed by a number of scientists [4; 5].

It should be noted that ecological mapping is a rather specific type of thematic mapping, since it is difficult to determine the subject area of the studied value. Such research is characterized by the uniqueness of each ecological system, the extent of human influence on the environment, the implementation of nature protection measures, as well as the relationships of different populations with each other and with the environment, which has been studied by the following scientists [6; 7].

The purpose of ecological mapping is the ability to analyze the ecological situation and its change over time, that is, to identify spatial and temporal changes in environmental components that affect the state of the ecosystem. To achieve this goal, it is necessary to collect and analyze environmental information, evaluate it, give it a territorial interpretation, as well as create a cartographic presentation of very diverse information on environmental pollution. These problems have been investigated by a number of researchers [8-10].

The legal and organizational principles of environmental impact assessment are aimed at preventing damage to the environment, ensuring ecological safety, environmental protection, rational use and reproduction of natural resources in the process of making decisions about the implementation of economic activities that may have a significant impact on the environment, taking into account state, public and private interests. This method of researching natural and man-made objects and taking into account environmental information determine the importance and necessity of using modern geographical methodologies using remote sensing data [11-25].

Unsolved aspects of the problem. The purpose of the paper. Water resources of the Lviv region play an important role for the population and economy. Water is used for drinking, technical, agricultural needs, in fisheries, for medical purposes, is a source of replenishment of underground water reserves, etc. The surface waters of Lviv Oblast are represented by rivers, reservoirs, lakes and ponds. According to the preliminary summarized data for the year 2021 of the state accounting of water use by types of economic activity and by administrative districts of the Lviv region, summarized information is provided on the withdrawal, discharge and irreversible use of water, the use of water for economic and domestic needs.

Priority areas in 2021 were the construction, reconstruction and capital repair of hydrotechnical structures, protective flood dams, shore fortification structures, clearing and regulation of rivers.

The purpose of the paper. The purpose of this article is an ecological study of the quality of surface water in the Lviv region and the creation of an interactive map based on these data in the ArcGIS Online software environment.

To achieve this goal, the work set and resolved:

- collection and systematization of statistical cartographic and remote sensing materials concerning the ecological state of surface waters in Lviv region.
- determination of the GIS software required for the development of an interactive surface water pollution map of the Lviv region.
- introduction of the algorithm of surface water pollution data of the Lviv region into the created web resource by means of GIS.

Main body. The assessment of surface water quality was based on the analysis of the values of hydrochemical indicators in comparison with the corresponding values of their threshold limit concentrations (TLC) and background indicators (Table 1).

Table 1 – Threshold limit values (TLV) of hydrochemical indicators

Hydrochemical indicator (mg/dm^3)	Threshold limit values	
	For water bodies of fishery purpose	For water bodies of household use
Dissolved oxygen	–	>4.0
The pH value	6.5 – 8.5	6.5 – 8.5
Sum of ions	1000	–
Chlorides	300	350
Sulfates	100	500
Magnesium ions	40	–
Calcium ions	180	–
Sodium ions	120	200
Ammonium nitrogen	0.39	2.0
Nitrate nitrogen	9.0	10.0
Nitrite nitrogen	0.02	1.0
Phosphates	0.17	3.5
Zinc	0.01	1.0
Manganese	0.01	0.1
Chromium (VI)	0.001	0.05
Lead	0.1	0.03
Nickel	0.01	0.1
Cadmium	0.005	0.001
Total iron	0.1	0.3
Petroleum products	0.05	0.3
Phenols	0.001	0.001

Hydrochemical and hydrophysical indicators were divided into the following groups according to their type and/or quantitative characteristics [2]:

Group 1 - components of salt composition: (total ions, bicarbonates, chlorides, sulfates, magnesium, calcium, sodium ions)

Group 2 - indicators of tropho-saprobiological state: suspended solids, dissolved oxygen, pH, dissolved organic matter, compounds of the main biogenic elements (ammonium nitrogen, nitrate nitrogen, nitrite nitrogen, phosphates);

Group 3 - specific substances: oil products, phenols; heavy metals (total iron, zinc, total chromium, lead, nickel, cadmium).

Lvivvodokanal has implemented the "Lviv Water Supply and Wastewater Treatment Project", which is funded by a World Bank loan, a grant from the Swedish government and the city budget [1]. Other measures are being taken to reduce the negative impact of the facility on the environment. The amount of pollutants discharged into the Poltva River after the sewage treatment facilities of the city of Lviv according to Lvivvodokanal is shown in Table 2.

Table 2 – Amount of pollutants discharged into the Poltva River

	1 production line		**2 production line**	
Pollutants	**2021 yr. (t)**	**2020 yr. (t)**	**2021 yr. (t)**	**2020 yr. (t)**
Suspended solids	435.55	572.13	1075.0	1039.44
Mineralization	11378.92	14462.54	26485.0	24969.13
Sulfates	1872.57	2940.64	3544.06	3785.36
Chlorides	3446.93	4444.38	7742.12	7440.48
Ammonium nitrogen	55.78	74.25	127.85	124.25
Nitrates	159.66	208.52	823.64	751.77
Nitrites	19.7	16.06	19.78	19.18
Phosphates	41.29	51.68	96.26	87.03
Iron	9.64	13.19	17.5	17.1

According to Lvivvodokanal, the comparison of the amount of wastewater discharged into the Poltva River from the sewage treatment plants of Lviv in 2021 to the amount in 2020 is shown in Table 3.

Table 3 – Amount of wastewater discharged into the Poltva River after sewage treatment plants

	2021 yr.	**2020 yr.**
1 production line	29 700 815 m^3	38 962 377 m^3
2 production line	78 723 753 m^3	75 984 646 m^3

Waste management and disposal: sludge after sewage treatment plants (STP) in the city of Lviv in 2021 amounted to 24,247.11 tons (in 2020 - 25,173.10 tons). During 2021, samples were taken from lakes, ponds, streams, and rivers. A total of 37 locations were investigated. The largest number of exceedances was recorded for the following pollutants: suspended solids (32 locations), total iron (16 locations), ammonium nitrogen and ammonia (16 locations), and phosphates (9 locations). According to the results of chemical tests carried out in 2021, the threshold limit concentrations of pollutants from 4 to 7 indicators were exceeded in 9 water bodies [1].

The most polluted water bodies according to the observations are the following: the Kryvchytsky stream (Staroznesenska str. 200); the Zubra river, bridge; the Lysynytsky stream (Trakt-Hlynyansky str. 150); the reservoir on Panas Sotnyk str.; the "Poltva" river (a bypass road), "Vse dlia Fur" store; the river "Myklasivka" (a bypass road); the stream "Vodyanii" near the Think Global School (Airport, behind the garages); the "Bilohorsky" stream (a bypass road), the village of Rudno (from the side of Sygnivka). In the water of most of these bodies, the threshold limit concentrations of suspended solids, total iron, ammonium nitrogen, and phosphates were recorded. Instead, the purest in terms of 1 exceedance of maximum permissible concentrations of pollutants in the Q1 were the following water bodies: the reservoir in "Levandivske Lake" park; the reservoir at Kulparkivska, 139 (Symonenko); Vakhnyanina str. 29 (Creativity Center of Children and Youth of Galicia); the "Betonka" reservoir on Antonycha str., the reservoir at Zamarstynivska-Naukova; the stream in the village of Pidryasne (at the junction); the stream near the Hrybovychi landfill (near the road); the river "Mlynivka" in Hryada (in front of the pig farm, bridge sign in front of the village Doroshiv)., the reservoir in Dubliany (Shevchenko str., the final bus stop); the water body at Lypynskoho street, 27 (near the monastery); the water body in the village of Volya-Homuletska (the largest in area, the recreation complex "Albatross"); "Snopkivskyi" park, Buchmy str. In general, the following pollutants were detected in Lviv's water bodies: suspended solids, total iron, ammonium nitrogen, nitrates, nitrites, phosphates, chlorides, sulfates, fats, synthetic surfactants, and oil products [2].

According to the results of the monitoring laboratory for environmental pollution of the Volyn Hydrometeorology Center, monitoring observations of the water quality of the Western Bug River basin were carried out in 2021.

Table 4 – Mean concentrations of pollutants in the Western Bug river basin

No	Dam location	pH, pH units	Oxygen, mg /dm^3	Calcium, mg /dm^3	Magnesium, mg /dm^3	Hydrocarbonates, mg /dm^3	Chlorides, mg /dm^3	Sulfates, mg /dm^3	Sodium, mg /dm^3	Bicarbonate. oxid. mg/dm^3	N (ammon.), mg N/dm^3	N (nitrite.) mg N/dm^3	N (nitrate.), mg N/dm^3	P (phosph.) mg P/dm^3	P total.,mg P/dm^3
1	The Western Bug (river), 781 km, Busk town	7.87	9.01	151	12.2	42333	50.4	15.37	3.63	29.2	1.03	0.297	0.13	0.199	0.241
2	The Western Bug (river), 723 km, Staryi Dobrotvir (village)	7.96	10.44	137.3	13.3	393.67	53.23	22.73	11.59	23.93	0.37	0.277	0.03	0.247	0.333
3	The Rata (river), 3.5 km, Mezhyrichchia (village)	7.98	9.41	109.3	9.47	331.67	22.23	21.77	6.77	35.07	0.49	0.065	0.25	0.046	0.070
4	Kyiv Stream 11 km, Nestanychi (village)	7.84	9.89	113	32.3	363	26.47	14.1	4.41	13.13	0.30	0.010	0.57	0.016	0.035
5	the Marunka river in Vynnyky under the bridge of the district road	7.99	11.3	114.3	18.1	478	40.07	37.8	27.4	18.4	1.19	0.084	0.23	0.121	0.204

The analysis of surface water quality is based on observations of the hydrochemical parameters provided by the Volyn Regional Centre for Hydrometeorology. The results of observations on the quality of surface water in the city of Lviv were provided by the municipal enterprise "Administrative and Technical Department" of the Lviv City Council. Data on the amount of pollutants discharged into the Poltva River from sewage treatment plants were provided by Lvivvodokanal.

In addition to statistical data, remote sensing materials obtained from various sources were used to assess the state of surface waters in Lviv region.

It should be noted that the change in water quality at the observation locations depends on the quantity and quality of wastewater from enterprises, unorganized runoff, meteorological factors, hydrological conditions of rivers during water sampling, etc.

Taking into account the above, we used quite a software environment "ArcGIS Online" to compile the web map. To get started in your chosen environment, you need to collect and structure data in Microsoft Office Excel. For our case, three Excel spreadsheets were developed with the following data:

- with data on monitoring of surface waters in Lviv region using remote sensing data.
- with data on recorded exceedances of indicators at enterprises that were investigated by the State Environmental Inspectorate in 2020-2021.
- with data on wastewater discharge from wastewater treatment plants.
- with observational data on the state of surface water pollution on border rivers.

For visualization our data, we used the OpenStreetMap map in the ArcGIS Online software environment with the given boundaries of the Lviv region and the boundaries of the districts of the region.

To begin with, we identified the locations of surface water pollutants and water sampling locations.

To solve the above-mentioned problem, we used the "ArcGIS Online" software environment, indicating the location of each enterprise in Lviv region (Fig. 1).

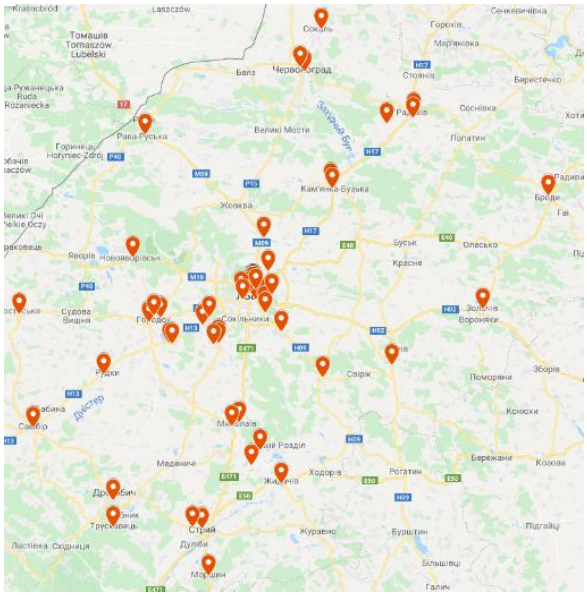

Fig. 1. Map of polluters in Lviv region

Also, the location of sample collection points in the rivers of Lviv region was determined (Fig. 2).

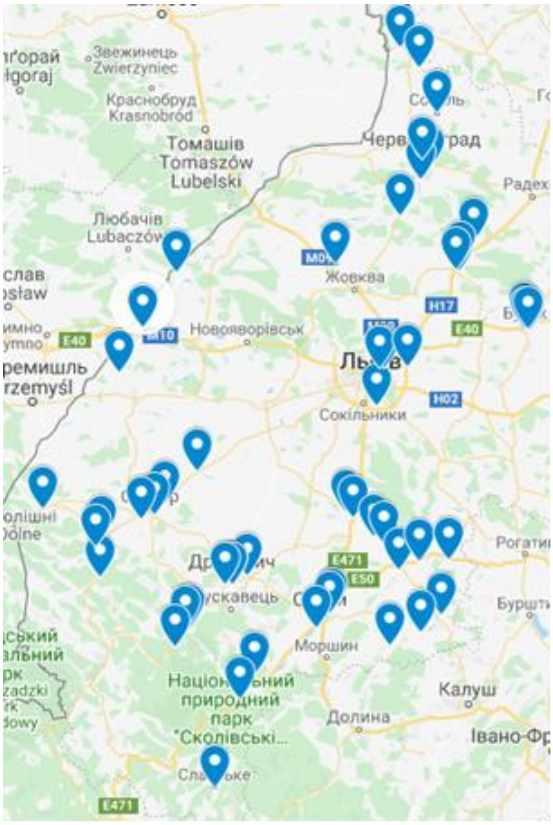

Fig. 2. Map with sample collection points in the rivers of Lviv region

Then, this information was uploaded to ArcGIS Desktop, and a layer with points was exported to KML / KMZ.

After completing these steps, it is necessary to open the ArcGIS Desktop environment, where the layer with the districts of the Lviv region was previously added, where we will use the ArcToolbox / Conversion Tools /From KML / KML to Layer menu to get the downloaded KML file in the ArcGIS software environment.

After that, this downloaded file is exported to the "Shapefile" using the "ArcToolbox" function. To do this, open the "ArcToolbox" function and locate the required KML file, along with enabling "M Values" and "Z Values" by means of the "Environments" function. This data includes M-values and Z-values, which are usually used to store route and altitude data.

After uploading the data into ArcGIS Desktop, it is necessary to select all the rivers where water samples were taken. To do this, the "Select By Attributes" function is used, where the necessary river is selected. The above steps lead to the generation of the following map in the "ArcGis", a software environment.

After compiling the map in the "ArcGIS Desktop", all the data are uploaded to "ArcGIS Online", with all the materials processed in the "Shapefile" being exported to the selected folder and archived.

After completing the process of styling, symbolizing and processing all layers, the map can be made publicly available using the "Share" function. This feature allows you to either insert into an existing site or develop your own program. In this case, we developed our own program.

As a result, we created two different maps:

• Surface water monitoring map of the Lviv region, obtained from remote sensing data (Fig. 3).

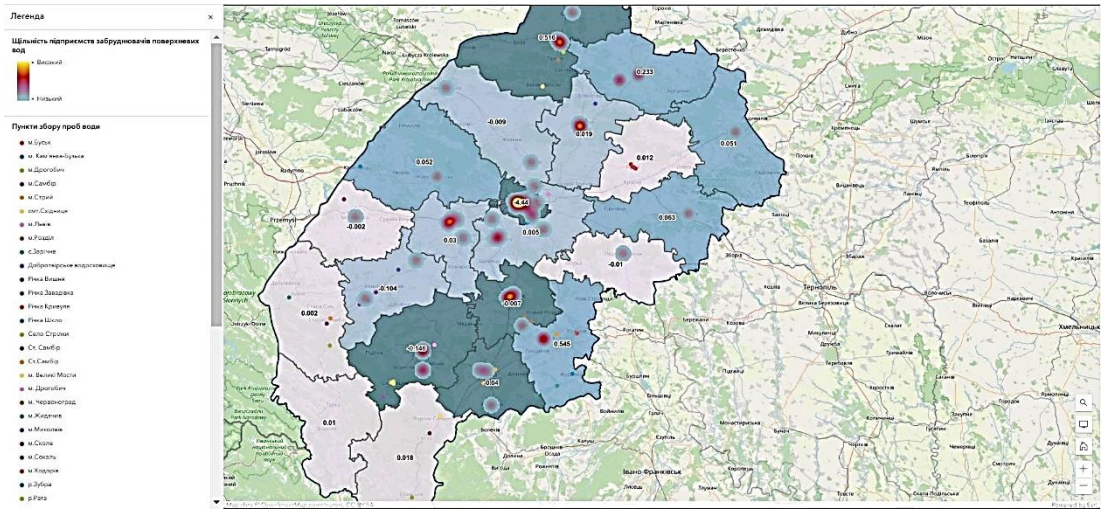

Fig. 3. Surface water monitoring map of Lviv region

• Map of wastewater discharge in Lviv region from treatment plants (Fig. 4).

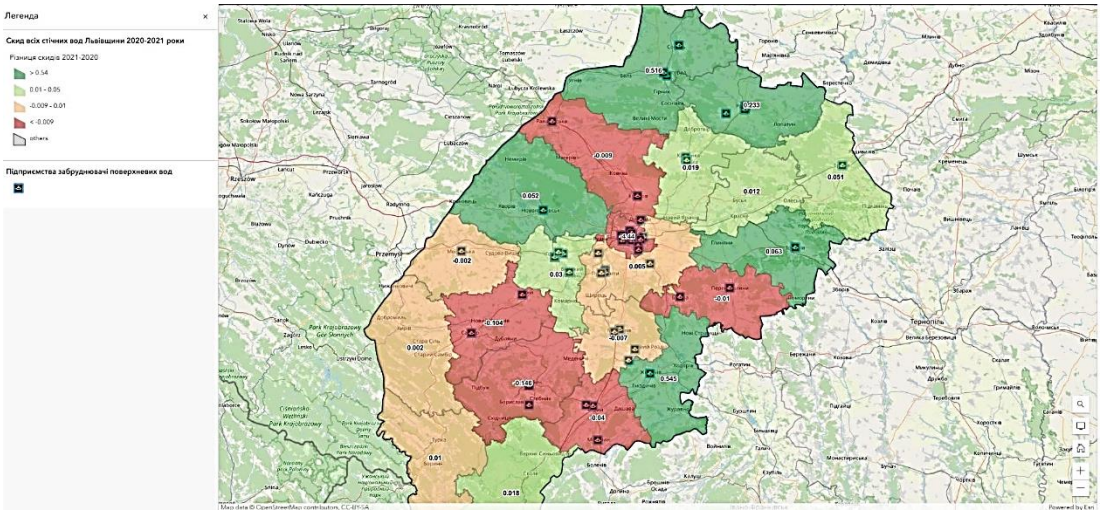

Fig. 4. Map of wastewater discharge in Lviv region from treatment plants

Conclusions and proposals. Thus, having studied the problem of surface water quality in Lviv region, the following can be concluded:

1. Based on the collected and systematized data, a map of enterprises polluting surface waters of Lviv region has been developed.

2. An interactive map with sample collection points in the rivers of Lviv region has been developed on the basis of GIS software.

3. Based on remote sensing data, a map monitoring of surface waters of the Lviv region has been developed.

4. A map of wastewater discharge from sewage treatment plants in Lviv region has been developed.

References

1. Department of Ecology and Natural Resources of Lviv Regional State Administration. (2021) Ecology of Lviv region 2020. Lviv: SPOLOM.

2. Department of Ecology and Natural Resources of Lviv Regional State Administration. (2022) Environmental passport of Lviv region for 2021. Lviv: SPOLOM.

3. Department of Ecology and Natural Resources of Lviv Regional State Administration. (2022) Regional report on the state of the environment in Lviv region in 2021. Lviv: SPOLOM.

4. Sohor, A.R., Fys, M.M., Brydun, A.M., Sohor, M.A. (2020). Web-mapping of environmental pollution of the surface waters of the Lviv region. Astronomical School's Report, 16(2), 33-37. https://doi.org/10.18372/2411-6602.16.05.

5. Sohor, A., Holubinka, Yu., Shapoval, V., Sohor, M. (2020). Interactive map of pollution of surface waters of Lviv. *Young Scientist, 2(78),* 193-199. https://doi.org/10.32839/2304-5809/2020-2-78-44.

6. Bijeesh, T.V., Narasimhamurthy, K.N. (2020). Surface water detection and delineation using remote sensing images: a review of methods and algorithms Sustain. *Water Resour. Manag, 6,* 68. https://doi.org/10.1007/s40899-020-00425-4.

7. Bilgin, A. (2018). Evaluation of surface water quality by using Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) method and discriminant analysis method: a case study Coruh River Basin. *Environ Monit Assess, 190,* 554. https://doi.org/10.1007/s10661-018-6927-5.

8. Kangyang, C., et al. (2020). Comparative analysis of surface water quality prediction performance and identification of key water parameters using different machine learning models based on big data. *Water Research, 171,* 115454. https://doi.org/10.1016/j.watres.2019.115454.

9. Kim-Anh, N., Yuei-An, L. (2019). Global mapping of eco-environmental vulnerability from human and nature disturbances. *Science of The Total Environment, 664,* 995-1004. https://doi.org/10.1016/j.scitotenv.2019.01.407.

10.Tiyasha, T., at al. (2021). Functionalization of remote sensing and on-site data for simulating surface water dissolved oxygen: Development of hybrid tree-based artificial intelligence models. *Marine Pollution Bulletin, 170,* 112639. https://doi.org/10.1016/j.marpolbul.2021.112639.

11.Feyisa, G.L., Meilby, H., Fensholt, R., Proud, S.R. (2014) Automated water extraction index: A new technique for surface water mapping using Landsat imagery. *Remote Sens. Environ, 140,* 23–35.

12.Frappart, F., Papa, F., Famiglietti, J.S., Prigent, C., Rossow, W.B., Seyler, F. (2008). Interannual variations of river water storage from a multiple satellite approach: A case study for the Rio Negro River basin. *J. Geophys. Res.-Atmos, 113,* D21104.

13.Wenbo, Li., et al. (2013). A comparison of land surface water mapping using the normalized difference water index from TM ETM+ and ALI. *Remote Sens., 5,* 5530–5549.

14.Normandin, C., at al. (2018). Quantification of surface water volume changes in the Mackenzie Delta using satellite multi-mission data Hydrol. *Earth Syst. Sci., 22,* 1543–1561.

15.Ogilvie, A., Belaud, G., Massuel, S., Mulligan, M., Le Goulven, P., Calvez, R. (2018). Surface water monitoring in small water bodies: Potential and limits of multi-sensor Landsat time series Hydrol. *Earth Syst. Sci., 22,* 4349–4380.

16.Pan, F., Wang, C., Xi, X. (2016). Constructing river stage-discharge rating curves using remotely sensed river cross-sectional inundation areas and river bathymetry. *J. Hydrol, 540,* 670–687.

17.Pan, F., Xi, X., Wang, C. (2020). A Comparative Study of Water Indices and Image Classification Algorithms for Mapping Inland Surface Water Bodies Using Landsat Imagery. *Remote Sensing, 12(10),* 1611. https://doi.org/10.3390/rs12101611.

18.Schwatke, C., Scherer, D., Dettmering, D. (2019). Automated extraction of consistent time-variable water surfaces of lakes and reservoirs based Landsat and Sentinel-2. *Remote Sens., 11,* 1010.

19.Yang X., Chen L. (2017) Evaluation of automated urban surface water extraction from Sentineel-2A imagery using different water indices. J. Appl. *Remote Sens., 11,* 026016.

20.Chang, N.-B., Imen, S., and Vannah, B. (2015). Remote sensing for monitoring surface water quality status and ecosystem state in relation to the nutrient cycle: a 40-year perspective. *Critical Reviews in Environmental Science and Technology, 45(2),* 101-166. https://doi.org/10.1080/10643389.2013.829981.

21.Habeeb, N. J., Weli, S. T. (2021). Combination of GIS with Different Technologies for Water Quality: An Overview. *HighTech and Innovation Journal, 2(3),* 262-272. http://dx.doi.org/10.28991/HIJ-2021-02-03-10.

22.Das, A. K., Prakash, P., Sandilya, C.V.S. and Subhani, S. (2014). Development of Web-Based Application for Generating and Publishing Groundwater Quality Maps Using RS/GIS Technology and P. Mapper in Sattenapalle, Mandal, Guntur District, Andhra Pradesh ICT and Critical Infrastructure. Proceedings of the 48th Annual Convention of Computer Society of India. (Vol. II). PP. 679–686. https://doi.org/10.1007/978-3-319-03095-1_74.

23.Fathy, A. (2012). Mapping of groundwater prospective zones using remote sensing and GIS techniques: A case study from the Central Eastern Desert. *Egypt Journal of African Earth Sciences, 70,* 8-17.

24.Chen, Q., Zhang, Y., & Hallikainen, M. (2007). Water quality monitoring using remote sensing in support of the EU water framework directive (WFD): A case study in the Gulf of Finland. *Environmental monitoring and assessment, 124,* 157-166.

25.Manap, M.A., Nampak, H., Pradhan, B. et al. (2014). Application of probabilistic-based frequency ratio model in groundwater potential mapping using remote sensing data and GIS. *Arabian Journal of Geosciences, 7,* 711-724. https://doi.org/10.1007/s12517-012-0795-z.

Отримано 05.03.2024

УДК 528.946

Андрій Бридун[1], Андрій Согор[2], Михайло Фис[3], Юрій Губар[4]

[1]кандидат фізико-математичних наук, доцент,
доцент кафедри картографії та геопросторового моделювання,
Національний університет «Львівська політехніка» (Львів, Україна)
E-mail: andrii.m.brydun@lpnu.ua. **ORCID:** https://orcid.org/0000-0001-5634-0512
ResearcherID: AAC-1271-2020. **Scopus Author ID:** 57212560353

[2]кандидат технічних наук, доцент, доцент кафедри картографії та геопросторового моделювання
Національний університет «Львівська політехніка» (Львів, Україна)
E-mail: andrii.r.sohor@lpnu.ua. **ORCID:** https://orcid.org/0000-0002-0084-9552.
ResearcherID: ABI-6288-2020. **Scopus Author ID:** 57224950613

[3]доктор технічних наук, професор, професор кафедри картографії та геопросторового моделювання
Національний університет «Львівська політехніка» (Львів, Україна)
E-mail: mykhailo.m.fys@lpnu.ua **ORCID:** https://orcid.org/0000-0001-8956-2293
ResearcherID: AAB-9528-2020. **Scopus Author ID:** 36091174500

[4]доктор технічних наук, професор, завідувач кафедри кадастру територій
Національний університет «Львівська політехніка» (Львів, Україна)
E-mail: yurii.p.hubar@lpnu.ua **ORCID:** http://orcid.org/0000-0003-2538-0727

ВЕБКАРТОГРАФУВАННЯ ЗАБРУДНЕННЯ ПОВЕРХНЕВИХ ВОД ЛЬВІВЩИНИ ЗАСОБАМИ ГІС ТА ДЗЗ

На екологічний стан поверхневих вод Львівщини впливають різні чинники: забруднення ґрунтів, атмосфери, техногенна завантаженість території, неефективна робота очисних споруд в населених пунктах, забруднення та засмічення річок побутовими та іншими відходами. Іншою важливою проблемою, що призводить до забруднення поверхневих вод в регіоні, є відсутність на території регіону водоохоронних зон та прибережних захисних смуг водойм. Відсутність картографічних матеріалів та невизначеність меж водоохоронних зон та прибережних захисних смуг призводять до порушень земельного та водного законодавства при їх використанні. Наразі стан водних об'єктів у Львівській області знаходиться на незадовільному рівні. Основними проблемами в цій сфері є прогресуючий характер негативного впливу на навколишнє середовище та здоров'я людей. Основною метою цієї роботи було створення вебкарти забруднення поверхневих вод Львівщини, зокрема, за даними дистанційного зондування Землі. Для досягнення цієї мети ми зібрали та систематизували геопросторові статистичні картографічні матеріали щодо екологічного стану поверхневих вод. Крім статистичних даних, для оцінки стану поверхневих вод були використані матеріали дистанційного зондування Землі (ДЗЗ), отримані з різних джерел. Визначено необхідне програмне забезпечення для розробки такої вебкарти. Розроблено алгоритм завантаження геопросторових даних у створений вебресурс. Таким чином, було розроблено вебкарти забруднення поверхневих вод Львівщини у програмному середовищі «ArcGIS Online».

Ключові слова: *геопросторові дані; ГІС; дистанційне зондування Землі; екологічне картографування; забруднення поверхневих вод; інтерактивна карта; середовище «ArcGIS Online».*

Рис.: 4. Бібл.: 25.

Brydun, A., Sohor, A., Fys, M., Hubar, Yu. (2024). Web mapping of surface water pollution in Lviv region by means of GIS and remote sensing. *Technical sciences and technologies*, (1(35)), 337-345.