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Web mapping of surface water quality in Lviv

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SUMMARY

The ecological condition of surface waters of Lviv region is influenced by various related factors: soil pollution, atmosphere, changes in landscape structure and man-made congestion, inefficient operation of sewage and treatment facilities, especially in settlements, pollution and littering of rivers with household and other waste, forest skidding along streams in the mountains. Ensuring balanced, ecologically safe development of the region is possible only with an understanding of the functioning of natural and anthropogenic complexes within it. Another important problem that leads to surface water pollution in the region is the lack of water protection zones and coastal protection zones in the region. Lack of cartographic materials and uncertainty of the boundaries of water protection zones and coastal protection strips lead to violations of land and water legislation in their use. Currently, the condition of water bodies in the Lviv region, in particular in the city of Lviv, is at an unsatisfactory level. The main problems in this area are the progressive nature of the negative impact on the environment and human health. As there is currently no cartographic material that would visualize the problem of surface water quality in Lviv, the main purpose of this work was to create a web map of surface water pollution in the city. To achieve this goal, we collected and systematized geospatial statistical cartographic materials on the ecological condition of the surface city of Lviv. The necessary software for the development of such a web map has been identified. An algorithm for loading geospatial data into the created web resource has been developed. Thus, a web map of surface water pollution in Lviv was developed in the ArcGIS Online software environment.

Keywords: web mapping, geospatial data, maximum permissible concentrations (MPC), surface water pollution, interactive map, sewage treatment plants (STP), ArcGIS Online, Microsoft Office Excel

Introduction

Water resources of Lviv region play an important role in people's lives and economy. Water is used as a source of drinking, technical, and agricultural water supply, in fisheries, and for medical purposes. It is a source of replenishment of groundwater reserves. The surface waters of Lviv region are represented by rivers, reservoirs, lakes and ponds. Surface water currently continues to be one of the polluted natural resources.

The ecological condition of surface waters of Lviv region is influenced by various factors that are closely related, namely: soil pollution, atmosphere, changes in landscape structure and man-made congestion, inefficient operation of sewage treatment plants, non-nature and cartographic materials of coastal protection strips and water protection zones, as well as their non-compliance, especially in settlements. Pollution and littering of rivers with household and other waste, skidding of forests along streams in mountainous areas. According to statistics, water intake from natural water bodies in the region in 2019 decreased by 3.7 million m³ compared to last year and amounts to 168.6 million m³. As of 01.01.2020 in the Lviv region there are 18447 water users (Department of ENR, 2019):

- in the basin of the Western Bug river - 6256 water users;
- in the Dnister river basin - 10,607 water users;
- in the basin of the Sian river - 1124 water users;
- 460 water users in the Styr River basin.

Currently, the condition of surface waters in the Lviv region and, in particular, in the city of Lviv is at an unsatisfactory level. The main problems in this area are the progressive nature of the negative impact on the ecological state of the environment and human health. Unfortunately, at the moment there is no interactive cartographic material that can visualize the problem of surface water pollution in Lviv (Sohor et al., 2020; Yarema et al., 2016).

Methods of investigation

The main purpose of this work is to create a web map of surface water quality in the city of Lviv.

To achieve this goal, the following tasks are set and solved in the work:

- Collection and systematization of geospatial cartographic data related to surface water quality in the city of Lviv.
- Construction of an algorithm for loading geospatial data into the appropriate web resource.
- Creation of a web map of surface water pollution in the city of Lviv.

Surface water quality was assessed on the basis of analysis of information on the values of hydrochemical parameters in comparison with the corresponding values of their maximum allowable concentrations (MPC) and background indicators.

Hydrochemical and hydrophysical parameters were divided into the following groups according to their type and / or quantitative characteristics (Department of ENR, 2020):

- Group 1 - components of the salt composition: (sum of ions, bicarbonates, chlorides, sulfates, magnesium ions, calcium, sodium);
- Group 2 - indicators of tropho-saprobiological state: suspended solids, dissolved oxygen, pH, dissolved organic substances, compounds of the main nutrients (ammonium nitrogen, nitrate nitrogen, nitrite nitrogen, phosphates);
- Group 3 - specific substances: petroleum products, phenols; heavy metals (total iron, zinc, total chromium, lead, nickel, cadmium).

Volumes of waste generation and disposal: sludge after sewage treatment plants (STP) in the city of Lviv - in the 1st quarter of 2021 amounted to 6102.77 tons (1st quarter of 2020 - 6218.3 tons). During the first quarter of 2021, samples were taken from lakes, ponds, streams and rivers. A total of 37 points from which surface water sampling was performed were investigated.

The largest number of excesses was recorded for the following pollutants: suspended solids - at 32 observation points, total iron - at 16, ammonium nitrogen and ammonia - at 16, phosphates - at 9 observation points. According to the results of chemical analyzes conducted during the first quarter of 2021, the maximum permissible concentrations of pollutants from 4 to 7 indicators in 9 reservoirs were exceeded (Department of ENR, 2019).

According to the results of the comprehensive laboratory for environmental pollution monitoring of the Volyn Center for Hydrometeorology, in the 1st quarter of 2021 monitoring observations of water quality in the Western Bug River basin were conducted (see Table 1).

Table 1 Average concentrations of pollutants in the Western Bug River basin

Number	Name of alignment	pH, units pH	Oxygen, mg/dm ³	Calcium, mg/dm ³	Magnesium, mg/dm ³	Hydrocarbons, g/dm ³	Chlorides, mg/dm ³	Sulfates, mg/dm ³	Sodium, mg/dm ³	Bihpom oxide, mg/dm ³	Ammonium, mg N/dm ³	Nitrites, mg N/dm ³	Nitrates, mg N/dm ³	Phosphates, mg P/dm ³	Total P, mg P/dm ³
1	Western Bug, 781 km, Busk	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	Western Bug, 723 km, village Old Dobrotvir	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	Rata river, 3.5 km, village Mezhyrichchya	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, village Nestanychi	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	Marunka river, Vynnyky, under the bridge of the ring 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

According to the results of observations in the first quarter, the most polluted water bodies were: Kryvchyskyi stream, 200 Staroznesenska street; Zubra river bridge; Lysynyskyi stream, 150 Trakt-Hlynyanskyi street; reservoir st. Panas Sotnik; the river "Poltva" bypass road, shop "Vse dlia fur"; Myklashivka river bypass road; stream "Vodianyi" near the school Think Global - Airport, behind the garages; Belogorsky stream bypass road, Rudno village from the side of Signivka.

Exceedances of the maximum permissible concentrations of suspended solids, total iron, ammonium nitrogen, and phosphates have been recorded in the water of most of these water bodies. Instead, the following reservoirs were the cleanest in terms of exceeding the maximum permissible concentrations of pollutants in the first quarter: the reservoir in park "Ozero Levandivske"; reservoir on the street Kulparkivska, 139 (Symonenko); street Vakhnyanina, 29 (Center for Children and Youth of Galicia); reservoir "Betonka" st. Antonycha; reservoir on the street Stryjska - street Naukova; reservoir in the park "Horikhovyi Hay"; reservoir "Stosika" st. Zamarstynivska, 270; the flow of the village of Pidryasne (junction); a stream near the Hrybovytsia landfill (near the road); Mlynivka river in Hryyada (in front of a pig farm, a signpost in front of the village of Doroshiv; a reservoir in Dublyany (Shevchenko street, the final stop of a minibus); a reservoir on 27 Lypynskoho street (near the

monastery); a reservoir in the village of Volya-Homuletska (the largest in size, the recreation complex "Albatross"); Snopkivsky park, Buchmy street.

In general, the presence and content of the following pollutants were determined in Lviv reservoirs: suspended solids, total iron, ammonium nitrogen, nitrates, nitrites, phosphates, chlorides, sulfates, fats, synthetic surfactants, and petroleum products (Department of ENR, 2020).

The analysis of the state of surface waters was performed on the basis of observational data on the content of hydrochemical parameters provided by the Volyn Regional Center for Hydrometeorology. The results of observations on the state of surface waters in the city of Lviv were provided by the municipal enterprise "Administrative and Technical Department" of the Lviv City Council. Information on the volume of discharges of pollutants into the Poltva river after sewage treatment plants was provided by the municipal enterprise "Lvivvodokanal".

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

Results of investigations

Given the above, to create an interactive web map, we used a very convenient and popular platform "ArcGIS Online". In order to start working in the selected platform, it is necessary to collect and structure data in the environment "Microsoft Office Excel" (Sohor et al., 2020; Yarema et al., 2016).

Excel spreadsheets were developed for our case:

- the state of surface waters on the basis of observational data on the content of hydrochemical indicators provided by the Volyn Regional Center for Hydrometeorology;
- the results of observations on the state of surface waters in the city of Lviv, provided by the municipal enterprise "Administrative and Technical Department" of the Lviv City Council;
- volumes of pollutant discharges in the Poltva river after sewage treatment plants provided by the utility company "Lvivvodokanal".

To visualize the map of the city of Lviv, the OpenStreetMap was used in the ArcGIS Online platform with the city limits and the city districts (Yarema et al., 2017; Yarema et al., 2018; Yarema et al., 2019). In order to plot our data on a map, a map with the defined coordinates of each pollutant and surface water quality values was first created using the ArcGIS Online environment. To do this, we exported the spreadsheet we created "Microsoft Office Excel" to the environment "ArcGIS Online" (Sohor et al., 2020; Yarema et al., 2016).

Following the steps above, we combine the city map and the surface water quality map to obtain our web map (Figure 1).

You can view the created web map at the following link:

- <https://arcg.is/D5avr>

Recommendations and conclusions

Thus, studying the problem of surface water quality in Lviv, we can summarize the following:

- We collected and systematized geospatial cartographic data on surface water pollution in Lviv.
- The software for development of a web map of surface water quality is defined.
- The algorithm of loading of geospatial data in the created web resource is developed.
- A web map of surface water pollution in Lviv has been developed in the ArcGIS Online.

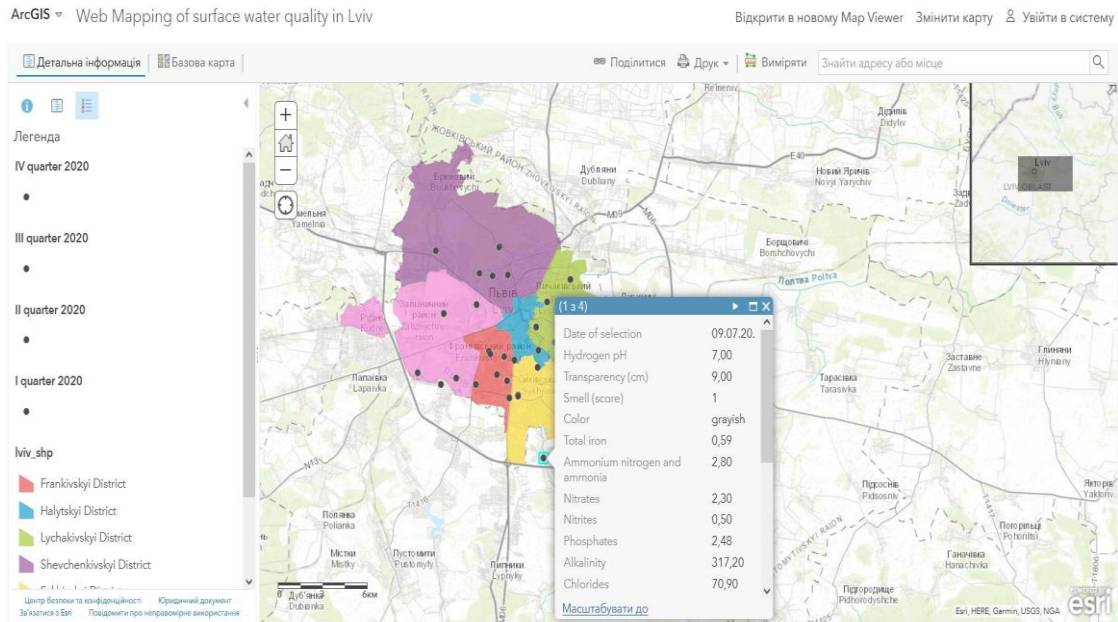


Figure 1 Map of surface water quality of the city of Lviv in the environment "ArcGIS Online"

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