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Landscape and geochemical characteristics of the territory of the town of Vyzhnytsia, Chernivtsi region

Vitaliy PRYSAKAR [1*] https://orcid.org/0009-0001-9566-1295
Halyna KOVBINKA [2**] https://orcid.org/0000-0002-4368-5754
Iryna DOBYNDA [2***] https://orcid.org/0000-0002-4368-5754

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[1]Separated Structural Subdivision «Applied College of Yuriy Fedkovych Chernivtsi National University»

[2]Yuriy Fedkovych Chernivtsi National University, Department of Physical Geography, Geomorphology and Paleogeography

Листування – *v.prusakar@chnu.edu.ua; **g.kovbinka@chnu.edu.ua; ***i.dobynda@chnu.edu.ua

Ключові слова: landscape; geochemical characteristics; settlement landscapes; landscape structure; city.

Анотація: This study presents an analysis of the physical and geographical characteristics of the Vyzhnytsia territory. The landscape map is employed to illustrate the landscape structure of the city. Furthermore, geochemical indicators of the landscapes are examined through the properties of natural waters. The study reveals relatively minor pollution in the natural components, with a focus on identifying pollution sources. Additionally, the degree of comfort is assessed based on specific indicators.

1. INTRODUCTION

The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance. The current state of the research field should be reviewed carefully and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the work and highlight the principal conclusions.

2. MATERIALS AND METHODS

The ongoing development of settlement landscapes and their spatial structures has led to an escalating anthropogenic and technogenic burden on the natural environment, impacting people's ecological surroundings. This underscores the necessity, significance, and heightened importance of their comprehensive investigation. The examination of settlement landscapes as holistic systems shaping specific areas emerges as a paramount and promising domain within the realm of constructive geography.

Human settlements have consistently driven transformations in land use patterns worldwide. The analysis of settlement landscapes serves various purposes, including understanding the evolving dynamic between human activity and nature for economic objectives.

Such studies often focus on the utilization of natural resources during settlement processes and the evaluation of the settlement landscape's effects on the biotic environment (Li et al. 2019; Simpson, I. A et al. 2019; McGovern et al. 2007; Miller et al. 2001).

3. RESULTS

The town of Vyzhnytsia is situated at the convergence point of two distinct physical and geographical sections within the Carpathian physiographic province (Herenchuk, 1978). Despite its relatively small size, the town experiences a direct collision of diverse landscapes, both of zonal and azonal character. The presence of the Cheremosh River and its valley significantly influences the spatial distribution of landscapes, particularly morphological units in specific directions. The town predominantly falls within the Carpathian Foredeep Basin, occupying the Precarpathian region of the territory, with absolute elevations of approximately 700 meters. A smaller portion of the city constitutes the Berehomet Lowlands, forming the mountainous section of the town's area, rising conspicuously with a distinct 200-meter ridge above the surrounding territory.

The prevailing topography within the town comprises terraced features, consisting of a series of floodplain terraces. The primary floodplain terrace, situated 3-4 meters above the Cheremosh River's level and encompassing the majority of the city, consists of brown loam and sand, underlain by layers of pebbles. The secondary floodplain terrace, positioned 8-15 meters above the river level, is primarily composed of pebbles at its base, transitioning to layers of sand or sandy loam, which gradually transform into loess loam towards the upper layers. The terrain exhibits a rapid ascent towards the southern direction, i.e., moving away from the Cheremosh River, originating from the outcrops of thick-rhythmic and massive sandstones. This geological configuration results in the formation of a complex system of terraced slopes and buttes.

The lithological composition of rocks across the town's territory is notably diverse and displays variations in facies. Eluvial deposits are concentrated on the ridges, their spurs, isolated peaks, and transverse sub-meridional ridges extending towards the village of Vyzhenka. Covering approximately 9-10% of the city's total area, these deposits primarily consist of hardened bedrock fragments with minor amounts of clay and loamy material. Deluvial sediments predominate over 20% of the territory, representing fragments resulting from ongoing bedrock erosion at different stages. These sediments drape all slopes and exhibit lithological characteristics aligned with the underlying bedrock. Colluvial-proluvial deposits are typical features within the bottoms of small streams and ravines. Alluvial deposits encompass the majority of the town's area and are distributed across nearly all noticeable terraced levels. Given that floodplain terraces primarily accumulate over a basement substrate, and the riverbed extensively incises bedrock, the alluvial deposits tend to be relatively thin in most cases.

The territory of Vyzhnytsia is situated amidst the foothills of the Bukovynian Carpathians. This locale is typically associated with a moderately warm climate characterized by elevated humidity levels, along with pronounced climate discrepancies between the mountain valleys and the ridges.

Across the major portion of the town's expanse, sod soils prevail, predominantly on the first and second terraces. In the lower sectors, meadow-marsh soils dominate, while the mountainous segment of the city features brown forest soils.

The diversity of natural geochemical landscapes in the area is distinctly shaped by significant landscape differentiation and tracts. This natural diversity is further compounded by the impact of anthropogenic and technological factors (Hutsulyak 2002), accentuating the variation in geochemical parameters, particularly in regions subject to human influence, known as anthropogenic functional zones. In a broader context, Vyzhnytsia is not just an administrative

center but also a place of recreation with a rich history of human habitation. Consequently, the patterns of anthropogenic and industrial influence have undergone shifts over time, leaving a lasting imprint on the geochemical indicators of both natural and anthropogenic elements within the landscape.

The territory of the town has heterogeneous landscapes. The landscape structure of Vyzhnytsia is complex, marked by a dynamic interchange between distinct landscape complexes, particularly at the level of morphological units. The town's geographic positioning places it at the confluence of multiple landscape types and variations. The variances in land utilization, spanning the historical and commercial core, residential districts, industrial zones, transportation networks, water management areas, recreational spaces, and suburban expanses, result in differing levels of human-made alterations and natural element saturation. Generally, the progression from the urban center toward the periphery follows the common trend observed in urban environments—an attenuation of fully transformed and artificial surfaces and a decline in built-up areas.

Overall, the urban landscape serves as a confluence of natural attributes and urban infrastructural elements, forming a hierarchical system comprising interdependent natural and technical subsystems that develop in harmony with both natural laws and societal dynamics.

The town's landscape structure predominantly consists of valley-terrace complexes. These landscapes are complicated by valley floors, streams, ravines, and gullies. In total, the city encompasses 28 landscape tracts, predominantly composed of floodplain and terraced regions, with the terraced areas further classified into low, medium, and high terraced zones (*Fig. 1*).

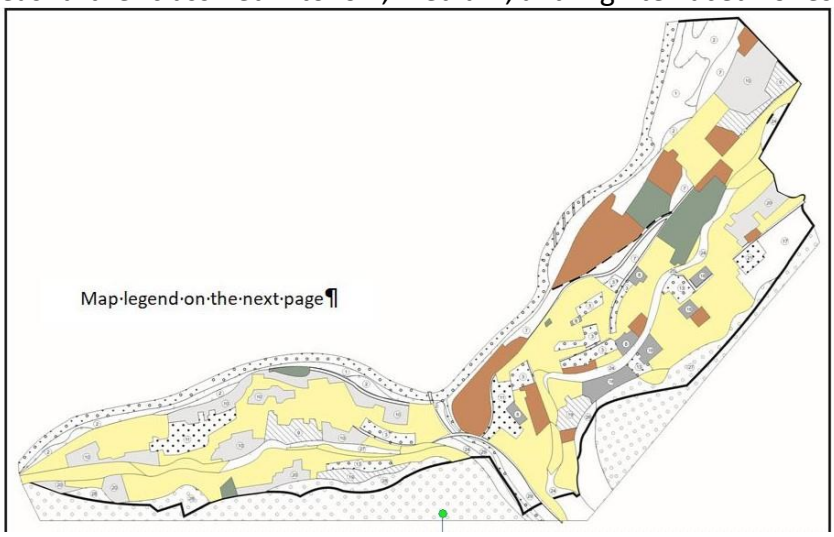

Fig. 1. Landscape and functional complexes in Vyzhnytsia

Floodplain regions within the vicinity exhibit soddy soils with sporadic shrub coverage. These encompass both the low and high floodplains of the Cheremosh River. The latter is distinguished by the absence of loess loam, supplanted by sandy loam, gravelly pebble deposits, occasional muddy material, and in certain areas, varying degrees of waterlogging, or even excessive waterlogging within specific tracts, such as oxbow lakes. This phenomenon is attributed to the elevated position of alluvial groundwater and surface water runoff from interfluve slopes. Key tracts within this context encompass the low floodplain featuring modern sand and pebble deposits, underscored by scant vegetation, and the high floodplain constituted of contemporary alluvial accumulations. The high floodplain houses underdeveloped sandy soddy soils, accompanied by shrubby vegetation.

The low-terrace landscape classification encompasses the first and second terraces of the Cheremosh River. Characterized by a flat topography, these terrains feature sandy loam, gravel, and pebble deposits, with localized waterlogging. Consequently, these areas exhibit shallow sod and sod gley soils, along with sod-podzolic soils beneath phorb-gramineous meadows, cultivated land, and structures. Prominent zones within this category encompass the Low Terrace (1) composed of alluvial material, showcasing shallow light loamy sod soils, accommodating buildings, arable land, and meadows. Additionally, the low terrace (2) is defined by alluvial-deluvial constituents, characterized by shallow sod, sod gley light loamy, and sod-podzolic high clay medium loamy soils, supporting buildings, arable land, and meadows.

Slope-terrace landscapes manifest as valley slopes interwoven with segments of terraces, primarily of medium scale. These regions exhibit modest surface fragmentation, occasionally indicating signs of planar and linear erosion. Ancient sand and pebble as well as deluvial deposits blanket the slopes. Consequently, this landscape category mainly encompasses gentle to moderately descending terrace slopes, boasting shallow sod and sod-podzolic surface-gleyed soils beneath buildings, cultivated plots, and meadows.

Vyzhnytsia is nestled within the foothills of the Chernivtsi region, occupying the meadow-forest and mountain-forest landscape zones. Dominant among these are the valley landscapes of the Cheremosh and Vyzhenka rivers, collectively forming floodplains, low, medium, and high terraces, alongside slopes of varying gradients and the recesses of minor rivers, ravines, and gullies. The natural landscape is significantly altered by anthropogenic activities related to urban, industrial, agricultural, and recreational functions.

Vyzhnytsia emerges as a multifaceted urban settlement, serving a variety of functions. Each segment of the city holds specific anthropogenic and technological demands while fulfilling distinct economic roles. The historical evolution of the city, its inherent natural attributes, and other influential factors collectively shape a particular composition of landscape complexes, functional zones, and subzones. The functional structure of the city is significantly steered by key physical and geographical variables such as orography, lithological composition, climatic factors, and soil attributes. A paramount role in the city's functional and territorial configuration is played by its landscape structure. As such, the primary functional planning zones encompass residential, recreational, agricultural, road infrastructure, industrial enclaves, and others.

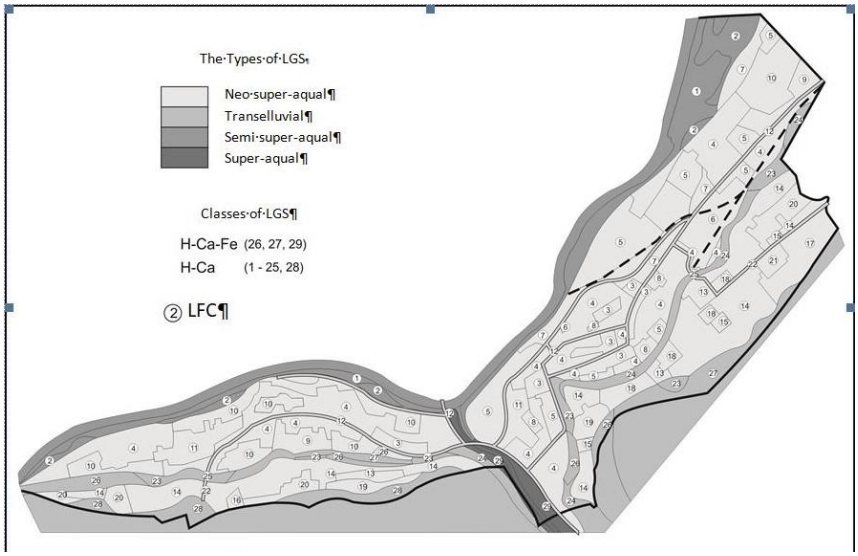

Fig. 2. Landscape-geochemical systems of Vyzhnytsia

From a geochemical perspective, Vyzhnytsia falls within the territory of the Cheremosh-Banyliv landscape-geochemical settlement region. This region is characterized as a valley-terrace meadow-forest environment, distinguished by gray and dark gray podzolic soils as well as sod-gley soils overlaying loam and sandy loam deposits (Prysakar, 2002). Notably, this area exhibits relatively slow water exchange, marked by a prevalence of neo-eluvial and super-eluvial elemental landscapes, coupled with the presence of eluvium and loess loams (Hutsulyak, 2004). The following elementary geochemical landscape types define the city's domain based on migration conditions:

Eluvial Type: This is prominent in elevated terrains. Groundwater lies at a significant depth, exerting minimal influence on both plants and soil. The soil here predominantly functions autonomously. Numerous elements undergo transport beyond the landscape's confines, rendering them unavailable to plants.

Super-Auqal Type: This is prevalent within floodplains and valley bottoms, characterized by low relief attributes. Here, groundwater exists in close proximity, leading to semi-hydromorphic soils with elevated chemical element concentrations compared to autonomous soils.

Subaquatic Type: This type thrives along the Cheremosh and Vyzhenka rivers, characterized by relatively rapid shifts in chemical element content.

Transalluvial-Accumulative Type: Associated with slopes, this landscape type propels swifter chemical element migration, occasionally giving rise to geochemical barriers.

The outcomes of groundwater analyses conducted within the town provide insights into the general geochemical attributes (Tables 1, 2):

1. According to alkaline-acid conditions, the water is neutral and slightly acidic (fluctuation range 6.7-7.3 with an average of 7.0);
2. Hardness levels span from hard to very hard, (range 2.1-4.3 with an average of 3.2 mg-eq/l). Notably, two distinct hardness concentrations are observed within the city. The first area exhibits a hardness of up to 10 mg-eq/l, while the second area surpasses 10 mg-eq/l, with the latter being significantly larger.
3. Mineralization levels are classified as fresh to slightly mineralized, with a fluctuation range of 0.35-0.57 g/l and an average of 0.46 g/l. As per O. A. Alekin's classification, adhering to the maximum standard, mineralization is graded as good and satisfactory. The primary contributors to mineralization are sodium and hydrocarbonates, although instances of heightened calcium and chloride content are also observed.
4. Calcium content ranges between 84 and 300 mg/l, averaging 202 mg/l, while magnesium content ranges from 32 to 91 mg/l, with an average of 59 mg/l. These figures signify the geochemical processes characteristic of the foothill region. They can be attributed mainly to lithogenic substrates, anthropogenic influence, and the robust migration propensity of elements.
5. Chloride content spans from 30 to 295 mg/l, averaging 144 mg/l, while sulfate content ranges from 30 to 296 mg/l, with an average of 144 mg/l. Certain samples display an elevated presence of these compounds.
6. Notably, the water exhibits a significant hydrogencarbonate content, varying between 109 and 646 mg/l, with an average of 506 mg/l.
7. Nitrates, nitrites, and ammonium ion content remain within permissible limits, showcasing minimal fluctuations.
8. Component composition tends to reflect the ionic attributes typical of the forest-steppe zone, in particular, among cations, the order is Na+ K > Mg > Ca, while among anions, it is HCO > SO > Cl.
9. The prevalent water type is sodium hydrogencarbonate (80%), although magnesium and calcium groups are also identified (single sample each).
10. Comprehensive analysis indicates that none of the indicators exceed the Maximum Permissible Concentrations (MPC).
11. Gross macro compound content in groundwater surpasses that of other landscapes' groundwater.

12. The content of main microelements in groundwater appears relatively consistent across distinct areas, signifying the mobility and sedimentation characteristics of these microelements.
13. The migration capacity of microelements varies, with Ca exhibiting the highest mobility, followed by Cl and Mg.

Table 1. Main ionic composition of groundwater in Vyzhnytsia

№	Address	Type of water source	pH	$Na^+ K^+$		Ca^{++}		Mg^{++}		Cl'		SO''_4		HCO'_3		NO'_3	NO'_2	NH^+_4	Total mineralization	Hardness
				mg/l	mg-eq/l	mg-eq/l	mg/l	mg-eq/l	mg/l	mg/l	mg-eq/l	mg/l	mg-eq/l	mg/l	mg-eq/l	mg/l	mg/l	mg/l	g/l	mg-eq/l
1.	Nevskoho 14	Well	7,0	101,2	4,4	3,4	48,0	0,2	2,4	22	0,6	67,2	1,4	361	6,0	0,2	-	4,0	0,42	3.4
2.	Kotsyubynskoho 6	Well	7,3	126,5	5,5	1,7	34,0	1,7	2,4	38	1,1	57,6	1,2	402	6,6	0,2	-	0,8	0,48	2.2
3.	Mazepy 25	Well	6,7	80,5	3,5	1,4	34,0	0,8	9,6	20	0,6	64,2	1,2	231	3,8	0,2	-	0,4	0,32	3.0
4.	Sichovykh Striltsiv 6	Well	6,8	78,2	3,4	2,0	40,0	1,0	12,0	20	0,6	57,6	1,2	280	6,4	0,2	-	0,4	0,35	2.9
5.	Haharina 17	Well	6,8	172,5	7,5	1,2	24,0	1,7	20,0	46	1,3	72	1,2	463	7,6	0,2	-	4,0	0,57	4.3
6.	8 Bereznia 2	Well	6,8	121,9	5,3	3,5	70,0	0,8	9,6	48	1,4	76,8	1,6	403	6,6	0,2	-	4,0	0,53	2.8
7.	Ukrainska 16	Well	6,7	108,1	4,7	0,6	12,0	2,2	26,0	30	0,9	67,2	1,4	317	5,2	0,2	-	0,4	0,4	2.7
8.	Flax storage facility	Well	6,8	103,5	4,5	1,0	20,0	1,7	20,0	24	0,7	72,0	1,5	305	5,0	0,2	0,1	0,2	0,39	2.1

9.	Mazepy 22	Well	6,7	167,9	7,3	1,8	36,0	0,3	3,6	52	1,5	62,4	1,3	402	6,6	0,2	-	0,1	0,52	3.8
10	Berezhnytsia village	Well	6,8	98,9	4,3	1,0	20,0	2,8	34,0	26	0,7	96	2,0	329	5,4	0,2	0,1	0,2	0,44	3.6

The chemical analyses of surface waters, particularly the Cheremosh River, indicate minimal pollutant content.

According to the Sanitary and Epidemiological Station, the soil content of nitrates, nitrites, chlorides, petroleum products, and ammonia remains below the Maximum Allowable Concentrations (MAC). For instance, nitrates in city soils range from 0.53 to 1075 mg/kg of soil, compared to the MPC of 130, while nitrites fluctuate between 0.02 and 0.06 mg/kg.

Table 2. Chemical composition of groundwater in Vyzhnytsia (according to the sanitary and epidemiological station)

№	Address	Transparency	pH	Nitrogen group			$Cl^{'}$ mg/l	$SO^{''}_4$ mg/l	Fe^{++} mg/l	Cu mg/l	Mn mg/l
				Ammoniamg/l	Nitrites mg/l	Nitrates mg/l					
1	Bukovynska,50	30	7,03	0,08	0,002	1,0	17,6	10	0,05	0,1	0,01
2	Bukovynska,18	30	7,05	0,04	0,001	1,0	20,2	10	0,05	0,2	0,01
3	Bukovynska,30	26	6,9	0,04	0,001	2,0	18,8	10	0,05	0,2	0,02
4	Bukovynska,74	30	7,1	0,04	0,001	1,0	22,6	10	0,05	0,1	0,03
5	Sichovykh Striltsiv, 8	30	7,1	0,04	0,002	0,8	68,6	20	0,05	0,2	0,02
6	Cheremosha, 19	30	7,1	0,1	0,002	0,8	19,6	20	0,05	0,25	0,02
7	Berehometska, 9	30	6,9	0,04	0,001	1,0	24,8	10	0.05	0,1	0,02
8	Bus station	30	7,0	0,04	0,002	0,8	14,0	20	0,05	0,25	0,02

In Vyzhnytsia there are objects that pollute the air. The primary sources contributing to pollution are vehicles and wood processing facilities. Notable pollutants encompass carbon monoxide, nitrogen oxide, sulphur dioxide, and wood dust. The total volume of air emissions has undergone a substantial reduction. Over the past 25-year period, the environmental condition has experienced notable enhancements, chiefly attributed to a marked decline in air emissions emanating from industrial facilities.

Broadly speaking, the environmental situation within Vyzhnytsia presents a more favourable profile when compared with other cities and towns within the region. This can be explained by several factors, particularly the absence of prominent industrial operations and a more effective sanitation strategy attributed, in part, to the enveloping influence of the mountain-forest and foothill meadow-forest natural systems.

Upon thorough landscape, geochemical, and ecological assessments of the region, it becomes apparent that Vyzhnytsia retains a notably high level of comfort, notably marked by minimal highway and limited industrial presence, and other sources of environmental pollution.

Consequently, the geochemical and ecological features of Vyzhnytsia landscape complexes manifest in a heterogeneous manner. They are depending on several factors, including, in particular, the ability to self-purification, the size of the territory, and its features - the nature of the landscape, urban development, the presence of closed and open spaces, water bodies, green

spaces, climatic conditions, the amount and harmfulness of pollution, etc. The influence of mountain-forest and foothill meadow-forest natural geosystems is palpable, contributing significantly to the urban area's sanitation.

4. CONCLUSIONS

The territorial expanse of Vyzhnytsia resides harmoniously within its natural context. The morphological structure of Vyzhnytsia landscapes derives from a multifaceted interaction of natural components. The terrain showcases a prominent prevalence of terraced formations, coexisting with sprawling sloping tracts and valleys etched by small rivers, ravines, and gullies. The low terraces are composed of pre-Quaternary clays overlain by chornozem podzolized light clay soils under housing residential spaces, industrial complexes, and vegetable gardens. Overall, the town is characterized by an extensive network of active ravines and gullies, coupled with unregulated surface runoff, elevated groundwater levels, poor condition of aquatic bodies, polluted and clogged riverbeds, poor soil conditions, and a limited variety of green spaces.

From a geochemical point of view, the territory of Vyzhnytsia aligns with the Cheremosh-Banyliv landscape-geochemical settlement region. This zone represents a valley-terrace meadow-forest domain, marked by gray and dark gray podzolic and sod-gley soils layered atop loams and sandy loam deposits. The character of this area is underscored by slow water exchange, the prevalence of neo-eluvial and super-aqual elemental landscapes, and the presence of eluvium and loess loams. Geochemically, Vyzhnytsia territory corresponds to the family of geochemical landscapes transitioning from forest to steppe, occupying the acid-calcium class. Slow to medium water exchange characterizes this territory, alongside a dominance of eluvial elemental landscapes. Groundwater attributes encompass neutrality and slight alkalinity within the alkaline-acid spectrum. Hardness stands as hard to very hard, with mineralization being fresh to slightly mineralized. Sodium hydrogencarbonate dominates, and the content of compounds and elements remains below the MPC. The geochemical signature of the water bodies reflects the typical meadow-forest zone's geochemical processes.

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В. Присакар, Г. Ковбінька, І. Добинда

Ландшафтно-геохімічна характеристика території міста Вижниці Чернівецької області

Keywords: ландшафт; геохімічна характеристика; поселенські ландшафти; ландшафтна структура; місто.

Abstract: Представлено ландшафтно-геохімічну характеристику території міста Вижниці Чернівецької області. Подано фізико-географічну характеристику досліджуваної території, зокрема природно-геоморфологічні умови, кліматичні особливості, ґрунтовий та гідрологічний фон. Охарактеризовано складену ландшафтну картосхему, яка відображає морфологічну структуру міста та співвідношення природних і антропогенно змінених ландшафтних комплексів. Здійснено аналіз геохімічних показників ландшафтів на основі властивостей природних вод, що дозволило визначити рівень забрудненості окремих компонентів довкілля. Встановлено, що забруднення має локальний і незначний характер, пов'язаний насамперед із діяльністю господарсько-побутових і транспортних джерел. Окрему увагу приділено просторовим відмінностям у якості природних вод та їхньому впливу на загальний стан довкілля. На основі інтегральної оцінки визначено ступінь комфортності міського середовища за рядом фізико-географічних та геохімічних параметрів. Результати дослідження можуть бути використані для подальшого моніторингу стану ландшафтів, планування екологічно збалансованого розвитку міста та оптимізації природокористування на його території.