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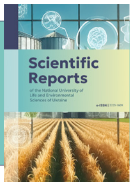


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# Transformation of floodplain phytocenoses under anthropogenic pressure (Shyianka river)

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**Abstract.** The study examines the influence of abiotic and anthropogenic factors on the formation of phytocenoses within the floodplain territory of the Shyianka River (Dnipro city). The relevance of the research is determined by the high level of anthropogenic pressure on urbanised floodplain ecosystems and the insufficient understanding of the integrated effects of abiotic factors on the formation of their vegetation cover. The aim of the study was to identify relationships between the physicochemical parameters of aquatic and atmospheric environments and the structural and functional characteristics of plant communities. The research was conducted under field conditions using geobotanical and ecological methods, including water sampling and measurements of key quality indicators (pH, redox potential, dissolved oxygen content, mineralisation, electrical conductivity), as well as assessment of atmospheric air quality based on concentrations of $CO_2$, $NO_2$, formaldehyde, ozone, and particulate matter ($PM_{2.5}$, $PM_{10}$). The results indicate that hydrochemical parameters of water are close to neutral values, with adequate aeration and moderate mineralisation; however, significant variability in redox potential reflects spatial heterogeneity of environmental conditions. Elevated $CO_2$ concentrations and the presence of technogenic impurities in the air were detected. The floristic composition includes 18 species of vascular plants, of which 50% are introduced and invasive taxa, with dominance of ecologically plastic species. The synanthropisation index (0.50) corresponds to a high level of anthropogenic transformation. A clear relationship between physicochemical environmental parameters and vegetation structure has been established, manifested in an increased proportion

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of invasive species and the formation of a mosaic phytocenotic structure. The novelty of the study lies in the integrated combination of geobotanical analysis with the assessment of physicochemical parameters of both aquatic and atmospheric environments within a unified research framework. The obtained results expand current understanding of transformations in urbanised floodplain ecosystems and can be applied in environmental monitoring and the development of restoration measures

**Keywords:** plant communities; abiotic factors; urbanised ecosystems; invasive species, synanthropisation; environmental monitoring; air quality

## Introduction

Floodplain-riparian ecosystems (riparian zones) are among the most dynamic and ecologically diverse components of the landscape, as they are formed at the interface between aquatic and terrestrial environments and integrate gradients of moisture, granulometric composition, and trophic regimes, as well as different stages of disturbance and recovery of vegetation cover. Such an ecotonal nature determines the high sensitivity of these ecosystems to changes in both aquatic and terrestrial environments, manifested in the rapid restructuring of their organisation in response to natural and anthropogenic factors. The high environmental heterogeneity of floodplains governs the mosaic structure of plant communities, the formation of numerous ecological niches, and substantial β-diversity. According to L. Dinca *et al.* (2025), this environmental heterogeneity underpins the key role of floodplains in maintaining biogeochemical cycles, regulating matter and energy flows, and delivering ecosystem services, particularly their buffering function in runoff regulation and pollutant retention. The authors also note that floodplain ecosystems act as natural filters, and their condition is directly linked to water quality and the overall ecological resilience of river systems.

The primary "organising" factor for floodplain vegetation is the hydrological regime, particularly the frequency, duration, and seasonality of flooding, which determine successional trajectories, the selection of life-history strategies, and competitive interactions among species. Periodic flooding creates specific environmental conditions characterised by alternating phases of aeration and anaerobiosis, affecting nutrient availability and soil microbial processes. As noted by Q. Li *et al.* (2025), variations in flow and moisture regimes strongly influence vegetation productivity and structure. Furthermore, the researchers emphasised that anthropogenic alterations of hydromorphology disrupt natural hydrological cycles, leading to changes in habitat conditions, disruption of successional processes, and transformation of species composition, particularly through an increase in stress-tolerant and invasive species.

According to existing studies, floodplains are recognised as among the most vulnerable ecosystems, as intensive human activities result in their fragmentation and degradation. Studies by D. Yoezer *et al.* (2026) demonstrated that the combined effects of hydrotechnical regulation, intensive land use, and urbanisation lead to the loss of natural floodplain dynamics and declining biodiversity. The authors describe most urban river valleys as being characterised by the superposition of multiple stressors, including the spread of secondary communities. In this context, J.A. Orr *et al.* (2024) considered the transformation of floodplain vegetation as a result of multiple stressors acting simultaneously on the ecosystem. Their research shows that these factors may operate in additive, synergistic, or antagonistic ways, consequently causing shifts in species composition, vertical structure, and functional characteristics of vegetation.

Urban riparian zones play a particularly important role within urban landscapes. They function as ecological corridors that facilitate species migration and maintain biotic connectivity. At the same time, these areas represent zones of elevated risk for biological invasions due to intense anthropogenic pressure, accumulation of diaspores, and their transport by water flows. As noted by R. Pabst *et al.* (2022), the number of invasive alien plant species tends to be exceptionally high in riparian ecosystems, particularly in downstream areas where human concentration is high.

M. Zhang *et al.* (2023) highlighted that river networks within cities can simultaneously support native species conservation and alien taxa spread, thereby complicating ecosystem management. The authors identify atmospheric pollution and surface runoff as additional drivers that alter the physicochemical environment, favouring species with high ecological plasticity. In addition to general atmospheric pollution, G. Sgrigna *et al.* (2015) pointed out that particulate matter deposition acts as a specific stressor for vegetation in industrial and urbanised areas.

According to L.V. Zavialova *et al.* (2021), the issue of biological invasions in Ukraine is particularly relevant due to the combination of intensive land use and significant technogenic pressure. They state that the introduction of alien species leads to substantial changes in plant community structure and the formation of novel, transformed coenoses. Research by D.V. Dubyna *et al.* (2019) focused on the analysis of the adventive fraction of flora in Ukraine. The authors note a significant proportion of alien species in pioneer communities under disturbed conditions, highlighting that certain species act as "transformers" capable of altering successional pathways and competitive interactions.

Regional studies conducted by Y.V. Lykholat *et al.* (2017) indicated that the steppe Dnieper region is characterised by a high level of naturalisation of alien species. The researchers emphasised the need to predict their spread and assess risks to native plant communities in Dnipro city, especially under conditions of climate change and ongoing urbanisation. Given the complexity and multifactorial nature of floodplain ecosystem transformations, the application of integrated research approaches is essential. T.W. Bulto *et al.* (2026) emphasised that the combination of geobotanical analysis with the assessment of abiotic environmental parameters provides a more comprehensive understanding of ecosystem condition. Their work highlights that physicochemical characteristics of water, particularly pH, play a crucial role.

Equally important is the consideration of atmospheric air quality as a potential factor influencing vegetation. The interpretation of relevant indicators is based on international guidelines, particularly those of the World Health Organization (2021), which define priority pollutants and their environmental impact levels. Thus, the study of floodplain vegetation within urbanised areas requires the integration of biotic and abiotic components, as well as consideration of hydrological, climatic, and anthropogenic factors, forming a methodological basis for comprehensive ecosystem assessment.

At the same time, despite the considerable number of studies, the issue of integrated assessment of the transformation of floodplain vegetation within urbanised areas remains insufficiently developed. This is especially true for the regional conditions of the steppe Dnieper region, where intense technogenic pressure is combined with the natural vulnerability of ecosystems. Therefore, the aim of this study is to establish the relationships between the physicochemical parameters of the aquatic and atmospheric environments and the structural characteristics of plant communities in the urbanised floodplain of the Shyianka River. To achieve this aim, the following main tasks were set: to assess the hydrochemical parameters of the surface water and the atmospheric air quality within the study area; to analyse the floristic composition, vertical structure, and the level of synanthropisation of the floodplain vegetation; to determine the influence of the identified abiotic and anthropogenic factors on the spread of invasive species and the overall transformation of the phytocenosis.

## Materials and Methods

Field studies were conducted during the 2025-2026 period within a riparian-floodplain section of the Shyianka River located in the city of Dnipro (Ukraine). During the field research, ethical standards and environmental regulations were strictly observed in accordance with the Convention on the Conservation of European Wildlife and Natural Habitats (1979). The selected site (48.412821 N, 35.146669 E) was chosen as a model area for assessing vegetation cover transformation under the influence of factors typical of urbanised ecosystems, primarily hydrological regime alteration and anthropogenic pressure. The study design involved an integrated approach combining geobotanical vegetation surveys with simultaneous measurements of physicochemical environmental parameters, enabling direct comparison between phytocenotic structure and local abiotic conditions. Such an integrated framework is particularly appropriate for riparian-floodplain ecosystems, as studies by T.W. Bulto *et al*. (2026) demonstrated a close relationship between vegetation condition, water quality, and local environmental factors.

Hydrochemical monitoring was carried out at three representative sampling points (Point 1: 48.412100, 35.148700; Point 2: 48.412466, 35.148754; Point 3: 48.413454, 35.148684), allowing the capture of spatial heterogeneity of the aquatic environment within the studied river corridor and enabling the characterisation of water conditions directly within zones of phytocenosis formation.

Vegetation descriptions followed the ecological-floristic approach using the Braun-Blanquet cover-abundance scale, which, according to N. Ivanova (2024), remains one of the most widely applied tools for field analysis of plant communities, interpretation of vegetation structure, and comparison of coenotic data across sites. During fieldwork, a complete inventory of species composition was performed, and the vertical structure of plant communities was recorded, distinguishing tree, shrub, and herbaceous layers. Dominant and subdominant taxa were identified. For each plot, total projective cover, species contribution to stratification, and the presence of disturbance indicators typical of urban riparian ecotopes were additionally assessed.

Taxonomic identification was carried out based on morphological characteristics directly in the field, followed by laboratory verification using photographic materials. Latin species names were standardised according to World Flora Online (2026), which serves as an up-to-date global reference database for plant nomenclature. To quantify the degree of anthropogenic transformation, each species was assigned a synanthropic status (native, introduced, or invasive). The synanthropisation index was calculated using the following formula:

$$Is = (N_{int} + N_{inv}) / S, \quad (1)$$

where $N_{int}$ is the number of introduced species, $N_{inv}$ is the number of invasive species, and $S$ is the total species richness of the studied site.

Hydrochemical parameters were measured in situ at a depth of 0.3 m using a multiparameter portable water quality analyser, Hanna HI98194, as detailed in the manual by Hanna Instruments (2015). According to the technical documentation, the instrument is designed for field measurements in rivers, lakes, and other water bodies and allows simultaneous determination of *pH*, oxidation-reduction potential (ORP), electrical conductivity, total dissolved solids (TDS), dissolved oxygen, and temperature. Prior to measurements, the device was calibrated using buffer and standard solutions in accordance with the manufacturer's instructions, and readings were recorded after stabilisation of the probe signal. The analytical framework included active reaction (pH), dissolved oxygen concentration, electrical conductivity (EC), total mineralisation (TDS), temperature, and oxidation-reduction potential (ORP). As emphasised by O. Zhukov *et al*. (2024) alongside M.I. Arce & M.M. Sánchez-Montoya (2024), these indicators are among the most informative parameters for rapid assessment of the state of riverine and floodplain water bodies and are sensitive to local variations in hydrological regime, morphofunctional characteristics, and anthropogenic impact.

Assessment of atmospheric air quality was carried out using a portable gas analyser "Saphire64" within the studied river corridor. Concentrations of key pollutants were recorded, including carbon dioxide ($CO_2$), nitrogen dioxide ($NO_2$), formaldehyde ($CH_2O$), ozone ($O_3$), and particulate matter ($PM_{2.5}$, $PM_{10}$). The obtained data were synchronised in time and space with geobotanical descriptions to enable subsequent analysis of abiotic influences on vegetation. Field air quality measurements were of a screening nature and were primarily used to identify local spatial contrasts within the study area. This approach is appropriate for short-term field surveys; however, as K. Okorn & L.T. Iraci (2024) pointed out, the results should be interpreted as indicative rather than equivalent to continuous reference monitoring, since portable and low-cost sensor systems are strongly influenced by calibration procedures, data quality control, co-location with reference instruments, and field operating conditions.

Statistical processing of the obtained data was performed using descriptive statistical methods. For all measured parameters, mean values and variability indicators were calculated. The relationship between vegetation condition (*Is*) and physicochemical parameters of water and air was assessed using correlation analysis. Statistical significance was accepted at $p < 0.05$. Calculations and data visualisation were carried out using specialised statistical software packages.

## Results and Discussion

The formation of plant communities in floodplain ecosystems is largely determined by the physicochemical characteristics of the environment, particularly the parameters of aquatic and atmospheric components. Water acidity, oxidation-reduction potential, dissolved oxygen content, mineralisation, and electrical conductivity, as well as concentrations of atmospheric pollutants, directly influence plant functioning and the structural organisation of phytocenoses. In urbanised environments, anthropogenic factors play a particularly significant role, as they alter the natural chemical background and promote the spread of ecologically plastic and stress-tolerant species. In this context, a study was conducted to assess the physicochemical parameters of the Shyianka River water and the quality of atmospheric air within the investigated site.

The combined influence of these factors determines not only species composition but also the functional characteristics of phytocenoses, including productivity, resistance to stress conditions, and recovery capacity. In particular, physicochemical properties of the aquatic environment affect nutrient availability and oxygen regime, while atmospheric pollutants can alter plant physiological processes such as photosynthesis and transpiration. Collectively, these processes create selective conditions favouring species with broad ecological amplitude and high adaptability to anthropogenic disturbances. The results of the surface water quality assessment of the Shyianka River are presented in Table 1. The analysis of the obtained data indicates that the reaction of the aquatic environment within the studied area is close to neutral (pH 7.66-7.96), which generally creates favourable conditions for the development of hydrophytic and riparian-terrestrial vegetation. The dissolved oxygen content exceeds the minimum permissible level (>4 mg/L) and ranges from 4.69 to 5.38 mg/L, indicating a satisfactory level of water aeration. Such conditions are favourable for the functioning of most aquatic organisms and ensure the stability of redox processes in the aquatic environment. Neutral pH values and sufficient dissolved oxygen levels are known to promote active biogeochemical cycling, particularly processes of organic matter mineralisation and the transformation of nitrogen and phosphorus compounds. At the same time, significant variability in oxidation-reduction potential was observed (from -75 to 132.4 mV), indicating spatial heterogeneity of environmental conditions. The presence of negative ORP values may reflect localised reducing conditions associated with organic matter accumulation and the development of eutrophication processes. Mineralisation values (338-343 mg/L) and electrical conductivity (677-685 μS/cm) indicate a moderate content of dissolved salts, which is typical for water bodies in urbanised areas influenced by surface runoff. Overall, the hydrochemical regime of the studied site can be considered relatively stable; however, spatial fluctuations of individual parameters create heterogeneous ecological conditions, which may contribute to the formation of a mosaic vegetation structure.

***Table 1.*** *Results of the surface water quality assessment of the Shyianka River in the area of sludge settling ponds within the city of Dnipro*

| **Date/Time** | **Permissible limit** | **05.09.2025 10:35-10:45** | | | **Mean value** |
|---|---|---|---|---|---|
| **Sampling point No.** | | **P1** | **P2** | **P3** | |
| **Coordinates** | | **48.412100. 35.148700** | **48.412466. 35.148754** | **48.413454. 35.148684** | |
| pH | 6.5 - 8.5 | 7.96 | 7.88 | 7.66 | 7.83 |
| pH electrode potential, mV | - | -58.9 | -53.8 | -40.9 | -51.2 |
| Oxidation-reduction potential (ORP), mV | - | 88.6 | 132.4 | -75 | 48.7 |
| Dissolved oxygen (DO), mg/L | >4 | 5.38 | 4.69 | 5.39 | 5.15 |
| Oxygen saturation (%DO), % | - | 59.1 | 51.6 | 59.2 | 56.6 |
| Total dissolved solids (TDS), mg/L | 1,000 | 343 | 338 | 338 | 339.7 |
| Electrical conductivity (EC), μS/cm | - | 685 | 677 | 677 | 679.7 |
| Temperature, °C | - | 19.81 | 19.91 | 19.92 | 19.88 |
| Salinity, PSU | - | 0.33 | 0.33 | 0.33 | 0.33 |
| Density (σ) | - | 0 | 0 | 0 | 0.0 |
| Water resistivity, MΩ·cm | - | 0.0015 | 0.0015 | 0.0015 | 0.0015 |
| Atmospheric pressure, psi | - | 14.698 | 14.71 | 14.719 | 14.709 |
| Depth, m | - | 0.3 | 0.3 | 0.3 | 0.3 |

**Note:** measurements were conducted along the left bank of the river
**Source:** compiled by authors

The obtained results are consistent with the studies of M.I. Arce & M.M. Sánchez-Montoya (2024) on urban watercourses, which also report near-neutral pH values and satisfactory aeration levels. At the same time, the pronounced variability of oxidation-reduction potential corresponds to the findings of O. Zhukov *et al.* (2024), who associated such fluctuations with local processes of organic matter accumulation and the development of anaerobic conditions. This suggests that even within relatively stable hydrochemical regimes, micro-heterogeneous ecotopes may form, significantly influencing vegetation structure. The results of atmospheric air quality measurements within the study area are presented in Table 2.

***Table 2.*** *Results of atmospheric air quality measurements obtained using the "Saphire64" device on 5 September 2025 (10:20-10:50) at coordinates 48.412060, 35.149097*

| **Sensor** | **Parameter** | **Value** |
|---|---|---|
| MH-$Z1_x$ | $co_2$ | 1181 ppm |
| ZE08-$CH_2O$ | $ch_2o$ | 11.50 ppb |

***Table 2.** Continued*

| Sensor | Parameter | Value |
|---|---|---|
| ZE03-$SO_2$ | $so_2$ | 0.00 ppm |
| ZE07-CO | co | 0.00 ppm |
| ZE12-$NO_2$ | $no_2$ | 29.50 ppb |
| SDS011 | $pm_{2.5}$ | 8.2 μg/$m^3$ |
| SDS011 | $pm_{10}$ | 11.3 μg/$m^3$ |
| NEO6M | lat | 48.412060 |
| NEO6M | lon | 35.149097 |
| NEO6M | alt | 52.81 |
| NEO6M | datetime | 2025-09-05 07:49:28 |
| system | signal | 0 dBm |
| system | signal-quality | 0% |
| system | accumulator-voltage | 10.92 V |
| ZE03-DG | dg | 0.27 ppm |
| ZE25-O3 | $o_3$ | 53.33 ppb |
| system | online | 2846 s |
| system | datetime | 2025-09-05 07:49:32 |

**Source:** compiled by authors

The analysis of atmospheric air quality indicators reveals the presence of anthropogenic pressure within the studied area. The carbon dioxide concentration is 1181 ppm, which exceeds background levels and may indicate local peculiarities of gas exchange and limited ventilation within the riparian zone. The concentration of particulate matter ($PM_{2.5}$ – 8.2 μg/$m^3$; $PM_{10}$ – 11.3 μg/$m^3$) falls within the guideline values established by the World Health Organization (2021); however, as K. Okorn & L.T. Iraci (2024) noted, it may still affect leaf surface condition and photosynthetic efficiency. Furthermore, a comprehensive review by J. Liu *et al.* (2025) emphasised that green space configuration directly impacts the deposition and absorption of PM2.5. Field assessments by K. Kais *et al.* (2025) also confirmed that tree canopy density plays a critical role in localised $PM_{2.5}$ mitigation. Formaldehyde (11.50 ppb) and nitrogen oxides (29.50 ppb) concentrations indicate a technogenic origin of pollution typical for urbanised areas. Overall, the atmospheric air within the study area is characterised by a moderate level of anthropogenic impact, which, in combination with hydrochemical conditions, forms specific ecological conditions for plant communities.

Studies by M. Zhang *et al.* (2023) show that similar levels of atmospheric pollutants are characteristic of urban areas with moderate technogenic pressure. In particular, elevated concentrations of carbon dioxide and nitrogen oxides are considered key factors influencing plant physiological processes, including photosynthesis and transpiration. According to J.A. Orr *et al.* (2024), prolonged exposure to such factors may lead to reduced biodiversity and the dominance of pollution-tolerant species. The formation of the studied phytocenosis structure occurs under the influence of a complex of physicochemical environmental factors that determine habitat conditions, competitive interactions, and spatial organisation of plant communities. It has been established that variability in oxidation-reduction potential (from -75 to 132.4 mV) contributes to the formation of locally heterogeneous environmental conditions, including reducing microhabitats. This promotes the development of hydrophytic vegetation and the dominance of *Phragmites australis*, which forms dense monodominant stands in the riparian zone.

Dissolved oxygen levels (4.69-5.38 mg/L) indicate generally favourable aeration conditions; however, their spatial variability contributes to the mosaic structure of species composition and vegetation organisation. Atmospheric factors were also found to significantly influence phytocenosis formation. Elevated $CO_2$ concentration (1,181 ppm), along with the presence of nitrogen oxides and formaldehyde, indicates anthropogenic pressure typical of urban environments. Such conditions create selective pressure that limits the presence of sensitive species while increasing the proportion of ecologically plastic and pollution-tolerant taxa.

In the herbaceous layer, this is manifested by the dominance of invasive species, particularly *Solidago cf. canadensis* and *Ambrosia artemisiifolia*, which are characterised by highly competitive ability and rapid colonisation of disturbed habitats. In the tree layer, similar processes are reflected in the presence of *Acer negundo* and *Ailanthus altissima*, which form regeneration cohorts and displace native species. Thus, a direct relationship between physicochemical environmental characteristics and phytocenosis structure has been established, manifested in an increased proportion of invasive species, disruption of vertical stratification, and the formation of a mosaic vegetation structure (Table 3).

***Table 3.*** *Relationship between physicochemical environmental factors and phytocenosis structure*

| Factor | Parameter | Ecological effect | Associated species |
|---|---|---|---|
| Oxidation-reduction potential (ORP) | -75-132.4 mV | Environmental heterogeneity, formation of local reducing conditions | *Phragmites australis* |
| Dissolved oxygen ($O_2$) | 4.69-5.38 mg/L | Generally favourable aeration, development of mosaic vegetation structure | Hydrophytes and mesophytes |
| Mineralisation | 338-343 mg/L | Moderate salt content, influence of urban runoff | Mesophytic species |
| $CO_2$ | 1181 ppm | Anthropogenic pressure | *Solidago cf. canadensis, Ambrosia artemisiifolia* |
| $NO_2$ | 29.50 ppb | Technogenic impact | Synanthropic species |
| $PM_{2.5}/PM_{10}$ | 8.2-11.3 µg/m$^3$ | Impact on leaf surface, photosynthesis | Ruderal species |

**Source:** compiled by authors

Thus, it has been established that the physicochemical characteristics of the environment, determined by both natural and anthropogenic factors, directly influence phytocenosis structure, shaping its mosaic pattern, the dominance of invasive species, and the overall transformation of vegetation cover. Within the studied riparian section of the Shyianka River, a total of 18 vascular plant species belonging to 15 genera and 11 families were recorded. All identified taxa belong to the division Magnoliophyta, indicating the predominance of ecologically plastic angiosperm species within the phytocenosis. This group is characterised by high adaptability to variable environmental conditions, rapid growth rates, and efficient dispersal mechanisms, which ensures its dominance in anthropogenically transformed habitats.

The floristic composition is characterised by an uneven distribution of taxa among families. The most represented family is Asteraceae, accounting for 33.3% of the total species composition, which is a typical feature of ruderalised and anthropogenically transformed areas. In terms of biomorphological structure, woody life forms predominate (42%), while herbaceous species account for 37% and shrubs and lianas for 21%. At the same time, only a portion of the tree layer consists of native species, whereas introduced and invasive taxa play a significant role in its structure and regeneration. This is due to their high ecological plasticity, rapid growth, effective seed reproduction, and resistance to anthropogenic disturbance, which provide them with a competitive advantage in urbanised ecosystems. It was found that alien species constitute 50% of the total flora, of which 22% are introduced and 28% are invasive species. To quantitatively assess the degree of floristic transformation, the *Is* was calculated, yielding a value of *Is* = 0.50, which corresponds to a high level of anthropogenic transformation. The proportion of native, introduced, and invasive species within the phytocenosis of the studied site is illustrated in Figure 1.

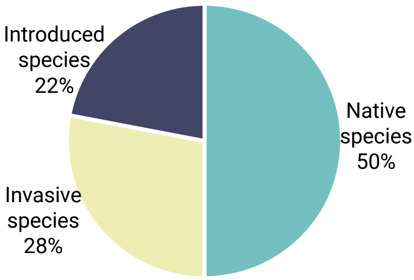


***Figure 1.*** *Proportion of native, introduced, and invasive species in the phytocenosis of the studied site*

**Source:** compiled by authors

As shown in Figure 1, alien species constitute a substantial proportion of the phytocenosis (50%), with invasive taxa predominating. This indicates a high level of anthropogenic transformation of the studied ecosystem and the dominance of ecologically plastic species. The increasing share of invasive species reflects ongoing processes of anthropogenic disturbance and the disruption of the natural vegetation structure. The obtained results indicate a simplification of the floristic structure and the formation of a secondary phytocenosis dominated by ecologically plastic and invasive species.

The phytocenosis of the studied site is characterised by a clearly expressed vertical stratification, including tree, shrub, herbaceous, and riparian-aquatic layers. The tree layer is formed by both native (*Salix alba*, *Populus alba*) and invasive species (*Ailanthus altissima*, *Acer negundo*), indicating a disturbance of the natural structure of the floodplain community. The shrub layer is fragmented and represented mainly by *Rubus fruticosus* agg. The herbaceous layer is characterised by the dominance of invasive species, particularly *Solidago cf. canadensis* and *Ambrosia artemisiifolia*, which form dense stands and displace native species. The riparian-aquatic zone is represented by monodominant stands of *Phragmites australis*, indicating stable moisture conditions and possible eutrophication processes. Overall, a disruption of the classical vertical structure of the floodplain phytocenosis has been identified, manifested in the significant presence of invasive species across all layers and the formation of a mosaic spatial organisation of the community (Table 4).

***Table 4.*** *Vertical structure of the phytocenosis of the studied site*

| Layer | Dominant species | Structural characteristics |
|---|---|---|
| Tree layer | *Salix alba, Ailanthus altissima, Acer negundo* | Mosaic, disturbed |
| Shrub layer | *Rubus fruticosus agg.* | Fragmented, degraded |
| Herbaceous layer | *Solidago cf. canadensis, Ambrosia artemisiifolia* | Dense, invasive |
| Riparian-aquatic layer | *Phragmites australis* | Monodominant, stabilised |

**Source:** compiled by authors

The obtained values of the *Is* reflect substantial changes in phytocenosis structure and indicate a significant contribution of the adventive component to vegetation formation. An increase in the proportion of alien species is accompanied by shifts in the spectrum of life forms and restructuring of competitive interactions among taxa, manifested in a reduced role of native species. Under such conditions, ecologically plastic species capable of functioning effectively under anthropogenic pressure and environmental instability gain a competitive advantage. This promotes the formation of communities dominated by invasive and synanthropic taxa, which, in turn, determine the specific spatial organisation of the phytocenosis. The obtained results are consistent with the concept of anthropogenic transformation of urbanised ecosystems proposed by L.V. Zavialova *et al.* (2021), according to which an increase in the proportion of invasive species results from the disruption of natural ecological niches. Similar trends have been observed in the studies of floodplain areas in other cities conducted by J.A. Orr *et al.* (2024), where the dominance of adventive species is accompanied by simplification of phytocenosis structure and a decline in the role of native taxa.

The observed changes are also consistent with the functioning patterns of urbanised floodplain ecosystems, where the combined influence of hydrochemical and atmospheric factors creates selective conditions favouring species with broad ecological amplitude and high colonisation capacity in disturbed habitats. Furthermore, the results align with general patterns of transformation in urban ecosystems. It is well established by K.C. Seto *et al.* (2012) that urban expansion is associated with significant biodiversity loss and restructuring of biotic communities due to habitat fragmentation and increasing anthropogenic pressure. Under such conditions, natural ecological niches are disrupted, creating opportunities for the replacement of native species by more stress-tolerant taxa.

Biological invasions play a crucial role in these processes. According to assessments of P. Pyšek *et al.* (2020), invasive species are among the primary drivers of global biodiversity loss, particularly in transformed ecosystems, where they can rapidly colonise disturbed habitats and displace native flora. The dominance of invasive and introduced species observed within the study area confirms these trends and indicates a high level of anthropogenic transformation of the phytocenosis. In addition, the results are consistent with the concept of the "urban stream syndrome" formulated by M.J. Paul & J.L. Meyer (2001), according to which river ecosystems within cities undergo complex degradation due to alterations in hydrological regimes, pollution, and disturbance of riparian zones. These changes lead to simplification of vegetation structure, reduced ecosystem stability, and the formation of mosaic, unstable phytocenoses. Thus, the results of the Shyianka River study are well aligned with current scientific understanding of the transformation of urbanised floodplain ecosystems and confirm that the combined effects of hydrochemical and anthropogenic factors are decisive in shaping the contemporary structure of vegetation cover.

## Conclusions

It has been established that the hydrochemical parameters of the Shyianka River water are characterised by near-neutral pH values, satisfactory aeration, and moderate mineralisation; however, significant variability in oxidation-reduction potential indicates the formation of spatially heterogeneous ecological conditions. It is shown that the atmospheric air quality within the studied area is influenced by anthropogenic factors, as evidenced by elevated concentrations of carbon dioxide and the presence of technogenic pollutants capable of affecting plant physiological processes. A direct relationship between physicochemical environmental characteristics and phytocenosis structure has been demonstrated, manifested in the formation of a mosaic vegetation pattern and changes in species composition.

The floristic composition is represented by a limited number of species (18), among which introduced and invasive taxa constitute a significant proportion, indicating structural simplification and loss of natural diversity of the phytocenosis. The proportion of the adventive component was determined to be 50%, and $Is = 0.50$ corresponds to a high level of anthropogenic transformation, confirming the dominance of ecologically plastic species. A disruption of the vertical structure of the phytocenosis was identified, manifested in the substantial presence of invasive species across all layers and the formation of a secondary, unstable plant community. Thus, it has been established that the combined influence of hydrochemical and atmospheric factors within an urbanised area creates specific ecological conditions that promote phytocenosis transformation, its ruderalisation, and a decline in biodiversity. Further research should focus on long-term monitoring of physicochemical environmental parameters, analysis of seasonal dynamics of phytocenoses, and evaluation of the effectiveness of restoration measures for floodplain ecosystems under conditions of anthropogenic pressure.

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None.

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## Трансформація фітоценозів заплавних екосистем під антропогенним навантаженням (річка Шиянка)

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**Анотація.** У статті досліджено вплив абіотичних та антропогенних чинників на формування фітоценозів заплавної території річки Шиянка (м. Дніпро). Особлива актуальність дослідження зумовлена високим рівнем антропогенного навантаження на урбанізовані заплавні екосистеми та недостатньою вивченістю комплексного впливу абіотичних факторів на формування їх рослинного покриву. Метою роботи було встановлення взаємозв'язку між фізико-хімічними параметрами водного та атмосферного середовища і структурно-функціональними характеристиками рослинних угруповань. Дослідження було проведено в польових умовах із застосуванням геоботанічних та екологічних методів, включаючи відбір проб води та вимірювання показників її якості (pH, окисно-відновний потенціал, вміст розчиненого кисню, мінералізація, електропровідність), а також оцінювання стану атмосферного повітря за концентраціями $CO_2$, $NO_2$, формальдегіду, озону та дрібнодисперсного пилу ($PM_{2.5}$, $PM_{10}$). Встановлено, що гідрохімічні показники води є близькими до нейтральних значень, при достатньому рівні аерації та помірній мінералізації, проте значна варіабельність окисно-відновного потенціалу свідчить про просторову неоднорідність умов середовища. Виявлено підвищену концентрацію $CO_2$ та наявність техногенних домішок у повітрі. Флористичний склад представлений 18 видами судинних рослин, серед яких 50 % становлять інтродуковані та інвазійні таксони, з домінуванням екологічно пластичних видів. Значення індексу синантропізації (0,50) відповідає високому рівню антропогенної трансформації. Встановлено чіткий зв'язок між фізико-хімічними параметрами середовища та структурою рослинного покриву, що проявляється у зростанні частки інвазійних видів і формуванні мозаїчної структури фітоценозу. Новизна роботи полягає у комплексному поєднанні геоботанічного аналізу з оцінкою фізико-хімічних параметрів водного та атмосферного середовища в межах єдиного дослідницького підходу. Отримані результати розширюють уявлення про трансформацію урбанізованих заплавних екосистем і можуть бути використані для екологічного моніторингу та розроблення заходів їх відновлення

**Ключові слова:** рослинні угруповання; абіотичні фактори; урбанізовані екосистеми; інвазійні види; синантропізація; екологічний моніторинг; якість атмосферного повітря