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SPECIES AND STRUCTURAL DIVERSITY OF FLORA AND AVIFAUNA ON THE TERRITORY OF URBAN WATER TREATMENT FACILITIES

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Background. The territories of urban wastewater treatment facilities, where the natural vegetation has been radically changed to synanthropic vegetation, promote the spread of ruderal plant species, including invasive ones, but at the same time create a favourable environment for nesting and staying of many bird species, including rare and those listed in the Red Data Book of Ukraine. The aim of this study is to investigate the species and structural diversity of vegetation on the territory of urban wastewater treatment facilities in order to determine their significance for the conservation of avifauna.

Materials and Methods. To analyse the state of biodiversity, an inventory of species of higher plant and avifauna in the technogenic areas of Kharkiv wastewater treatment facilities in the spring and summer of 2020–2021 was carried out using conventional methods.

Results. The flora of higher vascular plants includes 90 species belonging to 78 genera, 30 families, and 2 classes of the Magnoliophyta division. The leading families are: Asteraceae (30.0 %; n = 90), Poaceae (12.2 %), Brassicaceae (6.7 %), Fabaceae and Polygonaceae (4.4 % each). Herbaceous plant species (92.0 %; n = 90) dominated according to the C. Raunkiær classification (1934), with a predominance of hemicryptophytes (54.0 %) and terophytes (37.0 %). The increased proportion of the latter, compared to the zonal flora, indicates a significant disturbance of the habitat by anthropogenic factors. This is also evidenced by the predominance of synanthropic plant species (81.1 %; n = 90), including 40 species (54.8 %; n = 73) belonging to the apophyte group, and the remaining 45.2 % are adventitious species. In relation to moisture, most plants are mesophytes (71.0%; n = 90). In terms of geographical structure, the flora has a Holarctic-European-Eurasian character with admixtures of North American, Mediterranean, Nomadic and Mediterranean-Asian geoelements.

The avifauna includes 95 species belonging to 13 orders and 29 families. Birds of Passeriformes (32.6 %), Charadriiformes (24.2 %) and Anseriformes (13.7 %) predominate. The treatment facilities are important for nesting of 53 species (55.8 %; n = 95), and are also a trophic base for 23 (24.2 %) of wandering and 19 (20.0 %) of transient bird species. The nine faunal groups were dominated by boreal 26.6 % (n = 95) and tropical 13.8 %, as well as limnophilous (12.8 %) and nemoral (11.7 %) species. The nesting avifauna was formed mainly by nemoral 17.0 % (n = 53) and tropical 15.1 %, as well as alluviophilous and boreal (13.2 % each) species.

The greatest bird diversity is found in the overgrown silt areas, where vegetation with a projected cover of 50–70 % is interspersed with shallow water as close as possible to natural areas.

Among the identified bird species, the following breeding birds are listed in the Red Data Book of Ukraine: *Himantopus himantopus*, also transient and wandering species: *Milvus migrans*, *Hieraaetus pennatus, Columba oenas*.

Conclusion. The established plant communities with rich avifauna, including rare bird species, and the location of the treatment facilities within their migration routes, indicate the importance of these areas for the conservation of biota.

Keywords: flora, synanthropic vegetation, avifauna, urban wastewater treatment facilities, technogenic areas, adventive, ruderal species, rare species

INTRODUCTION

Changes in ecosystems as a result of anthropogenic pressure lead to large-scale transformation of biota (Bulakhov *et al.*, 2008; 2015; Koshelev *et al.*, 2020; Yarys *et al.*, 2021; Yuzyk & Chaplyhina, 2021). Wetlands, as one of the world's most productive ecosystems (Robledano et al., 2010; Perennou *et al.*, 2020), are extremely sensitive to anthropogenic pressures and global climate change (Čížková *et al.*, 2013; Reid *et al.*, 2019). The loss of natural waters can be compensated by artificial or restored wetlands, which contribute to the conservation of typical biota (Andersen *et al.*, 2003; Alexander *et al.*, 2011; Ashoori, 2011; Sebastián-González *et al.*, 2015; Keten *et al.*, 2020) and the spread of adventive or introduced species (Sirami *et al.*, 2008; Blinkova & Shupova, 2017, 2018). An example of such areas is the sludge areas of wastewater treatment facilities, where wastewater from households or municipal and industrial enterprises is treated. The biodiversity in such areas could exceed that of natural ecosystems in some respects (Møller *et al.*, 2012; Fedun *et al.*, 2015). Therefore, man-made reservoirs are often important for the conservation of rare bird species listed in the Red Book of Ukraine (Koshelev *et al.*, 2020; Mamedova & Chaplygina, 2021).

The number, species composition and structure of nesting avifauna are determined by the vegetation of water reservoirs and their succession (Bulakhov *et al.*, 2008; 2015; Slankard *et al.,* 2018; Koshelev *et al.*, 2020). In turn, the processes of vegetation succession depend on the diversity of birds that visit or live in the ecosystem and participate in the settlement of biota (Borthwick & Wang, 2015; Amanah & Yunanto, 2019; Pesotskaya *et al.*, 2020; Chaplygina & Pakhomov, 2020), in particular, invasive alien species, which are considered the second most significant threat to biodiversity in the world (Seath & Shackleton, 2022). Restoration and enrichment of biodiversity involves ecological monitoring of the flora and fauna of man-made wetlands (Murray & Hamilton, 2010; Borthwick & Wang, 2015; Bell *et al.*, 2017). Therefore, each man-made area has its specific formation patterns and the scale of changes, which requires more detailed research. The aim of this study is to investigate the species and structural diversity of flora and avifauna on the territory of municipal wastewater treatment facilities.

MATERIALS AND METHODS

Field studies were carried out on the territory of the Urban Wastewater Treatment Facility No. 2 (hereinafter referred to as the UWTF No. 2) – a subdivision of the "Kharkivvodovidvenennya" Complex. It provides full biological treatment of wastewaters from households and industrial facilities, and further treatment of sewage sludge. UWTF No. 2 is located in the south-western part of Osnovianskyi District (Kharkiv, Ukraine). The territory of the treatment facility is bordered by the territory of a construction hypermarket in the north, Bezlyudivka village in the south, an industrial zone in the west, and cemetery No. 18 in the east (**Fig. 1*A***).

The main part of the research was carried out on the territory of the sludge sites of the sewage treatment facilities, which were built in the 1960s on the site of Lake Lyman, which was 1.66 km long, 2 m deep, and 192 m wide (**Fig. 1*B***). The Brody River, which still flows north of Pidborivka, flowed into this reservoir. In the southern part, this lake was connected to Degtyarne Lake by a strait (Kyselenko, 2021).

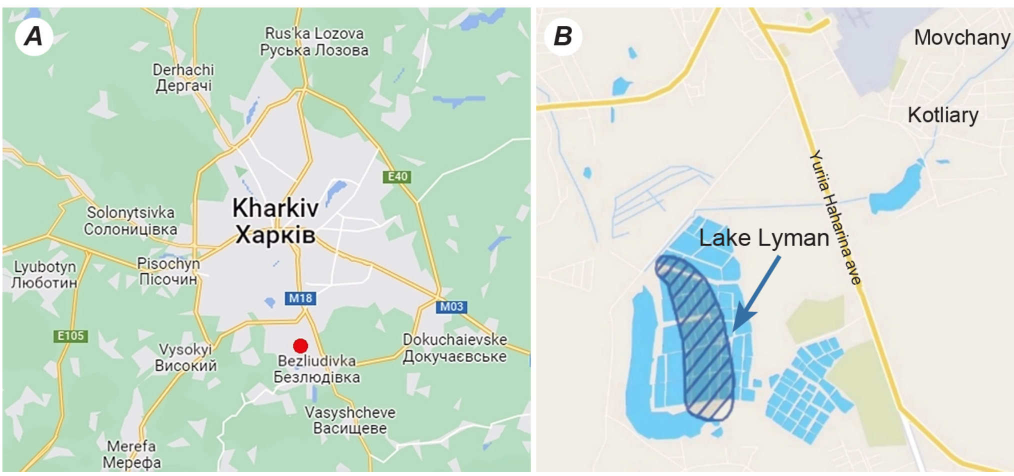


Fig. 1. Schematic location of the study area. Wastewater treatment facilities on the map of Ukraine (***A***); Location of the disappeared Lake Lyman on the modern map (***B***) (by Kyselenko, 2021)

Today, the sludge sites cover an area of 123 hectares. They are built according to the conventional scheme: the land plots are separated from each other and from the adjacent territory by dams, where industrial sludge is filtered through the soil layer. The UWTF No. 2 does not use the sludge sites to their full capacity, so each of them has a variety of habitats that make them attractive to different species of birds in all seasons. The sludge sites have an interior, a coastal strip of vegetation (2–10 m wide), and shallow waters or islands of varying size and vegetation composition. Some sites have not been used by the company for several years, and their sludge accumulations are densely overgrown with herbs and single trees, sometimes in clumps. Some sites have been dried for several years and have not received any treatment water, so they have become overgrown with ruderal vegetation. Taking into account different combinations of water content, dried areas, and vegetation, we classified sludge sites into five types (**Table 1**, **Fig. 2**).

Table 1. **Brief description of the main types of sludge sites**

Types	Share of water filling (%)	Share of drained areas or silt (%)	Vegetation cover (share and location) (%)	Examples of sludge sites
I	up to 100	None	Occasionally in the form of clumps along the perimeter of sludge sites	Fig. 2*A*
II	up to 80	Islets of dried sludge up to 20	Occasionally in the form of clumps along the perimeter of silt sites and on islands of dried silt	Fig. 2*B*
III	50–60	The silt is about 40–50	Vegetation projected coverage of 50–60 % in the form of a narrow strip of reeds and forbs around the perimeter and bottom of the site	Fig. 2*C*, *D*
IV	10–15	The silt is over 80	Vegetation projected coverage up to 70 %. Overgrown sludge areas that have not been used by the company for sludge treatment for more than three years	Fig. 2*E*
V	up to 10	The sludge is dried about 90	Occasional overgrowth along the bottom of the sludge sites and along the perimeter. Sludge sites that the company periodically fills with water	Fig. 2*F*

The research of plant and bird species diversity was carried out during the spring-summer period of 2020–2021 using generally accepted methods. The study of the vegetation species composition of the research area was carried out using the route-based method. For each species the location (number of the silt pad where the species occurs and its position: bottom, dam or its slope) was noted and quantitative characteristics were marked using the Brown-Blanquet method (Braun-Blanquet, 1932). These were further used to calculate species diversity indices and identify dominant species: 5 – continuous cover of a certain species; 4 – dominance of a certain species over others, the species occupies more than 50 % of the total cover; 3 – abundant distribution – the species occupies 20–50 % of the total projective cover; 2 – moderate distribution – the species occupies 5–20 % of the total projective cover; 1 – weak distribution – the species occupies less than 5 % of the total projective cover; p – scattered specimens in few numbers; n – single specimens; un – one or two specimens. The names of species are given according to the World Flora Online (WFO) Plant List, the systematic position – according to APG IV (2016). The studied plant species were analysed by life forms according to the C. Raunkiær classification (1934), ecological groups in relation to moisture, and geographical structure of species composition. Fractional analysis of synanthropic vegetation (time of introduction, degree of naturalisation, invasion path) was carried out according to the classification by J. Kornas (1968).

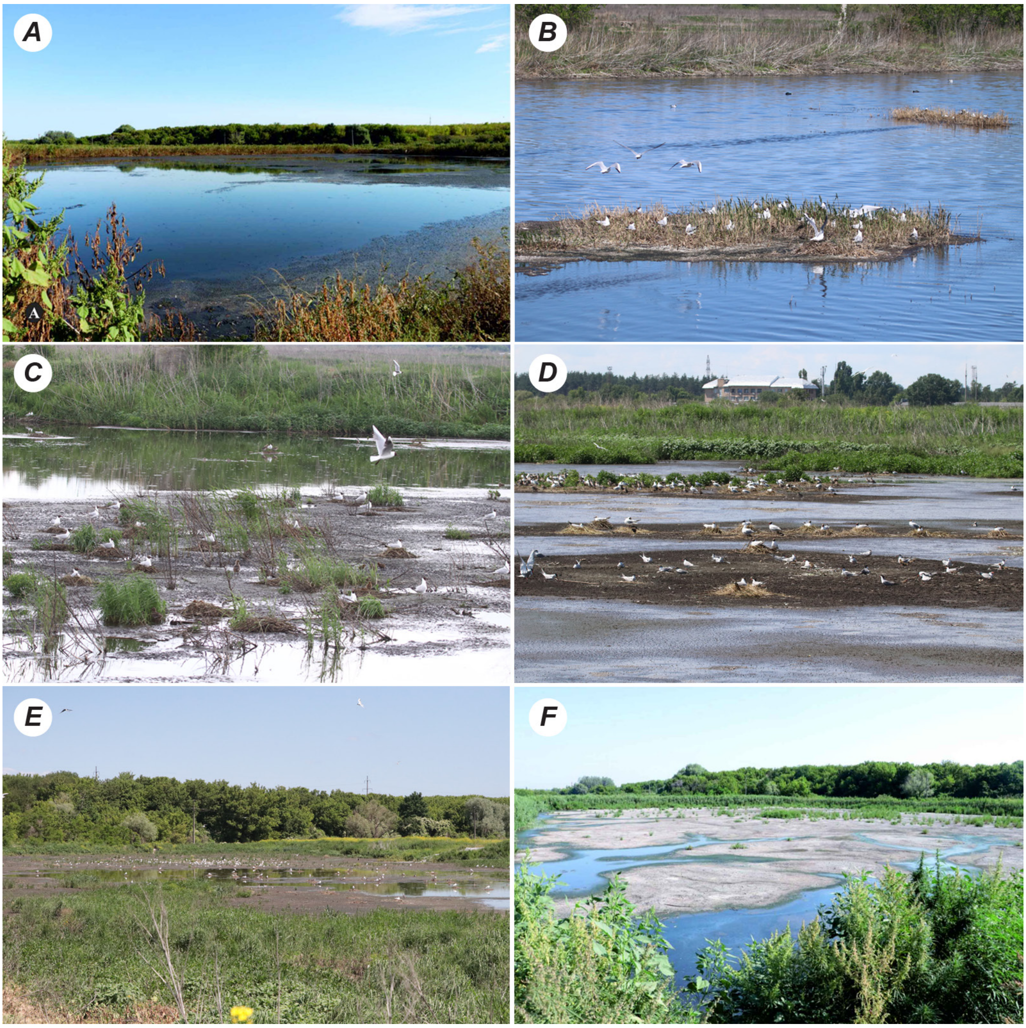


Fig. 2. Different types of sludge sites: ***A*** – type I; ***B*** – type II; ***C*** and ***D*** – type III; ***E*** – type IV; ***F*** – type V

Bird abundance and distribution are determined on permanent routes that cover all areas of the treatment facilities to the maximum extent possible (Bibby *et al.*, 2000). We used binoculars of 20·40 magnification and a Canon 80D camera with a Canon ef 100–400 mm f/4.5–5.6l is usm lens for bird counts. During the study period, 52 surveys were conducted, with a total length of over 450 km.

Based on the classification by L. A. Potish (2009) and our own observations, the species were divided according to their status: nesting (N) – species that reproduce in the study area; wandering (W) – species whose nesting sites are not in the study area, but which systematically appears here in summer; transient (T) – species that do not nest nearby, but constantly use the area for flights and stop there during seasonal migrations. The bird identification guide of Ukraine was used in the research (Fesenko & Bokotey, 2002). The bird taxonomy is presented according to G. V. Fesenko (Fesenko, 2018).

The assessment of α-diversity was carried out using a number of widely accepted indices that express the relationship between the number of species and their abundance. Since none of the indices developed to date is universal, we analysed the following: Menhinik and Shannon diversity indices; Berger–Parker, McIntosh, Simpson dominance indices; McIntosh and Pielu species evenness coefficients, and data on the relative number of indicator species in a community, the formulas for which are provided by A. Magurran (1992).

Shannon Diversity Index $H = -\sum_{i=1}^{S} p_i \cdot \ln p_i$, Menhinik Diversity Index $D_{Mn} = \frac{S}{\sqrt{N}}$,

McIntosh Diversity Index $D_m = \frac{N - \sqrt{\sum N_i^2}}{N - \sqrt{N}}$,

Berger–Parker dominance index $D = \frac{N_{\max}}{N}$, Simpson Dominance Index $H = \sum_{i=1}^{S} p_i^2$,

McIntosh evenness index $E_m = \frac{N - \sqrt{\sum N_i^2}}{N - \frac{N}{\sqrt{S}}}$, Pielu's evenness index $E = \frac{H}{\ln S}$.

Symbols in the formulas: S – number of species; N – sample size; n_i – number of individuals of the i-th species.

To determine the dependence between diversity indices of plant and bird species in the studied plots (Shannon, Berger–Parker, McIntosh diversity, McIntosh dominance and Mc Intosh evenness), Pearson correlation coefficient was used according to the formula:

$$r_{xy} = \frac{\sum_{i=1}^{N}\left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\sqrt{\sum_{i=1}^{N}\left(X_i - \overline{X}\right)^2 \sum_{i=1}^{N}\left(Y_i - \overline{Y}\right)^2}}.$$

To get the correlation between water filling (share of dry area or areas covered with slit, or vegetation cover), non-parametric rank Spearman correlation coefficient was used according to the formula:

$$\rho = 1 - \frac{6\sum_{1}^{n} d_j^2}{n\left(n^2 - 1\right)},$$

where n – the number of pairs under comparion, d^2 – squared difference between their ranks.

The obtained Spearman correlation coefficients were interpreted according to the qualitative rank scale which corresponds to the numeration of the studied plots. Thus, plots with the highest water content, absence of slit and patchy distribution of plant cover had rank 1 and plots with minimal water level and maximal slit content had the maximum rank (**Table 1**).

Cluster analysis and principal component analysis were used as multivariance analysis methods. Graphic representation was provided as dedndrograms (OriginPro 9.0) with Pearson correlation used to assess connection distance.

RESULTS

Flora structure: taxonomic, biomorphological, ecological, and geographical. On the territory of the sludge sites of the treatment facilities, 90 species of higher vascular plants were recorded, grouped into 78 genera, 30 families, 2 classes of the Magnoliophyta division (**Table 1**, **Appendix**). The ratio of Monocots to Eudicots is 1 : 6.5. The quantitative distribution of genera and species by leading families is given in **Table 2**.

Table 2. **Leading families of vegetation on the territory of the treatment facilities**

No.	Families	Quantity			
		genera		species	
		absolute (pieces)	relative (%)	absolute (pieces)	relative (%)
1	Asteraceae	23	29.5	27	30.0
2	Poaceae	10	12.8	11	12.2
3	Brassicaceae	6	7.7	6	6.7
4	Fabaceae	4	5.1	4	4.4
5	Polygonaceae	2	2.6	4	4.4
Together		45	57.7	52	57.8

Based on the taxonomic analysis, five leading families were identified (**Table 2**). They include 52 species from 45 genera, which account for 57.8 % of all plant species studied. The most numerous was the family Asteraceae, which includes 30.0 % of the total number of species (27 from 23 genera). The second position is occupied by Poaceae. Their share in the species composition is 12.2 % (11 species from 10 genera). The third position is occupied by Brassicaceae – 6 species from 6 genera, which makes up 6.7 %, families Fabaceae and Polygonaceae include four species eachwhich. Two families – Solanaceae and Papaveraceae – are represented by 3 species each; ten families – Amaranthaceae, Apiaceae, Boraginaceae, Convolvulaceae, Euphorbiaceae, Lamiaceae, Rubiaceae, Salicaceae, Sapindaceae and Scrophulariaceae – are represented by 2 species each and 13 families – Adoxaceae, Cannabaceae, Caryophyllaceae, Chenopodiaceae, Cucurbitaceae, Lythraceae, Moraceae, Plantaginaceae, Portulacaceae, Ranunculaceae, Rosaceae, Typhaceae and Urticaceae – are represented by 1 species each.

The distribution of the recorded plant species by life forms according to the classification by C. Raunkiær (**Fig. 3*A***) showed that the studied flora is represented by all possible biomorphs. The predominant fraction of species is represented by herbaceous plant species (92.0 %, n = 90), among which the most numerous group is hemicryptophytes (54.0 %). A significant number of species are therophytes (37.0 %), while geophytes (cryptophytes) constitute a very small part – only 1.0 %. The share of lignified species is 8.0 %, of which 7.0 % are phanerophytes and 1.0 % are chamaephytes. The increased fraction of therophytes in comparison with the zonal flora indicates a significant disturbance of the habitat by anthropogenic factors.

Following the results of the surveyed flora distribution in relation to the soil moisture regime, it was found that the recorded plant species are represented by five ecological groups of the terrestrial environment (**Fig. 3*B***). The largest group by the number of species is formed by mesophytes (71.0 %), e.g. *Datura stramonium* L., *Descurainia sophia* (L.) Webb ex Prantl, *Lactuca serriola* L., *Medicago falcata* L., etc.; the second position is occupied by subxerophytes (13.0 %), including *Chenopodium rubrum* L., *Echium vulgare* L., *Tragopogon major* Jacq. and others; the tenth part is composed of submesophytes (10.0 %), such as *Lythrum salicaria* L., *Rorippa austriaca* (Crantz) Spach, *Sonchus palustris* L. and others; the fifth part is made up of hygrophytes (5.0 %) (5.0 %) – *Eupatorium cannabinum* L., *Phragmites australis* (Cav.) Trin. ex Steud., *Typha latifolia* L.; and the smallest group of xerophytes (only 1.0 %) is represented by one species *Artemisia marschalliana* Spreng. The distribution of species of silt sites in relation to soil moisture indicates the mesophilic nature of the observed flora.

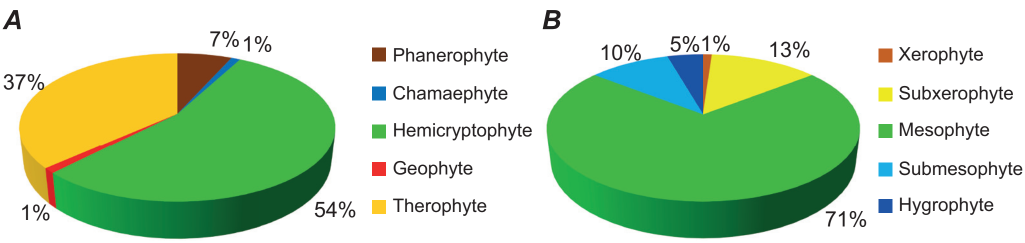


Fig. 3. The spectrum of biomorphs according to C. Raunkiær (***A***) and ecogroups in relation to soil moisture regime (***B***)

The geographical structure study of the species composition of the sludge sites showed that the observed flora has a Holarctic-European-Eurasian character with admixtures of North American, Mediterranean, Nomadic and Mediterranean-Asian geoelements. Overall, the recorded species are represented by 20 different geo-elements, among which the most numerous are the Eurasian and European types, respectively 26.7 % and 22.2 % of the total number of species. There are a? few species belonging to the Boreal, Asian (3.3 % each) and even South American geo-elements (1.1 %).

The natural fraction of the sludge site flora is represented by 17 species, which is 18.9 % of the total number of species. The remaining 81.1 % is occupied by synanthropic plants. Among them, 40 species (54.8 % of the total number of synanthropic species) belong to the group of apophytes (native species that have fully or partially migrated to anthropogenically altered habitats), and the remaining 45.2 % are adventitious species. The group of apophytes includes euapophytes – 18 species (e.g. *Convolvulus arvensis* L., *Polygonum aviculare* L., *Urtica dioica* L. etc.), hemiapophytes – 15 species (e.g. *Bidens tripartita* L., *Humulus lupulus* L., *Verbascum densiflorum* Bertol. and other) and occasional apophytes – 8 species (such as *Bromus inermis* Leyss., *Rorippa austriaca* (Crantz) Spach, *Potentilla argentea* L.). In terms of appearance time, the fraction of adventitious plants is represented by two groups: archaeophytes (introduced before the 16th century) – 19 species (e.g. *Capsella bursa-pastoris* (L.) Medik., *Lactuca serriola* L., *Lepidium ruderale* L., *Solanum nigrum* L. та ін.) and cenophytes/neophytes (introduced after the 16th century) – 13 species (*Ambrosia artemisiifolia* L., *Cyclachaena xanthiifolia* (Nutt.) Fresen, *Acer negundo* L., *Morus nigra* L. etc.).

According to the way of immigration, the adventive species are distributed among three groups: acolutophytes (species that spread independently across the territory with anthropogenic disturbance) prevail – 19 species, including *Conium maculatum* L., *Agropyron cristatum* (L.) Gaertn., *Fumaria officinalis* L., *Portulaca oleracea* L. etc.; the second group – ergasiophytes (deliberately introduced species for breeding, which later became wild and began to spread spontaneously) is represented by 7 species (*Acer negundo*, *Papaver rhoeas* L., *Lycopersicon esculentum* Mill., *Morus nigra*, *Robinia pseudoacacia* L. etc.); the third group – xenophytes (species accidentally introduced by humans) includes 6 species (*Ambrosia artemisiifolia* L., *Erigeron canadensis* L., *Chenopodium rubrum*, *Xanthium strumarium* L., *Echinochloa crus-galli* (L.) P. Beauv. and *Cyclachaena xanthiifolia* (Nutt.) Fresen).

In terms of the naturalisation degree, the adventive plants of the research flora are also represented by three groups. The majority of species (27) belong to the group of epecophytes (species that have almost or completely naturalised on anthropogenically altered ecotopes). This group includes *Amaranthus retroflexus* L., *Agropyron cristatum*, *Onopordum acanthium* L., *Tripleurospermum maritimum* (L.) W. D. J. Koch, etc. The other two groups – ephemerophytes and agriophytes – are not numerous and are represented by 3 and 2 species, respectively. The second group includes *Ambrosia artemisiifolia*, *Lycopersicon esculentum* and *Morus nigra*, and the third group includes *Acer negundo* and *Echinocystis lobata* (Michx.) Torr. & A. Gray.

Analyzing the location of the surveyed flora, it was found that 16 plant species occur at the bottom of the sludge sites, among which the most abundant were *Phragmites australis*, *Elymus repens* (L.) Gould, *Urtica dioica* and *Typha latifolia*. Less abundant species are *Lythrum salicaria* L., *Bidens tripartita* L., *Eupatorium cannabinum* L., *Ranunculus sceleratus* L., etc. The bottom of the sites that have not been used for sludge treatment for more than three years is covered with continuous vegetation of *Bassia scoparia* (L.) A. J. Scott with admixture of species of the genus *Chenopodium* and *Lactuca*. On the slopes of the dams, 36 species were found, among which hygrophytes prevail in the lower part, such as *Phragmites australis* (Cav.) Trin. ex Steud. and *Sonchus palustris* L., and in the upper part - ruderal mesophytes, for example *Sisymbrium loeselii* L., *Lactuca serriola*, *L. tatarica* (L.) C. A.Mey., *Humulus lupulus, Artemisia vulgaris* L., *A. absinthium* L., *Galium aparine* L., *Descurainia sophia* and other; most of them also occur on the dam. The largest number of plant species (74) was recorded on earthen dams, which are almost entirely covered with synanthropic vegetation. The dominant species are clumps of *Sisymbrium loeselii* L. and *Descurainia sophia* (L.) Webb ex Prantl, which are alternated with representatives of Asteraceae: *Lactuca, Artemisia, Achillea, Ambrosia artemisiifolia* L., *Erigeron canadensis* L., *Anthemis ruthenica* M. Bieb., *Centaurea arenaria* M. Bieb. ex Willd. etc.; Poaceae: *Elymus repens* (L.) Gould, *Echinochloa crus-galli* (L.) P. Beauv, *Bromus tectorum* L., *Calamagrostis epigejos* (L.) Roth., *Agropyron cristatum* (L.) Gaertn. and other ruderal species *Amaranthus retroflexus* L., *Ballota nigra* L., *Polygonum aviculare* L., *Conium maculatum* L., *Xanthium strumarium* L., *Portulaca oleracea* L. It should be pointed out that regardless of the location, the study area is dominated by an adventive plant *Cyclachaena xanthiifolia* (Nutt.) Fresen.

The avifauna structure. During the study period, 95 species of birds from 13 orders and 29 families were found migrating, nesting or breeding in the area (**Table 2**, **Appendix**). Representatives of the order Passeriformes dominated (32.6 % n = 95). The subdominants are Charadriiformes (24.2 %) and Anseriformes (13.7 %). The share of other orders is smaller: Falconiformes (5.3 %), Ciconiiformes (4.2 %), Columbiformes (4.2 %), Galliformes (3.2 %), Accipitriformes (2.1 %), Gruiformes (2.1 %), Cuculiformes (1.1 %), Strigiformes (1.1%), Bucerotiformes (1.1 %), Piciformes (1.1 %). The following families prevailed in terms of species composition: Anatidae – 13 species (13.7 %), Scolopacidae – 12 (12.6 %), Laridae – 8 (8.4 %), Accipitridae – 6 (6.3 %), Picidae – 5 (5.3 %). Other families were represented by less than five species.

The avifauna of the wastewater treatment facilities is distributed according to the status: nesting species – 53 (55.8 %; n = 95), wandering – 23 (24.2 %) and transient – 19 (20.0 %). The 53 species of nesting birds are grouped into 10 orders and 22 families. The majority are Passeriformes (50.9 %; n = 53), followed by Charadriiformes (12.7 %) and Anseriformes (9.1 %). Nesting bird species are most dependent on the development of vegetation cover, which enables them to place and build nests, feed, find safe conditions for breeding and staying in general, etc.

Limnophiles (50.5 %; n = 95) and dendrophiles (29.5 %) dominated the ecological communities, with different proportions among among all recorded bird species and breeding/ nesting birds – 35.9 % each. Campophiles and sclerophiles are much less represented (**Fig. 4*A***). The majority of bird species were recorded in the inner part of the sludge sites. *Chroicocephalus ridibundus* L. forms the basis of the population here, creating colonies on dried areas of silt, or reed beds on small islands, etc. (**Fig. 4*B***). In total, more than 2.0 thousand (2020) and 2.5 thousand birds (2021) nested on the sludge sites of the treatment facilities and on the islands of Novyi Lyman Lake, which averages 16.3–20.3 ind./ha. They are subdominant by number: *Sterna hirundo* L., *Fulica atra* L., *Luscinia svecica* L., *Motacilla alba* L. In colonies of gulls, less frequently but regularly, nest *Vanellus vanellus* L*., Himantopus himantopus* L. (**Fig. 4*C*, *D***) and *Charadrius dubius* Scop.

Strips of higher aquatic vegetation 3–6 m wide along the shoreline of the sludge sites provide nesting habitat for *Luscinia svecica* L., *Acrocephahis arundinaceus* L. They nest on the inner edge of such thickets in the presence of a water mirror: *Gallinula chloropus* L., *Anas platyrhyncho* L., *Fulica atra* L. The latter prefers sites of the first and second types with a vegetation base for feeding and hiding the nest (tall herbs). Sometimes the coot builds completely open nests (**Fig. 5**).

Motacilla alba L. and *Oenanthe oenanthe* L. were observed to nest in the excavations of dams. Sludge sites that have not been cleared of silt for several years are almost completely overgrown with vegetation. Such species as *Tringa totanus* L., *Anas clypeata* L., *Anas platyrhynchos* L., *Acrocephalus schoenobaenus* L., *Acrocephalus palustris* Bech., *Locustella luscinioides* Sav. and others nest in those areas. *Corvus cornix* L., *Pica pica* L., *Falco tinnunculus* L. nest in solitary or clumped trees found between the dams of sludge sites. *Columba palumbus* L., *Turdus merula* L., *Carduelis chloris* L., *Acanthis cannabina* L., *Remiz pendulinus* L. and other birds place their nests in tree stands near the New Estuary.

Most birds that nest in nearby ecosystems use sludge sites as a food source: *Buteo buteo* L., *Columba oenas* L., *Riparia riparia* L., *Hirundo rustica* L., *Parus major* L., different species of Fringillidae etc. During May and in late July – early August, various

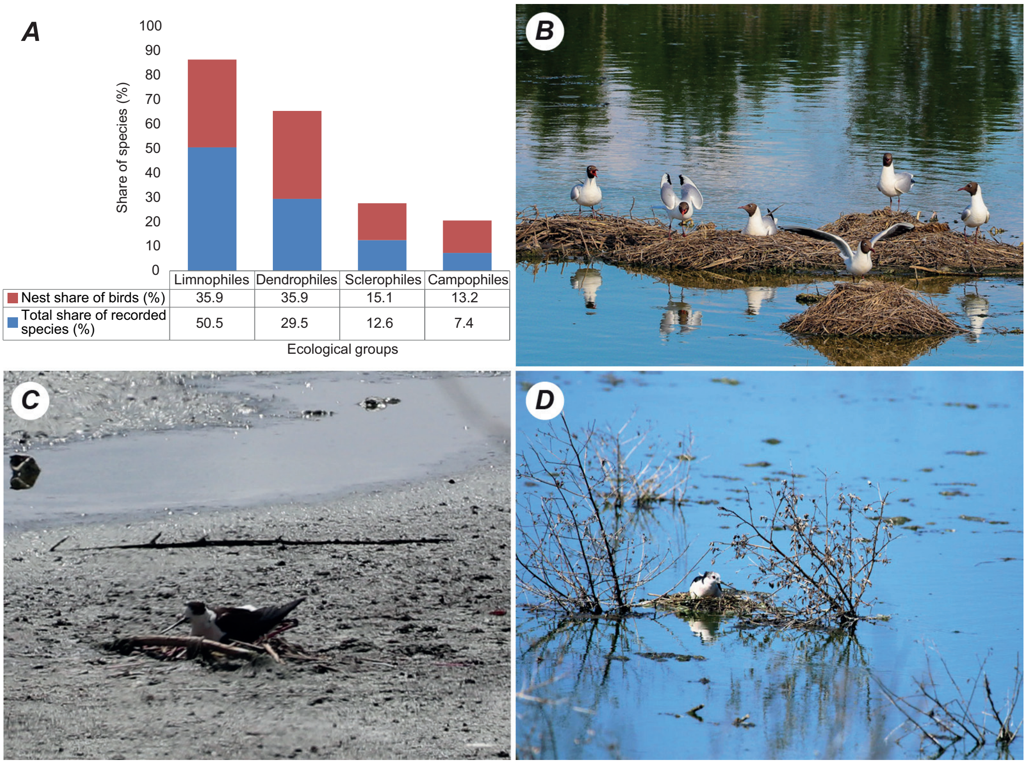


Fig. 4. The distribution of the urban wastewater treatment facilities avifauna by ecological groups (***A***). Nesting at the treatment facilities by *Chroicocephalus ridibundus* in 2021 (***B***); *Himantopus himantopus* in 2020 (***C***, ***D***)

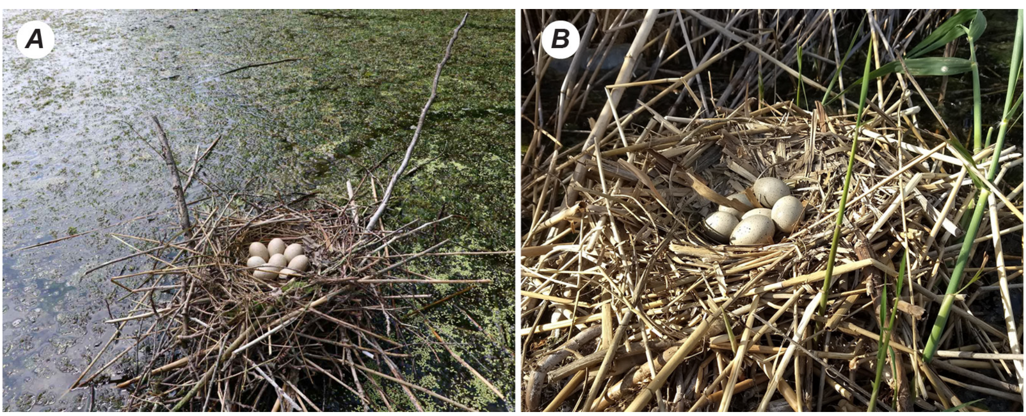
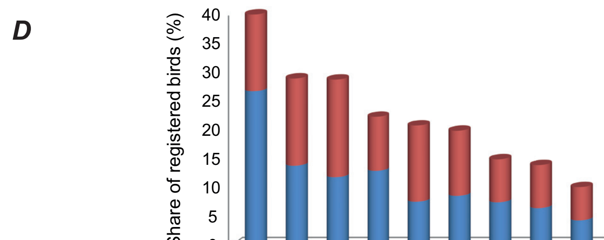


Fig. 5. Nesting of the coot at the wastewater treatment facilities: open nest (***A***); between reeds (***B***)

species of waders feed in the shallow water of the sludge sites: *Philomachus pugnax* L., *Tringa ochropus* L., *Tringa totanus* L., *Gallinago gallinago* L., *Tringa erythropus* Pall., *Calidris alpina* L., *Limosa limosa* L. and rarely occur: *Phalaropus lobatus* L., *Calidris temminckii* Leisl (**Fig. 6A, B, C**).

The avifauna of the treatment facilities is represented by 9 landscape-genetic faunal complexes (**Fig. 6*D***). The largest share of all recorded bird species belongs to the boreal group – 26.6 % (n = 95), while tropical (13.8 %), limnophiles (12.8 %) and nemoral (11.7 %) groups are subdominant. The following are less common: desert-mountainous (8.5 %), alluviophilous (7.5 %), forest-steppe (7.4%), ancient nemoral (6.4 %) and ancient forest-steppe (4.3 %). Among the less registered are: limnophiles (9.4 %), forest-steppe and ancient-nemoral (7.5 % each), as well as ancient-forest-steppe (5.7 %). Thus, the territory of the wastewater treatment facilities has a role for the resettlement of both northern and southern avifauna. Among the nesting species, the prevalence of nemoral species (17.0 %) was observed, however, their share was not high.



	Boreal	Tropical	Nemoral	Limnophile	Alluviaphiles	Desert-mountain	Forest-steppe	Ancient-nemoral	Ancient forest-steppe
Nesting species of birds (%)	13.2	15.1	17	9.4	13.2	11.3	7.5	7.5	5.7
Total share of recorded species (%)	26.6	13.8	11.7	12.8	7.5	8.5	7.4	6.4	4.3

Fig. 6. Birds feeding in shallow water: *Philomachus pugnax* (***A***); *Philomachus pugnax, Numenius arquata* and *Vanellus vanellus* (***B***), *Himantopus himantopus* у 2020 р. (***C***). Distribution of the avifauna of wastewater treatment facilities by landscape genetic faunal complexes (***D***)

At the treatment facilities, most of the birds have a conservation status, with 53 species included in Appendix II and 11 species in Appendix III of the Bern Convention. The Bonn Convention offers protection to 20 species listed in Appendix I and 33 species in Appendix II. Additionally, seven species find inclusion in Appendix II of the Washington Convention. The Red Data Book of Ukraine contains the following species: *Milvus migrans* Bodd., *Columba oenas* L., *Himantopus himantopus* L. *Hieraaetus pennatus* Gm. 12 species are included in the list of birds protected in Kharkiv region: *Podiceps ruficollis* Pall., *P. nigricollis*, *Ardea purpurea* L., *Cygnus olor* Gm., *Falco tinnunculus* L., *Charadrius dubius* Scop., *Limosa limosa* L., *Larus cachinans* Pall., *Sterna hirundo* L., *Asio flammeus* Pont., *Alcedo atthis* L., *Aegithalos caudatus* L.

DISCUSSION

Analysis of species diversity of floral and ornithological communities. With the growth of plant and animal diversity, the stability in the ecosystem increases (Bulakhov *et al.*, 2008; 2015). Pollution often reduces diversity, favoring a few dominant species. Therefore, the diversity of plant communities and avifauna is a factor in the successful management of species conservation.

Vegetation species diversity increases with decreasing levels of water saturation of the silt pad and the presence of dried areas, as evidenced by the Menhinick and Shannon diversity indices. Values of the Berger–Parker and McIntosh indices indicate that there is no dominance of one species or their even distribution in the studied areas, so some increase in the Simpson index at sites III and IV is not significant (**Table 3**).

Table 3. **Characteristics of species diversity of vegetation and avifauna of wastewater treatment facilities by types of sludge sites (Kharkiv)**

Indicators	Vegetation					Avifauna				
	Types of sludge sites *									
	I	II	III	IV	V	I	II	III	IV	V
Number of species, pcs	19	43	48	58	58	26	22	72	78	46
Shannon index	2.77	3.48	3.57	3.64	3.75	2.84	2.80	3.65	3.70	2.93
Menhinick index	3.35	4.90	6.13	8.65	9.11	4.65	3.34	5.19	5.25	4.5
Simpson's index	2.36	2.24	4.52	3.37	2.26	5.81	1.98	1.59	1.54	1.77
Berger–Parker index	0.16	0.06	0.07	0.09	0.10	0.15	0.18	0.23	0.24	0.34
McIntosh index	8.72	14.5	11.11	8.30	7.10	8.59	12.40	48.71	56.95	38.39
McIntosh dominance index	0.89	0.92	0.94	0.96	0.98	0.88	0.84	0.81	0.80	0.70
Pielou evenness index	0.94	0.93	0.92	0.90	0.92	0.96	0.97	0.97	0.96	0.76

Notes. Share of dried areas or silt: I – none; II – islands of dried silt up to 20 %; III – silt about 40–50 %; IV – silt over 80 %; V – silt dried about 90 %

The greatest species diversity of avifauna according to the Menhinick and Shannon indices can be found on the overgrown silt sites of types III–IV with established vegetation (projective coverage of 50–70 %) and shallow water, which are maximally close to natural wetlands (**Table 3**). An increase in the Simpson's index value indicates a decrease in diversity and an increase in the degree of dominance of one species, in particular *Chroicocephalus ridibundus* at sludge sites I–II. However, the Berger–Parker and McIntosh indices demonstrate an even distribution of birds in the studied areas.

Diversity of vegetation according to diversity indices was most similar at sludge sites IV and V, and also at sites I and II. The diversity of vegetation at site III differed from the first two and was similar to types IV and V of sludge sites (**Fig. 7*A***).

The diversity of avifauna according to diversity indices is most similar at sludge sites III and IV. The diversity of birds at site V was similar to sites III and IV. The diversity of birds at the first site was different from all the others and more similar to the second one (**Fig. 7*B***). It can be explained by regular technological fillings of the sites with water for cleaning.

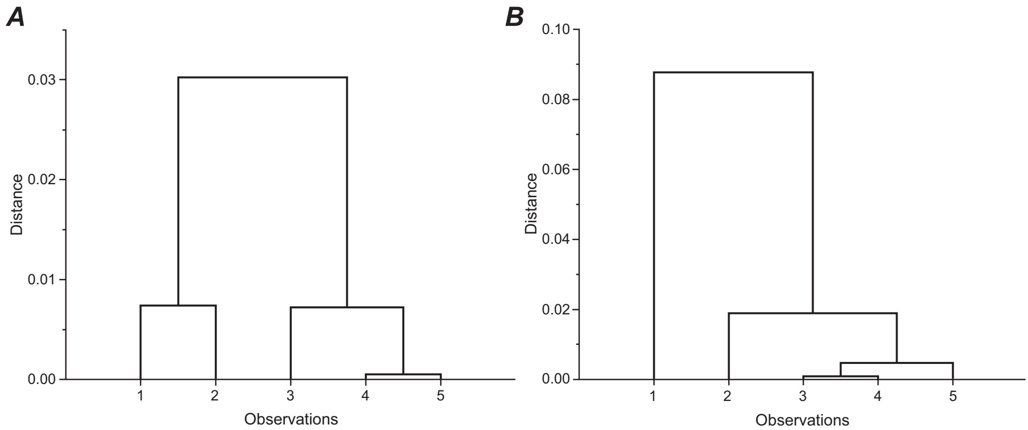


Fig. 7. Similarity of flora (***A***) and fauna (***B***) diversity in the sludge areas of the treatment facilities by Pearson correlation

We analysed the system of correlations between the ecological indices of vegetation and avifauna diversity of the sludge sites. We have identified significant correlations that show the relationship between different ecological indices of phyto- and ornithodiversity (**Tabl. 4**). A strong positive statistically significant relationship was found between the Berger–Parker dominance index in birds and the Menhinic diversity index in plants and the Mackintosh dominance index in plants. A strong statistically significant negative correlation was observed between the following pairs: Macintosh diversity index in birds – Piellou index in plants, Macintosh dominance index in birds – Macintosh dominance index in plants, Piellou index in birds – Macintosh dominance index in plants.

Table 4. **Interrelation of bird ecological diversity indices and vegetation of wastewater treatment facilities (Kharkiv)**

Indicators		Correlation coefficient (r)	Level of significance (P)
Ind Berg Park Aves	Ind Mn Plants	0.90	0.04
Ind Berg Park Aves	Domin Macintosh Plants	0.94	0.02
Divers Macintosh Aves	Ind Piel Plants	-0.91	0.03
Domin Macintosh Aves	Domin Macintosh Plants	-0.93	0.02
Eveness Macintosh Aves	Domin Macintosh Plants	-0.88	0.05

The results of the rank correlation analysis showed that with a decrease in the share of sludge site filling with water and an increase in the share of drained sludge, the species richness of plants increases, as well as the share of the dominant bird species (we observe an increase in index of Bergera–Parkera Aves), but at the same time, the Mackintosh dominance index for birds increases (**Table 5**).

The viability of anthropogenic wetlands is maintained by vegetation cover, which performs various functions, including the treatment of domestic wastewater and the distribution of biota formed under natural conditions with the influence of anthropogenic factors (Thullen *et al.*, 2002; Chaplygina *et al.*, 2023). That is, vascular aquatic plants growing in specific ecological conditions are an important component of these ecosystems and play a significant role in ensuring their sustainability. At the same time, plants of this group are considered to be the most vulnerable to human economic activity (Reid, 2019). Therefore, the natural share of flora at urban wastewater treatment facilities No. 2 is only 18.9 % (n = 90), despite the ancient natural Lake Lyman on which the sludge sites were built. Up to now, the majority of the vegetation at the wastewater treatment facilities has been formed by synanthropic species (81.1 % (n = 90), including 54.8 % of apophytes and the rest (45.2 %) are adventive species. Similar ruderal vegetation also prevails on the territory of the Poltava Mining and Processing Plant (Chaplygina *et al.*, 2023). The spread of alien species is facilitated by natural range expansion such as diffusion, accidental introductions (with imported agricultural products, ballast water, luggage, together with beneficial introductions, etc.). Reasons for the spread of alien species are as follows: anthropogenic changes of landscapes and certain biotopes, deliberate introduction and reintroduction of important utilitarian organisms, quasi-natural movements associated with population fluctuations and climate change (including extraordinary geological and climatic events), as well as natural dispersal of some species by jumping type (Leppäkoski *et al.*, 2002; Caplat & Fonderflick, 2009). Artificial reservoirs of wastewater treatment facilities are favourable for the spread of invasive species. This is the biggest current problem for the conservation of native flora (Čížková *et al.*, 2013).

Table 5. **Correlation coefficients between sludge site rank and ecological diversity indices of birds and vegetation**

Indeces	Correlation coefficient	P-value
Domin Macintosh Aves	-0.99	0.001
Ind Berg Park AVES	0.99	0.001
Domin MacIntosh Plants	0.99	0.001
Ind Mn Plants	0.99	0.001
Ind Mg Plants	0.99	0.001

The mosaic structure of landscapes, their heterogeneous vegetation cover, and the presence of phanerophytes on which dendrophilous birds nest are crucial for the formation of peculiar anthropogenic ornithological complexes. The dependence of birds on plant species composition is more typical for stenobiont species, in particular, *Acrocephalus arundinaceus* L., which nests on tall reeds that form narrow stripes, or *Remiz pendulinus* L., which typically builds a nest on willow (*Salix* spp.). For nesting and feeding birds of the hydrophilic complex, an alternattion of open water and overwater vegetation is important (Murray & Hamilton, 2010). This is also essential for the neutralisation of high NH_4 content (Thullen *et al.*, 2005). Therefore, the planning and implementation of technological processes is important both for the treatment of industrial and domestic wastewater and for creating favourable conditions for birds to feed, migrate and breed. We have registered 53 species of nesting birds, which is less than on the territory of the Chernihiv wastewater treatment facilities, where 71 species breed (Fedun *et al.*, 2015). However, we have recorded the largest nesting population of the common gull and 19 pairs of the long-legged sandpiper in Kharkiv region. It is important in maintaining populations of not only common but also rare bird species (Mamedova & Chaplygina, 2021).

CONCLUSION

A fairly high floristic diversity was found on the territory of the urban wastewater treatment facilities. We recorded the presence of 90 species of higher vascular plants grouped into 78 genera, 30 families, and 2 classes of Magnoliophyta. The leading ones include five families: Asteraceae, Poaceae, Brassicaceae, Fabaceae and Polygonaceae, which include 52 species from 45 genera, which is 57.8 % (n = 90). The most numerous was the family Asteraceae (30.0 % of all species). The flora is represented by all possible biomorphs, among which herbaceous plant species prevail (92.0 %). The most numerous group is made up of hemicryptophytes (54.0 %). The increased share of terrophytes (37.0 %) compared to the zonal flora indicates a significant anthropogenic disturbance of the environment. The distribution of species by ecogroup in relation to soil moisture indicates the mesophilic character of the studied flora (mesophytes – 71 %).

A fairly strong synanthropization of vegetation was noted in the surveyed area. Thus, the natural fraction of the flora of the silt plots is represented by only 17 species, which is 18.9 % (n=90). The remaining 81.1 % is occupied by synanthropic plants. Among them, 40 species (54.8 % (n = 73)) belong to the group of apophytes, and the remaining 45.2 % are adventitious species. In terms of introduction time, the fraction of adventitious plants is represented by two groups: archaeophytes – 19 species and cenophytes – 13 species. According to the degree of naturalisation, the vast majority of the adventive species (81.8 %, n = 33) belong to the epecophyte group. The other two groups, ephemerophytes and agriophytes, are not numerous.

The surveyed flora location revealed that 16 plant species are found at the bottom of the sludge sites, among which the most abundant were: *Phragmites australis*, *Elymus repens*, *Urtica dioica* and *Typha latifolia*. On the dam slopes, 36 species were found, among which hygrophytes prevail in the lower part, such as *Phragmites australis* and *Sonchus palustris*, and in the upper part ruderal mesophytes dominated, e.g. *Sisymbrium loeselii*, *Lactuca serriola*, *L. tatarica Descurainia sophia* etc. The largest number of plant species (74) was observed on earthen dams. The area is dominated by clumps *Sisymbrium loeselii* and *Descurainia sophia,* which are interspersed with representatives of Asteraceae: *Lactuca, Artemisia, Achillea, Ambrosia artemisiifolia, Erigeron canadensis*, *Anthemis ruthenica*, etc.; Poaceae: *Elymus repens, Echinochloa crus-galli*, *Bromus tectorum* and other ruderal species *Amaranthus retroflexus*, *Ballota nigra*, *Xanthium strumarium*, *Portulaca oleracea*. It should be noted that, despite its location, the study area is dominated by an adventive plant *Cyclachaena xanthiifolia* (Nutt.) Fresen.

Thus, the technogenic artificial wetlands of the sewage treatment facilities formed mainly by herbaceous mesophilic synanthropic flora alternating with areas of open water and dried silt are a feeding, stay during migrations and nesting ground for 95 bird species from 13 orders and 29 families. The species composition was dominated by representatives of the order Passeriformes (32.6 %). The subdominant ones were: Charadriiformes (24.2 %) and Anseriformes (13.7 %). The share of other orders was smaller. In terms of numbers during the reproductive period, the common gull prevailed (over 2.5 thousand individuals).

The territory of the treatment facilities is important for the settlement of both boreal (26.6 %; n = 95) and tropical (13.8 %) avifauna. Among the breeding species, non-moral species (17.0 %) were predominant, although their share was low.

The majority of the birds belonged to limnophiles (50.5 %; n = 95) and dendrophiles (29.5 %) with different proportions among all registered bird species and nesting birds

(35.9 % each). Fewer campophiles and sclerophiles were recorded. Most bird species were found in the inner part of the sludge sites. The combination of shallow water and vegetation cover closely resembles natural wetlands, which are important for the conservation of bird diversity, including birds that are rare in Europe and Kharkiv region and are listed in the Red Data Book of Ukraine, in particular, *Milvus migrans, Hieraaetus pennatus*, *Columba oenas* and *Himantopus himantopus* (up to 20 pairs).

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as apotential conflict of interest.

Animal studies: The experiment was conducted in compliance with bioethics, in accordance with the provisions of the Convention on the Protection of Vertebrate Animals Used for Experimental and Other European Scientific Purposes (Strasbourg, 1986), and does not violate the conventions on wildlife protection in Europe (Berne Convention), the Law of Ukraine "On Fauna" (March 3, 1993), the Law of Ukraine "On Environmental Protection" (June 26, 1991)

AUTHOR CONTRIBUTIONS

Conceptualization, [Y.M; R.V.; A.Ch.] methodology, [Y.M; R.V.; A.Ch.]; validation, [Y.M.; R.V.; A.Ch.]; formal analysis [Y.M.; R.V.; A.Ch.]; investigation, [Y.M; R.V.; A.Ch.] resources, [Y.M.; R.V.; A.Ch.]; data curation, [Y.M.; R.V.; A.Ch.]; writing – original draft preparation, [Y.M.; R.V.]; writing – review and editing, [Y.M.; R.V.; A.Ch.]; visualization, [Y.M; R.V.]; supervision, [A.Ch.]; project administration, [Y.M.; R.V.; A.Ch.]; funding acquisition, [Y.M.; R.V.; A.Ch.].

All authors have read and agreed to the published version of the manuscript.

REFERENCES

Alexander, K. L., Sebastián-González, E., Botella, F., & Sánchez-Zapata, J. A. (2011). Occupancy patterns of irrigation ponds by black-winged stilts *Himantopus himantopus. Ardeola*, 58(1), 175–182. doi:10.13157/arla.58.1.2011.175
Crossref • Google Scholar

Amanah, F & Yunanto, T. (2019). Mine reclamation period to successfully meet criteria in Indonesia. In A. B. Fourie & M. Tibbett (Eds.), *Mine Closure 2019: Proceedings of the 13th International Conference on Mine Closure* (pp. 1303–1314). Perth: Australian Centre for Geomechanics. doi:10.36487/acg_rep/1915_103_amanah
Crossref • Google Scholar

Andersen, D. C., Sartoris, J. J., Thullen, J. S., & Reusch, P. G. (2003). The effects of bird use on nutrient removal in a constructed wastewater-treatment wetland. *Wetlands*, 23(2), 423–435. doi:10.1672/17-20
Crossref • Google Scholar

Ashoori, A. (2011). Breeding ecology of the black-winged stilt *Himantopus himantopus* in Boujagh National Park, Gilan Province, northern Iran. *Podoces*, 6(1), 87–91.
Google Scholar

Bell, G., Sena, K., Barton, C., & French, M. (2017). Establishing pine monocultures and mixed pine-hardwood stands on reclaimed surface mined land in eastern Kentucky: implications for forest resilience in a changing climate. *Forests*, 8(10), 375. doi:10.3390/f8100375
Crossref • Google Scholar

Bibby, C. J., Burgess, N. D., Hill, D. A., & Mustoe, S. (2000). *Bird census techniques*, 2nd edn. London: Academic Press.
Google Scholar
Blinkova, O., & Shupova, T. (2017). Bird communities and vegetation composition in the urban forest ecosystem: correlations and comparisons of diversity indices. *Ekológia* (*Bratislava*), 36(4), 366–387. doi:10.1515/eko-2017-0029
Crossref • Google Scholar
Blinkova, O., & Shupova, T. (2018). Bird communities and vegetation composition in natural and semi-natural forests of megalopolis: correlations and comparisons of diversity indices (Kyiv city, Ukraine). *Ekológia* (*Bratislava*), 37(3), 259–288. doi:10.2478/eko-2018-0021
Crossref • Google Scholar
Borthwick, R. R., & Wang, Y. (2015). Bird species' responses to post mine reclamation in Alabama – a preliminary analysis. *Journal American Society of Mining and Reclamation*, 4(2), 1–19. doi:10.21000/jasmr15020001
Crossref • Google Scholar
Braun-Blanquet, J. (1932). *Plant sociology. The study of plant communities.* (Transl. by G. D. Fuller & H. S. Conard). New York, XVIII: 439 p. Reprint 1966.
Google Scholar
Browse the World Flora Online (WFO) Plant List [online]. Retrieved from https://wfoplantlist.org/plant-list
Bulakhov, V. L., Gubkin, A. A., Ponomarenko, O. L., & Pakhomov, O. Y. (2008). *Biologichne riznomanittya Ukrainy. Dnipropetrovska Oblast'. Ptahy: Negorobcepodibni* (*Aves: Non-Passeriformes*) [*Biological diversity of Ukraine. Dnipropetrovsk Region. Aves: Non-Passeriformes*]. Dnipropetrovsk: Dnipropetrovsk University Press. (In Ukrainian)
Google Scholar
Bulakhov, V. L., Gubkin, A. A., Ponomarenko, O. L., & Pakhomov, O. Y. (2015). *Biologichne riznomanittya Ukrainy. Dnipropetrovska Oblast'. Ptahy: Gorobcepodibni* (*Aves: Passeriformes*) [*Biological Diversity of Ukraine. Dnipropetrovsk Region. Aves: Passeriformes*]. Dnipropetrovsk: Dnipropetrovsk University Press. (In Ukrainian)
Google Scholar
Caplat, P., & Fonderflick, J. (2009). Area mediated shifts in bird community composition: a study on a fragmented Mediterranean grassland. *Biodiversity and Conservation*, 18(11), 2979–2995. doi:10.1007/s10531-009-9620-8
Crossref • Google Scholar
Chaplygina, A., & Pakhomov, O. (2020). Trophic links of the blackbird (*Turdus merula* Linnaeus, 1758) in transformed forest ecosystems of north-eastern Ukraine. *Ekológia* (*Bratislava*), 39(4), 333–342. doi:10.2478/eko-2020-0027
Crossref • Google Scholar
Chaplygina, A. B., Filatova O. V., Litvin L. M., Nykyforov V. V. (2023). The main factors and prospects for the restoration of biodiversity in technogenic territories (on the example of the Poltava Mining and Processing Plant). *Biosystems Diversity*, 31(1), 100–112. doi:10.15421/012311
Crossref • Google Scholar
Čížková, H., Květ, J., Comín, F. A., Laiho, R., Pokorný, J., & Pithart, D. (2013). Actual state of European wetlands and their possible future in the context of global climate change. *Aquatic Sciences*, 75(1), 3–26. doi:10.1007/s00027-011-0233-4
Crossref • Google Scholar
Fedun, O. M. Usov, O. Y., & Gavris, G. G. (2015). Breeding Avifauna of the waste water treatment plants, located in northern Left-Bank Part of Ukraine. *Vestnik Zoologii*, 49(2), 125–134. doi:10.1515/vzoo-2015-0014
Crossref • Google Scholar
Fesenko, H. V. (2018). *Vitchyzniana nomenklatura ptakhiv svitu* [*Homeland nomenclature of birds of the world*]. Kryvyi Rih: Dionat. (In Ukrainian)
Google Scholar

Fesenko, H. V., & Bokotey, A. A. (2002). *Ptakhy fauny Ukrainy* [*Birds of the fauna of Ukraine*]. Kyiv: New Print. (In Ukrainian)
Google Scholar

Keten, A., Sarcan, E., & Anderson, J. T. (2020). Temporal patterns of wetland-associated bird assemblages in altered wetlands in Turkey. *Polish Journal of Ecology*, 67(4), 316–330. doi:10.3161/15052249pje2019.67.4.004
Crossref • Google Scholar

Kornas, J. (1968). A geographical-historical classification of synanthropic plants. *Materiały Zakładu Fitosocjologii Stosowanej Uniwersytetu Warszawskiego*, 25, 33–41.
Google Scholar

Koshelev, A. I., Pakhomov, O. Y., Kunakh, O. M., Koshelev, V. A., & Fedushko, M. P. (2020). Temporal dynamic of the phylogenetic diversity of the bird community of agricultural lands in Ukrainian steppe drylands. *Biosystems Diversity*, 28(1), 34–40. doi:10.15421/012006
Crossref • Google Scholar

Kyselenko, V. (2021). *Istoriia Bezliudivky* [*The story of Bezlyudivka*] V. 1. Zhytomyr: Evenok. Retrieved from https://shron1.chtyvo.org.ua/Kysylenko_Vasyl/Istoriia_Bezliudivky_Tom_1.pdf?PHPSESSID=1u15fitpsrvdjc26oul5i3s7d5

Leppäkoski, E., Gollasch, S., & Olenin, S. (2002). Alien species in European waters. In E. Leppäkoski, S. Gollasch, S. Olenin (Eds.), *Invasive aquatic species of Europe. Distribution, impacts and management* (pp. 1–6). Dordrecht: Springer. doi:10.1007/978-94-015-9956-6_1
Crossref • Google Scholar

Magurran, A. E. (2004). Measuring biological diversity. Blackwell Publishing: Oxford, UK.
Google Scholar

Mamedova, Y. P., & Chaplygina, A. B. (2021). Breeding of black-winged stilt *Himantopus himantopus* in muddy sites of a wastewater treatment plant. *Biosystems Diversity*, 29(3), 286–293. doi:10.15421/012136
Crossref • Google Scholar

Møller, A. P., Diaz, M., Flensted-Jensen, E., Grim, T., Ibáñez-Álamo, J. D., Jokimäki, J., Mänd, R., Markó, G., & Tryjanowski, P. (2012). High urban population density of birds reflects their timing of urbanization. *Oecologia*, 170(3), 867–875. doi:10.1007/s00442-012-2355-3
Crossref • PubMed • Google Scholar

Murray, C. G., & Hamilton, A. J. (2010). Review: perspectives on wastewater treatment wetlands and waterbird conservation. *Journal of Applied Ecology*, 47(5), 976–985. doi:10.1111/j.1365-2664.2010.01853.x
Crossref • Google Scholar

Perennou, C., Gaget, E., Galewski, T., Geijzendorffer, I., & Guelmami, A. (2020). Evolution of wetlands in Mediterranean region. *Water Resources in the Mediterranean Region*, 297–320. doi:10.1016/b978-0-12-818086-0.00011-x
Crossref • Google Scholar

Pesotskaya, V. V., Chaplygina, A. B., Shupova, T. V., & Kratenko, R. I. (2020). Fruit and berry plants of forest belts as a factor of species diversity of ornithofauna during the breeding season and autumn migration period. *Biosystems Diversity*, 28(3), 290–297. doi:10.15421/012038
Crossref • Google Scholar

Potish, L. (2009). *Ptakhy Zakarpatskoi oblasti* (*anotovanyi spysok*) [*Birds of the Transcarpathian region of Ukraine* (*annotated list*)]. Lviv. (In Ukrainian)
Google Scholar

Raunkiær, C. (1934) *The life forms of plants and statistical plant geography*. Oxford University Press, London.
Google Scholar

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T. J. ... Cooke, S. J. (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews of the Cambridge Philosophical Society*, 94(3), 849–873. doi:10.1111/brv.12480
Crossref • PubMed • Google Scholar

Robledano, F., Esteve, M. A., Farinós, P., Carreño, M. F., & Martínez-Fernández, J. (2010). Terrestrial birds as indicators of agricultural-induced changes and associated loss in conservation value of Mediterranean wetlands. *Ecological Indicators*, 10(2), 274–286. doi:10.1016/j.ecolind.2009.05.006
Crossref ● Google Scholar

Seath, J., & Shackleton, C. (2022). Comparative avifaunal richness and diversity in invasive *Acacia dealbata* patches and adjacent montane grasslands. *African Zoology*, 57(1), 12–19. doi:10.1080/15627020.2022.2047104
Crossref ● Google Scholar

Sebastián-González, E., & Green, A. J. (2016). Reduction of avian diversity in created versus natural and restored wetlands. *Ecography*, 39(12), 1176–1184. doi:10.1111/ecog.01736
Crossref ● Google Scholar

Sirami, C., Brotons, L., Burfield, I., Fonderflick, J., & Martin, J.-L. (2008). Is land abandonment having an impact on biodiversity? A meta-analytical approach to bird distribution changes in the north-western Mediterranean. *Biological Conservation*, 141(2), 450–459. doi:10.1016/j.biocon.2007.10.015
Crossref ● Google Scholar

Slankard, K. G., Baxley, D. L., & Sprandel, G. L. (2018). The impacts of native-grassland restoration on raptors and their prey on a reclaimed surface mine in Kentucky. *Northeastern Naturalist*, 25(2), 277–290. doi:10.1656/045.025.0211
Crossref ● Google Scholar

Thullen, J. S., Sartoris, J. J., & Walton, W. E. (2002). Effects of vegetation management in constructed wetland treatment cells on water quality and mosquito production. *Ecological Engineering*, 18(4), 441–457. doi:10.1016/s0925-8574(01)00105-7
Crossref ● Google Scholar

Thullen, J. S., Sartoris, J. J., & Nelson, S. M. (2005). Managing vegetation in surface-flow wastewater-treatment wetlands for optimal treatment performance. *Ecological Engineering*, 25(5), 583–593. doi:10.1016/j.ecoleng.2005.07.013
Crossref ● Google Scholar

Yarys, O., Chaplygina, A., & Kratenko, R. (2021). Breeding phenology of common redstart (*Phoenicurus phoenicurus*) and its reproduction biology with artificial nests in northeastern Ukraine. *Ornis Hungarica*, 29(2), 122–138. doi:10.2478/orhu-2021-0024
Crossref ● Google Scholar

Yuzyk, D., & Chaplyhina, A. (2021). Great tits', *Parus major* (Passeriformes, Turdidae), diet in transformed forest ecosystems of northeastern Ukraine. *Ekológia* (*Bratislava*), 40(4), 392–400. doi:10.2478/eko-2021-0041
Crossref ● Google Scholar

ВИДОВЕ ТА СТРУКТУРНЕ РІЗНОМАНІТТЯ ФЛОРИ Й ОРНІТОФАУНИ НА ТЕРИТОРІЇ МІСЬКИХ ВОДООЧИСНИХ СПОРУД

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Вступ. Території очисних споруд міст, на яких докорінно змінена природна рослинність на синантропну, сприяють розповсюдженню рудеральних видів рослин, включаючи інвазійні, однак водночас створюють сприятливе середовище для гніздування та перебування багатьох видів птахів, зокрема, рідкісних і тих,

що занесені до Червоної книги України. Це дослідження спрямоване на вивчення видового та структурного різноманіття рослинності території міських очисних споруд задля виявлення їхнього значення у збереженні орнітофауни.

Матеріали й методи. Для аналізу стану біорізноманіття загальноприйнятими методами проведено інвентаризацію видів флори вищих рослин та орнітофауни на техногенних територіях очисних споруд міста Харкова у весняно-літні періоди 2020–2021 рр.

Результати. Флора вищих судинних рослин налічує 90 видів, що належать до 78 родів, 30 родин, 2 класів відділу Magnoliophyta. Провідні родини: Asteraceae (30,0 %; n = 90), Poaceae (12,2 %), Brassicaceae (6,7 %), Fabaceae і Polygonaceae (по 4,4%). За класифікацією К. Раункієра (1934), домінували трав'янисті види рослин (92,0 %; n = 90) з переважанням гемікриптофітів (54,0 %) і терофітів (37,0 %). Збільшена частка останніх, порівняно з зональною флорою, вказує на значне порушення місцезростання антропогенним чинником. Про це свідчить також переважання синантропних видів рослин (81,1 %; n = 90), серед них 40 видів (54,8 % n = 73) належать до групи апофітів, решта 45,2 % – адвентивні види. Щодо зволоження, то більшість рослин є мезофітами (71,0 %; n = 90). За географічною структурою флора має голарктично-європейсько-євразійський характер з домішками північноамериканського, середземноморського, номадійського та середземноморсько-азіатського геоелементів.

Орнітофауна налічує 95 видів птахів, які належать до 13 рядів і 29 родин. Переважають птахи Passeriformes (32,6 %), Charadriiformes (24,2 %) і Anseriformes (13,7 %). Очисні споруди важливі для гніздування 53 видів (55,8 %; n = 95), а також є трофічною базою для 23 (24,2 %) блукаючих та 19 (20,0 %) пролітних видів птахів. Серед дев'яти фауністичних груп переважали бореальні 26,6 % (n = 95) та тропічні – 13,8 %, а також лімнофільні (12,8%) та неморальні (11,7 %) види. Гніздова орнітофауна сформована переважно неморальними 17,0% (n = 53) та тропічними – 15,1 %, а також алювіофільними й бореальними (по 13,2 %) видами.

Найбільше багатство птахів представлено на заростаючих мулових майданчиках, де рослинний покрив із проєктивним покриттям 50–70 % перемежовувався з мілководдям, максимально наближеним до природних територій.

Із числа виявлених видів птахів до Червоної книги України занесено гніздові (*Himantopus himantopus*), а також пролітні та блукаючи види (*Milvus migrans*, *Hieraaetus pennatus*, *Columba oenas*).

Висновки. Сформовані рослинні угруповання з багатою орнітофауною за участю рідкісних видів птахів і розташування очисних споруд у межах їхніх міграційних шляхів свідчать про важливість цих територій для збереження біоти.

Ключові слова: флора, синантропна рослинність, орнітофауна, міські очисні споруди, техногенні ділянки, адвентивні, рудеральні види, рідкісні види

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APPENDIX

Table 1. **List of plant species of urban wastewater treatment facilities (Kharkiv), species location and their quantitative indicators by Brown-Blanquet**

No.	Name of		Location			Types of sites				
	species	family	bottom	slope	dam	I	II	III	IV	V
1	*Acer negundo* L.	Sapindaceae	*	*	*			1		1
2	*Acer platanoides* L.	Sapindaceae			*		un			
3	*Achillea millefolium* L.	Asteraceae			*			n	n	n
4	*Achillea setacea* Waldst. & Kit.	Asteraceae			*			n	n	p
5	*Agropyron cristatum* (L.) Gaertn.	Poaceae			*			n	n	n
6	*Amaranthus retroflexus* L.	Poaceae			*	2	2	1	1	1
7	*Ambrosia artemisiifolia* L.	Asteraceae			*		4	3	2	p
8	*Anthemis ruthenica* M. Bieb.	Asteraceae			*		2	n	n	1
9	*Arctium minus* (Hill) Bernh.	Asteraceae		*				un	un	un
10	*Artemisia absinthium* L.	Asteraceae		*	*		1	2	p	1
11	*Artemisia marschalliana* Spreng.	Asteraceae			*					un
12	*Artemisia vulgaris* L.	Asteraceae		*	*	1	1	1	1	1
13	*Asperugo procumbens* L.	Boraginaceae		*	*		3			
14	*Ballota nigra* L.	Lamiaceae		*	*		1		p	p
15	*Bassia scoparia* (L.) A. J. Scott	Chenopodiaceae	*	*	*				2	1
16	*Bidens tripartita* L.	Asteraceae	*	*			2			
17	*Bromus inermis* Leyss.	Poaceae			*				n	p
18	*Bromus tectorum* L.	Poaceae			*	1	3	2	2	1
19	*Calamagrostis epigejos* (L.) Roth.	Poaceae			*		1	1	p	
20	*Capsella bursa-pastoris* (L.) Medik.	Brassicaceae		*	*		4		p	p
21	*Carduus acanthoides* L.	Asteraceae			*		un	un	un	un

No.	Name of		Location			Types of sites				
	species	family	bottom	slope	dam	I	II	III	IV	V
22	*Centaurea arenaria* M. Bieb. ex Willd.	Asteraceae			*					p
23	*Chelidonium majus* L.	Papaveraceae			*		n	1		
24	*Chenopodium album* L.	Amaranthaceae			*	1	1	1	1	p
25	*Chenopodium rubrum* L.	Amaranthaceae		*	*	1	2	2	1	1
26	*Chondrilla juncea* L.	Asteraceae			*				un	
27	*Cirsium canum* (L.) All.	Asteraceae	*	*			2		1	
28	*Conium maculatum* L.	Apiaceae			*			1	1	1
29	*Convolvulus arvensis* L.	Convolvulaceae			*	1	1	1	1	1
30	*Crepis foetida subsp*. foetida L.	Asteraceae			*			un		un
31	*Cuscuta*	Convolvulaceae			*			1		p
32	*Cyclachaena xanthiifolia* (Nutt.) Fresen.	Asteraceae	*	*	*	5	5	4	4	4
33	*Datura stramonium* L.	Solanaceae			*			n		
34	*Descurainia sophia* (L.) Webb ex Prantl	Brassicaceae		*	*		1			1
35	*Echinochloa crus-galli* (L.) P. Beauv.	Poaceae		*	*	2	2	3	1	1
36	*Echinocystis lobata* (Michx.) Torr. & A. Gray	Cucurbitaceae		*					un	un
37	*Echium vulgare* L.	Boraginaceae			*				un	un
38	*Elymus repens* (L.) Gould	Poaceae	*	*	*	2	2	1	2	1
39	*Erigeron canadensis* L.	Asteraceae		*	*			n	n	n
40	*Eupatorium cannabinum* L.	Asteraceae	*	*					p	
41	*Euphorbia cyparissias* L.	Euphorbiaceae			*					
42	*Euphorbia virgata* Waldst. & Kit.	Euphorbiaceae		*	*				p	p
43	*Fumaria officinalis* L.	Papaveraceae			*		1		1	1
44	*Galium aparine* L.	Rubiaceae		*			3	2	p	1
45	*Galium mollugo* L.	Rubiaceae			*				n	

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No.	Name of		Location			Types of sites				
	species	family	bottom	slope	dam	I	II	III	IV	V
46	*Heracleum sphondylium* subsp. *sibiricum* (L.) Simonk.	Apiaceae			*					un
47	*Humulus lupulus* L.	Cannabaceae		*	*	3	4	2	p	p
48	*Lactuca muralis* (L.) Fresen.	Asteraceae			*					
49	*Lactuca serriola* L.	Asteraceae		*	*	2	3	2	1	1
50	*Lactuca tatarica* (L.) C. A. Mey.	Asteraceae		*	*		1	2	2	1
51	*Lepidium ruderale* L.	Brassicaceae			*			1	n	
52	*Linaria vulgaris* Mill.	Plantaginaceae			*				un	
53	*Lotus corniculatus* L.	Fabaceae		*	*		n			
54	*Lycopersicon esculentum* Mill.	Solanaceae			*				un	
55	*Lythrum salicaria* L.	Lythraceae	*	*				1		p
56	*Medicago falcata* L.	Fabaceae		*	*	n			n	
57	*Melilotus officinalis* (L.) Pall.	Fabaceae		*	*				p	
58	*Morus nigra* L.	Moraceae			*					n
59	*Onopordum acanthium* L.	Asteraceae			*				un	un
60	*Papaver rhoeas* L.	Papaveraceae			*		1			
61	*Persicaria hydropiper* (L.) Delarbre	Polygonaceae	*				un			
62	*Phragmites australis* (Cav.) Trin. ex Steud.	Poaceae	*	*		2	4	3	2	1
63	*Picris hieracioides* Sibth. & Sm.	Asteraceae			*			un		
64	*Poa annua* L.	Poaceae			*	1				
65	*Poa trivialis* L.	Poaceae	*	*	*		3	1	1	1
66	*Polygonum aviculare* L.	Polygonaceae			*	2	1	2	2	2
67	*Populus alba* L.	Salicaceae					1			
68	*Populus tremula* L.	Salicaceae	*	*	*			un		n
69	*Portulaca oleracea* L.	Portulacaceae			*	1	2	2	1	1

No.	Name of		Location			Types of sites				
	species	family	bottom	slope	dam	I	II	III	IV	V
70	*Potentilla argentea* L.	Rosaceae			*					un
71	*Ranunculus sceleratus* L.	Ranunculaceae	*				1	1		p
72	*Robinia pseudoacacia* L.	Fabaceae			*		1	2	1	p
73	*Rorippa austriaca* (Crantz) Spach	Brassicaceae	*	*				2		
74	*Rumex crispus* L.	Polygonaceae			*				n	n
75	*Rumex hydrolapathum* Huds.	Polygonaceae	*				un	un		
76	*Sambucus racemosa* L.	Adoxaceae			*	1		1		p
77	*Secale sylvestre* Host	Poaceae			*					n
78	*Silene latifolia* Poir.	Caryophyllaceae			*					un
79	*Sisymbrium loeselii* L.	Brassicaceae		*	*	3	4	3	2	2
80	*Solanum nigrum* L.	Solanaceae		*	*	1	1	1	p	p
81	*Sonchus palustris* L.	Asteraceae						1	n	p
82	*Stachys recta* L.	Lamiaceae		*	*				un	
83	*Thlaspi arvense* L.	Brassicaceae			*				un	
84	*Tragopogon major* Jacq.	Asteraceae			*				un	
85	*Tripleurospermum mariti-mum* (L.) W. D. J. Koch	Asteraceae			*			n	p	1
86	*Typha latifolia* L.	Typhaceae	*				2	1		
87	*Urtica dioica* L.	Urticaceae	*	*			3	3	2	1
88	*Verbascum densiflorum* Bertol.	Scrophulariaceae			*				un	
89	*Verbascum thapsus* L.	Scrophulariaceae			*		un			
90	*Xanthium strumarium* L.	Asteraceae		*	*				p	

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Table 2. **List of bird species of urban wastewater treatment facilities (Kharkiv) and their faunogenetic characteristics**

No.	Species of birds	Status of stay	Ecological group	Faunogenetic complex
1.	*Egretta alba* (L. 1758)	t	l	tr
2.	*Ardea cinerea* L. 1758	t	l	tr
3.	*Ardea purpurea* L. 1766	t	l	tr
4.	*Ciconia ciconia* (L. 1758)	w	d	fs
5.	*Anser anser* (L. 1758)	t	l	es
6.	*Cygnus olor* (Gmelin, 1789)	w	l	es
7.	*Tadorna ferruginea* (Pallas, 1764)	t	l	es
8.	*Anas platyrhynchos* L. 1758	n	l	br
9.	*Anas crecca* L. 1758	w	l	br
10.	*Anas penelope* L. 1758	t	l	br
11.	*Anas querquedula* L. 1758	n	l	al
12.	*Anas clypeata* L. 1758	n	l	es
13.	*Aythya ferina* (L. 1758)	w	l	es
14.	*Aythya fuligula* (L. 1758)	t	l	br
15.	*Aythya marila* (L. 1761)	t	l	br
16.	*Bucephala clangula* (L. 1758)	w	l	br
17.	*Melanitta fusca* (L. 1758)	t	l	br
18.	*Milvus migrans* (Boddaert, 1783)	w	d	af (tr)
19.	*Circus aeruginosus* (L. 1758)	n	l	es
20.	*Accipiter gentilis* (L. 1758)	n	d	an
21.	*Accipiter nisus* (L. 1758)	n	d	an
22.	*Buteo buteo* (L. 1758)	n	d	af
23.	*Hieraaetus pennatus* (Gmelin, 1788)	w	d	fs
24.	*Falco tinnunculus* L. 1758	n	s	tr
25.	*Perdix perdix* L. 1758	n	c	fs
26.	*Phasianus colchicus* L. 1758	n	c	tr
27.	*Porzana porzana* (L. 1766)	n	l	al
28.	*Gallinula chloropus* (L. 1758)	n	l	tr
29.	*Fulica atra* L. 1758	n	l	tr
30.	*Charadrius dubius* Scopoli, 1786	n	l	tr
31.	*Vanellus vanellus* (L. 1758)	n	l	es
32.	*Himantopus himantopus* (L. 1758)	n	l	tr
33.	*Tringa ochropus* L. 1758	t	l	br
34.	*Tringa glareola* L. 1758	t	l	br

No.	Species of birds	Status of stay	Ecological group	Faunogenetic complex
35.	*Tringa nebularia* (Gunnerus, 1767)	t	l	br
36.	*Tringa totanus* (L. 1758)	n	l	es
37.	*Tringa erythropus* (Pallas, 1764)	t	l	br
38.	*Tringa stagnatilis* (Bechstein, 1803)	t	l	es
39.	*Philomachus pugnax* (L. 1758)	t	l	br
40.	*Calidris minuta* (Leisler, 1812)	t	l	br
41.	*Calidris temminckii* (Leiser, 1812)	t	l	br
42.	*Calidris alpina* (L. 1758)	t	l	br
43.	*Gallinago gallinago* (L. 1758)	n	l	br
44.	*Limosa limosa* (L. 1758)	t	l	es
45.	*Larus ridibundus* L. 1766	n	l	br
46.	*Larus argentatus* Pontoppidan, 1763	w	l	es
47.	*Larus cachinnans* Pallas, 1811	w	l	es
48.	*Larus canus* L. 1758	w	l	br
49.	*Chlidonias niger* (L. 1758)	w	l	br
50.	*Chlidonias leucopterus* (Temminck, 1815)	w	l	br
51.	*Chlidonias hybrida* (Pallas, 1811)	w	l	tr
52.	*Sterna hirundo* L. 1758	n	l	br
53.	*Columba palumbus* L. 1758	n	d	fs
54.	*Columba oenas* L. 1758	w	s	fs
55.	*Columba livia* Gmelin, 1789	w	s	dm
56.	*Streptopelia decaocto* (Frivaldszky, 1838)	n	d	tr
57.	*Cuculus canorus* L. 1758	n	d	tr
58.	*Asio otus* (L. 1758)	n	d	af
59.	*Upupa epops* L.1758	w	s	tr
60.	*Picus canus* Gmelin, 1788	w	d	an
61.	*Dendrocopos major* (L.1758)	n	d	an
62.	*Dendrocopos syriacus* (Hemprich et Ehrenberg, 1833)	w	d	sm
63.	*Dendrocopos medius* (L. 1758)	w	d	nm
64.	*Dendrocopos minor* (L. 1758)	w	d	an
65.	*Hirundo rustica* L. 1758	n	s	dm
66.	*Delichon urbica* (L. 1758)	n	s	dm
67.	*Motacilla flava* L. 1758	n	c	br
68.	*Motacilla citreola* Pallas, 1776	n	c	br
69.	*Motacilla alba* L. 1758	n	l	br

No.	Species of birds	Status of stay	Ecological group	Faunogenetic complex
70.	*Sturnus vulgaris* L. 1758	n	s	dm
71.	*Pica pica* (L. 1758)	n	d	af
72.	*Corvus monedula* L. 1758	n	s	dm
73.	*Corvus cornix* L. 1758	w	d	fs
74.	*Troglodytes troglodytes* (L. 1758)	n	s	an
75.	*Acrocephalus schoenobaenus* (L. 1758)	n	l	al
76.	*Acrocephalus arundinaceus* (L. 1758)	n	l	es
77.	*Sylvia borin* (Boddaert, 1783)	n	d	nm
78.	*Phylloscopus collybita* (Vieillot, 1817)	n	d	nm
79.	*Saxicola rubetra* L. 1758	n	c	al
80.	*Oenanthe oenanthe* L. 1758	n	s	dm
81.	*Luscinia luscinia* (L. 1758)	n	d	nm
82.	*Luscinia svecica* (L. 1758)	n	l	al
83.	*Turdus pilaris* L. 1758	w	d	br
84.	*Turdus merula* L. 1758	w	d	nm
85.	*Remiz pendulinus* (L. 1758)	n	c	al
86.	*Parus caeruleus* L. 1758	n	d	nm
87.	*Parus major* L. 1758	n	d	nm
88.	*Passer domesticus* (L. 1758)	w	s	dm
89.	*Passer montanus* (L. 1758)	n	s	dm
90.	*Fringilla coelebs* L. 1758	n	d	nm
91.	*Chloris* chloris L. 1758	n	d	nm
92.	*Carduelis carduelis* L. 1758	n	d	nm
93.	*Linaria cannabina* L. 1758	n	d	nm
94.	*Emberiza schoeniclus* L. 1758	n	l	al
95.	*Emberiza citrinella* L. 1758	n	c	fs

Notes: Status of stay: nesting (n), wandering (w), transient (t).
Ecological groups: dendrophiles (d), sclerophiles (s), campophiles (c), limnophiles (l).
Faunogenetic complex: nemoral (nm), ancient nemoral (an), forest-steppe (fs), tropical (tr), desert-mountainous (dm), desert-steppe (ds), ancient forest (af), estuarine (es), boreal (br), submediterranean (sm) and alluviophilous (al)

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