How to Cite: Vinokurov A.A., Anufrieva O.A. (2026). Current state and ecological assessment of flora in man–made areas of industrial enterprises in the East Kazakhstan region. *Fundamental and Experimental Biology. 2026, 31, 2(122), 65-78.* https://doi.org/10.31489/2026FEB2/65-78

Research Article

https://doi.org/10.31489/2026FEB2/65-78

UDC: 58.02 Received: 8.01.2026 | Accepted: 19.01.2026 | Published online: 30 June 2026

A.A. Vinokurov*, O.A. Anufrieva

Altai Botanical Garden, Ridder, Kazakhstan
**Corresponding author: anvin64@mail.ru*

Current state and ecological assessment of flora in man–made areas of industrial enterprises in the East Kazakhstan region

The article presents the results of a floristic study of technogenically disturbed territories associated with industrial enterprises in the East Kazakhstan Region (EKR) and assesses the current ecological state of vegetation in these areas. The aim of the study was to evaluate the ecological features and current condition of flora in disturbed industrial territories based on an analysis of species composition and the ecological structure of plant communities at seven major non-ferrous metallurgy enterprises in the East Kazakhstan Region. The object of the study was the flora of technogenically disturbed industrial sites. The research was based on field botanical surveys using floristic and ecological–cenotic analysis methods. The disturbed flora was found to comprise 253 species of woody and herbaceous plants belonging to 171 genera and 53 families. Three leading families were identified: Asteraceae Bercht. & J.Presl — 41 species (16.1%), Poaceae Barnhart — 24 species (9.4%), and Rosaceae Juss. — 23 species (9.0%), which are characteristic of the boreal–temperate flora of the Holarctic region. The study includes an ecological and morphological assessment of plant adaptation to environmental conditions and analyzes patterns of vegetation recovery in disturbed habitats. Ecological characteristics of the phytocenoses are presented, the distribution of species among ecological–cenotic groups is examined, and a botanical–geographical analysis of the flora of technogenically disturbed territories is conducted. The obtained results expand current understanding of vegetation formation under technogenic impact and provide insight into the present state and ecological organization of technogenic flora.

Keywords: flora, ecosystem, phytocenosis, population, community, species, plants, technogenically disturbed areas, environmental assessment, succession.

Introduction

Intensive industrial development plays a leading role in the economic development of any country. Its growth has a negative impact on the environment, leading to changes in the integrity of the biogeocenotic cover and the degradation of natural landscapes, air, water, and soil pollution, increased waste, and a reduction in plant biodiversity. These processes give rise to anthropogenically disturbed lands, where secondary successions of biological communities occur spontaneously [1]. One such source of environmental destabilization in Eastern Kazakhstan is large industrial enterprises extracting and processing minerals. The region is a flagship for the development of non–ferrous metallurgy, the leading economic sector in the eastern part of the Republic. The region is home to large complexes for the extraction and processing of polymetallic ores: copper, zinc, magnesium, titanium, precious metals, and other minerals. The operations of these enterprises impact the environmental situation in the region, worsening the environment. Moreover, the environmental consequences of indirect impacts on the environment are often more extensive and often exceed the direct impact of mining enterprises on the environment.

The increasing area of technogenic land necessitates the identification and objective assessment of the current state of soil and vegetation cover at the region's major industrial enterprises. Scientific literature emphasizes the importance of studying technogenic flora, as such research allows for the assessment of the ecological state of disturbed areas, the identification of plant adaptations to extreme conditions [2], and the development of effective measures to restore and protect disturbed ecosystems [3, 4].

The aim of the work is to assess the current state and ecological characteristics of flora in man–made areas based on the analysis of species composition and ecological structure of populations at seven leading non–ferrous metallurgy enterprises in the East Kazakhstan region (EKR).

The main objective is to study the issues of degradation of plant communities and the study of the features of the formation of technogenic flora for further monitoring, planning and development of environmen-

tal measures, as well as conducting a geographic analysis of industrial flora, which will provide an understanding of the processes of formation of phytocenoses under conditions of technogenic impact and the patterns of plant distribution on the territory of industrial facilities.

Experimental

The study of vegetation cover in the zone of man–made pollution was carried out at 7 industrial enterprises in the East Kazakhstan region (Fig. 1).

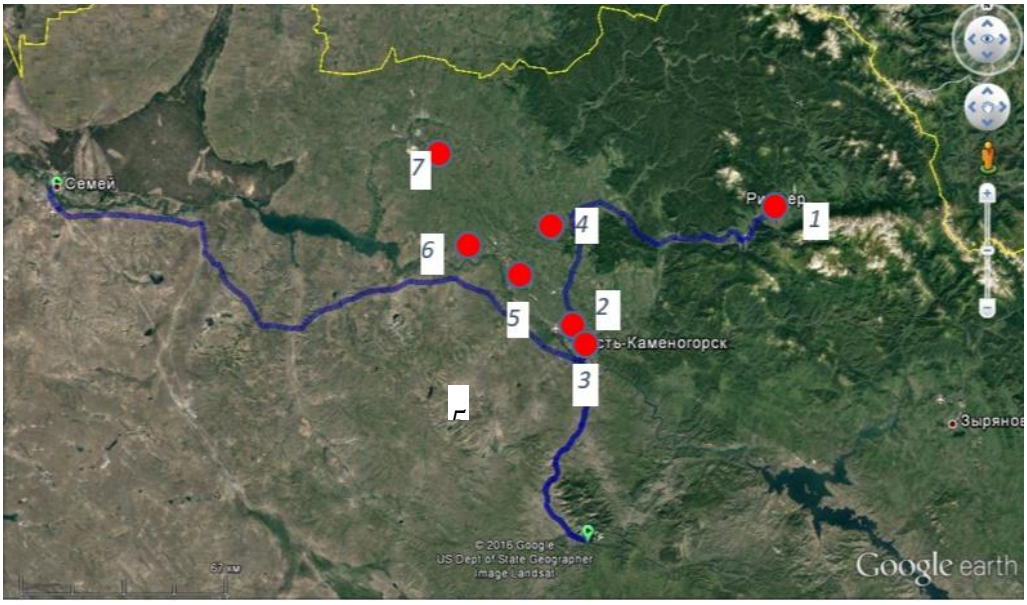


Figure 1. Study of vegetation cover at industrial enterprises in East Kazakhstan region
1 — Ridder Metallurgical Plant; 2 — Ust–Kamenogorsk Titanium and Magnesium Plant;
3 — Ulba Metallurgical Plant; 4 — Belousovsky Mining and Processing Plant; 5 — Irtysh Copper Smelter;
6 — Irtysh Rare Earth Company; 7 — Kazmineral

The study focused on natural and anthropogenically transformed plant communities located within the mountain forest, forest–steppe, and steppe zones near large industrial enterprises. Phytocenoses were studied using a route–reconnaissance method in areas adjacent to industrial enterprises in the East Kazakhstan region. A GARMIN GPS navigator was used to accurately determine the location of the monitoring zones (Etrex 22 X). During the research, the species composition of vascular plants was described, herbarium specimens were collected, and plant communities were identified taking into account the terrain and patterns of vertical zonation.

The species composition of herbarium specimens was clarified using plant identification guides [5–11] and the GBIF information system (https://www.gbif.org/).

The life forms of plants were established according to the ecological–morphological classification of I.G. Serebryakov [12]. The structural–dynamic analysis of life forms, taking into account the characteristics of the habitat and the nature of growth, was carried out according to the classification of G.M. Zozulin [13, 14]. The ecological conditions of plants were determined using the ecological scales of G.Ya. Stepanyuk, L.A. Zhukova and others, reflecting the distribution of species in anthropogenically disturbed areas based on the analysis of the species composition of plants, their taxonomic, morphological and ecological–geographical characteristics [15–19]. The identification of the structure of the flora by the belonging of species to ecological–cenotic groups, the assessment of the ratio of natural and anthropogenic components that determine the degree of transformation of ecosystems were carried out using ecological scales and methods of analyzing floristic diversity in accordance with the approaches developed by R.V. Kamelin for comparative floristic studies [20, 21].

The geographical analysis was conducted using the quantitative flora characterization method of A.I. Tolmachev et al. [22–27]. Species were distributed according to longitudinal and latitudinal geographic elements, which made it possible to identify patterns of their spatial distribution under conditions of anthro-

pogenic transformation of vegetation cover. Statistical processing of primary and secondary data from the comparative analysis of industrial phytocenosis systems was carried out using Microsoft Office Excel 2010.

Results and Discussion

The distribution of plant species in phytocoenoses was recorded at 132 locations across key sites of seven regional enterprises (Fig. 2). All areas are characterized by a high degree of anthropogenic impact due to the long–term development of the mining industry. The flora of the study areas includes apophytes, native, ruderal, synanthropic, and adventitious species that form secondary successional communities in disturbed areas.

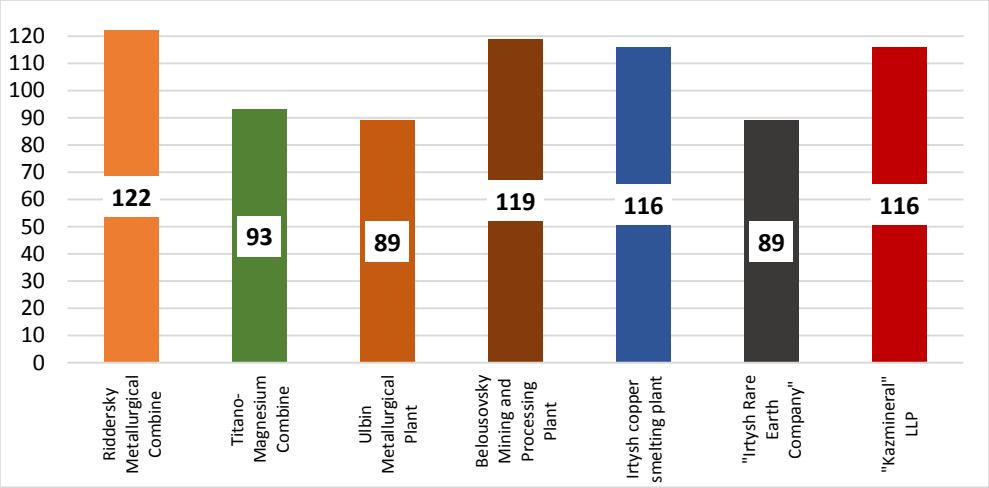


Figure 2. Distribution of the number of species by industrial sites in the East Kazakhstan region

According to the botanical and geographical zoning, the study area belongs to the Altai–Sayan mountain–taiga region, which is part of the South Siberian mountain forest vegetation region. The natural vegetation cover is located in two provinces [28, 29]:

– The Irtysh forest–steppe province of the Eurasian steppe region. Its territory is home to mining enterprises and large population centers, forming an independent type of urban phytocenosis vegetation. Natural vegetation is formed in the steppe and forest–steppe zones of the right bank of the Irtysh River. The natural vegetation type includes forest–steppe feather-grass–grass and fescue steppes, mixed forests, aspen–birch groves, floodplain forests, and shrub thickets. In flat areas, natural phytocenoses give way to arable lands and pastures with anthropogenic agrocenoses and associated weed vegetation. The relief is represented by a hilly surface, in places smoothed and indented by a moderate river network. The difference in altitude reaches up to 120 m (from 80 to 200 m). The climate is sharply continental. Winters are cold and with little snow. Precipitation ranges from 280 to 450 mm. Soils are predominantly a combination of light and dark chestnut soils.

– West Altai mountain forest province. The main enterprises of the non–ferrous metallurgy mining and processing industry are concentrated in the city of Ridder. The surrounding area belongs to the mountain–taiga zone and is characterized by high–altitude and mid–altitude terrain with characteristic vertical zonation. The natural vegetation type is coniferous and mixed forests. Due to intensive agriculture near populated areas, plant communities have been transformed by human economic activity. Degradation of the soil structure and a decrease in overall biodiversity are observed, accompanied by an increased number of adventitious species. The relief is a geomorphological depression with elevations of 700–900 meters above sea level. The climate is moderately cold due to the moderate altitudinal climatic zonation of the mountainous terrain. Precipitation ranges from 600 to 800 mm. The soils are soddy–podzolic.

Vegetation is one of the most sensitive biological components to human anthropogenic influence and, therefore, is becoming a key indicator of industrial pollution. The flora of the Kazakhstan Altai remains understudied. The total floristic diversity of the region comprises approximately 2,500 species of higher vascular plants from 531 genera and 108 families [5]. The studied provinces represent a limited portion of the Rudny Altai, experiencing significant anthropogenic influence from industrial zones. During route reconnaissance surveys in key flora areas, we noted 253 species of woody and herbaceous plants from 171 genera

and 53 families (Table 1). Species analysis showed that the proportion of flora represented at industrial sites reaches 10 % of the total species diversity of the Kazakhstan Altai.

Table 1

Leading flora families near industrial enterprises in the northeastern part of Rudny Altai, East Kazakhstan region

Families	Number of species	% of total
Asteraceae Bercht. & J. Presl	49	19.3
Poaceae Barnhart	24	9.4
Rosaceae Juss.	23	9.0
Fabaceae Lindl.	17	6.7
Salicaceae Mirb.	13	5.1
Lamiaceae Martinov	12	4.7
Caryophyllaceae Juss.	9	3.6
Apiaceae Lindl.	8	3.2
Ranunculaceae Juss.	7	2.8
Plantaginaceae Juss.	7	2.8
Polygonaceae Juss.	6	2.4

In disturbed ecosystems, the leading families are *Asteraceae* (491 species, 19.3 %), *Poaceae* (24 species, 9.4 %), and *Rosaceae* (23 species, 9.0 %), which is typical of the boreal–temperate flora of the Holarctic. Due to their high ecological plasticity, they inhabit a variety of habitats, including disturbed natural complexes, and become dominant in ecosystems for a given climate.

The dominant components of the Irtysh region's phytocenoses are typical meadow–steppe and shrub–meadow communities. In the Ridder mountain basin, meadow and forb–grass communities predominate, developing in the moderately cold and humid conditions of the low relief. Human activity has led to significant changes in the structure and composition of the mountain taiga forests around the city. Species like *Artemisia vulgaris* L., *Tanacetum vulgare* L., *Achillea millefolium* L., *Dactylis glomerata* L., *Lolium pratense* (Huds.) Darbysh., *Alopecurus pratensis* L., *Trifolium hybridum* L. and others are found in natural and anthropogenically disturbed areas. Among them, the overwhelming majority of the noted species (229, or 90.4 %) are native plants of the Kazakh Altai. Adventitious species make up a significant proportion of the cultivated flora near populated areas of the region (24, or 9.5 %). Due to their ecological plasticity, they are able to survive under stressful conditions and undergo a full cycle of ontogenetic development. Among them, predominantly tree species are traditionally used in landscaping cities and towns in the region: *Acer negundo* L., *Ulmuslaevis* Pall., *Populus balsamifera* L., *Malusbaccata* (L.) Borkh., *Fraxinus pensylvanica* Marshall, *Syringa vulgaris* L., *Ribes aureum* Pursh. Some species are invasive (*Acer negundo* L.) or potentially invasive plants in natural communities and in the vicinity of populated areas (*Echinocystislobata* (Michx.) Torr. et A. Gray, *Amaranthus retroflexus* L., *Xanthium strumarium* L. andetc.).

Plants in the surveyed area represent a diverse range of life forms. The overwhelming majority of 106 species (42 %) are perennial herbaceous plants of *the genus Elymus. repens* (L.) Gould, *Agropyron cristatum* (L.) Gaertn., *Artemisia austriaca* Jacq., *Cichorium intybus* L., *Senecio vulgaris* L., *Heracleum dissectum* Ledeb., *Origanum vulgare* L. andetc. They have a developed root system, are highly adaptable, and are capable of vegetative propagation, which ensures population stability in a variety of habitats. A relatively high proportion of annuals (57 %, or 22 %) and biennials (43 %, or 17 %) are found, occupying open and unstable areas lacking dense vegetation cover on industrial sites, along roads, in settlements, and in vacant lots (*Setariaviridis* (L.) P. Beauv., *Carduusnutans* L., *Sonchusoleraceus* L., *Chenopodiumalbum* L., *Amaranthusretroflexus* L.etc.). Dendroflora is represented by 47 taxa (18.5 %). Among them, adventitious species are noted—6 %, which have a high proportion of participation in the composition of cultivated plantings. Some of them act as "pioneers", becoming the basis of these formations with the gradual overgrowth of man–made objects—*Populustremula* L., *Betula* L., *Rosaspinosissima* L., *Spiraeahypericifolia* L., *Lonicera Tatarica* L., *Caraganafrutex* (L.) K. Koch, *Atraphaxisfrutescens* (L.) Eversm., etc. Subshrubs and vines (2 species each) are minimally represented in the industrial flora, accounting for 1.6 % (Fig. 3). It has

been noted that in disturbed areas, the presence of native woody flora ensures natural succession processes during the restoration of anthropogenic ecosystems.

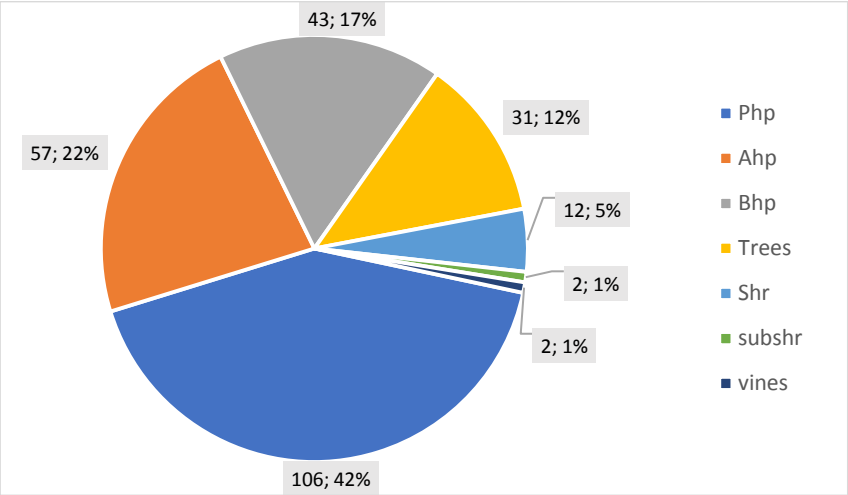


Figure 3. Life forms noted in plant populations in the areas of industrial pollution in East Kazakhstan region: Mtr — herbaceous perennials; Odn — annuals; Dv — biennials; D — trees; K — shrubs; Pk — subshrubs; L — vines

A structural and dynamic analysis of plant species was conducted to determine the stability of vegetation cover, the degree of disturbance, the stages of succession, and assess biodiversity. According to G.M. Zazulin's classification, the development of phytocenoses in disturbed ecotopes was determined by the ratio of restative, irruptive, and vagative plant groups, reflecting their adaptation and spatial distribution. The composition of plant groups in populations in the study areas varies depending on a range of factors related to the nature of industrial impact on the surrounding area (intensity of technogenic pollution, production characteristics, distance from the pollution source, the degree of accumulation of harmful substances in the soil, etc.).

In the disturbed areas of industrial enterprises in the region, the vegetation cover is dominated by restorative species (127 species, 50 %), indicating a pronounced ability of the community to maintain its occupied area and stabilize its spatial structure. The significant proportion of irruptive species (89 species, 35 %) indicates active dispersal and the development of vacant ecological niches, which is typical of anthropogenically transformed habitats. The smaller proportion of vagative species (38 species, 15 %) reflects their limited role in long–term population succession (Fig. 4).

Populations with different types of groups in disturbed areas located near an operating industrial enterprise and the enterprise after its shutdown and reduction of technogenic impact are presented in Figure 3. At sites with intense and constant pollution (Ust–Kamenogorsk "TMK"), irruptive species predominate in the technogenic flora — *Acer negundo* L., *Calamagrostis epigeios* (L.) Roth., *Cichorium intybus* L., *Cirsium vulgare* (Savi) Ten., *Convolvulus arvensis* L. Their share in the flora is 114 (45 %), indicating high ecological instability of plant populations under constant anthropogenic pressure. The proportion of stable regenerative populations decreases to 41 % (104 species), preventing the formation of a stable biocenosis. Among the existing species, plants with high ecological plasticity and resistance to environmental pollution are noted: *Artemisia absinthium* L., *Salvia dumetorum* Andrz. ex Besser, *Verbascum songaricum* Schrenkex Fisch. et C.A. Mey., *Origanum vulgare* L., etc. The low value of variable species 35 (14 %) indicates that plants do not tolerate active pollution well — *Melilotus albus* Medik., *Berteroa incana* (L.) DC., *Echium vulgar* L., *Erigeron canadensis* L. et al. Thus, the ecosystem is in a state of chronic stress, where slow successional processes are observed.

A somewhat opposite picture of technogenic flora development is observed at the former Irtysh Chemical and Metallurgical Plant, which began operations in 1958. The plant's production activities were gradually suspended from 2008 to 2015. In fact, the plant's impact on the surrounding flora and ecosystem during this period was minimized. Active technogenic impact on the flora decreased, and successional processes gradually began to develop toward the formation of resilient and stable plant communities characteristic of natural ecosystems. The current composition of the vegetation reflects this dynamic, manifested in the predominance of regenerative species: 46 (51 %) of the total 89 species noted. *Festuca rubra* L., *Artemisia sericea* Weber

(Besser), *Achillea millefolium* L., *Gypsophila paniculata* L., *Dianthus ramosissimus* Pall.ex Poir et al. The proportion of irruptive taxa is still high, amounting to 29 (33 %). The ecosystem has not yet stabilized, and active successional changes are underway. Many expansive species continue to maintain their numbers and play a significant role in plant communities, indicating the impact of environmental pollution. Among them are ruderal, synanthropic, and pioneer species: *Elymus repens* (L.) Gould, *Malva thuringiaca* subsp. *thuringiaca*, *Sonchus arvensis* L., *Rumex confertus* Willd., and *Leonurus glaucescens* Bunge. The low proportion of variable species (14; 16%) indicates that the ecosystem has not yet reached maturity and remains unstable. These species include *Carduus crispus* L., *Cannabis sativa* var. *ruderalis* (Janisch.) S.Z. Liou, *Senecio vulgaris* L., and *Amaranthus retroflexus* L. Overall, this area reflects a post-technogenic character. Successional processes are at the early and middle stages of development.

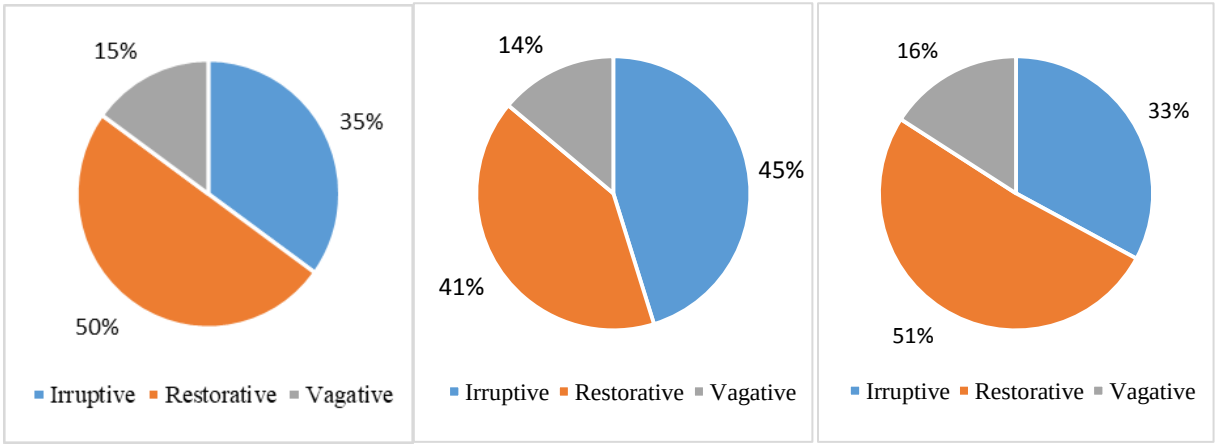


Figure 4. Distribution of plant groups in populations according to G.M. Zazulina in disturbed areas of East Kazakhstan region: A — Average data for all sites, B — Operating Ust–Kamenogorsk Titanium and Magnesium Plant, C — Mothballed Irtysh Rare Earth Company LLC

Plants growing in man–made landscapes differ in their ecological characteristics, including their relationship to moisture conditions, light conditions, and soil fertility (Fig. 5, 6).

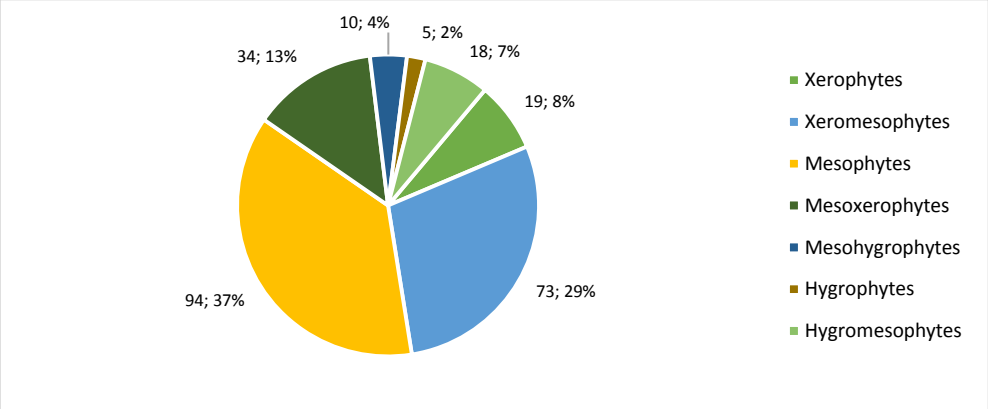
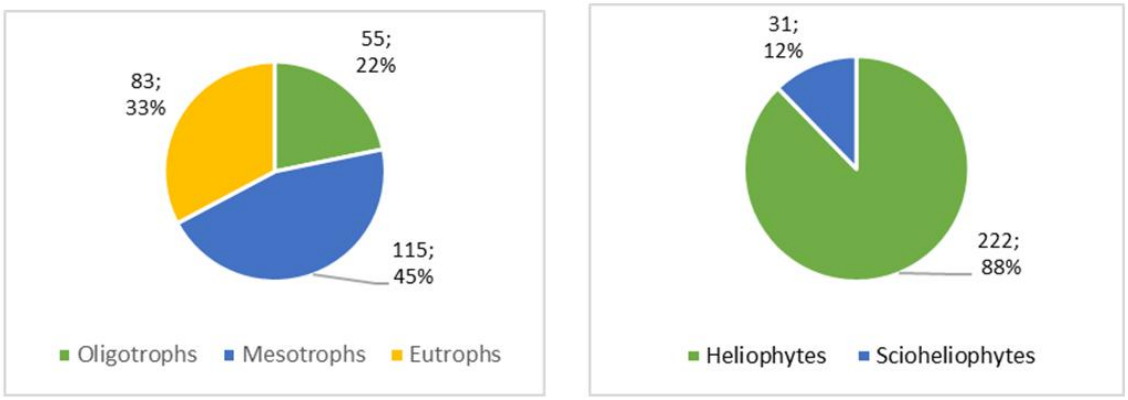


Figure 5. The ratio of ecological groups by the moisture factor of plants growing in man–made disturbed landscapes



A B

Figure 6. The ratio of ecological groups by the illumination factor (A) and soil fertility (B) of plants growing on man–made disturbed landscapes of the East Kazakhstan region

In terms of moisture requirements, plants adapted to moderate moisture predominate—mesophytes 94 (37 %), mesoxerophytes 13 %, xerophytes 19 (8 %), xeromesophytes 73 (29 %). Such types, like *Agrimonia pilosa* Ledeb., *Poa pratensis* L., *Lolium pratense* (Huds.) Darbysh., *Senecio vulgaris* L., *Veronica spicata* L., *Phleum phleoides* (L.) H. Karst., *Bromus inermis* Leyss., etc. reflect dry and moderately dry character conditions growth on violated territories. Marked moisture–loving types from groups hygrophytes with intermediate subgroups—33 (13 %) species, predominantly encountered on territories mountain taiga zones (Ridder): *Salix viminalis* L., *Rubus caesius* L., *Sanguisorba officinalis* L., *Equisetum sylvaticum* L., Angelica *decurrens* (Ledeb.) B. Fedtsch., *Cirsium alatum* (SG Gmel.) Bobrov and in relation to light, the flora of disturbed areas of industrial zones is represented predominantly by heliophytes—222 (88 %) and, to a lesser extent, by scioheliophytes 31 (12 %). This distribution is due to the open nature of the territories of industrial zones, including the mountain–steppe landscape, where well–lit areas predominate and dense vegetation is absent. In the surveyed areas, the greatest number of species develop with average soil fertility — mesotrophs 115 (45 %) — *Lonicera Tatarica* L., *Alopecurus pratensis* L., *Bromus inermis* Leyss., *Echinops tricholepis* Schrenk, *Origanum vulgare* L., etc. The ecological group of plants that inhabit soils with low nutrient content includes 83 (33 %) taxa (oligotrophs) — *Pinus sylvestris* L., *Caragana frutex* (L.) K. Koch, *Filipendula vulgaris* Moench, *Agropyron desertorum* (Fisch. ex Link) Schult., *Artemisia gmelinii* Weber ex Stechm., etc., and 55 (22 %) plants from industrial zones prefer fertile soils with a high humus content (eutrophs).

The eco–coenotic spectrum of flora in disturbed areas is characterized by high mosaicism. Analysis of flora by ecological groups and habitat types reflects habitat conditions, allows evaluating their ecological confinement, functional role in the structure of plant communities, and identify anthropogenic impact. Flora of disturbed areas is divided into 5 eco–coenotic groups: steppe and semi–steppe 65 species or 26 %; forest, forest–shrub and forest–meadow formations (64 species or 25 % of the total composition); weed–ruderal (62 species or 25 %); meadow (51 taxa or 20 %); wetland (11 species or 4 %). The dominance of steppe and forest species reflects the ecotone nature of the territories, caused by the interaction of forest–steppe, steppe and mountain–taiga landscapes. Meadow groups are present as a background element, displaced by weed and steppe vegetation. The proportion of wetland species is minimal due to the relief features and the predominance of dry growing conditions (Fig. 7).

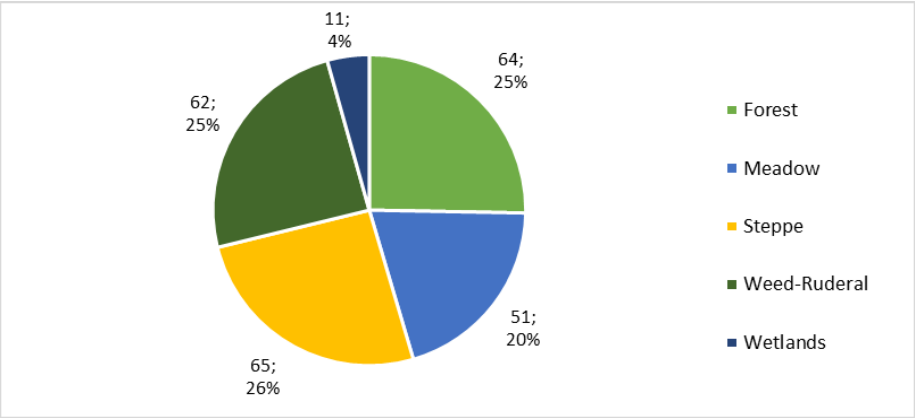


Figure 7. Spectrum of eco–cenotic groups of industrial flora of industrial enterprises of the East Kazakhstan region

An analysis of the spectrum of latitudinal elements of species, carried out on the basis of the classification of latitudinal elements according to A.I. Tolmachev [22], showed that the flora of the studied territories is almost entirely represented by species of the temperate zone (99 %), which corresponds to its physical and geographical position within the mountainous and foothill regions (Fig. 8).

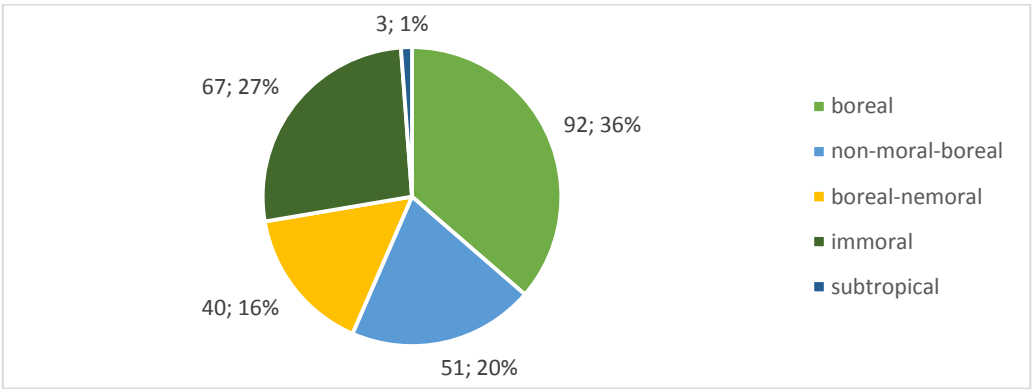


Figure 8. Spectrum of latitudinal elements of flora species of industrial enterprises of the East Kazakhstan region according to botanical and geographical zoning

The largest share in the urban flora is made up of temperate boreal elements 92 (36 %), characteristic of conditions with low temperatures and sufficient moisture—*Rosa acicularis* Lindl., *Potentilla chrysantha* Trevir., *Bromus inermis* Leyss., *Bunias orientalis* L., *Medicago falcata* L., and others. The predominance of this group reflects the significant influence of the mountain–taiga zone. A significant part of the flora is represented by temperate nemoral–boreal 51 (20 %) and boreal–nemoral elements 40 (16 %)—*Acer Tataricum* subsp. *ginnala* (Maxim.) Wesm., *Ulmus pumila* L., *Populus laurifolia* Ledeb., *Chamaenerion angustifolium* (L.) Scop., *Senecio nemorensis* L., *Veronica spicata* L., *Malva thuringiaca subsp. Thuringiaca*. These are ecologically flexible species, occupying transition zones between steppe and forest, with mountain–steppe and forest–steppe elements dominating. Moderately nemoral species account for 67 (27 %) of the studied species. The group includes species confined to warmer temperate climates associated with forest–steppe, meadow steppes, and anthropogenic species that form the basis of the vegetation cover of industrial zones and is represented by *Acer negundo* L., *Populus alba* L., *Ferula songarica* Pall. ex Willd., *Pulmonaria Mollis* Wulf. ex Hornem., *Dianthus ramosissimus* Pall. ex Poir., *Delphinium dictyocarpum* DC., and others. The subtropical element is insignificant, constituting 1.2 %, associated with introduced, anthropogenic alien and cultivated plants—*Echinochloa crus — galli* (L.) P. Beau., *Heliantus annuus* L. These species are not indicators of the natural conditions of the region.

An analysis of longitudinal flora groups reveals a distinct predominance of species with wide habitat ranges, a characteristic feature of anthropogenically transformed ecosystems. The Eurasian group dominates the vegetation structure, comprising 194 (77 %) species of the total flora of anthropogenically disturbed areas, forming the core of disturbed habitats. The proximity of their habitats and similar biogeographic origins

allows them to be considered a single Eurasian complex, possessing a broad ecological range and high resilience to anthropogenic impacts on the environment (Fig. 9).

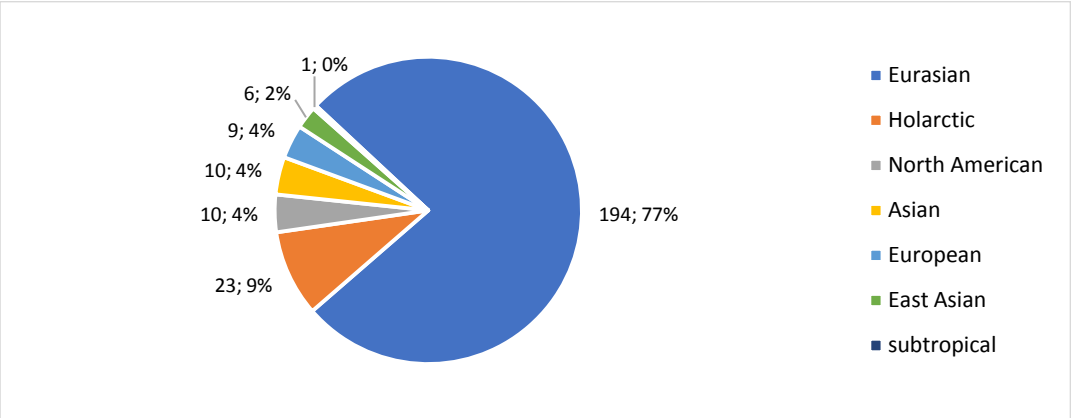


Figure 9. Distribution of industrial flora of industrial enterprises of East Kazakhstan region by geographical zoning

Among them *Acer tataricum* L., *Populus tremula* L., *Betula pendula* Roth, *Calamagrostis purpurea* (Trin.) Trin., *Poa pratensis* L., *Cirsium arvens e* (L.) Scop., *Plantago major* L., *Salvia dumetorum* Andrz. ex Besser etc. Holarctic elements are playing significant role — 23 (9 %) types, characterized by extensive areas growth V within Northern hemispheres — *Sanguisorba officinalis* L., *Festuca rubra* L., *Agrostis stolonifera* L., *Phragmites australis* (Gav.) Trin. ex Steud., *Equisetum hyemale* L. etc. Their presence highlights the ability of plants to adapt to various climatic conditions, including urbanized and man-made areas. The remaining longitudinal elements are represented in small proportions: North American and Asian species — 10 each (4 %) — *Populus balsamifera* L., *Fraxinus Pennsylvania* Marshal, *Solidago canadensis* L., *Ferula songarica* Pall. ex Willd., *Bupleurum longifolium* subsp. *aureum* and others; North American elements are represented by alien and naturalized species, widely distributed in disturbed and secondary habitats; Asian elements reflect continental floristic connections and adaptation to arid and mountain-steppe conditions; European elements make up 9 (4 %) species of the total number — *Salix daphnoides* Villa., *Syringa vulgaris* L., *Campanula rapunculoides* L. and other East Asian — 6 species or 2 % — *Acer Tataricum* subsp. *ginnala* (Maxim.) Wesm., *Salix integra* Thunb., *Malus baccata* (L.) Borkh. etc. Their participation reflects the historical and geographical connections of the region's flora with specific floristic regions and introduction processes. The tropical-subtopical element is represented by one species — *Portulaca oleracea* L., which indicates the absence of influence of southern floristic complexes.

The ecological–cenotic distribution of vegetation on the territory of industrial enterprises is formed under the influence of the degree of technogenic load, environmental conditions and biological characteristics of plant communities.

The conducted research has established that the structure of industrial phytocenoses reflects the adaptation of vegetation to disturbed ecotypes and combines elements of stabilization and active species dispersal with high ecological plasticity, taking into account zonal and climatic factors. The most favorable conditions for plant growth were also noted at the mothballed IREC LLC facility, where phytocenoses are in a state of restorative succession, compared to operating facilities, where natural plant communities are weakened due to constant anthropogenic impacts on the environment, with a predominance of ruderal species and a decrease in the diversity of natural vegetation.

Conclusion

Based on the results of the research, the floristic composition of key industrial flora sites comprises 253 species of woody and herbaceous plants from 171 genera in 53 families, accounting for 10 % of the total species diversity of the Kazakhstan Altai. The leading families of industrial flora are representatives of three families: Asteraceae—49 (19.3 %) species, Poaceae—24 (9.4 %) species; Rosaceae—23 (9.0 %) species, which is typical for the boreal–temperate flora of the Holarctic.

In terms of life forms, the overwhelming majority of plant species are perennial herbaceous plants—106 (42 %), followed by annuals—57 (22 %), and biennials—43 (17 %). Dendroflora is represented by 47

taxa (18.5 % of the total), including adventitious species (6 %): trees—31 (12 %), shrubs—12 (5 %), and subshrubs and vines—2 each (1 %).

Structural–dynamic analysis (the relationship between plant groups in populations) revealed that disturbed phytocenoses are in the recovery stage, with stabilization processes prevailing over active dispersal. Under conditions of intense environmental pollution from industrial enterprises, successional processes and the formation of stable plant communities are slowing down.

The ecological characteristics of phytocenoses in disturbed areas are represented by light–loving plants (heliophytes 88 %), adapted to moderate (mesophytes — 37 %, mesoxerophytes — 13 %) and limited moisture (xerophytes — 8 % and xeromesophytes — 29 %) with a predominance of species with average soil fertility (mesotrophs — 45 %), which corresponds to the ecological conditions of the steppe and mountain–steppe zones of the foothills.

The flora of the disturbed areas is divided into 5 ecological–cenotic groups: steppe and semi–steppe 65 species (26 %); forest, forest–shrub and forest–meadow — 64 species (25 %) of the total composition; weed–ruderal — 62 (25 %); meadow — 51 (20 %); wetland — 11 (4 %).

Botanical and geographical analysis shows that the latitudinal flora elements in disturbed areas are almost entirely represented by temperate zone species (99 %). It was established that the majority of the flora are temperate boreal species — 92 (36 %), nemoral–boreal species — 51 (20 %), and boreal–nemoral species — 40 (16 %). This indicates the dominance of temperate zone flora in the formation of plant communities in industrial ecotopes.

The longitudinal structure is characterized by the dominance of the Eurasian group—194 species (77 %), creating a unified Eurasian complex with high resilience to anthropogenic impacts in the technogenically disturbed areas of industrial enterprises. Other longitudinal elements are represented in minor proportions: North American and Asian species account for 10 each (4 %), European elements account for 9 (4 %), and East Asian species account for 6 (2 %). The presence of North American and Asian species indicates the introduction of introduced species and migration processes.

Thus, at present, industrial phytocenoses in the man–made territories of the enterprises of the East Kazakhstan region are in a state of restoration succession process.

Funding

The scientific work was carried out within the framework of the program BR24992837 “Comprehensive environmental monitoring of the East Kazakhstan region for sustainable development of the agricultural sector and improvement of environmental quality”, 2024–2026.

Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript. CRediT: **Vinokurov A.A.** — development of the topic, data collection and processing, research, formal analysis, methodology, and article writing; **Anufrieva O.A.** — data curation, supervision, drafting, summarizing the findings, and editing.

Conflict of Interest

The authors declare no conflict of interest.

References

1 Jackowiak B. Man-made changes in the flora and vegetation of Poland: Current review / B. Jackowiak // Diversity. — 2023. — Vol. 15, No. 5. — P. 618. https://doi.org/10.3390/d15050618

2 Rakhimov G. Life forms of plants of natural and anthropogenic landscapes / G. Rakhimove et al. // Scientific Horizons. — 2023. — Vol. 26, No. 1. — P. 62–72. DOI:10.48077/scihor.26(1).2023.62–72

3 Третьякова А. С. Урбанофлористика в России: современное состояние и перспективы / А. С. Третьякова // Turczaninowia. — 2021. — Т. 24, № 1. — С. 125–144. https://doi.org/10.14258/turczaninowia.24.1.15

4 Козыбаева Ф.Е. Естественное восстановление растительного покрова, его видового состав в условии самозарастания и рекультивации / Ф.Е. Козыбаева, Ю.А. Котухов, Г.Б. Бейсеева и др. // Почвоведение и агрохимия. — 2018. — № 4. — С. 53–69.

5 Васильева А.Н. Флора Казахстана [в 9 т.] / А.Н. Васильева, А.П. Гамаюнова, В.П. Голоскоков и др. — Алма–Ата: Изд–во Акад. наук Казах. ССР, 1966. — Т. 9. — 640 с.

6 Куминов А.В. Растительный покров Алтая / А.В. Куминова. — Новосибирск: Изд–во Сиб. отд–ния Акад. наук СССР. — 1960. — 450 с.

7 Куприянов А.Н. Флора и растительность / А.Н. Куприянов // Биологическое разнообразие Алтае–Саянского региона. — Кемерово. — 2003. — С. 23–126.

8 Котухов Ю.А. Список сосудистых растений Казахстанского Алтая / Ю.А. Котухов // Ботанические исследования Сибири и Казахстана. — Кемерово. — 2016. — С. 67–124.

9 Котухов Ю.А. Злаки Восточного Казахстана Дополнение к «Флоре Казахстана» [Электронный ресурс] / Ю.А. Котухов // Turczaninowia. — 2021. — Т. 24, № 2. — С. 156–169. — Режим доступа: https://cyberleninka.ru/article/n/dopolnenie–k–flore–kazahstana–zlaki–vostochnogo–kazahstana/viewer

10 Маслова О. Синантропная флора западных низкогорий Алтая / О.М. Маслова, И.А. Хрусталева, Т.О. Стрельникова // Вестник Томского государственного университета. Биология. — 2019. — № 47. — С. 74–102.

11 Анькова Т.В. Конспект флоры Ульбинского хребта (Рудный Алтай) / Т.В. Анькова. — Новосибирск: ЦСБС СО РАН. — 2006. — 144 с. doi: 10.17223/19988591/47/5

12 Серебряков И.Г. Экологическая морфология растений. Жизненные формы покрытосеменных и хвойных / И.Г. Серебряков. — М.: Высшая школа, 1962. — 378 с.

13 Зозулин Г.М. Система жизненных форм высших растений / Г.М. Зозулин // Ботанический журнал. — 1961. — Т. 46, № 1. — С. 3–20.

14 Зозулин Г.М. Жизненные формы растений в аспекте учения о биосфере / Г.М. Зозулин // Ботанический журнал. — 1976. — Т. 61, № 11. — С. 1506–1514.

15 Степанюк Г. Я. Оценка развития растительности техногенного отвала / Г.Я. Степанюк и др. // Техника и технология пищевых производств. — 2022. — Т. 52, № 4. — С. 807–818. https://doi.org/10.21603/2074–9414–2022–4–2407

16 Жукова Л.А. Экологические шкалы и методы анализа экологического разнообразия / Л.А. Жукова, Ю.А. Дорогова и др. — Йошкар–Ола: МарГУ. — 2010. — 368 с.

17 Раменский Л.Р. Экологическая оценка кормовых угодий по растительному покрову / Л.Р. Раменский, Н.А. Антипов и др. — М.: Сельхозгиз. — 1956. — 472 с.

18 Ellenberg H. Zeigerwerte der Gefasspflanzen Mitteleuropas / H. Ellenberg. — Gottingen; Goltze. — 1974. — 97 с.

19 Назаренко Н.Н. Классификация эколого-ценотических групп флоры сосудистых растений (на примере Ханты–Мансийского автономного округа — Югра) / Н.Н. Назаренко, У.Ю. Пасечнюк // Acta Bijljgica Sibirica. — 2019. — Т. 5, № 2. — С. 119–133. doi: https://doi.org/ 10.14258/abs.v5.i2.6194

20 Камелин Р.В. Флорогенетический анализ естественной флоры горной Средней Азии / Р.В. Камелин. — Л.: Наука, Ленингр. отд-ние. — 1973. — 356 с.

21 Камелин Р.В. Материалы по истории флоры Азии (Алтайская горная страна): монография / Р.В. Камелин. — Барнаул: Изд-во Алтайского университета. — 1998. — 240 с.

22 Толмачев А.И. Методы сравнительной флористики и проблемы флорогенеза / А.И. Толмачев. — Новосибирск: Наука. — 1986 — С. 197.

23 Письмаркина Е.В. Бореальные элементы флоры на северо–западе Приволжской возвышенности / Е.В. Письмарикана, Т.Б. Силаева // Проблемы ботаники Южной Сибири и Монголии. — 2024. — Т. 23, № 1. — С. 218–227. DOI: 10.14258/pbssm.2024040

24 Антипова Е.М. Структура флоры евро-сибирского географического элемента лесостепи Средней Сибири / Е.М. Антипова // Samara Journal of Science. — 2018. — Т. 7, № 1. — С. 15–19. DOI:10.17816/SANV25336–19863

25 Гончаров А.Н. Географический анализ флоры антропогенно нарушенных горнолесных фитоценозов Северо–Западного Кавказа / А.Н. Гончаров, А.Ф. Щербатова // Проблемы ботаники Южной Сибири и Монголии. — 2025. — Т. 24, № 1. — С. 40–44. https://doi.org/10.14258/pbssm.2025009

26 Макарова Ю.В. Материалы к эколого-географическому анализу флоры сосудистых растений горы Кузнецова / Ю.В. Макарова, А.А. Головлев, Н.В. Прохорова // Самарский научный вестник. — 2019. — Т. 8, № 1. — С. 59–65. DOI 10.24411/2309–4370–2019–11109

27 Эбель А.Л. Флора северо-западной части Алтае-Саянской провинции: состав, структура, происхождение, антропогенная трансформация: автореф. ... дис. д-ра биол. наук / А.Л. Эбель. — Томск, 2011. — 40 с.

28 Бондаренко А.В. Видовое разнообразие биоресурсов трансграничной биосферной территории: Россия, Монголия, Казахстан, Китай / А.В. Бондаренко // Развитие территорий. — 2016. — № 1 (4). — С. 114–118.

29 Огуреева Г.Н. Ботаническая география Алтая / Г.Н. Огуреева. — М.: Наука, 1980. — 192 с.

А.А. Винокуров, О.А. Ануфриева

Шығыс Қазақстан облысындағы өнеркәсіптік кәсіпорындардың техногендік бұзылған аумақтарындағы флораның қазіргі жағдайы және экологиялық бағасы

Мақалада Шығыс Қазақстан облысындағы (ШҚО) өнеркәсіптік кәсіпорындардың техногендік аумақтарындағы флораны зерттеу нәтижелері келтірілген, бұзылған аумақтардағы техногендік әсерге ұшыраған флораның қазіргі жағдайына экологиялық бағалау негізінде баға берілген. Зерттеу жұмысының мақсаты — Шығыс Қазақстан облысындағы түсті металлургия саласындағы жеті жетекші кәсіпорында жүргізілген түрлік құрамды және популяциялардың экологиялық құрылымын талдау негізінде техногендік аумақтардағы флораның қазіргі жағдайы мен экологиялық ерекшеліктерін бағалау. Зерттеу нысаны — өнеркәсіптік кәсіпорындардың техногендік бұзылған аумақтарының флорасы. Жұмыс флористикалық және экологиялық-ценотикалық талдау әдістерін қолдана отырып жүргізілген далалық ботаникалық сипаттамалар негізінде орындалды. Өнеркәсіптік флораның түрлік құрамының ерекшеліктері анықталды. Ол 53 тұқымдас пен 171 туысқа жататын ағаш және шөптесін өсімдіктердің 253 түрінен тұрады. Негізгі үш жетекші тұқымдас айқындалды: Asteraceae Bercht. & J.Presl — 41 түр (16,1 %), Poaceae Barnhart — 24 түр (9,4 %) және Rosaceae Juss. — 23 түр (9,0 %). Бұл тұқымдастар Голарктиканың бореальды–қоңыржай флорасына тән. Жұмыста өсімдіктердің қоршаған орта жағдайларына бейімделуіне және техногендік флораның қайта қалпына келу ерекшеліктеріне экологиялық-морфологиялық баға берілген. Сонымен қатар фитоценоздарға экологиялық сипаттама жасалып, түрлердің экологиялық-ценотикалық топтар бойынша таралуы талданды, техногендік аумақтар флорасына ботаникалық-географиялық талдау жүргізілді. Алынған мәліметтер техногендік әсер жағдайында өсімдік жамылғысының қалыптасу заңдылықтары туралы түсінікті кеңейтіп, техногендік флораның қазіргі жағдайын сипаттауға мүмкіндік береді.

Кілт сөздер: флора, экожүйе, фитоценоз, популяция, қауымдастық, түр, өсімдіктер, техногендік бұзылған аумақтар, экологиялық бағалау, сукцессия.

А.А. Винокуров, О.А. Ануфриева

Современное состояние и экологическая оценка флоры техногенно нарушенных территориях промышленных предприятий Восточно-Казахстанской области

В статье приводятся результаты исследования флоры на техногенных территориях промышленных предприятий Восточно-Казахстанской области (ВКО), дана оценка современного состояния техногенно нарушенной флоры на нарушенных территориях на основе экологической оценки. Цель работы — дать оценку современному состоянию и экологическим особенностям флоры на техногенных территориях на основе анализа видового состава и экологической структуры популяций на семи ведущих предприятиях цветной металлургии Восточно-Казахстанской области. Объект исследования — флора техногенно нарушенных территорий промышленных предприятий. Работа выполнена на основе полевых ботанических описаний с использованием методов флористического и эколого–ценотического анализа. Установлены особенности видового состава промышленной флоры, насчитывающей 253 вида древесных и травянистых растений из 171 рода, относящихся к 53 семействам. Выделены 3 ведущих семейства: *Asteraceae* Bercht. & J. Presl — 41 вид (16,1 %), *Poaceae* Barnhart — 24 вида (9,4 %) и *Rosaceae* Juss. — 23 вида (9,0 %), которые характерны для бореально–умеренной флоры Голарктики. В работе представлена эколого–морфологическая оценка адаптации растений к условиям среды и особенностям возобновления техногенных флор. Дана экологическая характеристика фитоценозов, проанализировано распределение видов по эколого–ценотическим группам, проведен ботанико–географический анализ флоры техногенных территорий. Полученные сведения расширяют представления о закономерностях формирования растительности в условиях техногенного воздействия и дают представление о современном состоянии техногенной флоры.

Ключевые слова: флора, экосистема, фитоценоз, популяция, сообщества, вид, растения, техногенно нарушенные территории, экологическая оценка, сукцессия.

References

1 Jackowiak, B. (2023). Man-made changes in the flora and vegetation of Poland: Current review. *Diversity, 15*(5). https://doi.org/10.3390/d15050618

2 Rakhimov, G. et al. (2023). Life forms of plants of natural and anthropogenic landscapes. *Scientific Horizons, 26*(1), 62–72. DOI:10.48077/scihor.26(1).2023.62–72

3 Tretyakova, A.S., et al. (2021). Urbanofloristika v Rossii: sovremennoe sostoianie i perspektivy [Urban floristry in Russia: current status and prospects]. *Turczaninowia, 24*(1), 125–144. https://doi.org/10.14258/turczaninowia.24.1.15 [in Russian].

4 Kozybaeva, F.E., Kotuxov, Yu.A., & Bejseeva, G.B., et al. (2018). Estestvennoe vosstanovlenie rastitelnogo pokrova, ego vidovogo sostava v uslovii samozarastania i rekultivatsii [Natural restoration of vegetation cover, its species composition under conditions of self-overgrowth and reclamation]. *Pochvovedenie i agrokhimiia — Soil Science and Agronomy,* 4, 53–69 [in Russian].

5 Vasil`eva, A.N., Gamayunova, A.P., Goloskokov, V.P., et al. (1966). *Flora Kazakhstana* [Flora of Kazakhstan]. Vols. 1–9. Vol. 9. Alma–Ata: Izdatelstvo Akademii Nauk Kazakhskoi SSR [in Russian].

6 Kuminov, A.V. (1960). *Rastitelnyi pokrov Altaia* [Plant cover of Altay]. Novosibirsk: Izdatelstvo Sibirnogo otdeleniia Akademii Nauk Kazakhskoi SSSR [in Russian].

7 Kupriyanov, A.N. (2003). Flora i rastitelnost [Flora and vegetation]. *Biologicheskoe raznoobrazie Altae-Saianskogo regiona — Biological diversity of the Altae–Sayan region.* Kemerovo [in Russian].

8 Kotuxov, Yu.A. (2016). Spisok sosudistykh rastenii Kazakhstanskogo Altaia [List of vascular plants of the Kazakh Altay]. *Botanicheskie issledovania Sibiri i Kazakhstana — Botanical studies of Siberia and Kazakhstan,* 67–124. Kemerovo [in Russian].

9 Kotuxov, Yu.A. (2021). Zlaki Vostochnogo Kazakhstana Dopolnenie k «Flore Kazakhstana» [Cereals of Eastern Kazakhstan. Supplement to the "Flora of Kazakhstan"]. *Turczaninowia, 24*(2). Retrieved from https://cyberleninka.ru/article/n/dopolnenie–k–flore–kazahstana–zlaki–vostochnogo–kazahstana/viewer [in Russian].

10 Maslova, O.M., Khrustaleva, I.A., & Strelnikova, T.O. (2019). Sinatropnaia flora zapadnykh nizkogorii Altaia [Synanthropic flora of the western lowlands of Altay]. *Vestnik Tomskogo gosudarstvennogo universiteta. Biologiia — Bulletin of Tomsk State University. Biology,* 47, 74–102 [in Russian].

11 Ankova, T.V. (2006). *Konspekt flory Ulbinskogo khrebta (Rudnyi Altai)* [A summary of the flora of the Ulbinsky Range of the Rudny Altai]. Novosibirsk: TszSBS SO RAN. doi: 10.17223/19988591/47/5 [in Russian].

12 Serebryakov, I.G. (1962). *Ekologicheskaia morfologia rastenii. Zhiznennye formy pokrytosemennykh i khvoinykh* [Ecological morphology of plants. Life forms of angiosperms of conifers]. Moscow: Vysshaia shkola [in Russian].

13 Zozulin, G.M. (1961). Sistema zhiznennykh form vysshikh rastenii [System of life forms of higher plants]. *Botanicheskii zhurnal — Botanical journal, 46*(1), 3–20 [in Russian].

14 Zozulin, G.M. (1976). Zhiznennye formy rastenii v aspekte ucheniia o biosfere [Life forms of plants in the context of studying the biosphere]. *Botanicheskii zhurnal — Botanical journal, 61*(11), 1506–1514 [in Russian].

15 Stepanyuk, G.Ya., et al. (2022). Otsenka razvitiia rastitelnosti tekhnogennogo otvala [Assessment of vegetation development of a man–made waste dump]. *Tekhnika i tekhnologiia pishchevykh proizvodstv — Technology of food production, 52*(4), 807–818. https://doi.org/10.21603/2074–9414–2022–4–2407 [in Russian].

16 Zhukova, L.A., Dorogova, Yu.A., et al. (2010). *Ekologicheskie shkaly i metody analiza ekologicheskogo raznoobraziia* [Ecological scales and methods of analysis of ecological diversity]. Yoshkar–Ola: Mariiskoi gosudarstvennyi universitet [in Russian].

17 Ramensky, L.R., Antipov, N.A. et al. (1956). *Ekologicheskaia otsenka kormovykh ugodii po rastitelnomu pokrovu* [Ecological assessment of forage lands based on vegetation cover]. Moscow: Selxozgiz [in Russian].

18 Ellenberg, H. (1974). *Zeigerwerte der Gefasspflanzen Mitteleuropas* [Indicator Values of the Vascular Plants of Central Europe]. Gottingen; Goltze [in German].

19 Nazarenko, N.N., & Pasechnyuk, U. Yu. (2019). Klassifikatsiia ekologo-tsenoticheskikh grupp flory sosudistykh rastenii (na primere Khanty-Mansiiskogo avtonomnogo okruga — Yugra) [Classification of ecological–cenotic groups of vascular plant flora (using the Khanty–Mansiysk Autonomous Okrug — Yugra as an example)]. *Acta Bijljgica Sibirica, 5*(2). doi: https://doi.org/10.14258/abs.v5.i2.6194 [in Russian].

20 Kamelin, R.V. (1973). *Florogeneticheskii analiz estestvennoi flory gornoi Srednei Azii* [A florogenetic analysis of natural flora of the mountains of Central Asia]. Leningrad: Nauka, Leningradskoe otdelenie [in Russian].

21 Kamelin, R.V. (1998). *Materialy po istorii flory Azii (Altaiskaia gornaia strana): monografiia* [Materials on the history of Asian flora (Altay Mountain Country): monograph]. Barnaul: Altaiskii Universitet [in Russian].

22 Tolmachev, A.I. (1986). *Metody sravnitelnoi floristiki i problemy florogeneza* [Methods of comparative floristry and problems of florogenesis]. Novosibirsk: Nauka [in Russian].

23 Pismarkina, E.V., & Silaeva, T.B. (2024). Borealnye elementy flory na severo-zapade Privolzhskoi vozvyshennosti [Boreal elements of flora in the northwest of the Volga Upland]. *Problemy botaniki Yuzhnyi Sibiri i Mongolii — Problems of botany in Southern Siberia and Mongolia, 23*(1). DOI: 10.14258/pbssm.2024040 [in Russian].

24 Antipova, E.M. (2018). Struktura flory evro-sibirskogo geograficheskogo elementa lesostepi Srednei Sibiri [Structure of the flora of the Euro–Siberian geographical element of the forest–steppe of Central Siberia]. *Samara Journal of Science, 7*(1), 15–19. DOI:10.17816/SANV25336–19863 [in Russian].

25 Goncharov, A.N., & Shherbatova, A.F. (2025). Geograficheskii analiz flory antropogenno naryshennykh gornolesnykh fitotsenozov Severo-Zapadnogo Kavkaza [Geographical analysis of flora of anthropogenically disturbed mountain forest

phytocenoses of the Northwestern Caucasus]. *Problemy botaniki Yuzhnyi Sibiri i Mongolii — Problems of botany of Southern Siberia and Mongolia*, *24*(1), 40–44. https://doi.org/10.14258/pbssm.2025009 [in Russian].

26 Makarova, Yu.V., Golovlev, A.A., & Proxorova, N.V. (2019). Materialy k ekologo–geograficheskomu analizu flory sosudistykh rastenii gory Kuznetsova [Materials for the ecological and geographical analysis of the vascular plant flora of Mount Kuznetsov]. *Samarskii nauchnyi vestnik — Samara scientific bulletin*, *8*(1), 59–65. DOI 10.24411/2309–4370–2019–11109 [in Russian].

27 Ebel, A.L. (2011). Flora severo-zapadnoi chasti Altae-Saianskoi provintsii: sostav, struktura, proiskhozhdenie, antropogennaia transformatsiia [Flora of the northwestern part of the Altae–Sayan province: composition, structure, origin, anthropogenic transformation]. *Extended abstract of Doctor's thesis* [in Russian].

28 Bondarenko, A.V. (2016). Vidovoe raznoobrazie bioresursov transgranichnoi biosfernoi territorii: Rossiia, Mongoliia, Kazakhstan, Kitai [Species diversity of bioresources of the transboundary biosphere territory: Russia, Mongolia, Kazakhstan, China]. *Ravitie territorii — Territory development*, 1(4), 114–118 [in Russian].

29 Ogureeva, G.N. (1980). *Botanicheskaia geografiia Altaia* [Botanical geography of Altaya]. Moscow: Nauka [in Russian].

Information about the authors

Vinokurov Andrey Andreevich — Altai Botanical Garden, State Enterprise on the Right of Economic Management, Kazakhstan, Ridder, Kazakhstan; e-mail: anvin64@mail.ru; Author ORCID ID: https://orcid.org/0000–0003–0154–8943

Anufrieva Olga Aleksandrovna — Altai Botanical Garden, State Enterprise on the Right of Economic Management, Kazakhstan, Ministry of National Economy and Higher Education, Ridder, Kazakhstan; e-mail: anufrievaolgaalex59@yandex.kz; Author ORCID ID: https://orcid.org/0000–0001–9675–7654