IRSTI 34.29.35; 34.35.51

Ye.A. Simanchuk[1]*, G.J. Sultangazina[1], A.N. Kuprijanov[2]

[1]A. Baitursynov Kostanay Regional University, Kostanay, Kazakhstan
[2]Kuzbass Botanical Garden, Federal Research Center of Coal and Coal Chemistry, SB RAS, Kemerovo, Russia
**Corresponding author: simyeandr.ksu@mail.ru*

Analysis of Group-Thicket Communities on Iron Ore Industry Dumps in Kostanay Region

Abstract. *Environmental anthropogenic transformation leads to technogenic landscapes emergence, characterized by complete or partial destruction of ecosystem components. Partial restoration of biodiversity is possible through reclamation and self-overgrowing. Formation of vegetation cover on technogenic landscapes – a process that takes place in three syngenesis stages. This article presents the results of studying the degree of self-overgrowing on iron ore industry dumps in the Kostanay region (SSGPO JSC and Kachary Ruda JSC) at the stage of a group-thicket community – the second stage of syngenesis. Sixty-three geobotanical descriptions were compiled, and group-thicket communities were found in twenty-six.*

A group-thicket community is usually formed by patients; certain relationships and mutual influence appear between plants, but they remain fragmentary, individuals are slightly interconnected trophically. The predominance of species with a wide ecological amplitude characterizes this stage.

It was found that the rate and patterns of vegetation cover formation at the second stage of syngenesis differ on saline and non-saline soils: the former are dominated by halophytes and long-rhizomatous plants, the latter are characterized by long-rhizomatous plants; moreover, the activity of species on the first soils is much higher than on the second ones, the number of species is approximately the same on both soil types.

Keywords: *group-thicket community, iron ore industry dumps, biodiversity, technogenic landscape, succession, syngenesis, dump flora, dump overgrowth*

Abbreviations: *CC – classes of constancy, CP – cenopopulation, GTC – a group-thicket community, LF – life form, PP - projective cover, TPC – total projective cover*.

DOI: 10.32523/2616-7034-2023-144-3-26-39

Introduction

Active development of human society is accompanied by the transformation of the natural environment. For the sake of own comfort, mankind extracts and processes colossal volumes of natural resources. And, naturally, in the course of these processes, partial or, more often, complete destruction of ecosystems occurs with the formation of technogenic landscapes. Complete restoration of disturbed soil and vegetation cover; lithological basis, hydrological regime to the original natural state is impossible [1-4].

Industrialization on a global scale has led to the replacement of some key landscape types by others: forests have been replaced by forest field and forest meadows; steppe and forest-steppe landscapes were replaced by field and agricultural landscapes [1, 2].

For (partial) restoration of the biodiversity of technogenic landscapes, reclamation is used, but when this is impossible for economic or other reasons, a wait-and-see policy is used, that is, conditions are created for self-restoration of vegetation and soil cover [4-7].

This article is a continuation of the description of the results of the study of the degree of natural overgrowing of dumps of the iron ore industry in the Kostanay region, the pioneer stage was previously described, in which the difference in the speed of syngenesis processes on saline and non-saline soils was noted.

The process of self-overgrowing of technogenic landscapes, which undoubtedly include dumps, takes place in three stages: pioneer grouping (low projective cover (PP) 10–15%, 13–25 species), group-thicket community (PP – more than 15%, 20-50 species) and complex phytocenosis (PP more than 30%, 20-50 species) [8].

The rate of syngenesis stages change depends on various factors. The ecological conditions of the dumps and the biological characteristics of the species determine the selectivity, which directly depends on the probability of introducing ovules from neighboring phytocenoses [9-11].

In this article, we analyze the GTC as a stage of syngenesis on the dumps of iron ore enterprises in the Kostanay region.

Materials and Methods

There are two large enterprises engaged in the extraction and processing of iron ore in the Kostanay region: SSGPO JSC (Sokolovsky, Sarbaisky deposits) and Kachary Ruda JSC (Kacharsky deposit). These deposits of magnetite ores are located in the northwestern part of Kazakhstan in the Turgai belt, which also extends into Russia. The Turgai deposits are associated with volcanic-sedimentary rocks of the Trans-Ural zone. These deposits, together with other satellite deposits and manifestations, form an extended magnetite-bearing belt extending in the NNE-SSW directions – the Turgai belt, which extends from the Sarbaisky deposit in the south to the Glubochensky deposit in the north [12, 13].

In the course of this study, the waste dumps of SSGPO JSC were studied: the South-East one of the Sokolovsky open pit, South-West - of the Sarbaisky and South-West - of the South-Sarbi area; as well as № 7 railway dump of Kachary Ruda JSC. These dumps are a place of accumulation of technogenic mineral formations, which are loose sandy-argillaceous overburden rocks of the platform cover; their initial raw materials are flasks, sands and clays [14-17].

The objects of study are located in the northwestern part of Kazakhstan – Kostanay region. Study period: spring-summer of 2022.

The territory of the facilities is under the influence of a sharply continental climate, which is characterized by a significant difference between day and night, as well as seasonal temperatures. The highest average temperature in the vicinity of the objects of study is +21˚C in July, the lowest average annual temperature is -15.4˚C in January [18].

The following types of soils are typical for the studied territories: ordinary and southern chernozems; dark and medium chestnut soils, complexes with solonetzes. According to the mechanical composition, these soils are classified as heavy loamy, clayey, or sandy loamy [18].

The route-expeditionary reconnaissance research method was used to study the flora of technogenic ecotopes. A total of 63 geobotanical descriptions were compiled. Floristic data were processed using the IBIS 7.2 program developed by A.A. Zverev [19]. Qualitative and quantitative accounting of plants was carried out in accordance with accepted methods: occurrence (%), total and partial projective cover (TPC, %) were noted [2, 11, 20].

Calculation of numerical data: herbage density (pcs/m2), number of species (pcs), occurrence (%), total and partial projective cover (%) – was carried out according to the previously indicated indicators. The occurrence rate made it possible to determine the classes of constancy (CC): a total of five CCs were determined, with a step of 20%: I – 20%; II – 40%; III – 60%; IV – 80%; V – 100% [11].

Results

Settlement of species from the composition of higher vascular plants on the surface of dumps begins in the first year after backfilling. The drift of ovules to dumps occurs mainly by wind from the surrounding territories, a much smaller role in this process belongs to animals and humans.

The distribution of ovules on the surface of dumps occurs randomly, while the germination and development of plants in certain ecotopes is a natural process that depends solely on their ecological stability of the plants themselves. In the course of succession, the development of plant communities is additionally influenced by interspecific competition, the role of which increases as the evolving cenosis develops its internal phytocenotic environment.

In this work, we studied cenopopulations at the stage of a group-thicket community (GTC) on dumps aged from 6 to 10 years (See Figure 1.). 26 geobotanical descriptions were made: 16 on saline soils (CP-27-42) and 10 on non-saline soils (CP 6-15) (see Table 1).

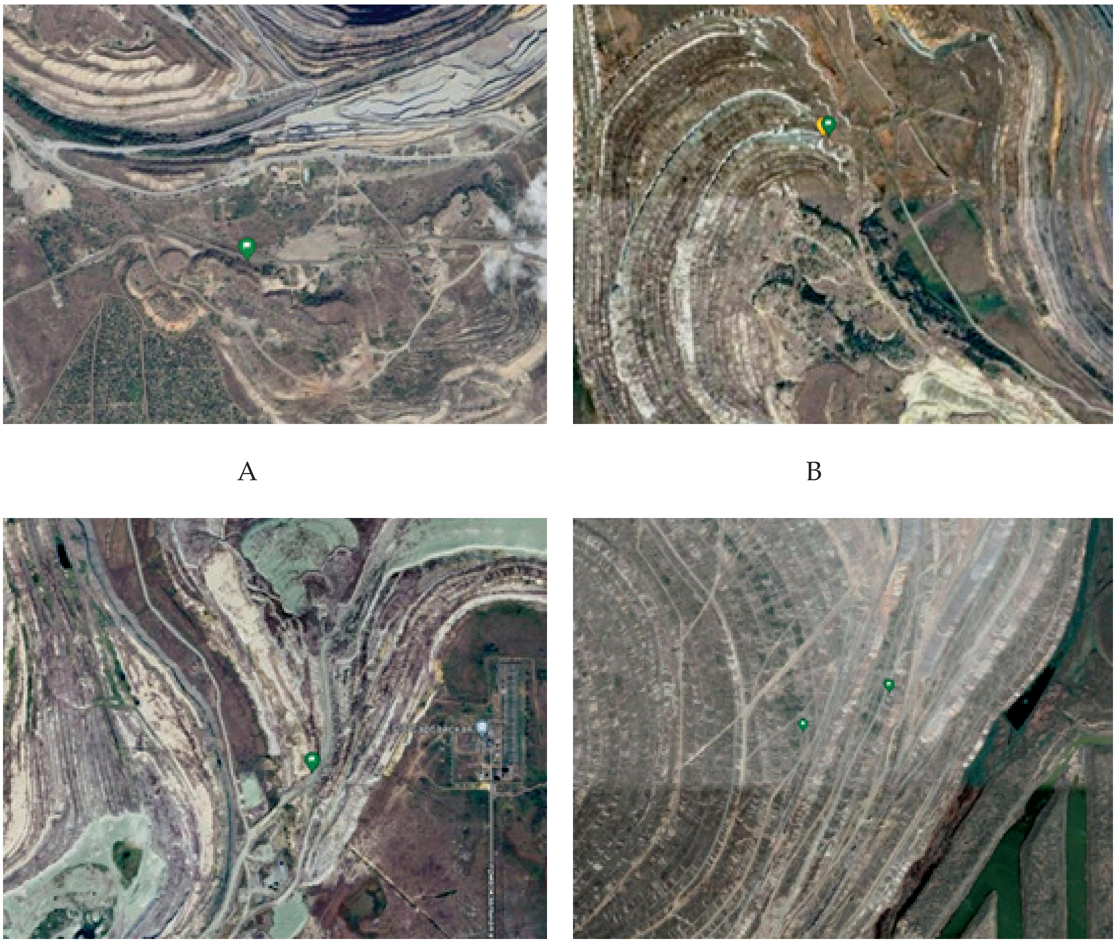

Figure 1. Location of the studied ecotopes of plants of the group-overgrown stage:
A - Soklovsky quarry; B, C – Sarbaisky quarry; D - Kacharsky quarry

In total, 65 species of plants were identified on the waste dumps of SSGPO JSC and Kachary Ruda JSC at the GTC stage: 41 species settled on saline soils, and 43 species settled on non-saline soils (See Tables 2, 3). Table 1 lists the dominants for each cenopopulation, the total projective cover, and the number of species.

It is also worth noting that, on average, the activity of species and the class of constancy are higher on soils with a lower salt content (CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}).

Table 1

Characteristics of cenopopulations of the GTC, May 18-19, 2022

CP No.	Dominants	TPC %	Species quantity
CP-6	*Artemisia austriaca, Artemisia dracunculus, Tanacetum vulgare*	20	21
CP-7	*Calamagrostis epigeios, Festuca valesiaca, Medicago sativa*	70	21
CP-8	*Artemisia austriaca, Medicago sativa, Calamagrostis epigeios*	30	11
CP-9	*Calamagrostis epigeios, Medicago sativa, Festuca valesiaca*	40	10
CP-10	*Calamagrostis epigeios, Artemisia dracunculus, Festuca valesiaca*	30	20
CP-11	*Calamagrostis epigeios, Artemisia dracunculus, Artemisia marschalliana*	40	11
CP-12	*Calamagrostis epigeios, Artemisia dracunculus, Medicago sativa*	30	11
CP-13	*Calamagrostis epigeios, Artemisia dracunculus, Achillea nobilis*	25	10
CP-14	*Achillea nobilis, Polygonum salsugineum*	20	5
CP-15	*Calamagrostis epigeios, Tanacetum vulgare*	20	5
CP-27	*Polygonum salsugineum, Calamagrostis epigeios*	20	5
CP-28	*Phragmites australis, Polygonum salsugineum*	70	3
CP-29	*Polygonum salsugineum*	3	1
CP-30	*Phleum phleoides, Agrostis gigantea*	40	5
CP-31	*Elaeagnus oxycarpa, Polygonum salsugineum*	30	7
CP-32	*Artemisia dracunculus, Cirsium setosum*	50	12
CP-33	*Artemisia dracunculus, Cirsium setosum, Polygonum salsugineum*	40	6
CP-34	*Artemisia dracunculus, Polygonum salsugineum, Taraxacum officinale*	70	11
CP-35	*Artemisia dracunculus, Polygonum salsugineum, Phragmites australis*	40	8
CP-36	*Artemisia dracunculus, Isatis costata, Polygonum salsugineum*	60	6
CP-37	*Artemisia dracunculus, Chenopodium album, Cirsium setosum*	70	10
CP-38	*Artemisia dracunculus, Calamagrostis epigeios, Polygonum salsugineum*	50	6
CP-39	*Artemisia dracunculus, Calamagrostis epigeios, Artemisia nitrosa*	70	13
CP-40	*Artemisia dracunculus, Calamagrostis epigeios, Gypsophila perfoliata*	70	12
CP-41	*Artemisia dracunculus, Calamagrostis epigeios, Chamaenerion angustifolium*	80	5
CP-42	*Artemisia dracunculus, Calamagrostis epigeios, Gypsophila perfoliata*	70	7

As can be seen from Table 2, on saline soils, *Polygonum salsugineum* and *Artemisia dracunculus* are common and have a high persistence class (IV) – the highest for GTC on the saline soils. *Gypsophila perfoliata* and *Calamagrostis epigeios* are found in constancy class III. The vast majority of species are rare and have class I constancy (See Figure 2 A).

Polygonum salsugineum (*"salsus" lat.* – salty) was found in 75% of the studied CPs on saline soils, *Artemisia dracunculus* in 68.8%, other species did not even reach 50% occurance (Table 2).

Table 2

Characteristics of communities of the group-thicket stage on saline soils

Plant species	V*	P	A	CC
Polygonum salsugineum (Ledeb.) Klok.	75	5.7	20.7	IV
Artemisia dracunculus L.	68.8	9.25	25.22	IV
Gypsophila perfoliata L.	43.8	0.5	4.68	III

Calamagrostis epigeios (L.) Roth	43.8	15.34	25.91	III
Chamaenerion angustifolium (L.) Scop.	37.5	0.19	2.67	II
Artemisia nitrosa Weber	31.3	0.31	3.13	II
Artemisia sieversiana Willd.	31.3	0.16	2.24	II
Lactuca tatarica (L.) C.A.Mey.	25	0.69	4.15	II
Carduus nutans L.	25	0.125	1.77	II
Isatis costata C.A.Mey.	25	0.125	1.77	II
Phragmites australis (Cav.) Trin. ex Steud.	25	4.44	10.54	II
Cirsium setosum (Willd.) Besser	18.8	0.84	3.97	I
Tragopogon orientalis L.	18.8	0.09	1.3	I
Taraxacum officinale F.H.Wigg.	18.8	0.09	1.3	I
Artemisia vulgaris L.	18.8	0.09	1.3	I
Gypsophila paniculata L.	18.8	0.09	1.3	I
Achillea millefolium L.	12.5	0.06	0.87	I
Convolvulus arvensis L.	12.5	0.22	1.66	I
Elaeagnus oxycarpa Schltdl.	12.5	0.06	0.87	I
Melilotus albus Medikus	12.5	0.06	0.87	I
Dracocephalum thymiflorum L.	12.5	0.06	0.87	I
Bromopsis inermis (Leyss.) Holub.	12.5	0.06	0.87	I
Acer negundo L.	6.3	0.03	0.43	I
Eryngium planum L.	6.3	0.03	0.43	I
Artemisia commutata Besser	6.3	0.03	0.43	I
Artemisia schrenkiana Ledeb.	6.3	0.03	0.43	I
Artemisia proceriformis Krasch.	6.3	0.03	0.43	I
Conyza canadensis (L.) Cronqist	6.3	0.03	0.43	I
Achillea nobilis L.	6.3	0.03	0.43	I
Artemisia marschalliana Spreng.	6.3	0.03	0.43	I
Senecio jacobaea L.	6.3	0.03	0.43	I
Chenopodium album L.	6.3	0.19	1.09	I
Limonium gmelinii (Willd.) Kuntze	6.3	0.03	0.43	I
Agrostis gigantea Roth	6.3	0.31	1.39	I
Phleum phleoides (L.) H.Karst.	6.3	0.19	1.09	I
Stipa lessingiana Trin. & Rupr.	6.3	0.03	0.43	I
Elytrigia repens (L.) Nevski	6.3	0.03	0.43	I
Festuca valesiaca Gaudin	6.3	0.03	0.43	I
Populus × sibirica G. Kryl. et Grig. ex A. Skvortsov	6.3	0.03	0.43	I
Populus tremula L.	6.3	0.03	0.43	I
Solanum kitagawae Schonb.-Tem.	6.3	0.03	0.43	I

Note: V – occurrence, %; P – partial projective cover, %; A – activity, score; CC - class of constancy

Table 3 illustrates interesting patterns of plant growth on non-saline soils: *Calamagrostis epigeios* and *Artemisia austriaca* have the highest V constancy class. Constancy class IV was noted in *Artemisia dracunculus, Achillea nobilis*, and *Medicago sativa* (see Figure 2 B).

Calamagrostis epigeios was found in 90% of the CP on non-saline soils. Interestingly, *Polygonum salsugineum*, which is common on highly saline soils, was not found in any of the CPs. While *Artemisia dracunculus* was also found in 70% of these CPs.

A B

Figure 2. GTC stage on iron ore industry dumps:
A – on saline soils
B – on non-saline soils

Table 3

Characteristics of communities of the group-thicket stage on non-saline soils

Plant species	V*	P	A	CC
Calamagrostis epigeios (L.) Roth	90	11.55	32.24	V
Artemisia austriaca Jacq.	80	2.95	15.36	V
Artemisia dracunculus L.	70	3.6	15.87	IV
Achillea nobilis L.	70	1.75	11.07	IV
Medicago sativa L.	70	2.25	12.55	IV
Artemisia marschalliana Spreng.	60	1.25	8.66	III
Hieracium virosum Pall.	50	0.25	3.54	III
Tanacetum vulgare L.	50	1.2	7.75	III
Achillea millefolium L.	50	0.25	3.54	III
Festuca valesiaca Gaudin	50	6.5	18.03	III
Poa angustifolia L.	50	1.9	9.75	III
Bromopsis inermis (Leyss.) Holub.	50	0.95	6.89	III
Centaurea scabiosa L.	40	0.2	2.83	II
Hieracium umbellatum L.	30	0.15	2.12	II
Artemisia commutata Besser	30	0.15	2.12	II
Taraxacum officinale F.H.Wigg.	30	0.15	2.12	II
Elaeagnus oxycarpa Schltdl.	30	0.15	2.12	II
Dracocephalum thymiflorum L.	30	0.15	2.12	II
Chamaenerion angustifolium (L.) Scop.	30	0.65	4.42	II
Stipa pennata L.	30	1.55	6.82	II
Malus domestica Borkh.	30	0.15	2.12	II
Linaria genistifolia (L.) Mill.	30	0.15	2.12	II
Artemisia proceriformis Krasch.	20	0.1	1.41	I
Lonicera tatarica L.	20	0.1	1.41	I

Gypsophila paniculata L.	20	0.35	2.65	I
Acer negundo L.	10	0.05	0.71	I
Lactuca serriola L.	10	0.05	0.71	I
Trommsdorffia maculata (L.) Bernh.	10	0.05	0.71	I
Cirsium setosum (Willd.) Besser	10	0.05	0.71	I
Artemisia vulgaris L.	10	0.1	1	I
Betula pendula Roth	10	0.05	0.71	I
Lappula stricta (Ledeb.) Guerke	10	0.05	0.71	I
Nonea pulla DC.	10	0.05	0.71	I
Medicago falcata L.	10	0.05	0.71	I
Trigonella arcuate C.A.Mey.	10	0.05	0.71	I
Trifolium pratense L.	10	0.05	0.71	I
Poa palustris L.	10	0.1	1	I
Poa urssulensis Trin.	10	0.05	0.71	I
Polygonum bordzilowskii Klokov	10	0.05	0.71	I
Potentilla argentea L.	10	0.05	0.71	I
Populus × sibirica G. Kryl. et Grig. ex A. Skvortsov	10	0.05	0.71	I
Populus tremula L.	10	0.05	0.71	I
Ulmus pumila L.	10	0.05	0.71	I

Note: V – occurrence, %; P – partial projective cover, %; A – activity, score; CC - class of constancy

Discussion

Table 4 shows the taxonomic structure of the general floristic list of communities of the GTC stage on the dumps of SSGPO JSC and Kachary Ruda JSC. The total number of families represented in these communities on saline and non-saline dumps is 22. The most numerous in terms of the number of species and genera are *Asteraceae* (13 genera, 25 species), then *Poaceae* (9 genera, 12 species), *Fabaceae* (4 genera, 5 species). The top ten most representative families of the dump flora include 54 species, or 82%.

The most multi-species genus is *Artemisia*: 19% of all species on saline soils, 14% – on non-saline soils. In total, there were 20 species found both on saline and non-saline soils.

Table 4

Taxonomic structure of communities of the group-thicket stage of dumps

Taxonomic indicators	Values
Total number of species	65
Total number of genera	48
Total number of families	22
Number of single-species genera	39
Number of single-species families	14
Number of homogeneous families	16
Share of species in 5 leading families, %	69
Share of species in 10 leading families, %	82

The dominance of the families *Asteraceae, Poaceae,* and *Fabaceae*, noted by us in the communities of the group-thicket stage of dumps, is characteristic of the taxonomic structure of the region as a whole [21–24].

The degree and rate of overgrowth of the dumps of the iron ore industry in the Kostanay region has been of interest since the 1970s. So, Terekhova E.B. et al. in 1974 note that in the seventh year after dumping, the syngenesis stage changes from the pioneer stage to the GTC, with a significant increase in the number of species up to 31. *Polygonum aviculare* L., *Artemisia marschalliana* Spreng., *Berteroa incana* (L.) DC., *Axyris amaranthoides* L. were dominant. The authors noted the increased importance of the *Fabaceae* family compared to the pioneer stage (*Genista tinctoria* L., *Medicago cancellata* M. Bieb., *M. Falcata* L., *Vicia cracca* L., *Melilotus albius* Medik., *M. officinalis* (L.) Lam.). Artemisia and legumes acted as dominants and co-dominants in those communities. There were also cereals *Agropyron sibiricum* (*Agropyron fragile* (Roth) P. Candargy), *A. pruiniferum* (*Elytrigia pruinifera* Nevski), *Poa angustifolia* L., *Festuca sulcate* (*Festuca valesiaca* Gaudin) [25].

In a later study by Konysbayeva D.T. 2003, 65 species are described at the GTC stage. The projective cover was 30-50%. Dominant families: *Asteraceae* (13 species), *Poaceae* (10), *Fabaceae* (8 species). There was also a large distribution of *Polygonum aviculare, Artemisia marschalliana, A. dracunculus, Berteroa incana, Melilotus albius, M. officinalis* [9].

We also conducted an analysis on the representation of geographical groups in the ecological and coenotic spectrum of the flora of dumps at the GTC stage. In the flora of the dumps, we identified 5 ecological-coenotic groups: meadow, forest, steppe, coastal-aquatic, and weedy [11].

Differences in the distribution of plant groups on saline and non-saline soils were found, which is not surprising and has already been repeatedly confirmed for other indicators in our study. The first soils at the GTC stage are mostly populated by weedy and steppe species, while the second soils are inhabited by meadow and steppe species. Coastal-aquatic and forest plants are the least numerous (see Figure 3).

The pan-Eurasian fraction of geographic elements plays a leading role in the composition of all ecological-coenotic groups on dumps (13, 18). Further on saline soils, in order, are Mediterranean-Asian (6), Cosmopolitan (6), East European-Asian (5); on non-saline soils, Holarctic (7) and Cosmopolitan (5).

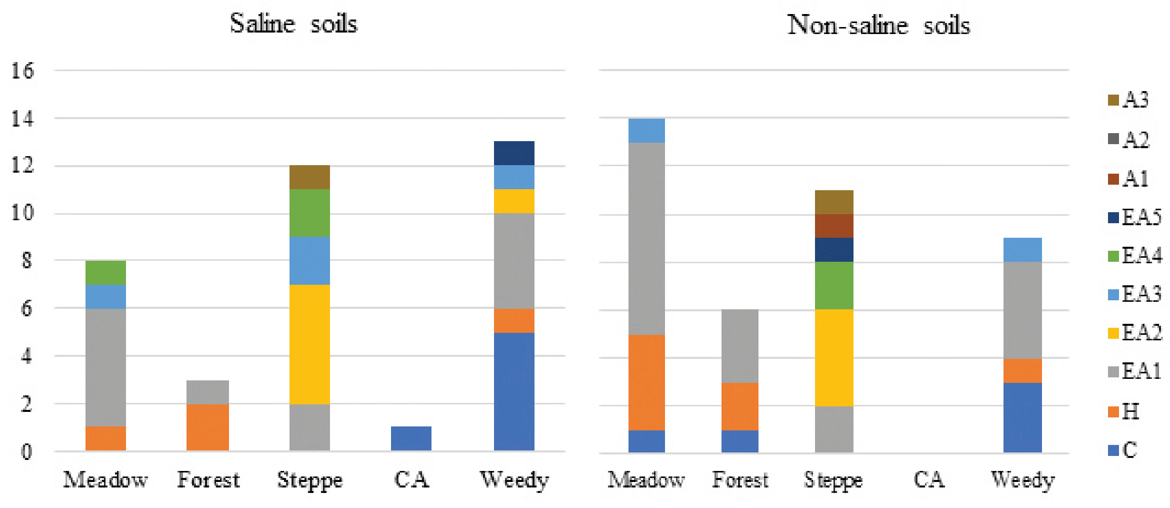

Figure 3. Characteristics of the flora on different soils

Note: geographical groups: C – Cosmopolitan, H – Holarctic, EA1 – Pan-Eurasian, EA2 – Mediterranean-Asian, EA3 – East European-Asian, EA4 – European-North Asian, EA5 – Eurosiberian, A1 – Asiatic, A2 – Central Asian, A3 – Siberian. CA – coastal aquatic plants

An analysis of life forms makes it possible to assess the characteristics of the flora from an ecological standpoint, to find correlative relationships between LF and confinement to a certain type of communities (habitats). At the second stage of syngenesis on the dumps we studied, the predominant life forms are: for saline soils – taproot (10), long-rhizomatous (9), annuals (5), and biennials (5); non-saline – taproot (11), short-rhizomatous (10), and long-rhizomatous (6).

As can be seen from Figure 4, plants with a tap root system or long rhizomes are the most common for this stage of GTC in terms of the number of species. However, it was previously noted that the highest class of constancy is characteristic of long-rhizomatous plants under these conditions.

On saline soils, steppe floras are dominated by taproot (50%) and turf (25%) species; in weedy – herbaceous annuals (31%) and long-rhizomatous plants (23%); in meadows – long-rhizomatous (38%); in the forest – trees (67%); coastal water – long-rhizomatous (100%).

On non-saline soils, steppe floras are more populated by taproot (40%) and turf (30%) species; in weedy – taproot (50%); in meadow – short-rhizomatous (57%) and long-rhizomatous (29%); in the forest – trees (50%).

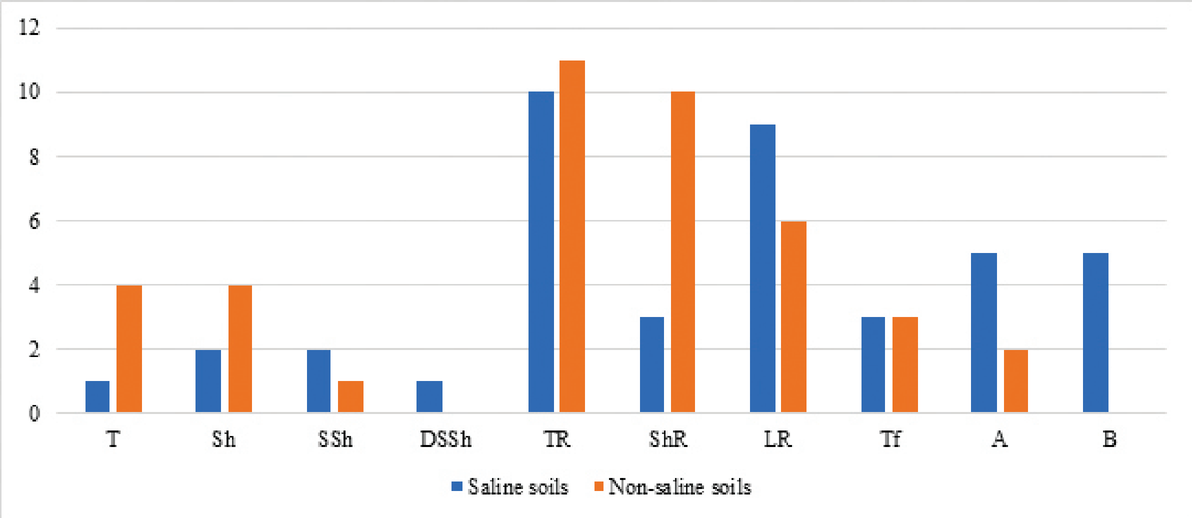

Figure 4. Characteristics of life forms of plants growing at the stage of GTC

Note: life form according to the classification of I.G. Serebryakov (1962): T - trees, Sh - shrubs, SSh - semishrubs, DSSh – dwarfs semishrubs, TR - taproot, ShR – short-rhizomatous, LR – long-rhizomatous, Tf – turf, A - annuals, B - biennials

The study of syngenesis on anthropogenically disturbed lands will make it possible to determine the directions of effective and economically beneficial reclamation for enterprises and society. In the studied territories, species with the most successful survival strategies in the conditions of technogenic landscapes of the former steppe and forest-steppe were identified, which can be used in the future to recreate ecosystems close to natural ones.

We strongly believe that restoration of biodiversity, even partial, will not only preserve the remaining bits of the former diversity of ecosystems, but will also allow the use of these lands for socially significant purposes in the future. We also consider it important to note that a Red Book species, *Stipa pennata*, was found on the dumps, which only confirms our point of view [26].

Conclusion

As a result of studying the patterns of natural overgrowing of dumps of mining enterprises in Kostanay region – SSGPO JSC and Kachary Ruda JSC, on the second stage of syngenesis established:

1) Halophytes (eg. *Polygonum salsugineum, Gypsophila perfoliata)* and long-rhizomatous plants (e.g. *Calamagrostis epigeios, Artemisia dracunculus*) dominate on saline soils at the stage of group-thicket communities. Long-rhizomatous plants (e.g. *Calamagrostis epigeios, Artemisia austriaca, Artemisia dracunculus*) have the highest class of constancy on non-saline soils.

2) Total projective cover on saline and non-saline soils of dumps is approximately the same and amounts to 33-37%.

3) Number of species is approximately the same on both types of soil – 12.5-14.0 pcs/100m^2. Compared to the pioneer group studied earlier, the number of species on saline soils significantly has increased both on saline – 41 and on non-saline soils – 43. Most species have CC I.

4) The activity of species in GTC on non-saline soils is much higher than those on saline soils.

5) The representation of geographical groups in the ecological-coenotic spectrum of the flora and life forms distribution of dumps differs depending on the degree of soil salinity.

In the future, it is planned to describe the results of studying the stage of a complex phytocenosis at the previously mentioned objects, as well as to continue work on the territory of the dumps in 2023 and beyond: compiling geobotanical descriptions in the same coordinates to compare the results, herbarization of previously unidentified species.

Acknowledgments. The authors express their gratitude to the management and staff of the Department for Ecology and Subsoil Use of SSGPO JSC and Kachary Ruda JSC for their assistance in conducting this study.

Special thanks are expressed to the staff of the Kuzbass Botanical Garden and the Institute of Human Ecology of the Federal Research Center for Coal and Coal Chemistry of the Siberian Branch of the Russian Academy of Sciences.

References

1. Brand U., Wissen M., Danso-Dahmen L., King Z. M., Jungwirth B. The Imperial Mode of Living: Everyday Life and the Ecological Crisis of Capitalism. – New York: Verso Books, 2021. – 256 p.

2. Куприянов А.Н., Морсакова Ю.В. Естественное зарастание отвалов Кузбасса // Вестник Кузбасского государственного университета. – 2006. – Т. 3. – С. 48-52.

3. Feng Y., Wang J., Bai Zh., Reading L. Effects of surface coal mining and land reclamation on soil properties: A review // Earth-Science Reviews. – 2019. – Vol. 191. – P. 12-25. DOI: https://doi.org/10.1016/j.earscirev.2019.02.015.

4. Koščová M., Hellmer M., Anyona S., Gvozdkova T. Geo-Environmental Problems of Open Pit Mining: Classification and Solutions. [Electronic resouce] – URL: https://doi.org/10.1051/e3sconf/20184101034 (Accessed: 01.02.2023).

5. Yu Feng, Jinman Wang, Zhongke Bai, Lucy Reading, Effects of surface coal mining and land reclamation on soil properties: A review, Earth-Science Reviews. – 2019. – Vol. 191. – P. 12-25. DOI: https://doi.org/10.1016/j.earscirev.2019.02.015.

6. Peco J.D., Higueras P., Campos J.A., Esbrí J.M., Moreno M.M., Battaglia-Brunet F., Sandalio L.M. Abandoned Mine Lands Reclamation by Plant Remediation Technologies. Sustainability. – 2021. – Vol. 13. – P. 6555. DOI: https://doi.org/10.3390/su13126555.

7. Pratiwi Narendra B.H., Siregar C.A., Turjaman M., Hidayat A., Rachmat H.H., Mulyanto B., Suwardi, Iskandar, Maharani R., Rayadin Y., Prayudyaningsih R., Yuwati T.W., Prematuri R., Susilowati A. Managing and Reforesting Degraded Post-Mining Landscape in Indonesia: A Review. Land. – 2021. – Vol. 10. – P. 658. DOI: https://doi.org/10.3390/land10060658.

8. Федотов В.И. Методические основы и методика изучения техногенных ландшафтов. – Москва, 1978. – 53-64 с.

9. Конысбаева Д.Т. Формирование растительного покрова на отвалах предприятий железорудной промышленности в Северном Казахстане: дис. ... канд. биол. наук: 03.00.05. – Екатеринбург, 2003. – 145 с.

10. Куприянов А.Н. Биологическая рекультивация отвалов в субаридной зоне. – Алма-Ата, 1989. – 104 с.

11. Манаков Ю.А., Стрельникова Т.О., Куприянов А.Н. Формирование растительного покрова в техногенных ландшафтах Кузбасса. – Новосибирск: СО РАН, 2011. – 180 с.

12. Hawkins T., Smith M.P., Herrington R.J., Maslennikov V., Boyce A.J., Jeffries T., Creaser R.A. The Geology and Genesis of The Iron Skarns of The Turgai Belt, Northwestern Kazakhstan // Ore Geology Reviews. – 2017. – Vol. 85. – P. 216-246. DOI: https://doi.org/10.1016/j.oregeorev.2015.10.016.

13. Herrington R., Smith M., Maslennikov V., Belogub E., Armstrong R. A Short Review of Palaezoic Hydrothermal Magnetite Iron-Oxide Deposits of The South and Central Urals and Their Geological Settings // Hydrothermal Iron Oxide Copper-Gold & Related deposits A global perspective. – 2002. – Vol. 2. – P. 343-353.

14. Паспорт «О» Техногенные минеральные образования №3/1057. Объект учета Юго-Западный отвал Сарбайского участка. – Рудный: АО «ССГПО», 2022. – 9 с.

15. Паспорт «О» Техногенные минеральные образования №3/1058. Объект учета Юго-Западный отвал Южно-Сарбайского участка. – Рудный: АО «ССГПО», 2022. – 10 с.

16. Паспорт «О» Техногенные минеральные образования №3/1068. Объект учета Юго-Восточный отвал Соколовского месторождения. – Рудный: АО «ССГПО», 2022. – 10 с.

17. Геологические и горнотехнические условия, отрабатываемых на автомобильный транспорт карьера Качарского РУ. – Качары: АО «Качары руда», 2022. – 10 с.

18. Байшоланов С.С. Агроклиматические ресурсы Костанайской области: научно-прикладной справочник. – Астана, 2017. – 139 с.

19. Зверев А.А. Информационные технологии в исследованиях растительного: учеб. пособие. – Томск: TML-Press, 2007. – 304 с.

20. Работонов Т.А. Фитоценология: учебник. – Москва: МГУ, 1992. – 356 с.

21. Пережогин Ю.В. Ботанико-географическое районирование и состав флоры Костанайской области (Северный Казахстан) // Вестник ОГУ. – 2008. – Т. 80. – С. 121-125.

22. Брагина Т.М., Борисова Е.С. Анализ лекарственной флоры памятника природы «Насаждения березовых и сосновых лесов у озера Боровское» // Вестник КГПИ. – 2021. – Т. 3(63). – С. 62-67.

23. Нурмухамбетова Р.Т. Флора и растительность долины реки Тобол: В пределах Костанайской области: автореф. дис ... канд. биол. наук. – Екатеринбург: РАН, 1999. – 21 с.

24. Кобланова С.А., Рогожкина Ю.О. Эколого-таксономический анализ прибрежной флоры Аулиекольского района (Костанайская область) // Вестник КарГУ Серия Биология. Медицина. География. – 2020. – Т. 3(99). – С. 83-90. DOI: https://doi.org/10.31489/2020BMG3/83-90.

25. Терехова Э.Б., Ланина Р.И., Фоменко Л.В. Естественное зарастание отвалов Соколовского железорудного карьера. МВ и ССО РСФСР, Уральский государственный университет имени А.М. Горького. – Свердловск: УрГУ, 1974. – 162-174 с.

26. Красная книга Республики Казахстан. Подлежащие охране сосудистые растения, мхи, печёночники, антоцеротовые и лишайники (374). [Electronic resouce] – URL: https://www.plantarium.ru/page/redbook/id/42.html (Accessed: 01.02.2023).

Е.А. Симанчук[1], Г.Ж. Сұлтанғазина[1], А.Н. Куприянов[2]

[1]А. Байтұрсынов атындағы Қостанай өңірлік университеті, Қостанай, Қазақстан

[2]Кузбас ботаникалық бағы, РҒА СБ көмір және көмір химиясы Федеральді зерттеу орталығы, Кемерово, Ресей

Қостанай облысының темір рудасы кәсіпорындарының топтасып өскен өсімдіктер жиынтықтарды талдау

Аңдатпа. Қоршаған ортаның антропогендік трансформациясы экожүйелердің барлық компоненттерінің толық немесе ішінара жойылуымен сипатталатын техногендік ландшафттардың пайда болуына әкеледі. Бұл аумақтардың биоәртүрлілігін ішінара қайта құру қалпына келтіру

ISSN(Print) 2616-7034 eISSN 2663-130X

және өздігінен өсу арқылы мүмкін болады. Техногендік ландшафттарда өсімдік жамылғысының өздігінен пайда болуы – сингенездің үш сатысында жүретін процесс. Бұл мақалада Қостанай облысының темір рудасы кәсіпорындарының («ССКӨБ» АҚ және «Қашары руда» АҚ) топтасып өскен өсімдіктер жиынтығы сатысында – сингенездің екінші сатысында өздігінен өсу дәрежесін зерттеу нәтижелері келтірілген. Біздің зерттеуімізде барлығы алпыс үш геоботаникалық сипаттама жасалды, бізді қызықтыратын топтасып өскен өсімдіктер жиынтықтар жиырма алтыда көрсетілген.

Топтасып өскен өсімшілер жиынтығы, әдетте, патиенттермен қалыптасады, өсімдіктер арасында белгілі бір қатынастар, өзара әсер пайда болады, бірақ сипаты фрагментті болып қалады, даралар бір-бірімен трофикалық байланыстармен шамалы байланысты. Бұл кезең кең экологиялық амплитудасы бар түрлердің басым болуымен сипатталады.

Сипатталған зерттеу барысында өсімдік жамылғысының пайда болу жылдамдығы мен заңдылықтары, соның ішінде сингенездің екінші сатысында, тұзданған және тұзданбаған топырақтарда ерекшеленетіні анықталды: біріншісінде галофиттер мен ұзын тамырлы өсімдіктер басым, екіншісіне ұзын тамырлы өсімдіктер тән; және алғашқы топырақтардағы өсімдіктер қауымдастығындағы түрлердің белсенділігі едәуір жоғары, екіншісіне қарағанда, ал түрлердің саны топырақтың екі түрінде де шамамен бірдей.

Түйін сөздер: топтасып өскен өсімдіктер жиынтығы, темір рудасының үйінділері, биоәртүрлілік, техногендік ландшафт, сукцессия, сингенез, үйінділердің флорасы, үйінділердің өздігінен өсуі.

Е.А. Симанчук[1], Г.Ж. Султангазина[1], А.Н. Куприянов[2]

[1]Костанайский региональный университет имени А. Байтурсынова, Костанай, Казахстан

[2] Кузбасский ботанический сад, Федеральный исследовательский центр угля и углехимии СО РАН, Кемерово, Россия

Анализ группово-зарослевых сообществ на отвалах железорудных предприятий Костанайской области

Аннотация. Антропогенная трансформация окружающей среды приводит к появлению техногенных ландшафтов, характеризующихся полным или частичным уничтожением всех компонентов экосистем. Частичное восстановление биоразнообразия данных территорий возможно путем рекультивации и самозарастания. Самопроизвольное формирование растительного покрова на техногенных ландшафтах – это процесс, проходящий в три стадии сингенеза. В данной статье представлены результаты изучения степени самозарастания отвалов железорудной промышленности Костанайской области (АО «ССГПО» и АО «Качары руда») на стадии группово-зарослевого сообщества – второй стадии сингенеза. Всего в ходе нашего исследования было составлено шестьдесят три геоботанических описания, причем интересующие нас группово-зарослевые сообщества отражены в двадцати шести из них.

Группово-зарослевое сообщество обычно формируется патиентами, между растениями появляются определенные взаимоотношения и взаимовлияние, но они остаются фрагментарными, разные особи в малой степени связаны между собой трофическими связями. Для данного этапа характерно преобладание видов с широкой экологической амплитудой.

В ходе описываемого исследования было установлено, что скорость и паттерны формирования растительного покрова, в том числе и на второй стадии сингенеза, отличаются на засоленных и незасоленных грунтах: на первых доминируют галофиты и длинно-корневищные растения, для вторых характерны длинно-корневищные растения; причем активность видов в растительных сообществах на первых грунтах значительно выше, чем на вторых, а количество видов примерно одинаково на обоих типах грунтов.

Ключевые слова*:* группово-зарослевое сообщество, отвалы железорудной промышленности, биоразнообразие, техногенный ландшафт, сукцессия, сингенез, отвальная флора, самозарастание отвалов.

References

1. Brand U., Wissen M., Danso-Dahmen L., King Z. M., Jungwirth B. The Imperial Mode of Living: Everyday Life and the Ecological Crisis of Capitalism (New York: Verso Books, 2021, 256 p.).

2. Kupriyanov A.N., Morsakova YU.V. Estestvennoe zarastanie otvalov Kuzbassa, Vestnik Kuzbasskogo gosudarstvennogo universiteta [Natural overgrowing of dumps of Kuzbass, Bulletin of the Kuzbass State University], 3, 48-52 (2006). [in Russian]

3. Feng Y., Wang J., Bai Zh., Reading L. Effects of surface coal mining and land reclamation on soil properties: A review, Earth-Science Reviews, 191, 2-25 (2019). DOI: https://doi.org/10.1016/j.earscirev.2019.02.015.

4. Koščová M., Hellmer M., Anyona S., Gvozdkova T. Geo-Environmental Problems of Open Pit Mining: Classification and Solutions. [Electronic resouce] – Accessed: https://doi.org/10.1051/e3sconf/20184101034 (Accessed: 01.02.2023).

5. Yu Feng, Jinman Wang, Zhongke Bai, Lucy Reading, Effects of surface coal mining and land reclamation on soil properties: A review, Earth-Science Reviews, 191, 12-25 (2019). DOI: https://doi.org/10.1016/j.earscirev.2019.02.015.

6. Peco J.D., Higueras P., Campos J.A., Esbrí J.M., Moreno M.M., Battaglia-Brunet F., Sandalio L.M. Abandoned Mine Lands Reclamation by Plant Remediation Technologies. Sustainability, 13, 6555 (2021). DOI: https://doi.org/10.3390/su13126555.

7. Pratiwi Narendra B.H., Siregar C.A., Turjaman M., Hidayat A., Rachmat H.H., Mulyanto B., Suwardi, Iskandar, Maharani R., Rayadin Y., Prayudyaningsih R., Yuwati T.W., Prematuri R., Susilowati A. Managing and Reforesting Degraded Post-Mining Landscape in Indonesia: A Review. Land., 10, 658 (2021). DOI: https://doi.org/10.3390/land10060658.

8. Fedotov V.I. Metodicheskie osnovy i metodika izucheniya tekhnogennyh landshaftov [Methodological bases and methodology for studying technogenic landscapes] (Moskva, 1978, 53-64 s.) [Moscow, 1978, 53-64 p.]. [in Russian]

9. Konysbaeva D.T. Formirovanie rastitel’nogo pokrova na otvalah predpriyatij zhelezorudnoj promyshlennosti v Severnom Kazahstane: dis. ... kand. biol. nauk: 03.00.05. [Formation of vegetation cover on the dumps of iron ore enterprises in Northern Kazakhstan: dis. ... cand. biol. Sciences: 03.00.05.] (Ekaterinburg, 2003, 145 s.) [Yekaterinburg, 2003,145 p.]. [in Russian]

10. Kupriyanov A.N. Biologicheskaya rekul’tivaciya otvalov v subaridnoj zone [Biological reclamation of dumps in the subarid zone] (Alma-Ata, 1989, 104 s.). [in Russian]

11. Manakov YU.A., Strel’nikova T.O., Kupriyanov A.N. Formirovanie rastitel’nogo pokrova v tekhnogennyh landshaftah Kuzbassa [Formation of vegetation cover in technogenic landscapes of Kuzbass] (Novosibirsk: SO RAN, 2011, 180 s.). [in Russian]

12. Hawkins T., Smith M.P., Herrington R.J., Maslennikov V., Boyce A.J., Jeffries T., Creaser R.A. The Geology and Genesis of The Iron Skarns of The Turgai Belt, Northwestern Kazakhstan, Ore Geology Reviews, 85, 216-246 (2017). DOI: https://doi.org/10.1016/j.oregeorev.2015.10.016.

13. Herrington R., Smith M., Maslennikov V., Belogub E., Armstrong R. A Short Review of Palaezoic Hydrothermal Magnetite Iron-Oxide Deposits of The South and Central Urals and Their Geological Settings, Hydrothermal Iron Oxide Copper-Gold & Related deposits A global perspective, 2, 343-353 (2002).

14. Pasport «O» Tekhnogennye mineral’nye obrazovaniya №3/1057. Ob”ekt ucheta YUgo-Zapadnyj otval Sarbajskogo uchastka [Passport “O” Technogenic mineral formations No. 3/1057. The object of accounting is the South-Western dump of the Sarbaisky site], (Rudnyj: AO «SSGPO», 2022, 9 s.) [Rudny: JSC “SSGPO”, 2022, 9 p.]. [in Russian]

15. Pasport «O» Tekhnogennye mineral’nye obrazovaniya №3/1058. Ob”ekt ucheta YUgo-Zapadnyj otval YUzhno-Sarbajskogo uchastka [Passport “O” Technogenic mineral formations No. 3/1058. Accounting object Yugo-Zapadny dump of the Yuzhno-Sarbaisky area] (Rudnyj: AO «SSGPO», 2022, 10 s.) [Rudny: JSC “SSGPO”, 2022,10 p.]. [in Russian]

16. Pasport «O» Tekhnogennye mineral’nye obrazovaniya №3/1068. Ob”ekt ucheta YUgo-Vostochnyj otval Sokolovskogo mestorozhdeniya [Passport “O” Technogenic mineral formations No. 3/1068. Accounting object South-Eastern dump of the Sokolovskoye field], (Rudnyj: AO «SSGPO», 2022, 10 s.) [Rudny: JSC “SSGPO”, 2022, 10 p.]. [in Russian]

17. Geologicheskie i gornotekhnicheskie usloviya, otrabatyvaemyh na avtomobil’nyj transport kar’era Kacharskogo RU [Geological and mining conditions, worked out for road transport in the quarry of Kacharsky RU] (Kachary: AO «Kachary ruda», 2022, 10 s.) [Kachary: JSC “Kachary Ruda”, 2022, 10 p.]. [in Russian]

18. Bajsholanov S.S. Agroklimaticheskie resursy Kostanajskoj oblasti: nauchno-prikladnoj spravochnik [Agro-climatic resources of Kostanay region: scientific and applied reference book] (Astana, 2017, 139 s.). [in Russian]

19. Zverev A.A. Informacionnye tekhnologii v issledovaniyah rastitel'nogo: ucheb. Posobie [Information technology in vegetable research: textbook. allowance] (Tomsk: TML-Press, 2007, 304 s.). [in Russian]

20. Rabotonov T.A. Fitocenologiya: uchebnik [Phytocenology: textbook] (Moskva: MGU, 1992, 356 s.) [Moscow: MGU, 1992, 356 p.]. [in Russian]

21. Perezhogin YU.V. Botaniko-geograficheskoe rajonirovanie i sostav flory Kostanajskoj oblasti (Severnyj Kazahstan), Vestnik OGU [Botanical-geographical zoning and composition of the flora of the Kostanay region (Northern Kazakhstan), Bulletin of the OSU], 80, 121-125 (2008). [in Russian]

22. Bragina T.M., Borisova E.S. Analiz lekarstvennoj flory pamyatnika prirody «Nasazhdeniya berezovyh i sosnovyh lesov u ozera Borovskoe», Vestnik KGPI [Analysis of the medicinal flora of the natural monument "Plantations of birch and pine forests near Lake Borovskoye", Bulletin of KSPI], 3(63), 62-67 (2021). [in Russian]

23. Nurmuhambetova R.T. Flora i rastitel'nost' doliny reki Tobol: V predelah Kostanajskoj oblasti: avtoref. dis ... kand. biol. nauk [Flora and vegetation of the Tobol river valley: Within the Kostanay region: author. dis ... cand. biol. sciences] (Ekaterinburg: RAN, 1999, 21 s.) [Yekaterinburg: RAN, 1999. - 21 p.]. [in Russian]

24. Koblanova S.A., Rogozhkina YU.O. Ekologo-taksonomicheskij analiz pribrezhnoj flory Auliekol'skogo rajona (Kostanajskaya oblast'), Vestnik KarGU Seriya Biologiya. Medicina. Geografiya [Ecological and taxonomic analysis of the coastal flora of the Auliekolsky district (Kostanay region), Bulletin of the KarSU Series Biology. Medicine. Geography], 3(99), 83-90 (2020). DOI: https://doi.org/10.31489/2020BMG3/83-90. [in Russian]

25. Terekhova E.B., Lanina R.I., Fomenko L.V. Estestvennoe zarastanie otvalov Sokolovskogo zhelezorudnogo kar'era. MV i SSO RSFSR, Ural'skij gosudarstvennyj universitet imeni A.M. Gor'kogo [Natural overgrowing of dumps of the Sokolovsky iron ore quarry. MV and SSO RSFSR, Ural State University named after A.M. Gorky] (Sverdlovsk: UrGU, 1974, 162-174 s.). [in Russian]

26. Krasnaya kniga Respubliki Kazahstan. Podlezhashchie ohrane sosudistye rasteniya, mhi, pechyonochniki, antocerotovye i lishajniki (374) [Red Book of the Republic of Kazakhstan. Protected vascular plants, mosses, liverworts, anthocerotes and lichens (374)]. [Electronic resouce] – Available at: https://www.plantarium.ru/page/redbook/id/42.html (Accessed: 01.02.2023). [in Russian]

Information about authors:

Simanchuk Ye.A. – Master of Natural Sciences, A. Baitursynov Kostanay Regional University, Abai ave. 10, Kostanay, Kazakhstan.

Sultangazina G.J. – Candidate of Biological Sciences A. Baitursynov Kostanay Regional University, Abai ave. 10, Kostanay, Kazakhstan.

Kuprijanov A.N. – Doctor of Biological Sciences, professor of Kuzbass Botanical Garden Federal Research Center of Coal and Coal Chemistry SB RAS, 10 Leningradsky Av., Kemerovo, 650065, Russia.

Симанчук Е.А. – жаратылыстану ғылымдарының магистрі, А. Байтұрсынов атындағы Қостанай өңірлік университеті, Абай даңғылы, 28, Қостанай, Қазақстан.

Сұлтанғазина Г.Ж. **–** биология ғылымдарының кандидаты**,** А. Байтұрсынов атындағы Қостанай өңірлік университеті, Абай даңғылы, 28, Қостанай, Қазақстан.

Куприянов А.Н. **–** биология ғылымдарының докторы, Кузбас ботаникалық бағы, РҒА СБ көмір және көмір химиясы Федеральді зерттеу орталығы, Ленинград даңғылы, 10, Кемерово, Ресей.