Floristic features of the Kostanay iron ore dump flora

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Abstract. This study investigates the floristic composition of the plant community established on the Kostanay iron ore dump, a man-made habitat resulting from long-term industrial activity. We aim to identify plant species that have successfully colonized this edaphically and chemically stressful environment and analyze their adaptations to the specific conditions. A comprehensive vegetation survey across three iron ore deposits (Sokolovo, Sarbai, and Kachar) dump sites documented a total of 284 plant species. This flora encompasses representatives from 163 genera distributed among 44 families. Notably, the iron ore dump flora exhibits a 37.6% degree of synanthropization, indicative of moderate anthropogenic transformation. This level of transformation is characterized by the dominance of synanthropic species adapted to thrive in human-disturbed habitats, potentially including species capable of tolerating elevated levels of salts, metals and other contaminants.

1 Introduction

Intensive mining operations in Kazakhstan have led to the formation of extensive technogenic landscapes, placing a significant strain on the land. According to the land cadastre data as of November 1, 2022, the area of disturbed land in Kazakhstan is 244.8 thousand hectares. These territories are occupied by dumps of overburden and mined rocks, tailings storage facilities, ash dumps, quarries, etc. The problem of land degradation is most acute in the Mangystau, Kostanay, and Karaganda regions [1].

The study of phytocenoses in technogenic environments is a relevant area of modern botany with practical applications for solving environmental problems. The impact of technogenic environments on phytocenoses is multifaceted and manifests at different levels: morphogenesis; physiological and biochemical processes; and cenogenetic relationships.

The first studies on the revegetation of iron ore dumps in the Kostanay Region were conducted in the 1970s. The Sarybai Mine dumps were specifically studied between 1997 and 2003 [2, 3].

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2 Material and Methods

Floristic surveys were conducted in May-August 2022 and 2023 on five differently aged dumps of SSGPO JSC and Kachary Ruda JSC. The survey of the territory began with the determination of habitat types, substrate features, assignment to a certain stage of syngenesis, and a list of the main plant formations of the given territory. Simultaneously, field material and soil samples were collected. Thus, the entire complex of existing ecosystems was covered and the maximum possible completeness of identification of plant species inherent in this territory was achieved.

Floristic data collected from iron ore dumps in the Kostanay Region were processed using the software package IBIS 7.2. A total of 72 geobotanical descriptions were conducted on the studied dumps, comprising 15 pioneer groupings, 26 group-thicket communities, 22 complex phytocenoses, and 8 on an old 50-year-old dump. For plant identification, the “Flora of Kazakhstan” [4] and the "Flora of Siberia" [5] were used.

The synanthropization coefficient was calculated using the formula proposed by E.P. Prokopyev and co-authors [6].

3 Results and Discussion

The flora of the Sokolov, Sarbai, and Kachar iron ore deposits comprises 284 species belonging to 163 genera and 44 families. Angiosperms are predominant in the flora of the dumps, accounting for 283 species (99.7%). Monocots are represented by 40 species (14.1%), while dicots number 243 (85.6%). Gymnosperms are represented by a single species.

DIVISION PINOPHYTA, OR CONIFEROPHYTA. Family **Pinaceae** Spreng. ex Rudolphi: *Pinus sylvestris* L.

DIVISION MAGNOLIOPHYTA. Class MAGNOLIOPSIDA, OR DICOTYLEDONES. Ranunculaceae Juss.: *Delphinium consolida* L., *Ranunculus pedatus* Waldst. et Kit., *Ranunculus polyanthemos* Steph., *Ranunculus repens* L.; **Papaveraceae** Juss.: *Chelidonium majus* L.; **Betulaceae** S. F. Gray: *Betula pendula* Roth; **Caryophyllaceae** Juss.: *Dianthus borbasii* Vandas, *Dianthus campestris* Bieb., *Dianthus rigidus* M. Bieb., *Gypsophila paniculata* L., *Gypsophila perfoliata* L., *Psammophiliella stepposa* (Klokov) Ikonn., *Silene multiflora* (Ehrh.) Pers., *Silene wolgensis* (Hornem.) Besser ex Spreng., *Stellaria graminea* L.; **Amaranthaceae** Juss.: *Amaranthus paniculatus* L., *Amaranthus retroflexus* L.; **Chenopodiaceae** Vent.: *Atriplex intracontinentalis* Sukhor., *A. sagittata* Borkh., *A. tatarica* L., *Axyris amaranthoides* L., *Bassia laniflora* (S.G. Gmel.) A.J. Scott, *B. prostrata* (L.) Beck., *B. scoparia* (L.) A.J. Scott, *Ceratocarpus arenarius* L., *Chenopodium album* L., *Chenopodiastrum hybridum* (L.) S. Fuentes, Uotila & Borsch, *Corispermum orientale* Lam., *C. declinatum* Steph.ex Iljin., *Oxybasis glauca* (L.) S. Fuentes, Uotila & Borsch, *O. rubra* (L.) S. Fuentes, Uotila & Borsch, *O. urbica* (L.) S. Fuentes, Uotila & Borsch, *Salsola collina* Pall., *Sedobassia sedoides* (Pall.) Freitag & G. Kadereit, *Teloxys aristata* (L.) Moq; **Polygonaceae** Juss.: *Fallopia convolvulus* (L.) A. Löve, *Persicaria minor* (Huds.) Opiz, *Polygonum aviculare* L., *P. bordzilowskii* Klokov., *P. novoascanicum* Klokov, *P. salsugineum* Bieb., *Rumex confertus* Willd., *R. crispus* L., *R. stenophyllus* Ledeb.; **Limoniaceae** Ser.: *Limonium gmelinii* (Willd.) Kuntze.; **Primulaceae** Batsch ex Borkh.: *Glaux maritima* L.; **Salicaceae** Mirb.: *Populus x sibirica* G. Krylov et Grigoriev ex A. Skvortsov, *P. tremula* L., *Salix caprea* L., *S. caspica* Pall., *S. triandra* L., *S. viminalis* L.; ***Cucurbitaceae*** Juss.: *Bryonia alba* L.; ***Brassicaceae*** Burnett: *Alyssum turkestanicum* Regel et Schmalh., *Arabidopsis toxophylla* (Bieb.) N. Busch, *Berteroa incana* (L.) DC., *Camelina sylvestris* Wallr., *Capsella bursa-pastoris* (L.) Medik., *Chorispora tenella* (Pall.) DC., *Descurainia sophia* (L.) Webb ex Prantl., *Erucastrum*

armoracioides (Czern. Ex Turcz.) Cruchet, *Erysimum canescens* Roth., *E. cheiranthoides* L., *Isatis costata* C.A. Mey., *Lepidium latifolium* L., *L. ruderale* L., *Odontarrhena tortuosa* (Waldst. et Kit. ex Willd.) C.A. Mey., *Sisymbrium loeselii* L., *S. polymorphum* (Murray) Roth., *Thlaspi arvense* L.; **Ulmaceae** Mirb.: *Ulmus laevis* Pall., *U. pumila* L.; **Cannabaceae** Martinov: *Cannabis sativa* L.; **Urticaceae** Juss.: *Urtica dioica* L.; ***Euphorbiaceae*** Juss.: *Euphorbia gerardiana* Jacq., *E. microcarpa* (Prokh.) Kryl., *E. subcordata* C.A.Mey. ex Ledeb., *E. uralensis* Fisch. ex Link, *E. virgata* Waldst. et Kit.; **Crassulaceae** J. St.-Hil.: *Hylotelephium stepposum* (Boriss.) Tzvelev; **Grossulariaceae** DC.: *Ribes aureum* Pursh.; **Rosaceae** Juss.: *Cerasus fruticosa* (Pall.) G. Woron., *Fragaria viridis* (Duchesne) Weston., *Malus baccata* (L.) Borkh., *M. domestica* Borkh., *Potentilla argentea* L., *P. bifurca* L., *P. canescens* Besser., *P. chrysantha* Trevir., *P. humifusa* Willd. ex Schltdl., *Prunus besseyi* L. H. Bailey, *Rosa acicularis* Lindl., *R. laxa* Retz., *R. majalis* Herrm., *Rubus sachalinensis* H. Lev., *Spiraea crenata* L., *S. hypericifolia* L.; **Onagraceae** Juss.: *Chamaenerion angustifolium* (L.) Scop.; **Fabaceae** Lindl., или **Leguminosae** Juss.: *Amoria repens* (L.) C. Presl, *Astragalus buchtormensis* Pall., *A. cornutus* Pall., *A. danicus* Retz., *A. macropus* Bunge, *A. onobrychis* L., *A. rupifragus* Pall., *A. scoparius* Schrenk, *A. sulcatus* L., *A. testiculatus* Pall., *A. varius* S.G. Gmel., *Genista tinctoria* L., *Glycyrrhiza korshinskyi* G. Grig., *G. uralensis* Fisch. ex DC., *Lathyrus pratensis* L., *L. tuberosus* L., *Lupinaster pentaphyllus* Moench, *Medicago falcata* L., *M. romanica* Prodan, *M. sativa* L., *Melilotus albus* Medik., *M. officinalis* (L.) Lam., *M. wolgicus* Poir., *Onobrychis arenaria* (Kit. ex Willd.) DC., *Oxytropis pilosa* (L.) DC., *Pseudosophora alopecuroides* (L.) Sweet, *Trifolium pratense* L., *Trigonella arcuata* C.A. Mey., *Vicia cracca* L., *V. nervata* Sipl., *V. sepium* L.; **Aceraceae** Juss.: *Acer negundo* L., *Acer tataricum* L.; **Santalaceae** R. Br.: *Thesium refractum* C.A. Mey.; **Elaeagnaceae** Juss.: *Elaeagnus angustifolia* L., *Hippophaë rhamnoides* L.; **Caprifoliaceae** Juss.: *Lonicera tatarica* L.; **Valerianaceae** Batsch: *Valeriana tuberosa* L.; **Apiaceae** Lindl., или **Umbelliferae** Juss.: *Eryngium planum* L., *Falcaria vulgaris* M. Bernh., *Silaum silaus* (L.) Schinz et Thell.; **Campanulaceae** Juss.: *Campanula sibirica* L.; **Asteraceae** Berht. et J. Presl.: *Achillea* × *kasakhstanica* Kupr. et Alibekov, *A. millefolium* L., *A. nobilis* L., *A. setacea* Waldst. et Kit., *Anthemis subtinctoria* Dobrocz., *Artemisia absinthium* L., *A. austriaca* Jacq., *A. commutata* Besser., *A. dracunculus* L., *A. frigida* Willd., *A. marschalliana* Spreng., *A. nitrosa* Weber, *A. pauciflora* Weber, *A. pontica* L., *A. proceriformis* Krasch., *A. schrenkiana* Ledeb., *A. scoparia* Waldst. et Kit., *A. sericea* Weber ex Stechm., *A. sieversiana* Willd., *A. vulgaris* L., *Aster tripolium* L., *Bidens tripartita* L., *Carduus thoermeri* Weinm., *Centaurea apiculata* Ledeb., *C. scabiosa* L., *Chondrilla ambigua* Fisch. ex Kar. et Kir., *Cirsium incanum* (S.G. Gmel.) Fisch., *C. intybus* L., *C. setosum* (Willd.) Besser., *C. vulgare* (Savi) Ten., *Conyza canadensis* (L.) Cronquist, *Crepis tectorum* L., *Cyclachaena xanthiifolia* (Nutt.) Fresen., *Erigeron acris* L., *Galatella angustissima* (Tausch) Novopokr., *G. biflora* (L.) Nees, *G. villosa* (L.) Rchb. f., *Helichrysum arenarium* (L.) Moench, *Hieracium umbellatum* L., *H. virosum* Pall., *Inula britannica* L., *I. helenium* L., *I. salicina* L., *Jacobaea erucifolia* (L.) Gaertn., Mey. et Scherb., *J. vulgaris* Gaertn., *Lactuca serriola* Torner., *L. tatarica* (L.) C. A. Mey., *Picris hieracioides* L., *Pilosella echioides* (Lumn.) F.Schultz et Sch. Bip., *Psephellus sibiricus* (L.) Wagenitz, *Rhaponticoides ruthenica* (Lam.) M.V. Agab. & Greuter, *Saussurea salsa* (Pall.) Spreng., *Scorzonera stricta* Hornem., *Sonchus arvensis* L., *Tanacetum vulgare* L., *Taraxacum officinale* F.H. Wigg., *Tragopogon capitatus* S.A. Nikitin, *Tragopogon dubius* Scop., *T. orientalis* L., *T. podolicus* (DC.) S. Nikit., *Tripleurospermum inodorum* (L.) Sch. Bip., *Trommsdorffia maculata* (L.) Bernh., *Tussilago farfara* L., *Xanthium strumarium* L.; **Rubiaceae** Juss.: *Galium aparine* L., *G. verum* L.; **Solanaceae** Juss.: *Hyoscyamus niger* L., *Solanum kitagawae* Schonb.-Tem.; **Convolvulaceae** Juss.: *Calystegia sepium* (L.) R. Br., *Convolvulus arvensis* L.; **Boraginaceae** Juss.: *Echium vulgare* L., *Lappula heteracantha* (Ledeb.) Guerke, *L.*

squarrosa (Retz.) Dumort., *L. stricta* (Ledeb.) Gürke, *Nonea rossica* Stev., *Onosma simplicissima* L. ; **Scrophulariaceae** Juss.: *Linaria genistifolia, L. ruthenica* Błonski., *L. vulgaris* Mill., *Odontites vulgaris* Moench, *Phelipanche ramosa* (L.) Pomel, *Verbascum phoeniceum* L., *Veronica chamaedrys* L., *V. incana* L., *V. longifolia* L., *V. spicata* L., *V. spuria* L.; **Plantaginaceae** Juss.: *Plantago major* L., *P. maxima* Juss. ex Jacq., *P. media* L., *P. salsa* Pall.; **Lamiaceae** Martinov, или **Labiatae** Juss.: *Dracocephalum nutans* L., *D. thymiflorum* L., *Glechoma hederacea* L., *Lycopus europaeus* L., *Phlomoides tuberosa* (L.) Moench, *Salvia stepposa* Des.-Shost., *Scutellaria galericulata* L., *Thymus marschallianus* Willd., *T. mugodzharicus* Klokov & Des.-Shost.

Class LILIOPSIDA. Lemnaceae Martinov: *Lemna minor* L., **Asparagaceae** Juss.: *Asparagus officinalis* L.; **Juncaceae** Juss.: *Juncus compressus* Jacq.; **Juncaginaceae** Rich.**:** *Triglochin palustre* L.; **Cyperaceae** Juss.: *Carex praecox* Schreb., *C. supina* Willd. ex Wahlenb.; **Typhaceae** Juss.: *Typha angustifolia* L., *T. latifolia* L.; **Poaceae** Barnhart: *Agropyron cristatum* (L.) Gaertn., *A. desertorum* (Fisch. ex Link) Schult., *A. fragile* (Roth) P. Candargy, *A. pectinatum* (Bieb.) Beauv., *Agrostis gigantea* Roth, *Anisantha tectorum* (L.) Nevski, *Avena fatua* L., *Bromopsis inermis* (Leyss.) Holub., *Bromus squarrosus* L., *Calamagrostis epigeios* (L.) Roth, *Dactylis glomerata* L., *Echinochloa crus-galli* (L.) P. Beauv., *Elytrigia repens* (L.) Nevski, *Eremopyrum triticeum* (Gaertn.) Nevski, *Festuca pratensis* Huds., *F. valesiaca* Gaudin, *Hordeum brevisubulatum* (Trin.) Link., *Koeleria cristata* (L.) Pers., *Leymus angustus* (Trin.) Pilg., *L. racemosus* (Lam.) Tzvel., *L. ramosus* (Trin.) Tzvel., *Phleum phleoides* (L.) H. Karst., *Phragmites australis* (Cav.) Trin. ex Steud., *Poa angustifolia* L., *P. bulbosa* L., *P. palustris* L., *P. pratensis* L., *P. stepposa* (Kryl.) Roshev., *P. urssulensis* Trin., *Setaria pumila* (Poir.) Roem. et Schult., *S. viridis* (L.) Beauv., *Sorghum sudanense* (Piper) Stapf., *Stipa capillata* L., *S. lessingiana* Trin. et Rupr., *S. pennata* L.

One species listed in the Red Book of the Republic of Kazakhstan, *Stipa pennata*, was found in the study area. This species was observed on non-saline soils. The species is classified as endangered (Category III) [7].

For the first time in the region, the following species have been discovered: *Rubus sachalinensis, Achillea × kasakhstanica, Bryonia alba, Chondrilla ambigua, Sorghum sudanense.*

Ten families were identified as the most dominant, comprising 221 species (77% of the total). The overall flora of the Kostanay Region consists of 1223 species belonging to 107 families [8]. Notably, the technogenic flora of iron ore dumps represents 18% of the region's total species diversity.

An analysis of the floristic spectrum of iron ore dumps and the Kostanay Region as a whole revealed a shared dominance of five families: *Asteraceae, Poaceae, Fabaceae, Chenopodiaceae,* and *Brassicaceae* (Table 1). Despite these common dominants, the number of species within these families can differ significantly between the dumps and the region. This suggests that the conditions on the dumps, while similar to the background conditions in general, still have their own unique characteristics that influence species diversity.

Table 1. Analysis of families by their share of participation in the flora of iron ore dumps in the Kostanay region

Family	Flora of the studied dumps			Flora of the Kostanay Region	
	Genera	Species		Species	
		Quantity	% of the flora	Quantity	% of the flora
Asteraceae	31	64	22,3	201	16,4
Poaceae	20	36	12,5	105	8,6
Fabaceae	14	31	11	80	6,5
Chenopodiaceae	11	18	6,1	67	5,5

Brassicaceae	14	17	6	66	5,4
Rosaceae	7	16	5,6	49	4,1
Scrophulariaceae	5	11	3,8	36	2,9
Polygonaceae	4	10	3,5	26	2,1
Lamiaceae	7	9	3,1	33	2,7
Caryophyllaceae	5	9	3,1	53	4,3
Other	45	63	23	507	41,5
Total	163	284	100	1223	100

Among the 57 families represented in the flora of the dumps, five - *Asteraceae, Poaceae, Fabaceae, Brassicaceae,* and *Chenopodiaceae* - stand out for their diversity. Each of them includes more than 10 genera, which is 65% of the total number of genera in the studied flora. 19 families are represented by only one species. Among the technogenic flora of the studied dumps, the following most numerous genera were identified: *Artemisia* (15 species), *Astragalus* (9), and *Poa* (6).

The plant community inhabiting the Kostanay iron ore dump exhibits a 37.6% degree of synanthropization. This signifies a moderate level of anthropogenic transformation on the applied scale. This level of transformation is typically characterized by a shift in plant species composition, with a significant proportion of the plant community being composed of synanthropic species. These synanthropic species are well-adapted to thrive in human-disturbed environments like the iron ore dump, potentially due to tolerance for altered soil conditions, such as heavy metal concentrations or unstable substrates.

4 Conclusion

An investigation of the flora of iron ore dumps in the Kostanay region revealed a unique taxonomic structure shaped by extreme habitat conditions. The low nutrient content, salinity, and sandy texture of the dump soils fostered a distinct plant community dominated by species tolerant of drought, salinization, and mechanical stress. The biodiversity of the dump flora is considerably lower than that of natural ecosystems in the region, attributed to the dumps' young age, low soil fertility, and limited range of ecological niches.

These findings hold significant value for developing science-based reclamation strategies for iron ore dumps and restoring biodiversity in the region.

References

1. *State of the Environment and Use of Natural Resources of the Republic of Kazakhstan for 2022*: National Report https://ecogosfond.kz/wp-content/uploads/2023/12/NDSOS-2022-RUS-gotov1-1.pdf (2023)
2. Z.B. Terekhova, R.I. Lanina, L.V. Fomenko. *Natural Overgrowth of Tailings Dumps of the Sokolovsky Iron Ore Quarry*. Vegetation and Industrial Environment. **3**, 162–174 (1974)
3. D.T. Konysbaeva. *Formation of vegetation cover on dumps of iron ore industry enterprises in Northern Kazakhstan*, c.b.s. thesis (Ekaterinburg, 2003)
4. *Flora of Kazakhstan*: in 9 volumes (Nauka, Alma-Ata, 1956–1964)
5. *Flora of Siberia*: in 14 volumes (Nauka, Novosibirsk, 1988–1997)
6. E.P. Prokopev, I.E. Merzljakova, T.A. Mineeva, V.A. Kudrjavcev. Urbanization and its impact on plant and animal life: Developing methods to assess synanthropization of flora and vegetation. 124–127 (Irkutsk, 2007)
7. *Red Book of the Republic of Kazakhstan*. Protected vascular plants, mosses, liverworts, hornworts, and lichens (374). https://www.plantarium.ru/page/redbook/id/42.html.

8. Yu. V. Perezhogin. *Taxonomic Analysis of the Flora of the Kostanay Region (Northern Kazakhstan)*. Bulletin of OSU. **5**, 137–139 (2008).