

# Formation of vegetation on 40-year-old overburden dumps in arid regions of Khakassia

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**Abstract.** The article presents the results of observations on the peculiarities of vegetation formation on 40-year old dumps in arid regions of Khakassia. The dumps of Chernogorsky open-cut mine were created as a result of open-cut coal mining. Five-year studies were carried out on different elements of the dumps mesorelief. It was established that primary succession is characterised by grass type of overgrowing 43 species of vascular plants were identified, among which 91% are native. Endemics group is represented by one species - *Thesium repens* Ledeb. The leading families are Asteraceae and Poaceae. The plant communities are dominated by grass species *Artemisia sieversiana*, *A. tanacetifolia*, *Chenopodium aristatum* and others, as well as grasses *Calamagrostis epigeios*, *Setaria viridis* and others. Among ecological groups, mesophytes are most widely represented (49%), and among geographical groups, species with Eurasian range predominate (39.6%). The analysis of species significance curves showed that during succession the structure becomes more complex with increasing number of species and equalisation of their abundance. The studied communities are at one of the intermediate stages of recovery and differ in composition and structure from zonal communities.

## 1 Introduction

The constantly increasing territories of disturbed lands, as a result of intensive mining, create a serious environmental problem. Restoring biological diversity, as the basis for the sustainability of biogeocenoses and the biosphere as a whole, on lands disturbed by mining, is a priority task of the national policy of many states in the field of ecology [1,2]. For the study area, this problem is especially relevant, since Khakassia is a supplier of raw materials to world markets, during the extraction of which vast territories are subject to severe technogenic impact. LLC "Suek-Khakassia" open-pit mine "Chernogorsky" is the largest open-pit coal mine in the Republic of Khakassia, belonging to hazard class 1. The Chernogorsk coal deposit is being developed in Khakassia with 1956. Considering the prospects and relevance of the coal mining industry for the Republic, it is necessary to understand the mechanisms of the impact of coal mining on environmental components and form an environmentally responsible approach to decision making [3].

## 2 Research methodology and conditions

From 2008–2012 On the dumps of the Chernogorsky open-pit mine, according to generally accepted methods, in July-early August, species-specific cuttings were collected to determine the composition of economic and botanical groups. To study the floristic composition of communities on all elements of the mesorelief, a herbarium was collected and geobotanical descriptions of these territories were made [4]. The classification of the habitats of plant species was based on the provisions developed by M.A. Albitskaya [5] and A.V. Positive [6]. The evenness of the relative distribution of individuals among vascular plant species was assessed using curves of the relative importance of species: the x-axis was the species ranked from most to least abundant, and the y-axis was the proportion of each species in the sample on a logarithmic scale [7, 8, 9]. Significance represents a group of scores by which species in a community can be compared to each other. To compare plant populations with each other, the weight of air-dry above-ground phytomass per unit area was used.

The climate of the study area is sharply continental with cold, long winters and hot, dry summers. The average annual air temperature ranges from +1.8 to –1.0 °C. The absolute minimum temperature was recorded in January – 40.6 °C, the absolute maximum in June +35.6 °C.

According to geobotanical zoning A.V. Kuminova et al. [10], the territory of the Chernogorsky section is assigned to the Priabakansky (Central Khakass) district of the Minusinsk Basin. The most typical for this territory

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are small-grass true steppes in the typical variant of the four-grass steppe, identified by V.V. Reverdatto.

The dumps were formed in the 70s. last century. Four elements of mesorelief on the dumps were identified: the northern slope, the eastern slope, the western slope and the plateau. Their rocks include siltstones, carbonaceous mudstones and sandstones, which, in turn, are overlain by Quaternary sediments.

### 3 Research results and discussion

The floristic composition of plant communities includes 43 species of higher vascular plants belonging to 39 genera and 17 families. The leading family is Asteraceae (Table), which is typical for the vast majority of boreal floras, as well as a relatively large number of species of the Poaceae family [11].

**Table.** Correlation of the main families of the cenoflora of 40-year-old dumps of the Chernogorsky open-pit mine by the number of species and genera.

Place in the cenoflora by number of species	Family	Number of species		Number of births
		absolute	V %	
1	Asteraceae	10	23.3	7
2	Poaceae	9	20.9	9
3–6	Chenopodiaceae	3	7.0	2
3–6	Brassicaceae	3	7.0	3
3–6	Fabaceae	3	7.0	3
3–6	Salicaceae	3	7.0	2
7	Scrophulariaceae	2	4.8	2
8–17	Betulaceae	1	2.3	1
8–17	Caryophyllaceae	1	2.3	1
8–17	Plantaginaceae	1	2.3	1
8–17	Polygonaceae	1	2.3	1
8–17	Primulaceae	1	2.3	1
8–17	Ranunculaceae	1	2.3	1
8–17	Santalaceae	1	2.3	1
8–17	Solanaceae	1	2.3	1
8–17	Ulmaceae	1	2.3	1
8–17	Hypolepidaceae	1	2.3	1

Of the 17 families, 10 are monotypic, including only one species, and 1 (Scrophulariaceae) is oligotypic with two species (Table). Most of the species have a wide Eurasian range (39.6%), pluri-regional (20.9%) and Holarctic ranges (20.9%), species with a Mongolian-South Siberian range (9.4%) are represented to a lesser extent. South Siberian (4.6%), East Asian (2.3%) and endemic steppes of Southern Siberia and Mongolia (2.3%).

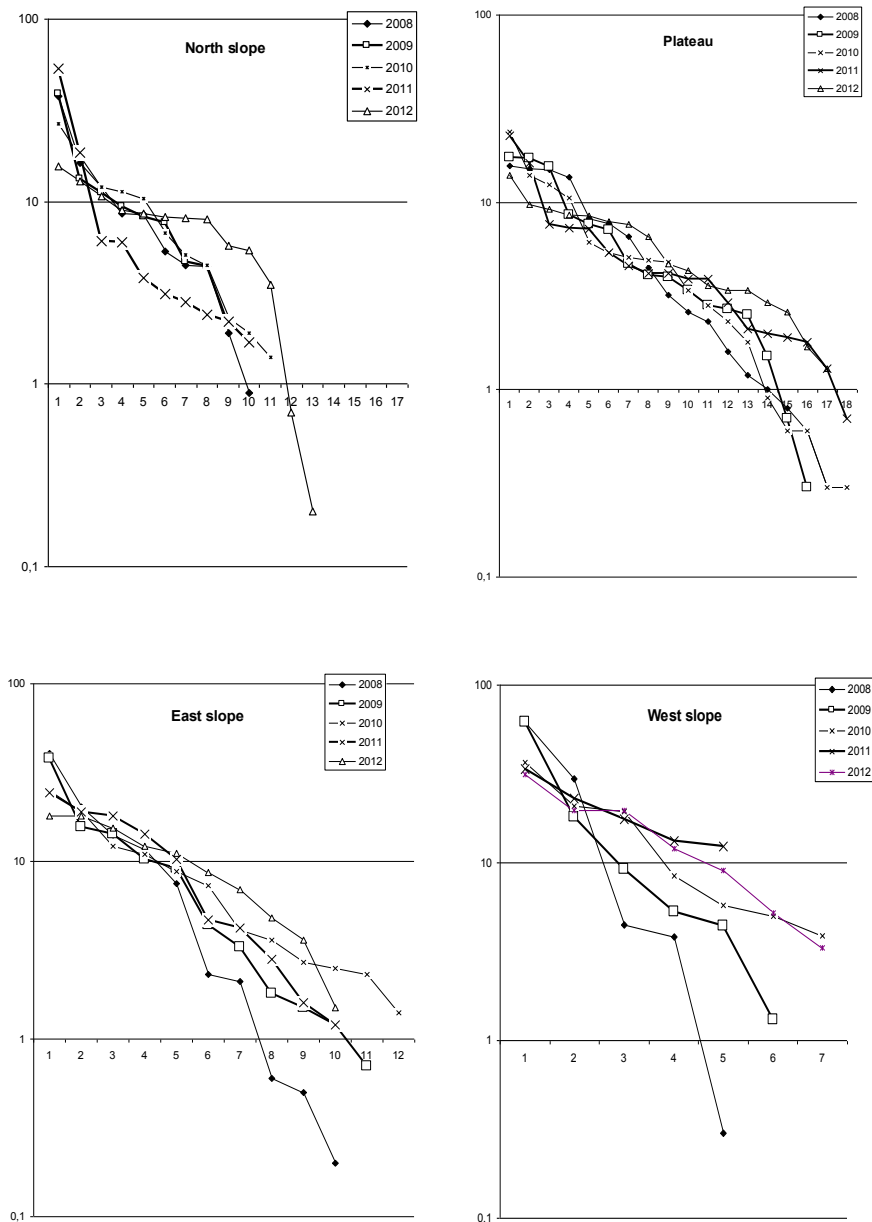
Primary successions on 40-year-old overburden dumps are characterized by a grass type of overgrowth. The majority of species that settle on dumps are native – 39 (91%). Four adventitious species were noted: *Hordeum jubatum* L., *Lactuca serriola* L., *Melilotus officinalis* (L.) Pall. and *Ulmus pumila* L., which are included in the list of invasive species in the Black Book of the Flora of Siberia [12].

When studying the restoration of plant communities on dumps, it is important to establish the belonging of plants to certain ecological groups. A.V. Kuminova [10] for Khakassia provides the following data on the ecological composition of the flora of small-grass steppes: petrophytes 33%, xerophytes – 28%, mesoxerophytes – 21%, mesophytes – 7%, xeromesophytes – 4%, psychrophytes – 3% and psammophytes – 2%. The ecological spectrum of the cenoflora of plant communities on the 40-year-old dumps of the Chernogorsky mine is as follows: mesophytes – 49%, xerophytes – 21% and mesoxerophytes – 23.1%, mesopetrophytes – 2.3%, xerohygrophytes – 2.3% and hygrophytes – 2.3%. Thus, we note that the percentage of mesophytes in the studied communities, compared with the zonal communities that grew on the dump site before stripping work, increased seven times.

Analysis of the composition of economic and botanical groups revealed that in all areas of the mesorelief during the studied period, the dominant role in the communities belongs to species of synanthropic herbs (*Artemisia sieversiana* Willd., *Tanacetifolia tanacetifolia* L., *Chenopodium aristatum* L. and etc.), among cereals – *Calamagrostis epigeios* (L.) Roth and *Setaria viridis* (L.) P. Beauv., among legumes – *Melilotus officinalis* (L.) Pall.

The magnitude of species diversity is considered an indicator of the best or worst state of an ecosystem. There is a transition from a geometric series with dominance of a few species with very low abundance of the rest (niche interception hypothesis) through log-row and lognormal distribution, in which species with average abundance become more and more abundant (niches are characterised by a large number of dimensions), to the situation represented by the "broken rod" model, when species abundance is distributed with the maximum possible uniformity in nature (the boundaries of hypervolumes of niches for different species are randomly located) [13].

The study of species diversity ( $\alpha$ -diversity) in plant communities growing on the slopes of different exposures and plateaus of the studied overburden dump of the Chernogorsky section was carried out for five years from 2008 to 2012 (Fig.).



**Fig.** Curves of the significance of species during the natural overgrowth of overburden dumps of the «Chernogorsky» section, formed in the 70s.

Horizontal axis – ranks of species in descending order of abundance. Vertical axis – relative importance in %, logarithmic scale.

#### 4 Conclusion

Analysis of the distribution of species by abundance on 40-year-old dumps showed that with increasing age of the dump on different types of slopes, the structure of the studied communities becomes more complex (an increase in the number of species and a leveling off of their abundance). On a plateau, the typical distribution is a log-normal distribution, which results in a situation where the community is dominated by species with moderate abundance. On the northern and western slopes, the community structure is most often described by the log-series model, which assumes a small number of “abundant” species and a large proportion of “rare” species. On the western slope there is a gradual transition from the geometric series to the log series. In 2011, over the entire observation period, the most uniform distribution of species abundance of a small number of species was observed here. These are types such as: *Artemisia sieversiana* Willd., *A. tanacetifolia tanacetifolia* L., *Melilotus officinalis* (L.) Pall, *Solanum dulcamara* L. and *Teloxys aristata* (L.) Moq.

In general, the indicators indicate that the structure of the studied communities according to this indicator has more or less formed.

In conclusion, it can be noted that plant communities over 40 years of self-overgrowing of dumps are at one of the intermediate stages of restoration and differ in composition and structure from zonal communities.

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