The stability of woody plants on reclaimed dumps of Donbass coal mines

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Abstract. The work carried out monitoring of some woody plants-bioindicators of the Donbass mine rock dump. After analyzing all the results of the study of bioindicator plants for damage, it can be concluded that the stability of plants depends on the state of the substrate and the spatial arrangement of trees.

1 Introduction

Donbass (the territory of the Donetsk People's Republic) is an industrial region that includes 13 cities and 5 districts with an administrative center in Donetsk. It is located in the south-east of the Rostov region.

According to the State Committee for Environmental Policy under the Head of the DPR, there are about 400 rock dumps on the territory of the Republic, most of which are located in the administrative territories of the cities of Donetsk (144), Makeyevka (118), Shakhtersk (69) and Torez (67). The accumulation of mining waste in landfills causes the release of numerous toxic compounds (hydrogen sulfide, sulfur dioxide, nitrogen and carbon oxides, benzene, heavy metals) into the atmosphere.

Water and wind erosion leads to the flushing into the natural environment of up to 400 m^3/ha of rock per year and the removal of more than 150 tons/year of rock from a hectare of its surface, respectively) [1]. The burning of rock dumps poses a threat to the public and employees of fire services. Gorenje

In the conditions of Donbass, a region with a high population density and a developed mining industry, these issues are becoming especially relevant.

The technogenic load in Donbass is 5-10 times higher than the average. The total area of man-made facilities in some cities of the region reaches 10% or more of their area.

The transformation of flora and vegetation in Donbas is extremely high. This is especially true of its central part, covering cities such as Donetsk, Makeyevka, Gorlovka, Khartsyzsk, Yenakiyevo, which are large industrial centers with a population of up to a million people. In places, such territories, alternating with each other, form continuous anthropogenic landscapes, with local intersperses and diverse natural communities in varying degrees of preservation. As a result, ecotopes that often have no natural analogues

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(including rock dumps) have been formed, which in their current state are almost impossible to integrate into the classification of ecosystems in the region, built taking into account the dominant classification, the characteristics of macroecotopes and edaphotopes [6].

In this regard, the state of vegetation cover of such territories disturbed by human activity, the direction of their development, and the possibility of restoring zonal or structurally similar communities are of great interest.

Bioindicator plants of a greened rock dump: summarize, without exception, important biological data about the environment, reflect its state as a whole; can respond to very weak effects due to dose accumulation; eliminate the need to register physical and chemical parameters of the environment; fix the rate of changes occurring in the environment; indicate the routes of entry and places of accumulation of various kinds of pollutants in ecosystems; help to normalize the permissible load on ecosystems [7].

2 Objects and methods of research

The purpose of the work is to monitor some woody plants-bioindicators of the Donbass mine rock dump in order to establish their resistance to the effects of the dump substrate.

The collection of leaf plates of plant material was carried out in September 2023 at the rock dump of the 5/6 mine named after him. Dimitrov, located within the city of Donetsk, DPR, according to the method of laying random plots of 0.25–4.0 m^2. The sample consisted of 100 individuals closest to a certain corner of the site [2].

The dump of mine No. 5–6 began operation in 1915, and was stopped in 1967, after 52 years of operation, excluding the period of the Second World War and post-war reconstruction (1941–1954). Initially, the dump had 4 conical peaks up to 48 m high, the total volume of rock was more than one and a half million tons. The base area is 58,000 m^2, the volume of waste is 900 thousand m2. Gorenje was noted in separate areas from the very beginning of the dumping [3].

Apparently, the dump of mine No. 5-6 turned out to be the first dump in the USSR (and possibly in the world), where the first stage of reclamation, mining engineering, was fully implemented. The project of extinguishing and reshaping the dump was carried out by the special directorate for extinguishing, Gorenje prevention and reclamation of the Donetskugol, and the project of terracing, slope irrigation and landscaping was carried out by the Donetsk Botanical Garden.

The technical stage of reclamation began in 1976, after extinguishing the dump, and provided for reformation with the removal of conical peaks. During the reformation, the height of the dump decreased by 20 m, and a common plateau with an area of more than 9,000 m^2 was created. On the plateau, small remnants were exposed – massifs of rock caked during combustion, which were not destroyed. Gorenje The slopes of the dump due to the dumping of the rock of the peaks turned out to be too steep, which was partially eliminated during subsequent work. Mechanical and sanitary protection zones around the dump were not installed, so it turned out to be in the center of residential and administrative buildings.

In the same 1976, soil was brought to the flat top and terraces and distributed with a layer 0.2–0.8 m thick. In the spring of 1977, the first planting of 6670 standard seedlings of Robinia pseudoacacia L. (white acacia) was carried out. During the observations, the best plant growth was noted in areas with a potentially fertile layer. Improved plant growth was also noted on the slopes when clay was transferred by precipitation from plateaus and terraces to the underlying areas. The average survival rate of seedlings was 84% in 1977.

In 1978, an additional 12,000 seedlings of the same species were planted. Grasses were also planted on an area of more than 30,400 m (top and terraces). Bean-cereal mixtures and

pure crops were used to test various options. Donnik, wheatgrass, grate, granary, clover, various types of alfalfa were used. It was noted that the average survival rate of tree seedlings decreased compared to the previous year due to adverse weather conditions and amounted to 62%. The growth of trees fluctuated depending on the conditions, in particular, the chemistry of the rock, since the developing edaphotopes of the dump were partially at the stage of oxidation. At the same time, the application of a screening layer of loam reduced the activity of oxidation processes and improved the mechanical composition of the stony rock.

Later, experimental plantings were carried out on the dump to test new phytorecultivants. Currently, self–thinning of plantings has occurred - the initial planting was carried out with the expectation that the excessive density of vegetation would quickly stop erosion and start the process of soil formation, and in the future it would spontaneously decrease. There is also a massive self-colonization of plants from adjacent territories, which is typical for dumps even in highly urbanized areas, and the self-renewal of most species of planted phytorecultivants. However, an area has been formed on the newly formed northern slope, which is still almost devoid of vegetation.

The plantations and crops created during reclamation form the basis of plant communities on the dump at the present time. The trees reach a height of 8 m and bear fruit regularly. Herbaceous plants have been redistributed over the years along the surface of the dump and occupy open spaces and edges of tree plantings [4].

Experimental plantings on the dump are carried out by employees of the Donetsk Botanical Garden to the present time. In particular, experimental populations of medicinal hyssop and kachim scorzonerol were created on this dump, which, along with other experiments, made it possible to recommend these species for the standard method of reclamation of mine dumps. Self-settling plants, for example, early flowering plants, are also of interest, showing the possibility of including such man-made territories in natural biogeocenotic cycles. New types of phytomeliorants (for example, red oak) are also being tested, promising for improving the decorative qualities of rock dump plantations in an urban area in order to bring them closer to park and recreational areas in this regard.

3 Research results

The studied phytomeliorant plants of the rock dump as bioindicators of environmental pollution in the area of its location were *Robinia pseudoacacia* L. – white acacia-southern and northern slope; *Aser tataricum* L. – Tatar maple-southern slope; *Ligustrum vulgare* L. – common privet-southern slope; *Crataegus laevigata* Poir. – common hawthorn-southern slope; *Ulmus pumila* L.-squat elm-southern slope.

The methodology for assessing plant resistance to man-made pollution and anthropogenic impact is based on the following indicators: premature yellowing of leaves, the presence of chemical burns of leaves, as well as leaf lesions by pests and pathogens. This set of indicators makes it possible to give a complete diagnosis of woody plants in an anthropogenically altered environment in comparison with existing methods and visually identify a wide range of adverse factors affecting the assimilating apparatus of the plant [5].

Robinia pseudoacacia L. on the northern slope, damage was detected in 94% of the leaves from the study sample, in *Robinia pseudoacacia* L. on the southern slope – 42%, *Ulmus pumila* L. – 95%, *Aser tataricum* L. – 82%, Ligustrum vulgare L. – 75%, *Crataegus laevigata* Poir. – at 10%.

The dynamics of the number of damaged leaves for each plant is clearly shown in the graph (Fig.). Histograms with the total number of leaves in the sample are indicated in blue, and the number of damaged leaves is indicated in orange.

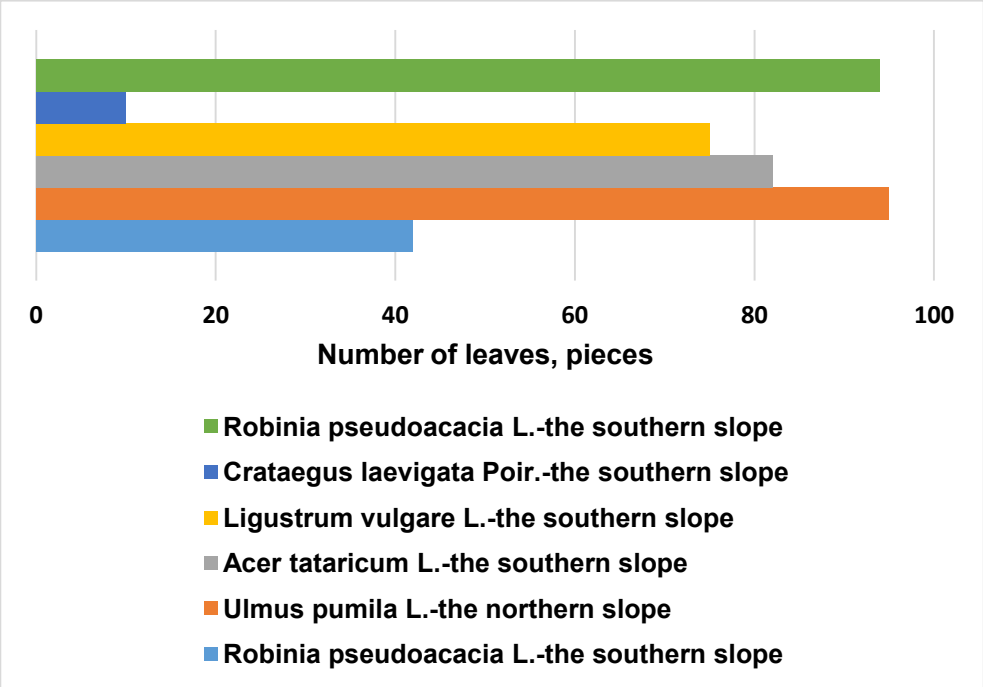

Fig. Dynamics of the number of damaged leaves of the rock dump

4 Conclusions

After analyzing all the results of the plant examination for damage, it can be concluded that the substrate on the northern slope of the dump is more toxic than on the southern one, since the plants at these points are more damaged. This is most characteristic of *Robinia pseudoacacia* L.– there are 2.2 times more damaged leaves on the northern slope than on the southern one.

With a total score of 26 points and below, the degree of plant resistance is characterized as very low and further division of this range into intervals makes no practical sense.

Based on the monitoring results, it is assumed that low plant resistance is presumably provided by the emission of pollutants and dust deposits into the atmospheric air, which is aggravated on the northern slope, where the intensity of sunlight is reduced and, along with this, a higher wind flow. The substrate of the dump acts as a storage and fixative pollutant, which, partly due to the effect of transpiration, are absorbed by phytomeliorants and accumulate mainly in their roots and aboveground vegetative organs. Some pollutants, presumably, still enter the atmospheric air.

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