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THE RECLAMATION OF THE SURFACE LAYER OF MINING LANDSCAPES OF KRYVYI RIH LANDSCAPE TECHNICAL SYSTEM

Purpose. To investigate the reclamation of the surface layer of mining landscapes of Kryvyi Rih landscape technical system on the example of Shymaniv and Hanniv dumps.

Methods. Historical analysis, comparative, cartographic, method of anthropogenic landscape forecasting.

Results. It has been determined that Shymaniv dump was created by the Southern Mining and Processing Plant in 1960–1967, belongs to mixed dumps, was formed by automobile tailings resulted into tiers with a leveled and plateau-like surface. The dump in the geological structure has a lower accumulative microstrip, which consists of crystalline rocks that are not involved into development, limestones, loess-like loams; the middle accumulative – denudation microstrip, which is characterized by crushed stone, sand, stone blocks and the upper denudation microstrip, which is represented by blocks and granites. The dump reclaimed and has favorable conditions for the germination of vegetation. By example of the Hanniv dump the possibility of rational use of the surface layer of mining landscapes was considered. The Hanniv dump is a mixed dump with its height of 90 m, partially reclaimed. A gradual biological reclamation technology is proposed for the rapid adaptation of plants to unusual terrain and the improvement of disturbed lands. Maps and technology of biological reclamation have been developed, which reflect the surface layer of mining landscapes of Kryvyi Rih landscape technical system.

Conclusions. The reclamation of the surface layer of mining landscapes of Kryvyi Rih landscape technical system exists and needs a detailed study in order to prevent the degradation of disturbed lands due to the action of the mining industry. On the example of Shymaniv and Hanniv dumps the reclamation of the surface layer of mining landscapes has been investigated, the history of the dumps has been determined, the geological - geomorphological, hydrological, climatic, soil - biotic processes that influenced the favorable formation of the reclamation of the surface layer of the dumps have been substantiated, and a gradual biological reclamation technology has been proposed on the example of Hanniv dump.

KEYWORDS: *surface layer, mining landscapes, Shymaniv dump, Hanniv dump, biological reclamation, microstrips*

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Introduction

Modern mining landscapes of Kryvyi Rih landscape technical system (KLTS) are the result of the long-term influence of technogenesis on natural landscapes. Mining landscapes are spread over the entire territory of KLTS, which is caused, first of all, by the spatial features of the iron ore deposits of the Kryvyi Rih iron ore basin. Nowadays, the area of mining landscapes is growing rapidly and amounts to almost

40,000 hectares, iron ore is extracted by open (quarry) and closed (mine) methods [8]. Also, depending on the method of iron ore mining the following types of localities are distinguished: quarries and mines, which lead to the appearance of two-tiered mining landscapes of KLTS.

KLTS is a unique system that in a short period of time, within 150 years, formed a mining landscape complex that has a marked

two-tiered structure, namely surface and underground tiers.

There is a small number of scientists whose works are devoted to the study of the reclamation of the surface layer of mining

landscapes, among them there are I.M. Voyna, H.I. Denysyk [3,4,5], H.M. Zadorozhnaya. [3, 6], Kazakov V.L. [4, 7, 8], T.S. Koptieva [9, 11,12 – 15], V.P. Palienko [16] and S.V. Yarkova [4].

Object and methods of research

The object of research is Shymaniv and Hanniv dumps. The subject of the study is the reclamation of the surface layer of mining landscapes of Kryvyi Rih landscape technical system. In the analysis of the reclamation of the surface layer of the mining landscapes of Kryvyi Rih landscape technical system (on the example of the Shymaniv and Hanniv dumps) the historical method was applied to

characterize the formation and development of this system. The comparison of Shymaniv and Hanniv dumps was made by using the comparative method. The cartographic method was carried out with the help of the analysis of cartographic materials. The method of anthropogenic landscape forecasting made it possible to predict the prospective changes in Kryvyi Rih landscape technical system.

Results and discussion

Features of the intensive development of mining landscape complexes in the past and nowadays are determined by the functioning of five mining and beneficiation plants within the KLTS: Southern, Northern, Novokryvorizkyi, Central and Inhuletskyi [6]. According to the

Fig. 1, the area of anthropogenic landscapes of KLTS is constantly growing. The percentage of agricultural landscapes occupies (61.2% of the area of the region), residential – 13.1%, industrial – 11.5%, water management – 8.1%, forestry – 3.5%, transport – 2%, others – 0.6% [3].

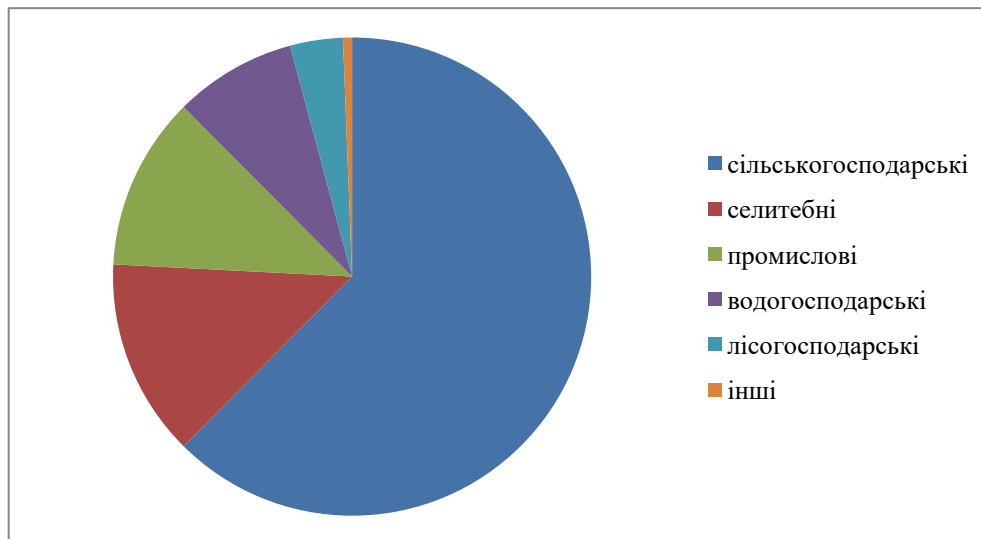


Fig. 1 – Areas of antropogenic landscapes on KLTS territory

However, among the anthropogenic landscapes of KLTS the background ones are residential and mining. As a result of the active action of technogenesis on the territory of the KLTS, the residential and mining landscapes are characterized by a double layer. On the territory of Ukraine, two-tiered anthropogenic landscapes also found in the Donetsk, Lviv-Volyn coal basins and the largest not only in

Ukraine, but also in Europe - Kryvyi Rih landscape technical system.

The two-tiered concept is currently rather weakly studied, but observed in anthropogenic landscapes. It is possible to draw through lines between two-tiered and high-altitude differentiation, but these concepts are quite different. High-altitude differentiation is determined by the diversity and change with altitude of

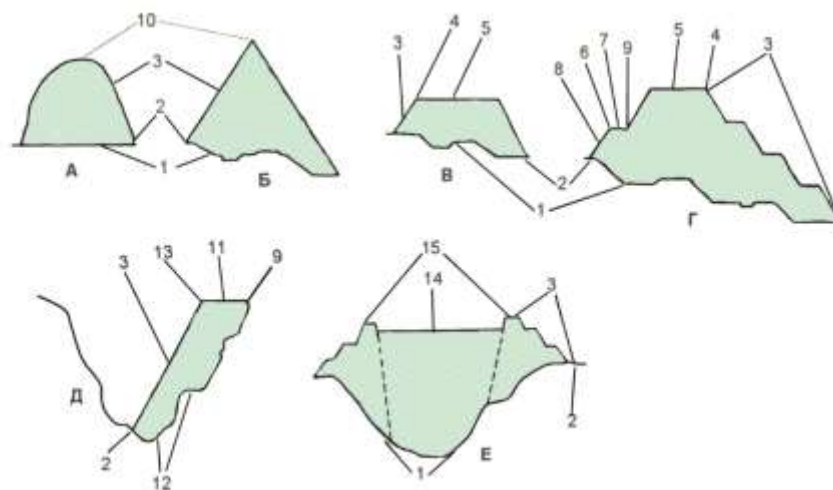
climatic factors and their effect on the vegetation cover, and two-tieredness arises as a result of the action of all landscape-creating factors, primarily lithogenic (geological structure of the territory, relief and their development), climatic, hydrological (functioning of surface waters), hydrogeological (groundwater), soil, plant.

With the development of mining technical progress, there is a common trend of a significant increase in the share of open (quarry) development of deposits and as a result, quarry and tailings complexes are formed, and in turn, the surface layer of KLTS. [3]. Dumps are one of the main forms of anthropogenic relief. They formed with the help of equipment and certain technology because of the following reasons: storage of overburden on the earth's surface, storage on the earth's surface of by-products of mineral enrichment - slurries; storage of overburden, slurries and household waste in spent quarries and mine hoppers [4].

Having analyzed the high-altitude differentiation of territories occupied by mining developments, it increased by 2.1-2.7 times. A low-mountain mining landscape, unique for the steppe zone of Ukraine, was formed with a height difference of up to 620-650 m, that is, a surface layer and underground workings to a depth of more than 1200 m - an underground layer [10].

Shymaniv and Hanniv dumpsites have taken as examples to study the surface layer of the mining landscape of KLTS.

Shymakiv dump belongs to mixed dumps according to the classification of H.I. Denysyk and H.M., namely crushed stone. Such dumps intensively weathered due to their formation and structure. According to the type of terrain, the Shymakiv dump belongs to the plateau-like multi-tiered dump (E), which was formed as a result of auto dumping, and due to this, tiers with a leveled and plateau-like surface were formed (Fig. 1)



Morphological types of dumps: A – comb-strand-shaped; B – tericon; C – single-tier plateau-shaped; D – multi-tiered plateau-shaped; E - sheltered sleeper; F is a multi-tiered plateau-shaped sludge storage facility.

Fig. 2 – Morphology of KLTS dumps [2]

Shymakiv dump is located in the city of Kryvyi Rih, in the Ingulets district, near the quarry of the Southern Mining and Processing Combine, and has the following geographic coordinates: 47°50'36"N 33°15'54"E. (Fig. 2).

The dump was built by the Southern Mining and Processing Plant in 1960–1967. The height of the Shymakiv dump is 80 m, the

steepness of the slopes is 45–50°, the area of the dump is 2.5 ha.

According to fig. 3 there are the following bulk layers - bands in the geological structure of the dump:

1. The lower accumulative microstrip consists of crystalline rocks that are not

involved in development, limestones, loess-like loams.

2. The middle accumulative – denudation microstrip, which characterized by crushed stone, sand and stone blocks.

3. The upper denudation microstrip is represented by boulders and granites.

The climate of the dump location is moderate – continental, the average temperature in January is 5.1 °C, the average temperature in July is + 22.5 °C, and the average annual temperature is + 10 °C. The highest amount of precipitation falls in June-July - up to 65 mm, the lowest - in February-March - 28 mm, the annual amount of precipitation - up to 483 mm. The height of the snow cover is 10 cm.

As for the study of the surface layer of mining landscapes, loose layers - strips that are recultivated and form altitudinal differentiation - were taken as a basis.

Szymaniv waste dump is now fully reclaimed, the plant communities on the dump are diverse:

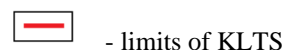
- The lower accumulative strip is represented by mostly tree-shrub vegetation: rake-leaved elm, white and pyramidal poplar, Tatar maple, Austrian wormwood and creeping heather, dog rose, black-fruited dogwood, oval yarrow, common viburnum;

- The middle accumulative-denudation strip (second tier) consists of: narrow-leaved loach,



Legend:

- 1- KLTS – Kryvyi Rih landscape and technical system
- 2- Szymanivsky quarry
- 3- Shymaniv dump



- limits of KLTS

Fig. 3 – Territorial location of Shymanivske dump

**Legend:**

1. Shimaniv dump 3. sludge storage No.2
2. career of PdGZK


 borders of the Shimaniv dump

Fig. 4 – Landscape structure of the territory of the Shymakiv dump.

common robinia; raked elm, white mulberry, common apricot, branch tamarisk, white and pyramidal poplar, dog rose;

- The upper accumulative strip (upper tier) consists of red currant, common viburnum, dog rose, black-fruited cotyledon, purple nettle, Danish astragalus, creeping wheatgrass, small sedge, Canadian goldenrod, horse sorrel.

- Synanthropic flora is widespread at the top of the dump: ambrosia, slinky, grindelia, chernoschir, etc.

This differentiation of the vegetation cover is primarily characterized by the fact that the upper parts of the dump are occupied by groups characterized as the most xerophilic. Species in such habitats constantly struggle not only with an extreme lack of moisture, because of the only source is atmospheric precipitation, but also with the poverty of mineral nutrition elements. Material from similar facies, which are similar to plakornym in natural landscapes, are carried both in deeper layers and on the slopes at the foot of the dumps. As a result, the processes of soil formation here are very difficult and retarded, especially in the accumulation of organic matter [2].

Hanniv dump of the Northern Mining and Processing Plant (Northern GZK) is located in the northern part of the city of Kryvyi Rih. 48.16791, 33.49565 (Fig. 4).

The area of biological reclamation is 181.2 ha, currently it can be carried out on the territory of 42.4 ha [14].

According to Fig. 4. Hanniv dump is filled with layers 10-20 m high for loose rocks and 20-40 m for rocky ones.

The height of the dump above the earth's surface is from 10 to 90 m. The dump consists of metamorphic, to a lesser extent, igneous rocks, as well as clays and loams. The size of rock fragments varies from 1 μ m to less than 1 m. Gravitational differentiation of the material causes the accumulation of large blocks at the foot of the dump, fine-medium-grained material makes up its plateau and slopes. The amount of dusty, fine- and medium-grained material that cements larger fragments is about 41% of the total mass of the waste mass. The Hanniv dump, as well as the adjacent Pershomai dump, is a source of dust pollution of the atmospheric air in nearby urban residential areas (Fig. 5).

Hanniv dump has been fully reclaimed yet, so it would be advisable to apply biological reclamation to improve the surface layer of the dump. The working projects for the reclamation of landfills of Northern GZK [14, 15] provide, mainly, for implementation during the storage of overburden and the formation of the dump. The biological stage of reclamation is carried out by the land user, to whom restored land is

**Legend:**


- | | | | |
|--|--------------------|--------------------------------------|--|
| 1. Hanniv dump | 3.- May Day dump | 5.- Voikiv sludge storage facility |  - the limits |
| 2. Hanniv quarry
of the Hannivskiy quarry | 4.- May Day quarry | 6.- Mykolaiv sludge storage facility | |

Fig. 5 – Territorial location of the Gannivsky dump

transferred, at the expense of the company that disturbed the surface layer. The biological stage begins immediately after the technical stage of reclamation.

The technology of biological reclamation depends on its chosen direction, the technology of technical reclamation, the capacity of scree layer and its structure, as well as agrochemical and water-physical properties of rocks located on the restored territory [15]. The selection of the assortment of plants for the creation of artificial forest communities on man-made landscapes is very important. At the first stages of land development, it is most appropriate to grow species that are undemanding to nutrition and moisture, capable of withstanding high temperatures that can exceed 50°C on the surface of the dumps - poplars, narrow-leaved larch, Tatar honeysuckle, etc. Common pine, common oak, white acacia, small-grained birch, common apricot, common ash, common hemlock, Crimean pine, Tatar maple, and other types of tree and shrub cultures are widely used.

To green the slopes of Hanniv dump it is proposed to create row of plantings from a

combination of white acacia and narrow-leaved loach, assuming a distance between plants in a row of 1 m, a distance between rows of 2.5 m, and taking into account that the total area of the slopes of the dumps is 10 hectares.

To ensure maximum germination and normal development of plants, it is necessary to carry out their careful care. Dust removal from the above-ground part of plants is carried out by washing plants with water, water consumption for trees under 10 years of age is 5-10 liters per 1 plant, 10-20 years - 20-30 liters. Care of the soil and the root system of trees and shrubs includes the following operations: loosening the surface of the trunk areas, watering, applying fertilizers. Watering rates: for plants up to 10 years old - 50 liters, older than 10 years - 100-150 liters. The optimal fertilizer is humus, 5-6 kg is applied to the hole; 350-400 g of mineral fertilizers are applied per 1 m of the hole. 3-4 kg of organic fertilizers and 200 g of a mixture of mineral fertilizers are applied under the bush.

Carrying out reclamation works is an expensive measure, but necessary for improving

**Legend:**


1. Hanniv dump 2. Hanniv quarry  - city limits of Kryvyi Rih

Fig. 6 – Landscape structure of the territory of the Hannivsky dump

the ecological condition of Kryvyi Rih landscape technical system.

Therefore, the following types of trees were selected for the biological reclamation of

the Hanniv dump: white acacia, narrow-leaved larch, small-leaved birch, common apricot, poplar, and white acacia and narrow-leaved larch for greening the slopes.

Conclusions

Therefore, based on the results of the research, it can be proven that the surface layer of the mining landscapes of KLTS was formed as a result of the active action of technogenesis, the areas of mining landscapes are growing every year. By the example of the Shymaniv and Hanniv dumps, it is possible to trace the reclamation of the surface layer of mining landscapes. The Shymaniv dump is currently reclaimed, it belongs to mixed dumps, according to the type of terrain, the Shimaki dump belongs to a plateau-like multi-level dump, built by the Southern Mining and Processing Plant in 1960–1967, has an area of 2.5 hectares and a height of 80 m. The dump was formed due to of automobile tailings, and due to this, tiers with a leveled and plateau-like surface were formed, due to which it is possible to clearly follow the tiering of the dump. Vegetation on Shymaniv dump grows

unevenly, and this is explained by the fact that the plants on the upper tier struggle not only with an extreme lack of moisture, since the only source is atmospheric precipitation, but also with the poverty of mineral nutrients. Hanniv dump, compared to the Shymaniv dump, is not fully rehabilitated, it also belongs to the mixed dumps, the height is 90 m, but it was built by Northern Mining and Processing Plant. During the study of the reclamation of the surface layer of the mining landscapes of KLTS, it was determined that it is necessary to introduce biological reclamation to improve disturbed lands, in order to overcome the man-made situation. A step-by-step biological reclamation technology of the surface layer of mining landscapes of KLTS is proposed for the improvement of the ecological condition of Kryvyi Rih landscape technical system on the example of Hanniv dump.

Conflict of interest

The author declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the author fully complied with ethical standards, including plagiarism, data falsification, and double publication.

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РЕКУЛЬТАЦІЯ ПОВЕРХНЕВОГО ЯРУСУ ГІРНИЧОПРОМИСЛОВИХ ЛАНДШАФТІВ ЛАНДШАФТНО-ТЕХНІЧНОЇ СИСТЕМИ КРИВОГО РОГУ

Мета. Дослідити рекультивуацію поверхневого ярусу гірничопромислових ландшафтів Криворізької ландшафтно-технічної системи на прикладі Шиманівського та Ганнівського відвалів:

Методи. Історичний аналіз, порівняльний, картографічний, метод антропогенно-ландшафтознавчого прогнозу.

Результати: Визначено, що Шиманівський відвал складений Південним гірничо-збагачувальним комбінатом 1960–1967рр, відноситься до змішаних відвалів, сформований автомобільною відсипкою і, внаслідок цього утворилися яруси з вирівняною і платоподібною поверхнею. Відвал у геологічній будові має нижню акумулятивну мікросмугу, яка складається із кристалічних порід, які не задіяні з розробками, вапняки, лесоподібні суглинки; середню акумулятивно – денудаційну мікросмугу, якій характерні щебень, супісок, кам'яні брили та верхню денудаційну мікросмугу, яка представлена брилами та гранітами. Відвал є рекультивованим і має сприятливі умови для проростання рослинності. На прикладі Ганнівського відвалу розглянуто можливість раціонального використання поверхневого ярусу гірничопромислових ландшафтів. Ганнівський відвал є змішаним відвалом висотою 90 м, частково рекультивованим. Для проведення біологічної рекультивації Ганнівського відвалу обґрунтовано і запропоновано поетапна технологія біологічної рекультивації задля швидкого пристосування рослин до несвоєрідної місцевості та покращенню порушених земель Криворізької ландшафтно-технічної системи. Розроблені карти та технологія біологічної рекультивації, які відображають поверхневий ярус гірничопромислових ландшафтів Криворізької ландшафтно-технічної системи.

Висновки: Поверхневий ярус гірничопромислових ландшафтів Криворізької ландшафтно-технічної системи наявний і потребує детального дослідження задля запобігання деградації порушених земель внаслідок дії гірничодобувної промисловості. На прикладі Шиманівського та Ганнівського відвалів досліджено поверхневий ярус гірничопромислових ландшафтів, виділені яруси, визначено історію формування відвалів, обґрунтовано геолого - геоморфологічні, гідрологічні, кліматичні, ґрунтово - біотичні процеси, які вплинули на утворення поверхневого ярусу відвалів, а також запропонована поетапна технологія біологічної рекультивації на прикладі Ганнівського відвалу.

КЛЮЧОВІ СЛОВА: *поверхневий ярус, гірничопромисловий ландшафт, Шиманівський відвал, Ганнівський відвал, біологічна рекультивація, мікросмуги*

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