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ANALYSIS OF THE VARIABILITY OF THE ECOSYSTEM OF THE TASHKUMYR COAL MINE, KYRGYSTAN

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Abstract: Coal plays a crucial role in global economic development and remains the most widely used fossil fuel worldwide. The exploitation of open-pit and underground coal mines certainly has an impact on the environment. This impact varies in the degree of their influence on the state and prospects of environmental services and biodiversity of coal-producing regions. Some researchers note a serious obstacle to the sustainable use of regional lands and the well-being of residents of such regions. Others believe that the problem lies in poor legislation and improper use of resources. It has been established that environmental change is the result of a combination of various factors, which determines the need for a differentiated approach to assessing their impact on specific ecosystems. The Tash-Kumyr coal mine has been in operation for almost a hundred years. Throughout this period, the economic activity of the mine has a significant impact on the environment of the region. At the same time, significant changes in local ecosystems occur, associated with the complete or partial destruction of plant species, degradation of land cover and changes in the distribution range of wildlife. Scientists began to study ecosystem changes in the region directly from the beginning of the two thousandth years. This article presents an analysis of the observations of the ecosystem of the Tash-Kumyr coal mine over the past 50 years. The history of the deposit formation, its variability, characteristics of the ecosystem and the impact of coal production on its development are given. Examples of the biological cycle of substances in the conditions of steppe ecosystems of the Tash-Kumyr coal deposit are given, and methods for restoring degraded areas are proposed. The result of the present research is the conclusion that changes in biocenoses in the area of the Tash-Kumyr coal mine are local in nature. They are not critical for the general ecosystem of the region, unlike the threats to nearby ecosystems noted in other studies. With regard to the further exploitation of the Tash-Kumyr coal deposit, we adhere to the point of view of the possibility of its further use subject to compliance with legislation and best practices. One of the options and the most promising, practically feasible way of restoring natural landscapes in the territory of the dumps and quarries observed in the study are artificial plantings of endemic plant species resistant to local conditions, a bright representative of which are plants of the genus Tamarix (*Tamarix L.).*

Keywords: Kyrgyzstan, Tash-Kumyr, coal mining, mining technologies, mining operations, deposit, ecosystem, biochemical features of the biological cycle, environmental risks

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INTRODUCTION

Tash-Kumyr is located in the north-east of the Fergana Valley, in the Jalal-Abad region of Kyrgyzstan. In the north-east it shares common borders with the city of Kara-Kul, in the north-west - with the Aksy region. The eastern borders of the city run along the Nooken region. The first settlements here arose in the pre-revolutionary period.

Industrial coal mining began in the 1930s after the completion of the construction of the railway line in the direction of Tash-Kumyr - Andijan and the opening of a small coal basin. At the same time, a small mining settlement was established. In 1933, a mine administration was founded (Jumashova et al., 2021).

The territory of Tash-Kumyr occupies the right bank of the Naryn River of the Syr-Darya basin. The Bishkek-Osh highway runs nearby. On the Andijan-Namangan line, Tash-Kumyr is connected by a railway line to the Uch-Kurgan station (Figure 1). In the 60s of the twentieth century, with the beginning of the construction of the Uchkurgan hydroelectric power station, and then the Toktogul hydroelectric power station, Tash-Kumyr became a city not only of miners, but also of builders and power engineers (the city of Kara-Kul until 1968, as an urban-type settlement, was administratively subordinate to the city of Tash-Kumyr).

Currently, the city includes the settlements of Shamalduu-Sai, Kyzyl-Dzhar and the village of Tendik (Figure 2).

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The technology of coal mining at the Tash-Kumyr coal deposit has remained unchanged throughout all the years of its operation. Mining is carried out by open-pit mining with partial involvement of blasting operations. The peak of mining occurred in the 60s - 70s of the last century. During this same period, the main changes in the ecosystem of the Tash-Kumyr open-pit mine occurred. The systemic crisis that broke out after 1991 significantly changed the situation with coal mining. For some time, the open-pit mine simply stopped working (Jumashova et al., 2021).

Coal mining in the noughties of the 21st century was carried out by small mining companies.

However, already in the early 2010s, Chinese companies received the right to use some open-pit mines. Coal mining began to increase and has now become so successful that the Tash-Kumyr - Andijan railway line, which had been idle for more than 15 years, has started working again.

Figure 1. Location of the city of Tash-Kumyr and adjacent coal mines (Source: Google Earth 1:125000)

Figure 2. General view of the northern part of Tash-Kumyr from the left bank of the Naryn River, Jalal-Abad region (Source: Authors, 2021)

The socio-political and subsequent physical changes in the region have entailed changes in all local biocenoses. These changes have common trends previously noted in other geographical coal-mining regions (Goswami, 2015; Beketova et al., 2019; Xiao et al., 2020; Zhang et al., 2022) and are directly related to changes in the biodiversity of local ecosystems. First of all, this concerns changes in the plant species composition. It has been established that changes in the ecological environment are the result of a combination of various factors (Doley, 2012), which determines the need for a differentiated approach to assessing their impact on specific ecosystems (Xiao, 2020). Considering the importance of a differentiated approach to assessing the impact of the coal mining industry on changes in the environmental situation, noted by previous studies in this area (Zhang, 2022), our observations focused on the general state of species diversity in the Tash-Kumyr region in order to determine the criticality of its change. In addition, special attention was paid to methods of reclamation of lands exposed to unfavorable factors as a result of anthropogenic impact.

METHOD

The following methods and techniques of ecological assessment of the territory were used to assess the species change of ecosystems and to form prognostic conclusions: visual observations and descriptive methods of territory assessment; comparative methods of territory assessment; botanical method of territory assessment; key site method (The key area method is a method of assessing various characteristics of an area (e.g. vegetation cover, raw material reserves, etc.) by studying small, representative areas of the area under study and then generalizing the results to the entire area); route method (The route method, or routing, is the process of selecting the best path between two points in a network) (Figure 3). The objects of observation were two sites on the territory of coal mines, located on both sides of the Naryn River. The first site (Figure 1) was located on the left bank of the Naryn River in a circle with a radius of 1 km with the center at the point $41^0 22' 28.34''$ and $72^0 15' 36.22''$. The second site (Figure 1) occupied the same area on the right bank of the Naryn River with the center at the point $41^0 22' 28.11''$ and $72^0 12' 51.77''$.

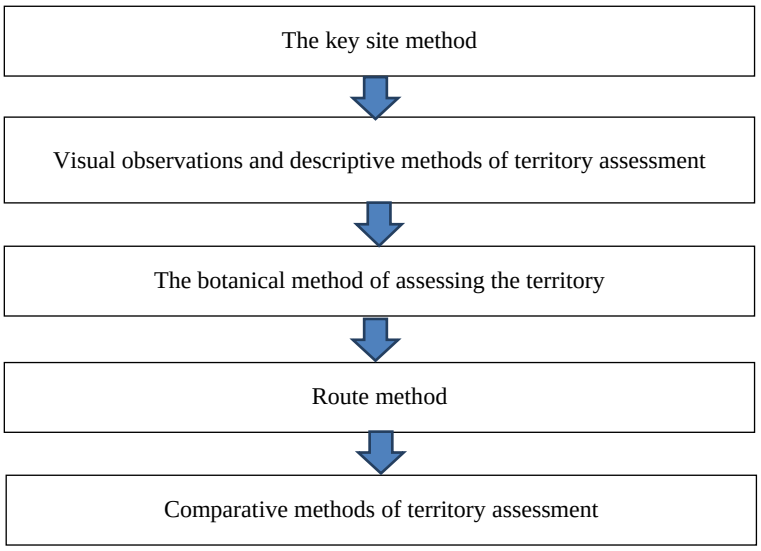

Figure 3. Stages of application of research methods

The information basis was the floristic descriptions contained in the materials of observations and experimental studies of the employees of the Research Institute Botanical Garden named after E. Gareev of the National Academy of Sciences of the Kyrgyz Republic, Kyrgyz National University named after J. Balasagyn and scientific experts. From the observational approaches, traditionally used ground data and field photographs were selected. The calculations used data from the National Statistical Committee of the Kyrgyz Republic. The basis of the proposed methods for solving the described problems was the database of regulatory legal acts of the Kyrgyz Republic.

RESULTS AND INTERPRETATION

Land use and climate are the most important factors in changes in vegetation composition and biodiversity (Treshkin, 2011; Sala, 2000). The geography, climate conditions and mining and technical characteristics of the Tash-Kumyr open-pit coal mine have had an impact on the environment of the region for the last 100 years.

This impact has been most intense over the last 50 years. In Tash-Kumyr, coal is mined in an open way, which leaves plots of land that are almost impossible to use. In this case, the existing species composition of vegetation is completely or partially destroyed, the genetic profile of the soil is destroyed (Figure 4).

Changes in habitat lead to the displacement or destruction of wild animals, deterioration of air quality, and changes in the land use process. The general profile of the earth's surface also changes (Figure 5). In place of previously existing natural landscapes, new structures (dumps) are formed, representing a catastrophic succession of natural geosystems, where the overgrowing of the disturbed surface occurs without human intervention. Previous studies have shown that the degree and speed of natural overgrowing of the soil cover with vegetation depend on the quality of overburden rocks (Chibrik et

al., 2022). The presence of toxic components in waste dumps significantly slows down or completely blocks the overgrowing process. In addition, climate, namely the water regime of the territory, has a significant impact.

The reduction in plant species diversity in the open-pit coal mine, in addition to changing the food supply of wild animals and displacing them from their usual habitat, entails a change in the biogeocenosis. The disruption of the relationships between individual components of the natural environment - between organisms, the atmosphere, water, soil and rocks - entails a change in the entire ecosystem (Mursaliev & Ernazarova, 2017; Carrick & Forsythe, 2020).

Figure 4. Dumps of unused rock cover hundreds of hectares of natural land surface North-Eastern quarry in the area of the first landfill, (Source: Author's, 2016)

Figure 5. The cut sites look like scars on the Earth - Northwest quarry in the area of the second testing ground (Source: Authors, 2021)

The overburden rocks of the Tash-Kumyr open pit are non-toxic and are represented by argillites, siltstones, sandstones and quaternary cover loams of varying thickness. The rocks of the dumps have high water permeability due to the rubble-stony fractions of argillites and fine earth of clay rocks. In combination with a small annual amount of precipitation (154.31 mm), hot summers and cold winters, quite difficult conditions are formed for the intensive development of natural vegetation. The depth and nature of the distribution of the plant root system are of great importance in the formation of the geochemical profile of the biogeocenosis. The bulk of the roots of most herbaceous plants, especially annuals, extend to a depth of 1.0–9.0 cm. The roots of some perennials (wormwood, astragalus, etc.) can reach a depth of 5.0–10 meters or more. The roots of some desert and steppe shrubs of the Kyzyl-Dzhar tract (*Caraganaleucophloea-Pyrovskia abrotanoides, Spireahypericifolia, Convolvulus pseudocantabrica, Halimodendronhalodendron, Cerasustianschanica, etc.*) deepen to 12 meters or more. The depth of distribution of the roots of most shrub plants of the desert and steppe zone of the Tegene River basin is within 3.0–8.0 meters (Mursaliev & Ernazarova, 2015; 2017).

Figure 6. Restoration of vegetation on the slopes of dumps of northwestern coal mines (Source: Authors, 2021)

The root and above-ground masses of plants are very large even in herbaceous annuals. In the horizons of maximum distribution of fine roots, the most intensive biological absorption of some elements and the release of others into the environment occurs. With the mass backfill of natural landscapes with rock, the vertical amplitude of the biological cycle of substances is significantly reduced or stops altogether, locally changing the ecosystem. The process of restoration of natural plant landscapes takes tens of years. Observations of vegetation directly in the dump zones showed that complete destruction of species does not occur. Beyond the dump territory, the species diversity of plant life noted before the development of the Tash-Kumyr coal basin is actually preserved.

At present, partial restoration of natural flora is observed in the areas of 50-60 year-old dumps. The main pioneers of the dump slopes are the following herbaceous plants: *Festucavalesiaca* – Valaisian fescue, *Poarilaxa* – narrow-leaved bluegrass, *Stipacaucasica (capillata)* – Caucasian feather grass, *Tanacetumvulgare* – common tansy, *Kochiaprostrata (L) Schrad* – prostrate kochia, *Artemisiatianschanica Krasch* – Tian Shan wormwood (Figure 6).

Among the tree species that actively inhabit waste dump areas and other previously degraded areas, it is necessary to note some species of perennial shrub plants of the genus Tamarix (*Tamarix L.*) (Barvinok et al., 2021) (Figure 7).

As for invasive plant species, which, according to some scientists, actively populate the territories of coal dumps (Goswami, 2015), we have noted the appearance of woody plants of the genus Ailanthus (*Ailánthus altíssima*) (Figure 8). However, the appearance of this plant species has been noted throughout the territory of Kyrgyzstan over the past 50 years.

Figure 7. Tamarix growth in the floodplain, tributary of the Naryn River, Jalal-Abad region (Source: Authors, 2021)

Figure 8. Ailanthus (*Ailánthus altíssima*) (right bank of the Kara-Unkur river) (Source: Authors, 2021)

It is known that, compared to underground coal mining, opencast coal mining disrupts regional land use and landscape patterns, as well as biological habitats, to a greater extent, which leads to serious changes in the functions of ecosystem services in the coal mining area and seriously hampers regional economic and social sustainable development and the well-being of residents (Caillault et al., 2012; Donbaeva & Shamshiev, 2013; Narynbek, 2022; Safarov et al., 2024).

Figure 9. Flowering Tamaix plant (southern shore of the Toktogul reservoir (Source: Authors, 2021)

Figure 10. Population of desert floodplain areas with Tamarix plants in the suburbs of Jalal-Abad (Source: Authors, 2021)

However, in the Tash-Kumyr opencast area, we cannot confirm such a trend due to the fact that the dump areas are semi-steppe, turning into semi-desert landscapes, unsuitable even for pastures. In addition to coal mining, anthropogenic

impact on the environment of the Tash-Kumyr region is also manifested in the uncontrolled development of clay quarries. During clay mining, depression funnels are formed, the area of which can reach hundreds of square kilometers. There is a shallowing or complete disappearance of nearby rivers and streams, flooding or swamping of developed areas, dehydration, salinization of the soil layer, resulting in damage to land and water resources.

Also, in the vicinity of the city of Tash-Kumyr, unlicensed mining of sand and gravel materials is carried out. The result of this is the disruption of river beds, water erosion, gully formation, which ultimately leads to possible loss of land. Observations of the vegetation of clay and sand quarries demonstrate the presence of the above-mentioned species in their species composition, but with some bias towards Tamarix. In conditions of periodic (regularly once every 2-3 years) mudflows, herbaceous vegetation takes root worse than this unpretentious shrub. Coal mining production is one of the most powerful factors of environmental destruction. The exploitation of the Tash-Kumyr coal deposit, where huge coal reserves are concentrated in a limited area, determines the inevitable transformation of natural landscapes into man-made ones, caused by subsidence of the earth's surface, extraction of minerals from the depths, formation of quarries and formation of mountains of waste dumps on an area of several hundred hectares.

CONCLUSION

Existing coal mining technologies lead to the destruction of the main components of the biosphere - the soil and vegetation cover of the earth, the upper layers of the lithosphere and hydrological conditions over large areas.

However, changes in biocenoses in the Tash-Kumyr coal mine area are local in nature. They are not critical for the overall ecosystem of the region, unlike threats to nearby ecosystems noted by other studies (Donbaeva et al., 2024). With regard to the continued exploitation of the Tash-Kumyr coal deposit, we adhere to the point of view of researchers who believe that "It is our opinion that the interest of the mining industry is better pro-tected by enshrining best practice in legislation rather than opposing it" (Amezaga & Younger, 2004:10). We also support advocates for the development of multidimensional, collaborative solutions that are based on broad participation of different social segments and take into account the diverse needs of communities (Sutrisno et al., 2024). One of the options and the most promising, practical way to restore natural landscapes on the territory of dumps and quarries are artificial plantings of endemic plant species resistant to local conditions, a bright representative of which are plants of the genus Tamarix (*Tamarix L.*) (Figure 9).

Representatives of the genus *Tamarix* are dominant in all encountered zones of tugai ecosystems in Kyrgyzstan, both degrading and newly formed (Figure 10). Tamarix is a pioneer in the colonization of various quarries, mudflow routes and alluvial floodplain deposits, which allows us to recommend its use to solve the problem of widespread degradation of tugai forests in modern rapidly changing environmental conditions.

The use of this plant species is also of great importance in the landscape construction of settlements located on sites with poor irrigation or on frankly waste lands (Barvinok et al., 2023).

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