Natural Restoration of Biota According to Earth Remote Sensing Data

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Abstract. Studies of the problem of natural recovery of biota are carried out within the boundaries of the influence of the closed mining enterprise "Kerbinsky mine of the Far Eastern Federal District from 2001 to 2011 Intensive development of gold and suprem deposits in the study area in the last century led to a huge accumulation of highly toxic mining waste. For their placement, the lands of the forest fund were seized. Large areas are disturbed here, where there is a weak natural renewal of vegetation. In this regard, the purpose of the study was to study the process of natural recovery of biota according to remote sensing data to ensure the environmental safety of gold mining. Based on the goal, the following tasks are defined: 1. Analyze and summarize the literary data on the named problem; 2. To study hyperspectral images, their decryption process, to analyze the relationship of the granulometric composition of soils with spectral reflectivity; 3. To calculate the areas of land disturbed by placer gold mining; 4. Develop proposals to reduce the negative impact of a mining facility on biota. Spectral analysis established high concentrations of compounds of copper, lead, zinc, mercury not only in waste, but also in environmental components. Experimental studies were conducted using methods of remote sensing of the Earth. The NDVI index was calculated, according to the formula NDVI = NIR - R / NIR + R, where NIR - the reflection coefficient in the near infrared region of the spectrum; RED - reflection coefficient in the red region of the spectrum. With the help of this index, the contours of the disturbed lands were also highlighted. The analyzed data indicate that in recent years (2011-2021) the area of disturbed land is increasing. The results of the NDVI calculation showed that in the summer months along the river valleys of the Kerbinsky mining region, it is 0.15-0.25, which indicates the absence of vegetation or a low degree of development of the green mass. The root vegetation is completely destroyed. These guidelines, written in the style of a submission to J. Phys.: Conf. Ser., show the best layout for your paper using Microsoft Word. If you don’t wish to use the Word template provided, please use the following page setup measurements.

1. Introduction
In the study area, the development of gold deposits began since tsarist times. When developing them in an open and closed way, huge mine workings remain on the earth’s surface - ditches, clearings, quarries, tunnels and often significant dumps of subserdinational ores and containing rocks [1].
Overburden dumps according to [1] are divided into different groups: according to the mechanical composition of the debris, their location, the nature of technogenesis, the relief of the surface, the chemical composition of the rocks, the acidity of the environment, the possibilities of utilization, the stages of evolution. Their creation leads to significant changes in the environment: the destruction of soil and vegetation cover, changes in the level of groundwater, the strengthening of exogenous relief-forming processes, etc. Researchers have established a very weak natural overgrowth of lands disturbed by gold mining within the boundaries of the closed mining enterprise "Kerbinsky mine". Of scientific interest is the use of methods of remote sensing of the Earth. Thus, the article by Yu.P. Galchenko et al. (2019) [2] presents the results of the study of the spatio-temporal dynamics of the natural recovery of components of natural and technical systems in the zone of impact of mining enterprises. Monitoring of the area impact of mineral resource development processes on high-resolution satellite images was carried out. Indicators-indicators of biomass quality measured in the process of satellite monitoring, including spectral brightness coefficients, are investigated. On their basis, vegetation indices of vegetation (NDVI) are calculated. As a result of the analysis and assessment of the current state of the problem of restoration of disturbed territories, the main criteria for the sustainable development of natural and technogenic systems have been determined. Yu.P. Galchenko and co-authors believe that, using space monitoring data, with a sufficient degree of reliability, it is possible to quantify the integral level of technogenic inhibition of phytocenoses of natural biota outside the land allotment of mining enterprises, as well as to determine the indicator of ecosystem resistance to the impact that changed the state of phytocenosis (Ku) and the time of its self-healing (TSV).

I.K. Lurie (2008) in the work "Geoinformation mapping. Methods of geoinformatics and digital processing of space images" argues that the most important source of relevant and operational information from any point of the earth's surface today is remote sensing of the Earth - remote sensing [3].

According to I.K. Lurie et al. (2017), satellite images serve as the basis for thematic layers in geographic information systems (GIS), keeping data up to date, monitoring territories and other purposes [4]. The data of S.V. Dubovikova et al. [5] indicate that GIS technologies contribute to the effective use of Remote Sensing Data of the Earth. Objective processing of information on satellite images allows you to regularly analyze and study the state of the environment, as well as the dynamics of phenomena [6].

A brief analytical review of the literature indicates that the problem of natural recovery of biota using remote sensing methods of the Earth in the study area is not sufficiently studied. In this regard, the purpose of the study was to study the process of natural recovery of biota according to remote sensing data to ensure the environmental safety of gold mining. Based on the goal, the following tasks are defined: 1. Analyze and summarize the literature data on the named problem; 2. To study hyperspectral images, their decryption process, to analyze the relationship of the granulometric composition of soils with spectral reflectivity; 3. To calculate the areas of land disturbed by placer gold mining; 4. Develop proposals to reduce the negative impact of a mining facility on biota.

2. Materials and methods of research
Research within the boundaries of the Kerbin gold-bulk node (on the territory of the closed mining enterprise "Kerbinsky mine") has been conducted by the Institute of Mining since 2001 [7,8]. The methodological basis was the teaching of academician V.I. Vernadsky about the biosphere and noosphere. Areas with varying degrees of degradation associated with gold mining waste were selected as model objects. Images of the Kerbinsky mining district were downloaded from the Glovis resource archives of the format.tar.gz the territory of the Khabarovsk Territory (Fig. 1) [9,10]. The hyperspectral image in Figure 1 of the Landsat 8 satellite of the Kerbinsky mining district of different spectral ranges shows that large areas of land have been disturbed by mining operations in the Kerbin mining region.
The calculation of the NDVI index was carried out according to the formula:

\[
\text{NDVI} = \frac{\text{NIR} - \text{R}}{\text{NIR} + \text{R}},
\]

where NIR is the reflection coefficient in the near infrared region of the spectrum; RED - reflection coefficient in the red region of the spectrum. To calculate the NDVI, layers B4 (R) and B5 (NIR) of the Landsat 8: LC08_L1TP_114023_20210706_20210713_01_T1_B4.tar satellite image, LC08_L1TP_114023_20210706_20210713_01_T1_B5.tar were loaded into the Qgis program. Through the raster calculator function, a formula is introduced, then the NDVI index map shown in Figure 2 is built in the program. This index makes it possible to clarify the locations and contours of technogenic placers [11,12].

**Figure 1.** Hyperspectral image of the Landsat satellite 8 of the Kerbinsky mining region: spectral ranges (channels) – 755, 652, 765, 543.

**Figure 2.** NDVI Index of the Kerbin mining region. Landsat 8 6.7.2021 Qgis 3.18 designated landfills (Fig. 3).
Figure 3. Digitization of the Landsat 8 satellite image on 07.07.2018 in the Qgis 3.18 program.

Figure 4 shows the calculation of the area of disturbed lands of the Kerbin gold-bulk region in the Qgis 3.18 program.

| Polygon | Area (ha) |
|---------|-----------|
| 1       | 1.541     |
| 2       | 1.433     |
| 3       | 0.021     |
| 4       | 0.029     |
| 5       | 0.178     |
| 6       | 0.27      |
| 7       | 0.819     |
| 8       | 0.819     |
| 9       | 0.034     |
| 10      | 0.111     |
| 11      | 0.036     |
| 12      | 0.034     |
| 13      | 0.356     |
| 14      | 0.069     |
| 15      | 0.007     |
| 16      | 0.618     |
| 17      | 0.649     |
| 18      | 0.138     |
| 19      | 0.031     |
| 20      | 0.025     |
| 21      | 0.025     |
| Total   | 10.549    |

Figure 4. Calculation of the area of disturbed land in the program Qgis 3.18.
3. Results and discussions

Analysis of literary data shows that 50,100 kg of gold was mined on the territory of the Kerbin mining district, while mercury losses amounted to 12525 kg. In the village of Briakan, which is located between the Kur-Angun and Khingano-Burein mercury zones, the mercury content in technogenic soils and dumps is 60 mg / kg, in the surface waters of artificial reservoirs 0.032-0.96 mg / dm³ [6].

By the nature of the relief, the Polina Osipenko district is divided into two parts, sharply different from each other: two-thirds of its territory is occupied by multi-height mountain structures. And some spaces are heavily swampy alluvial and lake-alluvial plains [13].

It has been established that several mineral associations are present in the waste of the Kerbinsky mine: garnet-magnetite-ilmenite, gold-quarry, tungsten. The main minerals are: tungscoinite, ilmenite, magnetite, garnet, hematite, scheelite. Limonite is widespread. Of secondary importance are: cassipirite, arsenopyrite, galenite, epidote, zircon, pyroxene. These data are consistent with the studies of Ostapchuk V.I., Nagorny V.A., Van-Van-E A.P. and others [14]. Of the large number of various chemicals entering the environment from man-made sources, a special place is occupied by compounds of heavy metals [15]. The intensive development of mining industries led to their accumulation in the components of the natural environment, and, consequently, to the deterioration of the environmental situation [16].

The application of remote sensing data of the Earth and the creation of methods and automated technologies for the study of technogenic pollution, and assessment of satellite images of territories damaged by gold mining, expand the ability to control any site [17].

The development of information technologies and the emergence of high-resolution and ultra-high-resolution satellite images make it possible to successfully solve problems in the analysis of pollution and dynamics, as well as in identification [18].

In the course of the research work, satellite images of Landsat 8 (Pixel size: 15 meters / 30 meters / 100 meters (panchromatic / multispectral / far infrared channel) from the Glovis resource were analyzed. For visualization, analysis and processing of remote sensing data of the Earth, the Qgis 3.18 program was used. In the thematic processing of remote sensing data, the main task is to determine the characteristics of mining objects on the earth's surface, compare them with natural objects, a control area, for example, a forest [12]. For these purposes, as a rule, multispectral (or even hyperspectral) images are used, that is, images that record reflected light not only in the optical range, but also in spectral ranges invisible to the human eye. When creating composite images (both color-synthesized and multi-temporal), data pre-processing was performed, namely, the images were transformed into one coordinate system with the same spatial resolution.

Each object has a characteristic spectrum corresponding to its chemical composition: when sunlight hits the object, some wavelengths are absorbed by chemical bonds, and the rest are reflected.

The study of the characteristics of reflectivity provides a theoretical basis for interpreting objects by a set of their spectral brightnesses or their relationships. Classical are the studies of E. L. Krinov [19], who developed a spectrometric classification of natural formations in the visible region of the spectrum, which are then continued in the IR region. He divided all the variety of landscape objects into four classes, each of which has a peculiar curve of spectral brightness.

In the process of decrypting the images, in addition to spectral characteristics, the texture and structure of the terrain were also taken into account. It has been established that class I - rocks and soils - is characterized by an increase in spectral brightness as it approaches the red zone of the spectrum. Class II - vegetation cover - is characterized by a characteristic maximum of reflectivity in green, a minimum - in red and a sharp increase in reflection in the near infrared zone. In the green and red zones, this behavior is associated respectively with the reflection and absorption of rays by chlorophyll, and the large values in the IR zone are explained by the transmission of infrared rays by chlorophyll and their reflection by the internal tissues of the leaves, i.e. the influence of the structure of the foliage. Class III - water surfaces - are characterized by a monotonous decrease in reflectivity from the blue-violet to the red zone of the spectrum, since with increasing wavelengths they are more strongly absorbed by water. Class IV - snow surfaces and clouds close to them - have the highest values of spectral brightness.
with a slight decrease in the near IR zone. The decrease increases dramatically when the snow is saturated with water.

Spectral reflectivity also differs in objects of the same class, which is associated with various factors: the state of the object, moisture, granulometric composition, etc. [19].

With the help of satellite images, the main types of disturbed lands were determined: primary mining grounds, quarries, dumps, tailings, tailings. The calculated NDVI index made it possible to identify problem areas of oppressed vegetation, making it possible to make the most correct decisions in the long term. With the help of this index, the contours of the disturbed lands were also highlighted. In addition, a plan for integrated rehabilitation, rational reforestation after mining in general and further environmental management in particular has been developed [20].

When studying ecosystems within the boundaries of the influence of gold mining, it was established that the indigenous vegetation was completely destroyed. The process of self-overgrowth proceeds unsatisfactorily, the weed-pioneer group prevails.

On overburden dumps there was a tendency to form a primitive underdeveloped soil profile.

Assessing waste as a potential source of pollution of natural systems, data on their primary halos in host rocks extracted during the opening of minerals by mine workings and moved to "rock" dumps, as well as data on the composition of the rock mass entering for enrichment, were taken into account. The degree of accumulation of toxic elements in waste and wastewater was taken into account.

Early studies of the Institute of Mining 2001-2007 found that the material composition of waste is diverse: according to spectral analysis, they noted a high content of Cu - 4.4 mg / kg, Pb - 10.0 mg / kg, Zn - 3.1 mg / kg. Dumps are practically not isolated from water systems. There is a constant migration of heavy metals and their accumulation in the components of the natural environment [14].

Technogenic mining areas receive a powerful flow of heavy metal compounds in comparison with background natural systems and contribute to the formation of natural and technogenic systems with high concentrations of pollutants in all components of the natural environment. The data of chemical analysis of soils indicate that the content of chemical elements in them is abnormal (lead, copper, arsenic) [8].

In soils with technogenic pollution, the accumulation of toxic metals is traced, which accumulate along food chains and have a negative impact on soils, water, and biota [7].

Analytical data of the images correlate with early studies of the IGD OF the Far Eastern Branch of the Russian Academy of Sciences: for 20 years of observations of the mining system, there is a significant degradation of the landscape in a large area [10], and areas of oppressed forest near tailings dumps expand by 3-6 times. In general, the gold mining enterprises of the Far Eastern region continue the trend of accumulation of land disturbed by mining, the total area of pollution increases. Reclamation is practically not carried out [6].

It has been established that for the study of soils and contouring, the most suitable are color images synthesized by groups of spectral bands (channels) 6-5-4 and 7-5-3 produced in the leafless and snowless period, i.e. in spring or summer [19]. Range 7-6-5 - does not include any visible range, is optimal for the analysis of the atmosphere; 4-5-1, 6-5-4, 6-5-2 for the analysis of vegetation and agricultural land; 6-4-5, 6-5-2 - convenient for vegetation cover and is widely used for analysis of the state of forest communities; 5-6-2 - used to determine the age of vegetation and use in parallel 3-2-1 for comparison.

4. Conclusion
Decoding images and analyzing various combinations of channels of the visible range allows us to study the technogenic impact on the environment, take into account most of the factors of change in disturbed lands and self-overgrowth processes. The NDVI index of the study area is 0.15-0.25, which indicates the absence of vegetation or a low degree of development of green mass. The analyzed data indicate that in recent years (2011-2021) the area of disturbed land is increasing. To reduce the negative impact on the habitat, it is recommended: to organize mountain-ecological monitoring of ecosystem changes, including using remote sensing, reclamation and cleaning of the territory from mercury pollution; development of new mining technologies that meet the requirements of geoecology.
5. References

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Acknowledgements
Authors wishing to acknowledge that the study was carried out with the financial support of the Russian Foundation for Basic Research (RFBR) within the framework of the scientific project No. 20-35-90021.