TECHNOGENIC TRANSFORMATION OF THE ENVIRONMENT OF THE BELGOROD REGION IN THE FIELD OF PRODUCTION OF COMMON MINERAL RESOURCES (CM)

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Abstract

The article notes the complex technique of environmental assessment of industrial transformation of geosystems influenced by open-pit mining of widespread minerals on the territory of the Belgorod region. During the research the areas within the region, characterized by various degrees of resistance to mining impacts and different acuteness of the geoecological situation caused by the extraction of common minerals were identified. The result of its comparison was a comprehensive evaluation of geo-ecological state of geosystems in the impact zone of the common minerals mining enterprises.

Keywords

Transformation of the environment, common minerals (CM), geosystem, geoecological evaluation, extraction, technogenic transformation, mining impacts, reclamation activities.

The Belgorod region is located in the south-west of the Russian Federation, its area is 27 thousand km2, and the region is part of the Central Federal District (CFD). Currently in the region more than 300 deposits of non-metallic common minerals (CM): sand, clay, loam, chalk are mined. Due to the shallow occurrence of raw materials, as well as taking into account the economic benefits, the production of non-metallic common minerals in the region is mined by the open method.

Open-pit mining of raw materials is accompanied by a fundamental transformation of the component of sustainable geosystems - the lithogenic base; there is a destruction of the soil cover, natural vegetation; changes of hydrogeological conditions of the territory; air pollution; changing the natural habitat of the animal world, etc. [4]. It is obvious that extraction of CM by the open method has a powerful comprehensive impact on all environmental components.

In the future, the pace of economic development of CM in the Belgorod region will be increased rapidly, thus, further development of the industry of construction materials will occur due to the use of its own mineral resources, so the geoecological estimation of the current status of pit dump areas for the extraction of the CM is an urgent task.

Pit-dumping complexes are geotechnical systems (GTS). The concept of "system" A.D. Armand characterizes through the properties of integrity, character, value, direction of the links between its elements [1]. According to A. Y. Reteume, geotechnical system is a technical system for systematic environmental effects in conjunction with areas of the earth surface under its control, forming integrated system due to the contour of the control links [3].

Geotechnical system includes natural, technical and management units [2]. *Natural unit (geosystem)* is the set of natural systems or their components, acts as a factor in the localization of objects of the mining industry.

The technical unit is a system of open-pit mining in conjunction with the pre-stripping and mining.

The administrative unit is a center for coordinating the work of the technical system, including maintenance with all technical facilities.

The evaluation of geoecological state of common mineral resources open mine workings was conducted in 3 stages.

I stage. We estimated the stability of the Western, Central, Eastern and South-Eastern areas, corresponding to the 4th physical-geographical regions represented in the Belgorod region: Sudzhansky district of the typical steppe, Oscola-Donetsk cretaceous area, Don cretaceous and Kalitvinsky wavy beam south forest-steppe district. The scheme of physical-geographical zoning of the Belgorod region was described in the work "Physical-geographical regionalization of the Central Chernozem regions" edited by F. N. Milkov [7].

Pit-dumping complexes has been formed within each of the 4 physiographic regions represented in the Belgorod region, so physical-geographical regions act as the territories, carrying mining impacts in various degrees.

The determination of geosystems mining impact sustainability indicators involves scoring and it is conducted with using a set of criteria, ranked according to their significance for the conditions of open-pit mining: the slope of the surface; type of sediments composing the territory; depth of the groundwater; the structure of the ecological network; the content of humus in the soil; the degree of soil erosion; hydrothermal coefficient; primary biological productivity.

Geosystems with varying degrees of resistance respond to mining impacts in different ways, which determines their ability to resist the impact or recover their former properties after mining operations.

Table 1: The distribution of points of the geosystems sustainability criteria to mining impact on the level of resistance

№ p/p	Criteria	The level of stability		
		low	middle	high
1	Surface incline	7.3	14.6	22
2	Type of sediments, forming the territory	6.6	13.3	20
3	Ground water depth	5.6	11.3	17
4	The structure of ecological frame (area of anthropogenic constituent of ecosystem)	4.6	9.3	14
5	Humus content in soils	3.6	7.3	11
6	The degree of soil erosion	2.6	5.3	8
7	Hydrothermic coefficient	1.6	3.3	5
8	The primary biological productivity	1	2	3
Total		min 32.9	66.4	max 100

Geosystems with *a low degree of resistance* (32.9 – 55.3) to the mining impacts are subject to rapid and intense changes, even at low mining pressure. Thus, there is a profound violation of self-regulation, reduction processes occur very slowly. To maintain environmentally safety state of geosystems in the shortest period of time is necessary to carry out the complex of measures on optimization of disturbed lands.

The average stability of geosystems (of 55.4 – 77.8) demonstrates the ability to withstand more prolonged and large-scale impact, while retaining the ability to heal itself, provided that the individual rehabilitation works.

Having *a high degree of stability* (77.9 – 100) geosystems able to withstand a long and heavy pressure. They are characterized by active formation of anthropogenic successions that does not exclude the additional activities on reclamation, in addition to those envisaged by the project.

Table 2: The sustainability of different areas (geosystems) indicators in the Belgorod region to mining impact

The name of the area	**∑ points**	**Degree of resistance**
Western	83,2	High
Central	72,8	Average
Eastern	54,1	Low
Southeastern	51,4	Low

The calculations allowed us to identify the areas with different degree of geosystems stability to mining impacts within the Belgorod region. The Western area is characterized by the high degree of stability. The Central area corresponds to the average degree of sustainability. Eastern and South-Eastern areas correspond to low resistance.

Spatial distribution of geosystems of the Belgorod region with varying degrees of resistance to mining impacts is reflected in Fig. 1.

II stage. Determining the severity of the geo-ecological condition of the territory, caused by CM open mining is also based on the point estimates on a set of criteria: stage of the mining landscape development; kind of extracted raw materials; amount of raw materials; efficiency of the mining dump using; area of pit field.

The combination of criteria is considered within each of the 4 areas, corresponding to physical-geographical areas, on key CM fields OPIE, within its boundaries.

Table 3: The distribution of scores of the severity geoecological condition criteria (in the levels)

№ p/p	Criteria	Levels		
		low	Middle	High
1	Stage of mining and industrial landscape development	11	22	33
2	Kind of the extracted raw materials	9	18	27
3	Amount of raw materials	6.7	13.4	20
4	Area of pit field	4.3	8.6	13
5	Efficiency of the mining dump using	2.3	4.6	7
Total		min 33.3	66.6	max 100

The *acuteness* of geo-ecological condition of the territory is determined by the territorial combination of environmental problems caused by open mining activities and their intensity. Its intensity increases with the spread of violations on all the components of nature.

Satisfactory geo-ecological condition of the territory (33.3 – 55.5) is characterized by complete cessation of mining operations (quarries conservation; carrying out the remediation complex) or by minor scale and intensity of violations of the geological environment. Overburden is suitable for biological reclamation (Quaternary loam, sandy loam) [5]. In pit dump complexes set the stage of the technogenic succession and recovery of the biota, the process of slowing the geodynamic processes.

With intense geo-ecological state of the territory (55.6 – 77.8); the mining impact continues, the size of the career field is increased, vegetation is destroyed, hydrological conditions are not violated, or are affected only slightly. Overburden is unsuitable for biological reclamation (sands) [6], the occurrence of anthropogenic successions - slow.

Conflict of geo-ecological condition of the territory (77.9 – 100) is observed in the case when mining developments affected all components of the geosystem: the lithogenic basis, hydrogeological conditions, atmosphere, biota. This type of situation is typical for the largest pit dump areas, in particular, it concerns the overburden dumps of iron ore pits - Lebedinsky and Stoilensky mining company, on which CM are associatesd raw materials extracted from the thickness of overburden. Typically, the overburden there is of little or no value (limestone, sandstone) [8] for biological reclamation, that complicate the restoration of natural functions that requires restoration of the landscape.

III stage. Comparison of the levels of stability of geosystems mining impact with the acuteness of geoecological condition allowed us to identify the degree of conflict between the natural and the man-made component of geotechnical systems (GTS) and to develop appropriate recommendations for reducing the negative anthropogenic impact on the environment for specific areas with acceptable acute or critical degree of conflict.

Table 4: Matrix of geoecological assessment of environmental status of territories, having a mining impact. The degree of conflict: 1 - acceptable 2 - acute 3 – critical.

Stability of geosystems to the impact of the mining industry	**Acuteness of geoecological condition of the territory**		
	Satisfactory	**Tense**	**Conflict**
High	1	1	2
Average	1	2	3
Low	2	3	3

This technique allows identifying three degrees of conflict between natural and anthropogenic components of geotechnical systems.

1. *Acceptable level* is characterized by the fact that the limit of stability of geosystems has not been reached yet, there is still functioning and ability of the recovering after anthropogenic impacts. The reclamation on this site will be effective.

2. *Acute degree of conflict*. The limit of stability of the natural component is reached, the ability of the landscape to restore fully engaged. The increase of mining pressure is undesirable, it will exacerbate the conflict. It is necessary to conduct active measures to restore natural components in parallel with mining operations and, of course, upon its completion.

3. *The critical degree of conflict*. The threshold of stability of geosystems is exceeded; the mining pressure is not correlated with its possibilities. Functioning and self-regulation is violated. The irreversible changes are possible. It is necessary to reduce the level of mining impacts and to adopt comprehensive environmental measures for optimization.

An acceptable degree of conflict is typical for most quarries, considered within the West of the mining area, except of the Polygon Belgorod deposit of chalk. Also the pits of the Central mining area with satisfactory acuteness of geoecological condition of the territory are belonged to acceptable degree of conflict level. Acute degree of conflict is characteristic for the most of the quarries of the Central mining area, where the geoecological situation is characterized as tense, and the degree of stability of geosystems is pointed as the average.

Pit-dumping complexes, characterized by a critical degree of conflict on the territory of Belgorod region located in Eastern and South-East of the mining area. The acuteness of geo-ecological state of the territory within these quarries is characterized as tense, and natural potential for healing processes is quite low. Further increase in the mining load is highly undesirable, it will exacerbate the conflict. It is necessary to conduct active actions for restoration of disturbed landscapes in parallel with mining.

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