Physical Geography

Natural Anthropogenic Mining Complexes and the Problems of their Optimization

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ABSTRACT. The present work concerns optimization issues of natural anthropogenic industrial mining complexes. Particularly, statistic interrelation between physical and geographic factors and reclamation time period is obtained by means of linear regression analysis. In combination with appropriate empiric data base, it allows to make scientifically well-reasoned statement about optimization of environmental conditions. © *2007 Bull. Georg. Natl. Acad. Sci.*

Key words: *landscape, landscape and ecologic situation, natural territorial complex (NTC).*

Realization of a complex approach to nature protection and rational use of natural resources is one of the basics of stable development of a country. Complex studies are of exceptional significance in mining regions, where proceeding with industrial processes without consideration of the sensitive landscape and ecologic situation is impossible.

It needs to be noted that natural landscapes formed as a result of technogenesis substantially differ from the earlier complexes by their morphologic parameters, structure and biocenosis as well as by substance circulation, biologic production and specifics of industrial utilization. In an ore extraction zone (within radiuses starting from several tens of meters to several kilometers) disturbance of the natural balance formed over many centuries takes place and a significant part of the agricultural lands gets out of use. There are several hundreds of hectares damaged in this way in Georgia, forming a considerable part of the entire territory of the country (1.5% approx) [1].

Slowing down of autoregulation of technogenic geologic complexes and activation of rehabilitation processes are possible only by means of different measures of optimization. Hence, the need of treatment of general theoretical issues for functioning of natural territorial complexes (NTC) and physical and geographical regional structures of ore, an extraction zone as well as shedding light on the nature of their space-time dynamics. This requires: a) development of a new approach to the theoretical basics of interaction between nature and society; b) prediction of the ability of autorehabilitation in harsh anthropogenic (technogenic) conditions, c) balanced regulation of utilization of natural resources and reproduction processes in mining zones, d) typification of technogenic complexes, elaboration of zoning principles and cartographic modeling [2].

Of the above mentioned problems, in this paper we shall speak about one of the main problems of optimization of natural anthropogenic mining complexes, such as reclamation.

Reclamation by itself takes place during technical impact on the environment which increases the asymmetry between the landscape components. In other words, it causes relatively fast progress of succession rehabilitation series. Therefore, landscape complex formed by reclamation is impossible to be the same as its pre-exploitation one as tectonic succession is characterized by increased asymmetry between the landscape components relatively to the natural one. Consequently, realization of this kind of landscape optimization has to be carried out sensibly and purposefully [3].

Among many other factors, physical and geographical ones are very important for successful realization of

landscape optimization processes. The time period, being one of the main characteristics of reclamation related to restoration of distorted landscape, also depends on the abovementioned (explanatory) factors. In order to determine this value, studies were carried out on 8 plateaus in Tchiatura district (Rgani, Merevi, Perevisa, Itkhvisi, Bunikauri, Tabagrebi, Mghvimevi and Darkveti) [4].

In order to reveal the relation between different values, methods of mathematical statistics are often used in practice [5]. One such method - regression analysis - is distinguished for the presence of independent (explanatory) and dependent (resultant) variables. Such separation of variables is made by a researcher issuing from the matter of the problem:

$$Y = a_0 + a_1 x_1 + a_2 x_2 + \dots a_n x_n + E,$$

where Y is a value of the dependent (resultant) factor and $x_1, x_2, \dots x_n$ are the independent (explanatory) ones, E is the fluctuation caused by unpredictable (incidental) events. The constant values – $a_0, a_1, a_2 \dots a_n$ are determined by the regression equation.

We have used this method to estimate the reclamation time period of damaged landscapes of Tchiatura ore based on the data obtained from the empiric mining and scientific literature. The following relationship was obtained with rather high statistical validity:

$$Y = 0.0044 x_1 + 0.039 x_2 + 0.006 x_3 + 0.06 x_4 - 0.2702 x_5 + \\ + 0.5587 x_6 - 0.1406 x_7 + 0.003 x_8 + 0.0028 x_9 + 0.0035,$$

where Y is the reclamation time period (resultant factor). The explanatory factors are: x_1 – the power of the roof layer (m), x_2 – the horizontal section of the relief (km/km^2), x_3 – the vertical section of the relief (m/km^2), x_4 – the relief inclination (deg.), x_5 – the soil humus layer thickness (sm), x_6 – indicator of the soil acidity(pH), x_7 – the maximal difference between project and surface indices of the dirt pile (m), x_8 – the dirt pile area (m^2) and x_9 – the dirt pile volume ($\cdot 10^3$m^3).

Elasticity coefficient of i-*th* explanatory factor ($Э_i$) is one of the important statistical characteristics that are used for the analysis of regression relationship:

$$Э = a_i \frac{\overline{x_i}}{\overline{y}},$$

where $\overline{x_i}$ and $\overline{y}$ are average values of i-*th* and output factors. These factors show the amount of percent of change of the dependent factors at 1% change of i-*th* factor when the others stay constant. In particular, for the physical and geographical factors that were selected by us, the following values of elasticity coefficients were obtained:

$$Э_1 = 0.1302, \quad Э_2 = 0.4895, \ Э_3 = 0.0499, \ Э_4 = 0.4042, \\ Э_5 = 0.0833, \ Э_6 = 0.5956, \ Э_7 = 0.0958, \\ Э_8 = 0.1624, \ Э_9 = 0.0617.$$

As one can see, the influence of x_2, x_4 and x_8 factors are important in the region under study.

The accuracy of the obtained statistical dependence is determined by the volume and objectivity of the empiric information. Due to shortage of necessary materials and some other reasons, the maximum needed information was not obtained. So, we have no claim to high accuracy of our results, although prognosis on the mining region optimization with satisfactory correctness is feasible by means of generalization of the obtained dependence and reasonable conclusions about the ecological quality of separate reclamation zones can be made.

ფიზიკური გეოგრაფია

სამთამადნო ბუნებრივ-ანთროპოგენური კომპლექსები და მათი ოპტიმიზაციის პრობლემები

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წარმოდგენილ სტატიაში განხილულია სამთო სამრეწველო ბუნებრივ-ანთროპოგენური კომპლექსების ოპტიმიზაციის საკითხები. კერძოდ, წრფივი რეგრესიული ანალიზის მეთოდის გამოყენებით მიღებულია

რეკულტივაციის დროის ხანგრძლივობისა და ფიზიკურ-გეოგრაფიულ ფაქტორთა სტატისტიკური ურთიერთდამოკიდებულება, რაც სათანადო ემპირიულ მონაცემთა ბანკის შემთხვევაში, შესაძლებლობას იძლევა გამოითქვას მეცნიერულად არგუმენტირებული მოსაზრება რეგიონის ბუნებრივი პირობების ოპტიმიზაციის შესახებ.

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