Concept of eliminating past environmental damage in the area of mining industry of the North Caucasus

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Abstract. The article presents the results of many years research on the surface infrastructure influence of mining industry of the North Caucasus on biosphere components in its area of activity. Considering that industrial mining of ores on the eastern slope of Caucasus Mountains (Sadonskoe silver-zinc deposit) began in the middle of the nineteenth century by Belgian industrialists and continues to the present. The accumulation of heavy and toxic metals in the soil horizon is shown (2.5–3.5 MAC), creating a real threat to health and livelihoods of the population living here. Fragmentary variability of landscapes, leading to the depletion of biological diversity, up to the disappearance of its various types has been revealed. According to the intensity of dust emission and the share of negative sources participation in the overall balance of dust pollution of the area atmosphere, it has been found that man-made deposits of ore processing waste are potential foci of catastrophic processes in the destruction of fencing dams by mountain streams, as they are located on terraced areas of mountain valleys. It is analytically established that safety, both general and environmental, can be achieved only by eliminating these sources from potentially dangerous places.

1. Ecological state of the research object

A specific characteristic of the Caucasian mountain ecosystems is their isolation, isolation with a strongly dissected relief, high gustiness of mountain-valley winds due to the proximity of zones with eternal snow, low barometric pressure of the atmosphere, etc. Air and water flows, solid runoff and gravitational structural anomalies are directed into the system, the most reduced relief areas, valleys of the gorges, where water, solid streams are accumulated, and local currents are largely regulated, and in general correspond to the hydraulic network. In turn, watercourses are a dendrated (branched multi-order) system in which the entire runoff is ultimately integrated into the trunk structure - the main river valley. By tracking the upstream of main rivers (Ardon, Fiagdon, Baksan, Urup, Dzhodzhora, Terek) variations in the content of pollutant substance, one can reach the tributary in each of the above watercourses, and the content of technogenesis ingredients rises above the mouth of the river and sometimes higher due to the release of the ore-bearing deposits into the river bed [1].
2. Research subject and results

Large-scale sampling of bottom sediments ensures prompt screening of the hydraulic network elements into contaminated and background. In the future, with this technology of processing information data in the absence of significant changes in distribution of man-made load on the hydrosphere, background areas can be excluded from research, many times reducing their volume.

Having established a network of monitoring reference stations, it is possible to have data on the distribution of pollutants that adequately reflect the level and nature of chemical pollution of water flows of any valley and territories of the Greater Caucasus mountain ecosystem. These stations will be located in the mouths of different orders streams, in the valleys of which there are sources of relevant pollution [4-6].

The transition from conceptual modeling to a formalized automated model is associated with the accumulation of a significant amount of quantitative information and systematization of the objects cited earlier, content of observations, inclusion of elements of air basin studies, materials of hydrochemical sampling and biological studies of soil and vegetation into the model. A new form for the choice and selection of criteria for assessing the environment state, parameters of permissible and normalized loads on ecosystem objects, especially in the absence of the developed MAC has been proposed. Integrated environmental load on natural environment of a mountain region is determined by formula 1.

\[ E_H = \left( \sum_{n=1}^{N} X_H \cdot \sum_{n=1}^{N} \Phi_H \cdot \sum_{n=1}^{N} B_H \right) \]

where \( \sum_{n=1}^{N} X_H \cdot \sum_{n=1}^{N} \Phi_H \cdot \sum_{n=1}^{N} B_H \) – indicators characterizing chemical, physical and biological deviations in the environment associated with activities of the natural-technical system (mining complex), c.u.;

\( \sum X_H \) – X1, X2, X3, …… Xn – parameters of chemical elements and phenomena affecting pollution and destruction of the environment (according to geochemical soil testing), c.u.;

\( \sum \Phi_H \) – \( \Phi_1, \Phi_2, \Phi_3, \ldots \Phi_n \) – parameters of physical processes associated with activities of the mining and industrial complex include noise, vibration, magnetic, thermal and other forms of environmental impact, c.u.;

\( \sum B_H \) – B1, B2, B3, …… Bn – indicators of unnatural biological processes caused by activities of the mining and industrial complex in the region, housing and communal, animal husbandry, etc., c.u.

Private models are developed for each element of a mountain object; subsequent similar objects can be combined with similar parameters.

The general model of sustainable development of ecosystem includes forms of the considered object negative impact on the hydrosphere, lithosphere and atmosphere through private indicators - on the integral environmental estimation of environmental management efficiency. Environmental load on the natural man-made system environment-infrastructure-mining-society is determined by formula 1 and compared with the normative (if available), and if it is not available, the comparison is made according to the preservation of biosphere basic properties (self-regulation and self-purification) and the acceptability of economic activity intensification or its weakening in the region. Monitoring studies conducted in the zone of influence of the natural-technical system environment-infrastructure-mining-society in the conditions of Sadonsky Lead-Zinc Combine, Tyrnyauz Tungsten-Molybdenum Combine, Urupsk MPC, Kvaisinsky Mine Directorate have found that the content of heavy metals in soils exceeds sanitary norms two or more times. Gross contents of main ore elements along vertical section of the soil to a depth of 1 m, with an interval of approbation of 0.2 m, in the area of Sadonsky LZC activity, showed a stable, sometimes quite sharp drop in the content of heavy metals with depth, which unequivocally confirms the man-made nature of the detected anomaly.
3. Obtained results and their scientific and practical value for the economy

It is established that maximum content of lead and zinc is confined to upper layers of the soil cut. The gross distribution of lead and zinc, relative to their maximum permissible concentrations, is shown in Fig. 1, which confirms man-made origin of lithosphere soil pollution.

![Figure 1. Maximum content of lead and zinc in different layers of the soil cut](image)

Block diagram of the model for the development of man-made environmental loads, including human environment, is shown in Fig. 2.

When a natural-technical system functions, the level of its impact on individual components of the biosphere depends on the integral index of entire system. When any parameter goes beyond the acceptable level, it is necessary to use effective means of neutralizing or reducing the effect of the disturbing factor to restore its normal functioning.

The intensification problem of production, with the continuous growth of requirements for its greening, is typical for all industrialized countries. In general, an integral part of enterprises high efficiency should be a high efficiency of environmental management, which refers to the environmental and socio-economic impact of the natural resources use and the exploitation of natural environment [3].

In this regard, the authors propose to estimate production impact on the environment by its intensification degree, which will make it possible to normalize emissions not by gross volumes, but by its specific values for final products.

Environmental efficiency indicator of $K_o$ in mining enterprises (2):

$$K_o = \frac{\sum \Pi_{Vox} + \sum \Pi_{Vod} + \sum \Pi_{Pochv}}{V}$$

where $\Pi_{Vox}$, $\Pi_{Vod}$, $\Pi_{Pochv}$ – amount of payments for air, water and soil pollution, respectively, c.u.;

$V$ – annual ore production, c. u.

Such a standard characterizes the efficiency of environmental management at a particular enterprise, and also makes it possible to judge environmentally acceptable products of different enterprises from the aggregate of harmful effects on biosphere components, determines technical level of production.
4. Conclusions
1. Accumulation of heavy and toxic metals of technogenic origin in the soil horizon (2.5–3.5 MAC) creates a real threat to health and livelihoods of the population living in this area.
2. Fragmentary variability of landscapes leading to the depletion of biological diversity, up to the disappearance of its various species is noted.
3. Potential foci of development of catastrophic processes remain coastal areas enclosing landfill sites for dams enrichment, since they are located in an area of increased risk when mountain rivers are poured.
4. Proposed indicator of environmental efficiency allows us to judge the environmentally acceptable products of different enterprises by the totality of harmful effects on biosphere components, at the same time determines technical level of production.

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