MINERAL RESOURCES AND ENVIRONMENT

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Abstract

Data on a role of minerals in Mankind development are resulted. Dynamics of negative consequences of mountain manufacture for environment is characterised and the mechanism of its restraint is formulated. Prospects of use of a waste of extracting complexes as stocks for extraction of mineral raw materials are underlined. The scheme of catastrophic destruction of ecosystems of environment is offered during natural vyshchelachivaniye metals and salts. The special attention is given a problem to an estimation of threat of chemicalixation of soils and plants. It is shown that infiuence of metals on biomatter structures is universal and is characterised by regular reduction of crops and deterioration of conditions of ability to live of live substance. The universal model for the description of catastrophic danger of technogenic chemicalixation of biosphere is offered.

Key words

Mineral deposits, development concept, mountain manufacture, environment,chemicalixation, biomatter.

1. Dynamics of consumption of mineral resources

The development of the country's economy is largely determined by the state of mineral resources. Complex development of mineral resources, re-development of deposits and, consequently, reduce of pollution of the environment are assuming ever greater importance [1].

The growth of scientific and technological progress and increase of population of the Earth, demand ever-increasing consumption of mineral resources. 80-85% of the total oil volume, about half of the coal and iron ore extracted in the human history have been consumed only for the last 30-40 years. The consumption of various metals, fertilizers and other minerals increased 3-5 times.

The volume of world market for 2006 shows the variety and quantity of the main metals, used in human activity. The constant rise of obtaining and usage of different metals (from 2 to 5% comparatively to the 2006 level) is run in posterior years (2007-2009).

As modern technology of development and processing of mineral deposits is not perfect and rejectous million tons of gas- and vaporous, liquid and solid wastes, causing total pollution of are released into environment. Location layout of mining and processing enterprises, as well as their impact on environmental pollution, air, water and arable land.

According to data given by many scientists into useful products from some of the extracted raw materials are produced no more than 2%, and more than 98% returns to nature in the form of various waste. In general, in the modern world with an annual extraction of about 25 milliard tons of all kinds raw materials (fuel, ores, building materials, etc.), in the form of finished products are used no more than 1.5 Mrd. t. About 2/3 of extracted volume in the form of various wastes is accumulated in different storages, i.e. dumping sites, tailings and in other long term storages. It should be noted that land resources of many regions are significantly reduced due to subsidence and surface collapse as a result of mining during development of deposits. Changes associated with the disturbance of the surface, significantly influence the biological, erosive and aesthetic characteristics of regions.

2. Ecological-economic estimation

Thus, at present time, emerged necessity to assess both natural and anthropogenic impacts on the environment, as well as need to eliminate the consequences.

Taking into account the fact, that the dumping sites and tailings have a negative impact on the environment, emerged an urgent need to carry out environmental-economic assessment. This assessment allows to define the environment protection with combined account of natural and anthropogenic influence mechanisms, as well as the quantitative use of mineral resources deposits, thereby to assess the avoided ecological damage to the environment.

In present-day conditions in average on every inhabitant of our planet annually are extracted over 20 tons of raw materials. These 20 tons using 800 tons of fresh water and 2500 watt power are processed into consumer products. Output of final products is 2% of the raw material mass [2].

Recycling of wastes, in addition, largely solves ecological problems, because wastes of mining enterprises, occupy the natural lands of hundred thousands hectares. These wastes poison the soil, are dispersed and pollute the atmosphere.

Thus, solid wastes of mining complexes are huge reserves for extraction of mineral raw materials out.

Each chemical element at excess content has toxic properties but its toxicity appears only if it is present in biologically active form and in quantities exceeding the threshold values. At the same time, many ore elements - sulfur, zinc, molybdenum, copper, iron, manganese are necessary for normal vital functioning of organisms, but only at concentrations that do not exceed the threshold: the top, above which the element becomes toxic, and the bottom, below which pathological changes occur in the organism due to the lack of this element. There is given a brief description of the toxicity and human impact on the most common ore elements.

The class of elements toxicity and danger of which has to be taken into account when assessing the risk of mining waste should be defined (Table 1).

Table 1: Toxicity and danger of chemical elements

Classes of danger	Chemical element
I	Selenium, lead, arsenic, zinc, cadmium, mercury
II	Boron, cobalt, nickel, molybdenum, copper, antimony, chromium
III	Barium, vanadium, tungsten, manganese, strontium
Elements, toxicity of which must be revised	Aluminum, sulfur, lithium, bromine, gallium, iron, tin, indium

3. Ecological significance of chemical elements

According to biological importance are defined the major, vitally needed - Mg, Ca, Mn, Fe, Na, K, Co, Cu, Zn, Mo.

Ecological impact of many highly toxic on the environment elements, is poorly studied. This concerns rare and trace elements such as selenium, thallium, tellurium, strontium, and others, that are scattered in volumes comparable with their industrial extraction when developing deposits.

Metal mines of Russia extract to the surface more than 1.3 billion m^3 of polluted wastewater per year. Thousands tons of complex ores are discharged in the form of mineral suspensions. Thus in the tin deposits of the Far East dumping waters contain Cu, Fe and S in concentrations comparable with their concentration in the ores, and for a number of fields the concentration of Zn and Cd exceeds these values.

Parameters of element concentration growth in soil in a result of natural leaching of the dust fractions are characterized by Table 2.

Table 2: Content of ingredients in the hydrosphere, mg / dm^3

Ingredients, mg/dm^3	In the area of mining enterprise	Outside the zone of mining enterprise	Δ
pH	7.0	5.5	1.5
Suspended matter	60	12	48
Solid residue	250	170	80
chemical oxygen demand	50	35	15
Phosphates	0.06	0.04	0.02
Ammohia nitrogen	0.18	0.04	0.14
Nitrites	0.01	0.002	0.008
Nitrates	18	12	6
Chiorides	23.6	10.0	13.6
Total hardness	9.7	6.5	3.2
Iron total	0.17	0.07	0.10
Copper	0.003	0.002	0.001
Lead	0.0015	0.001	0.0005
Zinc	0.002	0.001	0.001
Sulfates	82.33	42.3	40.03

4. Concentration of metals

The concentration of metals in the zone of influence of the enterprise is 1.5-2 times higher than outside it.

Metals that get into the soil with fine-dispersed dust fractions are concentrated in the upper accumulative horizon. Minerals of iron, that play the role of cathode are initiators of natural leaching of metals and salts. Effect of electrode processes occurs at the boundaries of minerals with different potentials [3].

The intensity of natural leaching is defined by the nature and time of contact of solid and liquid media. Increase of water inflow intensifies leaching and the metal content in solutions increases. Leaching occurs throughout complex chemical reactions with the formation of various compounds of the same metal.

Under the air and water influence in the mineral mass progresses katamorphism - destruction of the mineral fractions with heat emission due to decomposition of sulfides.

Waters take into the environment products of natural leaching in the form of compounds Zn SO_4, Cu SO_4, Ca SO_4, and Fe $SO_4 \cdot 7H_2O$. In the secondary tailings of natural leaching remain Zn CO_3, Pb CO_3, Cu CO_3, Pb SO_4 and Fe SO_4. Consequences of natural leaching of the tailings on the environment depends on the ratio of these groups.

Biological activity of soils that sustained a technogenic impact is, evaluated by their compliance with the criterion of vital activity (Table 3).

Table 3: Criterion of biological activity of soils

Depth, cm	Content of humus, %	Density, g/cm^3	Acidity, pH	Content of nitrogen, %	Content of CO_2, %	Content of Ca, mg	Content of Mg, mg
< 10	9.2	-	6.3	0.48	-	43.9	9.6
10-20	7.8	1.1	6.3	-	-	42.8	10.7
20-30	6.0	-	6.3	0.27	-	34.2	9.6
30-40	5.6	1.2	6.4	-	-	33.2	8.6
40-50	4.8	-	6.5	0.23	-	34.2	6.4
50-60	4.5	-	6.7	-	-	27.8	7.5
60-70	3.9	1.3	6.9	-	-	23.5	9.6
70-80	3.2	-	7.0	0.16	-	27.8	9.6
80-90	3.0	1.4	7.4	-	-	30.0	7.5
90-100	1.7	-	7.8	-	0.3	-	-
100-110	1.5	-	8.5	-	3.9	-	-
120-130	0.7	1.5	-	-	5.1	-	-
140-150	0.6	-	8.6	-	5.8	-	-

To determine the ability of soil to self-recovery, qualitative and quantitative analysis of the presence and distribution of heavy metals was conducted: Fe, Pb, Zn, Co, Cr, Cu, Ni and Cd – were founded in the soils of agricultural grounds in the zone of influence of mining enterprises.

Besides heavy metals a number of chemical and biochemical parameters was also determined in soils: the content of nitrogen and phosphorus, the concentration of organic carbon, hydrochemical acidity and activity of oxidative enzymes.

Zone of extremely dangerous pollution is located within a radius of 10 km from the quarry. In soils of this zone to the part of the first class danger elements falls 70%.

The second zone - of dangerous pollution extends to a distance of 10 to 20 km from the quarry. Soils of this zone contain up to 20% of the first class danger elements.

The third zone - the zone of moderately-dangerous pollution is located on a distance of more than 20 kilometers. Its boundary is the territory not exceeding the MPC norms (Table 4).

Table 4: Geochemical state of soils of the region

Parameter	Zone		
	first	second	third
Metals, mg/kg:			
Iron	78.00	41.40	28.02
Lead	21.70	47.00	13.30
Zinc	86.30	25.49	2.60
Cobalt	18.30	3.45	4.90
Cadmium	0.68	0.35	5.43
Chrome	21.00	23.30	19.60
Copper	60.30	37.67	19.24
Content, %			
Nitrogen	0.26	0.54	0.21
Phosphorus	0.93	0.75	1.03
Carbon	1.41	1.82	0.92
acid content	6.14	7.19	7.34
ferment strength, c.u.			
Catalase	16.83	22.45	32.79
Peroxidase	1.85	2.30	2.55
Dehydrogenase	1.40	4.00	5.60
polyphenol oxidase	0.043	0.215	0.051

It is determined that biota mass in soil is in inverse proportion with metals content (Fig. 1).

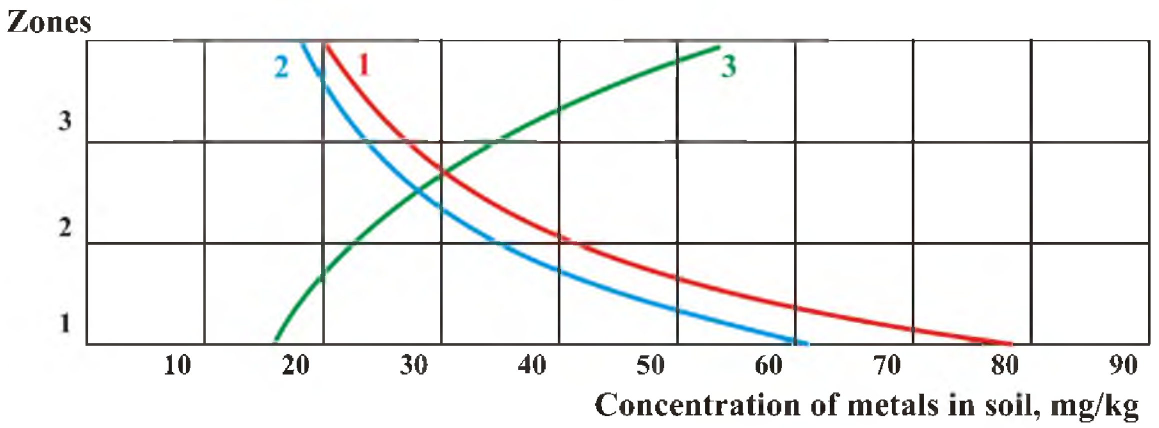

Fig. 1: Biota degradation at metal pollution of soil: 1 – iron concentration, mg/m^3; 2 – copper concentration, mg/m^3; 3 – ferments existence (catalase), c.u.

5. Estimation of pollution of soils

Soils pollution assessment must be performed not only in technogenic field but mainly by its response to impact using value of its ecological potential.

There were selected three sites (zones) in vicinity of mining enterprise for quality determination of soils degraded by dust emissions. Base site 3 is located at distance of 20 km, and others – closely to open-cast at distances 10 km (site 2) and 5 km (site 1). In each site 10 samples of trees and bushes leafs were collected [4].

Leafs investigation were performed during summer season in one month interval. Averaging data allows to estimate variation of metals concentration with distance from the source (Table 5).

Table 5: Content of minerals in vegetation, mg/kg anhydrous substance

Site	Metals	
	iron oxide	copper oxide
	bushes	
1	280	30
2	120	15
3	20	10
	trees	
1	410	39
2	190	19
3	70	9

It is determined that iron and copper concentration in vegetation is changing with distance from source in parabolic dependence (Fig. 2).

Fig. 2: Variation of metal concentration in vegetation with distance of dust source: 1 – iron in bushes; 2 – iron in trees; 3- copper in bushes; 4 – copper in trees

Metals immensely accumulate in trees leafs that in bushes ones, that can be explained by more large domain of mineral solutions absorption in area and depth.

Both vegetation groups prefer iron than copper that explained by more high copper mobility in propagation of metals in solutions of natural leaching.

Average content of metals in vegetation is changing less considerable: 162-450 mg/kg for iron, 4.5-6.7 for copper, 12-32 for zinc, 53-80 for manganese, 1.8-3.0 for nickel.

Soil dilution by toxic substances causes significant reduction in crop yields. At 20% of dilution soil productivity is less than 30% from basic value, and only 10% at 50% dilution.

Content of iron in human organism variates from 4 to 7g. Daily maintenance of human in iron is 11-30 mg.

Metals influence on biota structures is universal and characterized by regular reduction in yields and vital activity.

Metals getting in soils with fine dust particles are accumulated in upper, accumulational horizon and crop yelds reduction is observed.

Total soils pollution is dangerous not only by technogenic effect but also response to impact in consequence of synergetic effects phenomena of combined influence of their components.

Anthropogenic effect of metallic toxicants on biota is divided in insignificant, moderate and ultimate.

Mechanics of metals accumulation, assimilation and transformation in borders of system “enterprise – medium – biota” is described by model:

$$M_b = M_{b.base}\left(1 - \frac{Q_t k_f k_{am} k_a k_c}{k_{sd}}\right),$$

where M_b – mass of living material on the territory, weight units;

$M_{b.base}$ - mass of living material before technogenic effect, weight units;

Q_t - amount of generated toxicants, weight units;

k_f - soil filtration coefficient;

k_{am} - coefficient of toxicants transmission in aqueous medium;

k_a - coefficient of toxicants assimilation;

k_c - coefficient of collective toxicants influence;

k_{sd} - coefficient of soil depth or invaded zone influence.

6. Model of catastrophic chemical contamination of the nature

Proposed model describes state not only of vegetation, but also another representatives of living material including human taking into account individual characteristics [5].

Thus, the influence reduction of processes of extraction and processing of ores on the ecosystem of the natural environment is possible after:

- conversion from ecologically and socially dangerous methods of open pit and underground mining to the physical, technical and physical-chemical geotechnologies (borehole hydraulic mining, underground leaching, underground coal gasification, underground melting of sulfur, the use of coal-bed methane, coal-water fuels, etc.);

- development of high-performance complex processing technologies and opening of the mineral grains of middle quality and hardly separated ores, as well as technogenic materials;
- development of complex waste-free closed systems of separation obtaining of final products;
- development of fundamentally new technologies of mineral raw materials processing - in the first place using biological organisms, plasma-chemical reactions, etc.;
- development of new deep mineral deposits and the bottom of World ocean;
- involvement in the industrial use of unconventional energy resources (solar, wind, tides, etc.).

Implementation of the latest technologies can radically change our understanding of the quantitative and qualitative characteristics of the mineral resources of the planet and fully confirm the thesis of Academician A.E. Fersman that the future of geology is in technology.

References

[1] Golik V. I, Komashchenko V. I., Drebenstedt C.: Protection of the environment (The manual). The Higher school. M. 2007. 270 with.

[2] Golik V. I, Komashchenko V. I.: Theoretische Grundlagen der Methodenoptimirung der Prognose von Stau-begemissinen des Tagebaues. Management bergbaubedingter Emissionen. Freiberger Forschungsforum 59.Berg- und Hüttenmännischer Tag. 2008.