Technogenic Surface Formations within the Limits of Mining-Industrial System of the Dalnegorsky District of the Primorsky Krai as the Reclamation Site

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Abstract. The article presents the results of long-term researches of the problem of reclamation of technogenic surface formations (TSF), of tailings surface of Dalpolpolymetal mining enterprise containing toxic heavy metal compounds. The purpose of the research was to create a method of tailings surface reclamation, providing for increasing the reliability of its closing, shortening of reclamation period, reducing the risk of technogenic catastrophes and ensuring the ecological and social safety. Based on the purpose of the study, the following tasks were formulated: 1. Analyze and summarize the literary data on the problem of the research of technogenic surface formations (TSF) within the limits of impact of technogenic system as the reclamation site; 2. Estimate waste as a potential source of ecosphere technogenic pollution; 3. Give proposals on ecological and social safety of tailings containing toxic heavy metal compounds.

On the basis of soil-ecological conditions of the studied area the characteristic of technogenic surface formations is given. The proposals for environmental and social safety of tailings containing toxic heavy metal compounds have been developed.

1. Introduction
Subsoil resources are the primary material basis of civilization development. Their development in the Far Eastern Federal District (FEFD), the Primorsky Krai including, has acquired a large scale, and in the future the volume of georesources consumption will only increase. Undoubtedly, mining is becoming more and more resource-intensive. This is inevitably accompanied by economic reasons. Now, in the FEFD it is evident that the former guidelines of the development of mining industry, which lead to technogenic pollution, degradation and extinction of natural resources, as well as a sharp deterioration of the human environment, are hopeless.

Today, the world community is forced to solve the global problem of mineral development in such a way that, on the one hand, it would be possible to develop deposits, and on the other – not to disturb ecological balance in nature. In this regard, the purpose of the study was to create a method of tailings
surface reclamation, which provides for increased reliability of its closure, decreasing the time frame, reducing the risk of technogenic disasters and ensuring environment and social security. Based on the purpose of the study, the following tasks have been formulated: 1. To analyze and summarize the literary data on the problem of the research of technogenic surface formations (TSF) within the impact of technogenic system as the reclamation site; 2. To estimate waste as a potential source of ecosphere technogenic pollution; 3. To give proposals for ecological and social safety of tailings containing toxic heavy metal compounds.

2. Object and methods of research
The object of the research was the mining technological systems of the Dalnegorsky ore district in the Primorsky Krai (Dalpolimetall mining enterprise), including tailings, host rock and substandard ore dumps and quarries, galleries, and also mine, drainage, sludge water and gas emanations. This continuously developing system has a devastating impact on the eco-sphere. In the course of the researches the complex approach with application of modern instrumental and traditional physico-chemical, biological methods, mathematical and cartographic modeling, zoning (landscape-geochemical) statistical computer-based data processing was used.

3. Results and discussion
The analysis of literary sources [1, 2, 5, 8] and the patent search materials, testifies that the solution of the problem of reconstruction of the mining tailings surface productivity is especially actual at present. The urgency of the problem is due to the need to reclamation of disturbed tailing lands containing toxic heavy metal compounds to ensure environmental and social safety. These issues are practically not studied under the conditions of mining enterprises in the FEFD. In this regard, the research aimed at finding economically expedient methods of reclamation of the lands disturbed by mining and polluted by toxic heavy metal compounds (HM), has special importance. Mining and polymetallic ores processing in the Dalnegorsky district began in 1907 by open and underground methods [3, 4, 6, etc.]. The ores are complex. The main ore minerals are sphalerite and galenite, accessory minerals are arsenopyrite, chalcopyrite, pyrrhotine and pyrite. Every year millions of tons of ore are processed at the mining and processing plant in the city of Dalnegorsk, located in the town itself.

Two tailing dumps of the Central Concentrating Plant (CCP) and the Krasnorechenskaya Concentrating Plant (KCP) were established to ensure the work of the mining and processing plants of the Dalpolimetall mining enterprise. Specificity of extraction and enrichment of tin ores at this enterprise consisted not only in extraction and processing of huge volume of mining mass, but also using only a small part of the extracted rock, and the remaining part was stored in the form of technogenic waste, so-called "tails", in tailings ponds. Below, the characteristic of technogenic surface formations (TSF) within the limits of Dalpolimetall mining enterprise impact, the new tailings dump of the Central Concentrating Plant (CCP) as the object of reclamation is given:

3.1 Novoe (New) tailings dump of the Central Concentrating Plant (CCP), Dalpolypolymental (Fig. 1): Rubble-loam soil (N 44.49311 E 135.68442). The section is laid at a distance of 80 meters from the edge of tailings, on the north-eastern slope (about 35-40°). Broadleaved forest (Fig. 2).

![Figure 1. Soil sketch map of Novoe (New) tailings dump, CCP (1:100 scale).](image-url)
Figure 2. Gravel-loam soil of the New tailings of the Central Concentrating Plant
A₀ (0-1 cm) – dead, weakly decomposed forest litter from the leaf fall of wood-shrub vegetation, brown, smoothly passing into the coarse-humus horizon with traces of flushing by water flows on the surface.
A (1-5 cm) - medium loam, moistened, brownish-black, fine, loose, presence of wood-shrub vegetation roots, abundance of fine gravel material of rock fragments, transition is gradual in color and density.
AB (5-15 cm) – medium loam, grey, weakly moistened, humpy not solid structure, compacted, large number of roots of tree-shrub vegetation, high content of crushed gravel material - about 50%, transition by density, color and gravel material content.
BC (15-50 cm) - heavy loam, light brown color, weakly moistened, structureless, dense, a large number of stony-gravel eluvium (about 80%), abundance of tree-shrub vegetation roots.

3.2 Soil covering of old tailings dump of the Krasnorechenskaya Concentrating Plant (KCP). Dalpolymetall (fig.3):

Legend:
- Initial embryozem
- Organic-cumulative embryozem
- Soddy embryozem
- Water, flooded area

Figure 3. Soil sketch map of Old tailing dump of KPP (1:100 scale).

1) Nuclear zone (N44, 63309 E 135.36620) – Soddy gley embryozem. Surface with signs of prolonged moisture stagnation, the vegetation formed refers to hygrophytic and mesohygrophytic ecogroup: cattail, haircap moss, sedge, horsetail, willow, etc. (Fig. 4).

Figure 4. Nuclear zone of the soil cover of the old tailings dump of the Krasnorechenskaya Concentrating Plant (KCP), Dalpolymetall.
A₀ (0-2 cm) – weakly decomposed organic residues of cattail, lichens and moss owing to the prolonged swamp formation, a dense layer of herbaceous plants sod;
C₁ (2-10 cm) – clay, wet, rusty color, strongly gleyed, structureless, poorly consolidated, presence of vegetation roots, transition in color and structure;
C₂ (10-30 cm) – clay, wet, dove-grey with red patches of iron oxides, structureless, compacted, water – at the bottom.

2) Circum-nuclear zone (N44, 63271 E135, 36642) – Initial gley embryozem. The surface is fractured, characterizing moisture periodicity in water excess in spring and its long-term deficit in hot time, which leads to the formation of crust on the surface and its further cracking. The vegetation is almost completely absent, there are single specimens of mosses and lichens (Fig. 5).
Weiological. mps of coal quarries in Siberia—eless—xperimental studies have proved the possibility of successful use of the Russian Federation containing toxic waste.

4. Conclusion
The studies show that the waste stored in the tailings of the CCP and KPP are highly dangerous (2 hazard class). They are characterized by unfavorable mechanical composition, low hydric acidity, lack of ash supply elements, high toxicity. It is important that the toxic elements are fixed in a movable form. Humic matter and nitrogen were not found in them. The higher values of the dry residue and the amount of toxic salts negatively affect the living organisms. During the study of the soil cover in the nuclear and circum-nuclear zones of the CPP and the KPP tailings it was found that the main cause of weak (delayed) soil formation process on their surface is re-hydration of the parent material associated with low water transmission capability. This is due to their heavy granulometric composition.

The excess and stagnation of water leads to watering and as a result to damping off of both grassy and woody-shrub vegetation. During the periods of moisture reduction, compaction of layers (horizons) and dense crust formation on the surface and its further cracking occurs, which also adversely affects the vegetation. The soil survey shows that the substrate of tailings at the new CPP and old KPP containing toxic waste is not suitable for vegetation growth. Without rehabilitation and reclamation aimed at forming favorable root layer, these areas have long been without vegetation, do not overgrow naturally and negatively impact the adjacent areas. The soil-ecological state of these areas is characterized as unsatisfactory. The conclusion was made about necessity to develop and introduce new methods of reclamation of the tailings surface using various compositions, for example, inert materials [7].

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