Technological Possibilities of Decrease of Ecological Damage to the Ecosphere Impaired by the Activity of the Closed Mining Enterprises in the Far East Federal Region (FEFR)

KRUPSKAYA L.T. 1,2, ZVEREVA V.P. 1,3,4, GOLUBEV D.A. 1,2, BUBNOVA M.B. 5 and TAGIROVA V.T. 1

1 Pacific National University, 136, Tikhookeanskaya Str, Khabarovsk, 680035, Russia
2 Far East Scientific-Research Institute of Forestry, 71, Volochaevskaya Str, Khabarovsk, 680020 Russia
3 Far East Federal University, 8, Sukhanova Str, Vladivostok, 690091, Russia
4 Far East Geological Institute, FEB of RAS, 159, Prospect 100 let Vladivostoka, Vladivostok, 690022, Russia
5 Institute of Mining, the Far Eastern Branch of the Russian Academy of Sciences, 71, Turgeneva Str., Khabarovsk, 680000, Russia

Keywords: Ecological damage, Wastes of the processing of tin-ore raw materials, Tailing dump, technogenic contamination, Reclamation, closing down, ecosphere.

Abstract. The paper presents the results of the many-year investigations aimed at the realization of the bases of the State politics in the field of the ecological development of the Far East Federal Region (FEFR) of the Russian Federation, the decrease and/or liquidation of the accumulated ecological damage of the past economic activity of the former mining enterprises (toxic wastes stored in the tailing dumps), and the reproduction of the lands that were disturbed by them and now contain such wastes. The technological solutions are proposed using the innovation approach to the decrease of the negative action of the toxic wastes on the ecosphere. The novelty of these solutions is supported by the patents of the Russian Federation.

Introduction

One of the central tasks of the state politics in the field of the ecological development of the Russian Federation for the period till 2030 is the reproduction of the disturbed natural ecological systems. The solution of this task infers the use of different mechanisms, including the realization of the programs directed to the rehabilitation of the technogenic systems, minimization and/or liquidation of the ecological damage related with the past economic and another activity of the mining industry.

The improvement of the environment quality and ecological conditions of the man’s life in the Far East Federal Region (FEFR) is one of the terms of the achievement of the aim of the Conception of the long-term social-economic development of the Russian Federation till 2020. In this connection, the aim of the investigation was to justify the necessity of the elaboration of the way of rehabilitation of the surface territory of the tailing dumps of the broken mining enterprises of the FEFR with the use of the innovation approach (potential of the biological systems) to provide their ecological safety. From the purpose in hand, the following tasks have been formulated: 1. To analyse the available experience of the land reclamation in the FEFR that were disturbed by mining works through the development of the mineral raw materials; 2. To establish the main ecological problems connected with the ecological damage accumulated in the last century; 3. To propose the technological solutions of the problem of decrease and/or liquidation of the ecological damage, accumulated during the activity of the former mining enterprises, and reproduction of the disturbed natural ecological systems.
Materials and Methods of Investigation

The mining industrial technogenic systems, developed in the last century through the mining and processing of the solid useful minerals (considered by us as the ecological damage), became the object of the investigation. The teaching of Academician V.I. Vernadsky’s about the biosphere and noosphere [1] served the methodological base. We used the traditional chemical, physicochemical, and biological methods as well as the methods of the mathematical modeling, systematization, scientific prediction, and others.

Results and Discussion

n Russia, including the FEFR, the study of the problem of reclamation of the lands, disturbed by the development of the mineral raw materials, began much later than abroad, for example, in Germany and in the European part of the Russian Federation. In the study region several stages have been established [2, 3]. The first stage was from the 70s to the late 80s of the past century. During this period the area of the disturbed lands was about 1 million ha. The first stage was characterized by the accumulation of some factual material on the problems of the reproduction of the systems disturbed by the mining works, but it was fragmentary [4, 5 and others]. Simultaneously, the inventarization of them was done and the General scheme of reclamation was made on the volumes and directions of the reproduction measures. The first instruction on the reclamation of the disturbed lands was proposed by the workers of the VNII-1 (Magadan), but in it there were no recommendations on the optimization and reproduction of the water flow beds, their water-protected zones, and coastal protective belts. The reclamation works were carried out in accordance with the normative requisitions at the expense of the State budget as well as the State structures on the planning and control of the nature management (Resolution of the Sovmin of the USSR of June 2, 1976, № 407).

The second stage, which began in the 90s reorganization years of the past century, continues up to the present. In this period the reclamation process, as the main measure on the protection and rational use of the land resources, was discredited. In the Resolution of the Government of the RF of February 23, 1994, the reclamation conditions didn’t concretize the differences between the geographical zones of the country, social-economic conditions of the regions, and ecological situation. In this period, the works on the reclamation were performed at the expense of the own means of the entrails-users developing the mineral raw materials. Since 1993, the organs of the Gosgortechnadzor were obliged to control the carrying of the technical stage of the reclamation. However, in this period the entrails-users ignore the nature-protection requirements of the lease of the forest lands. The Resolution of the RF Government directed to create the man-made forest plantations on the disturbed lands, however, the sources of the financing and executors of the works were not pointed out. In this connection, the reclamation and return of the disturbed lands in the forest stock is fulfilled with the essential departure from the requirements of the current law. We examined the disturbed lands and revealed some shortcomings testifying that the works on the reclamation of the disturbed lands are practically not accoplished or only the technical stage with low efficiency is carried out without the preliminary evaluation of the forest-reproduction processes and the action of the chemical pollution on the forest complexes of the contiguous territories. The nature-protection requirements are practically not fulfilled. The reclamation rates are very low and, sometimes it is carried out without the designed documentation. Through the restoration works the dumps are often planned too high above the summer water level to provide the appearance and optimum development of plants. This is why the rates of the post-technogenic ecosystem formation didn’t increase. Often in the process of earthing the soil-grounds, put on the dump surface, even prevented from the normal process of the self-restoration of the soil-vegetable cover, forming at a depth of 10 cm a dense cemented layer of the fine-disperse material that limited the the penetration of moisture and precipitation to a great depth. In such cases the surface layer of the technogenic objects, reclaimed from the potentially fertile rocks, keeps the upper layers of the restored areas even in a drier state than they could be without earthing. Naturally, this prevents from the process of
the self-restoration of the vegetable cover. It is known that the disturbed lands represent a serious ecological danger for the environment. The ecosystems are poorly restored on them by the natural way, and this should be taken into account in the reclamation [6]. Unfortunately, the processes of the natural way of the forest vegetation development in the FEFR have been poorly studied. Therefore, there are no the scientifically substantiated technologies of reclamation of the disturbed lands to create the man-made forest plantations in the Far East Region. The unfavorable influence of the lands disturbed by mining works is negative for the health of the population of the miner settlements. This predetermines the necessity of the intensification of investigations on the land reclamation that will make it possible to minimize the ecological damage to the environment and man’s health. In the late 90s, some experience of the reclamation performance appeared in the southern part of the FEFR [8, 9]. The elaborated Temporal instruction [7] on the application of the technology of the rapid reclamation of the disturbed lands didn’t envisage the putting of the fertile soil layer. At the mining gold-placer and coal enterprises of Primorye and Primamurye [7] the innovation approach was performed: the use of the preparation of humic acids and active stamms of microorganisma. This approach allowed the reclamation of about 400 ha (dredging polygons, dumps of the stripping rocks in Khabarovsky and Primorsky Krai and in Sakhalinskaya Oblast’). In 1992, the author of this article elaborated the way of reclamation of the disturbed lands [8] with the use of the potentially fertile rocks and published the monograph [9], where presented the results of the long-term field investigations and generalized the experience of reclamation with the innovation approach in the southern part of the FEFR. The author attempted to give the theoretic justification and elaborate the methodology of practical measures on reclamation of the lands disturbed by mining works.

In the time of the reorganization in 1985-1991 in Russia many mining enterprises were closed. The hydrotechnic service was liquidated and the tailing dumps turned to be with no control, left to the mercy of fate. The intensive pollution of all environment objects and profound destruction of the nature landscapes happened. Up to the present, in Russia and in the FEFR there is no experience on reclamation of such technogenic objects representing a great ecological danger for the environment and man. This problem calls for the quickest solution. The situation is compounded by the natural-climatic features of this region and monsoon climate with the intense and long precipitation in the summer period. In this connection, the extremely dangerous for the environment and the population of the miner settlements are the tailing dumps containing the toxic wastes. For the recent years in the summer-autumn periods in different years in the FEFR several technogenic catastrophes happened due to the washout of the tailing dumps resulted from the hard monsoon rains. The liquidation of big mining enterprises made it necessary to reproduct the disturbed ecosystems and to improve the social-ecological situation in the FEFR. The important problem is the deficiency of the material needed for the formation of the root-inhabited layer on the surface of the tailing dump. To qualitatively improve the agrophysical and agrochemical properties of the root-inhabited layer formed on the disturbed lands and to decrease or liquidate their technogenic contamination with heavy metals we recommended the use of the method of bioremediation. Such approach makes possible to provide the continuity of the use of biological resources, and priority account of zonal features of the soil-vegetable complexes will significantly aid the preservation of the natural environment under conditions of the increasing technogenic press.

The long-term experimental investigations allow the proposal of the technological solutions of this problem using the innovation approach: potentially fertile rocks, local organic and mineral resources, forestry wastes, and bioremediation, i.e. the potential of biological systems (microorganisms, ferments, phototrophic bacteria, and so on). We have elaborated the ways of the rehabilitation, including the reclamation of the tailing dump surface, the novelty of which is supported by the patents of the RF [10], and proposed the way of purification of the industrial sewage with the use of the hydrophytes. The positive results of the experiments in the green house made it possible to introduce the proposed technological solutions in the work at the tailing dump, containing toxic wastes, of the “Khrustal’nensky” former mining enterprise. The principal criteria have been established for the realization of the Project on the ecological rehabilitation of the tailing
dump territory of the former mining enterprises (considered by us as the ecological damage), polluted with the toxic heavy metals: 1. Presence of a big volume of the accumulated toxic wastes of the high class danger on a significant territory (tens ha) within the boundaries of the former mining enterprises; 2. Location of the object on the territory with a high degree of the technogenic charge, exceeding the LPC and background indices, resulted in the ecosphere pollution, migration of toxic elements, and accumulation of them in the trophic chains; 3. Danger of the pollution of the water objects – sources of the water intake; 4. Possibility of the purification of soils, sewages, and bottom deposits of As, Cu, Hg, Pb, and other elements and the elaboration of a type technology of the utilization/processing of the wastes. All these criteria are met with the mining-industrial territories of the former mining enterprises: “Solnechnyi GOK”, “Khingansky GOK”, “Khrustal’nensky GOK”, “Karamkensky GOK”. Within the framework of this direction execution the following principles of the realization of the ecological rehabilitation have been developed for the territories in the FEFR, undergone the action of the objects of the accumulated ecological damage (wastes of the tailing dumps): 1. The correspondence to the Russian legislation; 2. Necessity of distribution of the contaminated mining-industrial territory by the level of ecological risks; 3. The use of the ecologically safe, nature-saving, and nature-restoring technologies in the process of the liquidation of the ecological damage, the waste transportation, harm-rendering and utilization of them; 4. Complex solution of the problem of the environment protection and protection of the population health; 5. Rational use of the land resources; 6. Development of the territory in the form of the territorial planning, town-planning zoning, planning of the territory, architecture-building projecting; 7. Economical efficiency of the technologies of the ecological rehabilitation of the territories undergone the action of the ecological damage; 8. Selection of new technologies of complex processing of the mining-industrial wastes and extraction of valuable components from the tailing dump wastes. The investigations we carried out allowed us to project the ways of the ecological rehabilitation in the FEFR consisting in the rational use of the natural, including the mineral-raw material resources. We propose three stages of the Program realization: 1. Estimation of the scales of the accumulated ecological damage (2017-2019); 2. Evaluation of the results of realization of the immediate projects, creation of the conditions for the circulation of the tested technologies (2020-2023); 3. Large-scale liquidation of the accumulated ecological damage on the base of the developed and tested technologies (2024-2027).

Conclusion

The urgency is evident for the solution of the problem of the ecological rehabilitation of the territories subjected to the action of the accumulated ecological damage, arisen from the past activity of the former mining enterprises: “Khrustal’nensky GOK” (Primorsky Krai), “Solnechnyi GOK” (Khabarovsky Krai”), and others in the FEFR. The paper gives the results of the many-year investigations indicating the necessity of the elaboration of the way of rehabilitation of the tailing dump territory of the closed mining enterprises using the bioremediation method to provide their ecological safety. Unfortunately, their conservation was not done in proper time, and the tailing dump surface was not cultivated despite the legislation of the RF, according to which it is the responsibility of the entrails-user. At present, it is established that the technical state of the tailing dumps, left to the mercy of fate, is in the breakdown state. Monitoring of their safety in accordance with the normative requirements is not carried out.

The criteria and principles are proposed for the ecological rehabilitation of the tailing dump surface in accordance with the Russian legislation. The technological solutions have been elaborated that use the potential of the biological systems (microorganism, ferments, higher vegetation, and others) directed to the decrease of the negative action of the ecological damage (tailing dumps containing the toxic wastes of the processing of the tin-ore raw materials) on the ecosphere, whose novelty is supported by the RF Patents.
Acknowledgement

The investigation is fulfilled at the expense of the grant of the Russian scientific fund (Project № 15-17-10016), Pacific National University

References

[1] Vernadsky V.I. Living matter. Moscow: Nauka, 1978. 357 p.

[2] Gadzhiev I.M., Kurachev V.M. Strategy and perspectives of solution of the problem of the disturbed land reclamation. Novosibirsk: TsERIS, 2001. 37 p.

[3] Krupskaya L.T. History of study of the problem of reclamation of the lands disturbed by mining works in the FEFR // Natural-technogenic complexes of reclamation and stable functioning. Materials of the Conference, June 10-15, 2013. Novosibirsk-Novokuznetsk. Novosibirsk: Okarina Publishing Firm, 2013. P. 12-23.

[4] Zamoshch M.I. Reclamation of the disturbed lands of the mining districts of North-East Russia (history, reality, perspectives) // Materials of the interregional conference “Problems of development of the technogenic complex of gold deposits”. Magadan, 2010. P. 92-103.

[5] Podkovyrkin V.V. Biological stage of the land reclamation in the North-East USSR. Novosibirsk, 1985. 90 p.

[6] Khanchuk A.I., Krupskaya L.T., Zvereva V.P. Ecological problems of development of the tin-ore raw material in Primorye and Primamurye and modern approaches to their solution // Geography and Natural Resources (English translation), 2012. Vol. 33. №1. Pp. 62-67.

[7] Shevkun E.B., Krupskaya L.T., Morin V.A., Krupsky A.V. Substantiation of the way of reclamation of the mined quarries and stoping zones in the districts with the severe climate // Mining Information-Analytical Bulletin, 2009. № 11. P. 246-252.

[8] Trubetskoy K.N., Galchenko Yu.P., Grekhnev N.I., Krupskaya L.T., Ionkin K.V. Main directions of the solution of the ecological problems of the mineral-raw material complex in the Far East Region // Geoecology, 2009, №6. P. 483-489.

[9] Krasavin A.P., Khoroshavin A.P., Krupskaya L.T., Novikova E.V. Temporal instruction on the use of the technology of the rapid reclamation of the disturbed lands without putting of the soil fertile layer with the use of the preparation of humic acid and active stamms of microorganisms in Primorye and Primamurye. Vladivostok: 1990. 12 p.

[10] Krupskaya L.T., Borisova V.I. The author certificate of the USSR “Way of Reclamation of Unproductive and Low-productive Lands”, 1992. A.C. 16588852 MKI F 01 В 79/02.

[11] Krupskaya L.T. Protection and rational use of the lands at the mining enterprises of Primamurye and Primorye. Khabarovsk: Amurskoe Geographical Society, 1992. 176 p.

[12] Patent № 2486733. The reclamation way of the lands disturbed by the toxic wastes stored in the tailing dumps under the monsoon climate. Claim № 20111455846. Published on 10.07.2013. Bull. № 19 (authors Krupskaya L.T., Mayorova L.P., Orlov A.M., Zvereva V.P., Izotov D.V., Morin V.A., Leonenko A.V., Golubev D.A.)