ECOLOGICAL BASIS OF BIOLOGICAL RECULTIVATION OF DUMPS OF DIAMOND DEPOSITS IN YAKUTIA

Mironova S.I., Ivanov V.V., Gavrilyeva L.D., Kudinova Z.A.

Scientific-Research Institute of Applied Ecology of the North, North-Eastern Federal University, Yakutsk, e-mail: mironova47@mail.ru

The article presents the results of the studies of surface, soils and vegetation of diamond mines piles and experimental work on biological remediation. Yakutia produces 97% of all diamonds in Russia, and its world market share is 25%. Open mining led to the formation of large open cuts, waste rock dumps, tailings ponds. If no recultivation is provided, the permafrost conditions may increase these areas by many times.

Keywords: biological recultivation, diamond deposits, company «Alrosa», Yakutia

The diamond mining operator in Yakutia is the joint-stock company «Alrosa» – the second largest diamond mining company in the world, which produces 97% of all diamonds in Russia, and the proportion of its production in the world market is 25%.

Diamonds are mined by open and underground methods with the resulting formation of vast areas of man-made forms of relief – the pits with a depth up to 500 meters, waste rock dumps up to 60-100 meters, tailings along the valleys of the dead rivers, etc. Currently, the area of disturbed mining lands occupy over 300 hectares. The processes of thermoerosion, thermokarst, solifluction and impairment start immediately in the permafrost of the disturbed areas (Fig. 1).

Fig. 1. Output of permafrost in industrial outlets

The «Mir» kimberlite pipe, where diamond mining had been carried out since 1957, produced 140 396 000 m^3 of overburden rock, and Mirny city – the center of the diamond industry – is surrounded by dumps and tailings with area more than 1000 thousand square meters (Fig. 2). In Mirny region there are three such pipes along with the «Mir» – the «Aykhal» and the «Udachnyi».

Tailings pits are composed of marl, dolomite, limestone, and their destruction to loam under the influence of external factors is very slow, requiring human intervention, i.e. recultivation.

Diamond mining companies' recultivation procedure, especially its biological stage, has been poorly developed, as reclamation projects started to develop in 2000. More comprehensive studies of man-made surface, soils and the degree of overgrowing vegetation is required. In this regard, we conduct landscape, geobotanical and soil studies of diamond mines (Mironova et al, 1990, Mironova, 2000, Landscape-geochemical features of ..., 2006). General research methods are used.

Dumps are a hilly terrain with a plateau-like tops with steep slopes and an average height of 60 m. The surface is mainly composed of marls,

dolomites, limestones of various sizes – from the blocks, boulders, gravel to sand and dust and is heavily compacted by bulldozers. All these factors make it very impervious for plant roots.

According to the classification of natural and man-made landscapes the above-mentioned territories are classified as pipe-depleted, according to the classification of soil – rock and half-rock frozen (seasonally frozen) man-made soils (GOST 25100-95).

Zonal soils are frozen sod-calcareous typical and leached types developed on eluvium and eluvium-deluvium of Cambrian, Devonian, Silurian limestones and dolomites under the canopy of larch forests. In disturbed areas the soils are utterly destroyed.

Fig. 2. Mirny mine dumps

The dumped ground is characterized by various size and heterogeneity of rocks. The bedrock is represented by Mesozoic and Paleozoic siltstones and sandstones with interbedded conglomerates with a mixture of clay and loam with a high content of pyrite. A small amount of fine material has a heavy grain size as it is formed on the surface of the dumps as a result of weathering (Table). The heavy fraction can have a positive effect for the recultivation activities, as the more there is the «physical clay» fraction, the richer it is gross and moving elements of plant nutrition (Avksentiev et al, 2004). This is due to high sorption properties of soils and heavy soils.

Having a thin profile the soil of dumps are homogeneous in the morphological structure and are not differentiated into distinct layers (none of morphogenetic traits).

The analysis shows light and strong alkaline reaction of the environment, a small amount of carbon and nitrogen. The concentration of mobile forms of phosphorus and potassium depends on the redistribution of carbon. In terms of particle size and chemical composition of the studied soils, or mixtures of these species belong to the group unsuitable for use in biorecultivation (GOST 17.5.1.03-86).

Spectral semi-quantitative assay of soils revealed the accumulation of a wide range of microelements, including elements of toxicant-1, 2 and 3 hazard classes. Zinc and lead are the 1st class of hazard. Their concentration in the soil dumps exceeds the local background from 2 to 6 times. The second class of hazard includes boron, chromium, cobalt, nickel, copper, molybdenum, they exceed the norm by 1,5-7 times. The 3 rd class of hazard includes vanadium and manganese, their excess is minor.

Thus, the dumps' soils are toxic man-made rocky soil and groundwater mixture (TKPGS), and they can not be used to revive the natural vegetation, and the cultivation of agricultural crops and forest without a special screening or decontamination activities (Menshikov, 2004).

On a heavily compacted dumps soils there are currently the not stocked communities of puccinellia Haupt (Puccinellia hauptiana V. Krecz.) and the bearded barley (Hordeum jubatum L.) with a willow-tea, and lambsquarters. The average plant cover ranges from 5 to 25 %. The average plant height varies from 3-20 cm.

At the pipe dumps higher plants include 14 families of 40 species. Dominated by families of Gramineae (16 species), Compositae

(8 species), legumes (4), Fig-wort (3), sedge (2 species). More common are the species of the genera Chamaenerion, Astragalus, Taraxacum, Artemisia, Puccinellia, Hordeum. The total projective cover of grass varies from 10 to 60 %.

Granulometric composition of dumps' soils of The «Mir» pipe
(Sampling depth 0-10 cm)

Location of sampling	Hygroscope moisture, %	Loss from HCL, %	Fractions value, %						Physical clay < 0,01	Physical sand > 0,01	Type of granulometric condition
			1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	< 0,001			
Dump №2											
Southern Exposure											
Mnt foot (T-6)	1,011	29,18	2,67	8,73	15,52	8,26	13,56	22,08	43,90	26,92	ТС
Peak 1 (T-7)	1,007	28,91	0,53	6,65	17,48	7,76	15,28	23,40	46,44	24,65	ТС
Slope (T-8)	1,010	23,97	0,27	1,24	19,20	8,08	9,60	37,64	55,32	20,71	ЛГ
Peak (T-9)	1,013	26,40	0,72	5,76	20,08	6,76	16,68	23,60	47,04	26,56	ТС
Northern Exposure											
Brow (T-11)	1,208	24,59	4,50	1,03	19,64	10,20	20,85	19,19	50,24	25,17	ЛГ
Mnt foot (T-10)	1,144	43,37	1,05	0,79	16,14	11,09	12,38	15,17	38,64	17,99	СС
Peak 1 (T-12)	1,146	47,43	2,46	3,79	17,92	3,44	18,73	6,23	28,40	24,17	ЛС
Mnt foot 2 (T-13)	1,047	35,41	2,21	2,08	17,22	11,56	13,90	17,62	43,09	21,51	ТС
Peak (T-14)	0,897	28,37	0,89	1,20	24,62	7,63	14,61	22,68	44,92	26,71	ТС

On a more moist gullies and rivers, there are also species of Equisetum, Arabis, and rare sprouts of Salix and Larix.

The slopes of the piles, consisting of pebble-cloddy structure of different sizes, lack the vegetation, and only the fine earth and experimental plots have some separate groups of barley and puccinellia.

Thus, biological recultivation is obligatory to obtain the land cover on the dumps.

Fig. 3. Seedlings at the old man

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