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TECHNOLOGICAL ASPECTS OF REHABILITATION OF DISTURBED LANDS

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ABSTRACT

Industrial exploitation of the deposits of the North is followed by the large scale use of natural resources (land, water, forest, fish, etc.) along with intensive disturbance and contamination of the environment. The successful decision of the problem of sustainable nature management is largely determined by the presence of ecologically and economically "weighted" system of norms, standards, regulations, which are restricting the pressure on the components of the environment. By present in Russia there are more than 20 state standards concerning the remediation of lands and conservation of soils. The Federal law "About the recultivation of lands" is under the preparation. But all-Russian standards are not well adapted for the concrete conditions. Such norms need to be regional. They should take into account the specific of the disturbance of the environment, type of waste, climatic and economic conditions along with sustainability of the ecosystems.

Such technological methods of remediation, as creation of reservoirs in the depressions of technogenic relief, covering of dusty sands (waste of smelter industries) by erosive-stable fractions of minerals, hydro-sowing of the perennial herbs, use of plant vegetative reproduction in recultivation, seem prospective. If natural fertile soil is absent, lake ground deposits can be a source of the local organic fertilizer for the purposes of recultivation. Also sideration (sowing followed by plowing at the stage of maximal aboveground biomass) can be used. Such method as the formation of water reservoirs in technogenic depressions should be wider used. Technological methods should take into consideration conservation and protection of the environment. It is important to prevent negative processes leading to the destruction of the landscape. Therefore it is expedient to have such technical methods for the environmental protection which could allow quickly and efficiently to stop negative process and to provide ecological safety.

PAPER

Industrial exploitation of the mineral deposits is followed by the large scale use of natural resources (land, water, forest, fish, etc.) along with intensive disturbance and contamination of the environment. The successful decision of the problem of sustainable nature management is largely determined by the presence of ecologically and economically "weighted" system of norms, standards, regulations, which are restricting

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the pressure on the components of the environment. At present there are more than 20 state standards in Russia that concern the reclamation of lands and conservation of soils. The Federal law "About the recultivation of lands" is under the preparation.

Disturbances of the earth surface are the result of geological survey, industrial excavations, working over and transportation of mineral and hydrocarbon deposits, peat excavation, construction of pipelines, electrical transmission lines, highways and railways. Underground mine works are followed by appearance of overburden stockpiles, tailing ponds, pits, failures etc. Lands, degraded under influence of exhausts from metallurgical and power enterprises, as well as oil spills, with various degree of heavy metals and hydrocarbons contamination, should be attributed in a special group. These lands usually are not officially included in the category of disturbed and are not taken into account by land management authorities. But, in fact, they have completely or partially lost their natural fertility.

Complex assessment of mineral deposits and industrial waste is an important condition for finding out the possibilities of their utilisation in different branches of national economy and also for determining their suitability for biological rehabilitation. Utilisation of waste let to decrease of the areas occupied by them and respectively decrease the cost of waste storage. The preliminary condition of utilisation is the determination of lithological, mineralogical, chemical, granulometric and technological properties of the waste, revealing an environmental danger class of the waste (Kapelkina, 1993).

Industrial and mining waste can be used for different purposes:

in construction – road construction (gravel, sand overlaying the ore); production of silicate and red bricks (sand, clay); production of concrete and building mixtures, ceramics;

in mining industry - for filling the empty shafts or cracks, extraction of rare elements;

in agriculture – use of calcareous grounds for neutralisation of acidic soils;

in landscape management – at the stage of geo-engineering remediation of the territory, for filling the failures, levelling, etc;

for the isolation of toxic mineral waste prior to biological rehabilitation.

There is a certain regulative base for choosing the way of utilisation of the waste: construction norms and rules, technical conditions, state standards. If necessary an additional scientific investigations are organised to assess the possibilities of utilisation of waste and conditions of rehabilitation of disturbed lands. Non-utilised waste are stored in special territories, disturbed lands are the subject for rehabilitation.

The State Standards for reclamation (recultivation) are the regulative base for solving the problems connected with remediation of lands disturbed by excavations and working over of mineral resources. Russian State Standards let us to classify all disturbed lands by directions of remediation and by technogenic relief, to set down the criteria of their suitability for different use taking into account ground characteristics, moisture, and also, to evaluate rocks due to their suitability for biological rehabilitation.

The initial stage of economic development of territories is accompanied by destruction of a soil-vegetative cover. Regulations, accepted in Russia, require the removal of the fertile soil layer before the beginning of mining or construction. At the end of the works the earth surface should be restored. Taking into account importance of preservation and restoration of vegetative cover as a component of biosphere, when choosing the directions of remediation of disturbed grounds, the preference should be given to biological rehabilitation (Kapelkina, 1988, 1997).

Depending on the following land-use, there are 7 main directions, or strategies of rehabilitation: agriculture, forestry, construction, recreation, water recovery, nature conservation, sanitary-hygienic. The choice of appropriate direction of rehabilitation can be determined accounting to (a) the relief of the territory, (b) geological and hydrological conditions, (c) the compound of grounds and their suitability for biological rehabilitation, (d) the location of disturbed lands in relation to adjacent agricultural lands, settlements and transportation corridors, (e) presence of storages of fertile soil layer or potentially fertile ground, (f) expected cost of lands rehabilitation and financial effectiveness. Such factors as (g) developmental prospects of the region of excavations, (h) the need in lands of certain category, (i) the period of existence of rehabilitated land, (j) possibility of new disturbances connected with utilisation of waste, (k) use of those lands for the other purposes are taken into consideration as well. Ecological conditions (l) are also analysed: presence of impoundment, desiccation, erosion, contamination of soil. If disturbed lands are situated in the zone of heavy aerial pollution (coal electric stations, chemical and metallurgical plants) possible effects of exhausts (m) on the state of planned forest plantations or agricultural fields are also taken into account. Natural-climatic conditions of the region (n) is an important factor influencing the choice of the direction of rehabilitation.

Technological schemes of the mining activities should require the formation of the upper layer of overburden stockpiles from the rocks suitable for biological rehabilitation; removal of fertile layer, its transportation, storage and covering the restoring surfaces with this fertile layer; separate excavation of potentially fertile waste rocks and their separate storage in cases when toxic and unsuitable for biological recultivation rocks are present in overburden; formation of optimal by shape and structure overburden stockpiles of shafts, quarries, smelters, electric power stations and other industrial enterprises; drying of overburden stockpiles made by hydro-mechanical techniques (Kapelkina, 1993).

Agriculture is a preferred rehabilitation strategy. It means the creation of arable lands, pastures, hay meadows, etc. on disturbed lands. If agricultural direction of rehabilitation is chosen, chemical composition of waste rocks and particularly their microelement composition should be taken into account. It should be compared with maximum permissible concentrations (or conventionally permissible concentrations) approved by the Ministry of Health Care, or at least with average concentrations in the Earth core and soils (Table 1). Creation of agricultural lands on the overburden waste rocks should have first of all ecological basis. Migration of chemical elements

Table 1. Concentrations of some elements in soils, mg/kg

Element	Average content[1]		MPC in soil, mg/kg			CPC[5]
	in litho-sphere, mg/kg	in soil, mg/kg	In Germany[2] total content	In Russia[3] Total content	In Russia[3] Movable forms[4]	
Beryllium	3.8	6	10	-	-	-
Boron	12	10	25	-	-	-
Fluorine	660	200	200	-	10*	-
Arsenic	1.7	5	20	2		a) 2 b) 5 c) 10
Cadmium	0.13	0.5	3	-		a) 0.5 b) 1.0 c) 2.0
Mercury	0.083	0.01	2	2.1	-	-
Cobalt	18	10	50		5	-
Chrome	83	200	100	0.05	6	-
Copper	47	20	100		3	a) 33 b) 66 c) 132
Nickel	58	40	50		4	a) 20 b) 40 c) 80
Molybdenum	1.1	2	5	-	-	-
Lead	16	10	100	32		a) 32 b) 65 c) 130
Vanadium	90	100	50	150		-
Selenium	0.05	0.01	10	-		-
Zinc	85	50	300		23	a) 55 b) 110 c) 220
Manganese	1000	850	-	1500	-	-
Antimony	0.5	-	5	4.5		-
Tin	2.5	10	50	-		-
Zirconium	170	300	300			
Germanium	1.4					
Silver	0.07	0.1				
Wolfram	1.3					
Rubidium	150	60				

Strontium	340	300				
Barium	650	500				
Cesium						
Uranium	2.5	1	5			
Gallium	19		10			

Notes: 1) Data from: Voitkevich et al., 1990; 2) Maximal permissible concentrations (MPC) in Germany are given by: Ruetze & Kyrstya, 1986; 3) MPC in soils in Russia are given according to: Bespamyatnov, Krotov, 1985; Tonkopii et al., 1988 and regulations approved by the Ministry of Health Care: Anonymous, 1985; Anonymous, 1988; 4) MPC of movable forms of Cobalt, Chrome, Nickel, Copper and Zinc are determined by the extraction from soil with acetate-ammonium buffer solution with pH=4.8; *) MPC of Fluorine is estimated by movable form, extracting from soil by 0.006 M HCl solution if soil pH is ≤ 6.5 and by 0.03 M K2SO4, if pH is ≥ 6.5; 5) CPC - Conventionally permissible concentrations of heavy metals in soil, given by: Anonymous, 1992 and the same sources as for MPC: a) in sands and sandy soils, b) in clay and clayey acidic soils with $pH_{KCl} < 5.5$; c) in nearly neutral clayey and clay soils with pH > 5.5. from waste rocks and their accumulation in plant tissues in dangerous concentrations can be a factor, excluding the agricultural use of waste rocks. Presence of big industrial enterprises which are the source of additional pollution also limits the agricultural use of waste.

Chemical substances, leaching into the soil, according to the State Standard 17.4.1.02-83 "Nature conservation. Soils. Classification of chemicals for the control of pollution" can be divided into 3 classes. Arsenic, cadmium, mercury, selenium, zinc, fluorine, benzpyren belong to the 1st class of danger; boron, cobalt, nickel, molybdenum, copper, chrome, antimony belong to the 2nd class; barium, vanadium, manganese, strontium – to the 3rd class of danger. Concentration of these elements in the soil should be under the control in process of agricultural rehabilitation.

Evaluation of disturbed lands by man-made relief should account the minimal square and configuration of plots, which provide the expediency of creating the tillage. Sometimes, creation of tillage is not expedient due to the remoteness of rehabilitating territory from the other agricultural lands and the presence of forest plantations nearby. For such territories formation of forest plantations or hay meadows or sanitary-hygienic rehabilitation could be more expedient. When agricultural rehabilitation is not expedient, forest plantations are created. They are aimed to increase the forest fund, to improve the environment, to make the recreation zones or to protect soil against corrosion. In this case a special surface layer of certain thickness and quality is prepared for plants from fine-grained non-toxic rocks favourable for forest growing. The selection of woody, shrub and herbaceous species should be based on physical properties of substrata (ex. rate of upper layer weathering) and biological demands of the plantations.

Sanitary-hygienic direction of rehabilitation means biological and technical conservation (i.e. inhibition) of disturbed lands, which has negative impact on environment, if other directions of rehabilitation are economically inefficient. Its measures are applied if the damage caused by the disturbed lands to the environments is essential and exceed the costs of rehabilitation works. Tailing ponds of different smelters, ash stockpiles of coal power stations, lands destroyed by excavations in the Far North regions with severe climatic conditions are the subjects of sanitary-hygienic rehabilitation. Complex grass mixtures including native species should be used for this purpose. In this case dropping out of some species but spreading of more adapted ones allowed to get satisfactory vegetative cover. Selection of plants should be carried out with regard to the properties of soil-rocks (Kapelkina, 1997).

Such methods as hydro-sowing, use of sapropel (lacustrine bottom organic deposits, muds) as a fertile layer, covering of dusty sands by stable fractions of mineral materials, creation of reservoirs in depressions of man-made relief in disturbed sites should be taken into account. It is prospective to use more wider the methods of vegetative plant reproduction. Sapropel can be used as the source of local organic fertiliser. It is available everywhere in the North. We tested sapropel on the dumps of Kovdor smelter (Murmansk region) together with sowing grass and creating forest plantations. High stocks of organic matter and mineral nutrition elements, raised water capacity of sapropel provide good growth of plants. Technology of excavation and scattering sapropel should be environment- friendly.

For spreading of fertile grounds on slopes of tailing ponds, ore dumps and places impossible for machine treatment we offer to use ground gun which can scatter to up to 30m a fertile top-soil, peat, local or transported soils and rocks and other materials (Kapelkina, 1993). Adding the seeds of perennial grasses into the scattering top-soil allows to combine the processes of ground spreading and plants sowing.

Hydro-economic (water recovery) direction of rehabilitation have not yet found a wide use in the Russian North. It can be expedient to make water reservoirs of different purpose in man-made depressions.

Elaboration of environment-friendly technologies should always take place before industrial exploration of the territory.

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