

# The Best Available Techniques for Disturbed Lands Reclamation in Kuzbass

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**Abstract.** Remediation of disturbed lands is a stage of elimination of negative consequences of coal production. In Kuzbass traditional methods to create the plantations of pine and sea buckthorn for economic use. Now dumps are objects for restoration of natural ecosystems and biodiversity. During the UNDP-GEF project in Kuzbass, the best available technologies for the restoration of disturbed lands were developed. They have been included in the new state standards and are subject to mandatory application in the mining industry in Russia.

## 1 Introduction

In 1992 in Rio de Janeiro the agenda for the 21st century [1] was discussed and the thesis about sustainable development when mankind progressive advance is based on cautious natural management was accepted as the basis. Also it has been declared that biodiversity conservation is the basis of environmental stability, and, consequently, the possibility of human's survival on Earth. Consequently, disturbed lands, including rock dumps of coal companies should be considered as objects for rehabilitation of natural ecosystems with the high level of biodiversity. The value of these territories will increase in process of rehabilitation of structural and functional ecosystem indicators corresponding to certain natural and climatic zone.

Since the beginning of the 50th years and until the end of the 20th century many research groups of the Russia studied natural overgrowing of disturbed lands. Thanks to long-term system researches [2,3,4] the major limiting factors, plant successions stages and mechanisms of vegetation cover restoration in Kuzbass were determined. It was understood that in foreseeable historical period process of natural overgrowing on rock dumps will not be able to provide qualitatively restoration of vegetation typical for this phytogeographical zone. As consequence, it is necessary to develop completely new methods of reclamation of vegetation cover for restoration of territories floristic diversity existing prior to mining work.

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## 2 Best available technologies for the disturbed lands restoration

Therefore the paradigm of modern stage of disturbed lands reclamation is restoration of a vegetation cover capable to keep and maintain the stable level of biodiversity. The translation of this idea into technique became possible due to work of the project of the UNDP/GEF-Ministry of Natural Resources and Environment of Russia “Mainstreaming Biodiversity Conservation into Russia’s Energy Sector Policies and Operations” (further. Project), aimed to minimize negative impact of the coal companies on biodiversity. During 5 years (2013-2017) Kuzbass was the demonstration territory of Project where in cooperation with coal companies – official partners of Project, – new methods of biodiversity restoration on rock dumps were developed and approved [5].

### *Method 1: Development of technique of meadow-steppe communities restoration.*

Today steppe and meadow-steppe lands in the Kemerovo region are presented by small-area or strongly fragmented sites. The main threat to steppe areas is created by open pits which fundamentally change natural landscapes, forming on their place characteristic technogenic relief. Process of steppes self-restoration is too long, at the same time species composition and structure don't correspond to natural communities and therefore this process can't be regarded as acceptable for territories restoration [6]. As consequence, development of nature similar techniques is necessary for restoration of meadow-steppe communities in the territories disturbed by the mining industry.

This work was carried out by research scientists of the Kuzbass botanical garden of The Federal Research Center of Coal and Coal Chemistry of Siberian Branch of the Russian Academy of Sciences. The experimental test site was created on the external dump of overburden rocks of Vinogradovsky open-pit (Kuzbasskaya Toplivnaya Company). Mine technical works on designing of dump surface were carried out. 12 experimental sites were created by adding potentially fertile soil layer and fertile soil layer. Gathering of grass-seed mix in different fruiting seasons was carried out at three sample sites of meadow-steppe vegetation. Crop of grass-seed mix on experimental sites was made. In 2015 and 2016 accounting of types settled on separate variants has been made, all types were conditionally divided into ruderal, steppe and meadow-steppe plants, above ground phytomass was determined. Feather grass (*Stipa capillata*) was used as indicator species of the experiment success. The obtained results demonstrate quality improvement of condition of restored vegetation communities on indicators: quantity of species, occurrence of indicator steppe species, projective cover of grass stand, productivity [7].

### *Method 2: Formation of sustainable forest plantations on dumps of coal industry.*

Now forest remediation – is the leading aspect of restoration of lands disturbed by coal industry in Kuzbass. Planting of tree vegetation on post-technogenic lands is already carried out for 50 years in the region. For this period methods of forest remediation have returned in economic turnover more than 15 thousand hectares that makes about 60% of all recultivated lands in Kuzbass. Formation of monospecific tree plantations with high economic and biological efficiency on dumps was the main task of forest remediation. Today there is a formation of stable self-sustained wood-grassy communities with high biological diversity and the maximum compliance with conditions of technogenic habitats to ecological and biological characteristics of forest vegetation at the fore [8]. Using of wide range of trees and bushes from composition of zone vegetation is the important condition of formed forest plantations. It is reasonable to use shade enduring species (rowan – *Sorbus sibirica*, elder – *Sambucus sibirica*, acacia – *Caragana arborescens*) and other species of bushes forming an underbrush of local wood species) as shrub layer in addition to coniferous and hardwood crops. It is required to plant perennial grasses (gramineous, leguminous, composites) in young stands for activation of soil-building process. It is necessary to provide fire fighting measures in all cases.

*Method 3: Ecological assessment of disturbed lands for determining of package of measures for lands reclamation taking into account biodiversity.*

Overgrowing of dumps surface is observed in many Kuzbass coal enterprises. However the speed and degree of vegetation cover restoration in technogenic landscapes can greatly differ not only in different natural-climatic zones, but also within the territory of one dump. The diversity of technogenic habitats causes different degree of vegetation cover formation. Therefore development of assessment methods of ecological state of site of disturbed land surface and vegetation cover state allows to assess natural reduction potential on the basis of several criteria and to develop the optimum plan of conducting remediation works. The method is based on calculation of the Integrated index on the accumulative formula considering the score of five biological-ecological indicators which is multiplied by climatic hydrothermal coefficient (Kk) and coefficient of similarity of floristic structure with zone communities according to Sørensen- Czekanowski index (CS) expressed as a percentage [9].

$$\Sigma i = Hc \times CS (Of+Pl+H+D+ Su) \quad (1)$$

Where  $\Sigma i$  – integrated indicator of condition of technogenic disturbed lands; Hc – hydrothermal coefficient; KS –Sørensen- Czekanowski similarity coefficient; Of – orographic factor score; Pl – soil potentiality score; H – the humidity of the substrate; D - density of technogenic residual rock score; Su – stage plant succession score. Arranging of coal enterprise territory is made by relative integrated index, calculated as the attitude of real score of ecological and biological indicators towards their maximum quantity expressed as a percentage. This method allowed to carry out objective assessment of ecological state of land allotment territories at two enterprises of “Yuzhny Kuzbass” (Mechel), to rank in terms of area, to plan suitably remediation activities taking into account the natural potential of surrounding natural areas and to conserve the populations of rare plants species found on dumps [10].

During Project realization in the Kemerovo region the new remediation techniques allowing to create vegetation communities with high diversity of plants and high values of projective cover have been presented and approved. Among them the best results have been shown by methods of restoration of meadow-steppe communities, methods of creation of multilayered forest plantations, including landscape forms, methods of ecological assessment by Integrated index [11, 12]. These and other techniques were included into federal documents: information and technical reference books on the best available techniques "BREF 16-2016. "Mining industry. Common processes and methods" and state standard GOST R 57446-2017 "Best available techniques. Disturbed lands reclamation. Restoration of biological diversity".

More detailed descriptions of flow charts for the staff of municipalities, coal companies, engineering companies and environmental experts have been described in best practices. Techniques were approved at a meeting of the Board of the Kemerovo Region Administration and have been recommended to the coal enterprises in carrying out remediation works in the territory of the Kemerovo region (Order of 10.08.2017 No. 357-r) [12].

### 3 Conclusion

The base of scientifically based methods on disturbed lands reclamation for achievement of high rates of biological and economic efficiency is created now in the Russian Federation. Some coal industry enterprises already work at adding of innovative methods in working drafts of remediation at the enterprises, claim them as corporate standards. Nevertheless,

it's necessary to carry out informational work for business attraction to active actions for conservation of the region biodiversity and implementation of the best available techniques only under constant and objective control of interested parties.

## References

1. *Convention on Biological Diversity* (UN, Washington, 1992)
2. *Ecology and remediation of technogenic landscapes* (Science Publish. Siberian branch of RAS, Novosibirsk, 1992)
3. Yu. A. Manakov, T. O. Strelnikova, A. N. Kuprijanov, *The formation of vegetation in technogenic landscapes of Kuzbass* (Science Publish. Siberian branch of RAS, Novosibirsk, 2011)
4. V. Ufimtsev, *Ecology of pine plantations on the dumps of coal mine. On the example of Kuznetsk coal basin* (Lambert academic publishing, Saarbrüchen, 2013)
5. S. K. Kearns, *Prairie restoration*, **8**, 197–200 (1983)
6. V. I. Ufimtsev, *Modern problems of science and education*, **5**, 299 (2016)
7. V. I. Ufimtsev, *News of Irkutsk State University*, **6:3**, 63-69 (2013)
8. A. N. Kuprijanov, Yu. A. Manakov, *Bulletin of the Krasnoyarsk State Agrarian University*, **3**, 29-35 (2010)
9. T. O. Strelnikova, Yu. A. Manakov, A. N. Kuprijanov, O. A. Kuprijanov, S. S. Kazmina, *Botanical studies of Siberia and Kazakhstan. Kemerovo*, **23**, 85-95 (2017)
10. *Compendiums on the best available industry biodiversity solutions for the coal mining sector* (INEKA, Novokuznetsk-Kemerovo, 2015)
11. *Compendiums on the best available industry biodiversity solutions for the coal mining sector* (INEKA, Novokuznetsk-Kemerovo, 2017)
12. *Methodical recommendations on the use of the integral indicator of the suitability of disturbed lands for reclamation of dumps of the coal industry of Kuzbass* (RAS Sib. Br. Federal Research Center for Coal and Coal Chemistry, Kemerovo, 2017)