Transformation of the Ecological Functions of Soil in the Coal Mining Regions of Kuzbass

Vladimir ANDROKHANOV*1)

Abstract: It has now been found that soil, being at the junction of all the geospheres of the earth, is a unique node of ecological links with numerous global functions. Soil disturbance, as surely as a gap in the links between geospheres, leads to significant changes in the functioning of natural ecosystems.

It is especially noticeable in regions with intensive development of mining industry. In these areas there is a transformation of basic soil-ecological functions and replacing of the native landscapes into natural-technogenic complexes. In addition technogenic desertification processes occur over large areas and it leads to a radical transformation of the natural landscapes and ecosystem functioning regimes. Therefore, it is required a very long period to rebuild disturbed functions without reclamation works at the disturbed areas. To restore damaged ecosystems it is necessary to restore the soil, because soil is the basis of any terrestrial ecosystem. Currently tendency to partially restoring economic and environmental damage caused by disturbance of the natural soil takes a place at the practical reclamation. When developing remediation methods it is necessary to provide such range of processing methods, which allows generating soil-like substrates, which have properties as much as possible close to the properties of the undisturbed soil. Soil restoring with creating soil-like substrates must be a general aim of the reclamation. Technogenic landscapes will forever save the technogenic specificity of their functioning. And these landscapes will negatively impact on ecological situation in region for a long time.

Key Words: Coal mining, Soil-ecological functions, Technogenic landscapes.

1. Introduction

According to various sources seventy to a hundred and five thousand hectares of natural landscapes have been disturbed to date as a result of coal mining activities in the Kuzbass. The largest coal deposits in Russia are located in this region. Coal mining is accompanied by a transformation of the entire spectrum of natural ecosystems, the total destruction of the soil cover and the formation of numerous spoil dumps and exhausted open-pits.

The soil cover, which is the foundation of any terrestrial ecosystem, primarily performs a variety of regulatory and stabilizing functions in the biosphere. Ultimately, it is the soil and environmental conditions that determine the quality of our living space. Therefore, mass destruction of the soil cover leads to a decrease in the surface area of comfortable living space available and deterioration in the entire system of ecological indicators. In terms of soil ecology this means an abrupt deceleration or total absence of soil-recovery processes. In geobotanical terms this leads to delayed revegetation and a significant reduction in botanical diversity. In terms of general ecology it indicates the conservation of ecoclines, land areas and ecosystems inappropriate to that natural environment, for an indefinite period of time. In terms of hygiene it implies a general deterioration in the quality of all aspects of the environment surrounding man.

2. Data and Methods

The objects of study are the technogenic landscapes formed as a result of coal mining in the Kuzbass. Technogenic landscape is a kind of anthropogenic landscape, which by definition is formed as a result of human economic activity. If the ordinary anthropogenic landscapes are often found to be no more than natural landscapes transformed to varying degrees, then the technogenic landscapes (topography, composition, structure, etc.) are almost entirely formed by technical means. Thus, if a natural landscape is a naturalistic formation, created by the combined and simultaneous action of all factors of the geographical environment, technogenic landscapes are characterized by an extreme degree of disturbance in the interrelations between these factors (Androkhанов et al., 2004). The waste dump quarry landscapes formed when mining mineral deposits by the open-pit method (Fig. 1) may be considered the most characteristic examples of such landscapes.

The profile-genetic classification of soils developed in the soil reclamation laboratory of the Institute of Soil Science and Agrochemistry SB RAS became the methodological basis for the study of the transformation of the soil-ecological functions in the disturbed mine land areas (Kurachev and Androkhанов, 2002). According to this classification, the new soils formed on the disturbed surface can be divided into two large groups

* Corresponding Author: androhan@rambler.ru
Novosibirsk, Russia
1) Institute of Soil Science and Agrochemistry SB RAS

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-embriozems and technozems. Technozems are consciously formed as a result of reclamation processes. Embriozems occur naturally by restoring the vegetation and soil formation processes. Each group and type of new soil is characterized by a certain level of recovery of soil-ecological functions. At the same time, the degree of compliance of the properties of recovering soils with the soil properties common in natural landscapes in the given area serve as a yardstick of the recovery level. Hence there is an urgent need to research the particularities of the modes of operation and recovery processes of soil-ecological functions in the new soil cover on the technogenic landscapes.

3. Results and Discussion

Currently the man-made technogenic landscapes occupy a territory where, in its natural state, a wide variety of soils functioned. Each of them has its own set of ecological functions. The natural diversity of the soil therefore, ensures the sustainability of the landscape. The natural soil cover in the Kuzbass is represented as follows: 11 types of soils; 33 subtypes; more than 100 genera and over 1000 species/varieties. Therefore, we can imagine the scale and diversity of the environmental impacts caused by disturbance of the natural soil cover.

Despite the differences in conditions in the man-made habitats, the soil cover in technogenic landscapes is much less diverse, due, primarily, to the short time of development of the soil formation processes. However, it is possible to estimate the perspectives of revegetation and soil recovery on disturbed areas at the early stages in the study and analysis of the leading factors of topographical soil formation and soil-forming rocks. The role of almost any of the soil-ecological functions is multifaceted. It is not limited to its significance in biogeocenotic processes alone. Generally speaking, the spectrum of soil-ecological functions can be depicted as follows: biosphere - interlandscape - intralandscape - intrasoil. As all these functions are interrelated, the destruction of their relationship as a result of violation of the completeness of soil, the entire range of soil-ecological functions is disrupted. The low efficiency of recultivation is therefore, inevitably reflected in the level of recovery of all biological components of the emerging ecosystem. It should also be noted that in case of any anthropogenic impacts on soil, the intrasoil biogeocenotical features are the first to be disturbed, yet they also serve as a kind of cornerstone with regard to all the other functions (Dobrovolsky and Nikitin, 1986). Thus, as noted by many researchers, soil being at the junction of all the geospheres of the earth, is a unique node of ecological links with numerous global functions. Soil disturbance, as surely as a gap in the links between geospheres, leads to noticeable changes in the functioning of natural ecosystems as seen, for example, in coal mining regions (Dobrovolsky, 1997).

The array of intrasoil ecological functions is very wide. Their total number is in hundreds, perhaps even thousands. It would be virtually impossible to measure and evaluate all of them. However, to simplify the problem, all soil-ecological functions can be divided into two groups based on resistance to anthropogenic influences and susceptibility to technological reclamation techniques: stable and dynamic (Fig. 2).

Stable soil and ecological functions are, among other things, responsible for the water- and gas-regulating capacity of the soil, the concentration of nutrients in the soil solution for plants, and directly determine the conditions for the formation of the entire group of dynamic soil-ecological functions. Dynamic soil-ecological functions are responsible for the fertility of soil, its sanitary conditions and may only indirectly affect the stable group of soil-ecological functions. While it is relatively easy to form the first by technological methods laid down in the reclamation project, through the formation of a favorable topsoil layer, the second are restored naturally, with varying degrees of speed, with the help of a set of biological and soil-forming mechanisms, such as the restoration of the humus status. Thus, although the stable soil-ecological functions are relatively few in number, they determine the set of dynamic functions and the speed of their recovery. The level of stable functions, achieved by a fixed set of technological reclamation methods, largely determines the economic and environmental prospects of the recovery of disturbed areas and their further use.
Currently practical reclamation aims to partially restore economic and environmental damage caused by the disturbance of natural soil. However, theoretical calculations and experimental studies show that it is impossible to fully restore the lost functions in the foreseeable future, since certain functions cannot be artificially created. Their restoration requires the development of natural biological and soil-forming processes. The maximum result achieved to date in small experimental plots, is about 90%. Moreover, the achievement of such a result in the conditions of the Kusbass calls for large financial and resource investment. Therefore, at this stage, such reclamation work is rarely performed in the Kuzbass. Most technogenic landscapes come under natural overgrowing with the development of young soils - embriozems with a very sluggish recovery of soil functions (Androkhanov and Kurachev, 2009).

4. Conclusions

Thus, there is clearly a need to switch over to another ideology in the execution of reclamation work on the industrially disturbed lands in the Kuzbass. While undertaking reclamation work the peculiarities of the soil conditions must be constructively assessed, individually for each technogenic landscape, as they determine the completeness of the recovery of soil-ecological functions. This will determine the prospects for the development of soil-forming processes, a self-restoring system of soil properties and regimes and, ultimately, ecosystems as a whole. When conducting recultivation works with varying degrees of soil-environmental efficacy, the main purpose is to restore the soil, by creating soil-like substrates, taking into account the fact that soil is the basis of all terrestrial ecosystems. Without the restoration of the main soil-ecological functions, technogenic landscapes will inevitably retain the peculiarities of their functional operation and will have a negative impact on the environment in the region for a very long period of time.

References