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REGULARITIES OF VEGETATION COVER SELF-REHABILITATION IN TECHNOGENICALLY DISRUPTED LANDSCAPES AND TECHNOLOGIES OF THEIR ECOLOGICAL RESTORATION

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The formation of a sustainable vegetation cover on the rock dumps in postindustrial landscapes is an essential condition of the achievement of ecological balance and decrease of negative impact on the environment. This problem is of great significance for the territory of the Belgorod region, as it is the region with the developed ore mining. More than 30 outside dumps and sludge depository that occupy about 30 000 hectares of fertile lands [4] have been formed as the result of open pit running in the basin of Kursk Magnetic Anomaly (KMA).

Little amount of annual works on recultivation of the technogenically disrupted soils, the constantly growing disbalance between the areas of degraded and recultivated soils account for the increasing interest to the technologies of ecological restoration of industrial and polluted areas. Geosystem successions have a different duration depending on the degree of vegetation cover and the exposed substrate properties disruption. Primary successions (biota reproduction + soil reproduction) may last for thousands of years, secondary successions (biocenose restoration on the conserved soil) may take centuries, and sometimes decades. If the process of succession was taken under control, the general medium-forming and medium-stabilizing efficiency of the ecosystem restoration would be considerably increased.

Ecological restoration is one of the several activities striving to alter the biota and physical conditions of a site, and are frequently taken for restoration. These activities include reclamation, rehabilitation, mitigation, ecological engineering and various kinds of resource management, including wildlife, fisheries and range management, agroforestry, and forestry [3].

We have investigated the multi-aged ecosystems that have been formed under the conditions of self-accretion on pit-dumping complexes of Lebedinskiy and Stoylenskiy iron ore mining and processing plants of KMA. Among the subjects of inquiry are dumps of different kind: excavator dumps, autodumps, hydrodumps, where the recultivation of soils by means of fertile soil coating hasn't been carried out but the stage of biological recultivation has been fulfilled. The explored newly formed geosystems represent different stages of successional restoration of biocenose. Mixed vegetative groups with a lean species composition (3-5 species per square meter) and low projective cover [4] are formed under the natural overgrowing of freshly-filled (two-year-old) dumps of KMA. All biometrical indices of forest plantation growing on dumps are 1.2-1.8 times lower than those of the forest stands growing in zonal soil.

The successions have mainly the natural character because of the considerable area of dumps, though a high speed of the land cover restoration has been stated in a number of cases. Multi-aged surfaces of dumps are the object of study of their soil reproduction process due to the possibility of studying the isolated cases of this process in the various biotapolitological combinations of soil-formation conditions. We have investigated multi-aged (13-47 years) young soils that are under the process of automorphic soil-formation on the subhorizontal surfaces of dumps. It has given us the chance to analyze the results of their morphological structure and physico-chemical properties reproduction 'in pure form' [6].

The plant-free dump surface has a considerable amount of mineral resources and moisture for plant nutrition. The species diversity of the association depends on its removal from the seeds source. The mechanism of phytocenosis formation during the process of self-spread on the newly-formed soils of the dumps is identical to plough field overgrowing. The process of succession includes: ruderal association - rhizome - loose-bunch + forest overgrowing. In some cases forest

overgrowing takes place at the second stage under the conditions of a sufficient moisture level. Tree vegetation appears on the 10-year-old soils. We have ascertained that the newly-formed soil depth is lower in phytocenosis with the domination of tree vegetation, than in herb communities on the soils of the same age. The initial ruderal association with *Artemisia vulgaris, Daucus dubium, Centaurea pseudophrygia, Carduus acanthoides* and etc. dominating plays a minute part in soil-formation. It is the result of the fact that though ruderal plant species form a substantial vegetative mass, the greater part of it is formed on the top soil. The second stage of association formation on the dumps is called rootstock grasses association. Grasses include mainly *Calamagrostis epigeos, Elytrigia repens*, that have a low level of underground and aboveground mass proportion and do not form a grass sod. Bluejoint *(Calamagrostis epigeios)* predominates in such associations. Bunch and motley grass associations are formed at later stages. The inclusion of short grasses with a developed fibrous system and a high level of underground and aboveground mass proportion favours fast humus accumulation in the soil.

The tendency of the growth of phytocenosis species diversity as the soil age increase (r = 0,39) (Table 1) is found.

The capacity of horizon A grows during the increase of vegetation species diversity and projective plant cover degree. It is important to note the negative, confirmed by the method of correlation analysis, influence of the increase of tree vegetation species diversity and its projective cover on the capacity of horizon A.

Restoration ecology provides clear concepts, models, methodologies and tools for practitioners in support of their practice. The number of

Table 1. Dependence of the capacity of horizon A on some geobotanical indices (for dumps under 50 years old)

Geobotanical indices	Correlation coefficient
General number of phytocenosis species, in items	0,655…0,776
The number of tree species, in items	-0,415…-0,443
The number of plant species, in items	0,687…0,797
Projective cover of tree vegetation, %	-0,356…-0,366
Projective cover of plants, %	0,422…0,454
Projective cover of moss layer, %	0,067…0,088

methods of ecological restoration of disrupted soils steadily increases. Depending on the initial conditions (the type of the substrate, geomorphological conditions, remoteness from natural associations, etc.) one can choose an optimum procedure of ecological restoration from the point of view of its ecological-economical effectiveness. We carried out the number of fixed experiments in the BelSU botanical garden in 2002-2005 [2] for the purpose of studying the methods of plant associations restoration that depend on ecological conditions and different methods of soil preparation.

Experiment № 1: The fixed experiment on studying the influence of the reserved regime on the vegetation dynamics and top - soil of the steppe association was performed in 2002 - 2005 on the site of steppe restoration of the BelSU Botanical garden, on the south - eastern exposition steep slope of 5 - 12^0. The investigations were carried out in 7 areas located in different landscape conditions. The total area of one plot is 8 m^2, the experiment is made with the method of randomized reiterations, replication is sixfold.

Experiment № 2**:** The investigations were implemented in 2003-2005 during the fixed experiment on studying the influence of ecological conditions and methods of soil preparation on growth and development of multicomponent mixed grass crop with a wide range of steppe species, located on the site of steppe restoration of the BelSU Botanical garden. The total area of one plot is 8 m^2, the experiment is made with the method of randomized reiterations, replication is sixfold.

Experiment № 3**:** The investigations were implemented in 2003-2005 during the fixed experiment on studying the influence of ecological conditions on the establishments of grass sod during their transplantation to the steam site and steppe association.

Experiment № 4**:** The investigations were implemented in 2003-2005 during the fixed experiment on studying the influence of ecological conditions on plant establishments in ecological niches.

Experiment № 5: The investigations were implemented in 2003-2005 during the fixed experiment on studying the steppe community restoration with the method of reduced top-soil from the pattern steppe biocenose including to the degraded steppe community.

Experiment № 6: The investigations were implemented in 2003-2005 during the fixed experiment on studying the influence of ecological conditions methods of seeds sowing on growth and development of the multicomponent mixed gross crop with a wide

range of steppe and calciphilous species under the conditions of chalky exposure with the development of intensive erosive processes.

RevilTec technology, developed by the scientists of the University of Bremen, is aimed at ecological restoration of dramatically degraded soils. The idea that forms the base of the technology is simple, modular and innovative. Substrate unsuitable for plant growth is upgraded to fertile soil with compost, soil amendments (e.g., mineral, organic and synthetic water absorbers) and bioactivaion (inoculation with site specific plant seed and soil organisms). Biodegradable bags (e.g., from jute) prevent erosion; soil amendments and organisms stabilize nutrient cycling and water balance.

RevilTec initiates and accelerates ecological succession. Besides, the modular conception allows expanding of restoration processes by using the mechanisms of water-holding usually in dried up technogenic substrates.

Scientific and technical results of RevilTec technology:

- The bags, that are put on the modified substrate, create an effective erosive protection. Due to quick decay of the lower side of the bag a rapid link of substrate with composted soil is available.
- The water-holding amendments are multi-functional. Hydrogel, performing its function, gradually decays in soil.
- Eminently the plants growth is activated, first of all, by means of adding site plants seeds into the compost.
- Admixture of sawdust leads to a nitrogen block. It must be compensated by the application of appropriate mineral fertilizers.
- The bags make the microclimate in favour of the soil fauna development and, consequently, soil-formation. The initially dominant compost fauna has been replaced by a successional fauna.
- At the initial stage of vegetation plants spread everywhere from the islands (bags). Water-holding effects increase.
- Due to the damp microclimate the plant growth is higher on granulometry multicomponent substrates than on the sand (construction waste was used for the experiments).

RevilTec - <u>modules</u>

Basic module (soil science, soil ecology):

- Bags from biodegradable fabric (e.g., coffeebags from jute) filled with bioactivated substrate, plant seeds and amendments for the improvement of water and nutrient matters in the soil;
- Initial erosion control, improvement of microclimate;

• Scale - 0,5 meters.

Complex modules (applied botany, ecology):

• Structures of various shapes and functions, assembled from a great number of bags with biotic and abiotic diversity;

• Starting points of colonization, safe-sites for new inhabitants, overgrowing, water and nutrient matters accumulation;

• Autonomous environment with growing erosion protection;

• Scale - 0,5 meters.

Mosaic and contours (monitoring, remote sensing, modeling, GIS):

• Mosaic or other structures with connecting corridors.

• Development from mosaic to network.

• Scale - 20 meters.

The evidence of RevilTec functionality:

1) The analysis of factors which ensure success of RevilTec implementation:

- Alteration of abiotic parameters, the increase of soil fauna diversity, a better plant growth;

- Hydrogel preserves its qualities within the period of a year and then it starts decaying;

- The results show the significance of the whole mixture rather than separate substrate components;

- The substrates should be optimized in accordance with N- parameters. By means of sawdust amendments (branches and roots cut into small pieces) N - block can be provoked because of extensive size of C (N - immobilization). Though initial disbalance is quickly eliminated by natural plant overgrowth;

-The reduction of erosion on the slopes can be provided by linear objects (banks, crescents) and root layer formation (organic stabilization).

2) Ecological effects evaluation. Renaturation activities do not only promote natural growth, biodiversity and succession, but also cause some risks:

- Introduction of alien organisms in a definite site (neobiota), which can develop there into invasive species -mixtures of seeds of site plants and soil organisms of the same region are used in RevilTec.

- The use of the ecologically harmful (toxic) materials - only ecologically harmless bags are used in RevilTec. Hydrogel contains polyacrylamide, but the ecological risk of its use is insignificant because of its little amounts and its substance degradation.

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Succulents form an ecological-morphological group of plants which have tissue in which they are able to accumulate water and food