

ALTERNATIVE METHODS OF RESTORATION AND REGENERATION OF POSTMINING LANDSCAPE – BEST PRACTICES FROM COBRAMAN

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ABSTRACT

The primary requirement for landscape regeneration affected by mining in addition to restoration of functional use is also the permanent sustainability of landscape. The paper deals with the alternative possibilities of using redevelopment procedures for general restoration of the landscape, also principles of using spontaneous succession, managed succession, forest and non-forest reclamation (including the recovery of the residential areas) on the basis of ecological and land-technical values and potential of landscape segments. Ecotones should be an integral part of all types of reclamation goals. They should not fulfill only ecological but also aesthetic and, to some extent, the economic functions.

Keywords: mining landscape reclamation, spontaneous succession, managed succession, ecological potential of landscape segments, COBRAMAN



INTRODUCTION

We have already for long time (since 1990) been dealing with the issues of reclamation and regeneration processes of postmining and industrial landscape. This contribution summarizes the findings and knowledge in the area of renewal and regeneration processes in the postmining landscape. The contribution therefore represents synthetic summaries and current recommendations, by means of which we want to contribute to possible methods and procedures of reuse of landscape and abandoned areas on an example of mining landscape of the Ostrava basin (Czech Republic). The main goal of the strategic procedures for landscape reuse is the restoration and protection of species diversity of ecosystems of cultural landscape and restoration of permanent sustainability of mining influenced areas. The results presented in this contribution are associated with the solution of the project 1CE014P4 “Manager Coordinating Brownfield Redevelopment Activities” (COBRAMAN). Apart from others we derive from the assumption that any dump, storage of waste and tailings, subsidence trough, abandoned area – these are all brownfields, therefore areas with high potential of reuse. The paper is realized also thanks to the project

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MINING LANDSCAPE CHARACTERS

In the very beginning it is necessary to note that it is not possible to perform that what is called landscape renewal in an area significantly affected by exploitation of mineral raw materials. Why? Because in fact this landscape can not be renewed. The landscape always remains, and that what changes is its appearance: it is pleasing, favourable, neutral or unattractive, depressing; the components in the landscape can be in the form of advanced natural and nature-affine communities in the mutual dynamic balance, or significantly affected by mining, industrial influence, population or intensive agriculture, where ecosystems are often labile, with limited species. In an intensively exploited landscape we can only try to renew the original landscape structure. And in a series of cases not even that is possible. Due to significant subsidence values, huge volumes of removed tailings or soils by extraction of significant quantity of raw materials it is only possible to create new landscape, as the basic characteristics change (relief, soils, hydrogeological conditions, vegetation, population structures etc.) [1].

On an example of the territory of Ostrava basin (north-eastern part of the Czech Republic) it is possible to evaluate direct and indirect impacts of extraction of mineral raw materials on the landscape. Until the 18th century the Ostrava basin had a nature of farm landscape with a series of non-forest and forest landscape features, with a dense network of fish-pond systems and typical "Silesian" residential construction in the village cadastres.

The important factors markedly changing the overall character of the landscape (landscape type) included development of mining, industrial production and associated increase of population of the area. Gradual development of mining and associated activities was connected with pressure on ecosystems in such extent that it resulted in a substantial change of surface (coal mining was initiated in 1780's), development of new landscape structure, concurrent resettlement or extensive resettlement in the mining area of Ostrava basin in the course 200 years.

Mining landscape is characteristic by gradual diffusion of residential and "production" zone (influence of underground mining on surface, technological reservoirs and waste rock dumps including area redevelopments) at the cost of residential and production zone, which is associated also with the recession of natural components of permanent green (with all the environmental impacts on the species diversity and ecologic stability). The mining and associated industrial activities result in area and space changes of individual landscape components and elements – they completely change the original landscape character of the agricultural land towards the formation of a specific type of landscape with fast dynamics of changes of abiotic and biotic factors. The real vegetation cover in an area affected by underground mining corresponds to the duration and degree of exploitation, i.e. apart from natural types of communities characteristic for cultural Central European landscape (development of communities depending on phytogeographic conditions, vegetation degree and succession stage) specific types of phytocenoses are formed with specific composition of species, development trends and energy-material links. Vegetation in a landscape forms a component influencing both its structure as well as possibilities of further functional use. The nature of permanent vegetation (its area and qualitative representation) is concurrently directly and indirectly influenced by functional use of the landscape and its parts [2].

MINING LANDSCAPE RESTORATION

The determining factor constituting specific character of the mining landscape is the way of achievement of large-area and small-area reclamation goals in the landscape part reclamation process. The reclamation process is an integral part of the raw mineral material mining technology. Reclamation is based on realization of technical and biological procedures and works, whose aim is to restore the possibilities of economic use of devastated territories, restore the **overall functional use of landscape** – general regeneration of the landscape. The final objective of the reclamation is to incorporate the reclaimed land within the surrounding landscape or to create a “new face of the landscape”. Apart from the improvement of the environmental characteristics of the land (restoration of natural and nature-affine ecosystems) the reclamations include also consideration of social – economic and territorially-technical conditions.

In the deciding on the future functional use of landscape parts – on the reclamation goals – it is also necessary to realize the fact that returning to the functional articulation of the landscape before the start of devastation can be a denial of the landscape development (depending on the economic and technical-agronomic background or potential). The “new” landscape is to ensure approximately the same potential of possibilities of use of territory as before the start of devastation. The quality of reclamations should be such to make the economic or social profits from the restored territory comparable with extra-mining territories. Important is also the fact that each landscape carries features that remind of its history (landscape memory, landscape character). The requirement for quality reclamation should therefore be accompanied by the requirement for preservation of certain features that are typical for the mining activity in the territory and can be evaluated as terrain and architectonic or construction dominants (in case of mining landscape this is followed by characteristic terrain modelling documenting the artificially created territorial relief). They are a document of landscape development stage for the future, concurrently they can become a very attractive feature with recreation or residential function (an example can be industrial monuments and areas of mine plants in Germany, Doclands area in London, and in the Czech Republic the premises of Anselm and Michal mine in Ostrava etc.).

The limiting factor in general restoration of landscape (“formation of a new face”) is the fact that it is a relatively short-time process, which as opposed to the “normal” development must correctly specify the acceptable functional use of the area under solution. The effort to imitate an arbitrary “landscape picture” during reclamation is an unsuitable way, as the concrete landscape type did not originate by intent, but due to necessity to adapt the activity of humans to the landscape conditions. The design of landscape structure can not be based on the typology of landscape and comparison of areas of individual features like forests, farmland, ratio of arable lands and permanent grassland etc. Functional use of the areas is, apart from the natural background, the main physiognomic feature of current landscape.

The resulting physiognomy of the landscape and its individual parts is defined by the natural frame and layout of human activity products. The most sensitive components and features, i.e. fauna, vegetation and water regimen gave in to the conscious as well as subconscious transformation of landscape parts in the first place. In the later period, in connection with the developing extraction of mineral raw materials and origination of extensive industrial and urbanized wholes the relief is remodelled and the climatic, pedologic and hydrologic conditions changed. Apart from intensification and industrialization other changes of forest management activities appear – associated with

significant decrease of landscape diversity, diversity of biota species, disturbance of processes of ecological homeostasis, and a series of other influences and factors decreasing the environmental stability of the landscape systems.

The use of areas is a manifestation of agronomic and extra-economic action on environment depending on natural properties of the given territory, economic and intellectual abilities and possibilities of the population, historical – political and social development and possibly also on the mental (aesthetic) relation of people to the surrounding environment.

The main forms of use of areas typical for mining landscape (underground mining) include for example natural water streams and water reservoirs and recent antropogenic water areas (technological reservoirs, watered subsidence); agronomic forests and forest cultures on the reclaimed areas; meadows and permanent grassland; free landscape greenery elements; arable and agricultural land and agricultural reclamation; pomologic cultures; parks; gardens, urban and suburban permanent greenery, transport infrastructure, residential areas; industrial and mining areas; industrial barrens and demolition zones (brownfields) dumping sites; dumps, etc.

Specific types of landscape elements and components in fact corresponds to the selection, combination and disposition of shape and size-differentiated areas of the aforementioned forms of area use. Territorial structure of landscape use is thus created in every area. Territorial structure of use of areas existing concurrently with the natural background characterizes the nature of the landscape and defines units of present cultural landscape.

In present practice the reclamation methods are focused on the individual landscape features in the territory, i.e. the territory is either fragmented or subject to “large-area solutions”. The areas concerned are thus gradually transformed in evacuated areas redeveloped with tailings with realization of reclamation measures, whose method and target culture depends on the time of performance. The population of the concerned areas is gradually resettled to urban centres. Large-area agricultural reclamations (target culture – arable land) were preferred until 1989. After that year the general opinion changes, but to another extreme – afforestation is the dominating procedure (species composition includes especially meliorative trees with significant share of phytogeographically foreign tree species). The landscape structure and functional use of reclaimed part of part of the area thus gradually changes – planting of tree species have 50 to 80% share in the forest cover and environmentally unstable covers. Thanks to the efforts of some of our experts - "renewal of original landscape” (the landscape before being populated had 90% forest cover) the large-area cultural landscape is thus evacuated (people are resettled to big cities) and forest covered (serious problem is the nature of herb layer and absence of bushes in regular plantings).

There is another question for discussion here: Is the aim of reclamation to return the landscape to the beginning of last millennium, or to return the landscape the functions and aim towards harmonic cultural landscape with natural and nature-affine ecosystems but inhabited by humans?

SPONTANEOUS SUCCESSION – A NEW METHOD OF LAND RESTORATION

One of the substantial goals of landscape restoration is the restoration of the vegetation cover. It is in practice achieved by several procedures: spontaneous succession,

controlled succession (“nature-affine reclamation”) or forest and agricultural reclamations (including water management ones).

Many experts, such as [3], [4], have currently been dealing with the study of natural processes of population and restoration of ecosystems = by natural succession on dumps, waste piles and other postmining landscape segments. They state that spontaneous succession is a long-term process, but in terms of biodiversity it is the highest quality way to systems regeneration. We can agree with this statement, if the reclaimed areas are located in the territories with sufficient reserves of diaspores and minimum occurrence of barriers – they are located in areas with natural occurrence with steppe and xerotherm species, which feel comfortable with early stages of development of soil substrate on dumps with sufficient reserve of minerals.

Spontaneous succession nowadays represents a very frequently discusses direction in reclamation practice. The experts claim that every mining landscape has high potential for spontaneous restoration of ecosystems, they also evaluate the financial “convenience” of this reclamation methods – “do nothing”. Our team also very intensively deals with the processes of spontaneous development of vegetation on the dumps, in subsidence troughs and other postmining forms of reliefs and based on our results we can state the following:

1. Spontaneous succession is a spontaneous development of communities of plants and animals on recent landscape stations; especially the facilitation model of ecological succession is important for the reclamation practice. Succession series is started in the initial stage by simple biocenoses of R- and S-strategists depending on the station conditions (terophytes, chamaephytes or phanerophytes). Ruderal and segetal species of early succession stages positively influence the development in soil substrate, decrease and level the extremity of environment (high irradiance, high substrate temperature, lack of nutrients, especially nitrogen etc.). Gradual shading of soil surface, formation of litter fall and gradual changes of soil properties generates conditions for expansion of types typical for more matured succession stages. The limiting factor is especially the seed reserve or the distance of the site from the source of diaspores.
2. Spontaneous succession is the method very suitable and recommended there where sufficient passability of the territory is ensured for the genetic information – for diaspores of plants and also for animals that are important for forming of natural ecosystems.
3. Utilization of spontaneous succession within further reclamation methods and goals will allow for propagation of genetic information and population by flora and fauna also on reclaimed areas (seeding and planting of plants within the seeding procedures constitutes basis that is saturated spontaneously from the source biotopes).
4. The areas therefore will not in the long term be blocked by ruderal, sometimes even invasive plant species (for example in the conditions of the Czech Republic massive population of areas *Calamagrostis epigeios* limits the excess and development of multi-species herb covers), on the other hand they provide for space – refugium for species bound to azonal vegetation (debrital and saxicolous communities, water and wetland communities).

5. Spontaneous succession, as the reclamation goal is in terms of preparation of territory equally demanding as "classic" reclamation methods. The areas with spontaneous succession require elaboration of a detailed procedure and realization project, the territory must be prepared already within the preparation stage – by formation of terrain and surface, evaluation of passability for genetic information. It does not apply that spontaneous succession is a room for “doing nothing”, on the contrary, follow-up monitoring must also be ensured.
6. “Spontaneous succession”, i.e. processes of restoration of biotopes and landscape segments without substantial human influence are preferred in free landscape, in restoration of the elements outside the visual part, on the research surfaces, in the inner space of the waste rock piles, in watered subsidence troughs with fishing use, with recreation and ecological function.
7. The areas that are inaccessible for diaspores (distance from the source, impermeable barrier in the landscape etc.) and on which long-term blocked stages with prevailing ruderal species of herbs and grasses, trees with wide ecological valence in the conditions of the Czech Republic, such as *Betula pendula*, *Salix capraea*, *Populus tremula* are developed should be reclaimed using other methods.

MANAGED SUCCESSION

This approach, first developed in the Netherlands and Britain, is based on the principle of natural succession assisted through management. Managed succession is cursed by some and praised by others. Managed succession is based especially on self-regulation and regeneration of ability of natural ecosystems in the landscape [1]. Its usage is intended especially for those parts of the landscape that are in contact with the residential units, further in the free and suburban part of the landscape, as a part of ecological networks in landscape (ECCONET etc.), in segments of the landscape that should fulfil early and efficiently eco-stabilization functions; in visually exposed parts of territories, in territories that are to fulfil recreation, cultural and instructive function, in segments protected in categories of general environmental protection, in biotopes with occurrence of highly and critically endangered species of plants and animals, with occurrence of species and communities of plants, protected by means of NATURA 2000.

In terms of current practice controlled succession belongs to so-called special types of reclamations, because it is a renewal of natural and nature-affine landscape components and elements with various functional use (forest, meadow, wetlands, water areas, boundary etc. in free as well as residential zone).

Basic starting point is the knowledge of the individual succession stages in relation to type and properties of concrete soil substrate. For planting and seeding autochthonous species of 2nd to 3rd succession stage are used (species spectrum of plant community) both in the components of forest as well as non-forest permanent green (including bush or herbal layer base).

Creation of planting and seeding mixtures of tree species for restoration of vegetation on dumps is associated also with the way of distribution of plants in the territory. Planting of tree species in stripes and rows is used in standard technologies. On the basis of our research we recommend clustered dispersion or group clustered dispersion

to be used during planting and seeding of tree species – planting of combination of species of dominant, co-dominant and bushy cover – faster growing leafy shrubs will provide for protection of young seedlings, together with the supply of nutrients and biomass.

We would like to conclude by referring to issues associated with absence of planting of protective stripes, margins and boundaries in reclamations. On the basis of our research we therefore recommend defining of a special category for reclamation practice that would imply the **obligation to incorporate non-forest elements of permanent green** in all the types of target cultures on the reclaimed areas (agricultural and forest types of reclamations, landscape gardening reclamations, special and hydrogeologic types of reclamations and the like). The request derives from the fact that the elements of permanent non-forest green are a functional and natural part of the cultural landscape. The character of the newly incorporated elements of the permanent extra-forest green must derive from the species composition and structure of natural types of ecotone communities. The significance of ecotone in the landscape derives from its basic characteristics – usually thick vegetation with the development of high-herb margin and herb and tree cover coat (protective function of the internal environment, dense vegetation canopy, high biomass per area unit, favourable nutrient balance, protective and self-purification ability in the contaminated and erosion-affected areas and the like). The ecotone width is influenced by relief, shape of landscape component and light penetrability in the cover.

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