HISTORY AND PRESENT SITUATION ON RECLAMATION OF SPOIL BANKS IN THE SOKOLOV REGION*

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The article is a review of history and actual "art of knowledge" of reclamation of spoil banks in mining areas, namely in Sokolov region. Creation of new landscape on spoil banks in Sokolov brown coal shell using agricultural, forestry and hydrological systems of reclamation is unique in frame of former Czechoslovakia as well as in the Czech Republic, nowadays. It has their original solutions which are specific for Czech system that is different from others in Europe. The method working in system frame of **"soil – water – vegetation – infrastructure"** gives good possibilities for improvement and reclamation of the whole landscape degraded by mining and other industry activities. The main strategic goal of reclamation in the region is ecological stability in terms of biodiversity, fulfilling all economic and non-economic functions.

reclamation; brown coal mining; forestry; agriculture; hydrology

Introduction

Agricultural, forestry and hydrological system of reclamation applied in our country, which is unique in frame of the former Czechoslovakia as well as in Czech Republic (Dimitrovský, 1976). They have their original solutions, which are specific for Czech system that is different from others in Europe (Dimitrovský, 1989). The method – working in a system frame of **"soil – water – vegetation – infrastructure"** – gives good possibilities for improvement and reclamation of the whole landscape degraded by mining and other industry activities (Havlena, 1964; Chlupáč et al., 2002; Knobloch et al., 1996; Kupka et al., 2007). The main strategic goal of reclamation in the region is ecological stability in terms of biodiversity. The strategy is based on experience of the oldest reclamation areas in our country, that is on spoil bank Bohemia (3.6 ha) and Vilem (7.2 ha) where forest reclamation was done in 1934–1936 (Dimitrovský, 1999). *Alnus glutinosa* (L.) was used on Bohemia bank and for Vilem there were mixtures of Black pine, European larch – Jesenik provenance, Norway spruce, Grey alder and Silver birch, which came later on from natural regeneration. Regeneration cuts were done on these plots by gap felling and/or wedge system in the year 1962. Large spectrum of valuable broadleaves were introduced after these fellings (Vaněk et al., 1998).

Research history on spoil banks and its focus

The mining area Sokolov represents complicated landscape system with components changing within time and space (Mísař et al., 1983). Reclamation after mining started at the beginning of the twenties of the last century. In fact the first Mining law of the former Austrian-Hungarian Empire put the obligation for miners to make reclamation of landscape after the area is mined out (Malkovský et al., 1985). Later on in fifties of the last century the Mining Law No. 41/1957 Coll. stresses even more the duties of miners for reclamation based on rigid plans for reclamation of former mining areas (Svoboda et al., 1964). The Research Institute for Agricultural and Forest Amelioration was the main research institute in that time dealing with the subject. It should be mentioned that former German Democratic Republic started the spoil bank reclamation namely in forestry earlier than our country and German methodology strongly influenced our system. They used the upper layer classification of anthropogenic substrates in spoil banks, which was accepted and used in our system later on (Jonáš, Semotán, 1958). The classification prepared by S. Beneš, J. Semotán and V. Voráček (Beneš et al., 1964) was later modified by Dimitrovský (1976) for the Sokolov region.

Another important aspect is the different methodology for agricultural and forest reclamation. While the former has common system with agrobiology, forest reclamation needs to be based on totally different bases. The first step was the broadleaves classification used in former German Democratic Republic, where broadleaved species were grouped into: (i) reclamation species, (ii) reclamation species with s pecific economic purpose and (iii) species for wood production. The next step was to use "ecovalence" of particular tree species. The idea is coming from Prof. P. Svoboda as a key factor for species evaluation and the idea was used also for forest reclamation.

Forest reclamation and afforestation of spoil banks has to take into account following variables:

– geological and petrographic structure of substrates,

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Fig. 1. Successful afforestation by Norway spruce of different provenances creating functional biocorridors

– mineralogical composition,
– chemical, physical and hydro-pedological features,
– ecovalence of tree species,
– ecotype and phenotype of selected species.

All above given variables strongly influence the forests on spoil banks where main key factors are **"anthropogenic substrate – micro climatic conditions – tree species"**. As applied science there are two main domains for successful forest reclamation. First of all it is "dendrology" and then "method s of forest reclamations", which have to be applied with regards to local conditions. The results of the effort and its successful application can be seen on Figs 1–3.

Fig. 2. Natural regeneration of Douglas fir at larch stands (arboretum Antonin)

Important aspect of the successful reclamation is the recovery of water regime (Semotán, Dimitrovský, 1967). Our research confirmed that infiltration strongly influenced root system of tree species on spoil bank, which has totally different architecture when compared with "natural" one in a forest soil. Our research suggests that the root architecture is formed by interactive system **"rock – water – tree species"** (Dimitrovský et al., 2001). In fact more research on this topic is needed as water regime and its influence on spoil banks is complicated and variable, depending on anthropogenic substrates, type of reclamation and species composition (Dimitrovský et al., 2006). Succession usually failed in this phase of reclamation (Fig. 4).

Retention and infiltration on spoil banks

Water retention in the landscape is complicated phenomenon, which is usually differently described by authors depending on their scientific profile. Geomorphology, geology, soil conditions and vegetation cover are the most important key factors in water retention. There are some attempts to create *artificial wetlands* on spoil banks. Unfortunately these attempts failed as anthropogenic substrates have different structure with macro-voids which made artificial wetlands soon empty and dry. The anomaly water regime is typical for the anthropogenic substrates and it makes in most cases artificial wetlands impossible on spoil banks. The specific water regime lasts for 10 years after spoil bank creation or even longer. The only source

Fig. 3. Provenance trials for Serbian spruce (*Picea omorika* Pančič) in arboretum Antonin

Fig. 4. Final stage of "succession" recommended by "new ecologists"

of water in the area is precipitation, which together with anthropogenic substrate structure with large macro-voids leads to specific water regime as explained above.

The infiltration intensity could be classified according to Table 1.

Anthropogenic substrates have very specific structure with large macro-voids and cavities, which makes water circulation very specific. That is why specific test should be used. The test is called **"moisten profile evaluation"**, which is done on vertical profile on typical chosen pit. The evaluation is done according to the classification in Table 2.

For example cypriss clays have low degree of disintegration the first 10 years and that is why they belong to the group with very extensive infiltration intensity and extensive moisten profile. The anthropogenic substrate under

Table 1. Infiltration intensity classification used for anthropogenic substrates (D i m i t r o v s k ý , 1972)

Infiltration intensity (mm per hour)	Classification
< 1	extremely small
1–10	small
11–50	medium
51–100	rather extensive
101–200	extensive
201–500	very extensive

Table 2. Moisten profile evaluation classification

Moisten profile capacity (cm)	Classification
0–20	extremely small
21–40	small
41–60	medium
61–80	rather extensive
81–100	extensive
> 100	very extensive

1964. Besides of research there is also a forest park, which covers the area 29 ha.

Silvestr – the area 8 ha – seed orchard of Lodgepole pine founded in 1992.

Velký Riesl – the area 23 ha, research objects founded in 1962. The main goal is conversion of common alder stands to valuable broadleaves such as sycamore, Norway maple, small-leaved lime, English oak, durmast oak, common ash, English elm, beech etc.

Table 3. Reclamation of coal mining areas in the Czech Republic in ha (as for January 2007)

Area	Reclamation (ha)			
	finished	on going	planned	total
Sokolov	3 066	2 574	3 610	9 250
Northern Bohemia	3 556	3 050	6 561	13 167
Most	3 128	1 379	4 596	9 103
Karviná	710	1 010	584	2 034
Total	10 460	8 013	15 351	33 824

Table 4. Costs of reclamation according to areas and type (data based on results for last 10 years)

Mining area	Type	Cost in mill. CZK per ha
Sokolov	agricultural	0.8
	forest	0.6–0.8
	hydric	1.1–2.1
	other	0.7–0.9
Northern Bohemia	agricultural	0.9
	forest	1.1–1.35
	hydric	1.8–2.0
	other	1.0–1.2

forest reclamation after 25–50 years has medium infiltration intensity and medium moisten profile. The important facts are that infiltration intensity and moisten profile capacity are not decreasing with higher amount of precipitation and that is why the water erosion phenomenon is not very common on these types of spoil banks.

The following description of chosen spoil banks illustrates the history of all types of reclamations in the Sokolov region. The most important are:

Antonín – the area 165 ha – the forest reclamation arboretum, founded in the years 1969–1972, 224 taxons including seed orchard of Lodgepole pine (Murray).

Bohemia – the area 3.6 ha, founded in 1934, forested by common alder, later converted to mixture of broadleaved species as oak, maple, lime etc.

Dvory – the area 105 ha, pheasantry, founded in 1963 as the combination of forest and game management. Shooting lines are forested by different species such as spruce, white pine, Douglas fir, Black locust etc.

Gustav – the area 67 ha, the combination of agricultural and forest reclamation. Research plots founded in

Velká Loketská – the area 109 ha, the combination of agricultural and forest reclamation. Agricultural reclamation there could be divided into: (i) direct (22 ha) and (ii) indirect (20 ha). Another part of the area is devoted to forest reclamation (67 ha). Species used for forest reclamation are: Scots pine, Black pine, Macedonian pine, Lodgepole pine (Murray pine), Dwarf pine, Norway spruce, Blue spruce, European larch etc. There are 22 provenances of dwarf pine and 18 provenances of Lodgepole pine. Agricultural reclamation area is used for pasture of cattle.

Discussion and conclusions

Philosophy and methodology of landscape reclamation in the system **"soil – water – vegetation – infrastructure"** in the mining areas where also industrial activities are enormous (chemistry and power plant stations etc.) are hot topics for ongoing discussion not only among specialists but also in the public.

Actual situation in reclamation areas in the Czech Republic is given in Table 3.

Research and actual results of landscape reclamation are always based on good theoretical bases and practical knowledge, permanent comparison of results and starting conditions. The basic limits were always taken into account, namely:

- geo-morphological changes of landscape,
- microclimatic changes,
- type and size of mining area,
- emission,
- type of anthropogenic substrates,
- type of vegetation and
- system of management.

The above given limits led to ecosystem management, which means management under specific conditions

driven by socio-economic principles. As a result it should be a landscape, which could fulfill all economic and non-economic functions.

The cost of reclamation depends on type of reclamation. The general data on cost for last decades are given in Table 4.

Forest reclamation belongs to rather cheaper system of reclamation creating valuable forest ecosystem supporting auto-regulation capacity of landscape. Within the topic it needs to be explained the specific phenomena, which new forests on spoil banks – especially those with specific structure and species composition – have created. There is an attempt for new definition of the phenomenon.

Close-to-nature forests on spoil banks after reclamation could be defined as follows: **"Forests with the given structure and species composition as the result of suitable species and ecotypes for its good future growth and development preserving its regeneration capacity."**

The mining area of Sokolov is supposed to be empty of accessible brown coal shell about the year 2035. During the period, which lasts of approximately hundred years where namely mining from surface drastically changed the landscape, the real reclamation started at about half of the last century. One can see the new attitude to reclamation especially to forest reclamation when local ecotype forest tree species is the fishbone of spoil bank forest reclamation.

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KUBÁT, J. (Česká zemědělská univerzita, Fakulta lesnická a dřevařská, Praha, Česká republika):

Historie a současná situace rekultivací výsypek v oblasti Sokolovska.

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Proces tvorby nové krajiny na výsypkových stanovištích Sokolovské hnědouhelné pánve formou rekultivace zemědělské, lesnické, hydrické a ostatní je v podmínkách bývalého Československa (a nyní České republiky) ojedinělý, historicky prakticky nejstarší a v této disciplíně zcela ojedinělý. Vypracování metodiky rekultivace v systému **„půda – voda – vegetace – infrastruktura“** se stalo jedním ze stěžejních úkolů rekultivace tohoto území postiženého báňskou a další průmyslovou činností. Jde o široce pojatý problém, zahrnující řadu technologických způsobů dobývání, geologicko-petrografických skladeb skrývaného nadloží a různých postupů při rekultivaci.

Při volbě rekultivace byly získány neocenitelné znalosti a zkušenosti z prvních rekultivací. Zejména je třeba zmínit pravděpodobně vůbec nejstarší lesnické rekultivace na dvou maloplošných výsypkách Bohemia (3,6 ha) a Vilém (7,2 ha), zalesněných v letech 1934–1936. Na obou výsypkách byla v letech kolem roku 1962 provedena přeměna původně založených porostů kombinací standardních obnovních prvků – převážně kotlíků. V nově zakládaných porostech je použita široká paleta cenných listnáčů, vesměs domácí provenience.

Lesnická rekultivace, tak jak se ustanovila v českých zemích, vychází v zásadě ze dvou základních vědních disciplín: (i) obecné dendrologie a (ii) rekultivace, zejména její lesnické části. V první části je třeba připomenout zejména prof. P. Svobodu, který byl nejen významným dendrologem, ale také jedním ze zakladatelů krajinné ekologie. Z důležitých osobností v oblasti rekultivací je třeba zmínit zejména F. Jonáše, J. Semotána a V. Voráčka.

Retence a infiltrace vody je další významnou součástí rekultivační vědy, důležitou zejména proto, že je nezbytná k udržení funkčního vegetačního krytu výsypek. Celá řada „ekologů“ se snaží při rekultivacích výsypek vytvářet *mokřady* rozdílných tvarů a velikostí. Všechny tyto mokřady končí jako bezvodé prohlubně. Retence a infiltrace vody je totiž mnohem komplikovanějším problémem souvisejícím s vysokou infiltrační schopností jílů a zcela odlišnou strukturou těchto substrátů s velkými makropóry a dutinami. Přitom jediným zdrojem vody na těchto výsypkách jsou srážky. Specifické poměry také vysvětlují skutečnost, že eroze je na tomto typu výsypek spíše vzácným jevem. Postupná obnova hydrologického cyklu je tedy důležitou součástí každého typu rekultivace.

V závěru tohoto přehledu historie výzkumu a metod – zejména lesnických – rekultivací je definován přírodě blízký les na výsypkovém hospodářství. V tomto pojetí je tento les charakterizován určitou strukturou a skladbou vhodných dřevin místních ekotypů a je schopen trvalé existence a vlastní reprodukce.

rekultivace; těžba hnědého uhlí; lesnictví; zemědělství; hydrologie

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