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PLANT COMMUNITIES ON BROWNFIELD SITES IN UPPER SILESIA (CZECH REPUBLIC)

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Abstract: Research was directed towards the collection of phytocenologic, dendrologic and site-related data in the area of interest. From March 2012 to the end of November 2012, 19 spoil heaps situated in mining claims within the Ostrava-Karviná Coalfield, in the cadastral areas of municipalities of Doubrava, Horní Suchá, Karviná-Doly, Karviná – Louky, Ostrava, Paskov, Rychvald, Stařίč and Stonava were mapped. The subject of research is plant communities in various stages of spontaneous succession in reclaimed and unreclaimed areas, site conditions; the research is focused on assessing the significance of specific nutrients to the development of herb and woody plant compositions of stands growing on the brownfield sites. Based on the results, the biodiversity in both the layers was found in the case of areas reclaimed technically and biologically with soiling was the lowest.

Key words: Brownfield sites, spoil heap, Upper Silesia, herb and woody plant communities.

1. INTRODUCTION

All over the world, places untouched by man disappear. The intensity of negative impact of human activity on nature and the environment grows continuously. In the past, excessive deforestation, unsuitable agricultural use of land, and others contribute to the anthropogenic destruction of a landscape. However, the devastation of land is an accompanying feature of human activities of the present. The number of people is increasing rapidly and their demands for the production of food and material goods are growing. These demands can be satisfied above all by the intensification of agricultural production and the development of industries. The greatest destruction of landscape environment in the Moravian-Silesian Region is associated with the mining of mineral resources. The area of Ostrava-Karviná Coalfield belongs to the areas where the mining industry is highly developed (Raclavská, 2003; Filipová, 2007). Owing to the extraction of hard coal and its further treatment, mining waste continuously accumulates and other effects connected with coal exploitation and treatment occur, such as brownfield sites - spoil heaps, subsidence troughs, increased dustiness, degradation of and changes in natural ecosystems and communities (Debehault, 1968; Skjerdal, 1993; Skjerdal & Odland, 1995). Although generally, spoil heaps are taken as negative externalities of mining, it is also possible to take them as very valuable high-potential sites – spoil heaps become suitable safe sites for endangered to critically endangered species plants (and animals too). In the majority of cases, reclamation of these areas has not a nature of the restoration of landscape functions because the methods of "rapid greening" are preferred over the restoration of natural communities of organisms (Rumpel et al., 1999; Frankard, 2000; Jochimsen, 2001). For this reason, these newly emerging - recent habitats must be integrated into the surrounding landscape to create a resistant, close-to-nature area of higher biodiversity as soon as possible.

Since nowadays prefer more rapid methods for greening the expense of restoration of natural communities of organisms in reclamation (in organic phase) the recent and very convenient to use the knowledge in spontaneous settlements plant succession (Jochimsen, 1996; Sádlo & Tichý, 2002) with regard to chemical and physical substrate, the adaptability of species to the newly created position and the distance from the area stands in the surrounding landscape. The only way to restore these areas to landscape features, create a resistant near-natural areas with high biodiversity and as soon as possible to integrate it into the surrounding countryside. Methods remediation and reclamation sites affected by mining and quarrying in the Czech Republic deals Štýs (1981), dumps in the North Bohemian brown coal basin is analyzed in this by Čermák & Ondráček (2009). Even abroad, a large group of experts discusses the use of different types of reclamation on spoil heaps (brownfield sites) and dumps (Hüttl et al., 1996; Fox et al., 1998; Evans & Willgoose, 2000; Paithankar et al., 2001; Hancock et al., 2003; Krzaklewski & Pietrzykowski, 2007).

2. DESCRIPTION OF AREA OF INTEREST

The Ostrava-Karviná Coal Basin is a part of the Upper Silesian Basin in the Czech Republic, which lies, for the greater part, in the territory of neighbouring Poland. The whole area is about 7 000 km^2, of which the Czech Republic only occupies about 1 500 km^2. This is an area in the surroundings of the towns of Ostrava, Karviná, Český Těšín, Frenštát pod Radhoštěm, and others, where coal-bearing strata of Carboniferous age are there. The Ostrava-Karviná Coal Basin is divided into the following areas:

- Ostrava-Karviná – where mining operations have already been performed for a long time and affected significantly the landscape shape, form and pattern and also social elements;
- Podbeskydí – mining operations have not been carried out yet.

The southern boundary of Czech part of the Basin has not been confirmed unambiguously yet; the majority of authors are of the opinion that the coal-bearing Carboniferous strata descend into great depths and run over great distances.In the Ostrava-Karviná area, the Ostrava and the Karviná Formation are there. The Ostrava Formation was formed under the conditions of coastal climate and under the influence of frequent volcanic activity; it is characterised by coal of higher quality from seams having smaller thicknesses when compared with the Karviná Formation. It is fine-grained arkosic sandstones, clayey siltstones and sandy claystones that constitute the largest portion of the whole Formation. Conglomerates occur here sporadically. On the other hand, the younger Karviná Formation was formed after the final retreat of the sea; the average thickness amounts to 885 m. It is composed of coarse-grained greywacke sandstones with garnet, clayey siltstones, claystones and conglomerates (consisting of quartz).

3. MATERIALS AND METHODS

In the framework of research, several tasks were determined that were solved in the following ways: the area of interest was divided into smaller landscape units; for the determination of location of spoil heaps in the field, a tourist map (Ostravsko – Hlučín, Bohumín, Ostrava, Karviná, Český Těšín, Frýdek-Místek, Havířov, scale of 1:50 000, issued in the year 2005) was used. By means of a navigation device Garmin eTrex Vista Cx, coordinates of research areas, including altitudes were measured; for specific areas the orientation, slope and shape of spoil heap (tabular, terrace-like, conical, ridge-like, cumulous, steep, levelling - Fig. 1) were recorded.

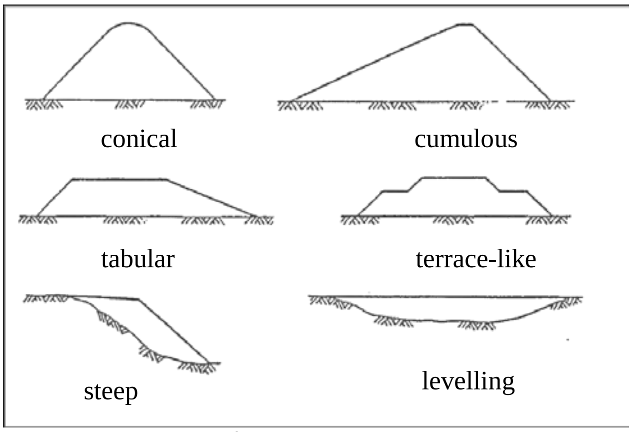

Figure 1. Shapes of spoil heap (adjusted by Havrlant, 1980)

Altogether 19 spoil heaps were mapped using the method of phytocenological recording; the size of areas was selected according to Mueller - Dombois & Ellenberg (1974). Individual species of plants were determined according to Rothmaler (1985). The species were classified according to Mlíkovský & Stýblo (2006); they were also evaluated from the point of view of their abundances in individual categories of areas (see below). The determination of forest woody plants is carried out all the year round – in both the vegetation period and outside the vegetation period, in various stages of development. In the winter season, woody plants are determined by the habitus, buds, seeds and fruits (Büntgen, 2007), for the designation of woody plants, abbreviations or numerical codes (code list of Forest Management Institute - ÚHUL) were used. Results of partial investigations are presented by means of graphs in the following chapter.

The study areas were divided into the following three categories:

1. Areas with only spontaneously occurring species (Fig. 2)
2. Areas after technical and biological reclamation (TBR) without soiling (Fig. 3)
3. Areas after technical and biological reclamation (TBR) with soiling (Fig. 4)

Figure 2. NW-facing slope of spoil heap (photo: Dana Žampachová)

Figure 3. N-facing reclaimed slope (photo: Eva Lacková)

Figure 4. Top of reclaimed spoil heap Hohenegger (photo: Eva Lacková)

4. RESULTS OF RESEARCH AND DISCUSSION

In the area of Ostrava-Karviná Coalfield, hard coal is mined by underground methods. By gradual deposition of spoil, convex landforms are created. It follows from the research that shapes of spoil heaps mapped by us are most frequently tabular (30%) and terrace-like (25%); on the contrary, spoil heaps of conical (5%) and ridge-like (5%) shapes occurred in the representative sample of spoil heaps least (Fig. 5).

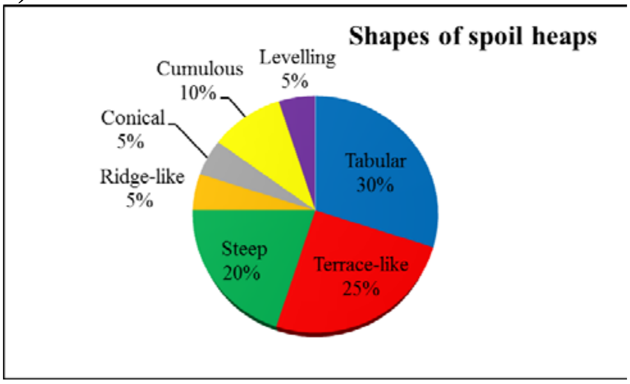

Figure 5. Shapes of mapped spoil heaps in Upper Silesia

In the study sites on spoil heaps in Upper Silesia, the following spontaneous species were found in the herb layer: *Anthemis arvensis, Artemisia vulgaris, Betula pendula juv., Calamagrostis epigejos, Cirsium arvense, Cirsium vulgare, Daucus carota, Echium vulgare, Epilobium dodonaei, Eupatorium cannabinum, Euphorbia cyparissias, Fragaria vesca, Hypericum perforatum, Impatiens glandulifera, Leontodon autumnalis, Medicago lupulina, Oenothera biennis, Parthenocissus inserta, Pastinaca sativa, Populus x euroamericana juv., Pyrethrum parthenium, Rosa canina juv., Rubus fruticosus, Rubus ideaus, Rumex acetosa, Sanguisorba minor, Solidago gigantea, Symphytum officinale, Tanacetum vulgare, Tussilago farfara, Urtica dioica, Urtica urens, Verbascum lapsus, Vicia hirsuta, Vicia sativa.*

On the basis of field research it has been found that on the Upper Silesian spoil heaps investigated by us, above all autochthonous species occur; allochthonous species – so-called ***archeophytes*** and neophytes (*Impatiens glandulifera Parthenocissus inserta, Populus x canadensis, Tanacetum vulgare*, etc.) are less abundant.

The found species require high sunlight intensity during the vegetation period and high substrate moisture – evaluated according to Ellenberg (1974). In spite of the fact that this is a case of areas having different site conditions and stands of different ages, anemochorous plant species gain ground in the majority of the areas (these species are equipped with dispersal-promoting appendages or have very light diaspores) - *Daucus carota*, *Betula pendula*, *Pastinaca sativa*, and other species. Less frequently the species the ecesis of which is connected mainly with zoochory (*Rosa canina*, *Rubus fruticosus*, and other species) occur on the study spoil heaps.

Figure 6 describes the average number of spontaneously occurring species in all 9 areas of each category. It is clear that more species occur in unreclaimed areas and areas after technical and biological reclamation without soiling.

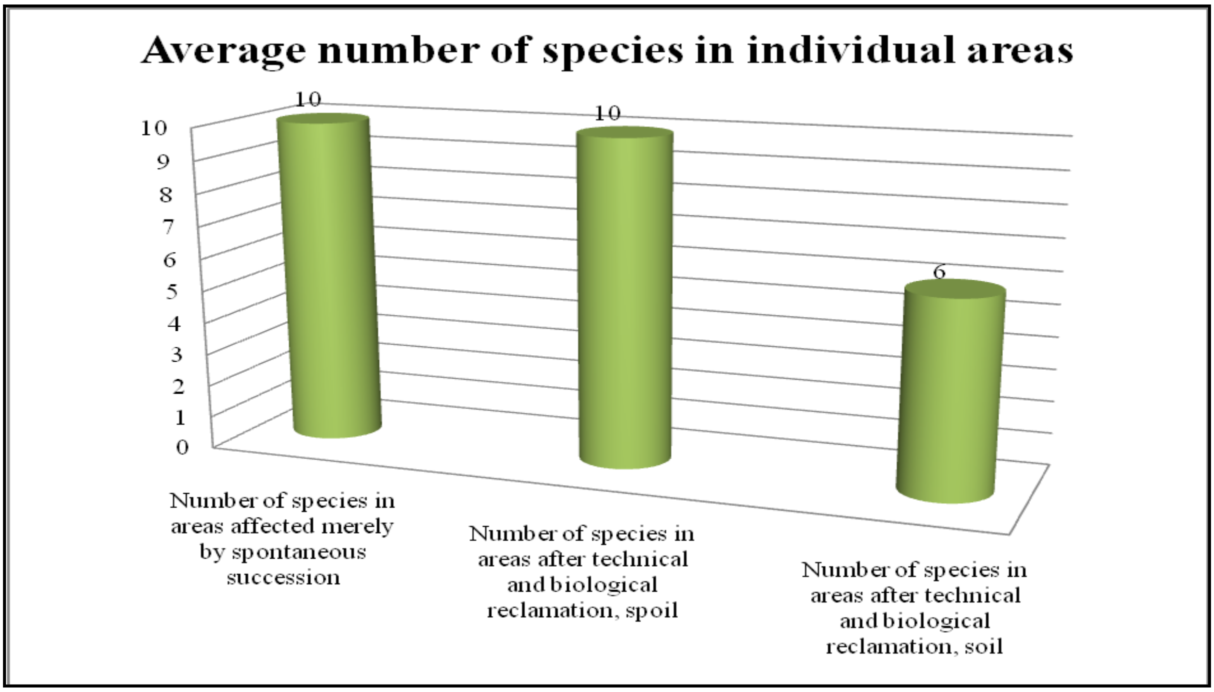

Figure 6. Comparison of average number of species in the herb layer in all types of areas

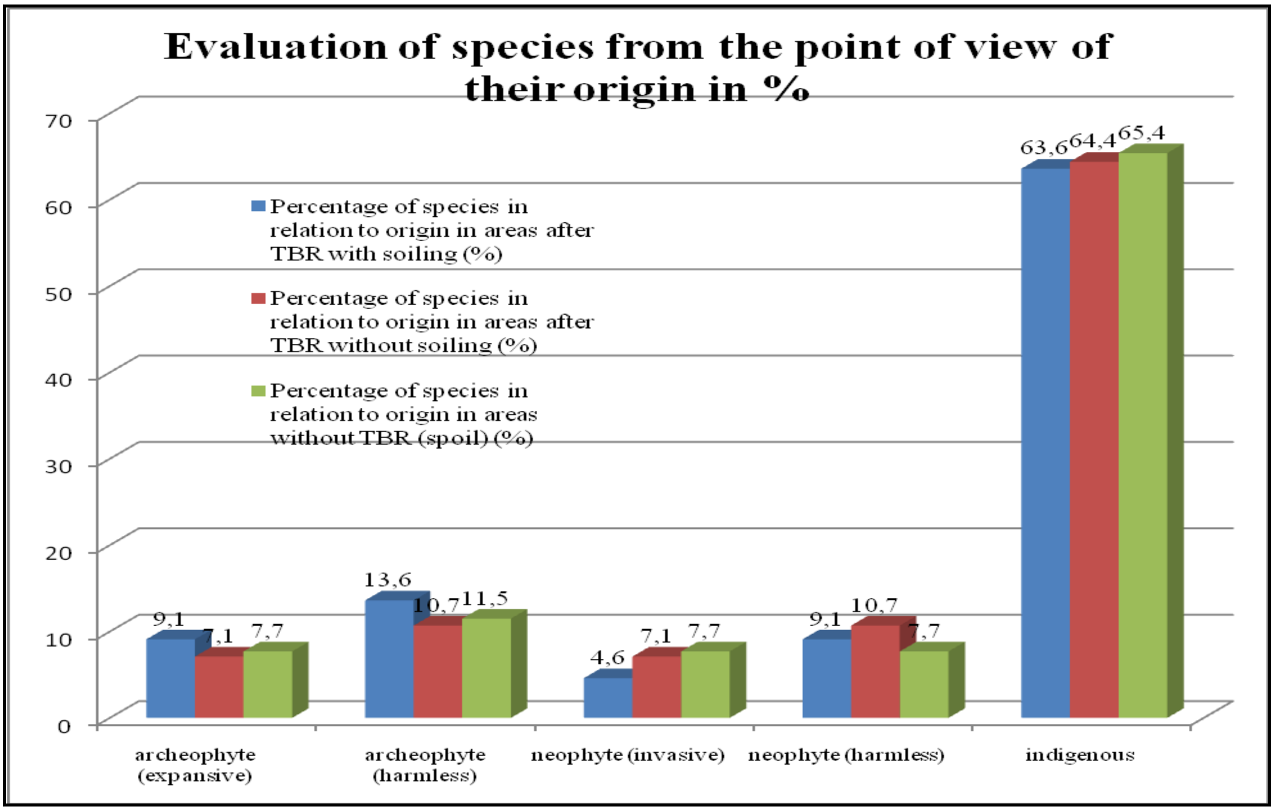

Figure 7. Evaluation of species in the herb layer from the point of view of their origin in %

The low abundance of species spontaneously occurring in areas where TBR and simultaneously soiling have been carried out may be a result of application of underseeding technique to the soil – thus any ecesis of spontaneous species in extent comparable with that in open areas with a spoil substrate is not possible (spoil substrate porosity enables the easier ecesis of plant species).

In the case of technical and biological reclamation, undersown seeds (prevailingly a clover grass mixture) can cause a reduction in possibility of applying species from the surroundings of spoil heaps; thus the species diversity of the site and the rate of integration of such an area into the surrounding landscape decrease.

In the study spoil heaps mainly indigenous species occur, i.e. these areas really become favourable sites for autochthonous species, are valuable refugees for the species that lose their natural habitats.

Furthermore, on the spoil heaps, non-indigenous species of flora occur, harmless archeophytes, expansive archeophytes, neophytes evaluated as harmless and neophytes invasive (Fig. 7).

In the open areas (without TBR and without soil), non-indigenous species also play a very important role in addition to the indigenous species; the presence of specific species (indigenous as well as non-indigenous) is influenced very markedly by the surrounding stands

The species diversity of forest stands is a very important identifier of the condition of forest stands, influences considerably the stability of stands and the fulfilment of out-of-production functions of forest ecosystems. Figure 8 describes the average abundance of woody plants on the spoil heaps where spontaneous succession occurs. Of the three study categories of areas, species variability is the highest here because not only anemochorous species with a wide range of ecological valence, such as *Betula pendula, Salix sp.* (so-called ameliorative woody plants) but also target woody plants the principal function of which is wood production (*Fagus sylvatica*, *Fraxinus excelsior*, *Acer platanoides*) are there here.

The situation of spontaneously growing woody plants on the spoil heaps where technical and biological reclamation without soiling has been carried out is described by figure 9. It follows from the results that the highest species abundances are those of pioneer woody plants (*Betula pendula*, *Salix sp*., etc.), which prepare owing to their properties better conditions for the growth of principal woody plants. Nevertheless, introduced and/or ornamental woody plants are there here (*Robinia pseudoacacia, Populus x euroamericana*); although they are relatively more resistant to some environmental factors, they participate in disturbing the ecological relations.

The worst ever results of our research are associated with the spoil heaps after technical and biological reclamation with soiling. The number of spontaneously dispersed woody plants was very small Only 3 species of woody species, namely *Salix sp.*, *Populus tremula* and *Betula pendula* were found here. This finding can be affected by the higher degree of coverage and abundance of target planted woody species.

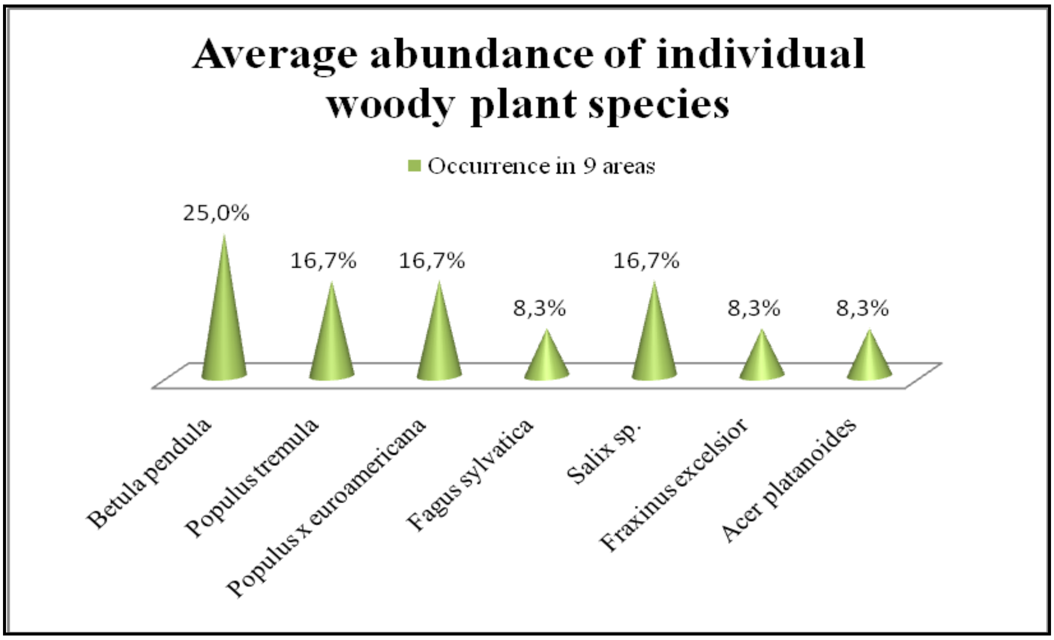

Figure 8. Average abundance of woody species in areas without TBR

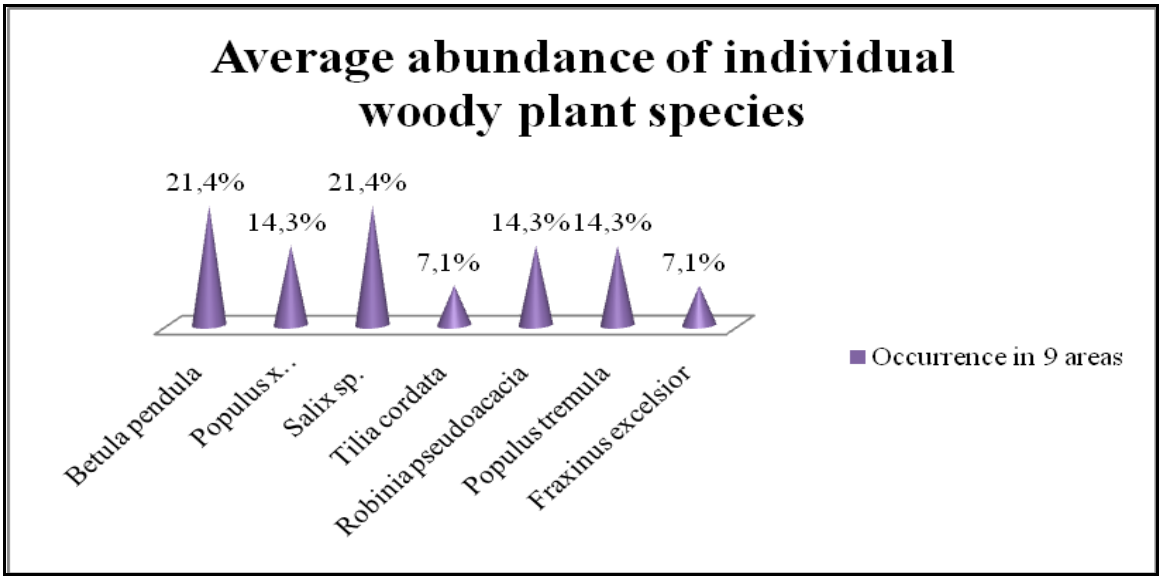

Figure 9. Average abundance of woody species in areas with TBR

5. CONCLUSIONS

Together with the mining of mineral resources, efforts to restore disturbed and devastated landscape segments have appeared in recent years. Thanks to landscape remediation, to areas affected by heavy industries, stability and self-regulation capability have been slowly returned. Because it is not possible to restore the original scenery of the landscape, new landscapes are created with characteristic sceneries.

In the Czech Republic the first reclamation works were performed in the 50's of the 20th century; since then thousands of hectares have been reclaimed in the country. After completing the mapping of the area of interest, herb and woody plant communities were evaluated subsequently from the point of view of their abundance, species composition and origin. Merely spontaneous species in the herb layer were evaluated.

It follows from the results that the highest species biodiversity as well as abundance is connected with areas not affected anthropogenically, i.e. not reclaimed technically and biologically in the herb and the tree layer (the highest abundance of autochthonous species, such as *Betula pendula, Fagus sylvatica*, etc.). The lowest biodiversity in both the layers was found in the case of areas reclaimed technically and biologically with soiling, which may be caused by underseeding and planting a great number of target woody plants. The ecological value of such stand depends on the species composition of material planted; allochthonous species may lead to a decrease in species diversity in the whole newly developing ecosystem. On the contrary, autochthonous species lead to the restoration of close-to-nature stands, and thus to the restoration of ecosystems.

In the case of areas after technical and biological reclamation without soiling, the species composition and abundances of species are comparable with the 1st type of areas - areas where merely spontaneous succession has occurred.

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REFERENCES

Büntgen, U., 2007. *Growth responses to climate in a multi-species tree-ring network in the Western Carpathian Tatra Mountains Poland and Slovakia*. Tree Physiology, 27, 689-702.

Čermák, P. & Ondráček, V., 2009. *Stanovištní a rhizologické vlastnosti dřevin využívaných při zalesňování výsypek severočeské hnědouhelné pánve. Habitats and rhizological characteristics of tree species used in reforestation spoil banks the North Bohemian brown coal basin.* .Metodika. Praha: Výzkumný ústav meliorací a ochrany půdy, v. v. i., ISBN 978-80-904027-8-2, 53 p.

Debehault, C., 1968. *Les terrils de charbonnage du Borinage. Etude de géographie régionale.* Revue Belge de Géographie 92, 9-57.

Ellenberger H., 1974. *Zeigerwerte der Gefäßpgflanzen Mitteleuropas,* Scripta geobotanica. Göttingen, 122p.

Evans, K. G. & Willgoose, G. R., 2000. *Post-mining landform evolution modelling: 2. Effects of* *vegetation and surface ripping.* Earth Surface Processes and Landforms 25, 803–823 p.

Fox, H. R., Moore, H. M. & Mcintosh, A.D., 1998. *Land Reclamation Achieving Sustainable, Benefits.* Proc. 4th Intern. Conf. Intern. Association of Land Reclamationists, Nottingham, UK, 7-11 Sept. Balkema, Dordrecht, 560 p.

Filipová, K., 2007. *Hodnocení vegetačních poměrů antropogenního reliéfu Ostravska v různých stádiích sukcese a rekultivace. The evaluation of vegetation conditions of the anthropogenic relief of Ostrava in the various stages of the succession and reclamation.* Disertační práce, Brno: Mendelova zemědělská a lesnická univerzita v Brně, 119 p.

Frankard, P., 2000. *Aperçu de la flore et de la végétation des terrils de la région liégeoise.* Bulletin de la Société Royale des Sciences de Liége 69, 265-287p.

Hancock, G. R., Loch, R. J. & Willgoose, G. R., 2003. *The design of post-mining landscapes using geomorphic principles.* Earth Surface Processes and Landforms 28, 1097–1110 p.

Havrlant, M., 1980. *Antropogenní formy reliéfu a životní prostředí v ostravské průmyslové oblasti. The anthropogenic forms of the relief and the environment in the Ostrava industrial area.* Praha: Státní pedagogické nakladatelství, 153 p.

Hüttl, R. F., Heinkele, T. & Wisniewski, J., 1996. *Minesite Recultivation*. Springer, 172 p.

Jochimsen, M. E. A., 1996. *Reclamation of colliery mine spoil founded on natural succession.* Water, Air, & Soil Pollution 91, 99–108 p.

Jochimsen, M. E. A., 2001. *Vegetation development and species assemblages in a long-term reclamation project on mine spoil.* Elsevier, Ecological Engineering 17, 187–198p.

Krzaklewski, W. & Pietrzykowski, M., 2007. *Diagnoza siedlisk na terenach pogórniczych rekultywowanych dla leśnictwa, ze szczególnym uwzględnieniem metod fitosocjologiczno−glebowej.* Kraków: Sylwan nr 1, 51-57 p.

Mlíkovský J. & Stýblo P., 2006. *Nepůvodní druhy fauny a flóry České republiky*. Non-native species of fauna and flora of the Czech Republic. Praha, Český svaz ochránců přírody, 496 p.

Mueller-Dombois, D. & Ellenberg, H., 1974. Aims and methods of vegetation ecology. Wiley, New York.

Paithankar, A. G., Jha, P. K. & Agarwal, R. K., 2001. *Geoenvironmental Reclamation*. International Symposium, November. Taylor & Francis. 20–22p.

Raclavská, H., 2003. *Problémové parametry při posuzování využitelnosti hlušin v OKR. Problematic parameters in assessing the the usability of spoil rocks in the Ostrava-Karvina district.* Ostrava: Uhlí-rudy-geologický průzkum, No. 9, 20-26 p.

Rothmaler, W., 1985. *Allgemeine Taxonomie und Chorologie der Pflanze.* Grundzüge der speziellen Botanik. Jena: Gronau, 215 p.

Rumpel, C., Kfgel-Knabner, I. & Hqttl, R. F., 1999. *Organic matter composition and degree of humification in lignite-rich mine soils under a chronosequence of pine.* Plant and Soil 213, 161–168 p.

Sádlo, J. & Tichý, L., 2002. *Sanace a rekultivace po lomové a důlní těžbě, Tržné rány v krajině a jak je léčit. Remediation and reclamation after the quarry and mining, lacerations in the landscape and how to treat them.* Brno: ZO ČSOP Pozemkový spolek Hády, *ISBN 809031211 – X, 35p.*

Skjerdal, G., 1993. *Kvantitative undersokjingar av vegetasjonen pa steintippar i Aurland,* Vest-Noreg. Cand scient. Thesis, Univ. Bergen, Bergen, urubl.

Skjerdal, G. & Odland, A., 1995. *Vegetasjonsutvikling pa 15 steintippar i Sor-Noreg: ei botanisk-okologisk vurdering etter opp til 40 ar med suksesjon.* Hogskulen i Telemark, Bo.

Štýs S., 1981. *Rekultivace území postižených těžbou nerostných surovin*. Land reclamation affected by mining of raw materials. Praha: SNTL, 678 p.

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