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CLIMATIC CHANGES AND NEXT TOPICAL PROBLEMS OF THE MOST BASIN AREA RECLAMATION LOCALITIES

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ABSTRACT

The Brown Coal Research Institute j. s. c. is realising the long term research and survey in the field of restoration problems. The target of these works changed during development of localities. The main problems of present days are reclamation during frequent hot and dry periods, the extreme alkaline soil reaction of any localities soils, occurrence of phytotoxic and sterile areas and methodology of areas retained to natural succession founding. The article is devoted to the methodology of research and to the description of main case study areas. The methodology is composed of terrain mapping, sampling and sample analysis. It is grain-size determination, X-RAY analyses, determinations of pH/KCl, pH/H₂O soil reactions, C_{ox}, CaCO₃, N_c contents, S, T, V sorption capacities, acceptable P, K, Mg nutrients contents and. determination of the content of risk trace elements. The main case study areas are primarily Mariánské Radčice with the loss of seedlings because of hot and dry periods. Next case study areas are Libouš internal dump, Prunéřov and Bílina internal dumps and Pokrok external dump.

Keywords: climatic changes, reclamation, methodology, soil

1. INTRODUCTION

The Brown Coal Research Institute j. s. c. is realising the long term research and survey in the field of restoration problems. The target of these works changed during development of localities. The first stage was the problem of application of the fertilizable rocks, dosage and deposit survey of these rocks. The most important activity was big application of marls in the Radovesice dump. The main problems of present days are reclamation during frequent hot and dry periods, occurrence of phytotoxic and sterile areas and methodology of areas retained to natural succession founding.

The target of the restoration research changed after 2010, important reason was decreasing of fertilizable rocks deposits. The massive application of these rocks finished, now it is realising application to concrete small sterile and phytotoxic areas. The most important topics are restoration methodology in hot and dry climatic periods, occurrence of sterile and phytotoxic areas in Doly Nástup Tušimice (DNT) and Doly Bílina (DB) and the natural succession areas founding and development in the DB area.

The paper summarises the situation and brief characteristic of different types of problematic restoration areas and the modern methodology of restoration of these

localities Mariánské Radčice, Libouš, Prunéřov and Bílina internal dumps and Pokrok external dump.

2. METHODOLOGY OF THE TERRAIN WORKS AND LABORATORY ANALYSES

Research areas were selected by the Brown coal research Institute in cooperation with mining companies according to pedological soil properties. The research methodology of the areas of interest and the reclamation works themselves described in this article arises from a reclamation philosophy of this research project. It is based on the knowledge of overburden rocks properties and on a detailed survey of each reclaimed sites provided in co-operation with the mining companies, the Jan Evangelista Purkyně University and the best Czech laboratories.

The first step of the research was the selection of the suitable dump locality, selection of areas with different restoration history and terrain pedological mapping [2]. The second step of the research was sampling, photo documentation and laboratory analyses.

A wide scale of mineralogical, physical, mechanical, chemical and pedological qualities will be evaluated on the samples. Physically mechanical (granularity, porosity), mineralogical (X-ray analysis), and chemically pedological analyses (finding of pH/KCl, pH/H₂O soil reactions, C_{ox}, CaCO₃, N_c contents, S, T, V sorption capacities, acceptable P, K, Mg nutrients contents and. determination of the content of risk trace elements. All analyses were realised according to the guideline of the accredited laboratory No. 1078.

3. MAIN TARGETS OF RESEARCH

Sterile and phytotoxic areas are situated in the Vrsany, DNT and DB areas. The areas retained to natural succession are situated in the DB area. The topical present problem of the Most Basin is damages in reclaimed areas because of frequent dry periods these days.

3.1. RECLAMATION PROBLEMS DURING HOT AND DRY CLIMATIC PERIODS

In the period 2015 – 2019, the incidence of dry periods in the growing season increased. Overall, a very dry growing season can be noted in 2015 and especially 2018, in 2019 the months were exceptionally dry in April and July.

These periods caused unusually high seedling mortality. In some cases it was a combination of drought and soil properties of the area, but in some cases the death was caused solely by drought. An example is the forest restoration in the Mariánské Radčice.

Situation of the forest reclamation area Mariánské Radčice

The area is situated in the north – eastern part of the Mariánské Radčice village. The forest reclamation started in 2018 and we observed high level of the loss of seedlings in 2019. The survey of the soil horizon pedological properties was realised. We sampled mixed samples from 0,6 m deep pits. The number of pits was 6 in the research area, one comparative pit (No 7) was realised in near, functional forest. We sampled 2 samples

per every pit (0 – 0,3 m and 0,3 – 0,6 m). The important results of laboratory analyses are shown in tables No 10 – 12 (it was selected the pit No 1 as typical example in comparison with the comparative pit No 7).

According to the results of laboratory analyses the soil horizon consists of middle quality soil suitable for the forest reclamation and properties of research area soil (S1 – S6) are very similar as soil properties of comparative pit (S7) realised in the functional forest. These soil properties are shown in the tables No 1 – 3).

Table No 1: Geological description of samples

No of sample /No of pit	Sampling interval (m)	area	Geological description
97974/S1	S1 0–0,30	Mariánské. Radčice area	brown - grey dusty loam, with content of clay, quartz, gneiss and organic mass
97975/S1	S1 0,30–0,60	Mariánské. Radčice area	brown - grey dusty loam, with content of clay, quartz, gneiss and organic mass
97986/S7	S7 0–0,30	Mariánské. Radčice area	brown - grey dusty loam, with content of clay, quartz, gneiss and organic mass
97987/S7	S7 0,30–0,60	Mariánské. Radčice area	brown - grey dusty loam, with content of clay, quartz, gneiss and organic mass

Table No 2: Content of N, C_{ox}, CaCO₃ and soil reaction

No of sample	CaCO ₃ (%)	pH/H ₂ O	C _{ox} (%)	Nc (%)
97974	0,8	6,7	0,9	0,05
97975	0,7	6,2	0,7	0,03
97986	1,1	6,7	1,2	0,06
97987	0,9	6,5	0,9	0,05

Table No 3: Acceptable nutrients content and sorption capacity value

No of sample	Acceptable nutrients (mg.kg ⁻¹)			sorption (mmol .100g ⁻¹) (%)		
	P	K	Mg	S	T	V
97974	2	156	433	13	13	100
97975	1	135	412	11	11	100
97986	4	223	505	15	15	100
97987	2	198	416	14	14	100

The Mariánské Radčice locality was very dry and it was exposed to sun shine all day. According to our observation and laboratory analyses results (see tables No 11 – 12) the drought was the main reason of the loss of seedlings in 2019. The dry period 2015 – 2019 is too short for exact evaluation but in the case of continuation of this trend the number of localities damaged because of drought will increase. It is possible to propose first, uncomplicated preventive measures. It is recommended to change the methodology of grass mowing. Grass is good for seedlings protection and it is possible to eliminate damages of seedlings because of grass cutters (these damages were observed in the Mariánské Radčice locality). Next step will be the change of the range

of woody plants with preference of woody plants resistant to drought and improvement of water absorption capacity of soils.

3.2 STERILE AND PHYTOTOXIC AREAS

The limited occurrence of sterile and phytotoxic areas was discovered in DNT, DB and Vršany localities. The characteristic of these areas is very different.

3.2.1 SITUATION OF DNT AREA

The number of typical phytotoxic areas with occurrence of coaly clays and sands is minimal in the DNT area because of overburden rocks properties. We expect it only during Libouš mine slopes reclamation near the coal seam outcrop. The problem of DNT dumps is inverse, it is high number of very alkaline areas. The areas with pH value more than 8 are from point of view of forest reclamation sterile and it is recommended the methodology of ammonia sulphate application. We discovered here only one phytotoxic area. It was part of the area Pruněřov VI.

Reclamation of phytotoxic area Pruněřov VI

The survey was realised in three typical posts. We observe partial death of larch forest in posts 2 and 3 and complete death of larch forest in the case of post 1.

We sampled mixed samples from 0,4 m deep pits. The number of pits and samples was 15 (5 pits per every stand). The typical pit core is shown in the figure No 1. The important results of laboratory analyses are shown in tables No 4 – 6 (it was selected the pit No 1 as typical example).

Table No 4: Geological description and mineralogical content of samples

No of sample/No of pit	Sampling interval (m)	area	Geological description	Mineralogical content
88017/S1	S1 0–0,4m	Pruněřov VI	Grey and white material with humus admixture	Gypsum, clay and calcite admixture

Table No 5: Content of N, C_{ox}, CaCO₃ and soil reaction

No of sample	CaCO ₃ (%)	pH/H ₂ O	C _{ox} (%)	N _c (%)
88017	3,1	8,6	1,2	-

Table No 6: Acceptable nutrients content and sorption capacity value

No of sample	Acceptable nutrients (mg.kg ⁻¹)			sorption		
	P	K	Mg	(mmol .100g ⁻¹)	(%)	
				S	T	V
88017	8	20	111	3	3	100



Figure No 1: The pit core with high content of energy gypsum (Photo M. Řehoř)



Figure No 2: Area Pruněřov VI after upper horizon elimination (upper part of the snap)
Photo M. Řehoř

The survey area is definitely phytotoxic according to the soil properties (see tables No 4 – 6), primarily because of soil reaction value. The source of bad soil properties and larch forest death is energy gypsum contamination.

The successful solving of this problem was elimination of upper contaminated strata (depth 0 – 0,7 m) and application of fertilisable soil (see figures No 1 - 2).

3.2.2 SITUATION OF DB AREA

The situation of Bílina Mines is totally different because of overburden rocks properties and it was selected no area with gypsum contamination. The large phytotoxic areas with coal clays and sands were situated in external dumps in the history [1]. These areas are reclaimed (application of fertilizable rocks, following forest restoration). The typical example is the Střimice dump. Areas with high content of sand are more frequent. These areas are not phytotoxic, but in practice sterile. The reclamation of sterile area “ČOV–first stage” is the typical example of these areas.

Reclamation of sterile area „ ČOV – first stage“

The target of the area „ČOV – “first stage“ research was the area soil pedological parameters evaluation and the reasons of the loss of forest reclamation seedlings detection.

We sampled mixed samples from 0,4 m deep pits. The number of pits was 6, we sampled 2 samples per every pit (0 – 0,2 m and 0,2 – 0,5 m). The important results of laboratory analyses are shown in tables No 7 – 10 (it was selected the pit No 1 as typical example).

Table No 7: Geological description and mineralogical content of samples

No of sample/No of pit	Sampling interval (m)	area	Geological description
94895/S1	S1 0–0,20	ČOV – first stage	yellow- grey clayey sand with content of clay, quartz, gneiss and organic mass
94896/S1	S1 0,20–0,50	ČOV – first stage	yellow- grey clayey sand with content of quartz and gneiss

Table No 8: X – Ray analysis

No of sample	mineralogy
94895	quartz, admixture of kaolinite and feldspar
94896	quartz, admixture of kaolinite and feldspar

Table No 9: Content of N, C_{ox}, CaCO₃ and soil reaction

No of sample	CaCO ₃ (%)	pH/H ₂ O	C _{ox} (%)	N _c (%)
94895	0,3	6,1	0,4	0,03
94896	0,1	5,8	0,1	0

Table No 10: Acceptable nutrients content and sorption capacity value

No of sample	Acceptable nutrients (mg.kg ⁻¹)			sorption (mmol .100g ⁻¹) (%)		
	P	K	Mg	S	T	V
94895	2	85	198	10	10	100
94896	1	74	155	9	9	100



Figure No 3: Sampling in the area “ČOV – first stage” (Foto M. Řehoř)

The soil properties of the research area are very unfavourable according to laboratory analyses results. The reasons are the sandy character of the soil (see tables No 5 – 7), very high content of quartz (see table No 6), bad sorption properties and low content of acceptable nutrients (see table No 8). The area is problematic, but not phytotoxic. The main reason of the loss of forest reclamation seedlings is the combination of bad soil properties and extreme dry period in 2018 and high slope slant (see figure No 3).

The optimum of this area type is application of about 0,2 m of fertilizable rock (it is possible to use brown clays) and ploughing it to the surface of the area. It is difficult in this area because of prevailing forest restoration. The second possibility is only grass with the rest of forest restoration without new technical reclamation.

3.3. AREAS RETAINED TO NATURAL SUCCESSION

The problem of areas retained to natural succession was evaluated during research grant projects solving. These areas were founded, it started long term sampling, pedological and biological research. Next step was comparison with different types of reclaimed areas. All succession areas are situated in the Bilina Mines area.

It is recommended to found the succession area in dumps with spontaneous development of functional ecosystems, in the case of necessity of protection of any biological, geological and paleontological phenomena. The possibility of future making accessible these localities is very important too [2], [3]. The selection of locations suitable for natural succession founding is based on pedological and biological survey. It follows the long term pedological and biological research after the succession area foundation [4].

The main succession areas of the Most Basin are Radovesice XVIIIA (30 years old, 20 ha), Radovesice XVIIIB (20 years old, 30 ha), Pokrok XI (ten years old, 2 ha now) and Střimice I (50 years old, 2 ha). The area Pokrok XI is described in this paper.

Situation of the natural succession area Pokrok XI

The research area Pokrok XI retained to natural succession was founded in 2010, the original area was about 10 ha. Long term research of soil horizon, fauna and flora is coming from 2011.

Majority of former succession area consists of brown clay (about 80%) with very good soil properties. Western part of the area (about 20%) consists of yellow – grey dusty clay with worse pedological properties. The natural succession area was reduced to this small western part (about 2 ha) in 2012. The pedological properties of area soils are quite bad (see table No 11), but these soils are not phytotoxic.

The morphology of the area was broken, with about 2 m “hills”, it changed because of long term water and wind erosion (see figures No 4 – 5). The quick increasing of herb cover was observed from 2015 to 2019 (90% of the area now). Quite slow improvement of the soil properties (soil reaction pH, Cox content and sorption capacity) was observed in the same period too. The natural succession area development is possible to see in the figures 4 – 5. The changes of pedological – chemical soil properties are shown in following table No 11.

Table No 11: The development of chemical – pedological soil properties in natural succession area Pokrok XI

upper horizon soil	Nc (%)	Cox (%)	CaCO ₃ (%)	pH KCl	acceptable nutrients content (mg.kg ⁻¹)			sorption		
					P	K	Mg	S mmol/100 g	T	V (%)
2011										
brown clay	0,05	1,9	2,0	6,8	6	312	1012	15	15	100
grey dusty clay	0,01	0,5	0,4	5,7	0	158	343	7	7	100
2015										
grey dusty clay	0,03	1,5	0,9	6,6	2	175	591	12	12	100
2017										
grey dusty clay	0,04	1,7	0,9	6,8	3	201	657	13	13	100
2019										
grey dusty clay	0,06	2,1	0,9	6,9	6	225	681	14	14	100



Figure No 4: Natural succession area Pokrok XI in 2012 (Photo M. Řehoř)



Figure No 5: Natural succession area Pokrok XI in 2019 (Photo M. Řehoř)

4. CONCLUSION

The article summarises the main problems during reclamation works in the area of the Most Coal Basin. The attention is devoted to the reclamation during frequent hot and dry periods, the extreme alkaline soil reaction of any localities soils, occurrence of phytotoxic and sterile areas and methodology of areas retained to natural succession founding. The methodology of the research is described in the chapter 2.

The first experiences with forest reclamation damages caused by dry climatic periods are shown in the chapter 3.1. The case study area was the Mariánské Radčice locality with unusual high level of the loss of seedlings during the forest reclamation. The recommendation of first, uncomplicated preventive measures is described here.

The majority of large phytotoxic areas are reclaimed these days, so this problem is not so important as in the history. Small phytotoxic areas of different characteristic are situated in DB and DNT areas now. The methodology of reclamation of phytotoxic "Pruněšov VI" area contaminated by energy gypsum and sterile sandy area "ČOV – first stage" is described in the chapter No 3.2. The topic of areas retained to natural succession is introduced in the chapter No 3.3.

Conclusions of this research are based on results of granularity, mineralogical and chemical - pedological analyses shown in this article [5].

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