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HISTORY, PRESENT AND FUTURE OF REVITALIZATION OF THE RADOVESICE DUMP***

1. Introduction

The construction of the Radovesice dump started in 1964. It was situated in the cadastre area of Radovesice, Kostomlaty and Světec villages. It has an elongated form from the South-East to the North-West and the dump body connects the České Středohoří massif. It concerns the most extensive as yet operated dump of the Bílina mines and the largest dump in the Czech Republic. Filling overburden was completed at the Radovesice dump in the year 2003. Biological, mostly forestry reclamation takes place in the areas with the completed technical reclamation. A suburban park serving the needs of the Bílina town citizens will be built in a part of the area.

The difficulty in reclamation of the North Bohemian Basin dumps consists in extremely severe properties of rocks in most of the dumps. It mainly concerns the rocks of the overlying formation and the formation of brown coal seams. Sands, kaolinitic clayey sands and kaolinitic and illitic clays are the main materials bulk to the dumps. The admixtures of the bulk rocks consist of organic coal, siderite and pyrite. These rocks are mechanically unstable against wind and water erosion and they have obtained adverse, acid up to phyto-toxic character. The Radovesice dump is a typical example of this situation.

2. Geological properties of rocks of Radovesice dump bedrock

Geological situation of the bedrock of the dump Radovesice was described in the journal *Zpravodaj hnědé uhlí*. Only the accumulation of cretaceous marls and marlites in underlying strata is significant for restoration works.

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Marls and marlites used at restoration are formed by the mixture of calcite, quartz, illite and kaolinite. The granularity is influenced by the calcite content and gravel and stones forms a significant share at fresh marlites. The content of calcite fluctuates between 40÷55%. Soil reaction in water leach is slightly alkaline, the values of sorption capacity and acceptable nutrients are low [1].

Marlites were deposited in on a large stock-pile situated on the dump body for a long time due to their hardness and piece size and a fast dumping progress. The optimum time of marlite application as a fertilisable rock is ca 5 years after their depositing. Marlite mining place is overlaid by dumped overburden rocks at present.

3. Geological situation of dump rocks

The reclamation work methodology in the North Bohemian Basin is above all determined by the properties of overburden rocks which occur in the top horizon of the reclaimed sites.

In the area of Bilina mine there are quaternary rocks well usable for reclamation. It concerns topsoil, loess and loess loams, which are selectively mined and used as fertilizable rocks. Grey kaolinite and illite claystones which form the top horizon in a part of the area are also usable. Deeper deposited rocks of the delta sandy formation representing the biggest volume of overburden rocks are not usable from the reclamation perspective and the coal claystones from the seam formation can be rated as phytotoxic.

Significant properties of typical overburden rocks of the open pit mines Bilina are mentioned in following Tables 1 and 2.

TABLE 1
Mineralogical composition and restoration useability of typical overburden rocks of the Bilina mine

Location	Stratigraphic horizon	Type of the rock	Restoration useability	Mineralogy
Bilina mine	Quaternary deposits	top soils, loess loams, loams, gravel sands	perfect	quartz, kaolinite, illite, dash of anorthoclase, calcite and montmorillonite
	„Libkovice“ overlying strata	grey k.-i. clays	good	quartz, kaolinite, illite, dash of siderite
	sand-clay strata	sandy clays, sands	bad	quartz, dash of kaolinite, illite, siderite
	overburden rocks of coal bed	sandy clays, sands, coal	phytotoxic	quartz, kaolinite, illite, dash of coal and siderite

TABLE 2

Properties of rocks of Radovesice dump after application of marlites

Rock	N, %	Cox, %	CaCO ₃ , %	pH /H ₂ O	Receivable nutrients mg · kg ⁻¹			Adsorbing capacity, mmol, %		
					P	K	Mg	S	T	V
¹ sandy clay	0.01	2.1	0.9	6.8	1	105	765	9	9	100
² grey clay	0.02	2.2	1.4	7.4	3	234	912	14	14	100
³ sand	–	1.8	0.8	6.2	0	92	335	7	7	100
⁴ dusty coal clay	–	6.5	0.6	3.8	0	25	195	5	20	25
⁵ marl	–	0.3	27.5	8.1	1	105	342	11	11	100

Loess, loess loams and bentonites are used for the technical reclamation of the dumps the upper horizon of which is formed by phytotoxic rocks and the rocks with bad usability for reclamation (Tab. 1). The bentonites were stopped from applying with regard to high market price of the material. Typical example of application of this methodology is application of marles and marlites in the Radovesice dump.

4. History of reclamation of the Radovesice dump

The reclamation of the Radovesice dump is one of the most important reclamation activities in the Czech Republic because of large area of the dump and public interest. The reclamation of the Radovesice dump picked up on 3 stages of the reclamation of the Jirásek dump. Agricultural restoration predominated there.

The first phase of reclamation of the Radovesice dump started in 1986 (forest restoration of 30 ha area). It was the start of application of marles and marlites in creation of anthropogenic soil profile. Large stock-pile of marles was founded in the second phase of reclamation. Phases III–XVII followed. Marles and marlites were used for creation of anthropogenic soil profile always with exception of phase XVII (2 areas retained for natural succession). Methodology of their application developed on the base of research work results. Only 0.2–0.3 m were applied instead of original 0.6 m layer in the last years and an emphasis was laid on their embedding into the terrain surface. Top soil from original surface was used for an agricultural reclamation.

Depth and quality of applied top soil and marlites were verified by the means of machine drilled probes for single phases of the reclamation from 2009 to 2010. Measured depth of top soil and marlites were suitable, quality of marlite embedding into original dump surface was a little problem sometimes.

Forestry and other reclamation prevails on the Radovesice dump, agricultural recultivation is less implemented, and hydrologic reclamation is minimum used. Technological stage of the reclamation has been practically finished at present. The combination of biological and other reclamation types planned so that reclaimed area incorporated well to the landscape of the České Středohoří Mountains.

5. Methodology of reclamation of Radovesice dump

Main restoration method applied on the surface of Radovesice dump is application of fertilizable rocks. The application of fertilizable rocks is the most efficient in areas consisting of highly arenaceous to phyto-toxic rocks. The stated methodology was successfully used in a lot of sites of the Bilina Mine. Anthropogenic soil profile created by bentonite application in the Strimice dump, an anthropogenous soil profile created with the application of marl in the Radovesice dump and the anthropogenous soil profile created with the application of loess loams at the inner dump of the Bilina Mine can be used as an example. The application of marl in the Radovesice dump is described in this paper.

Experimental restoration method applied on the surface of Radovesice dump is foundation of areas left for natural succession. The areas left for natural succession have been tentatively filled in the areas where functional ecosystems spontaneously started to develop under specific conditions where protection and research of some biological, geological and paleontological phenomenon is necessary and where future access to public may be assumed within the overall concept of the locality reclamation. The selection of these areas proceeds based on the research of dumps. After the area is filled and plotted into the planning maps detail research is provided based on which entry documentation is created. Thus long-term research of the area starts evaluating its pedological and biological development. The paper briefly characterizes the areas filled at the Radovesice dump.

5.1. Application of marls and marlites on the surface of Radovesice dump

With regard to dump extent, its significance and unfavourable character of majority of bulked soils, the preparation of dump surface with utilization of local marlites is performed according to methodics of Dr. Fiserá [2]. Those form the geological surface of erosion valley in the underlying strata of the dump [1]. The marlite excavation runs in direct nearness of the dump and this fact substantially decreases the costs. With regard to the first very positive results it was decided to use this method on the whole dump surface.

The preparation of dump surface, melioration and restoration works are executed gradually, after finishing — bulking of technical parts of the dump. The basic significance has the shortening of interval bulking — restoration, because it means shorter time of erosion of original material of dump surface. Oxidation of pyrite and decay of clay minerals are low [3]. Melioration of surface of Radovesice dump begins with bringing 0.3 m marlites for determined area and ploughing with plough into the depth 0.5–0.7 m. With regard to

compactness of dump, stone character of marlites and required depths of ploughing these works are technically the most difficult moment of restoration. By the ploughing the dump materials will again get on surface, these are again carried by 0.3 m marlites and ploughed into depth 0.7–1.0 metres. So they enter into the mixture the originally ploughed — in marlite and the final mixture is gained with real depth 0.6–1.0 metres (Fig. 1).



Fig. 1. Anthropogenic soil profile on the surface of Radovesice dump

Properties of arising rooting horizon are runningly followed up. At present research of experimental areas runs and various quantities of marlites are applied by various way (with ploughing-in and without ploughing-in) or with cover by other soils.

The arising rooting horizon is as a rule formed by the mixture of disaggregating or plastic marls and marlites, clays and loams. This group of rocks is the result of restoration works and from that reason many samples of this type were taken here. The values of sorption capacity increased to 14–18 mmol/100 g soil. The granularity analysis proves the presence of gravel composed from the fragments of marlites and basalts. The content of calcite is sufficient, with depth it decreases as a rule. Very significant soil reaction in water leach is mostly slightly alkaline what proves by evidence the action of marlites in depths to one meter and it means the possibility of elimination of presupposed acid precipitations [4].

The decreasing of quantity of backfilled marlites was proposed about one third on the base of this research. The properties of new soil horizon are shown in the following Table 3. The sample No. 1 forms the grey – brown marl loam, sample No. 2 is formed by grey marl with fragments of marlite and sample No. 3 is formed by grey — brown dump clay and fragments of coal mass.

TABLE 3

Properties of rocks of Radovesice dump after application of marlites

Sample taking interval, m	N, %	Cox, %	CaCO ₃ , %	pH /H ₂ O	Receivable nutrients mg · kg ⁻¹			Adsorbing capacity, mmol, %		
					P	K	Mg	S	T	V
0,00–0,20	0.2	2.4	2.2	6.7	8	232	912	18	18	100
0,20–0,50	–	1.5	11.3	8.0	1	106	100	12	12	100
0,50–1,00	–	1.9	3.5	6.4	2	150	198	9	9	100

5.2. Experimental foundation of areas left for natural succession

Natural succession retained areas on Bílina and Libous mines dumps emerges from the philosophy of Severoceské doly mining company locations reclamation. These areas have been founded in places where functional ecosystems began developing spontaneously under specific conditions, where a preservation and research of some biologic geologic and palaeontologic phenomena is needed, and where a future provision of access can be presupposed [5]. The areas are selected after the research of the dump and it is decided of their establishment after the agreement of Severoceské doly, a.s. (mining company), VÚHU, a.s. (Brown Coal Research Institute. j.s.c.), VÚMOP (Research Institute for Melioration and Soil Preservation), and ZUP (University of Agriculture in Prague). The detailed research of the area is made for setting an introductory documentation after its establishment and input to SD mining company planning maps. This is the start of long time research of the territory evaluating its pedologic and biologic development. In this contribution the areas established on Radovesice dump are briefly characterised.

Two relatively large areas determined for experimental retaining to natural succession were selected after the thorough survey of not reclaimed part of the dump (about 670 ha) which consisted of field mapping, evaluating of upper soil profile by boring rod and laboratory analysis of selected samples.

Succession area No. 1 with 32 ha was selected in the south part of the dump. Prevailing rock type is heterogeneous mixture of brown clay, grey clayeite and grey sandy clayeite with the increased amount of brown clay. Brown grey kaolinic illitic clays. Sandy rocks took significant part in the east of the area and shape its natural border. A series of natural water sheets and little marshes occur here (Fig. 2)

Succession area No. 2 with 20 ha was selected in the north part of the dump. Prevailing rock type is heterogeneous mixture of brown clay, grey clayeite and grey sandy clayeite with the increased amount of brown clay, too. Brown grey kaolinic illitic clays. “Sandy dunes” shape southern border of the area. Two big natural water reservoirs and some little water sheets and marshes occur here. Some of the little water sheets changed to marshes during the year.

Comparison of the pedologic characteristics of the rocks of the dump areas retained to natural succession are shown in following Table 4.

TABLE 4

Pedologic characteristics of upper horizon of the area retained to natural succession

Sample taking interval, m	N, %	Cox, %	CaCO ₃ , %	pH /H ₂ O	Receivable nutrients mg · kg ⁻¹			Adsorbing capacity, mmol, %		
					P	K	Mg	S	T	V
0,00–0,90	–	1.3	0.4	7.8	0	593	1736	13	13.5	96

Spontaneously originated little water sheets and marshes on succession area No. 1 (south part of the dump) are situated in the south part of the dump. Plant and animal genera composition were evaluated on both areas.

Both area are recommended to be retained to natural development without reclamation actions. The territory should be observed on and should served as a research area. Already by now the way in which some genera (mostly vegetable kingdom) adapt to the environment not too typical for them is interesting to observe. With respect to their localisation both areas will serve as natural corridor for animals movement during necessary technical works in surrounding parts of the dump.



Fig. 2. Northern succession area — Radovesice dump

6. Conclusion

The shareholding company Severoceské doly, a.s. Chomutov is today the largest mining company in the Czech Republic. Big volumes of stripped rocks and the extent of areas designated for reclamation require the application of new, efficient reclamation methods. Typical example of application of these methods is the reclamation of the Radovesice dump.

The application of fertilizable minerals remains the basic methods of technical reclamation proving its success at the locality of Radovesice. It is possible using the mentioned methodics to protect erosion effects such it came in the restoration of Radovesice dump. Properties of new anthropogenic soil profile are shown in this paper.

Application of fertilizable rocks is main method of technical restoration of Radovesice dump, but the first attained results of the research prove that some new progressive methods can become a significant complement of this method. Thanks to great morphological and geological variety of areas of the Radovesice dump there is enough space for filling the areas left for natural succession the target of which is the protection of unique ecosystems developing in the dump.

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