Utilization of Result of Trial Seeding Experimental Plots in the Course of Rehabilitation of Central Tailing Heap of Ján Šverma Mine in Žacléř

Vlastimil Hudeček*[1], *Kristýna Černá *and* ***Zdeněk Adamec*[2]**

The contribution contains results of trial seeding with application of various fertilizers and soil conditioners. A procedure for the recovery of land of the heap is presented, which includes ground shaping to achieve stability and to prevent water from uncontrolled running down during prolonged or heavy rains in the area and biorehabilitation to cover the heap with vegetation, i.e. to bind the surface by crops able to grow on the heap.

On the basis of knowledge of specific properties of the site, a grass mixture for extensive non-agricultural utilization was proposed for the model experiment.

Key words: *restoration, rehabilitation, heap, grassing, hydroseeding, coconut mats.*

Introduction

The Jan Šverma Mine in Žacléř is one of the oldest hard coal mines in the Czech Republic. At present, the plant is operated by the company GEMEC – UNION, JSC, which took charge of it from the East Bohemian Coal Mines, state enterprise, (VUD, SOE) in Trutnov to perform the final part of closure, i.e. remediation of damage caused by past mining activities. Among other matters, mine remediation work, i.e. filling the excavation voids with hydraulic non-elutable mixtures produced on the basis of mainly ash, fly ash from energy processes, from ironmaking, etc. was done here. The Žacléř mining claim is situated north-east of the municipality of Žacléř, near the frontier with the Polish Republic. The company GEMEC-UNION, JSC, ensures in the framework of agreement with VUD, SOE remediation and rehabilitation work in the localities of Central Tailing Heap, Small Tailing Heap and Eliška Heap produced by the activities of the mine concerned. [1] In this article, the authors describe the method of rehabilitation of Central Tailing Heap that has undergone great changes in recent years. The procedure of implementation and the result of rehabilitation of the Central Tailing Heap will be described in the article.

Fig. 1. Central Tailing Heap [1].

[1] *prof. Ing. Vlastimil Hudeček, CSc., Ing. Kristýna Černá,* VŠB-Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava, Czech Republic

[2] *Ing. Zdeněk Adamec, Ph.D.*, GEMEC-UNION,JSC, 542 01 Žacléř, Czech Republic

Possibilities of restoration and rehabilitation

Generally, the purpose of restoration and rehabilitation is to recover and functionally incorporate lands affected by mining back into the landscape and the environment, which means to perform such final treatment of an area affected by mining that will ensure the recovery of natural functions of the ecosystem and simultaneously the complete utilization of the land affected by mining [4].

Restoration and rehabilitation lead to the following treatment in the area:

- Returning into the original state (restoration of the original relief), when original functions of the area are renewed, e.g. farming and forest management.
- Partial restoring of the original relief, when the partial renewal of original functions occurs and new activities will arise.
- The origin of new landscape relief, when the area is utilized newly and a new landscape element is created. [2]

Procedure for the recovery of lands

- Restoration of exploitation voids, including all lands affected by mining, which represents the Shaping of Ground, design of spoil tips, heaps, closing benches, closing slopes of excavation, residual shafts, made-ground of filling materials, creation of artificial elements – protective embankments, barriers, and others.
- Engineering rehabilitation – soil usefulness renewal, ground shaping using dozers, bulldozers, trench ploughs and ditch rotary hoes. Groundwork (spreading of top soil and matrices).
- Biorehabilitation – fertilisation and adding of nutrients to soils, modification in soil physical and chemical properties (soil acidity, structure), agrotechnical measures and plant breeding. Return of life into a restored and rehabilitated area. [2]

Tailing heaps in the Ján Šverma mine in Žacléř and rehabilitation of them

Eliška Heap

The Heap is situated north-north-west of the premises of Jan Šverma Mine near an approach road. The Eliška Heap consists of tailings from extractive industries and bands in hard coal. Deposition took place in the years 1867 – 1920. In the mid-seventies of the 20th century, spontaneous combustion occurred in the Heap. At the top of the Heap, an area about 20 x 20 m in size still exists, where temperature differs evidently from that in the surroundings – during the winter months any mantle of snow does not remain here. At present, the heap is covered with self-seeding trees and shrubs with the prevalence of birch trees. The area is secured partially by fencing to prevent unauthorized persons from entering. [1]

Fig. 2. Eliška Heap [1].

Small Tailing Heap

It is the case of a tailing heap on which tailings were deposited prevailingly in winter seasons, when trucks transporting the tailings were not able to reach the top of steep slope of the Central Heap. The rainfall water runs down the Small Heap to the stream, Lamperický potok, and causes thus channel aggradation. The comprehensive drainage of the area is being dealt with, and this issue is the subject matter being discussed. [1]

Central Tailing Heap

The Central Heap was constructed in the year 1930, when materials began to be piled up on the Heap manually by means of cars, and later in the 40's and the 50's, the Heap was shaped conically; the height from heap bottom is 64 m. [1]

Grassing the central tailing heap of Ján Šverma mine

In this chapter, the authors will be concerned with the Central Tailing Heap because works on it is the most conspicuous feature of rehabilitation.

Process of grassing the Central Heap

Activities carried out on the Central Heap consist of two parts, namely technical and biological.

At first it was necessary to shape the heap so that stability might be achieved and the uncontrolled running down of water during prolonged or heavy rains might be prevented. For this purpose, heavy machines were utilized (loading shovels, dozers) by means of which levels and sloping surfaces were formed. [1]

Fig. 3. Machines in operation on the Central Heap [1].

Fig. 4. Machines on the Central Heap [1].

As the second step the biological part was carried out. The fundamental objective of it was the covering of the heap with vegetation, i.e. binding the surface by crops able to grow on the heap.

The first attempts to grass the Central Tailing Heap were made on the north-west slope of the heap in the year 2005; nevertheless, particularities of an extraordinarily extreme site occupying altogether the area of 18 hectares were not probably respected, and this covering with vegetation failed completely. For these reasons a team of specialists with a view to determining conditions for the successful grassing of the heap of Central Tailing Heap was built in the spring of the year 2009. To that end, a methodology was proposed after long discussions and in the May of the year 2007, a small-scale site, multifactor experiment was set up directly on the slope of the heap of Central Tailing Heap.

The locality is situated in a mild climate region with a mean annual temperature of 6 ºC. The long-term annual average precipitation amount has a value of 905 mm and the highest place– top of the heap is at the altitude of 629.5 m. Before the commencement of the experiment, a soil sample was taken from the locality. The results of chemical analysis of the sample for the content of nutrients were not favourable to carrying out the grassing of the heap. [1]

Tab. 1. Result of soil analysis for nutrient content (according to Morgan, Mehlich III) [1].

pH/KCl	**P** [mg.kg^{-1}]	**K** [mg.kg^{-1}]	**Mg** [mg.kg^{-1}]	**Ca** [mg.kg^{-1}]
7.8	0	152	317	678

It follows from the above-mentioned results (Tab. 1) that it is especially the zero content of phosphorus being of importance to plant rooting that is problematic at the site. A shortage of phosphorus causes the lower sprouting, short and poorly developed blades in monocot species; the dark green colour of leaves gradually

changes to red-violet. What was found was a high value of magnesium content in soil, which should in the case of grassland move depending upon the matrix granularity in the range from 40 to 90 mg.kg^{-1}. [1]

On the basis of knowledge of specific properties of the site, a drought proof clover-grass mixture for extensive non-agricultural utilization was proposed for the model experiment. The composition of the mixture is as follows:

Sheep's fescue	30 %
Tufted red fescue	15 %
Short creeping red fescue	10 %
Creeping red fescue	15 %
Sweet vernal grass	10 %
Rye-grass	5 %
Clover crops	15 %

Fig. 5. An example of clover-grass mixture and fertiliser [1].

This clover-grass mixture was seeded on 3x3 m experimental plots (in the amount of 30g.m^{-2}) on the 3rd May 2007; the plots had been delineated directly on the slope of the Central Tailing Heap, and the following seven variants of fertilisers and soil conditioners had been applied to them before the seeding:

1. B.A.Granulate (100 g.m^{-2})
2. Fertiliser Floranid Permanent (30g.m^{-2}), B.A. root concentrate (22.2 ml.m^{-2})
3. Agrosil LR (150 g.m^{-2}, B.A.Granulate (100g.m^{-2}), B.A. root concentrate (22.2 ml.m^{-2})
4. Agrosil LR (150 g.m^{-2}), Floranid Permanent (30 g.m^{-2}), B.A.S-90 (22.2 ml.m^{-2})
5. B.A. Granulate (100 g.m^{-2}),B.A.S-90 (22.2 ml.m^{-2})
6. Floranid Permanent (30 g.m^{-2}), B.A.S-90 (22.2 ml.m^{-2})
7. B.A. Granulate (100 g.m^{-2}), B.A. root concentrate (22 ml.m^{-2})

In the course of selection of fertilisers and soil conditioners, and subsequently of various variants of their combinations, an emphasis was put especially on the adding of phosphorus and trace elements to the vegetation profile, on the support provided to the development of a root system, on the activation and increasing of a soil capacity and on the improving of formation of a crumbly soil structure. Considering these aspects, preparations based on bioalginates, Agrosil LR and the fertiliser Floranid Permanent were selected for this experiment. [1]

Implementation of grassing the Central Heap

After 105 days from seeding the stand on experimental plots, clover-grass mixture coverage was evaluated in the framework of individual variants on the 16th August 2007. From the presented results (see Tab. 2) it is evident that the limiting factor for the growth of plants and the incorporation of the stand at the site is a shortage of nutrients, especially of phosphorus, which is proved by results of variants 3 and 4, where Agrosil LR was applied, and where stand coverage has also the highest values – 35 % and 45 %. [1]

Another significant piece of knowledge is a change in species composition of the stand, because the majority of vegetation cover of experimental plots was represented, after 105 days from the seeding, by clover crops, although clover crops formed merely 15 percent of the original composition of the mixture seeded.

Tab. 2. Evaluation of stand coverage in the case of individual variants [1].

Experimental variant	Stand coverage
B.A. Granulate	5 %
Floranid Permanent, B.A. root concentrate	15 %
Agrosil LR, B.A. Granulate, B.A. root concentrate	35 %
Agrosil LR, Floranid Permanent, B.A. S-90	45 %
B.A. Granulate, B.A. S-90	10 %
Floranid Permanent, B.A. S-90	20 %
B.A. Granulate, B.A. root concentrate	10 %

Dealing with grassing the Central Heap

On the basis of knowledge obtained in the small plot experiment, a hydroseeding technology was proposed for the gradual grassing of the whole area of Central Tailing Heap. This technology makes it possible to spread simultaneously seed, fertiliser and all proposed soil conditioners on the site; these components will be applied evenly also to less accessible places.

After application, a continuous layer of a sprayed mixture with an elastic film of admixture for erosion prevention will be formed on the soil surface. The Central Tailing Heap has the highest gradient of 28 degrees and hydroseeding could be carried out by means of ways constructed for practical reasons along the circumferential contour. [1]

Fig. 6. Central Heap after hydroseeding and coconut mats [1].

The composition of admixture for erosion protection was modified with regard to the need for accelerated covering the surface of soil on the slopes so that sweet vernal grass was removed from the original composition and the mixture was enriched with tall fescue and Italian rye-grass ensuring rapid initial development, which would gradually disappear in the future and would be replaced with more perennial species; the proportion of clover crops in the mixture was decreased from 15 % to 11 %. The composition of the used mixture after modifications made was as follows:

Tall fescue	10 %
Sheep's fescue	30 %
Red fescue	24 %
Italian rye-grass	10 %
Ray-grass	15 %
Honeysuckle grass	5 %
Black seed	3 %
Ayseed	3 %

From the observed variants of combinations of effects of selected auxiliary soil substances, a variant under the number 4 was selected with regard to results obtained. In this variant, Agrosil LR at a rate of 150g.m^{-2}, a long-term fertiliser Floranid Permanent at a rate of 30g.m^{-2} and bioalginate B.A.S – 90 at a rate of 22.2 ml.m^{-2} were applied. [1]

Fig. 7. Results of hydroseeding after about 2 months [1].

Fig. 8. Coconut mats [1].

Fig. 9. Equipment – Hydroseeder [1].

Specifics of soil conditions and their improvement by means of soil conditioners on the heap of Central Tailing Heap had to be respected in the formulation of mixture composition and also, in relation to the danger of erosion on the slopes of the heap, in practical realization, and thus the research team recommended the utilization of soil surface stabiliser Terra-Control in the hydroseeding technology to protect grass seed on the soil surface from water and wind erosion. The auxiliary soil preparation Terra-Control is water-dilutable polyvinyl acetate dispersion. By its ability to form a three-dimensional net structure in the topsoil and to fix seed on the soil surface for a long time it protects the soil from erosion washing away, and thus makes it possible to increase very significantly the effectiveness of greening at problematic sites.

The steepest places were covered with coconut mats imported from Sri Lanka. They are fastened through oak bolts to avoid rather large local landslides. These mats will decay in several years and the function of them will be replaced gradually by greenery grown. [1]

Method of hydroseeding

Hydroseeding is one of advanced and very progressive forms of seeding of soil localities with a suitably chosen mixture of grass seed or plant and/or woody species. Above all it is carried out on transport, water management, industrial and sports structures, in the course of various types of landscaping and landscape gardening and in the course of rehabilitation of land resources in areas devastated due to industrial and other activities. Hydroseeding is a special way of seeding of areas, in the course of which a mixture of seed, water, fertiliser, organic matter and admixtures for erosion control is sprayed over the area determined. It is used mostly for the purpose of grassing. This is the manner of vegetation improvement by means of grass assemblage with a rather small share of other herbs, forming a continuous cover, the aim of which is above all the hardening of area being seeded against erosion and also improvement in appearance and prevention

of dust formation. Hydroseeding can also be used for vegetation improvement by means of herbs and woody species (trees and shrubs). This way of greenery can fulfil all ecological, aesthetic and also microclimatic functions. [3]

Equipment used for spraying the mixture was supplied from the U.S.A. under the name FINN HYDROOSEEDER; it is mounted as detachable superstructure on a truck chassis. The hydroseeder has a tank and an agitator assembly that mixes perfectly all components, a pump for required pressure generation and a working platform with a monitor. The volume of the tank is dimensioned at 6600 l of mixture and with one fill, about 2000-3000 m^2 of the area can be sprayed. The range of spraying of 60 m enables application in inaccessible places; for larger distances, hoses are available. [3]

Conclusion

At present, rehabilitation work is finished on 11 of 18 hectares of the area concerned. What remains to be done is the part of the heap that is situated on the south side of the heap; grass seeding will continue this year. In future, another utilization of the heap is considered, e.g. the construction of summer sports ground or a ski lift and a piste.

The article was prepared thanks to support from the grant project VaV ČBÚ No. 42-05.

Fig. 10. Central Heap after grassing, July 2009 [1].

Fig. 11. A view from the top of grassed Central Heap, July 2009 [1].

References

[1] Materials supplied by the company GEMEC-UNION, JSC
[2] Kryl, V., Frölich, E., Sixta, J.: Zahlazení hornické činnosti a rekultivace. Ostrava 2002, 79 pp.
[3] Internet presentation of the company Gabriel, Ltd.[online]. Updated 2010-04-21 [cit. 2010-04-21]. http://www.gabriel.cz/default.asp .
[4] Dirner, V. a kolektiv: Ochrana životního prostředí. Ministerstvo životního prostředí a VŠB-TU Ostrava, ISBN 80-7078-490-3, 332 pp.