Annals of the Academy of Romanian Scientists
Series on Agriculture, Silviculture and Veterinary Medicine Sciences
Online ISSN 2069 – 1149 Volume 4, Number 1-2/2015

PRELIMINARY RESEARCHES ON ECOLOGICAL RECONSTRUCTION BY REVEGETATION OF MINE WASTE DUMPS FROM CĂLIMANI MOUNTAINS

Teodor MARUŞCA[1], Emil Ciprian HAŞ[2]

Abstract. *The problem of ecological reconstruction of sulphur mine waste dumps from Călimani Mountains is complex due to the highly acid reaction of soils, with pH values ranging between 2.9 to 3.0. Encouraging results have been obtained only after liming with CaO (5 to 10 t/ha) and chemical fertilization with medium dosages, were, after 4 years from seeding, the herbaceous vegetation covers, in average, 50% of soil surface. Without liming and fertilization the revegetation with spontaneous species was inexistent, the soil being exposed to water erosion and the water with sulphuric acid cause serious damages to aquatic fauna.*

Keywords: ecology reconstruction, restauration, rehabilitation

1. Introduction

The ecological reconstruction of a mine waste dump (mine waste, ore flotation, solid fuel heating, domestic garbage and others) – results of economic activities and human being existence, is a complex process trough witch is installed herbaceous and/or wood vegetation on a surface with a low natural fertility, more or less suitable for plant growing in order to fixate the soil, environmental protection, economic valorization and landscaping function. This term has various names such as restauration, recultivation, revegetation, reverdissment, rehabilitation, reclamation and others.

Amongst the methods of ecological reconstruction known it is used mainly the reforestation one because is the ultimate goal for all areas suitable for forests.

In some cases, when the mine waste dumps are composed by pulverulent materials, until reforestation is required a fast revegetation in order to stop the wind and water erosion.

Thus, on mine waste dumps the revegetation can be a universal “panacea”, cheaper compared to reforestation that is carried out only in a few cases and with big expenses. The mine waste dumps from different origin are real air and soil pollution outbreaks [1, 2].

[1]Title: PhD, Eng., Senior Researcher: Research and Development Institute for Grasslands, Braşov, Romania, corresponding member of the Academy of Romanian Scientists (e-mail: maruscat@yahoo.com).
[2] Eng. Puchenii Mari

In order to fix this situation, before using reforestation as a final consolidation method, is considered that the rapid revegetation is, as a first stage, the best method to prevent the active erosion occurring on slopes and on the top flat part of mine waste dump. The success of revegetation on slopes and top part before beginning of erosion process depends mainly to the installation and survival of herbaceous vegetation for many years, until reforestation. It can be considered that there is a competition between the factors that are determining the erosion and the installation of vegetation.

In the revegetation process the most important role is held by the seed mixtures, the species composing them have to meet a few mandatory conditions as:

- immediate and long term adaptation to the soil and local climate condition;
- rapid installation in order to prevent the wind and water erosion, after shaping the terrain, and the consolidation of protective vegetation;
- protection of the species that are installing slower in the first vegetation stages but are more persistent (perennial);
- providing the fertilizers and the participation of nitrogenous fixing species such as the species from *Leguminosae* (*Fabaceae*) family;
- installation in successive stages of seeded species similar to natural revegetation, meaning annual, biannual and perennial species;
- achieving an economic value for seeded vegetation for forage production, medicinal flora, honey production etc., for sports grounds and many others in addition to the main eco-protective function;
- easy seeding on rough terrains composed by pulverulent materials.

The making process of seed mixtures that are complying with so many demands is more complicated than the forage production on arable lands.

In the seed mixtures there must be introduced annual species like cereals that can fixate rapidly the soils layers and ensure a protection against drought and insolation for species of grasses and legumes more sensitive in the early growth stages. On pulverulent soil layers with water shortages is recommended the inclusion in mixture of cultivated *Amarantaceae* species that ensures a greater protection for sensitive species in the early growth stages [3]. Another problem for mixtures is seed dilution with sand, mainly for a better manual seeding on the steep slopes. One of the solutions, maybe the best one, is the seed mixture with chemical fertilisers providing both the dilution and the fertilization.

The studies carried out have indicated that is possible to mix seeds with chemical fertilisers, the mixture validity lasting one year since making [4, 5].

The results obtained are supporting the importance of complex seed - chemical fertiliser mixtures for a various soil and climatic conditions with a known validity term.

A particular problem is the ecological reconstruction of the mine waste dumps located in protected areas, such as the ones resulted from the sulphur exploitation in Călimani Mountains.

In the protected areas it is forbidden the introduction of new species and even of new variety of existing species. Gathering seeds from spontaneous flora is a utopia, because the seeds gathered will not cover even 1 % from the Călimani bare land. Also, in this protected areas it is strictly forbidden the chemical fertilization, although this products are containing the main nutrient elements, Nitrogen, Phosphorus and Potassium, required by herbaceous and wood vegetation for growing.

Without the nutrients present in organic and chemical fertilisers the vegetation cannot emerge on a bare ground without natural fertility, just like in the case of waste dumps from Călimani Mountains. Providing of organic fertilisers from local households is not possible, because it is not for sale and secondly due to the long transporting distance (40-50 km) and the quantities required per hectares are significant (30-50 tones/ha).

We ask ourselves what is to be done in this situation. Should we wait for a number of decades for natural restauration or should we intervene in order to stop, as much as possible thought revegetation, the erosion of those waste dumps and the pollution of all downstream water for kilometers around leading to the disappearance of aquatic fauna due to the acidity and the high content of harmful elements.

Our opinion is that we have no choice; we should act immediately to stop the erosion with all available methods (barrages etc.) after hydro ameliorative measures followed by seeding for fixing and consolidation of residual materials resulted from mining activities.

Those "open wounds" without protective vegetation are more polluting and dangerous for the environment and biodiversity than the usage for seeding and restoration of some variety of grass and legume species present in that area along with the liming and chemical fertilization with a limited time effect that can make possible the revegetation, providing a protective role for soil and the spontaneous species that will appear naturally on improved areas. Thereby the seeded species more "pretentious" towards the nutrients, with a shorter presence in sward, are gradually replaced by the spontaneous species from local flora, more adapted to these extreme conditions and, in this way, on long term, the biodiversity will be maintained.

2. Material and methods

The mine waste dumps from Călimani National Parc are similar, from the ecological reconstruction point of view, to the ones from Bozanta and Meda lakes, located near Baia Mare. The soil layers physical and chemical characteristics, the highly acid reaction, low content in nutrients and the toxic effect of mobile Aluminium are the main similitudes between the sites.

In August and November 2009 have been taken soil and residual materials samples from the mine waste dumps from Călimani Mountains, the samples have been analysed by the Office of Pedological and Agrochemical Studies from Brasov according to national methodology (Table 1).

Table 1. The properties of soil and residual materials samples from Călimani waste dumps

Nr	*Localization*	*Sample depth*	*pH in H_2O (indices)*	*Humus (%)*	*Mobile P (ppm)*	*Mobile K (ppm)*	*Degree of base saturation (V%)*	*Mobile Al (me)*
Puturosu waste dump								
1	New material	Surface	2,9	0,12	2,0	6,0	7,2	3,256
2	New material	Surface	2,7	0,17	3,2	8,0	7,9	4,202
3	Old material	0 – 15	3,9	1,23	13,0	57,5	16,3	11,638
4	Old material	15 – 30	3,9	0,79	15,5	54,0	16,8	14,586
Pinu waste dump								
5	New material	Surface	3,5	0,35	5,8	18,0	34,2	4,400
6	Old material	0 - 15	3,8	0,61	14,1	77,5	12,5	19,800
Warping								
7	Pinu Barrage	Surface	3,0	0,47	12,5	18,0	18,3	13,332
8	Haita Dumitrelu	Surface	3,3	2,12	14,1	22,0	19,7	9,570

The residual materials found within Puturosu waste dump have a high acidity (pH 2.9), a low content of humus, phosphorus, potassium and others minerals that makes impossible the growth of plant species without intervention with lime and fertilisers.

Settled residual materials, after 15 to 20 years of in-depth leaching, have the acidity higher by one unit, reaching pH values of 3.8 and 3.9, favouring the installation of a few pioneer species spread in isolated clumps. The most present species found in this areas is *Deschampsia flexuosa* followed by *Deschampsia caespitosa* and in patches spruces (*Picea abies*) that are dying out within several years of colonisation, when the roots are reaching the bottom residual materials layers that are accumulating year by year greater quantities of mobile Aluminium (up to 11 – 20 me/100 grams of soil) very toxic for plant species.

Thought water erosion significant quantities of residual materials have been transported from the waste dump slopes to the valleys and barrages. The residual materials deposited in valleys and barrages are also high acid (pH values of 3.0 to

3.3) and are having a high mobile Aluminium content of 9 up to 13 milligram equivalents / 100 grams of soil.

In areas with deposited residual materials the humus content is higher (0.5 – 2%) and minerals content is higher also, mostly originated from upstream forests soils.

The residual materials from Dumitrelu waste dump have better agrochemical characterises compared to the ones from Pinu Barrage, and are being recommended as “fertile” layer, in case of need, to cover more acid soil layers like the ones found in Puturosu waste dump.

Considering the urgent need of ecological reconstruction measures by revegetation, with the support an approval of the constructor, a German firm, the Research and Development Institute for Grasslands had initiated a simple field experiment with liming and seeding in 8 different locations: 5 on Puturosu waste dump (3 near the old headquarters and 2 at the processing station); 2 on Pinu waste dump and one at Haita Dumitrelu according to constructor`s recommendations.

Experimental plots:

A. Control
B. No liming
C. Liming with 5 t/ha (CaO)
D. Liming with 10 t/ha (CaO)

Seeding

1. Fall 2009 in 22 September, taking a chance because it was not within the recommended seeding period (up to 20 August);

2. Spring of 2010, just after the snow has melted and the weather is warmer.

B, C and D plots have been fertilised with chemical fertilisers in 2009, 2011 and 2013 with 75 kg/ha N, 75 kg/ha P_2O_5 and 75 kg/ha K_2O.

The surface of a plot is of 37,5 m^2 (7,5x5 m) and a parcel has 6,25 m^2 (2,5x2,5).

After the experiment started (in 22 September 2009), the first observation have been carried out in November and it was noticed that the seeding had a good result on limed plots and almost no effect on plots not limed.

The complex mixture used was composed by 20 % grasses and perennial legumes, 13 % by cereals and 67 % chemical fertilisers (NPK).

3. Results and discussions

Soil samples (0-15 depth) from each experimental plot have been taken after 4 years since the experiment started (Table 2).

Table 2. Agrochemical proprieties of soil layers following 4 years of liming and fertilization

Plot	*Depth (cm)*	*pH in H_2O*	*Ah (me)*	*SB (me)*	*VAh (%)*	*Humus (%)*	*NI*	*P-AL ppm*	*K-AL ppm*
A. Control	0 – 15	2,9	12,9	1,5	10,4	0,56	0,05	6,0	54,0
	15 - 30	3,9	26,8	3,8	12,4	1,19	0,13	11,5	89,0
B. Chemical fertilization, over seeding	0 – 15	3,0	11,4	1,2	9,5	0,35	0,03	15,5	46,0
	15 - 30	3,9	27,2	3,8	12,2	1,40	0,17	23,8	120,0
C. liming 5 t/ha CaO, chemical fertilization, over seeding	0 – 15	4,3	5,4	6,0	52,6	0,63	0,33	21,0	46,0
	15 - 30	4,5	14,9	12,9	46,4	1,05	0,48	15,0	105,0
D. Liming 10 t/ha CaO, chemical fertilization, over seeding	0 – 15	4,9	8,3	19,0	69,5	0,98	0,68	22,0	132,0
	15 - 30	5,6	4,8	20,1	80,7	1,55	1,67	24,8	168,0

It is noticed the high acidity of plots not limed (pH 2.9 – 3.9) and a visible improvement of limed plots, after liming the pH values are increasing up to 4.3 – 5.6.

As a result of leaching, on all experimental plots, the acidity is higher on 0-15 depth than on 15-30 one.

The hydrolytic acidity (Ha) and the sum of bases in exchangeable forms (SB) are improved as a result of liming.

The degree of base saturation (VAh) on plots not limed is 11.1% and over 5 times higher (62.3 %) on limed plots.

As well, the content in mobile Phosphorous (P-Al) and mobile Potassium (K-Al) is higher on limed and fertilised plots.

These improvements, meaning reducing of acidity and the fertilization have made possible the success of seeding (Table 3).

Table 3. Coverage degree and botanical compositions of experimental plots (Călimani, 2013)

Plot	*Coverage degree (%)*			*The principal species presented in the order of participation in sward*
	Seeded		*Mean*	
	Fall	*Spring*		
A. Control	X	X	0	*Deschampsia flexuosa,* 2 pioneer herbs
B. Chemical fertilization, over	6	10	8	*Deschampsia caespitosa, Deschampsia flexuosa, Festuca*

seeding				*rubra*
C. liming 5 t/ha CaO, chemical fertilization, over seeding	38	58	48	*Festuca rubra, Dactylis glomerata,* *Lotus corniculatus, Trifolium repens,* *Festuca pratensis, Phleum pratense,* *Deschampsia caespitosa, Deschampsia flexuosa, Lolium perenne, Poa pratensis, Salix caprea, Picea abies* etc
D. Liming 10 t/ha CaO, chemical fertilization, over seeding	47	65	56	

On A plots, after 4 years of experimentation and over 5 years since the modeling of soil layers resulted from the sulphur mine, there are present only 2 clumps of *Deschampsia flexuosa* species in all of the 8 places (totalling 100 square meters), extremely low coverage with vegetation proving that the revegetation does not happen naturally.

As a result of fertilization, without liming, in B plots the coverage degree with vegetation is very low (8 %) the species present are *Deschampsia caespitosa*, *Deschampsia flexuosa* and a few clumps of *Festuca rubra*, in this case the revegetation period is very long.

After fertilization and liming (C and D plots) the coverage degree with vegetation is 52 %, 6 ½ higher than in B plots that had not been limed. On limed plots the seeding in spring leaded to coverage of 62 % meaning with 20 % higher that the plots seeded in fall (42 %).

The results obtained are confirming the possibility of revegetation of the waste dumps with restrictive vegetation conditions using two simple methods: liming and fertilization.

CONCLUSIONS

The ecological reconstruction by revegetation of mine waste dumps from Călimani Mountains is a complex problem that requires a fast solving, because the natural revegetation is very slow.

As a result of liming (5 to 10 t/ha CaO), for increasing initial pH values of soil layer, and fertilization it makes possible the growth of seeded species on a soil with a pH ranging between 4.3 and 5.6 and with medium concentration of nutrients.

After the vegetation has growth (installed), on limed and fertilized plots, the coverage degree resulted after 4 years at 50 % leading to a diminishing of soil erosion processes and increasing the pedological processes.

References

[1]. Harris A.J., Birch P., Palmer J.P., *Land restoration and reclamation* (Wesley Longman Ltd., Singapore, 1996).

[2]. Dumitru M., Blaga Gh., et al., *The recultivation of the mining exploatation degraded lands from Oltenia Coal Basin*, (Transilvania Press publishing house, Cluj – Napoca, 1999).

[3]. Maruşca T., Mocanu V., Hermenean I., Blaj V.A., Filip Monica, Maruşca S.,: *Research regarding estabilishment of the sown grassland for the antierosion protection of a thermal power station ash dump*, (EGF, Grassland Science in Europe) **Vol. 14**, p. 173-176, Brno, Czech Republic (2009)

[4]. Maruşca T. et al., *Principii şi metode noi de restaurare ecologică a haldelor de zgură şi cenuşă de la termocentrala pe lignit – Braşov*, (Simpozionul "Managementul Mediului Urban şi Industrial în contextul integrării europene", Editura Universităţii Transilvania din Braşov, 2000), p. 43-49

[5]. Maruşca T., Dincă L., *Contributions to herb and wood species range improvement for the rehabilitation of slag and waste heaps from coal – power – stations*, (Proceeding of the Symposium "Restoration Ecology" University of Agricultural Sciences Timişoara, September 20-23, Editura Orizonturi Universitare, Timişoara, 2001) p. 89-93