"BABEŞ - BOLYAI" UNIVERSITY OF CLUJ-NAPOCA
FACULTY OF BIOLOGY AND GEOLOGY
Department of Taxonomy and Ecology

THE STRUCTURE AND DYNAMICS OF VEGETATION ON THE TAILING DUMPS IN CĂPUŞ, CIONCA AND AGHIREŞ (CLUJ COUNTY)

SUMMARY OF THE PhD THESIS

PhD STUDENT:
SABINA MÂŢ (married TOT)

SCIENTIFIC ADVISOR:
Prof. Dr. VASILE CRISTEA

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Key words: flora, vegetation, vegetation dynamics, vegetal communities, dumps, tailings, plateaus, terraces, banks, slopes.

Introduction

The geobotanical research performed by the author were directed towards the thorough knowledge of the flora, potential vegetation and dynamics of the vegetation on the tailing dumps in Aghireş and Căpuş, on the one hand, and on the other hand, towards the highlight of the ecological and economic integration actions of the tailing dumps subjected to study.

Beside the classical aspects of the flora and vegetation, we intended the approach of the aspects regarding the dynamics of the vegetation by an intensive study. In this regard, we have tried to:

- highlight the ecological, biological and geomorphological conditions whose parameters have determined the dynamics of the vegetation;
- determine the changes of the grass vegetation composition: on a monthly, seasonal and multiannual basis, in order to highlight the dynamics by various methods of study;
- present the progressive changes of the vegetation on the tailing dumps in Căpuş, but especially the regressive dynamics of the vegetation on the tailing dumps from Aghireş;
- highlight the evolution of the vegetation dynamics by means of investigations on the vegetal communities from Aghireş, in parallel with those from Căpuş, as the vegetation is completely stabilized on these tailing dumps.

The paper is structured in 5 chapters, of which we will synthetically present general information approaching the topic of the thesis.

Chapter I. THE PHYSICAL-GEOGRAPHICAL CHARACTERIZATION OF THE TERRITORY SUBJECTED TO STUDY

A. The Aghireş commune

The Aghireş commune is located in the North-Western part of the Cluj County and covers 105.79 km^2 (Simon A. et al., 2003).

From the geographical point of view, the commune is located in the Someşan Plateau, Nadăşului Hills.

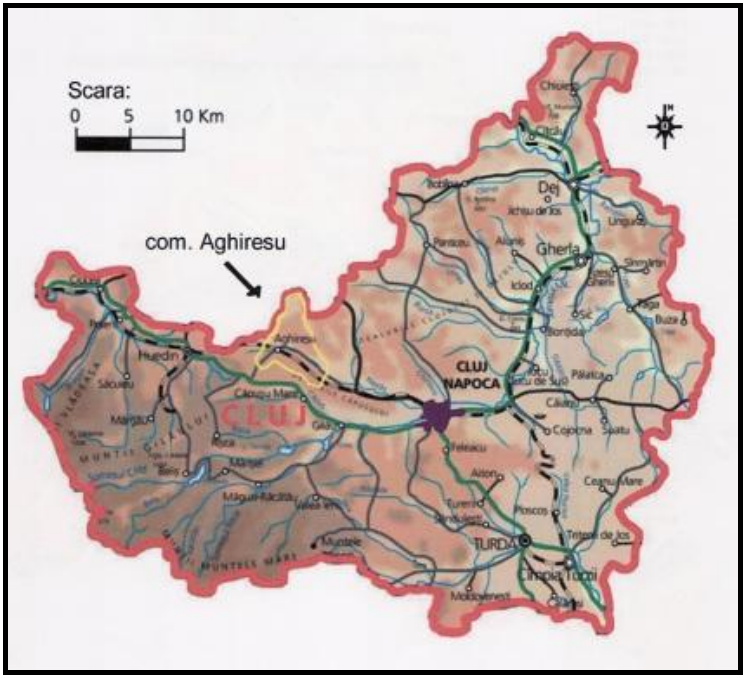
From the economic point of view, one can mention industrial facilities based on quartz-kaolin sand, whose exploitation dates back in 1928 (Magda, 1971), but it was only in 1936 that the quartz-kaolin sand of Pârâul Ursului and the kaolin of Aghireş became significant for the national economy.

The territory of the commune displays sedimentary rock depositions dating back in Oligocene (*ap.* Stoicovici et. Mureşan 1963), when the Cetate strata were deposited. At this level the quartz-kaolin sand is found.

By the action of external agents on the geological substratum, the following specific landforms occurred: maritime deposition units and fluvial deposition units.

The territory of the commune includes two drainage basins, that of the Nadăş and that of Almaş river, crossed by the Nadăş river and by the right side tributaries of the Almaş, Arghişu and Dâncu watercourses.

The following types of soils may be found in the commune: brown forest soil, brown-red forest soil, rendzinas, black valley soils and gleysoils.



The location of the Aghireş commune in Cluj county (*ap*. Simon A., et al. 2003)

B. The Căpuşu Mare commune

The Căpuşu Mare Commune is located in the Western part of the Cluj County, 25 km away from the Cluj-Napoca municipality. This commune lies on a 13,456 ha territory.

The evolution and development of the Căpuşu Mare commune is related to the main resources of the subsoil, especially by the iron ore discovered in 1960 by Stoicovici and Mureşan (1963). The raw ore has an iron mineralization content found as oolitic limonite.

From the geographic and geologic point of view, the territory of the commune displays a clear division into two distinct units:

- the mountainous unit in the South, composed of crystalline schists;
- the plateau unit in the North, composed of sedimentary formations.

One may clearly distinguish an anthropic relief on the territory of the commune, lying on 3 areas of former open pits: Căpuș-N, Cionca and Șatra.
Three water courses flow through the commune: Căpuș, Agârbiciu and Râșca. The Crișul Repede river springs from the North-Western part of the commune, and the Leghia river flows through Leghia basin in the Northern part.

Chapter II. THE FLORA

2.1. History of botanical and phytocenological research

Phytocenological researches on the pastures in the Aghireș commune and on the tailing dumps from Aghireș were performed by: Stana et Rosza (2001), Stana et Vârban (2005) and Rosza (2005).
However, the first floristic data on the tailing dumps from Aghireș and Căpuș were provided by Blaga in 1981.

2.2. The work method and the presentation of the flora

The analysis of the flora on the tailing dumps from Aghireș and Căpuș was performed based on the botanical material gathered and determined during the 2005-2011 period.

The species determination and the nomenclature of the taxa was performed according to *Flora RSR*, vol I-XIII (1952-1976), *Flora of Romania – illustrated determinator of the vascular plants (in Romanian)*, vol I and II, Beldie Al. (1977, 1979), *Illustrated flora of Romania (in Romanian)*, Ciocârlan V. (2000, 2009) and *Flora Europaea* vol. 1-5, Tutin et al. (1964 – 1980) .

The systematic characterization of the species was performed according to the classification system adopted by Cristea V. (2007).

The presentation of the flora included: the scientific name of species, the author, the popular name of the plant, followed by ecological data, bioform, geoelement, number of chromosomes, economic categories and phytocenologic data, according to the following authors: Löve A. et Löve D., 1961; Pop I., 1968; Pop I. et al., 1978; Sanda V. et al., 1983; Popescu A. et Sanda V., 1988, 1998; Ciocârlan V., 2000; Cristea V., et al., 2004.

The economic categories were noted according to the notation system elaborated by Pop I., in the paper published in 1982.

2.4. The analysis of the vascular flora on the tailing dumps in Aghireș and Căpuș

The flora compendium indicates that the tailing dumps in Aghireș and Căpușber are very rich in terms of numerical values, totalling 575 species cormophyte, 165 subspecies, 21 varieties and 12 forms, classified in 63 families.

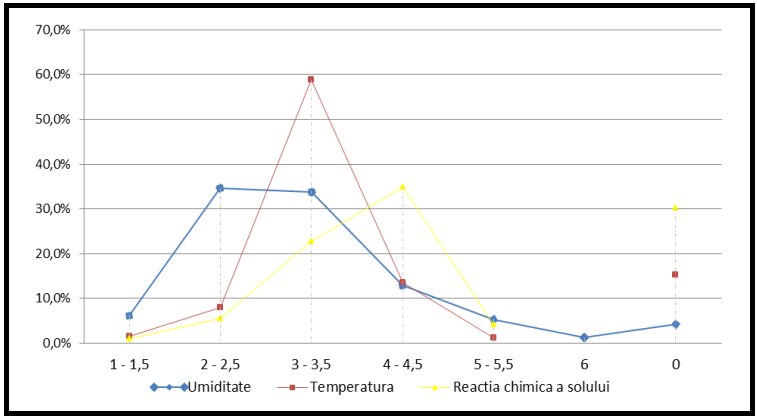
The spectrum of the ecological indices highlights the prevalence of the xero – mezophile species (34.7%), micro – mezotherm species (58.9%) and slightly acid – neutrophyle species (34.8%).

From the bioforms spectrum one may notice the high prevalence of the

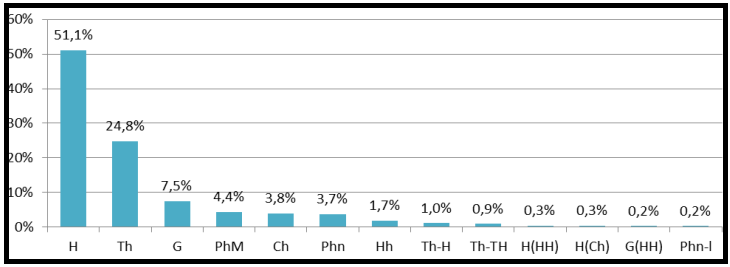
hemicriptophytes (51.1%).

From the geoelements spectrum one may notice that the prevailing floristic element is the eurasiatic one (46.2%).

Of the total of species vegetating on the tailing dumps from Aghireș and Căpuș, 45% are polyploid, 41% are diploid, and 14% are diplo-polyploid.



The spectrum of ecological indices



The spectrum of bioforms

Chapter III. THE VEGETATION OF THE TAILING DUMPS IN AGHIREŞ AND CĂPUŞ

3.1. Research methods

Based on the 296 phytocenological surveys performed during the 2005 – 2011 period,

the author has identified and described 37 vegetal associations, one sub-association and two communities (with *Trifolium medium* and *Poa nemoralis*) and 12 facieses classified into 20 alliances, 17 orders and 15 classes.

The vegetal association was used as cenotaxonomic unit for the study of the vegetal layer.

3.2. The general characterisation of vegetation

In some places there is no vegetation on the terraces, banks and the plateaus of the tailing dumps from Aghireș, but in other places there may be found a pioneer vegetation, and the oldest tailing dumps the treading process occurs.

The largest occurrence and the best cenotic development on the waste dumps from Aghireș and Căpuș belong to the phytocoenoses of the associations *Bromo sterilis – Robinietum*, for wood associations, *Tussilaginetum farfarae* for the pioneer vegetation, and *Trifolio repentis – Lolietum, Agrostetum stoloniferae, Agrostio capillaris – Festucetum rupicolae, Festuco rubrae – Agrostetum* for the grass vegetation.

3.3. The compendium of vegetal associations

QUERCETEA PUBESCENTI-PETRAEAE (Oberd. 1948) Jakucs 1960
QUERCETALIA CERRIS Borhidi 1996
Aceri tatarici - Quercion Zólyomi et Jakucs 1957
1. *Bromo sterilis - Robinietum* (Pócs 1954) Soó 1964

QUERCO – FAGETEA Br-Bl. et Vlieger 1937 em. Soó 1964
PRUNETALIA Tx. 1952
Prunion spinosae Soó (1930, 1940) 1951
2. *Pruno spinosae - Crataegetum monogynae* (Soó 1927) Hueck 1931

ALNETEA GLUTINOSAE Br.-Bl. et Tx. 1943 em. Müller et Görs 1958
SALICETALIA AURITAE Doing 1962 em. Westhoff 1969
Salicion cinereae Müller et Görs 1958
3. *Salicetum cinereae* Zólyomi 1931

SALICETEA PURPUREA Moor 1958
SALICETALIA PURPUREAE Moor 1958
Salicion triandrae Müller et Görs 1958
4. *Salicetum purpureae* (Soó 1934 n.n.) Wendelbg. - Zelinka 1952

Salicion eleagni (Aichinger 1933) Moor 1958
5. Hippophaë – Salicetum eleagni Br.-Bl. et Volk 1940

(Syn.: *Hippophaëtum* Issler 1924, *Hippophaëtum rhamnoides* Borza 1931)
TRIFOLIO – GERANIETEA SANGUINEI Th. Műller 1961
ORIGANETALIA VULGARIS Th. Műller 1961
Trifolion medii Th. Műller 1961
6. Communities with *Trifolium medium*

MOLINIO – ARRHENATHERETEA Tx. 1937
MOLINIETALIA W. Koch 1926
Holco-Juncion Pass. 1964
7. *Holcetum lanati* Issler 1936

Agrostion stoloniferae Soó (1933, 1943) 1971
8. *Agrostetum stoloniferae* (Ujvárosi 1941) Burduja et al. 1956
9. *Junco – Agrostetum* Resmeriță 1970
10. *Poëtum palustris* Soó 1940
11. *Festucetum pratensis* Soó (1938), 1955, 1969

(Syn.: *Poo-Festucetum pratensis* Soó 1949)
12. *Phleetum pratensis* Popescu et Bujoreanu 1952

dactyletosum glomerati Grigore 1971
(Syn.: *Dactyletum glomerata* Bărbulescu et al. 1964, Anghel et al. 1965)
ARRHENATHERETALIA Pawl 1928
Arrhetherion elatioris (Br.-Bl. 1925) Koch 1926
13. *Arrhenatheretum elatioris* (Br.-Bl. 1919) Scherrer 1925

14. *Trifolio - Poëtum pratensis (*Răvăruț et al. 1956) Resmeriță 1975

(Syn: *Poëtum pratensis* Răvăruț et al. 1956)
Cynosurion cristati Br.-Bl. et Tx. 1943, Tx. 1947
(Syn: *Agrostideto – Festicion rubrae* Puşcaru 1956)
15. *Lolio – Cynosuretum* Br.-Bl. et de Leew 1936, em. Tüxen (1937) 1940
16. *Anthoxantho - Agrostietum capillaris (tenuis)* Sillinger 1933, Jurko 1969
17. *Agrostio capillaris (tenuis) - Festucetum rupicolae* Csűrös -Káptalan (1962) 1964
18. *Festuco rubrae - Poëtum nemoralis* Păucă et al. 1960
19. *Galio veri – Festucetum rubrae* Resmeriță (1965) 1980

(Syn: *Festucetum rubrae xeromezofilum* Resmeriță 1965)
20. *Agrostio capillaris (tenuis) - Cynosuretum* Resmeriță 1963
21. *Festuco rubrae – Agrostetum capillaris (tenuis)* Horv. 1951 (1952)

ASPLENIETEA RUPESTRIS Br.-Bl. 1934
ASPLENIETALIA RUTAE – MURARIE Oberd. et al. 1967

Moehringion muscosae Horv et H-ić 1967
22. Communities with *Poa nemoralis*

PUCCINELLIO SALICORNIETEA Ţopa 1939
ARTEMISIO-FESTUCETALIA PSEUDOVINAE Soó 1968
Festucion pseudovinae Soó 1933
23. *Achilleo-Festucetum pseudovinae* (Magyar 1928) Soó (1933) 1945

CHENOPODIETEA Br.-Bl. 1951 em. Lohm. et Tx. 1961
SISYMBRIETALIA Lohm. et Tx. 1961
Convolvulo arvensi – Agropyrion repentis Görs 1966
24. *Agropyro-Convolvuletum arvensis* Felföldy (1942) 1943

(Syn: *Agoropyretum repentis* Felföldy 1942)
ARTEMISIETEA Lohm., Prsg. et Tx. 1950
ARTEMISIETALIA Lohm. et Tx. 1947
Arction lappae Tx. 1937 em Siss.1946
25. *Sambucetum ebuli* (Kaiser 1926) Felföldy 1942
26. *Tussilaginetum farfarae* Oberd. 1949

BIDENTETEA TRIPARTITI Tx., Lohm. et Prsg. 1950
BIDENTETALIA TRIPARTITI Nordh. 1940
Bidention tripartiti Nordh. 1940
27. *Xanthio strumarii-Chenopodietum albii* Pop 1968

PLANTAGINETEA MAJORIS Tx. et Prsg. 1950
PLANTAGINETALIA MAJORIS Tx. (1947) 1950
Polygonion avicularis Br.-Bl. 1931 em. Tx. 1950
28. *Pöetum annue* Gams 1927
29. *Juncetum tenuis* Schwik. 1944

(Syn: *Juncetum macri* (Diemont, Siss. et Westhoff 1940) Tüxen 1950)
30. *Trifolio fragifero-Cynodontetum* Br.-Bl. et Bolós 1958

(Syn: *Trifolietum fragiferi* Morariu 1969, *Trifolietum fragiferi – neglecti* Puşcariu et Ţucra 1960)
Agropyro-Rumicion crispi Nordh. 1940
31. *Trifolio repenti-Lolietum perennis* Krippelová 1967, Resmeriţă et Pop 1967

(Syn. *Lolieto-Cynosuretum trifoliosum repentis* Resmeriţă et Csűrös 1966)
32. *Ranunculetum repentis* Knapp 1946, em. Oberd. 1957

EPILOBIETEA ANGUSTIFOLII Tx. et Prsg. 1950
CHAMAENERIETALIA ANGUSTIFOLII (Vlieger 1937) Tx. 1950
Chamaenerion angustifolii Soó 1940
33. *Calamagrostietum epigei* Juraszek 1928, Eggler 1933

BETULO-ADENOSTYLETEA Br.-Bl. et Tx. 1943, 1948
CALAMAGROSTIETALIA VILLOSAE Pawl. 1938, em. Klika, in Klika et Hadač 1944
Calamagrostion arundinaceae (Luquet 1926) Jenik 1961
34. *Calamagrostetum arundinaceae* Zlatnik 1928

PHRAGMITETEA Tx. et. Prsg. 1942
PHRAGMITETALIA Koch 1926, em. Pignatti 1953
Phragmition australis Koch 1926, em. Soó 1947
35. Scirpo-Phragmitetum Koch 1926
36. *Typhetum angustifoliae* (Allorge 1922) Pignatti 1943

(Syn: *Typhetum angustifoliae-latifoliae* (Eggler 1933) Schmal 1939)
37. *Typhetum latifoliae* Soó 1927
38. *Glycerietum fluitantis* Eggler 1933

NASTURTIO-GLYCERIETALIA Pignatti 1953
Glicerio-Sparganion Br.-Bl. et Siss., ex Boer 1942
39. *Eleocharetum palustris* Schennikov 1919, Soó 1933

(Syn: *Alismato – Eleocharidetum* Máthé et Kovács 1967)

Chapter IV. THE DYNAMICS OF THE VEGETATION ON THE TAILING DUMPS IN AGHIREŞ AND CĂPUŞ

This chapter begins with several notions referring to the parameters causing the installation and dynamics of the vegetation on the tailing dumps: microrelief, slope, orientation, and grazing and wind factor.

The first Romanian studies on the dynamics of the vegetation were published in 1930, by Bujoreanu. Clemets set the basis of the vegetation dynamics worldwide and he indicated the laws and work methods in his work published in 1929 (*ap.* Bujoreanu 1930).

4.2.2 The study method

The *method of direct observation, measurement, numbering and inventory* was used for the study of the vegetation dynamics on the tailing dumps, on a monthly, seasonal and multi-annual basis, to determine the evolutionary seasonal and multi-annual dynamics.

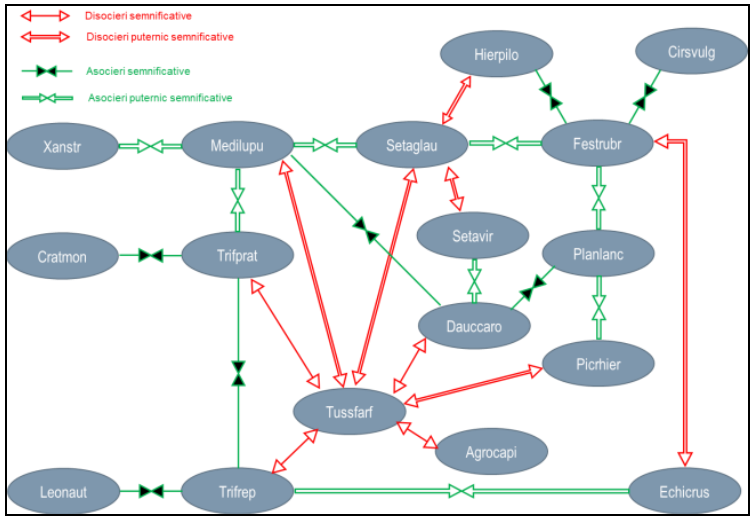
The *inventory squares method* was used for the study of the *evolutionary dynamics* by means of the metric frame, located differently on plateaus and slopes.

Drawings, photographs, diagrams, vertical and horizontal projections were elaborated on site and in the laboratory.

4.2.3.1 The dynamics of the pioneer vegetation on the tailing dumps in Aghireş

Tussilago farfara prevails in most of the cases in Aghireş, followed by *Trifolium fragiferum* on the Eastern terrace and in many places by *Hieracium pilosella*, among which *Festuca rubra* occurs rarely.

4.2.3.2 The dynamics of the floristic composition of the phytocoenoses occurred on the tailing dumps in Aghireş and Căpuş



Associations /Dissociations at the species in the quadrates in September 2009

In Aghireş, on the Eastern bank, a detailed analysis at a fine scale was performed in order to determine: the distribution of specimens, possible spatial-temporal correlations (associations/dissociations), and the differentiation of the vegetal groups.

The distribution along the topographical gradient highlighted 4 types of answers, different in June as compared to September.

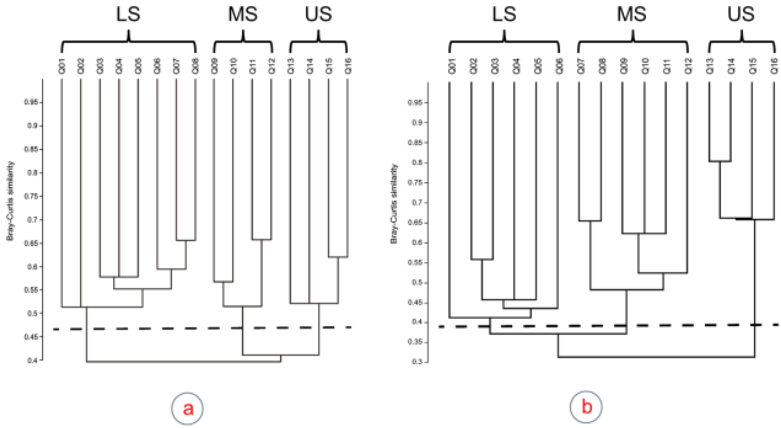
Abbreviations. The following abbreviations of species were used for associations / dissociations:

Agrostol	-	Agrostis stolonifera	Leonaut	-	Leontodon autumnalis
Centbieb	-	Centaurea micranthos	Medilupu	-	Medicago lupulina
Centcyan	-	Centaurea cyanus	Picrhier	-	Picris hieracioides
Cirsvulg	-	Cirsium vulgare	Planlanc	-	Plantago lanceolata
Cratmono	-	Crataegus monogyna	Setaglau	-	Setaria pumila

Dauccarro	-	Daucus carota ssp. carota	Setaviri	-	Setaria viridis
Echicrus	-	Echinochloa crus-galli	Trifprat	-	Trifolium pratense
Elaeangu	-	Elaeangus angustifolia	Trifrepe	-	Trifolium repens
Festrubr	-	Festuca rubra	Tussfarf	-	Tussilago farfara
Hierpilo	-	Hieracium pilosella	Xantstr	-	Xantio strumarium

In terms of association / dissociation of species, *Tussilago farfara* does not associate spatially with any other species.

Depending on the distribution of specimens, determined first by the abiotic factors, three micro-habitats were highlighted on the banks.



The spatial highlight of the three micro-habitats in: June (a) and September (b)

The seasonal dynamics in the acacia plantation was also monitored and two vertical transects.

The observations performed during the 2005-2009 period regarding the dynamics of the paludal vegetation, from the ambiance of the *Eleocharetum palustris* association have captured qualitative evolutionary changes (14 sp. in 2005, 17 sp. in 2006 and 20 sp. in 2007 and 2008), but also quantitative (20% coverage in 2005, 55% in 2009), depending on the hydric regime during the 5 years of research.

Table – The studied stable surfaces.

The study site	Period 2009 (month)	Surface (m^2)	Number of squares / month	Locality
The Southern plateau	June, September	5	5 + 5	Aghireş
The South-eastern plateau	June, September	5	5 + 5	Aghireş
The hummock on the Eastern terrace	June, July, August, September	4	4 + 4 + 4 + 4	Aghireş
The Southern bank	June, September	10	10 + 10	Aghireş
The Northern bank	June, September	10	10 + 10	Aghireş
The Eastern bank	June, September	16	16 + 16	Aghireş
The Western bank	June, September	8	8 + 8	Aghireş

Eastern sodded slope	June, September	2	2 + 2	Aghireș
Eastern sodded slope near the natural lake	June, September	2	2 + 2	Căpuș
Eastern sodded slope near the artificial lake	June, September	2	2 + 2	Căpuș
The plateau on the side of the artificial lake	June, September	4	4 + 4	Căpuș
The Southern plateau at the edge of the hardwood plantation	June, September	2	2 + 2	Căpuș
The Northern plateau at the edge of the pine plantation	June, September	2	2 + -	Căpuș

Chapter V. THE POSSIBILITIES FOR ECOLOGICAL AND ECONOMIC INTEGRATION AND USE OF THE TAILING DUMPS SUBJECTED TO STUDY

This chapter begins with the peculiarities of the tailing dumps in the two localities followed by the analysis of the economic potential provided by the identified flora, the functions of pastures and of the plantations, but also possibilities of ecological, economic and recreational use of the lakes in the open pit voids, as the substrata of the tailing dumps in Aghireș does not contain the toxic substances.

Conclusions and recommendations

The researches that we performed on the tailing dumps from Aghireș and Căpuș are part of a theoretical and practical domain with good present and future opportunities, but extremely necessary, as the plants are the main *provider*, for the large part of the industry.

The practical significance of the studies performed on the flora, vegetation and dynamics of the vegetation on the tailing dumps from Aghireș and Căpuș provides clues for the rational use of the tailing dumps and their integration in the ecological and economic circulation.

Based on the personal researches and the literature data from, *the floristic inventory* performed on the tailing dumps from Aghireș and Căpuș, during the 2005-2011 period totals: 575 sp. cormophite, 175 ssp., 21 var. and 12 f., classified in 63 families.

The ecological spectrum of the analyzed flora highlights the xero-mezophyous (34.7 %), micro-mezotherm (58.9 %) and slightly acid-neutrophyle (34.8 %) character.

The interference and communion of the mezo-higrophylous species with the mezo-xerophylous and even xerophylous species is a clear indication of the oscillating water regime (edafic humidity), during the vegetation periods on the low areas of the tailing dumps.

The analysis of the flora by the *biological forms* highlights the weight of the hemicryptophytes (51.1 %), consequence of the perennial grass species prevalence and of the anthropo-zoogenetic influence in these places.

The spectrum of the floristic elements is dominated by the eurasiatic elements (46.2 %), followed by the European (12.6 %) and circumpolar (8.4 %) elements.

The cariological analysis shows that the *genofund of the cormoflora* on the tailing dumps from Aghireș and Căpuș is prevailed by the polyploidy species (45 %), which have a high colonization capacity in an empty space, respectively a very good accommodation and resistance capacity under extreme ecological conditions such as those on the tailing dumps.

The researches performed on the *vegetation* were materialized by the identification of

two vegetal “communities”, 37 associations, one sub-association and 12 facieses.

The structure of phytocoenoses on the tailing dumps from Aghireş is not fully defined and consolidated, as the vegetal communities on these tailing dumps are continuously changing their structure and floristic composition, under various stages of formation and consolidation.

The vegetation of tailing dumps from Căpuş is defined, consolidated and structured much better.

The results of the vegetation dynamics study on the tailing dumps in Aghireş and Căpuş, during the 2005-2011 period compared to the observations and results obtained by Blaga and presented in the paper published in 1981 clearly prove the fact that:

- the rehabilitation of the vegetation on the damaged and empty lands develops extremely slow;
- the highest significance in the primary colonization belongs to the closeness to the seed sources;
- the newly formed phytocoenoses are not restored to the same composition and structure as those before the exploitation.

The studies performed at the stable squares level (quadrates) and the fine scale analysis prove to be suggestive in explaining the phytocenosis mechanisms, whose activation is strongly influenced by the distance from the seed source and the presence of a nitrogen fixing species.

The results of the observations and measurements performed on the tailing dumps from Aghireş and Căpuş have shown the rapid improvement of the tailing dump material and its reintegration in the landscape is mainly performed by planting the wood species (acacia, seabuckthorn and balsam), nitrogen-based species which contribute to growth stimulation of other wood species, in mixed plantations.

In the end, the following recommendations are outlined:

- the performance of several forest plantations, using native species to create protection curtains, consolidation of tailing dumps and their integration into the landscape;
- the avoidance of grazing during and after the rainy periods, in the pastures on the slopes and banks of the tailing dumps, as this enhances degradation and erosion;
- the management of lakes resulted from the accumulation of rainfall water in the open pit voids or in the low areas between the tailing dumps, both in Aghireş and in Căpuş and their management for a recreational purpose.

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