Technogenic Ecological Sequences in Tailing Pond from Căpușu Mare, Built between 1975-1981

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ABSTRACT

In Romania, all actions related to mining management are found in "Strategy of the mining industry for 2012-2035". Today, numerous tailing ponds have remained outside rehabilitation operations, and they are becoming more natural, as is the case of the tailing pond in Capusu Mare. The vegetation study was conducted in 2015, at the tailing pond III in Căpușu Mare that was operational between 1975-1981. The following phytopopulation and phytocenotic indices were calculated: presence, frequency, class of presence, abundance-dominance and average abundance-dominance (ADm) of species. Floral studies show the presence of 40 plant species. The wood species with the highest mean dominant abundance are *Hippophæ rhamnoides* (14.78%) and *Salix alba* (10.55%), and of herbaceous species stands *Phragmites communis* with 7.49%. After 34 years from the heap closure, the degree of vegetation coverage is 77%. Wood species occupy about 32% of the heap surface.

Keywords: tailing pond, vegetation study, natural revegetation, phytopopulation and phytocenotic indices

INTRODUCTION

The European Union attaches great importance to reduce the impact of mining tailings ponds on the environment. The main Directive developed in this area is Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC (**Directive 2006/21/EC**).

Programmatic document elaborated by the Government and mining industry entitled Strategy of the mining industry for the period 2012-2035 shows that, under the Mining Law 85/2003 was issued 11 government decisions which approved the closure of 556 mines/quarries. Since 1998 and until the end of 2011, 192 objectives have been closed and rehabilitated, at which we can add 53, with partially completed works (Strategia industriei miniere pentru perioada 2012-2035).

This process proves to be a difficult and costly one, given that Romania was a country subject to forced and aggressive industrialization until 1990. Thus, many tailing ponds have remained outside rehabilitation operations, and they have entered into a process of natural grassing. In this situation, there is also the tailings pond in Căpușu Mare, which is the object of our study.

Under this circumstances, the cover with spontaneous vegetation of tailing ponds is ecologically beneficial as wind erosion and the transport of dust and toxic materials in the river basin to which they are part or neighbouring are reduced. Vegetation also brings with it aesthetic advantages (Maxim, 2008).

In Căpușu Mare, Cluj county, iron ore was exploited, resulting in four tailings dumps completed in 1969 (keep I), 1975 (keep II), 1981 (keep III) and 1985 (keep IV) (Clapa, 2003; Măț,

2012; Maxim *et al.*, 2015). This paper presents a vegetation study conducted in 2015 at the tailings heap III built between 1975 and 1981 (Fig. 1).

MATERIALS AND METHODS

Floral description was made using botanical determinants. The determination of phytopathogenic indices (presence, abundance-dominance, frequency) was done by the geobotanic method. For establishing the abundance-dominance indicator, the 7-grade Braun-Blanquet scale was used, as described by Maxim *et al.* (2015). Subsequently, the raw table was compiled, and on the basis of these data, each species ran into a class of presence (1-20, 20-40, 40-60, 61-80, 81-100%), then the abundance- the average dominance was calculated (Maxim *et al.*, 2016; Păcurar and Rotar, 2014). In addition to the specific coverage, the general cover of the dump with vegetation was also appreciated.

Soil analysis shows that the pH of the soil in vegetation-covered areas is 5.4 and in uncove-

red portions of vegetation is 4.9. There is no data on the natural attenuation of the pollution phenomenon, but naturally it is assumed that the concentrations of the pollutants have decreased by self-purification.

RESULTS AND DISCUSSION

34 years after the tailings pond closure, vegetation coverage is 77%, and wood species occupy approximately 32% of the landfill area. The floral inventory shows the presence of 40 species, as follows: 8 species of trees, 3 species of shrubs and 29 grass species.

The tree species are as follows: *Betula pendula*, *Salix alba*, *Populus tremula*, *Populus alba*, *Pirus piraster*, *Salix fragilis*, *Robinia pseudoacacia* and *Acer negundo*. It has been found the presence of three species of bushes, respectively, *Hippophæ rhamnoides*, *Rubus fruticosus* and *Salix caprea*.

The grass vegetation on the waste dumps is represented by 29 species: *Phragmites communis*, *Festuca sp.*, *Calamagrostis arundinacea subsp.*

Fig. 1. The tailing ponds from Căpușu Mare, Cluj – a satellite image (www.google.com)

Tab. 1. The presence of identified vegetable species on the TAILING DEPOSIT III (1975-1981) from Căpușu Mare, Cluj County, in the year 2015

Species	Survey no./abundance-dominance																				Pre- sence
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Trees																					
<i>Salix alba</i>	-	-	-	-	1	2	1	-	-	2	-	-	2	-	3	3	2	2	-	3	10
<i>Populus tremula</i>	r	-	-	3	-	-	-	r	1	-	r	-	+	-	-	+	-	-	1	-	8
<i>Betula pendula</i>	-	-	-	-	r	-	-	1	-	+	1	-	-	-	2	2	-	-	-	2	7
<i>Acer negundo</i>	-	-	-	-	-	2	-	-	-	2	-	2	-	-	-	-	1	2	-	-	5
<i>Salix fragilis</i>	-	-	-	-	2	2	-	-	-	-	-	-	1	1	1	-	-	-	-	-	5
<i>Populus alba</i>	-	-	-	-	2	-	-	-	3	-	-	-	-	2	-	-	-	-	1	-	4
<i>Pirus piraster</i>	-	-	-	-	-	-	1	-	-	-	-	2	-	-	-	r	-	-	-	-	3
<i>Robinia pseudoacacia</i>	4	-	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Shrubs																					
<i>Hippophaë rhamnoides</i>	1	-	-	-	-	3	-	-	-	3	2	2	-	2	-	4	-	3	-	4	9
<i>Rubus fruticosus</i>	-	-	1	1	-	-	-	1	2	-	-	-	-	-	1	-	-	-	-	2	6
<i>Salix caprea</i>	1	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Herbaceous plants																					
<i>Phragmites communis</i>	-	1	2	1	+	-	2	2	+	+	2	1	3	+	-	-	2	+	1	-	15
<i>Calamagrostis arundinacea</i> subsp. <i>Brachytricha</i> (Steud.)	-	-	r	r	-	2	-	2	-	-	1	-	1	+	+	-	1	+	-	-	10
<i>Festuca sp.</i>	-	-	r	-	1	1	2	2	-	-	+	1		-	+	r	-	-	-	-	9
<i>Vicia sativa</i>	-	-	-	-	-	-	-	1	1	-	+	1	2	-	-	2	-	+	-	+	8
<i>Dactylis glomerata</i>	-	-	2	1	-	+	-	r	-	-	1	-	r	-	+	-	+	-	-	-	8
<i>Poa nemoralis</i>	-	-	r	+	+	r	-	r	-	-	-	-	+	-	-	-	-	+	-	-	7
<i>Galium album (mollugo)</i>	-	-	+	+	+	+	-	-	+	-	-	-	-	-	+	-	+	-	-	-	7
<i>Trifolium pratense</i>	-	-	-	+	-	-	1	1	-	-	1	+	-	-	+	-	-	1	-	-	7
<i>Trifolium montanum</i>	-	-	-	-	-	-	r	-	-	1	-	-	-	+	-	1	-	-	+	+	6
<i>Cichorium intybus</i>	-	-	-	-	-	-	r	1	-	-	-	1	-	+	-	-	-	1	1	-	6
<i>Tussilago farfara</i>	-	-	r	-	+	-	-	-	r	-	-	1	-	-	-	-	-	1	r	-	6
<i>Hypericum perforatum</i>	-	-	-	-	+	1	-	1	-	-	1	-	-	-	+	-	-	+	-	-	6
<i>Achillea millefolium</i>	-	-	-	-	+	+	-	r	-	-	r	r	+	-	-	-	-	-	-	-	6
<i>Onobrychis viciifolia</i>	-	-	-	r	-	r	-	-	-	-	r	r	-	-	r	-	-	-	-	+	6
<i>Lotus corniculatus</i>	+	-	-	1	r	-	1	-	-	-	+	-	-	-	-	-	r	-	-	-	6
<i>Sonchus arvensis</i>	r	+	+	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	5

Species	Survey no./abundance-dominance																				Pre- sence
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
<i>Plantago lanceolata</i>	-	-	+	-	-	+	-	-	-	-	+	-	+	-	-	-	+	-	-	-	5
<i>Daucus carota</i>	-	-	+	-	r	-	-	r	r	-	-	-	-	-	-	-	-	-	r	-	5
<i>Cirsium arvense</i>	r	r	-	-	-	-	-	-	-	-	+	-	-	-	r	-	+	-	-	-	5
<i>Kanutia arvensis</i>	-	-	-	-	-	-	-	-	-	-	1	-	+	-	-	1	-	-	+	+	5
<i>Leuchantemum vulgare</i>	-	+	-	r	-	-	+	1	-	-	r	-	-	-	-	-	-	-	-	-	5
<i>Carex sp.</i>	-	-	-	-	r	-	-	+	-	-	+	-	-	-	+	-	-	-	-	-	4
<i>Vicia craca</i>	-	-	-	-	+	r	-	-	-	-	-	-	-	-	-	-	+	-	+	-	4
<i>Medicago sativa</i>	-	-	-	-	1	-	-	-	-	+	-	+	-	-	-	-	-	-	+	-	4
<i>Equisetum arvense</i>	1	-	-	r	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	3
<i>Rhianthus angustifolius</i>	-	-	-	-	-	-	r	-	+	-	-	-	-	-	-	-	-	-	+	-	3
<i>Papaver rhoeas</i>	r	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	2

Brachytricha (Steud.), *Galium album* (mollugo), *Tussilago farfara*, *Vicia sativa*, *Cirsium arvense*, *Poa nemoralis*, *Hypericum perforatum*, *Trifolium pratense*, *Trifolium montanum*, *Cichorium intybus*, *Dactylis glomerata*, *Onobrychis viciifolia*, *Medicago sativa*, *Achillea millefolium*, *Lotus corniculatus*, *Plantago lanceolata*, *Leuchantemum vulgare*, *Kanutia arvensis*, *Daucus carota*, *Sonchus arvensis*, *Vicia craca*, *Stipa pennata*, *Carex sp.*, *Silene vulgaris*, *Rhianthus angustifolius*, *Equisetum arvense* and *Papaver rhoeas*.

The presence of trees varies between 3 and 10 markers, out of the 20. At shrubs the presence is 9 at *Hippophæ rhamnoides* and 2 at *Salix caprea*. In herbaceous plants, the values of this indicator range between much larger values, from 15 at *Phragmites communis* up to 2 at *Papaver rhoeas*.

In Table 1, the species in the raw table were transcribed in order of their descending order. In trees, *Salix alba* (P = 10), *Populus tremula* (8), *Betula pendula* (7), *Acer negundo* (5), *Salix fragilis* (5), *Populus alba* (4), *Pirus piraster* (3), *Robinia pseudoacacia* (3), and in shrubs, *Hippophæ rhamnoides* (9), *Rubus fruticosus* (6) and *Salix caprea* (2). As for the grass species, the presence in descending order was as follows: *Phragmites communis* (15), *Calamagrostis arundinacea subsp.* *Brachytricha* (Steud.) (10), *Festuca sp.* (9), *Vicia sativa* (8), *Dactylis glomerata* (8), *Poa nemoralis* (7), *Galium album* (mollugo) (7), *Trifolium pratense* (7), *Trifolium montanum* (6), *Cichorium intybus*

(6), *Tussilago farfara* (6), *Hypericum perforatum* (6), *Achillea millefolium* (6), *Onobrychis viciifolia* (6), *Lotus corniculatus* (6), *Sonchus arvensis* (5), *Plantago lanceolata* (5), *Daucus carota* (5), *Cirsium arvense* (5), *Kanutia arvensis* (5), *Leuchantemum vulgare* (5), *Carex sp.* (4), *Vicia craca* (4), *Medicago sativa* (4), *Equisetum arvense* (3), *Silene vulgaris* (3), *Stipa pennata* (3), *Rhianthus angustifolius* (3) and *Papaver rhoeas* (2).

The frequency of the species and the 5 classes of presence are transposed in Table 2.

On trees, the most widespread species was *Salix alba*, with a frequency of 50%, followed by *Populus tremula* with 40%, *Betula pendula* with 35%, *Salix fragilis* and *Acer negundo* with 25%, *Populus alba* with 20%, *Pirus piraster* and *Robinia pseudoacacia* with 15%. One species falls under Class III of presence (*Salix alba*), four under Class II (*Populus tremula*, *Betula pendula*, *Salix fragilis*, *Acer negundo*), and the remaining three (*Pirus piraster*, *Robinia pseudoacacia* and *Populus alba*), in Class I of presence.

Shrubs are found in 45% of the surveys at *Hippophæ rhamnoides*, 30% at *Rubus fruticosus*, and 10% at *Salix caprea* and in terms of class of presence, *Hippophæ* falls under Class III, *Rubus fruticosus* falls within Class II and *Salix caprea* falls within Class I.

The most widespread herbaceous species on the tailings dumps at Căpușu Mare, *Phragmites communis*, has a frequency of 75% of the surveys,

Tab. 2. Frequency, class presence and average abundance-dominance of vegetable species on the TAILING DEPOSIT III (1975-1981), from Căpușu Mare, Cluj County, in the year 2015

Species	Frequency (%)	Class of presence (c.)	AD _m
Trees			
<i>Salix alba</i>	50	III	10.55%
<i>Populus tremula</i>	40	II	2.49%
<i>Betula pendula</i>	35	II	3.21%
<i>Acer negundo</i>	25	II	3.78%
<i>Salix fragilis</i>	25	II	2.58%
<i>Populus alba</i>	20	I	3.9%
<i>Pirus piraster</i>	15	I	1.15%
<i>Robinia pseudoacacia</i>	15	I	6.88%
Shrubs			
<i>Hippophaë rhamnoides</i>	45	III	14.78%
<i>Rubus fruticosus</i>	30	II	2.85%
<i>Salix caprea</i>	10	I	0.28%
Herbaceous plants			
<i>Phragmites communis</i>	75	IV	7.49%
<i>Calamagrostis arundinacea</i> subsp. <i>Brachytricha</i> (Steud.)	50	III	2.66%
<i>Festuca</i> sp.	45	III	2.64%
<i>Vicia sativa</i>	40	II	2.65%
<i>Dactylis glomerata</i>	40	II	1.51%
<i>Poa nemoralis</i>	35	II	0.12%
<i>Galium album</i> (mollugo)	35	II	0.19%
<i>Trifolium pratense</i>	35	II	1.18%
<i>Trifolium montanum</i>	30	II	0.64%
<i>Cichorium intybus</i>	30	II	1.13%
<i>Tussilago farfara</i>	30	II	0.59%
<i>Hypericum perforatum</i>	30	II	0.91%
<i>Achillea millefolium</i>	30	II	0.09%
<i>Onobrychis viciifolia</i>	30	II	0.04%
<i>Lotus corniculatus</i>	30	II	0.61%
<i>Sonchus arvensis</i>	25	II	0.60%
<i>Plantago lanceolata</i>	25	II	0.13%
<i>Daucus carota</i>	25	II	0.04%
<i>Cirsium arvense</i>	25	II	0.06%
<i>Kanudia arvensis</i>	25	II	0.63%
<i>Leuchanthemum vulgare</i>	25	II	0.33%
<i>Carex</i> sp.	20	I	0.09%
<i>Vicia craca</i>	20	I	0.09%
<i>Medicago sativa</i>	20	I	0.36%
<i>Equisetum arvense</i>	15	I	0.31%
<i>Silene vulgaris</i>	15	I	0.008%
<i>Stipa pennata</i>	15	I	0.58%
<i>Rhianthus angustifolius</i>	15	I	0.06%
<i>Papaver rhoeas</i>	10	I	0.055%

followed by *Calamagrostis arundinacea* subsp. *Brachytricha* (Steud.) with 50%, *Festuca* sp. with 45%, *Vicia sativa* with 40%,

Dactylis glomerata with 40%, *Poa nemoralis* with 35%, *Galium album* (mollugo) 3 with 5%, *Trifolium pratense* with 35%, *Trifolium montanum* with 30%, *Cichorium intybus* with 30%, *Tussilago farfara* with 30%, *Hypericum perforatum* with 30%, *Achillea millefolium* with 30%, *Onobrychis viciifolia* with 30%, *Lotus corniculatus* with 30%, *Sonchus arvensis* with 25%, *Plantago lanceolata* with 25%, *Daucus carota* with 25%, *Cirsium arvense* with 25%, *Kanudia arvensis* with 25%, *Leuchantemum vulgare* with 25%, *Carex* sp. with 20%, *Vicia craca* with 20%, *Medicago sativa* with 20%, *Equisetum arvense* with 15%, *Silene vulgaris* with 15%, *Stipa pennata* with 15%, *Rhianthus angustifolius* with 15% and *Papaver rhoeas* with 10%.

As far as the classes of presence are concerned, of the 29 herbaceous species, one belongs to the fourth class (*Phragmites communis*), two fall in class III (*Calamagrostis arundinacea* subsp. *Brachytricha* (Steud.) and *Festuca* sp.), 18 in class II (*Vicia sativa*, *Dactylis glomerata*, *Poa nemoralis*, *Galium album* (mollugo), *Trifolium pratense*, *Trifolium montanum*, *Cichorium intybus*, *Tussilago farfara*, *Hypericum perforatum*, *Achillea millefolium*, *Onobrychis viciifolia*, *Lotus corniculatus*, *Sonchus arvensis*, *Plantago lanceolata*, *Daucus carota*, *Cirsium arvense*, *Kanudia arvensis*, *Leuchantemum vulgare*), eight in Class I (*Carex* sp., *Vicia craca*, *Medicago sativa*, *Equisetum arvense*, *Silene vulgaris*, *Stipa pennata*, *Rhianthus angustifolius*, *Papaver rhoeas*).

The mean abundance-dominance indicates the average coverage of a species of all the achieved results. On Hump III in Căpușu Mare, this indicator recorded values higher than 5 for the following species: *Hippophæ rhamnoides* (14.78%), *Salix alba* (10.55%) and *Phragmites communis* cu 7.49%.

The plant species present on the tailing ponds are also found around these ponds, except *Hippophæ rhamnoides*, which prefer acidic pH soils.

CONCLUSION

The tailings pond III from Căpușu Mare operated for about 6 years, from 1975 until 1981.

After 34 years since the heap was closed, wood species occupied about 32% of the heap's surface, with the general vegetation coverage of 77%. Floral studies show the presence of 40 species, of which 8 species of trees, 2 species of shrubs and 30 grass species.

The woody species with the highest mean abundance-dominance are *Hippophæ rhamnoides* (14.78%) and *Salix alba* (10.55%), and of herbaceous species stands *Phragmites communis* with 7.49%.

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