Studies Regarding Primary Succession in a Mine Tailing Pond from Bozanta, Maramureş County

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Abstract

The objective of this study is to carry out a vegetation study at the Bozanta's tailing pond, located 5 km away from Baia-Mare. Between 2016 and 2017, using the metric frame, the existing species were identified and the following phytocenotic and population indices were determined: presence, frequency, presence classes, and the average abundance-dominance. Soil samples were taken to perform the following physico-chemical analyses: pH, P, K, N, humus and heavy metals. The floral inventory shows the presence of six tree species, four species of and 30 herbaceous species. Eleven years after the pond closure, the surface is covered with: 30% vegetation coverage, 35% water gloss and the 35% difference is occupied by arid. The average abundance-dominant synthetic indicator showed that the highest coverage is found in *Betula pendula*, *Salix caprea*, and in the grass species, *Phragmites australis*. The results of physicochemical analyses of the substrate showed very wide ranges of pH and different amounts of phosphorus, potassium and humus, and low amounts of nitrogen. The presence and concentration of the following heavy metals were determined from three samples: Cd, Pb, Ni, Cr. In regards to lead and chromium level, the alert threshold has not been reached.

Keywords: heavy metals, phytopopulation and phytocenotic indices, tailing pond, vegetation study.

INTRODUCTION

Surface mining has a major impact on the environment. This alters the landscape, affects the integrity of the habitat and ecosystem functions, influence negatively the quality of air and soil, leads to loss of soil structure and fertility, change the hydrology of the area, is a source of water contamination with toxic substances from tailings ponds (Miller and Zegree, 2014; Mummey *et al.*, 2002; Isosaari and Silanpaa, 2010; Li, 2006; Ramani, 2012).

Van Herck *et al.* (2000) underlines the risk of storage in ponds facilities contamination through

groundwater with heavy metals. In the area of Murcia (Spain), land holdings adjacent mining become unsuitable for agriculture because of contamination with heavy metals (Clemente *et al.*, 2007).

Quantities of tailings resulting from mining activities are immense. Adiansyah *et al.* (2005) estimates these quantities reach the value of 10 billion tones each year. To these are added the sterile layers resulted from historical mining pollution.

Managing the mining sterile is a great challenge for the protection of the environment. Chemical and physical methods of treatment are

very expensive. Numerous studies show that the phytoremediation of tailings ponds remains the most efficient remedial method “in situ” for both organic and inorganic pollutants (Dary *et al.*, 2010; Glick, 2010; Mendez et Mayer, 2008).

In the case of tailing ponds and heap of debris, the regrass process is stabilizing the soil. In this way the global risk of pollution with mine waste is reduced (Pourrut *et al.*, 2011, Teixeira *et al.*, 2011). Plants decrease the air dispersion, and their roots limit the transfer risk of pollutants to other compartments of the ecosystem and also lower soil erosion (Hartley *et al.*, 2012; Huot *et al.*, 2015). Passive and active techniques can be used for the phytoremediation of ponds and heap. Passive techniques involve the elimination of anthropogenic disturbance and spontaneous regrass of the pond (Hodacova and Prach, 2003). The active techniques accelerate the ecosystem rehabilitation and shall consist of the following: chemical fertilizers application (Holmes, 2001; Daws *et al.*, 2013), revegetation by sowing or plantation (Holl and Aide, 2011), and by covering with a green layer (Ferreira *et al.*, 2015; Cristescu *et al.*, 2012). A major problem of ponds revegetation by artificial insemination is given by the plant resistance to heavy metals.

Several experiments were performed in which different species of plants on tailing ponds with mining sterile rich in zinc, copper, lead, cadmium were involved. The results showed that for the rehabilitation are preferred native species tolerant to heavy metals, instead of ones from other environments (Lan *et al.*, 1997; Berti and Cunningham, 2000; Wang *et al.*, 2007; Blidar, 2009; Muszynska *et al.*, 2013). Ciarkowska et al, 2017 mentioned risk foreign species for native species. The same authors recommended the application of amendments on tailing ponds for the acceleration of ecological succession.

Although Romania benefits from significant funding for the rehabilitation of tailings ponds, many tailing ponds have remained outside rehabilitation operations (Maxim *et al.*, 2015; Maxim *et al.*, 2016; Maxim *et al.*, 2017). In this situation, there is also the tailings pond in Bozanta, Maramures County. Therefore, it has been created the possibility to study the vegetation that has been installed on the natural way, on this pond.

MATERIALS AND METHODS

The objective of this study was to carry out a vegetation study at the Bozanta's tailing pond, located 5 km away from Baia Mare municipality. The pond is one of champaign, was operating between 1976 and 2006 and has an area of 60 ha. The scroll is from flotation and comes from the processing of ores containing non-ferrous and precious metals from five mines located in the area.

The vegetation investigation was undertaken using botanical determinants and planimetric method. The observations were made during 2016-2017. Plant species have been identified and the following phytopathogenic indices: presence (the raw table), class of presence (5), abundance-dominance (%), frequency (%), the average of abundance-dominance (%), were calculated using the method described by Maxim *et al.* (2005). The crest of the tailing pond is occupied in a ratio of 35% by the body of water, 30% is covered with vegetation and the remaining 35% is represented by tailings. For the chemical properties of the soil and tailings from Bozanta's tailing pond, samples have been taken from different places considered representative, on the crest of the pond and the sample depth has not exceeded 30 cm. The following physico-chemical analyses: pH, Nitrogen, Phosphorus, Potassium, Humus content have been conducted. The measurement units used for expressing results were: ppm for P and K, % for N and Humus, and a scale of 1-14 for pH values.

RESULTS AND DISCUSSIONS

From the vegetation studies that were carried out on the crest of the Bozanta's tailing pond, floral inventory showed the presence of 40 species, as follows: 6 species of trees, 4 species of shrubs and 30 grass species, as shown in Tab. 1. In details the tree species found are: *Betula pendula* (14), *Salix caprea* (11), *Populus alba* (9), *Robinia pseudacacia* (4), *Quercus robur* (3) și *Prunus padus* (2). Four shrub species were present namely: *Rubus fruticosus* (3), *Rosa canina* (3), *Viburnum rhytidophyllum* (2) și *Rubus idaeus* (2). The grass vegetation on the crest of the tailing pond was represented by 20 species: *Phragmites australis* (16), *Rumex acetosella* (9), *Polytrichum commune* (7), *Tussilago farfara* (6), *Rhinanthus minor sp* (6), *Poa pratensis* (5),

Equisetum arvense (5), *Nardus stricta* (5), *Apera spica-venti* (5), *Calamagrostis arundinacea* subsp. *Brachytricha* (5), *Festuca rubra* (4) *Stellaria media* (4), *Sorghum halepense* (4), *Solanum nigrum* (4), *Setaria glauca* (4), *Agropyrum repens* (3), *Achillea millefolium* (3), *Erigeron canadensis* (3), *Rorippa sylvestris* (3), *Scirpus maritimus* (2), *Chenopodium album* (2), *Crepis biennis* (2), *Frangula alnus* (2), *Taraxacum officinalis* (2), *Juncus trifidus* (2), *Polygonum chinense* (2), *Polygonum lapathifolium* (2), *Solidago canadensis* (1), *Erigeron annuus* (1) and *Tragopogon orientalis* (1). In parenthesis, after each species, is listed the presence. Overall, the analysis of plant species presence revealed that the trees presence varied between 2 and 14 markers, out of the 20. In case of shrubs, the presence was 3 in *Rubus fruticosus* and *Rosa canina*, and 2 in *Viburnum rhytidophyllum* and *Rubus idaeus*. In herbaceous plants, the values of this indicator ranged between much larger values, from 16 for *Phragmites australis* up to 1 for *Solidago canadensis*, *Erigeron annuus*, *Tragopogon orientalis*. These native species have showed tolerance to heavy metals, which is in line with the research carried out by the Bradshaw *et al.* (1978), Hao *et al.* (2004) and Parraga-Aguado *et al.* (2014), who recommended native species instead of exotic plants for the tailings ponds rehabilitation. The frequency of the species along with the 5 classes of presence and the average of abundance-dominance are transposed in Tab. 2. Regarding the trees, the most widespread species was *Betula pendula*, with a frequency of 70%, followed by *Salix caprea* with 55%, *Populus alba* with 45%, *Robinia pseudacacia* with 20%, *Quercus robur* with 15 % and *Prunus padus* with 10%.

Shrubs are found in 15% of the surveys at *Rubus fruticosus*, *Rosa canina* and in 10% of them at *Viburnum rhytidophyllum* and *Rubus idaeus*. The most widespread herbaceous species on the crest of the tailing pond at Bozanta, was *Phragmites australis* which had a frequency of 80% of the surveys, followed by *Rumex acetosela* (45%), *Polytrichum commune* (35%), *Tussilago farfara* (30%) and *Rhinanthus minor* (30%). The same 25% frequency was found for *Poa pratensis*, *Equisetum arvense*, *Nardus stricta*, *Apera spica venti* and *Calamagrostis arundinacea* subsp. *Brachytricha* while *Festuca rubra*, *Stellaria media*, *Sorghum halepense*, *Solanum nigrum* and *Setaria glauca* were found with 20%. Lower frequencies of

15% were revealed for *Agropyrum repens*, *Achillea millefolium*, *Erigeron canadensis* and *Rorippa sylvestris*. Other species such as *Scirpus maritimus*, *Chenopodium album*, *Crepis biennis*, *Frangula alnus*, *Taraxacum officinalis*, *Juncus trifidus*, *Polygonum chinense* and *Polygonum lapathifolium* had a frequency of 10% of the surveys. The lowest frequency (5%) was determined for *Solidago canadensis*, *Erigeron annuus* and *Tragopogon orientalis* with 5%. Regarding the trees species, the first one, *Betula pendula* belonged the Class IV of presence, two plant species *Salix caprea* and *Populus alba* fitted into the Class III of presence and the last three namely, *Robinia pseudocacia*, *Quercus robur* and *Prunus padus* were part of the Class I of presence. Furthermore, all four shrubs *Rubus fruticosus*, *Rosa canina*, *Viburnum rhytidophyllum*, and *Rubus idaeus* had fallen into the Class I of presence. Results from this study regarding the herbaceous species showed that *Phragmites australis* had fallen under the Class V of presence, *Rumex acetosela* in class III, and *Polytrichum commune*, *Tussilago farfara*, *Rhinanthus minor* sp., *Poa pratensis*, *Equisetum arvense*, *Nardus stricta*, *Apera spica venti*, *Calamagrostis arundinacea* subsp. *Brachytricha* (Steud.) had fallen into in the Class II of presence.

Finally, several herbaceous species had fallen in Class I of presence falls namely, *Festuca rubra*, *Stellaria media*, *Sorghum halepense*, *Solanum nigrum*, *Setaria glauca*, *Agropyrum repens*, *Achillea millefolium*, *Erigeron canadensis*, *Rorippa sylvestris*, *Scirpus maritimus*, *Chenopodium album*, *Crepis biennis*, *Frangula alnus*, *Taraxacum officinalis*, *Juncus trifidus*, *Polygonum chinense*, *Polygonum lapathifolium*, *Solidago canadensis*, *Erigeron annuus* and *Tragopogon orientalis*.

As far as the classes of presence are concerned, of the 12 herbaceous species, one belonged to the fifth class (*Phragmites australis*), one had fallen in class III (*Rumex acetosela*), five species were placed in class II namely, *Polytrichum commune*, *Tussilago farfara*, *Poa pratensis*, *Apera spica venti*, *Calamagrostis arundinacea* subsp. *Brachytricha* and the last five herbal species *Stellaria media*, *Setaria glauca*, *Erigeron canadensis*, *Juncus trifidus* and *Polygonum chinense* belonged to the class I of presence.

The average abundance-dominance indicated that the major coverage at tree species was found for *Betula pendula* (43.7%) and *Salix*

Table 1. Plant species identified, number of surveys and presence values, in the period 2016-2017, on the crest of Bozanta's tailing pond (1976-2006) located in Maramureş County – Romania

Species	Survey no.																				Presence
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Trees																					
<i>Betula pendula</i>	4	3	4	-	4	-	4	4	4	-	3	4	4	-	3	4	-	4	-	3	14
<i>Salix caprea</i>	3	-	2	3	-	-	3	-	3	2	-	-	3	3	-	2	-	3	-	3	11
<i>Populus alba</i>	-	-	1	r	-	2	+	-	1	-	-	1	-	2	-	1	-	1	-	-	9
<i>Robinia pseudacacia</i>	r	-	-	-	r	-	-	-	-	-	-	-	r	-	-	r	-	-	-	-	4
<i>Quercus robur</i>	-	-	-	-	-	r	-	-	-	-	-	-	-	r	-	-	-	r	-	-	3
<i>Prunus padus</i>	-	-	-	-	-	r	-	-	-	-	-	-	-	r	-	-	-	-	-	-	2
Shrubs																					
<i>Rubus fruticosus</i>	-	-	-	r	-	-	-	-	-	-	-	r	-	-	-	-	r	-	-	-	3
<i>Rosa canina</i>	-	-	-	-	-	-	r	-	-	-	-	r	-	-	-	-	-	-	r	-	3
<i>Viburnum rhytidophyllum</i>	-	-	-	-	r	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	2
<i>Rubus idaeus</i>	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	r	-	-	-	-	2
Herbaceous plants																					
<i>Phragmites australis</i>	5	5	-	4	4	-	5	5	4	5	4	5	-	5	5	4	-	4	4	5	16
<i>Rumex acetosella</i>	r	r	-	+	r	-	-	r	-	r	-	-	r	-	r	-	-	-	r	-	9
<i>Polytrichum commune</i>	+	-	+	-	1	-	-	+	-	-	+	-	-	-	-	1	-	-	+	-	7
<i>Tussilago farfara</i>	-	+	-	-	+	-	-	r	-	r	-	-	-	-	+	-	-	-	+	-	6
<i>Rhinanthus minor sp</i>	+	-	-	+	-	-	-	-	r	-	-	+	-	-	+	-	-	r	-	-	6
<i>Poa pratensis</i>	r	-	-	-	+	r	-	-	-	-	+	-	-	-	-	-	r	-	-	-	5
<i>Equisetum arvense</i>	-	-	r	-	-	r	-	-	-	-	r	-	-	-	r	-	-	r	-	-	5
<i>Nardus stricta</i>	r	-	-	r	-	-	-	-	-	r	-	-	-	-	-	r	-	-	r	-	5
<i>Apera spica-venti</i>	-	-	-	r	-	-	-	-	r	-	-	r	-	r	-	-	-	-	-	r	5
<i>Calamagrostis arundinacea subsp. Brachytricha</i>	r	-	-	-	r	-	-	-	-	r	-	-	-	-	r	-	-	r	-	-	5
<i>Festuca rubra</i>	-	r	-	-	-	-	r	-	-	-	-	-	r	-	-	-	-	r	-	-	4
<i>Stellaria media</i>	-	-	-	r	-	-	-	r	-	-	-	-	-	r	-	-	-	-	r	-	4
<i>Sorghum halepense</i>	r	-	-	-	-	-	+	-	-	-	r	-	-	-	-	r	-	-	-	-	4
<i>Solanum nigrum</i>	-	r	-	-	r	-	-	-	-	r	-	-	-	-	-	-	r	-	-	-	4
<i>Setaria glauca</i>	r	-	-	-	-	r	-	-	-	-	-	-	r	-	-	-	-	-	-	r	4
<i>Agropyrum repens</i>	-	-	-	-	-	-	-	r	-	-	-	r	-	-	-	-	-	r	-	-	3
<i>Achillea millefolium</i>	-	-	-	r	-	-	-	-	-	-	r	-	-	-	-	-	-	-	r	-	3
<i>Erigeron canadensis</i>	-	-	-	r	-	r	-	-	-	-	-	-	-	-	-	r	-	-	-	-	3
<i>Rorippa sylvestris</i>	-	-	r	-	-	-	-	r	-	-	-	-	-	r	-	-	-	-	-	-	3
<i>Scirpus maritimus</i>	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	2
<i>Chenopodium album</i>	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	2
<i>Crepis biennis</i>	-	-	-	-	-	-	-	r	-	-	-	-	-	-	r	-	-	-	-	-	2
<i>Frangula alnus</i>	-	-	-	-	r	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	2
<i>Taraxacum officinalis</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	r	-	-	-	-	-	2
<i>Juncus trifidus</i>	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	r	-	-	-	2
<i>Polygonum chinense</i>	-	-	-	-	-	-	-	r	-	-	-	-	r	-	-	-	-	-	-	-	2
<i>Polygonum lapathifolium</i>	-	r	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	2
<i>Solidago canadensis</i>	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Erigeron annuus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	1
<i>Tragopogon orientalis</i>	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	1

Table 2. Frequency, class presence and average abundance-dominance of plant species during 2016-2017 on the crest of Bozanta's tailing pond (1976-2006) located in Maramureş County,

Species	Frequency (%)	Class of presence	ADm (%)
Trees			
<i>Betula pendula</i>	70	IV	43.7
<i>Salix caprea</i>	55	III	20.6
<i>Populus alba</i>	45	III	16.8
<i>Robinia pseudacacia</i>	20	I	1.1
<i>Quercus robur</i>	15	I	0.82
<i>Prunus padus</i>	10	I	0.55
Shrubs			
<i>Rubus fruticosus</i>	15	I	0.82
<i>Rosa canina</i>	15	I	0.82
<i>Viburnum rhytidophyllum</i>	10	I	0.55
<i>Rubus idaeus</i>	10	I	0.55
Herbaceous plants			
<i>Phragmites australis</i>	80	V	70.0
<i>Rumex acetosela</i>	45	III	16.8
<i>Polytrichum commune</i>	35	II	6.10
<i>Tussilago farfara</i>	30	II	5.25
<i>Rhinanthus minor sp</i>	30	II	5.25
<i>Poa pratensis</i>	25	II	4.37
<i>Equisetum arvense</i>	25	II	4.37
<i>Nardus stricta</i>	25	II	4.37
<i>Apera spica venti</i>	25	II	4.37
<i>Calamagrostis arundinacea subsp. Brachytricha (Steud.)</i>	25	II	4.37
<i>Festuca rubra</i>	20	I	1.1
<i>Stellaria media</i>	20	I	1.1
<i>Sorghum halepense</i>	20	I	1.1
<i>Solanum nigrum</i>	20	I	1.1
<i>Setaria glauca</i>	20	I	1.1
<i>Agropyrum repens</i>	15	I	0.82
<i>Achillea millefolium</i>	15	I	0.82
<i>Erigeron canadensis</i>	15	I	0.82
<i>Rorippa sylvestris</i>	15	I	0.82
<i>Scirpus maritimus</i>	10	I	0.55
<i>Chenopodium album</i>	10	I	0.55
<i>Crepis biennis</i>	10	I	0.55
<i>Frangula alnus</i>	10	I	0.55
<i>Taraxacum officinalis</i>	10	I	0.55
<i>Juncus trifidus</i>	10	I	0.55
<i>Polygonum chinense</i>	10	I	0.55
<i>Polygonum lapathifolium</i>	10	I	0.55
<i>Solidago canadensis</i>	5	I	0.27
<i>Erigeron annuus</i>	5	I	0.27
<i>Tragopogon orientalis</i>	5	I	0.27

caprea (20.6%), and for the herbaceous species *Phragmites australis* (70.0%). Comparing the research carried out by Maxim *et al.* (2016) and Maxim *et al.* (2017) at two mining tailings pond (iron ores) from Capusu Mare located in Cluj county, we noticed some similarities but also differences between the vegetation installed on this tailings ponds and the one at Bozanta.

Thus, at the first tailing pond from Capusu Mare, after 40 years since the heap was closed, the woody species with highest mean abundance-dominance were found to be: *Hippophae rhamnoides* (ADm = 18.7%), *Salix alba* (ADm = 18.4%), *Populus tremula* (ADm = 14.1%) and *Robinia pseudacacia* (ADm = 14.5%). At the second tailing pond closed 34 years ago, the most widespread wood species were found to be *Hippophae rhamnoides* (ADm = 14.78%) and *Salix alba* (ADm = 10.55%). Instead, at Bozanta, the highest values of the mean abundance-dominance were found for *Betula pendula* (ADm = 43.7%) and *Salix capraea* (ADm = 20.6%), as can be seen, other than those identified at Capusu Mare. About herbaceous plants, at both Capusu Mare and Bozanta, the most abundant species was *Phragmites australis*.

Cover vegetation of tailings pond at Bozanta was found to be 30%, while those from Capusu Mare were 77% (after 34 years), respectively 82% (after 40 years). We therefore, appreciate that the space with vegetation cover is approximately the same if we consider that at Bozanta, the tailing pond was closed 12 years ago.

The physico-chemical test results indicated very wide intervals (2.65-7.28) for the pH. Phos-

phorus quantities were found varying between 2-75 ppm while Potassium between 12-112 ppm and humus content ranged between 1.65-6.86%. Insignificant quantities (0.02-0.49%) of nitrogen were determined. Besides, nitrogen content was comparable to that found by Ye *et al.* (2002) in the useless rock from the northern part of Guangdong, in southern China, respectively 0.016-0.075%. Waste heap comes from the exploitation of minerals rich in zinc and plumb. The amount of humus is noticeably higher at tailing pond studied by us (1.65-6.86%) compared to the ponds of Guangdong, where the values of this parameter had vacillated between 0.58 and 1.78%

For the determination of heavy metals from the soil were taken two samples of soil and one of waste rock. In the three sample have been determined the presence and the concentration of the following heavy metals: Cd, Pb, Ni, Cr. In Tab. 3 are given the concentrations of heavy metals, but also the normal values, alert threshold, where the authorities have to start monitoring the pond. The intervention thresholds, when the authorities will take steps to reduce concentrations to the normal value, are also mentioned.

The results obtained showed that in the case of lead and chromium the concentrations are two and a half higher than normal values, but in neither of these cases the alert thresholds have not been yet achieved. This had allowed the installation of a variety of vegetation on the tailing pond. Even though we cannot exclude that, probably, at depths higher than 30 cm, the concentration of heavy metals could be larger.

Table 3. Concentration of heavy metals at Bozanta tailing pond located in Maramures County (2007) determined by chemical analysis

Chemical tracer	UM	Concentration of samples				Benchmark (Order nr. 756 from 3 november 1997)			
		P1	P2	P3	Normal value	Alert threshold		Intervention threshold	
						Sensitive areas	Less sensitive areas	Sensitive areas	Less sensitive areas
Cd	mg/kg	0.14	0.20	0.21	1	3	5	5	10
Pb	mg/kg	39.73	59.77	37.95	20	50	250	100	1000
Ni	mg/kg	13.52	11.59	9.18	20	75	200	150	500
Cr	mg/kg	50.16	68.96	57.18	30	100	300	300	600

The concentration of heavy metals at the tailing pond from Bozanta were found to be significantly smaller compared to those of manganese mines in the northern city of Xiangtan from Hunan province, China. There, cadmium from the waste rock was 119 mg/kg, manganese was 31903 mg/kg, copper was 126 mg/kg, and the zinc was 2490 mg/kg. Wang *et al.* (2007) assigned to these high concentrations of heavy metals the absence of vegetation on the tailings ponds. The same conclusion was drawn earlier by Lan *et al.* (1997) at lead/zinc mines of Shaoguan, from southern China stating that the natural colonization with plant species on these ponds was impeded by the high concentrations of lead (34300 mg/kg), zinc (36500 mg/kg), copper (251 mg/kg) and cadmium (83 mg/kg).

CONCLUSION

The observations were made during 2016-2017 at Bozanta's tailing pond, Maramures County, after 11-12 years from the closure of the pond.

The pond is one of champaign, was operating between 1976 and 2006 and covers an area of 60 ha. The scroll is from flotation and comes from the processing of ores containing non-ferrous and precious metals from five mines located in the area.

Floral studies showed the presence of 40 species, of which 6 species of trees, 4 species of shrubs and 30 grass species.

After 11 years since the pond was closed, vegetation coverage was found to be of 30%, the body of water occupies approximately 35% of the area and the remaining 35% was found to be represented by tailings. The mean abundance-dominance indicated that the major coverage at tree species level was represented by *Betula pendula* (55.3%) and *Salix caprea* (32%), and at herbaceous species level by *Phragmites australis* (78.8%).

The physico-chemical test results indicated very wide intervals of pH (2.65-7.28), Phosphorus (2-75 ppm), Potassium (12-112 ppm) and Humus (1.65-6.86%), as well as insignificant quantities of Nitrogen (0.02-0.49%). For lead and chromium the concentrations were found to be two and a half higher than the normal values, but in neither of these cases, the alert of thresholds have not been yet achieved, which surely allowed the installation plant species.

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