10.2478/umcsbio-2013-0002

ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. LXIX, 1 SECTIO C 2014

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Flora and vegetation of a copper mine heap in Richtárová (The Starohorské Vrchy Mts., Slovakia)

Flora i roślinność hałdy kopalni miedzi Richtárová (Starohorské Vrchy, Słowacja)

SUMMARY

The paper presents the results of floristic and phytosociological research conducted during growing season 2011 on a copper mine heap Richtárová, near the village Staré Hory situated in buffer zone of the Low Tatras National Park. In total, we found 147 taxa of vascular plants. The dominant plant species of the mine heap is *Agrostis capillaris*, which sometimes forms relatively continuous cover, and other species growing in small islands of plants tolerant to specific environmental conditions, especially *Silene dioica*, *Acetosella vulgaris*, *Arabidopsis arenosa*. We sampled 8 phytosociological relevés. Localities of relevés were selected considering variability of plant communities on the all mine heap.

Key words: copper mine heaps Richtárová, flora, vegetation, Slovakia

STRESZCZENIE

W pracy przedstawiono wyniki badań florystycznych i fitosocjologicznych przeprowadzonych w sezonie wegetacyjnym 2011 roku na hałdzie kopalni miedzi Richtárová, w pobliżu wsi Staré Hory, położonej w otulinie Parku Narodowego Niskie Tatry (Słowacja). Łącznie znaleziono na tym terenie 147 gatunków roślin naczyniowych. Dominującym na hałdzie taksonem, miejscami tworzącym dość zwartą pokrywę, jest *Agrostis capillaris*. Natomiast w niewielkich skupieniach rośnie tu kilka innych gatunków, które także zaliczane są do roślin tolerujących szczególne warunki

siedliskowe np.: *Silene dioica* (= *Melandrium rubrum*), *Acetosella vulgaris* (= *Rumex acetosella*), czy *Arabidopsis arenosa* (= *Cardaminopsis arenosa*). Na badanym terenie wykonano 8 zdjęć fitosocjologicznych, reprezentujących zróżnicowanie roślinności hałdy kopalnianej.

Słowa kluczowe: hałda kopalni miedzi Richtárová, flora, roślinność, Słowacja

INTRODUCTION

Mining heaps are habitats with the specific environmental conditions differing from their environment. Often, they contain heavy metals elevated to extreme amounts in comparison with their natural content in soil, which are unaffected by human activities. There can live only plants taxa, which are able to survive extreme conditions by their special strategy (1). Specific features of heaps are strong stoniness (from 52.90 % to 87.38 %) and lack or absence of a humus layer (1). Weathering of slag and subsequent creation of fine soil progress is very slow. Outside the heaps there has increased the content of heavy metals in comparison with natural soils. This is considerably limited diversity of plants that can grow here (2). The positive of this vegetation is to protect the fragile vegetation of slopes against erosion (3).

In the course of time, on the heaps there has been selected a group of plants that can grow in these specific environmental conditions. Initiating vegetation cover is composed of species tolerant to heavy metal content, including metalophyts.

Succession of plants on the metalliferous heaps progresses in special and difficult environmental conditions, as a result, new or little known plant associations are created. The most common pioneer species are trees, for example, *Betula pendula*, *Populus tremula*, *Picea abies*, *Pinus sylvestris*. Of these, the most important and dynamic on mine heaps is the birch element, which refers to the focus on initial stages of vegetation, thanks especially to the creation of litter, shade and leeward (1). From the herbal plants there are often found for example: *Acetosella vulgaris* (= *Rumex acetosella*), *Agrostis capillaris*, *Arabidopsis arenosa* (= *Cardaminopsis arenosa*), *Avenella flexuosa* (= *Deschampsia flexuosa*), *Calamagrostis epigejos*, *Luzula luzuloides*, *Silene dioica*, *Thlaspi caerulescens* (4,5,6).

A successful existence, survival and spread of the plant population depend on how the population can suitably respond to the environmental conditions, which restrict their existence on the position. Adapting to such a habitat is the result of the strategy of the plant - which means a set of properties that the evolutionary selection proved to be beneficial for the successful existence of the population. One of the criteria is biomass production. This context includes plants growing on mine heaps resistant to stress strategy. Their common symptoms are mainly the following features: slower rate of growth, lower biomass production, most are perennial plants, flowers and seeds do not need to create an annual, they have smaller leaves, they have lower metabolic activity and they often spread vegetatively. The first colonization on the heaps begins with lichens, which retain moisture, and thereby contribute to faster physico-chemical weathering, preparing a substrate for vascular plants (7, 8).

The aim of the current investigation is to contribute to the knowledge of floristic composition in the copper heap in Richtarová (Staré Hory – Špania Dolina mining district, central Slovakia near Banská Bystrica) and also to describe the basic characteristic of soil.

STUDY AREA

According to the latest conclusions of archaeological research, the signs of copper ore mining in Staré Hory – Špania Dolina mining district, date back to the Neolithic. Anyway, at the end

of the 4th millennium BC, stone threshing findings and instruments indicate that ore was mined extensively here in this time and mining was relatively on a high level (9, 10). Intensive mining activity for a hundred years in the country left its traces in a form of mine dumps (heaps).

Locality of Richtárová (N 48°49,573´ E 19°07,929´) was one of the most prominent of Europe's localities of copper mining throughout the Middle Ages – Fig. 1 (map of locality). Ore which was mined in this area was mainly tetrahedrite, a minor chalcopyrite, and from the others there were still occurring galena and stibnite. From the local copper ore there was obtained black copper that was rich of silver. Silver was separated by decantation. (10) Currently, it is forming a dump-field oriented to the northeast, with multiple etazas that are mostly covered with sparse vegetation of higher plants, like small islands are represented by trees, dominated communities of bryophytes and lichens and grasslands with *Agrostis capillaris*.

According to historical sources, traces of the old mining can be observed in this part of the ore. The first deepwater mine was opened on the bearing Haliar in 1006 (11).

Definitive end of deep mining in the whole mining area was in 1888. Cubic capacity of heaps in Richtarová is estimated to 140 000 m^3 (12). Part of the heaps, which are situated on the northern slope of valley Richtárová and mining heaps in the upper part of the total cubic capacity, are estimated to 200 000 m^3 (13). During the years 1963–1964, old mine heaps (incurred during the 16th – the 19th century) in the area of village Richtárová were re-mined with surface mining, which significantly changed original configuration (14).

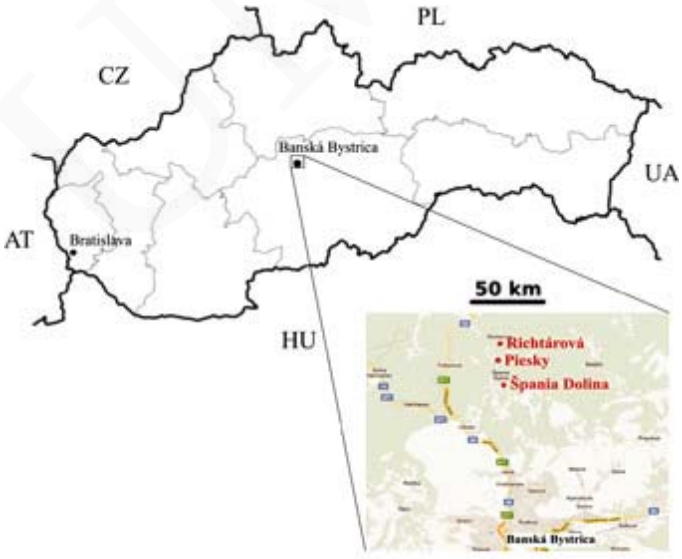

Fig. 1 Map of mining locality Špania Dolina – Staré Hory.
Ryc. 1. Mapa lokalizacji górnictwa Špania Dolina – Staré Hory.

MATERIAL AND METHODS

Field research was realized from April to September 2011 (12 days) on the whole dump fields in transects. These transects capture all types of habitats in different successional stages. The no-

menclature of the plants taxa was accepted following Marhold & Hindák (16). Polish synonyms are presented in parentheses and were accepted following Mirek et al. (17).

Phytosociological reléves were drawn up by using Braun-Blanquet scale, which is combined with coverage and frequency, and modified by Barkman et al. (15). Reléves capture the variability of vegetation cover on the heap, from the youngest successional stages to developed grasslands communities.

For the knowledge of characteristic of abiotic heap, we determined the soil reaction (pH), which is used to indicate the acid-base reactions in the soils, and it has a significant impact on the release of heavy metals to the environment, and into plants. From the whole area of the heap, we collected a total of 90 samples of soil by a stratified selection. From them, we created three mixed, stratified samples. In them we have identified active and interchangeable pH and electrical conductivity Eh. Eh and pH were determined in the water and in 1 M KCl solution (18). Into the 10-g sample we added 25 ml of distilled water or 1 M KCl, and after one hour of stirring in an electromagnetic stirrer there was determined acidity of pH meter (19).

RESULTS

In the soils from dump-field, we set the active pH values from 5.2 to 6.35 and exchangeable pH from 5.14 to 6.77, which are presented in Table 1.

Table 1. Values of soil pH and Eh.
Tabela 1. Wartości pH gleby i Eh.

Sample	pH	Eh [mV]	pH	Eh [mV]
	H_2O		KCl	
heap 1	6.33	-5	6.28	-1
heap 2	5.2	69	5.14	73
heap 3	6.35	-6	6.77	-33

The soil reaction is slightly acid to neutral, which may be caused by genesis of soil sampling sites, where prevails dead plant material (decomposed leaves, etc.). These areas subsequently developed the vegetation cover. Eh value of the heap varies in the range from -5 to 73 mV.

The representation of higher plants in waste dump-field is relatively low, they cover about 30% of the area. Vegetation is concentrated mainly in the field depressions, on even surfaces or in the areas with fine substrate. Vegetation is incoherent and forms a mosaic pattern. On considerably exposed parts of the heap grow only lichens and mosses. Dominant trees are *Picea abies* and *Pinus sylvestris*.

We have found 13 taxa of the lichens: *Acarospora fuscata, Cladonia arbuscula* subsp. *mitis, C. cf. cornuta, C. furcata, C. glauca, C. pyxidata, C. squamosa,*

Hypogymnia physodes, Lecanora polytropa, Lepraria sp., *Peltigera rufescens, Rhizocarpon geographicum* and *R. obscuratum*.

The mosses represent the genus of: *Ceratodon, Dicranum, Hylocomium, Plagiomnium, Pleurozium, Polytrichum, Rhytidiadelphus* and *Thuidium*.

List of vascular taxa

It was found 147 taxa of vascular plants:

***A**bies alba, Acer platanoides, A. pseudoplatanus, Acetosa pratensis* (= *Rumex acetosa*), *Acetosella vulgaris* (= *Rumex acetosella*), *Acinos alpinus, Aegopodium podagraria, Agrostis capillaris, A. stolonifera, Achillea millefolium, Ajuga reptans, Alchemilla* sp., *Alnus incana, Angelica sylvestris, Anthoxanthum odoratum, Anthriscus sylvestris, Arabidopsis arenosa* (= *Cardaminopsis arenosa*), *Arenaria serpyllifolia, Armoracia rusticana, Arrhenatherum elatius, Artemisia vulgaris, Aruncus vulgaris* (= *Aruncus sylvestris*), *Asplenium septentrionale, Astragalus glycyphyllos, Avenella flexuosa* (= *Deschampsia flexuosa*), *Avenula pubescens,*

***B**etula pendula, Brachypodium pinnatum,*

***C**alystegia sepium, Campanula patula, C. serrata, C. trachelium, Carex hirta, C. michelii, C. ovalis, Carpinus betulus, Cerastium holosteoides, Chaerophyllum aromaticum, Chamerion angustifolium, Chelidonium majus, Cirsium eriophorum, Corylus avellana, Crepis biennis, Crocus discolor* (= *Crocus scepusiensis*), *Cruciata glabra, Cystopteris fragilis,*

***D**actylis glomerata, Daucus carota, Dianthus carthusianorum, Dryopteris filix-mas,*

***E**chium vulgare, Epilobium montanum, Equisetum arvense, E. sylvaticum, Euphrasia rostkoviana,*

***F**agus sylvatica, Festuca pratensis, F. rubra, Fragaria vesca, Fraxinus excelsior,*

***G**alium mollugo, Galeopsis* sp., *Geranium phaeum, G. pratense, G. pyrenaicum, G. robertianum, Glechoma hederacea,*

***H**eracleum sphondylium, Hieracium murorum, Hylotelephium maximum* (= *Sedum telephium* subsp. *maximum*), *Hypericum perforatum,*

***K**nautia arvensis,*

***L**amium maculatum, Lapsana communis, Lathyrus pratensis, L. vernus, Leontodon hispidus, Leucanthemum vulgare, Lotus corniculatus, Lupinus polyphyllus, Luzula luzuloides, L. sylvatica, Lychnis flos-cuculi, Lysimachia nummularia,*

***M**edicago falcata, M. lupulina, Melampyrum pratense, M. sylvaticum, Melilotus albus, Myosotis sylvatica,*

***P**arthenocissus quinquefolia, Pastinaca sativa, Petasites albus, Phyteuma spicatum, Picea abies, Pimpinella saxifraga, Pinus sylvestris, Plantago lanceola-*

ta, Poa nemoralis, Polygonum aviculare, Polypodium vulgare, Populus tremula, Potentilla heptaphylla, Primula veris, Prunella vulgaris, Prunus domestica,

***R**anunculus acris, R. repens, Ribes uva-crispa, Robinia pseudoacacia, Rosa canina agg., Rubus fruticosus agg., R. idaeus,*

***S**alix caprea, S. purpurea, Salvia pratensis, S. verticillata, Sanguisorba minor, Scrophularia nodosa, Securigera varia* (= *Coronilla varia*)*, Senecio germanicus, Silene dioica* (= *Melandrium rubrum*)*, S. nemoralis, S. vulgaris, Stellaria nemorum, Stenactis annua* (= *Erigeron annuus*)*, Steris viscaria, Swida sanguinea* (= *Cornus sanguinea* subsp. *sanguinea*)*,*

***T**anacetum vulgare, Taraxacum sect. Ruderalia, Thymus pulegioides, Tilia platyphyllos, Tragopogon orientalis, Trifolium aureum, T. montanum, T. pratense, T. repens, Tussilago farfara,*

***U**rtica dioica,*

***V**accinium myrtillus, Verbascum chaixii* subsp. *austriacum, V. nigrum, Veronica chamaedrys, V. officinalis, Vicia cracca, V. tenuifolia, Viola tricolor.*

In the floristic composition of the heap from vascular plants dominate *Agrostis capillaris*, *Arabidopsis arenosa* (= *Cardaminopsis arenosa*), *Silene dioica* (= *Melandrium rubrum*), the lichens *Rhizocarpon geographicum*, *Cladonia arbuscula* subsp. *mitis* and *C. glauca*.

Specific association of the copper mine heaps, which we also confirmed on the heap Richtárová, is *Cladonio mitis-Silenetum inflatae*, Banásová 1974 (20). Its floristic composition approximates this following phytosociological note:

Phytosociological reléves

Reléves No. 1: waste heap in Richtárová, bottom of the heap, stabilized scree with developed shallow soil, 590 m a.s.l., N 48° 49,661´, E 19°07,974´, slope 40°, slope orientation E, area 2 × 2 m, E_1 60 %, E_0 50 %, 11.5.2011.

E_1: *Arabidopsis arenosa* 2b, *Galium mollugo* 2a, *Silene dioica* 2a, *S. vulgaris* 2a, *Viola tricolor* 2a, *Abies alba* 1, *Acer pseudoplatanus* 1, *Acetosella vulgaris* 1, *Campanula patula* 1, *Agrostis capillaris* +, *Achillea millefolium* +, *Ajuga reptans* +, *Arrhenatherum elatius* +, *Carpinus betulus* +, *Dactylis glomerata* +, *Dianthus carthusianorum* +, *Picea abies* r.

E_0: *Cladonia arbuscula* subsp. *mitis* 2a, *Dicranum* sp. 2a, *Ceratodon purpureus* 1, *Lepraria* sp. 1, *Acarospora fuscata* +, *Cetraria islandica* +, *Cladonia* cf. *cornuta* +, *C. glauca* +, *C. squamosa* +, *Lecanora polytropa* +, *Rhizocarpon obscuratum* +, *Rhytidiadelphus squarrosus* +.

Character of the last vegetation of mining dump-field and dominance of these taxa express these following phytosociological reléves:

Reléves No. 2: waste heap in Richtárová, bottom of the heap, grassland vegetation, 600 m a.s.l., N 48°49,655´, E 19°07,971´, slope 25°, slope orientation E, area 4 × 4 m, E_1 70 %, E_0 10 %, 11. 5. 2011.

E_1: *Lychnis flos-cuculi* 2b, *Agrostis capillaris* 2a, *Ajuga reptans* 2a, *Silene dioica* 2a, *Viola tricolor* 2a, *Acetosella vulgaris* 1, *Arabidopsis arenosa* 1, *Cruciata glabra* 1, *Galium mollugo* 1, *Hylotelephium maximum* 1, *Acer platanoides* +, *Acetosa pratensis* +, *Achillea millefolium* +, *Anthoxanthum odoratum* +, *Anthriscus sylvestris* +, *Arrhenatherum elatius* +, *Carex ovalis* +, *Carpinus betulus* +, *Dianthus carthusianorum* +, *Fragaria vesca* +, *Galeopsis* sp. +, *Hypericum perforatum* +, *Pimpinella saxifraga* +, *Potentilla heptaphylla* +, *Salvia pratensis* +, *S. verticillata* +, *Trifolium montanum* +, *Veronica chamaedrys* +, *Vicia cracca* +, *Knautia arvensis* r, *Picea abies* r, *Tilia platyphyllos* r,

E_0: *Dicranum* sp. 1, *Acarospora fuscata* +, *Cladonia glauca* +, *C. arbuscula* subsp. *mitis* +, *C. pyxidata* +, *C. squamosa* +, *Lepraria* sp. +, *Pleurozium schreberi* +, *Rhizocarpon obscuratum* +.

Reléves No. 3: heap in Richtárová, steep scree slope on the west side of the heap, 577 m a.s.l., N 48°49,654´, E 19°08,015´, slope 45°, slope orientation W, area 2 × 2 m, E_1 40%, E_0 50%, 11.5.2011.

E_1: *Acetosella vulgaris* 2a, *Agrostis capillaris* 2a, *Silene dioica* 2a, *Picea abies* 1.

E_0: *Dicranum* sp. 2a, *Acarospora fuscata* 1, *Ceratodon purpureus* 1, *Cladonia arbuscula* subsp. *mitis* 1, *Pleurozium schreberi* 1, *Rhizocarpon geographicum* 1, *Rhizocarpon obscuratum* 1, *Cetraria islandica* +, *Peltigera rufescens* +.

Reléves No. 4: heap in Richtárová, equal area in the middle of the heap with developed soil, 597 m a.s.l., N 48°49,638´, E 19°07,992´ (ujednolicić zapis współrzędnych geograficznych – patrz str. 2), slope 0°, slope orientation - , area 2 × 2 m, E_1 65%, E_0 30%, 12.5.2011.

E_1: *Agrostis capillaris* 2b, *Silene dioica* 2a, *Tussilago farfara* 2a, *Acetosella vulgaris* 1, *Salix caprea* 1, *Acer pseudoplatanus* +, *Betula pendula* +, *Carpinus betulus* +, *Galium mollugo* +, *Picea abies* +, *Steris viscaria* +, *Taraxacum* sect. *Ruderalia* +, *Trifolium pratense* +, *Artemisia vulgaris* r, *Urtica dioica* r.

E_0: *Dicranum* sp. 2a, *Lecanora polytropa* 2a, *Ceratodon purpureus* 1, *Cladonia furcata* +, *C. arbuscula* subsp. *mitis* +, *Hylocomium splendens* +, *Lepraria* sp. +, *Rhizocarpon geographicum* +, *R. obscuratum* +.

Reléves No. 5: heap in Richtárová, overgrown scree slope with a slight dominance of *Arabidopsis arenosa*, 580 m a.s.l., N 48° 49,631´, E 19° 07,974´, slope 5 °, slope orientation NE, area 2 × 2 m, E_1 75%, E_0 90%, 12.5.2011.

E_1: *Arabidopsis arenosa* 3, *Cerastium holosteoides* 2a, *Dianthus carthusianorum* 2a, *Agrostis capillaris* 1, *Silene vulgaris* 1, *Taraxacum* sect. *Ruderalia* 1, *Trifolium pratense* 1, *Abies alba* +, *Acetosa pratensis* +, *Acetosella vulgaris* +, *Achillea millefolium* +, *Anthoxanthum odoratum* +, *Arrhenatherum elatius* +, *Betula pendula* +, *Daucus carota* +, *Galium mollugo* +, *Leontodon hispidus* +, *Leucanthemum vulgare* +, *Lotus corniculatus* +, *Pimpinella saxifraga* +, *Prunella vulgaris* +, *Silene dioica* +, *Verbascum chaixii* subsp. *austriacum* +, *Arenaria serpyllifolia* r, *Artemisia vulgaris* r, *Hylotelephium maximum* r, *Hypericum perforatum* r, *Plantago lanceolata* r, *Salix caprea* r, *Tanacetum vulgare* r.

E_0: *Ceratodon purpureus* 3, *Dicranum* sp. 2a, *Lepraria* sp. 2a, *Plagiomnium undulatum* 1, *Rhizocarpon obscuratum* 1, *Rhytidiadelphus squarrosus* 1, *Acarospora fuscata* +, *Cladonia glauca* +, *C. pyxidata* +, *Rhizocarpon geographicum* +.

Reléves No. 6: heap in Richtárová, vegetation cover dominated by *Alnus incana* in the middle of the heap with deeper soil, 590 m a.s.l., N 48° 49,605´, E 19° 07,941´, slope 3 °, slope orientation N, area 20 × 10 m, E_3 20%, E_2 35%, E_1 80%, E_0 40%, 12.5.2011.

E_3: *Alnus incana* 2a, *Salix caprea* 1, *Robinia pseudoacacia* +.

E_2: *Betula pendula* 3, *Acer pseudoplatanus* 1, *Salix caprea* 1, *Tilia platyphyllos* 1, *Acer platanoides* +, *Carpinus betulus* +, *Picea abies* +, *Pinus sylvestris* +, *Rubus fruticosus* agg. +.

E_1: *Aegopodium podagraria* 3, *Agrostis capillaris* 2a, *Lysimachia nummularia* 2a, *Abies alba* 1, *Acer pseudoplatanus* 1, *Arrhenatherum elatius* 1, *Betula pendula* 1, *Campanula trachelium* 1, *Carex hirta* 1, *Cruciata glabra* 1, *Dactylis glomerata* 1, *Galium mollugo* 1, *Picea abies* 1, *Rubus idaeus* 1, *Urtica dioica* 1, *Acer platanoides* +, *Acetosa pratensis* +, *Achillea millefolium* +, *Alchemilla* sp. +, *Alnus incana* +, *Anthoxanthum odoratum* +, *Arabidopsis arenosa* +, *Carpinus betulus* +, *Cerastium holosteoides* +, *Crepis biennis* +, *Daucus carota* +, *Dryopteris filix-mas* +, *Equisetum arvense* +, *Festuca pratensis* +, *Festuca rubra* +, *Fragaria vesca* +, *Geranium pratense* +, *Hypericum perforatum* +, *Leontodon hispidus* +, *Myosotis sylvatica* +, *Pastinaca sativa* +, *Pimpinella saxifraga* +, *Poa nemoralis* +, *Ranunculus acris* +, *R. repens* +, *Rosa canina* agg. +, *Salix caprea* +, *Silene dioica* +, *S. vulgaris* +, *Tanacetum vulgare* +, *Taraxacum* sect. *Ruderalia* +, *Trifolium repens* +, *Tussilago farfara* +, *Verbascum chaixii* subsp. *austriacum* +, *Veronica chamaedrys* +, *Vicia cracca* +, *Viola tricolor* +, *Echium vulgare* r, *Heracleum sphondylium* r, *Medicago lupulina* r, *Prunus domestica* r.

E_0: *Cladonia arbuscula* subsp. *mitis* 2a, *Rhytidiadelphus squarrosus* 2a, *Pleurozium schreberi* 1, *Cladonia furcata* +, *C. glauca* +, *C.* sp. +, *Dicranum* sp. +, *Hypogymnia physodes* +, *Lepraria* sp. +, *Plagiomnium affine* +, *Rhizocarpon obscuratum* +, *Thuidium abietinum* +.

Reléves No. 7: heap in Richtárová, top of the heap, steep slopes with developed vegetation cover and skelet soil, 630 m a.s.l., N 48° 49,487′, E 19°07,887′, slope 45°, slope orientation NE, area 2 × 2 m, E_1 70 %, E_0 45 %, 12.5.2011.

E_1: *Agrostis capillaris* 3, *Acetosella vulgaris* 2b, *Ajuga reptans* 1, *Alchemilla* sp. 1, *Aruncus vulgaris* 1, *Betula pendula* 1, *Campanula patula* 1, *Carpinus betulus* 1, *Cerastium holosteoides* 1, *Fragaria vesca* 1, *Rubus fruticosus* agg. 1, *Silene dioica* 1, *Trifolium pratense* 1, *Angelica sylvestris* +, *Epilobium montanum* +, *Picea abies* +, *Salix caprea* +, *Urtica dioica* +, *Veronica chamaedrys* +, *Abies alba* r, *Arenaria serpyllifolia* r, *Dryopteris filix-mas* r, *Verbascum nigrum* r.

E_0: *Ceratodon purpureus* 1, *Rhizocarpon geographicum* 1, *Pleurozium schreberi* 1, *Acarospora fuscata* +, *Cetraria islandica* +, *Cladonia glauca* +, *C.* cf. *cornuta* +, *C. arbuscula* subsp. *mitis* +, *C. squamosa* +, *Thuidium tamariscinum* +, *Polytrichum* sp. r.

Reléves No. 8: heap in Richtárová, top of the heap, scree with grassland cover and developed soil, 600 m a.s.l., N 48°49,545′, E 19°07,879′, slope 40°, slope orientation NE, area 4 × 4 m, E_1 90 %, E_0 40 %, 12.5.2011.

E_1: *Acetosella vulgaris* 3, *Agrostis capillaris* 3, *Silene dioica* 2a, *Galium mollugo* 2a, *Viola tricolor* 2a, *Abies alba* 1, *Dianthus carthusianorum* 1, *Festuca pratensis* 1, *Fragaria vesca* 1, *Silene vulgaris* 1, *Veronica chamaedrys* 1, *Acer pseudoplatanus* +, *Anthoxanthum odoratum* +, *Arabidopsis arenosa* +, *Arrhenatherum elatius* +, *Avenula pubescens* +, *Festuca rubra* +, *Hylotelephium maximum* +, *Picea abies* r.

E_0: *Pleurozium schreberi* 2a, *Cladonia arbuscula* subsp. *mitis* 1, *Dicranum* sp. 1, *Lepraria* sp. 1, *Rhizocarpon obscuratum* 1, *Acarospora fuscata* +, *Cladonia furcata* +, *C. glauca* +, *C. squamosa* +.

DISCUSSION

The first data about vegetation on copper mining dumps in the Staré Hory region have been published by Prat and Komárek (21). In specific environmental conditions of copper mine heaps, grows mainly the selection of a group of species that are able to survive these specifics of this habitat. Vegetation creates tolerant ecotypes of grass and herbs, often with the absence of trees, but with a rich cover of lichens (1, 22, 23, 24). From the past to the present, there have been published studies of tolerance of plants to heavy metals with reference to tolerant species *Acetosella vulgaris* (= *Rumex acetosella*), *Agrostis capillaris*, *Avenella flexuosa* (= *Deschampsia flexuosa*), *Calluna vulgaris*, *Silene dioica* (= *Melandrium rubrum*) and *Vaccinium myrtillus* (23, 25, 26, 27). Lichens on copper mine heaps in Slovakia are studied in detail by Lackovičová et al. (28), on the calamine heaps in southern Poland by Bielczyk et al. (29).

Floristic and phytosociological research on the copper mine heap in mining district of Špania Dolina – Staré Hory, were also realized by Banásová et al. (30). On the Richtárová heap, the authors have indicated the same dominant species except *Agrostis stolonifera* and *Silene vulgaris*. Currently, this species are not in dominant composition. The highest abundance among the moss and lichen were, according to Banásová (1) and Banásová et al., (30), *Ceratodon purpureus*, *Cladonia arbuscula* subsp. *mitis*, *C. fimbriata*, *C. coniocraea*, *C. pyxidata* and *Stereocaulon incrustatum,* which have not been confirmed yet.

On the heap, we have found the presence of run wild species *Parthenocissus quinquefolia* and *Lupinus polyphyllus*, which are grown as decorative in the nearby recreation chalets.

ACKNOWLEDGEMENTS

The work was financially supported by grant schemes APVV-0663-10 and VEGA 2/0099/13. For determination of lichen taxa, the authors would like to thank Dr hab. Urszula Bielczyk and Dr Robert Kościelniak (Institute of Biology, Pedagogical University of Cracow).

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