**Environmental impact of mining activities on the settlement of spoil heap in Gelnica and its impact on human**

Mining heaps are piles of spoil which as remnants after uneffective medieval mining of ores pose permanent environmental threat. This work analyses a secondary complex of mining heap with a total area of around 5500 square meters which is located at Slovenske Cechy-Gapsle in Košice region in the east of Slovakia. The work describes geoecological characteristics, occurrence of different types of organisms which occupy the heap despite the given inhospitable conditions, as well as it watches the environmental impact of the heap on human. Moreover, it presents pH properties of heap´s soil, description of occurence and occupation of vegetation (worked out phytocenological listings), fungi and animals. It is also about presence of toxic metals in a lichen *Cladonia arbuscula* subsp. *mitis* which is a result of their high concentration in the soil of the heap and also about their presence in water from a well that is located on the heap as well as in the one located under the heap which is used a source of water for local population. Our conclusions state that the most spread species occupying the heap are *Agrostis capillaris* and lichens *Cladonia arbuscula* subsp. *mitis* a *Stereocaulon dactylophyllum.* Vegetation covers around 40% of the total surface of the heap. In spite of the fact that the occurance of lichens *Stereocaulon* is still rich in the numbers we may include them in the list of endangered and critically endangered species. The soil is characterized by acicid pH of 5.1. Our conclusions fully corelate with those of Ms Banásová (2006), who examined mining heap located in Smolnicka Huta. In terms of occurance of animals, we recorded mainly invertebrates to live on the heap. In the most frequent lichen *Cladonia arbuscula* subsp*. mitis* there were primarily present elements like aluminium, iron, antimony and copper. By comparing metals present in examined lichen and their content in the soil from the heap which was examined by Ms Banásová (2003) we found out that the lichen accumulated large amounts of the metals (except aluminium) that are mainly present in the soil. In the samples of water taken from the both wells mentioned above, there were such amounts of metals that are not toxic to human and satisfy normal values set by NV SR 496/2010. In a contrary view on the heap as a potential source of dangerous metals, as well as a place suitable for a broad spectrum of endangered and valuable lichens we might say they require and should have at least some of our attention – as well as educational eko-geological pathway which will belong and serve to everyone.

Goals

* To describe ecological conditions, geological composition of the heap and content of toxic metals in the soil from the heap in Gelnica more precisely in Slovenske Cechy-Gaple
* To determine acid-base properties of the soil
* To describe vegetation occupying central and peripheral part of the heap, determine dominant species of the heap and conduct phytocenologic records
* To determine fungi species which habitate the heap as well as animal species which live on the heap either temporarily or permanently
* To find out the in Gelnica located in Slovenske Cechy
* To compare the content of the metals in the heap with their content in the lichen
* To conduct chemical analysis of the samples from both wells wihch are on and under the heap in Gelnica on the Banicka street
* To compare the presence and content of the elements in water samples from both researched places with the content of metals in the heap and also with standards for drinkable water

Methods

* We conducted our terrain research with respect to the Zurrich-Montpeliere methods and we used combined Braun-Blanquet coverage and frequency scale when creating the phytocenological (Braun-Blanquet, 1964).
* To determine pH properties of the water and soil we used a special pH-meter
* When determining vegetation species we worked with publications Trávy (Graun a kol., 1998), Zoznam nižších a vyšších rastlín Slovenska (Marhold a Hindák, 1998), Veľká kniha rastlín hornín, minerálov a skamenelín (Krejča a kol., 1997) and a pack of different websites and other publications which are listed under the used literature
* When determinig lichen species and content of toxic metals in a lichen *Cladonia arbuscula* subsp. *mitis* we cooperated  prof. doc. RNDr. Martin Bačkora, PhD. from Katedra botaniky Prírodovedeckej fakulty UPJŠ in Košice. To verify the content of toxic metals we used a method of Flame Atomic Absorption Spectroscopy (FAAS).
* When determing species of fungi we discussed it through email with Dr. Ivona Kautmanova from Slovak National Museum
* Analysis of water from the wells either on the heap and from the one under the heap took place on 23. of January by FAAS in cooperation with Accredited chemical laboratory in Spišsá Nová Ves

Introduction

Gelnica is an old mining town located in Košice region in the east of Slovakia. History of the town inextricably intervowen with mining, primarily with mining of copper and iron ores, but also of silver, mercury, lead and gold in locations like Turzov and Zenderling.

Results

**1.1 Geologic and ecologic characteristic of the heap**

Mining heap in Gelnica in a location Slovenske Cechy-Gaple is, according to the data provided by Mining Museum of Gelnica, almost 200 years old secondary complex with a total area of around 5500 square meters. It is created mostly by crystalline slate, quartz, siderit, chalcopyrite, pyrite, tetrahedrite and also partially by limonit and secondary copper minerals malachite, azurite, olivenite, antlerite and cornwallite. A part of the heap is located outside of Slovenske Cechy.

From the ecological point of view, the heap represents a specific type of habitat characterized by a lack of water and soil, a high content of toxic metals, very limited variety and also population of vegetation species – islet habitation. We may there very often find solitary and stunted organisms, occasionally they might suffer from visible impaired vitality. (Pict.)

**1.2 pH properties of soil**

The soil from the heap in Gelnica is characterized by an acidic pH of 5,1. We verified the value multiple times to get the most precise results.

**1.3 Habitation of the heap by vegetation**

The area of of the heap is strictly separated from the surrounding environment, habitation of the heap is located in the peripheral areas and hollows. Total coverage of the heap reaches up to 40%. The most frequent species were *Betula pendula* a *Pinus sylvestris.* The plants were often stunted and their impaired vitality was actually very easy to spot for example thanks to the orange and red spots on the needles of *Pinus sylvestris*.The other plants occurying there were *Agrostis capillaris, Vaccinium myrtillus* and *Calluna vulgaris*. The most frequent representatives of the mosses *Ceratodon purpureus* and *Racomitrium lanuginosum.* The central part is characterized by places with irregular habitation, the most common plant is *Agrostis capillaris*. Besides the others, we would like to point out species like *Dianthus cartusianorum, Acetosella vulgaris*, *Gypsophila muralis* and *Silene vulgaris.*

A very sovereign representation in the centre had both *Cladonia*  *arbuscula* subsp. *mitis and* *Stereocaulon dactylophyllum*. We have to point out a fact that although the species of *Stereocaulon* (*S.tomentosum* can be found in great numbers on the heap) are in the Red List of endangered species they achieve great numbers on the mining heap in Gelnica.

**1.5 Fungi on the heap**

Despite the fact that the heap is characterized by a very poor variety of species and also by its relatively low coverage, in months August and September we may find here also different species of fungi, next to the mosses and lichens. The most common fungi is *Suillus luteus* that may be found not only in the peripheral parts of the heap, but in its centre as well reaching seriously great numbers there. Altogether, we were able to record 8 different fungi species, as they are presented in the table.

**1.6 Fauna**

Similarly to the group of plants and lichens which slowly sorted out as a possible habitants of the heap, there are also certain xerophilic and thermophilic animal species, primarily invertebrates. The strict separation of the heap from surrounding meadow areas is not a barrier for a continuous migration of various animal species. We observed movement of different mammals, such as *Capreolus capreolus or Lepus europaeus* through the area of the heap. It acts as kind of so-called biocorridor for them, where fauna from both ecosystem meets, thus creating a very unique environment. We may permanently observe occurence of e.g. grasshoppers, butterflies or other species, which are, hovewer, tied to the meadow ecosystem. To mention some of the invertebrates which permanently habitate the heap, we may talk about ants, *Vespa crabro* and protected *Mantis religiosa*. We alsou found Vipera berus and Lacerta agilis, as the representatives of reptiles.

**1.7 Metals content in lichen *C. mitis***

Since there is a high concentration of different toxic metals in the soil from the heap and being aware of a fact that lichens have an ability to accumulate metals from their environment, we examined presence and content of accumulated metals in the most common occurying lichen *Cladonia arbuscula* subsp. *mitis.* Detected content of the metals is to be seen in Graph 1.

**1.8 Physical properties and content of toxic metals in the water from the wells on and under the heap**

Temperature of the water taken from the well under the heap (sampling place no. 1) was 10°C and temperatureof the water from the well on the heap (sampling place no. 2) was 7°C. pH properties were slightly acidic, with a value of pH 6,6 on the sampling place no. 1 and 6,9 on the sampling place no. 2. Hardness of the water sample from sampling place no. 1 was 2,92 mmol/l, whereas that of the water from sampling place no. 2 was 3,81 mmol/l.

**1.9 Microbiological analysis of the water samples**

**1.10 Designing a geo-ecological pathway in Gelnica**

The results ,obtained by our obserbations, were summarized into the design of educational geo-ecological pathway in Gelnica. We designed information and educational table as a miniature of the pathway which is currently placed in the garden of local grammar school. We set out a route which includes the most interesting places from historical, geological, ecological and either recreational point of view.

**Discussion**

Mining heaps those of inhospitable conditions, insuffiency of water and humus and also they tend to be habitated by only very limited and specialized group of species. Weathering of the heap and creation of fine soil takes place very slowly (Banásová, 2003), which together with a complex of other unfavourable conditions results in its slow settlement either by animal of vegetation species.

Designated pH of the soil from the heap in Gelnica is 5,1, which is in correlation with findings of Banásová (2003), who examined the soil from the heap in Smolnicka Huta, where copper ores were mined, and found it to be 4,8 which is very close to our value obtained from the heap in Gelnica. This acidic pH is a result of presence of high amounts of sulfides in the soil. According to Banásová (2006), heaps with anomalous content of metals (e.g. Staré Hory, Gelnica, Smolník), are so-called ecological islands, since their very specific vegetation in comparison with their environment.

On the heaps in Slovakia we may find many rare and endangered species of lichens (Pišút a kol. (2001), we personally managed to detect presence of species from genus *Stereocaulon – Stereocaulon tomentosum*, *S.dactyllophylum* and *Cladonia furcata,* which into the category of Vulnerable.

Presence of lichens in such numbers might be, according to authors Lange and Ziegler (1963), explained by a fact that the pioneers do not have their optimal conditions here, but in comparison with other species they are strong and competitive.

Speaking of metals found in the most common lichen *Cladonia arbuscula subsp. mitis*, we were able to create the following list, starting with the most concentrated ones: aluminium, iron, antimony and copper. When we compare the content of the metals in lichen with that of the soil from the heap (Banásová, 2006 - Fe >> Cu >> As > Sb > Pb > Zn ) we might conclude that the lichen accumulated, with an exception of aluminium, the most concentrated metals in the soil.

**Conclusions**

Habitation of the heap is, in terms of variety of species, very limited. Total coverage of the heap is around 40%. Its soil is characterized by an acidic pH. The most common species which can be found on the mining heap in Gelnica, location Slovenske Cechy-Gapsle, is *Agrostis capillaris*. Quite frequent are also *Betula pendula* a*nd Pinus sylvestris*, with visibly impaired vitality. Moreover, another common species to be found on the heap are certainly lichens - *Cladonia arbuscula* subsp. *mitis* and protected species *Stereocaulon dactylophyllum.* Altogether, we were able to identify 8 representatives of fungi – the most common one was *Suillus luteus*, which can be found primarily in the central parts of the heap. Most of the permanent habitants are invertebrates – we may spot here even protected species of *Mantis religiosa*. Elements with the highest concentration in the lichen *Cladonia arbuscula* subsp. *mitis* were aluminium, iron, antimony and copper. Presence of toxic metals in the analyzed lichens is corresponds and is caused by the content of the metals in the soil of the heap. Amount of the metals in the water taken from both sampling places, with an exception of content of calcium, meets the standards set by NV 496/2010.