Journal of International Scientific Publications: Ecology and Safety

Volume 8, ISSN 1314-7234 (Online), Published at: http://www.scientific-publications.net

ECOLOGICAL CHARACTERISTICS OF MINE HEAPS AFTER URANIUM MINING IN NOVOVESKÁ HUTA (SLOVAKIA)

Danica Fazekašová[1], Ján Štuler[2], Eva Michaeli[3], Peter Adamišin[1], Jana Chovancová[1],

Zuzana Boguská[2], Vladimír Solár[3]

[1]Department of Environmental Management, Faculty of Management, University of Prešov,

Ul. 17. Novembra 1, 081 16 Prešov, Slovakia

[2]Department of Ecology, Faculty of Humanities and Natural Sciences, University of Prešov

Ul. 17. Novembra 1, 081 16 Prešov, Slovakia

[3]Department of Geography and Regional Development, Faculty of Humanities and Natural Sciences,

University of Prešov, Slovakia

Ul. 17. Novembra 1, 081 16 Prešov, Slovakia

Abstract

Uranium activity in the bearing area of Novoveska Huta (48°54´6.0632119´´E; 20°31´1.5474701´´N) was associated with the storage of contaminated materials of heaps near the worksite, and the result is that today we are talking about old mining load of uranium mining. Mine dumps and heaps are contaminated with uranium and its derived products, heavy metals such as arsenic, lead, cadmium and others. Their presence causes radiological and toxicological risk to the environment. Thus the heaps after uranium mining represent basic objects, which are examined in this work, in order to assess the impact of uranium mining and the subsequent revitalization on the biotic component of the environment. Mining heaps in the area of Novoveská Huta act as habitats with specific ecological conditions for vegetation. The revitalization of biological reclamation was carried out on individual heaps, which included covering heaps with humus material and subsequent seeding of grasses and planting trees. Phytocenological research on investigated dumps showed a relatively small number of species forming vegetation cover. Resistant species known from heaps with high level of heavy metals were dominant (e.g. Agrostis capillaris, Rumex acetosella) and plants that were planted on individual heaps in the process of restoration measures (e.g. Picea abies, Larix decidua, Abies alba).

Key words: *uranium mining, biological reclamation, phytocenological research*

1. INTRODUCTION

Recently, uranium mining is not active in Slovakia, but importance of the topic related to the uranium mining is undeniable. It is not just about the negative influence of remains of former mining burdens, but also about the idea – which is becoming more and more realistic – renewing the mining of uranium ores in areas where investigation is being held recently, i. e. Jahodná, near Košice and Novoveská Huta. It is possible to predict, that considerable storage of uranium in these areas will be, taking into account the trend in usage of this energetic source, more and more interesting for investors focusing on mining of energetic raw materials. In this connection it is inevitable to assess the impact of uranium mining on the environment of mining areas.

It is possible to understand the mine heaps as a form of waste produced by intense mining activity. Heaps represent alien inorganic element in the landscape, which disturbs the collection of environmental factors. The procedure of mine heaps establishing is connected with piling waste material from underground exploitation (Lintnerová, 2002, Bednárová, et al., 2013).

Mining structures cause changes in hydro-geological characteristics in bedrocks, and influence the quality of ground and underground waters as well. By the cycle of ground and underground waters chemical substances are spread wide to the environment. Low pH of water, which is often guided by increased mineralization, causes modification of soils and species composition of vegetation, which are present on such soils (Fľaková, et al., 2005).

Soil covering pile consists of various substances, is not matured and typologically developed, has weak stratigraphy, shallow profile and creation of aggregates is absent. Natural process of weathering begins after finishing piling the heap, takes considerable amount of time and is incomplete. Mechanical and physical

weathering is influenced by climatic factors and at the same time they build preconditions for chemical weathering, by which sulphuric acid plays important role. Significant factor influencing the weathered pile material is wind and water erosion (Križáni and Andráš, 2006).

By creating heaps by mining activity, new space is being created where floral diasporas can land and consequently germ and grow. Spontaneous overrunning of heap areas by vegetation species depends on present local ecological conditions (Banásová, 1976). One of important factors which influence catching of vegetation on heap areas, especially in early stage, is microclimatic condition. By sunny weather, intense overheating of upper layers of substratum and lower layers of air happens, especially in those parts of heaps which are not covered by vegetation. Sufficiency of light influences presence of heliophil vegetation in forming heap scrub. Another factor influencing catching vegetation species and their selection by populating heaps is insufficient amount of water, which is caused by quick run of rain water to lower layer due to stony structure. Water runoff down the hill and forming erosion rills is also abundant. Intensive overheating also degrades water regime and causes rapid evaporation. Another important factor is limited amount of organic nutrients. The most significant factor which influences vegetation catching on heap surface, as well as elimination of species and species composition, is chemical weathering of ore residuals, which produces large amount of metals and their compounds. Based on this reason, mining heaps can be considered as specific locations for vegetation occurrence and their population is effected by concentration and toxicity of metals. An important ecologic factor, with selective effect to vegetation populating heap surface, is pH of soils. Soil reaction of heap areas is influenced by abundance of sulphides, which strongly acidify newly created soils (Banásová, 2006).

Heaps after uranium mining represent basic objects of this paper, with the aim of evaluation of the influence of uranium mining and consequent revitalisation to biotic component of environment.

2. MATERIALS AND METHODS

The bearing area of Novoveská Huta (48°54´6.0632119´´E; 20°31´1.5474701´´N) is associated with more than forty year history of exploration and mining of uranium ores. During the years 1961 - 1990 from various sites of bearing field Novoveská Huta approximately 153 500 kg of uranium ore was harvested (Petrik, 2005). Political and economic changes in Slovakia in 1989 led to a decrease of extraction of uranium ore and closure of all works in the bearing area of Novoveská Huta, with subsequent tunnel disposal, as well as the revitalization of the heaps.

Except uranium and molybdenum mineralization bearing area of Novoveská Huta is also characterized by the occurrence of other mineral resources. It is a bearing of gypsum - anhydrite and the presence of venous structures with copper ores (Daniel, et al., 2011).

Novoveská Huta territory is located in the landscape unit Volovske hills, representing the eastern part of the Slovak Ore Mountains with a length of about 70 km, a width of about 30 km and a total area of about 1320 km^2 (Mazúr and Lukniš, 1986). The main part of the territory is in moderately cold climate zone, northern margin area falls within the temperate climate zone. The average annual temperature is 6.4 °C and long-term annual average rainfall is 767 mm. Seasonal torrential rains are quite common in the form of abundant rainfall. Climatic conditions greatly affect the ecology of the area; the specific features of the relief are expressed as the deployment of flora. Narrow valleys are covered mostly by meadows (meadow community). In the valleys along the stream banks grow *Salix caprea*, *Populus tremula*, *Alnus glutinosa* and *Betula pendula*. Slope of the hills is covered predominantly by softwood represented by *Picea abies*, *Abies alba* and *Pinus sylvestris*, to a lesser extent there occur deciduous trees such as *Fagus sylvatica*, *Quercus petraea* and *Carpinus betulus*. For the area were native forest types mixed forests. Today, however, we can talk about the predominance of coniferous forests. Special positions in the area of Novoveská Huta have mine heaps, acting as habitats with specific ecological conditions for vegetation. Biological reclamation was carried out in particular heaps under the revitalization, which included a cover of heaps by internal humus material and then sowing grass and planting trees.

Phytocenological investigation was conducted during the growing season of 2012 at six mine dumps after the exploration and production of U - Mo ores in the bearing field of Novoveská Huta (Fig. 1). On the research localities was performed a semi-quantitative analysis of present taxa on an area of $16m^2$. Frequency and cover of species population was determined by estimation based on the seven stage combined scale (5- cover of 75 to 100%, 4 - cover of 50 to 75%, 3 - cover of 25 to 50%, 2 - cover of 5 to 25%, 1 - under cover of 5%, + - cover of negligible, r – occasionally) by Braun – Blanquet (1964). Terminology is given in accordance with Marhold and Hindák (1998).

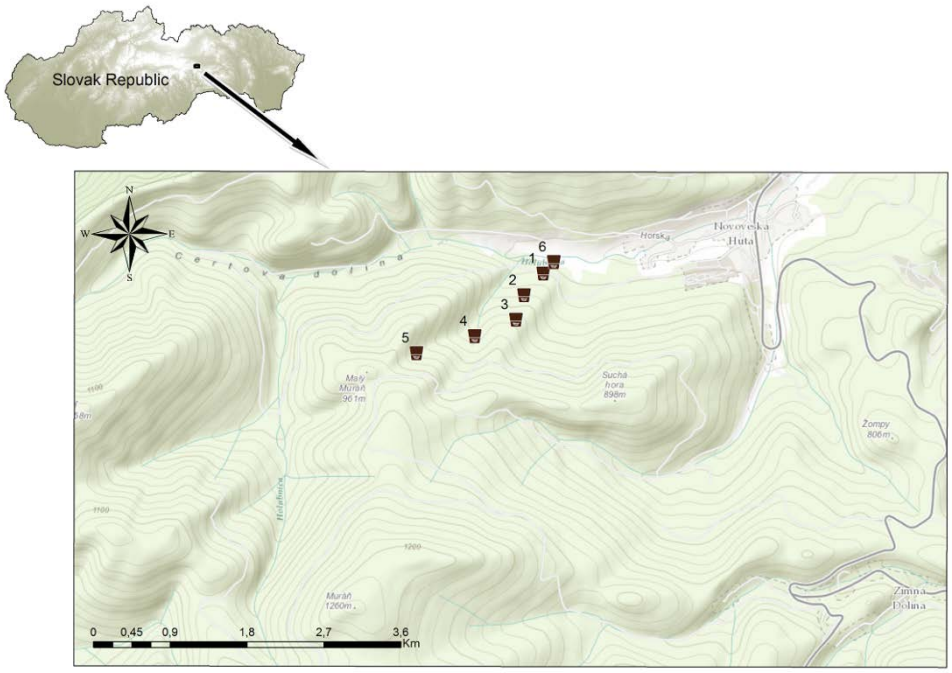

Fig. 1. Situation map of the bearing area of Novoveská Huta and research sites (1-6) on mining heaps

3. RESULTS AND DISCUSSION

Most plants are sensitive to the effects of the heavy metals (Ernst, et al., 2004). Some heavy metals, so-called bio-elements, for example copper, zinc, iron, manganese, molybdenum plants needs in small quantities. Larger concentrations of these heavy metals are toxic to plants. Lead, mercury, cadmium, silver and other heavy metals in minimal concentrations are significantly toxic to plants. Heavy metals are brought into the environment in the form of emissions from production processes in the processing of ores. Heaps from deep mining ores represent substrates with high content of heavy metals, as well as settling lagoons, and many other toxic waste dumps. They cause serious damage to vegetation, such as growth retardation, breathing difficulties, and reduced photosynthesis. Heavy metals entering the soil are often unavailable to plants. Part of these heavy metals may pass into biologically available forms for plants via various processes occurring in the soil. Soil parameters such as soil reaction and organic matter affect the availability of heavy metals to plants (Xian and Shokohifard, 1989, Otte, et al., 1993, Mandaokar, et al., 1994). Plant species resistant to higher concentrations of heavy metals was subject of interest of Banásová (2006), which describes a small group of plants – specialists, who tolerate such an environment. In the context of a particular plant species, the tolerant ecotypes evolve. Ecotypes tolerance is restricted to the limited number of heavy metals (usually one or two).

Ecotypes tolerant to heavy metals are created by some grasses, such as *Agrostis capillaris*, *Agrostis stolonifera*, *Festuca ovina*, *Festuca rubra*, *Anthoxanthum odoratum*. From herbs may be mentioned, for example *Calluna vulgaris*, *Rumex acetosella*, *Thlaspi cearulescens*, *Silene vulgaris*, *Melandrium rubrum*. According to Banášová (2006) plant individuals inhabit various depressions of the mine dumps, possibly those parts with high humidity and accumulations of raw humus. Characteristic is the presence of perennial plants, the occurrence of the annual and biennial plants is rare.

By Andráš (2008) a surface treatment of heaps morphology is essential if it is a large-capacity heap or heap with very irregular topography. Inappropriate adaptation procedure morphology heaps is now considered applanation (spreading waste heaps into larger area in order to reduce the height of heap), as it creates conditions for the water erosion of long slopes. For a more efficient procedure is considered stacking of heap, which is achieved by shortening the length of the fall lines, which significantly reduces the dynamic energy of the water stream. Bioremediation of mine waste heaps is associated with overlapping waste heaps with layer of soil and subsequent planting trees *Betula pendula*, *Picea abies* etc., and cultivation of grass mixtures. Utmost importance of vegetation cover of heaps lies in anti-erosion control. Bioremediation process has been mostly unsuccessful because layer of soil does not provide adequate amounts of nutrients for stable vegetation. The necrosis of

vegetation is caused also by capillary action of salts from the subsoil, which contains high concentrations of contaminants.

Overall, in the site of Novoveská Huta were identified 14 contaminated sites that relate to the former uranium activities. Natural radioactive radiation caused by the presence of uranium in the waste heaps can be considered the most important risk associated with the mining of uranium ores. High natural radiation makes the use of waste heaps for construction, road rash, etc. impossible, resulting in a long term environmental burden. For the purpose of the research the six heaps were described (Figure 1).

Heaps 1

Dump plateau and upper slopes is characterized by nearly continuous soil cover, which a pH is in the acidic category (5.3). Relatively diverse vegetation cover, which was planted within the restoration works, is particularly evident on the platform dump. To the planting conifers were included *Picea abies*, *Picea pungens* and *Larix decidua*. Dump slopes are characterized by a smaller coverage and they are mostly overgrown with deciduous and coniferous trees and shrubs (Table 1).

Heaps 2

Almost the entire surface of dump is superimposed with thin layer of soil cover with a thickness of 5-10 cm. Soil reaction is slightly acidic (5.6-6.5). Across the dump bank leads the way, which is composed of bare waste heaps without soil cover. Process of reclamation was carried out in the pile; which is related to vegetation cover. The most of it is covered with vegetation of young birch forest. *Abies alba*, white birch *Betula pendula* and European larch *Larix decidua* were planted in regular buckle almost on the entire surface of a pile. Grass vegetation consists of several species (Table 1).

Heaps 3

As part of the revitalization there was implemented flattening of the surface by cover of a humus layer (overlay topsoil - 2360 m^3). Soil cover is characterized by a slight thickness - up to 5 cm and covers the platform dump and local side slopes of dump (pH - acidic soils, 5.1-5.5). Soil cover is not present in the bulk of the side slopes. Biological reclamation represents 1.57 ha of forest area mostly coniferous trees *Abies alba, Picea abies* in a ratio of about 1:1 in a regular buckle. Grass vegetation is also evident. Side parts of the heap with a bare rock sections are characterized by vegetation of shrubs *Betula pendula, Picea abies* (Table 1).

Heaps 4

The treated surface of the pile was covered with topsoil with volume of 400 m^3 and subsequently there was planted the forest cover. Quarry area has undergone partial reclamation, resulting in a young birch - spruce vegetation, but it does not occur in the northern part of the quarry consisting of a dump. Atmospheric conditions caused local washout of soil, so the rock is exposed. Spillage from the pile bottom reached pH of 7.5-7.63. As a result of the cover strip the contact with radioactive material is possible. Characteristics of vegetation are given in table 1.

Heaps 5

Humic material, a volume of 1800 m^3 was adapted to the entire pile area with a thickness of 10-15 cm. Currently, continuous soil cover occurs only on the platform dump with the thickness of 3-6 cm (pH - slightly acidic soils). On the slopes of the dump is a tiny layer of soil, slope foot is without soil cover. Restoration work included the planting of vegetation, especially in the area of the plateau area of 1.8 hectares. Afforestation of the area was performed after the end of mining operations in 1991. The bulk of the area is represented by *Larix decidua* in almost regular buckle 2 to 2,5 meters, to a lesser extent there was realized the planting of *Abies alba* and *Betula pendula* (Table 1).

Heaps 6

Dump area is covered by a layer of fine-grained soil, containing no mineral fragments whose thickness ranges up to 6 cm (pH - acidic to slightly acidic soils). Dump plateau is overlapped with mosses, grasses and shrubs. The northern part of the mining dump represents the young forest vegetation with predominance of *Betula pendula* and *Alnus glutinosa*. Southern part of is covered by *Picea abies* (Table 1).

4. CONCLUSION

Novoveská Huta area, associated with rich mining history, is specific by occurrence of different types of minerals that have been mined in relatively different spatial and time dimensions. Subject of interest of mining activities were ore minerals (copper and iron), energy raw materials (uranium), non-metallic minerals (gypsum and anhydrite) and construction materials (Triassic limestone). Geological work centered on radioactive materials was conducted in bearing area Novoveská Huta with some pauses from 1948 to 1992. In those years were made surface and mining works, as well as research and technological work. After completion of mining works, the individual workings were continuously revitalized.

Table 1. Characteristics of vegetation on mine heaps in Novoveská Huta (Slovakia)

Tailings pile	Numbers of species	Species
1	10	*Larix decidua* 3, *Picea abies* 2, *Picea pungens* 1, *Pinus sylvestris* 1, *Fagus sylvatica* 1, *Alnus glutinosa* 1, *Abies alba* +, *Betula pendula* +, *Vaccinium myrtillus* +, *Agrostis capillaris* +.
2	6	*Abies alba* 3, *Betula pendula* 2, *Larix decidua* 2, *Agrostis capillaris* 1, *Poa pratensis* +, *Dactylis glomerata* +
3	6	*Abies alba* 3, *Picea abies* 3, *Alnus glutinoda* 1, *Salix caprea* 1 *Betula pendula* +, *Calamagrostis epigejos* +
4	7	*Picea abies* 3, *Betula pendula* 2, *Poa pratensis* 1, *Agrotis capillaris* 1, *Salix capraea* 1, *Ceratodon purpureus* +, *Leontodon hispidus* +
5	7	*Larix decidua* 3, *Vaccinium myrtillus* 1, *Abies alba* 1, *Betula pendula* 1, *Poa pratensis* 1, *Trifolium pratense* +, *Trifolium repens* +
6	7	*Betula pendula* 2, *Picea abies* 2, *Poa pratensis* 2, *Alnus glutinosa* 1, *Salix capraea* 1, *Agrotis capillaris* +, *Ceratodon purpureus* +

5- cover of 75 to 100%, 4 - cover of 50 to 75%, 3 - cover of 25 to 50%, 2 - cover of 5 to 25%, 1 - under cover of 5%, + - cover of negligible, r – occasionally

Mining heaps, which consist of diverse contaminated material from exploration and extraction of radioactive materials, with their chemical composition represents long-term negative impact on the surrounding environmental components. Moreover, they create significant morphological features, and interfere with the natural landscape, forest habitats and so on.

Phytocenological research of examined dumps after mining of uranium ores showed a relatively small number of species forming vegetation cover. In heaps dominated resistant species known from heaps with content of heavy metals eg. *Agrostis capillaris, Rumex acetosella* and trees planted within the restoration measures *Picea abies, Larix decidua, Abies alba*. Except planted species, also *Betula pendula, Populus tremula, Salix caprea* and others occur in tailings heaps. Conducted biological reclamation, within revitalization of workings minimizes negative impacts on the environment.

ACKNOWLEDGEMENT

The study was supported by VEGA 1/0627/12 Diversity, resiliency and health of ecosystems in different farming system and polluted territories in anthropogenic land and KEGA 012PU-4/2012 Preparation and realization of the research focused on creating teaching aids for education of environmental subject.

REFERENCES

Andráš, P. (2008) Geochemistry for environmentalists. Banská Bystrica: Univerzita Mateja Bela.

Bednárova L., Pacana A., Chovancova J. (2013) Environmental information as a key to solve a problem with polluted territories, in Proc. of International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, Albena, Bulgary, 16-22 June, Vol. 2, 2013, pp. 135-140.

Banásová, V. (1976) Vegetation copper and antimony heaps. Bratislava: Veda.

Banásová, V. (2006) Plants on mine waste. In: Development and evaluation of mining pollution. Bratislava: UK. pp. 56-61.

Braun-Blanquet, J. (1964) Pflanzensoziologie. Grundzüge der Vegetationskunde. 3. Edition Aufl. Springer Verlag. Wien.

Daniel, J., Mašlárová, I., Novotný, L. (2011) Spišská Nová Ves – Novoveská Huta – copper - uranium - sulphate. Mining and Geology in the file - history, present and prospects for mining waste. In: Development and evaluation of mining pollution. Spišská Nová Ves: Banícky spolok Spiš.

Ernst, W. H. O., Knolle, F., Kratz, S.,- Schnug, E. (2004) Aspects of ecotoxicology of heavy metals in the Harz region a quided excursion. In Landbauforschung Völkenrode. vol. 54, pp. 53 - 71.

Fľaková, R., Koškár, P., Ženišová, Z. (2005) Acidification of surface and groundwater in the ore strength Augustine (bearing Pezinok). In Groundwater. vol. 1, № 2, 2005, pp. 157–165.

Križány, I., Andráš, P. (2006) Heavy metals from waste dumps after the extraction and processing of 103 polymetallic ores in the area novovulkanitov Štiavnicke hills - the processes and products of weathering. In Mineralia Slovaca. 2006, vol. 38, № 4, pp. 283-302.

Lintnerová, O. (2002) Impact of mining on the environment. Bratislava: UK.

Mandaokar, S.S., Dharmadhikari, D. M., Dara, S.S. (1994). Retrieval of heavy metal ions from solution via ferritisation. In Environmental Pollution. vol. 83, 1994, pp. 277–282.

Marhold, K., Hindák, F. (eds.) (1998) Checklist of Non-Vascular and Vascular Plants of Slovakia Veda: Bratislava, 1998, 687 s.

Mazúr, E., Lukniš, M. (1986) Geomorphological subdivision SSR and ČSSR. Bratislava: SAV.

Otte, M. L., Haarsma, M. S. Broekman R.A. Rozema J. (1993) Relation between heavy metal concentrations in salt marsh plants and soil. In Environmental Pollution, vol. 82, 1993, pp. 13 - 22.

Petrík, J. (2005) Novoveská Huta. Spišská Nová Ves: Polygrafia.

Xian, X., Shokohifard, G. (1989) Effect of pH on chemical forms and plant availability of cadmium, zinc and lead in polluted soils. In Water Air Soil Pollut. vol. 45, 1989. p. 265–273.