GEOECOLOGICAL STRUCTURE OF THE DUMP OF TECHNOLOGICAL WASTE (FE – CONCENTRATE) AT SEREĎ

Eva MICHAELI[1], Martin BOLTIŽIAR[2], Monika IVANOVÁ [3]

Abstract : *The area of the Nickel smelting plant s. p. (NSP s. p.) in Sereď, situated at the borders of cadastral territories of Sereď and Dolná Streda (in the former region Galanta, where are 57 old environmental ballast loads), so-called brown park - brownfield, presents a highly negative phenomenon form environmental point of view, which impacts extremely depressingly in the countryside structure. This area is strongly degradated, scattered with old ecological ballast loads, which still have not been solved in complexity for 45 years. Apart from the small exceptions, they were left to the natural self-cleaning landscape ability. The situation is more important as it concerns the region with the oldest settlement of the lowland landscape in Slovakia with the most productive, highly and very productive agricultural landscape, which fulfilled mostly agrarian function. The soil ownership was the matter of basic substitence reliability, but all such values were denied by forming of socialism. The soil was not value after liquidation of the private ownership yet, and motivation to make an investment and put work into the soil was lost. According to the statement of the existing governmental configuration the region with a backward agricultural production was changed into a agricultural-industrial region with „ great perspective". Present state of the landscape structure and environment does not confirm this statement after 30 years of metallurgical industry existence. Degradation of the region is the result of the non-conceptual socialist industrialization of Slovakia with reference to the distibution of labour in former economic association of socialist countries in RVHP (Council for Mutual Economic Assistance – CMEAS).*

Key words: *technological waste, Nickel smelting plant, primary and secondary landscape structure, pollymetalic dust, anthropogenic sediments and relief form, Sereď*

INTRODUCTION

Construction of Czechoslovak plant for nickel production in Sereď was decided by the government resolution number 1735/56. The main reason was embargo of the capitalist countries to export nickel and its increasing consumption not only in Czechoslovak metallurgical and engineering industry. The construction of the plant started in 1959 and

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first nickel was produced in 1963. The main raw material began laterite iron-nickel ore which was imported from Albania. The building up of Nickel smelting plant was in the given period all-society contribution and impulse for the town Sereď and its surroundings development regarding infrastructure development, flat construction and new labour possibilities. It is understood, that interested did not consider the fact concerning the range of negative influences on environment of the town, its surroundings and the content of nickel, about 1 % in one tonne of imported ore. Manufacturing process in Nickel smelting plant in Sereď was stopped because of economic and ecological reasons in 1993 as it entered the liquidation which was finished on June 30th 1994.

METHODOLOGY

Methodology is oriented towards the research of the primay geoecological structure of the territory on the basis of the analysis of its individual components, further secondary landscape structure according to the corresponding categories of land use, where individual elements were identified by using the interpretation of colourful satellite orthophoto pictures from 2007 (pict.1) with high resolution. Digitalization of spatial data –individual elements were processed manually by method „on screen“ (directly on the PC screen) using software ArcView GIS 3.1 in scale 1: 3 000. Identified landscape elements were consequently categorized into purposefully arranged the legend according to their content characteristics. Obtained results were verified in the terrain research realized in 2008-2009.

STUDY AREA

The dump of technological waste is situated to the south of Sereď on the Váh flood-plain in the northest promontory of Danube plain, to the south-west of former Nickel smelting plant. It is bounded by railway Sereď – Galanta n.133 in the west, where steep dump slope formed by Fe-concentrate tower above. The south, east and north-east edge of the dump is similar.

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Fig. 1 *Satellite image of study area taken by LANDSAT in 2007.*

The dump material is overfloated and partially disrupted by present exploitation in the north and end practically at the level of the river Váh floodplain next to the siding rail, which is connected to the Nickel smelting plant objects in the west and joins the above mentioned railway. The dump is situated at the distance approximately 250 m to the important main road number 51 in the north, and in the east approximately 800 m to the road number 62.

CHARACTER OF THE PRIMARY LANDSCAPE STRUCTURE OF THE TERRITORY (PHYSICAL-GEOGRAPHICAL STRUCTURE)

Geological structure. Sereď town lies in the south end of Dolnovážska niva, which gradually continues into Danube plain. From tectonic point of view it is a dividing line of two neotectonic blocks with different moving tendency. (Maglay et al. 2005). The region at Sereď and to the north shows slightly positive vertical movement, the region to the south of the town shows slight neotectonic decrease (Maglay et al. 2005). These different moving tendencies reflect in different development of post-tertiary sediments and their forms. While in the northern parts there are developed terraces, to the south and south-west direction the post –tertiary sediments lie in superposition. The whole area is built by fluvial sediments of upper Pleistocene and Holocene discordantly bedded over Pliocene sediments of (Maglay et al. 2005). In the north they are developed in the coarseclastic

material, to the south they change into pelletic components with gravel locations (Maglay et al, 2005). They reach the thickness of 10 to 12 metres under the Fe-concentrate dump in the part of Dolnovážska flood-plain. Sediments of the upper Pleistocene present bottom accumulation in the Váh floodplain and they occur at the surface from under Holocene bottom land sediments only in artificially made gravel deposits at Dolná Streda (Maglay et al. 2005). Their thickness is variable within the limits 7 – 9 m, locally to 10 – 12 m. They are mostly covered incoherently with würm-holocene gravels, but mainly with Holocene flood-plain loams and sandy loams of aluvial flood-plain facies. Petrographical gravel structure of the Váh is polymict. There are dike quartzite, siliceous sandstone (34 – 50 %). The Váh flood-plain to the south from Sereď is made of the highest part of the middle complex of the Danube gravel series of upper Pleistocene. These are well selected and worked coarse sandy gravels and sands with thickness from 10 to 30 (Maglay et. al. 2005).

The last individual evolutional cycle of post-tertiaty sedimentation is presented by Holocene sediments. Substantial part of these sediments are clay-sandy, clay and flood loam sediments.Their thickness significantly varies (2 – 6 metres) due to recent vertical movements of the neotectonic blocks. Strata base is composed of gray flood-plain loams with concretion of $CaCO_3$ and clay sands (0.5 – 1.5 metres). On the strata base there was formed and retained significant dark gray to black humic horizon of decalcificated gley fluvisols – Gleyic Fluvisolswith high content of humus up to 17 – 19%, covered with upper holocene lithofacially undivided loams, which regarding their impermeability stimulate tense level of the ground water in some localities. The best developed is this soil horizon in the Váh floodplain, to the south of Sereď, where it reaches the thickness to 1 metre. It does not occur on the surface anywhere. (Maglay et. al. 2005). Supraincumbent layers are lithologically more variable, mostly flood-plain loams and humic clays sediments of flood-plain facies (0.5 – 2 m).

Regarding anthropogenic sediments there is a significant dump of technological waste –Fe-concentrate, which was originating at Nickel smelting plant s. p. during more than thirty years of its existence.. I t is a homogenuos formation from petrographic point of view. Fe-concentrate is granulometric very fine material, black colour, originated by grinding and washing Albanian laterite iron-nickel ore. The penetrantion of this mass is very high, so rainfall very quickly can reach to its down layers, big part is evaporated as Fe-concentrate absorbs sunshine intensivelly and overheats.

Relief. Regarding morphology the area is variable a little. The basic type of the relief is erosive-accumulating relief of fluvial plains. It is represented by the accumulation plain – flood-plain of Váh with minimal sloping, with the remains of the abandoned meanders and sandy aeolian dunes to the south of Dolná Streda. It was made gradually by depositing of young gravel layers, sand and floody sediments in the young tectonically decreasing morfostructure of the West Pannonian basin bordered with the pre-Post-Tertiary rille lines in the west and the east following by the young pre-Quternary faults in the direction northeast – southwest. It is bordered with the young pre-Quternary faults in the direction northwest – southeast. The most contrast forms of the relief are convex, concave and flat anthropogenic forms.The most remarkable of them is the dump of metallurgical technological waste – Fe-concentrate, which was originated by depositing on the Váh floodplain during the manufacturing process of nickel at Nickel smelting plant

in Sereď from 1963 to 1993. The dump contrasts sharply the accumulation plain area of the Váh flood-plain in vicinity. Its relative hight is about 30 metres in the south and in the west side, in the east and the northeast approximately 22 metres and in the north it is about 5 – 14 metres.The dump heel altitude ranges from 125.4 metres in the north to 123.4 metres in the south. According to the anthropogenic relief forms classification (Zapletal 1969, 1976, Lacika 1999, Hronček 2002) the Fe-concentrate dump is classified as industrial, matured, fireproof, surface, convex, accumulating, negative macroform. Its shape is partially terraced table with wide, slightly degraded surface which significantly predominates steep slopes of the dump (anthropogenic table). The biggest length of the dump is 750 metres and the width is 550 metres. It is slightly narrowed towards the top plain. The dump plan is the isosceles triangle .The dump area is 35 – 50 hectares according to the literature, recent area , according to our measurement is 27 hectares. Volume data does not correspond in the literature. (5.5 , 6.5, 8.5 mil. t, according to our calculation the dump volume was about 9.0 mil. t). Slope inclination of the dump is between 5 - 10° in the north and northeast and to 45° in the east, west and south.

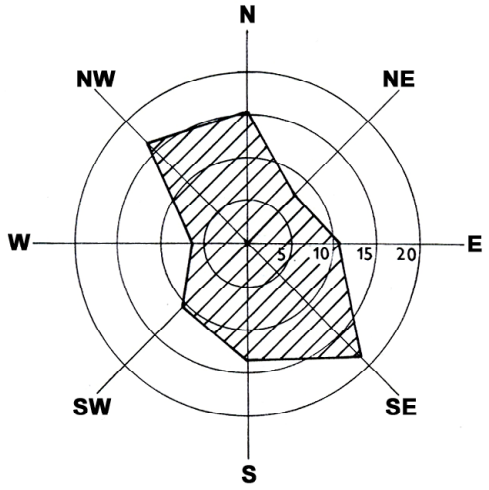
Fe-concentrate as a fine pelitic material is subject to recent fast natural erosive geomorphologic and anthropogenic processes as well. These ones change gradually the original shape of the dump, mostly at the places without vegetation cover, which presents the part of the plain and slope in the south and west side.

Regarding geomorphologic processes there are mostly following – slope rinsing, material creeping, deflation and anthropogenic processes, which accelerate all above mentioned. Gravitation component of moving is asserted here and dislocate Fe-concentrate parts in the direction of slope inclination. The same process is occuring on the dump plain, where is slower, especially on its slopes. The dump slope and its slightly leaning plain rinsing is done with rain water, melted snow water and sprinkling water. Water flows in thin threads over slopes and takes fine parts of Fe-concentrate. Both processes blend together. Creeping predominates in the upper part of the dump, rinsing intesity increases towards down parts. Rainfall water and sprinkling water concentrates gradually to the smaller or bigger streams in the direction of the biggest dump slope inclination and forms numbers of smaller and deeper (relief microforms) ditches and rilles in the fine material of Fe-concentrate. Their depth varies from 50 cm to 1 m on the dump slopes. They can be observed on the south and west slopes mostly. Their depth on the dump plain is about 30 – 40 cm. Surfaced material deposit at the dump heel in small cones. Deflation occurs on the dry, non-sprinkled and without vegetation overgrown dump body, mostly in the places, where the dump plain destroyed by mining process. Fine parts of Fe-concentrate are carried to the wide surroundings depending on the predominated wind circulation. The net of earth roads was originated on the dump for mining and transport purposes by anthropogenic activity (the dump owner mines Fe-concentrate for iron production).

Climate. The investigated area is in the warm climatic (Atlas of the Slovak republic countryside 2002, map 27). It lies in the bordery line of two climatic zones T1 and T2. T1 is a warm and very dry zone and T2 is warm and dry. Winter is very mild here with average temperature -3^0 C. This region reports a rainfall shortage from 100 to 150 mm per year. Total annual rainfall in Sereď is 550 mm, absolute monthly maximum is 200 mm, daily maximum is 70 mm. Average rainfall in July is 60 mm. Average annual air temperature is 9.5^0 C, average July temperature is 19^0 C. Average number of close weather days and

relatively low air humidity is from 20 to 30 per year. Average number of summer days is more than 60 per year. Average number of days with snow cover, which height is from 9 to 10 cm, is 40. Average number of foggy days si from 20 to 45 per year. The region is a significant number of sunshine hours, more than 2000 per year. The sunshine lasts 285 hours in average in July and 50 hours in December, during the vegetation period it is 1 450 hours. Predominated wind circulation is the southeast and the northwest wind (50.2 %). The region is aerated well, there is a dispersion of pollutants occured in the ground layers of the atmosphere, mostly by the wind systems of NW – SE direction (Graf. 1).

Graf. 1. *Wind direction and speed in study area.*



Waters. The region belongs to the river Váh (4-21-10) basin. The dump of technological Fe-concentrate waste lies between the river Váh and the brook Derňa. It is about 1 700 metres far from the river Váh and about 3 000 metres far from the brook Derňa. The last mentioned brook flows parallelly with the river Váh, approximately in the distance of 4 km from its river-bed. To the southwest direction from Dolná Streda the Váh river basin finishes in the water dam Kráľová. An annual average overflow of the Váh at Sereď is 152.6 $m^3.s^{-1}$. There is a rain-snow mode of the flow in the hilly-lowland region reaching maximum in February and and high wateriness in March and April and with minimum in September. An annual average specific flow is 1 l $.s^{-1}$ per km^2. The icy phenomena start to occur on the river Váh in the half of December and finish in the second decade of February in average .The area of the dam Kráľová is 12 km^2 and it influences the mode of the underground waters significantly. It prevents the region from flood waters sufficiently. The rest artificial water areas are placed in the localities of sands, gravel and clays exploitation at Sereď and Dolná Streda. The underground waters react to the river Váh mode. Their collectors are in the depth of 2 – 3.5 m under the surface. They are formed by infiltration of the river Váh water and partially by the damp penetration into the pre-Quaternary fluvial sediments. There is no occurence of common underground water springs or thermal or mineral waters.

Soils. Regarding the soil cover of the floodplain sediments in agraded mound of the river Váh there are Hapli – Gleyic Chernozems predominant. Calcaric fluvisols occur on the new Holocene floodplain sediments. Anthropo-Skeletic Leptosols, or technosoils (soil on anthropogenic substrates of technogenous origin) occur on the Fe-concentrate dump and in the area of Nickel plant itself. There are Urbi-Anthropic Regosols on the residential terrace of habitual area in Sereď and Dolná Streda, and Hortic Anthrosols occur in the gardens of houses vicinities . The soil reaction of Chernozems and Fluvisols is slightly or medium alcalic. Regarding granulosity they belong to the group of clayic and sandy-clayic soils. The humus contant ranges from 2.3 to 5 % (Šály 2000). Soils on technogenous substratum are not suitable for agrosystems. The dump surrounding is utilized agriculturally but soils in industrial Nickel smelting plant vicinity is soil chemically degraded.

Vegetation. According to the phytogeographic classification of the Slovak Republic territory (Futák 1972) the Sereď surrounding belongs to the region of Pannonicum flora, subregion of own Eupannonicum flora into the district of Danube lowland. Primary vegetation was formed by forest-steppe and steppe phytocoenose , however, dominant were phytocoenose of lowlands and phytocoenose of soft willow-poplar forests along the river Váh.There were formed oak-hornbeam Pannonian forests over the agrading mound of the Váh.

Danube lowland has changed into cultural steppe and plenty of primary specieses lost their stands. The largest areas are taken by arable land , small area of meadows occur in the wettest places. Permanent vineyards can be found in smaller areas to the east from Sereď and to the south from Dolná Streda. Forest communities have been kept in the form of game refuges. Bushes occur sporadically, ruderal and synantropic communities occur often. The dump of technological waste Fe-concentrate shows specific vegetation, which is classified as metahemerobic vegetation with minimal biogeneous processes (Jurko 1990) on the areas of toxic and industrial waste from hemeroby (vegetation authenticity) point of view. Polyhemerobic to metahemerobic type of vegetation can be observed in inhabited terraces and industrial areas. Euhemerobic type of vegetation occurs in vineyards, gardens, fruit orchards and in arable land (Jurko 1990). No protected area or protected zone interfere the locality directly. Regarding nature protection from types point of view, no permanent occurence of protected plants or animals was noted. The coeficiet of ecological stability is low, up to 0.2 in the cadastral regions of Sereď and Dolná Streda.

Animals of the given territory belong to the region of Danube lowland, into its West Pannonian basin province with very significant steppe and forest-steppe fauna character, which most of varieties were decimated by agrarian and industrial activity. Corridors for animal migration, regarding industrial and agricultural utilization, are not observed in this locality. A *Lepus europaeus, Capreolus capreolus*, *Phasianus colchicus,* predator as *Buteo buteo*, that was able to adjust to intensivelly utilized agricultural landscape and reaches high density also in such conditions, live in the broader dump surroundings. Regarding the *Molusca* occurence there are plenty of sniles like *Helix pomatia* and *Xerolenta obvia*.

The region is utilized polyfunctionally (industry, agriculture, inhabiting, transport). It is represented by geoecologic countryside type of the intermountanious lowland countryside of temperate zone (Mazúr, Krippel, Porubský, Tarábek 1980) localized on the flood-plain of the Váh, strongly modified by industrial activities. The dump locality in the south and partially in the east interferes the arable land of Sereď and Dolná Streda cadastral region

with open relief of accumulation plains with good visibility, without any obstacles in the terrain. The dump itself presents significant anthropogenic barrier. The surroundig of the dump is utilized above average with significant disruption of natural values.

CHARACTER OF THE SECONDARY LANDSCAPE STRUCTURE

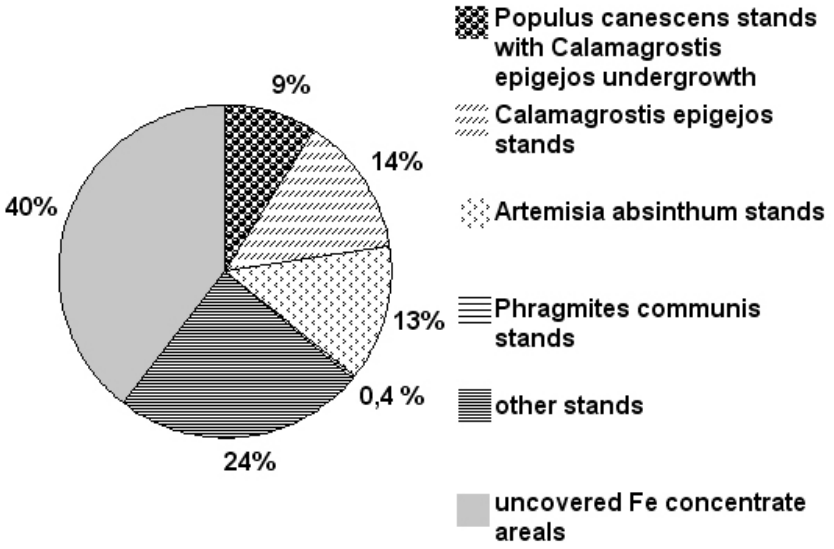
More detailed map of the secondary landscape structure (SLS) of the territory under investigation has not been elaborated yet. Mapping SLS was done, inter alia, for purposes of substantial and detailed analysis of given landscape space. Recent studies solved only partial problems in frame of the broader area, however, to know the present day dump condition of SLS, as its significant influence to the life quality in the region, is consider as very important. SLS map presents relevant basic document for further landscape characteristics evaluations (e.g. evaluation of vulnerability, heterogenity, evaluation of landscape changes and their prediction etc.) and preparation for territorial planning documentations as well. According Ružička (2000) there were identified almost 200 landscape elements of the territory under investigation and regarding the specific character of the region, these were classified into 6 undergroups and 3 groups (table 1):

1. Group of forest and non-forest vegetation elements
   1.1. *Populus canescens* stands with *Calamagrostis epigejos* undergrowth
2. Group of tallus-herbaceous stands elements
   2.1. *Calamagrostis epigejos* stands
   2.2. *Artemisia absinthum* stands
   2.3. *Phragmites communis* stands
   2.4. other stands
3. Group of uncovered substrate elements
   3.1. uncovered Fe concentrate areals

Tab. 1 *Landscape elements area and number of patches in 2009.*

Landscape elements	**area in ha**	**number of patches**
Populus canescens stands with *Calamagrostis epigejos* undergrowth	2,5	117
Calamagrostis epigejos stands	3,8	21
Artemisia absinthum stands	3,7	1
Phragmites communis stands	0,1	1
other stands	6,8	17
uncovered Fe concentrate areals	11	32
Total	**28**	**189**

Graf. 2 *Landscape elements proportion of study area in %*

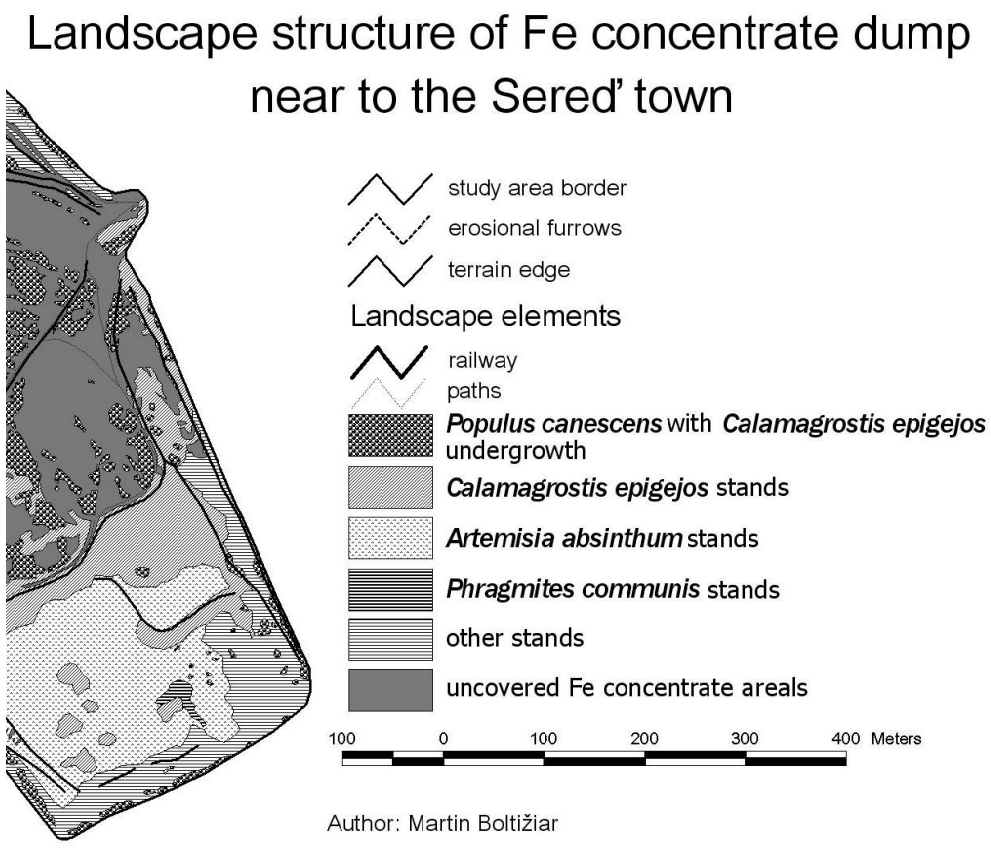


Analyzing visual (map 1, graph 2) and followingly statistic (table 1, graph 2) thematic SLS map, created by ourselves, depicting the territory under investigation and analyzing knowledge received during the field investigation it was found out, that the region is formed by 189 areas of landscape elements, which are further characterized in more details regarding their content and spatial expansion.

Regarding the area of individual units of landscape elements the biggest share is presented by grass vegetation. The dump vegetation presents completely new specific type. Its variety composition is not similar to any overgrown occuring at the similar stands of another dumps (Banásová, Hajdúk, 1984). The highest number of plant varieties grows from its foothill to the height approximately 2 metres. Fe-concentrate is thinner in these parts to the excavated and imported soil and gravel-sands, which made a dam during tank building for Fe-concentrate in the past. Increased seeds transport from nearby fields and specific microclime of this contact zone have a big contribution for the overgrown at the slope basis. Total overgrow is 60-80 % here and and varieties show higher abundance and dominance. Plants with taproots, where are e.g. hoary cress, *Cardaria draba*, *Carduus acanthoides* and *Convolvulus arvensis*. There are another ruderal varieties as *Agropyrum repens*, *Reseda lute*a and mainly wormwood *Artemisia absinthum* above this margin. *Bromus inermis, Cynodon dactylon,* and *Arrhenatherum elatius* occur there as well.

Vegetation, concentrated into clusters, occurs sporadically in the upper parts of the slopes, which are formed by pure Fe-concentrate. Vegetation can be seen in the small cavities mostly in the oldest dump parts. Regardingthe area, they occur only in very little places as species monotonous incoherent. There can be found grasses as *Dactylis glomerata*, *Poa pratensis, Festuca rubra* which occur on pure Fe-concentrate as relics after unsuccessful hydro-seeding by Rašelinové plants during 1976-1978 and in 1980.

Map 1. *Landscape structure of the Fe-concentrate dump.*



The two last mentioned species grow scattered, they do not form inflorescence and dikes. The most vital species with relatively high seed germinative activity (78 %) is *Dactylis glomerata* as was confirmed by research experiments realized in the past (Banásová, Hajdúk, 1977, 1984).

Among the plants of spontaneous succession there are following plants occuring predominantly on the pure Fe-concentrate spotted *Centaurea stoeb*, which grows mostly on the foothill *Carduus acanthoides* and *Salsola kali*. The occurence of this variety was noticed also on the asbestos dumps in Dobšiná (Banásová, 1970).

Tree vegetation is presented mostly by *Populus canescens*, which forms scattered overgrow mainly in upper horizontal positions in the central and south parts of the dump, its undergrow is formed mostly by *Calamagrostis epigejos*, which forms wide overgrow as regards the area mostly in the terrain edge towards the east, where the slope lower. Other species are sporadically presened by *Prunus spinosa*, *Crataegus monogyna*, *Pinus sylvestris* and bush representant *Rosa canina*.

The big part of the southeast dump part is covered with herbaceous-grass vegetation presented by monocenosis of *Artemisia absinthum*, which also represnts significant allergen together wiht another species occuring in the dump.Close to the east margin of the dump there is a smaller shallow depression fulled with water and overgrow of *Phragmites communis*. *Uncovered Fe-concentrate areals (no overgrown with vegetation*) take more than 7 ha of the dump area,which presents 40 % of its total area.

THE DUMP INFLUENCE UPON ENVIRONMENT

The Nickel smelting plant s.p.Sereď was processing in hydrometallurgic way (Carron) Albanian laterized iron-nickel ore during the plant existence since 1963. The principle of this process was to change nickel and cobalt into their soluble form and then lime them in the selective liming solution, and the rest of the ore left the process in the form of mud. There were made 3 000 t of nickel in the form of metal and salt, 60 t of cobalt in the form of metal per year and the waste was made of 300 000 t reduced ore – Fe-concentrate. 2 800 t of ammonia, 1 200 t Na_2S, 144 t Na_2SO_4, 611 t HCl, 1013 t H_2SO_4 were used at process per year. Detailed chemical-technological research of Fe-concentrate at Sereď has shown, that material contains about 50 to 80 % of iron, 2.5 – 3.5 % Cr_2O_3, 6 – 8 % SiO_2, 6 – 8 % Al_2O_3, 2.5 – 3.5 % CaO, 0.6 – 0.18 % P_2O_3, 0.28 – 0.3 % Ni (Kalebáč, Souček, Had 1987). Fe-concentrate presents medium rich waste, which is with its iron content close to iron ore used for batch into the blast furnace. Problematic is, however, high level of chrome and Fe-concentrate texture, which restrict its wider utilization in metallurgy (Koudelka, Drabina, Vítek, Schmidt, Benoni, 1985). The concentrate, processed into pelets in 1984, was used for chrome iron production , where was 96% of chrome reduced into raw iron. The next attempt for pellet production consisting of 62 % Fe-concentrate , 22.6 % sinter ore from Krivoj rog and 15.3 % dolomite as batch into the blast furnace did not bring expected results. According to Kalebáč, Souček, Had (1987) the processing of given material would not be effective (high energy consumption and forming of new waste, low sale of chrome iron).There was processed 146 968 t of Fe-concentrate in Czechoslovak metallurgic industry during period of 1985 – 1987, which did not presented a half of its annual supply to the dump.The evaluation of the smelting resuls shows the use of Fe-concentre in one ton of fusing iron maximum to the weight of 50 kg, in which the

quality of produced steel would be without the change, that is very low need regarding the material amount in the dump (Kalebáč, Souček, Had 1987).

The utilization of Fe-concentrate for ferochromium is is not real, according to the information of Orava feroalloy plants in Istebné, because it does not contain the sufficient amount of chromium. The high contentent of Si and Al oxids causes the increased production of slag and increases the electricity consumption. (Kalebáč, Souček, Had 1987).

Fe-cnocentrate offtaking for building material indutry, as cement additive was stopped, because it contains chromium remnants, which is non – permissible as additive into building materials according the European legislation. It is used for brown coal washing process only in non-significant amount, but it is not suitable for all coal cleaning plants.

The dump presents a kind of anthropogenic bearing at present. Present owner of the dump, Ferroport company Bratislava, exploits Fe-concentrate as a raw material, obtaining iron from it. Conditions of Fe-concentrate exploitation are given by District Environmental Office in Galanta. Environmental effect of the company approach is mainly in old ecological ballast disposal, although very slowly and with a risk of air polluting by polymetallic dust from exploiting areas. Regarding exploitation safety point of view there does not occure sinking of exploiting mechanisms. Fe-concentrate was transported to the dump hydraulically, but gradually it was disposed of liquid component – transporting medium – by percolation to the Váh floodplain and partially by the evaporation.

According to the environmental regionalization of the Slovak Republic by the Department of the Environment (2008) the territory after investigation belongs to strongly disturbed environs according to the environmental quality. The problem is more important as there occured unsuitable fusion of landscape potential for agricultural production with metallurgy of non-ferrous metals and urbanization process. The most important environmental problem concerning the Sereď surroundings (except another phenomena) is old environmental ballast load, althouhg nickel and cobalt production was stopped. The dump of Fe-concebtrate, which still influences environment actively, causes significant ecological problems in the Sereď surroungings at present days.

The pollution of base rocks, underground waters, soils and in connection with wind system acceleration, as well, air pollution was noticed during Nickel smelting plant operation. The pollution continues at present days in the area of processing simplex itself (area 60 – 70 ha), at the dump of Fe-concentrate, and in the rest of accessoric premises of former Nickel smelting plants and in their vicinity.

As regards georelief point of view , there is a lowland scenery and the dump, with its physiognomic shape, affects as significantly allochthonous, barrier element – convex form of the relief, which form the integration into the country point of view, as results from many suggested solutions, but mainly regarding the length of a human life, could be considered as incontrovertible phenomenon. There is another consecutive ecological balast load in the territory under investigation and its mutual interconnection – territorial interlock, shows significant contribution to landscape structure devaluation, e.g. the area of the industrial plant, where the basement has not been investigated as regards its influence to the subbase, water and soil.

The dump of metallurgical technological waste in approximately of 6.5 – 8.5 million tons at the area of 27 hectares was forming during 30 years of manufacturing process in the

floodplains of the river Váh. As to granulometry this is very fine-grained material, where 97% form elements smaller than 0,1 mm (contains a large amount of iron and ist oxids, nickel remnants, cobalt and NH_4+ and another alloys). Fe-concentrate from the beginning of it depositing in 1963 till present days has been the source of the secondary dustiness – escape of the polymetallic dust into the air. This wast must be kept at a certain level of humidity to avoid its spreading to the surroundings during stronger wind circulation and while it is manipulated (e.g. during mining). Fe-concentrate areas, which are not covered , and where the vegetation was not able to spread itself by spontaneous succession not even during decennaries in order to avoid spreading of the toxic dust into the surroundings, present nowadays serious problem concerning the life quality in the region. During dry weather and strong gust wind the dump is a significant emitter of dustiness, which influence was observed and still is mostly in the south part of Sereď and in Dolná Streda, in spite of sprinkling the dump body with water.To avoid spreading of polymetallic dust, regarding the transporting medium (air) is practically impossible. At present it is carried mainly from the parts of the dump, which are not overgrown by vegetation (annual compensation by Ferroport company 20 000 Sk for Sereď, Dolná Streda is without compesation). Emissions are presented at meso and mainly at microclimatic level. The final result is resedimentation of the polymetallic dust on the soil cover, water and settled areas of the region and on the vegetation. There is no monitoring station dealing with air pollution observation in the given locality so data concerning secondary dustiness and another emissions are missing.

The worst water quality occurs in the river Váh at Sereď, according to the long-lasting observations of the state observing net. The main source of the pollution is industry, agricultural production, municipal water waste and ecological ballast produced by nickel production. Water contamination was conditioned by industrial technological and sewages releasing until the munufacturing finish in 1993, without any cleaning to the waste dump and directly to the inundation area of the river Váh, where it penentrated or passed the system of abandoned meanders and artificially formed dredging basins and directly to the river.The river pollution occured in the underground water quality, where increased content of heavy metals, nitrogen, chloride and disulphate compounds were measured. Indication drillholes for underground water quality investigation were built in the dump vicinity in 1990 (after 27 years of Nickel smelting plant manufacturing). Results of sample analysis showed unsuitable quality of the underground waters. High concentration of disulphates, ammonium ions, nitrates and nitrites exceeded border limit of the state standards. Their content showed increasing tendency. Harmful pollutants concentration presented emergency pollution of underground water in the dump vicinity and also near another objects of Nickel smelting plant – historical pollution of underground waters (Klaučo, Filová, Kovařík 1998). This pollution is hard to classify as emergency, as it was a continuous process lasting 30 years during activity of Nickel smelting plant and there was nobody to pay attention to it. Finally, in 1990 on the basis of underground water samples analysis showing its pollution, an expert team was created. This team recommended Nickel smelting plant to accept particular arrangements for underground water protection in given locality: to elaborate a project so called hydraulic screen and removal pumping and cleaning water mouthing to the Váh.

On July 1st 1993 started liquidation process of Nickel smelting plant s.p. in Sereď. Liquidator ensured to elaborate final report and expertise study by December 1993. The

aim of the expertise was to state, on the basis of available materials, the condition and extension of pollution of the environment in wider vicinity of NSP s.p. Sereď and design the relation to the above mentioned removal and protective, unfortunately, not realized arrangements.

The District Environmental Office in Sereď issued a resolution in 1993, and stated compulsory special conditions for the dump operator regarding the law, according to which a project of the Fe-concentrate dump recultivation should be elaborated, ensured this process and observe the influence to the environment for 50 years after finishing the unloading. To avoid unloading of another companies in its area, that means to ensure closing of the approach roads and their checking and do not allow new enterprise subjects any activities which could lead to the wet processes, consequently which could lead to the forming of sewerage industrial waters without building of sewerage plant (ČOV) for particular typ of sewerage waters. To ensure possible customer for Fe-concentrate utilization and observe the dump influence upon underground waters. Until recultivation dump period ensure water sprinkling of the dump, as a protection against deflation and ensure the protection of underground waters in the dump surroundings. The liquidater of s.p. NSP stated, that these tasks, dealing with environmental protection, will be transmitted to succession enterprise subjects. Company ABH – BEL s.r.o. Bratislava, which bought the Fe-concentrate dump, introduced the suggestion of the dump removal and its biological recultivation in 1994. All responsibilities , resulting from arrangements for former s.p. Nickel smelting plant Sereď in 1990, should be assumed, but the company did not agree with taking responsibility. NSP s.p. offered 2 millions Sk for covering the Fe-concentrate dump and settled obligation 11 millions Sk to environment. All attemps of NSP s.p. Sereď led to the cancellation of the arrangements stated by DEO in Sereď.

In 1994 an expertise study to evaluate the quality and prognosis of underground water in wider vicinity of dump was elaborated and also a suggestion to protect the territory at s.p. NSP SKOV – Bratislava (Klaučo 1994). The first areal photo of underground water quality concerning former production of Nickel smelting plant was taken in the same year. The study states pollution decrease in the area of source depending on stopping production of smelting plant, in spite of it, the content of ammonium iones in the dump vicinity exceeds several times allowed limit concetration. Underground water flow caused tearing off „polluted water cloud“ from the source area and proceeded towards the southeast, west and southwest to the distance of more than 1000 m to the inundation area of Derňa. The next factor is adulteration of pollution concentration by the river Váh water or water of the water dam Kráľová. The colmatage of the dump subbase and its body is reported by the authors at the Fe-concentrate dump. At the end of the study it is stated that to build sealing underground wall, or hydraulic screen round the dump would be unreal and too expensive regarding the contaminant dispersion into the wide surroundings of evident sources of pollution. The suggestion to use this water after suitable adulteration for watering is considered as extremely inadequate. To build a canal or another melioration measure, which could avoid the penentration of contamined waters towards from Sereď to Dolná Streda, Váhovce, Gáň, Galanta and Veľká Mača is not real because of slight slope of of the territory, agraded mound of the Váh, protective dikes, soil engagement, high costs of investment and operating costs (Klaučo 1994).

Areal and concetration decrease of ammonium pollution mainly in dump occured in 1997. The highest concetrations of ammonium iones are on surface of the watered layer. After 30 year, so in 2027 it will be possible to expect gradual penentration of polluted, but dilluted underground water into the Derňa water stream. The final average ammonium ions concetration in the creek would range about 2.07 mg. l^{-1}. The period of increased ammonium ions concetrations was estimated for approximately 10 years by the authors. Concentrations should gradually fade by natural dillution after this period.For this purpose the water stream basin of the Derňa is necessary to clean and operating buildings make functional.

Resulting from the suggested solution, the pollution of underground and surface waters was left to its natural elimination by dispersing and diffusive processes without artificial hydraulic influence of underground waters flow.The realization of this solution is not possible without systematic monitoring and finishing to build observation net in the line of supposed movement of the pollution.

The territory does not belong to the water management protected areas, there are not any active collectors of underground waters suitable for supplying of inhabitants, but it does not mean that they can be wasted and ignore their pollution. Water does not serve only for population supply. Their function is irreplaceable in frame of the country structure. 100 % defective samples regarding physical-chemical water pollution results from the investigation of water quality in natural bathing areas (gravel deposits and abandoned meanders). There is V.degree of cleanliness (very strongly polluted water) according to the micropollutants pollution of the river Váh at Sereď. At present days the severage waters are emitted to the Váh by subjects , which settled in the former Nickel smelting plant after 1994 , without sewerage plant (ČOV). The amount of the sewerage industrial waters decreased and thereby pollution of surface and underground waters by risk elements was partially limited.The dump was formed on floodplain sediments without isolation against subbase, that is why risk elements under its bottom and at the edges migrate into the soil, geological subbase and waters, in spite of supposed colmatage of the dump bottom with pelitic material of Fe-concentrate (Klaučo 1994).

Agricultural landscape and soils under permanent cultures in near south, southwest and northwest Sereď and Dolná Streda vicinity were and are highly influenced by industrial activities, agriculture and old ecological balast. The river Váh waters are significantly polluted at Sereď, in spite of it they have a function of an irrigation source. Large irrigation equipment influence the soil profiles secondary by clogging and diffusion of contained contaminants (cumulation effect – risk elements deposition in the soil).

According to the findings of National Health Department in Galanta, the content of the risk elements in the soils cover near Sereď is below the high allowed concetration but for example, the nickel content is 7 – 8 times higher than its phon values in the surroundings of Trenčín. It is estimated, that the agricultural landscape acreage, which is affected with pollutant emission influence, presents in the territory under investigation the area approximately 1500 ha. Deflation of the dump material significantly participates at this state.

Primary agroclimatic conditions of the region indicate the development of present modern directions of ecological agriculture, but soil contamination and general devastation of the region exclude such trends.

CONCLUSION

The presented contribution was focused on the character of the original physical-geographical structure of the landscape, which was significantly disrupted by anthropogenic activity and on the detailed characteristics of escondary landscape structure of the territory. The special attention was given mainly to floristic composition of vegetational communities on the Fe-concentrate dump. Physical and chemical Fe-concentrate characteristics preconditioned origin and development of a very specific ecosystem, which cannot be found in any natural landscape and these factors also significantly influence organization of individual landscape elements. More than a half of the dump is covered by herbaceous-grass formations of larger monocenosis of wood small-reed *(Calamagrostis epigejos) and* wormwood, green ginger *(Artemisia absinthum)*. The tree vegetation is presented mostly by gray poplar *(Populus canenscens)*, which grow it the highest places of the dump. 40% of the dump area take uncovered material.

There were several directions in liquidation solution of the Fe-concentrate dump at Sereď: to use Fe-concentrateas a material Cor-Ten steel production, for production of oxide pellets, for direct batch into the blast furnace, the dump recultivation (searching the possibilities of the dump recultivation, the experimental investigation to find out grow abililities of chosen grass varieties on this toxic waste was realized and the most perspective grass varieties were accepted for seeding the dump, Banásová, Hajdúk, 1984), the dump irrigation , building of green polyfunctional zone in its vicinity, using Fe-concentrate in cement factories, for brown coal washing process. Project documentation was elaborated for each of these Fe-concentrate removal form, but except monitoring sound of the underground water pollution, partial recultivation of the dump and Fe-concentrate exploitation for metallurgical industry, all these suggestions remains on the level of projects and pollution elimination, mainly of underground and surface waters, was left to the self-cleaning ability of natural structure. All mentioned form of dump liquidation were, and still are ineffective and process of its liquidation is very slow. At present rate of Fe-concentrate exploitation and export (company Ferroport), according to the estimation of environment department workers in Sereď , it is possible to liquidate the dump in approximately 600 years. The environment devastation of the given region, caused by old ballast loads, presents a key problem for foreign investors to enter this area and it is an obstruction to modern trends in agriculture development. This region is utilized above average with sigificant disruption of the natural structures. The region belongs among unstable regions with low quality of environment.

Resulting from this investigation, the issue concerning environment conservation was necessary to solve „ex ante“ at the premise building, not „post factum“ that is after 27 or 30 years of s.p. Nickel smelting plant full operation and with a scenario which is significantly pessimistic for the landscape, hence relying on the self-cleaning ability of the landscape. To finish the nickel and cobalt production in NSP s.p. meant the decay of the main source of contamination, but the pollution definetely does not decay itself, it still persists.

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GEOEKOLOGICKÁ ŠTRUKTÚRA HALDY TEHNOLOGICKÉHO ODPADU LÚŽENCA PRI SEREDI

Zhrnutie

V príspevku sme sa zamerali na charakter pôvodnej fyzickogeografickej štruktúry krajiny, ktorá bola vo veľkej miere narušená antropogénnou činnosťou ako aj na podrobnejšiu charakteristiku druhotnej krajinnej štruktúry skúmaného územia, pričom zvláštnu pozornosť sme venovali najmä floristickému zloženiu rastlinnych spoločenstiev na halde lúženca. Fyzikálne i chemické vlastnosti lúženca podmienili vznik a vývoj veľmi špecifického ekosystému, ktorý nemá v prírodnej krajine obdobu, pričom tieto faktory výrazne ovplyvňujú aj usporiadanie jednotlivých krajinných prvkov. Viac ako polovicu haldy pokrýva vegetácia zastúpená bylinnotrávnymi formáciami rozsiahlejších monocenóz *Calamagrostis epigejos* a *Artemisia absinthum*. Stromová vegetácia je zastúpená najmä *Populus canenscens*, ktoré porastajú najvyššie položené miesta haldy. Odkrytý materiál lúženca zaberá 40 % rozlohy haldy.

Riešenie likvidácie haldy lúženca pri Seredi sa uberalo niekoľkými smermi: využitie lúženca ako materiálu pre výrobu nízkolegovaných ocelí, pre výrobu oxidických peliet, pre priame vsádzkovanie do vysokých pecí, rekultivácia haldy, zavlažovanie haldy, vybudovanie zelenej polyfunkčnej zóny v jej okolí, využitie lúženca v cementárňach a pri prepieraní hnedého uhlia. Pre všetky tieto formy sanácie lúženca bola vypracovaná projektová dokumentácia, ale okrem monitorovacích sond znečistenia podzemných vôd, čiastočnej rekultivácie skládky a ťažby lúženca pre hutnícky priemysel, všetky návrhy ostali na úrovni projektov a eliminácia znečistenia, najmä podzemných a povrchových vôd, bola ponechaná na samočistiacu schopnosť prírodných štruktúr. Uvedené formy likvidácie haldy lúženca boli a sú z aspektu množstva lúženca neúčinné a proces jeho likvidácie je veľmi pomalý. Pri súčasnom tempe ťažby a exportu lúženca (spoločnosť Ferroport), podľa odhadov pracovníkov oddelenia životného prostredia v Seredi je možné haldu zlikvidovať zhruba až za 600 rokov. Znehodnotenie životného prostredia starými environmentálnymi záťažami v predmetnom regióne predstavuje v súčasnosti kľúčový problém pri vstupe zahraničných investorov do tohto priestoru a je brzdou rozvoja moderných trendov v poľnohospodárstve.

Z toho vyplýva, že otázky ochrany životného prostredia bolo potrebné riešiť „ex ante“ pri výstavbe závodu, nie „post factum“ teda po 27 až 30 rokoch plnej prevádzky š. p. Niklovej huty a to variantom, ktorý je značne pesimistický, teda ponechaním na samočistiacu schopnosť krajiny. Ukončením výroby niklu a kobaltu v NHS š. p. zanikol síce hlavný zdroj kontaminácie, ale znečistenie určite nezanikne samo, pretrváva.

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