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EXPLOITATION AND USE BROWN COAL FROM NOVÁKY DEPOSIT AND ITS ENVIRONMENTAL IMPACT

Summary. Influence of exploitation and ulilization of Tertiary brown coal deposit Novaky in Horna Nitra region (Slovakia) on the natural environment was presented. The region has been subjected to a long-term deterioration (of soils, water and air) caused by excessive concentration of coal mine, energetic and chemical industry. Data characterising industrial activity and natural environment has been related to main ways of economical-social development of the region.

WPŁYW EKSPLOATACJI I UŻYTKOWANIA WĘGLI BRUNATNYCH ZŁOŻA NOVAKÝ (SŁOWACJA) NA ŚRODOWISKO NATURALNE

Streszczenie. Przedstawiono wpływ eksploatacji i użytkowania trzeciorzędowych węgli brunatnych złoża Novaky na środowisko w regionie Horna Nitra (Słowacja). Region ten poddawany jest długotrwałej deterioracji (gleb, wody, powietrza) spowodowanej nadmierną koncentracją przemysłu górniczego, energetycznego, chemicznego. Dane charakteryzujące działalność przemysłową oraz środowisko naturalne skojarzono z głównymi kierunkami ekonomiczno-społecznego rozwoju regionu.

Introduction

Handlovsko-novácka pánva (the coal basin of Handlovská-Nováky) is located in the territory of Horná Nitra (Upper Nitra) region that belongs to the basin's of medium height degree with expressive territorial geomorphology. From the hydrological view the territory belongs to Nitra River catchment, and most significant tributary is Handlovka River. In neighbourhood of the county city Prievidza there is thermal spa Bojnice of national

significance. The Horná Nitra Region is typical with industrialisation of high degree, dominant are particularly mining, energetic and chemical industries, respectively. Long-term industrial activities of the region caused environment deterioration - of soils, water and atmosphere. Therefore the Upper Nitra territory was within Slovakia environmental politics included to the category "hot spot regions" with accent on immediate landscape revitalisation.

Geology of the Handlová-Nováky coal basin

Brown coal of Nováky is a part of the Handlová-nováky coal basin. It is located in Central Slovakia and it belongs to the intramountainous basins of Western Carpathians. The deposit is most significant brown coal resource in Slovakia.

The basin deep underlying bed consists of crystalline complex and rocks of Choč and Krížna nappies and melaphyre series. This is followed with sedimentation cycle of the Subtatra Group of Central Carpathian paleogene. It is represented with mudstone, flysch and sandstone lithofacia. The Paleogene upper part is missing due to denudation. Mainly in northern part there are on denuded Paleogene sediments deposited rocks of the botton-myocene sediment cycle (eggenburgien).

The basin Neogene sedimentation filling has begun in Baden with stony group of beds that is representing immediate underlying productive layers. It is formed with alternating positions of epiclastic volcanic conglomerates and sandstones with irregular to lentil-formed bedding.

Productive layers are represented with group of beds of (Sarmatien) Nováky and Handlová, respectively. In principle there is developed one coal seam that in Handlová part is divided in two coal seams, while in the part of Nováky, there is exploited so called main coal seam, with thickness approximately 10 m (Petrik - Verbich, 1995). The coal seams are autochtone and they often comprise tuffitic and clay coal sheds. The coal seams in the part of the Handlová have complicated tectonic structure, while in the deposit of Nováky there is overwhelming germanotypic structure (Petrik - Šimeček, 1988). The tectonic faults general direction is N-S with turning NE-SW direction, only in the coal deposit of Nováky northern part is the direction of tectonic faults NW-SE.

Productive overlying rocks is built up of clays and marl clays group beds of Koš that in Nováky deposit territory comprises diatomitic clay attitudes. In higher overlying rocks there is deposited so called detritic-volcanic formation: rock group of Lehota. In the space of

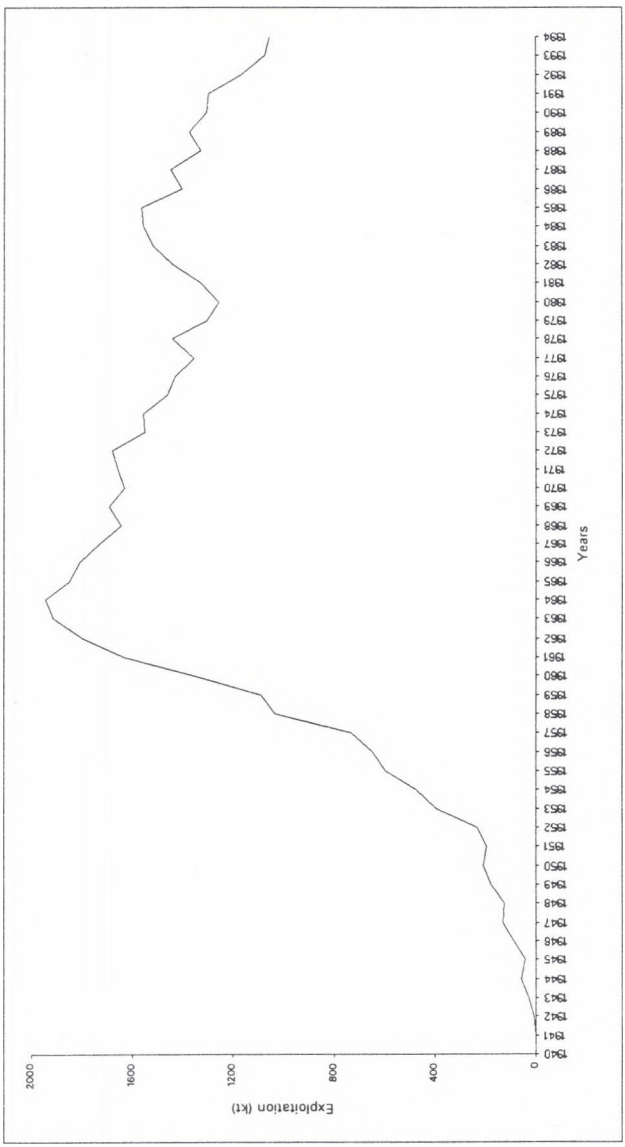

Fig. 1 Nováky mine – development of coal exploitation
Rys. 1. Rozwój eksploatacji węgla

Handlová deposit there above rock group of Lehota are deposited volcanism products of Vtáčnik mountains. They are formed of the set of lava flows of andesites and their pyroclastics.

Coal - petrographic characteristic of coal seams

The coal seam of Nováky is formed with coal lithotypes that from quantitative view are presented in order - detritic, xylitic-detritic, xylitic, detritic-xylitic and mother of coal. Most spread maceral group in the deposit is huminitic, represented with humotelinite, humodetrinite and humokolinte. From order maceral groups were in the deposit identified macerals from group of liptinite (kutinite, suberinite, rezinite) and inertinite (inertodetrinite, fuzinite and sklerotinite).

From the view of carbonisation the coal of Nováky seam is included into brown-coal stadium of the change with medium vitrinite reflectance: R_0=0.275%. The coal of the Handlová deposit, with aspect to volcanic rocks in its overlying rocks, has higher carbonisation with medium reflectance of vitrinite: R_0=0.324%.

The mineralization coal seam of Nováky

It is formed of clay component, tuffites, quarz various forms, sulphides of iron and arsenic, and dolomite. Iron sulphides (pyrite, marcasite) most have form of micronodule. Arsenic sulphides (realgar and auripigment) as one of the harmful substances at energetical coal exploitation, take place at discontinuity areas (layered areas, dilatation cracks, dislocations), they are fixed to the volcanic mountain Vtáčnik hydroterms (Petrik - Šimeček, 1988).

Within the geochemical-ecological survey of the Nováky coal deposit (Vrána et al., 1991) were in coal identified following minerals by means of RTG-analysis, optically and spectrochemically:

- silicates - spars (plagioclasses, K-spars), biotite, chlorite, muscovite, pyroxenes, amphibols, grenats, clay minerals (mainly kaolinite, illite, less halloyzite and montmorillonite), hydromicas;
- carbonates - calcite, siderite, manganocalcite;

- phosphates - apatite (?), rock phosphate;
- oxides - quarz, opal, limonite, magnetite;
- sulphides - pyrite, arsenopyrite, realgar, auripigment;
- sulphates - gypsum, anhydrite, melanterite.

From mineralogical research results can be concluded that in the coal of Nováky deposit occur autigenous and allogenous minerals, and minerals of wheathering processes, or minerals of the hypergenous zone.

Geochemistry and chemical-technological characteristics of coal

Coal geochemistry of the Handlová-Nováky coal basin has been object of intensive study since 60-ties, whereby various analytical methods were used, and various element spectra were investigated.

Petrik (1964) balanced 102 technical coal analyses and 32 samples of basic coal type qualitative spectral analyses. From the coal technical analyses he revealed that sulphur levels in the coal of Nováky ranged in the interval 1.81-11.57% at modal interval 3-5%.

Mecháček-Petrik (1967) studied coal seam geochemistry from Handlová-Nováky coal basin, based on the balance of 400 semiquantitative spectrochemical analyses of coal ash sampled in the mines Handlová, Cígeľ and Nováky. Determined elements were based on concentration classified in following groups:

- amount above 1%: Al, Ca, Fe, K, Mg, Si, rarely Ba, Na;
- 0.01- 1%: Ba, Mn, Ti, rarely Be, Na, Sr;
- 0.01% - traces: B, Be, Mn, Sr, Ti, rarely Ag, As, Ba, Co, Cr, Cu, Mo,Ni, Pb, V, Zn;
- rarely or only in some areas, most only in trace concentration are occurring elements: As, Bi, Cd, Ga, Ge, Li, Sb, Zn, W.

Mecháček (1975) as the first studied qualitative and quantitative trace elements distribution parameters in the coal from Tertiary basins of Slovakia and contemporarily also mutual relationships among the elements. For the coal from the deposit of Nováky he revealed very high concentrations of B, Ba, Sr a Ge (Tab.1). Correlations among the studies elements attained following values: Ni/Co = 0.8, Ba/Sr = 0.9, B/Ba = 0.6, B/Sr = 0.7, B/Cu = 0.5, B/Ni = 0.5, V/Ni = 0.7, V/Cr = 0.5, V/Co = 0.6, V/Cu = 0.6, Cu/Co = 0.7.

Table 1

Statistical characteristics of trace element distribution in coal

Element	Minimum	Average	Maximum	Median
B	20	1665	3200	150
Ba	100	1170	3000	800
Sr	70	965	3000	490
Ni	5	25	90	20
Co	2	10	80	10
V	10	125	740	80
Cr	5	35	360	20
Cu	5	50	280	35
Pb	-	56	310	-
Ge	-	15	170	-
Mo	-	22	70	-

Table 2

Trace elements mean values

Element	Handlová	Cígeľ	Nováky
B	2300	1890	1600
Ba	1620	1300	1300
Sr	880	740	1250
Cr	90	73	45
V	440	195	210
Ni	100	75	30
Co	50	20	20
Ge	?	?	10
Cu	205	150	65
Pb	30	25	55
Ag	traces	traces	traces
Sn	15	34	12
Mo	40	24	22

Petrik -Šimeček (1988) based on elements distribution mean values compared three parts of the Handlová-Nováky coal (Tab.2), whereby the deposit of Nováky has on average highest concentration: Sr, Ge and Pb, respectively. The authors found coal petrographical composition, carbonisation rate and on inorganic bymixtures in a coal seam. Main significance is ascri to the resource region characteristics, petrographical lithotype and hydrothermal solutions influence.

Halmo, J. et al. (1991 in Vrána et al., 1991) balanced distribution of As and S in coal from Nováky deposit in 73 exploratory wells, implemented within the survey stage in period 1977-1990. The authors came to following As distribution heterogeneity:

- As content is highest in a seam uppermost part and it is decreasing towards underlying (24 boreholes). As highest concentration was proved in the borehole Z-309 - 3.64%. As level maximum values in first coal layer under roof stone in most cases ranged 0.1% to 0.3% As, rarely 0.06-0.07%.
- As content is lowest in a seam upper part and towards underlying bed it increases: 7 boreholes. Substantially this is contrary trend, when compared to foregoing case. This type of trend in vertical As distribution is least frequent in the Nováky deposit. Under roof stone As values range 0.01-0.04%, and above seat rock 0.1-0.14% As.
- As level is nearly uniform in all the coal seam profile: 17 boreholes. To this distribution type should be included also the boreholes, where is not possible to follow basic As level change in vertical direction. As values are either uniform in all profile in some interval. As determined concentrations range in interval 0.0328-0.1414%.
- As content maximum is in some distance under roof stone, and from it decreases both towards to seat rock and roof stone - 25 boreholes.

From mentioned is resulting that As level in coal of the deposit Nováky, with some exceptions in vertical direction and decreases from roof stone to seat rock. Sulphur level show similar trends of As vertical distribution.

Vrána et al. (1991) within complex geochemical, mineralogical and ecological research studied bothe chemical elements distribution, their concentrations were determined by AAS method. Based on horizontal changes, studied elements can be classified in following six groups with following trends:

- The elements contents decrease in N and NE directions from the deposit with not marked local maximums and minimums in central and northern parts of the deposit - As, Ba, Cr, Fe, Ge, S, Sr.

- Increase in NE direction - Mn.
- Increase in W direction - B, Cd, Cu a Pb.
- Medium growth in direction to deposit centre - Cl.
- Medium decrease towards the centre of deposit with not marked local maximums and minimums - Hg, Mo, Ni, Sb, Se, V, Zn.
- Not visible trends of the elements - F, Sn.

Chemical elements distribution mean values and caloricity in vertical direction of a coal seam and interstratified beds are documented in Tab. 3. Distribution character of ecologically most important elements in coal of main seam is summarised in Tab. 4, from it is very clear their distribution high variability at coal seam average thickness 8.35 m.

Sulphur: S mean level in coal of Nováky is 3.4%. S lowest levels are in upper part of coal seam - 3.03% and they grow with depth to 3.17% in medium of coal seam part, and 3.76% in bottom part. S mean levels in volcanoclastics, when compared with coal are nearly - 1.77%, and lowest in interstratified beds of main coal - 1.25%. Sulphur level in volcanoclastics also moderately grows with depth.

From genetic view is sulphur in the coal of Nováky deposit participating in four basic types:

- sulphid-S, mainly pyrite, less realgar and auripigment;
- sulphate-S, mainly gypsum, less anhydrite and melanterite, into this group is included sulphur precipitated from sulphate and water (liquid) phase;
- organic-S introduces organic substances part, forming part of the proper coal mass;
- elementary-S is obviously a product of secondary pyrite decomposition.

Arsenic: mean As level in the coal of Nováky deposit 900 ppm and interstratified beds 941 ppm. Minimum and maximum As levels for coal are 249 a 3137 ppm, with maximum numerousness in interval 600-800 ppm (31 samples). As contents are connected particularly with sulphidic minerals (realgar and auripigment, but there is assumption for its fixation to organic matter). With depth As levels in the coal of Nováky deposit relatively markedly decrease from 1121 ppm in coal seam upper part, through 880 ppm in its central part to 770 ppm in bottom part. In roof stone of main coal seam mean As level is 522 ppm. Similarly As decrease trend with depth occurres also in the case of terrigene-volcanogenic interstratified beds.

Caloricity: in average of the coal of Nováky deposit it is 12.08 MJ. The coal from main seam central part has highest caloricity - 12.30 MJ and in direction to roof stone and seat rock id decreases in 0.64 or 0.72 MJ. In the coal of underlying seam it has the 9.95 MJ.

Table 3

Mean values of chemical elements and coal caloricity in the Coal deposit of Nováky

Units	N	Q	S	As	F	Cl	B	Hg	Cd	Pb	Se	V	Cr	Ge	Cu	Sr	Ba	Zn	Mn	Fe	Sb	Mo	Sn	Ni
		MJ	%	ppm																				
1	154	11,86	3,29	860	659	56	270	0,06	0,13	4,52	0,14	50,0	8,00	3,0	8,10	170	170	32	249	10 329	0,14	3,0	1,0	9,00
2	138	12,08	3,24	900	663	57	280	0,06	0,12	4,25	0,14	46,0	9,00	3,0	7,10	186	178	32	225	8 844	0,14	2,7	1,0	10,00
3	21	11,66	3,03	1 121	664	54	277	0,06	0,11	7,74	0,15	39,0	11,00	7,7	7,80	78	168	25	253	6 721	0,16	3,1	1,0	15,00
4	94	12,30	3,17	880	667	54	296	0,05	0,12	3,67	0,14	45,1	7,70	2,2	6,50	243	190	29	217	7 716	0,14	2,6	1,0	7,50
5	23	11,58	3,76	770	652	75	217	0,07	0,14	3,60	0,13	56,9	9,40	2,7	8,70	50	146	51	227	12 468	0,11	2,4	1,0	13,00
6	16	9,95	3,66	522	614	42	180	0,08	0,17	6,50	0,17	79,7	5,20	3,9	16,30	35	87	34	464	23 246	0,09	1,2	1,0	4,00
7	27	3,00	1,77	941	668	62	137	0,08	0,16	8,60	0,29	87,9	14,80	3,2	16,40	250	209	48	289	16 079	0,20	2,3	1,3	18,70
8	7	2,53	1,25	1 375	741	70	95	0,05	0,17	10,40	0,33	33,6	9,10	1,0	11,70	643	478	42	295	12 508	0,30	1,0	2,8	7,10
9	10	3,60	2,25	336	575	38	147	0,10	0,14	8,40	0,33	121,0	20,60	5,7	18,60	148	129	53	252	20 438	0,12	2,0	1,0	26,90

Notes:

1 - coal total

2 - coal, main coal seam

3 - coal, main coal seam upper part

4 - coal, main coal seam central part

5 - coal, main coal seam bottom part

6 - coal, seat rock of main coal seam

7 - terrigenic-volcanogenic cliffs total

8 - terrigenic-volcanogenic cliffs of main coal seam

9 - terrigenic-volcanogenic cliffs in seat rock

Table 4

Ecologically most important elements of coal in main coal seam - character distribution (N = 138)

Parameter	S	As	F	Cl	B	Mn	Fe	Zn	V	Ba
	%	ppm								
Min.	1.59	249	364	13	65	25	569	7	1	1
Mean	3.24	900	663	57	280	225	8844	32	46	178
Max.	8.25	3137	1420	386	684	813	51528	365	213	1627
SD	0.79	504.8	197	53	121	122	6714	39	42	210

Hydrogeochemical investigation of the Nováky deposit mine-water showed that water chemism has following character: Ca-Mg-HCO_3, Na-HCO_3, Na-Ca-HCO_3. For mine-water characteristic is lower sulphate level, they are included into group of silicate-hydrosilicategenous water.

Most of ecologically interesting elements (Ni, Se, Sr, Co, Cd, Pb, Hg) is mobilised into ground water, in given conditions, only in limited rate, their concentrations in ground water are partically under limited concentrations defined with standard for drinkable water. Contemporarily was revealed that As level, predominantly in hollow-water reach values that are higher than limit. In given conditions however there is no Zn and Cu mobilisation into ground water in greater rate. Concentrations of Sr, Fe, Mn and Al considerable heterogeneous and from ecological view they introduce no serious problem.

From the view of coal use possibilities of the basin Handlová-Nováky in new technologies and products, it is important to mention mean values comparison of selected chemical-technological parameters by the exploitation locations - Tab.5 (Boroška, 1995).

Table 5

Coal qualitative parameters produced in the coal basin Handlová-Nováky

Parameter	Symbol	Unit	Cigeľ mine	Handlová mine	Nováky mine
Caloricity	Q_i	MJ/kg	11.56	12.90	10.70
Water	W^a_t	%	20.70	24.32	33.90
Ash	A^a	%	15.20	33.90	7.00

con. table 5

Volatile substances	V^{daf}	%	55.60	55.04	57.62
Arsenic	As^{r}	ppm	62	67	590
Sulphur total	S^{r}_{t}	%	1.35	1.36	1.99
of it: organic	S_o	%	0.79	0.82	0.83
sulphatic	S_{SO4}	%	0.11	0.10	0.10
pyritic	S_p	%	0.47	0.44	1.06
Sulphur in ash	S_A	%	0.31	0.13	0.69
Sulphur volatile	S_C	%	1.04	1.23	1.30
Carbon	C^{daf}	%	63.5	62.9	59.5
Hydrogen	H^{daf}	%	8.86	8.09	9.66
Nitrogen	N^{daf}	%	5.36	6.71	5.74
Oxygen	O^{daf}	%	26.32	24.38	27.31
Ash					
SiO_2		%	45.6	50.4	44.2
Al_2O_3		%	18.6	17.4	19.8
Fe_2O_3		%	13.8	12.0	12.3
CaO		%	8.6	5.3	8.7
MgO		%	4.3	3.2	4.8
Na_2O		%	0.67	0.95	1.04
K_2O		%	1.71	1.69	1.92
Start of caking	t_s	°C	900	960	925
Point of softing	t_A	°C	1220	1200	1200
Point of melting	t_B	°C	1295	1360	285
Point of flowing	t_C	°C	1310	1310	1280

Coal exploitation and use

The coal deposit of Nováky is filling western part of the basin of Upper Nitra on total area 37 km^2. Detection of the coal deposit of Nováky can be dated in period 1937-1938. At geological mapping in 1:25 000 in 1937 V. Čechovič revealed in the Čausa's group of beds (eggenburgien) a dook of schliers clays to west. Based on this information he came to the opinion that in the space of Nováky should be developed an independent coal deposit and it

should be only narrow projection of the deposit of Handlová. Based on mentioned assumption, started in 1939 drilling works under Mr. Čechovič leadership, after this was definitely confirmed existence of independent coal deposit of considerable extent (Halmo - Verbich, 1995). The coal rights hire in the mineral territory of Nováky obtained Handlovské uhoľné bane, joint stock company, with hire agreement of march 27, 1940, when first inclined shaft started to be driven.

Quantitative character of brown coal exploiting in the deposit of Nováky in period 1940-1994 is documented in Fig. 1, from it is resulting that 50-ties were the period of permanent exploitation increase, with maximum in 1964 (1943.9 kt). Since this time exploitation extent decreased till 1980 (1256.2 kt), then break came, and gradually until 1985 exploitation extent was growing. However till now has been exploitation extent permanently decreasing. In exploitation history of the deposit Nováky three deep mines have been in operation: the Mine Youth (1940-42, 1948-presence), the Mine of Peace (1942-1977), the Mine Lehota (1952-1993) and one surface mine Lehota (1980-1988).

The Hornonitrianske bane š.p. (Mines of Upper Nitra) at present are producing approx. 2.8 mil. t coal and lignite. The Baňa Cígeľ proportion is 29%, Baňa Handlová 31% and Baňa Nováky 40%. The mines Cígeľ and Handlová produce brown coal, and Nováky mine lignite. All coal production has been used for energetic purpose, for small-scale and large-scale consumers, respectively (mainly ENO Power Station, Zemianské Kostoľany), and chemical processing (Chemical plants, Nováky). Well know fact that the coal of Nováky exported to Schweiz in period 1943-1944 was used mainly for chemical processing (Boroška, 1995).

Environment of Upper Nitra

The Prievidza county territory introduces geographically closed territory, in S-side open and by Nitra catchment connected with Nitra Basin. Considerable area is covered with Strážovské vrchy mountains, as well as mountains Vtáčnik, less Malá Fatra, Žiar and Kremnické vrchy and Tribeč. Climatic conditions are presented with three climatic areas (warm, medium warm, and cool ones). Average annual temperature is 8.5°C. Annual precipitation is 685 mm. The extent of the county is 960 km^2, i.e. less than 2% of total Slovakia. Population - 140 000, and its density 147 inhabitants. km^2.

Agricultural potential introduces soil - 36 000 ha, i.e. 37% county territory. Natural agro-ecological conditions are under normal level and markedly differentiated. For cereals is suitable 20%, and for fodder crops 19% of land. Forest are on 52 000 ha, i.e. 53% territory.

Existing natural raw materials base influenced the county character that has changed from originally agricultural to typical industrial one. To the change contributed new exploitation fields, power station, chemical plants, engineering industry, production of constructional materials, shoe industry, textile industry, and other processing objects. Rapid growth of industry positively influenced development of the county (employment, dwelling construction, services, etc.), however their environmental influence has been negative, and soils are indisputable component of environment.

Soils and their geochemical characteristics

Soil character and development in Upper Nitra are conditioned by geological structure, hydrological and geomorphological territory conditions. Thirteen soil types occur here (Ranker, Rendzina, Pararendzina, Phaeozem, Orthic Luvisol, Albic Luvisol, Eutric Cambisol, Mollic Andosol, Podzol, Pseudogley, Gley, Fluvisol, Kultisol) with several forms and varieties. Most frequented are loamy soils, sand-loamy soils, and silty soils. Most productive agricultural soils (Fluvisols, Luvisols, Cambisols, and Pseudogleys) are protected in the territory. Landscape morphology has marked influence on water erosion. Erosion risk in Prievidza county is following (Čurlík et al., 1993):

- week and medium erodible soils - 42.3%
- severely erodible soils - 16.5%
- very severely erodible soils - 4.7%.

Soil sliding occurrence in areas of Handlová, Chrenovec, Veľká Čausa and Malá Čausa is conditioned with natural conditions (geological structure, hydrology and morphology of territory), and land use.

The Prievidza county industrialisation has also effect on farming land use, their acreages are permanently decreased due to mining activities, building up coal processing measures, construction of setting pits and pit tips, and also due to soil contamination with risk elements of organic inorganic character.

Within Slovakian soils geochemical mapping (Čurlík - Šefčík, 1994) were here identified 60 soil profiles with sampling A and C horizons for analyses total contents of 36 chemical elements. From the results statistical elaboration concerning risk elements levels (Tab. 6) is resulting that soils of the territory are in A horizon enriched, or contamined with some elements (As, Cd, Cr, Cu, Mo, Pb, Sb a Zn), when compared to C horizon. On average risk elements contents do not overlap the limits given by legislation (MP SR, 531/1994-540), but some partial values of the set overlap the limits. This contamination resource is processing technology and use of the coal exploited from the basin Handlová-Nováky. It is interesting that fluorine and mercury contents are in C horizon relatively higher than in A horizon that is conditioned by the character of mineralogical, petrographical composition of soil substrata.

Table 6

Distribution of chemical elements in soils - Prievidza region

Descriptive Statistics	Trace chemical elements (ppm)													
of A-horizon	As	Ba	Cd	Co	Cr	Cu	F	Hg	Mo	Ni	Pb	Sb	Se	Zn
Mean	20.8	383.5	0.5	10.4	68.3	17.8	380.0	0.2	0.7	23.8	34.1	1.1	0.1	78.0
Median	16.2	397.0	0.5	10.0	70.0	15.5	300.0	0.1	0.5	19.0	29.5	0.8	0.1	72.0
Mode	11.2	399.0	0.2	10.0	90.0	14.0	150.0	0.1	0.5	24.0	26.0	0.9	0.1	57.0
Standard Deviation	15.3	104.0	0.3	3.7	25.0	8.4	382.7	0.1	0.7	18.0	18.4	0.8	0.1	38.1
Minimum	3.9	103.0	0.1	3.0	18.0	6.0	150.0	0.0	0.1	0.5	13.0	0.3	0.1	26.0
Maximum	90.0	587.0	1.7	21.0	130.0	44.0	1850.0	0.8	4.5	100.0	90.0	4.2	0.4	199.0
Count	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Descriptive Statistics	Trace chemical elements (ppm)													
of C-horizon	As	Ba	Cd	Co	Cr	Cu	F	Hg	Mo	Ni	Pb	Sb	Se	Zn
Mean	28.3	396.5	0.3	11.3	71.2	17.6	454.0	0.1	0.6	28.0	18.2	0.7	0.1	65.4
Median	7.1	417.5	0.3	10.5	67.5	15.0	300.0	0.1	0.4	21.5	14.0	0.5	0.1	52.0
Mode	1.7	289.0	0.2	7.0	61.0	11.0	150.0	0.1	0.1	25.0	11.0	0.3	0.1	48.0
Standard Deviation	128.1	143.6	0.3	4.6	26.9	11.0	442.7	0.5	0.7	24.8	11.1	0.8	0.1	39.2
Minimum	0.9	135.0	0.1	3.0	11.0	2.0	150.0	0.0	0.1	0.5	8.0	0.1	0.1	24.0
Maximum	913.0	829.0	1.2	22.0	143.0	52.0	2000.0	3.4	3.6	124.0	54.0	4.9	0.4	248.0
Count	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Main direction of economical and social territory development with aspect to environment

In agricultural and food industry will necessary, with aspect to ecological load of the territory with exhalates (38% farming land), to form assumptions for specific forms of farming focused on special crops production for industrial processing. Concrete possibilities are in winter rape and its processing to bionafta. Its should be oriented mainly to the farms focused to alternative farming forms, to protected areas of water management and for local transport carriages.

Conservation of soil, forest and rock environment needs to reduce large-scale production of crops for food purposes in areas with most harmed environment (Nováky-Oslany). Similarly is desirable to look for a solution of the exploited coal mine spaces use in the county and to implement revitalisation of the territories disturbed with mining activities, surface coal exploitation, dolomite, andesite and other raw materials for building activities, and areas eroded after wood mass exploitation.

Atmosphere purity is conditioned by ecological constructions implementation at the ENO Zemianské Kostoľany; from them we are waiting for marked reduction of SO_2 emissions, nitrogen oxides, ashes, significant reduction flyof As, Cl, F and other risk elements. Similarly modernisation and new technologies application in manufacture processes of the Chemical Plants, Nováky are conditions for emissions reduction at heavy metals, volatile organic substances, solid substances, and reduction Cl and freons fly.

In the region of rational water use, there is necessary substantial increase of pollutant amounts in municipal slugde water flowing freely into open recipients, i.e. to reduce pollution of waters by to classes.

Very important task will be design of waste economy, both from qualitative and quantitative aspects and increased waste recyclation. Main problem are ashes and wastes from power plants and district heating plants, wastes from building industry and raw material exploitation, industry of wood, rubber industry and chemical industry.

Conclusions

From view of qualitative parameter at the coal of Nováky most important are following facts:

- highest caloricity in main coal seam was found in its central part;
- at sulphur levels was proved their increase with depth;
- sulphur contents in volcano-sedimentary cliff are nearly half, when compared with coal;
- As contents, contrary to sulphur case with depth decrease;
- contents of another most important harmful elements F and Cl are in coal and in cliffs are approximately the same and do not show significant changes with depth;
- Fe contents in volcanic- sedimentary cliffs are approximately double than in coal and in coal and cliffs there is visible their marked increase with depth;
- in planar element distribution is important the fact of harmful As, S, Fe decrease to the north of deposit;
- F levels in all the deposit are more or less homogenous and Cl levels show moderate tendency of growth to the centre;
- increased S content in seat rock part of coal seam can be also the result of gypsum concentration, its occurrence is increased in seat rock part of coal seam.

According present starting point ecological situation in the Upper Nitra region national environmental politics in the future should be focused on:

- atmosphere protection against pollutants and global environmental security;
- to secure drinkable water abundance and reduction of remaining water pollution under acceptable rate;
- protection of the soil against degradation and food perfect quality as well as other products;
- waste origination minimisation, recyclation and hygiene;
- biological diversity conservation, natural resources rational use and conservation, spatial structure optimisation and optimum land use.

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Streszczenie

W pracy przedstawiono wpływ eksploatacji i użytkowania węgli brunatnych złoża Novaký na środowisko w regionie Horna Nitra (Słowacja), obszaru o dużej koncentracji przemysłu górniczego, energetycznego oraz chemicznego. Region ten poddawany jest długotrwałym procesom deterioracji (gleb, wody i atmosfery). Węgle brunatne złoża Novaký są częścią obszaru złożowego Handlova-Novaký o dużym znaczeniu przemysłowym dla Słowacji. W trzeciorzędowym złożu węgli brunatnych występują dwa pokłady, z których główny o miąższości ok. 50 m jest eksploatowany w złożu Novaký. Złoże to charakteryzuje się skomplikowaną strukturą tektoniczną (deformacje typu germańskiego) z obecnością uskoków o przebiegu N-S, NE-SW, a w północnej części złoża Novaký uskoki mają przebieg NW-SE. W złożu występują utwory piroklastyczne oraz wulkaniczne skały typu andezytowego. Charakter petrograficzny węgli brunatnych jest: detrytyczny, ksylitowo-detrytyczny, ksylitowy oraz detrytyczno-ksylitowy. Stopień uwęglenia w złożu Novaký wynosi R_o = 0,275%, zaś w złożu Handlova R_o = 0,324%, co wiązać należy z obecnością skał wulkanicznych. Mineralizacja pokładów węgli związana jest z obecnością: krzemianów, węglanów, fosforanów, tlenków, siarczków i siarczanów. Minerały z tych grup są zarówno allo-, jak i autigeniczne. Badania geochemiczne wykazały istotny udział takich pierwiastków jak: B, Ba, Sr i Ge. Poddano szczegółowej analizie prawidłowości dystrybucji w złożu siarki i arsenu. Zwrócono także uwagę na chemizm wód podziemnych. Dokonano analizy wielkości eksploatacji w latach 1940-1994, a także charakterystyki środowiska regionu (klimatu, uwarunkowań agroekologicznych, ludności, udziału poszczególnych branż przemysłowych). Ponadto dokonano szczegółowej charakterystyki geochemicznej gleb oraz ich podatności na erozję. Przedstawione dane charakteryzujące środowisko skojarzono z głównymi kierunkami ekonomiczno-społecznego rozwoju regionu.