



GEOHEALTH

The impact of geological environment on health status of residents of the Slovak Republic.

Geochemical background and health status of inhabitants of the Slovak Republic

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INTRODUCTION

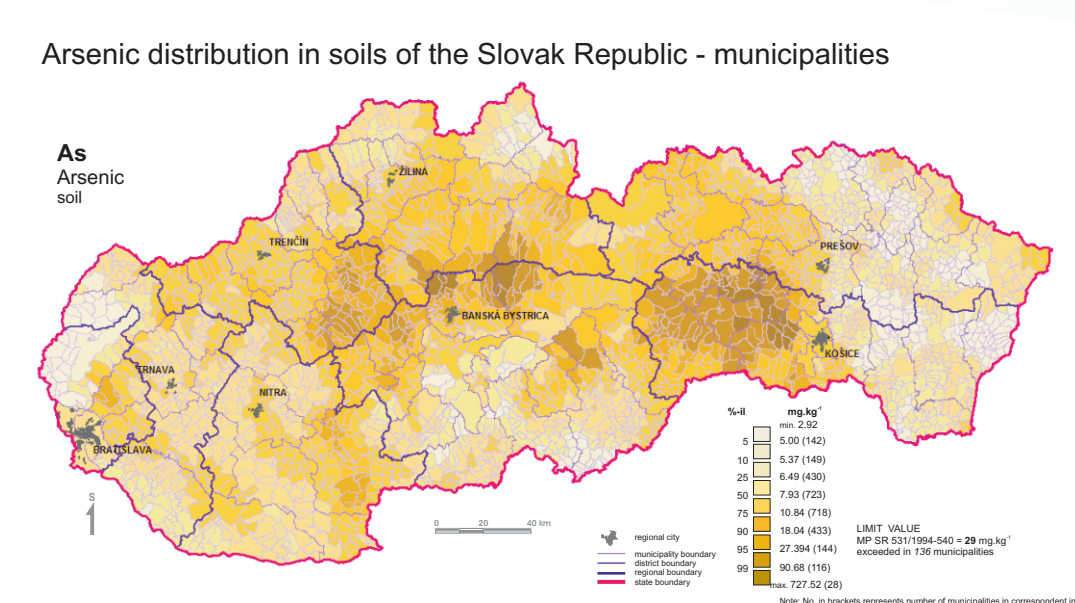
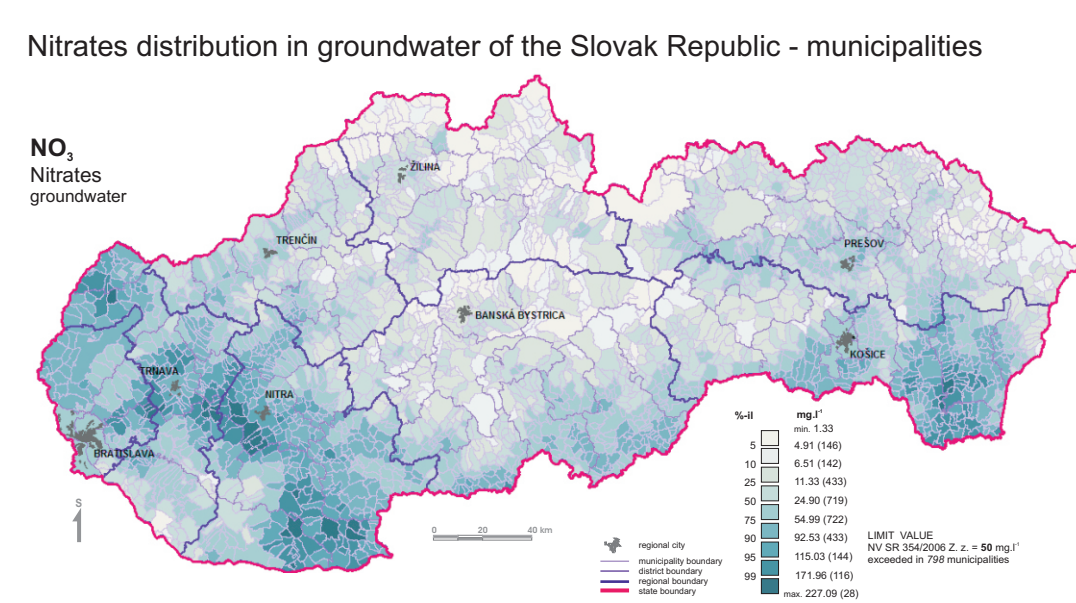
Geological structure of the Slovak Republic is particularly varied. It reflects different geochemical background that has various influences (positive or negative) on human health. The main objective of this current study was to determine the association of diverse geological environments and health of inhabitants. In other words, we intended to find out whether the differences in the geochemical background are reflected in the health status of the Slovak population.

MATERIAL

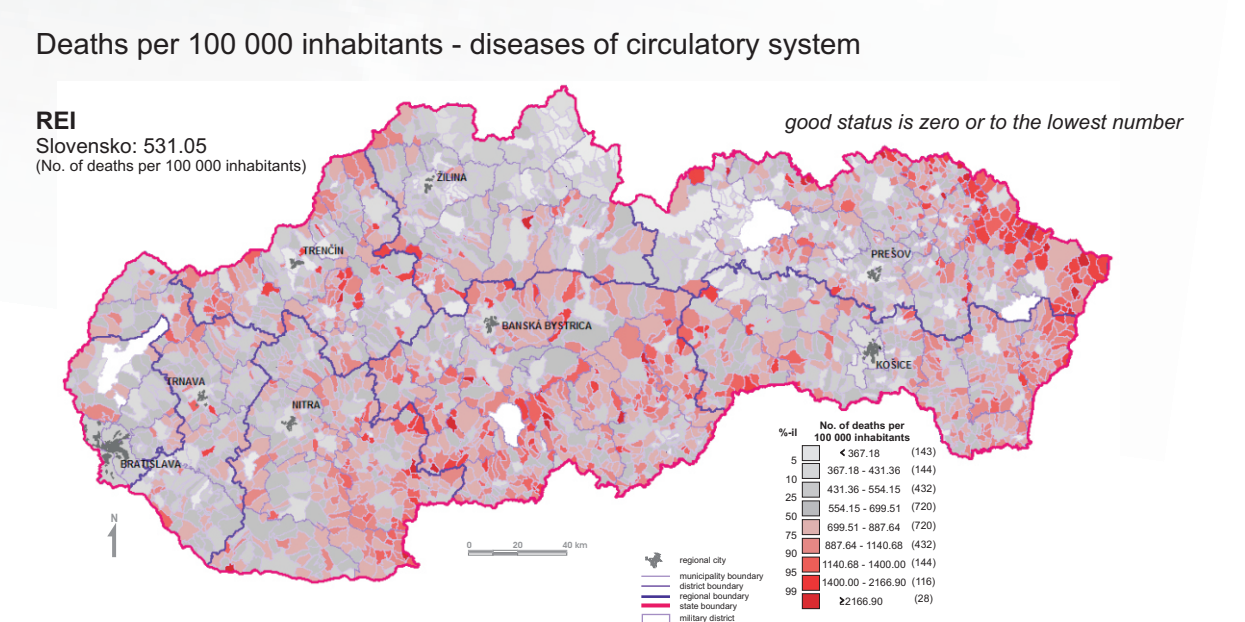
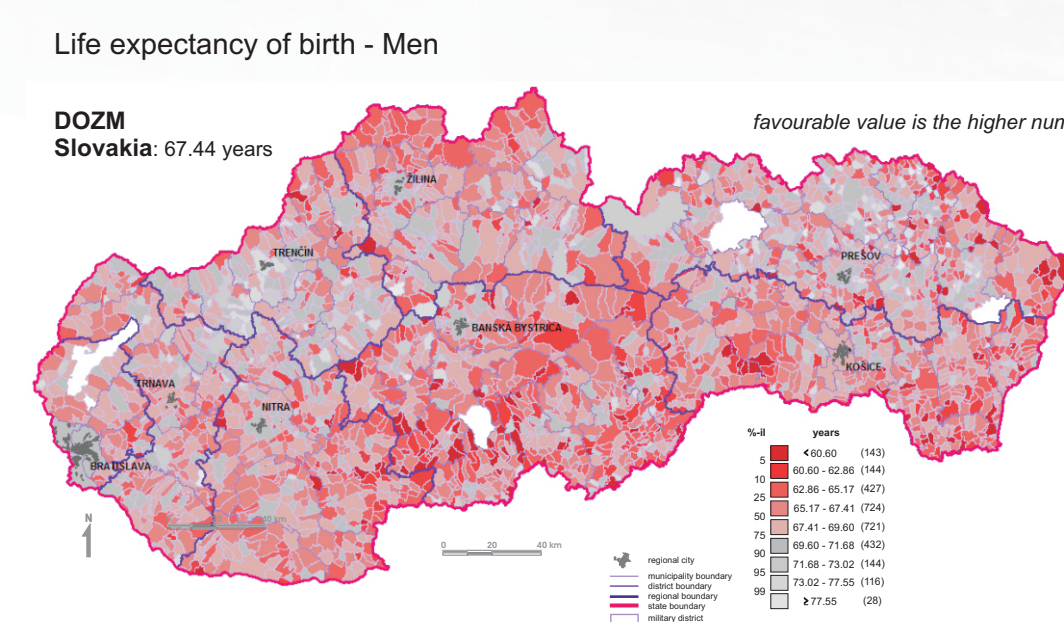
The evaluation of the impact of geological environment on the health status residents was based on datasets of environmental and health indicators. Environmental indicators - contents of chemical elements/compounds/parameters were compiled for groundwaters/drinking waters (20 339 chemical analyses) and for soils (10 738 chemical analyses). Health indicators - indicators of demographic growth and health status of residents were compiled based on 10 year average values of health indicators for the period 1994 - 2003.

For each of 2883 municipalities of the Slovak Republic mean value for all environmental and health indicators were calculated. The results presented in map as well as table forms are available on www.geology.sk/geohealth.

ENVIRONMENTAL INDICATORS

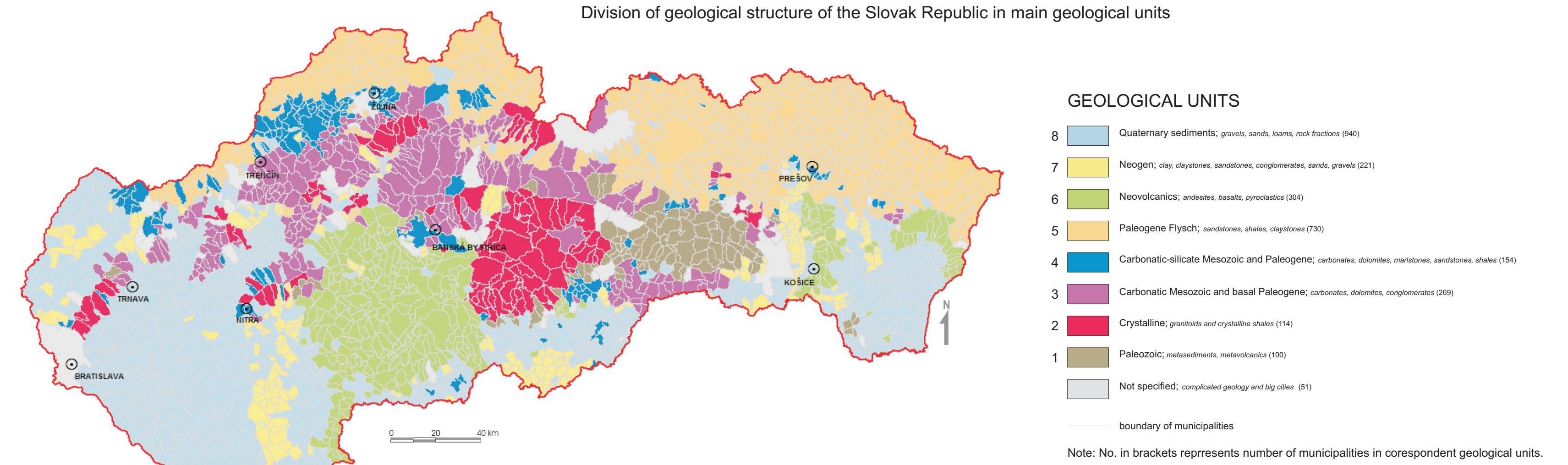
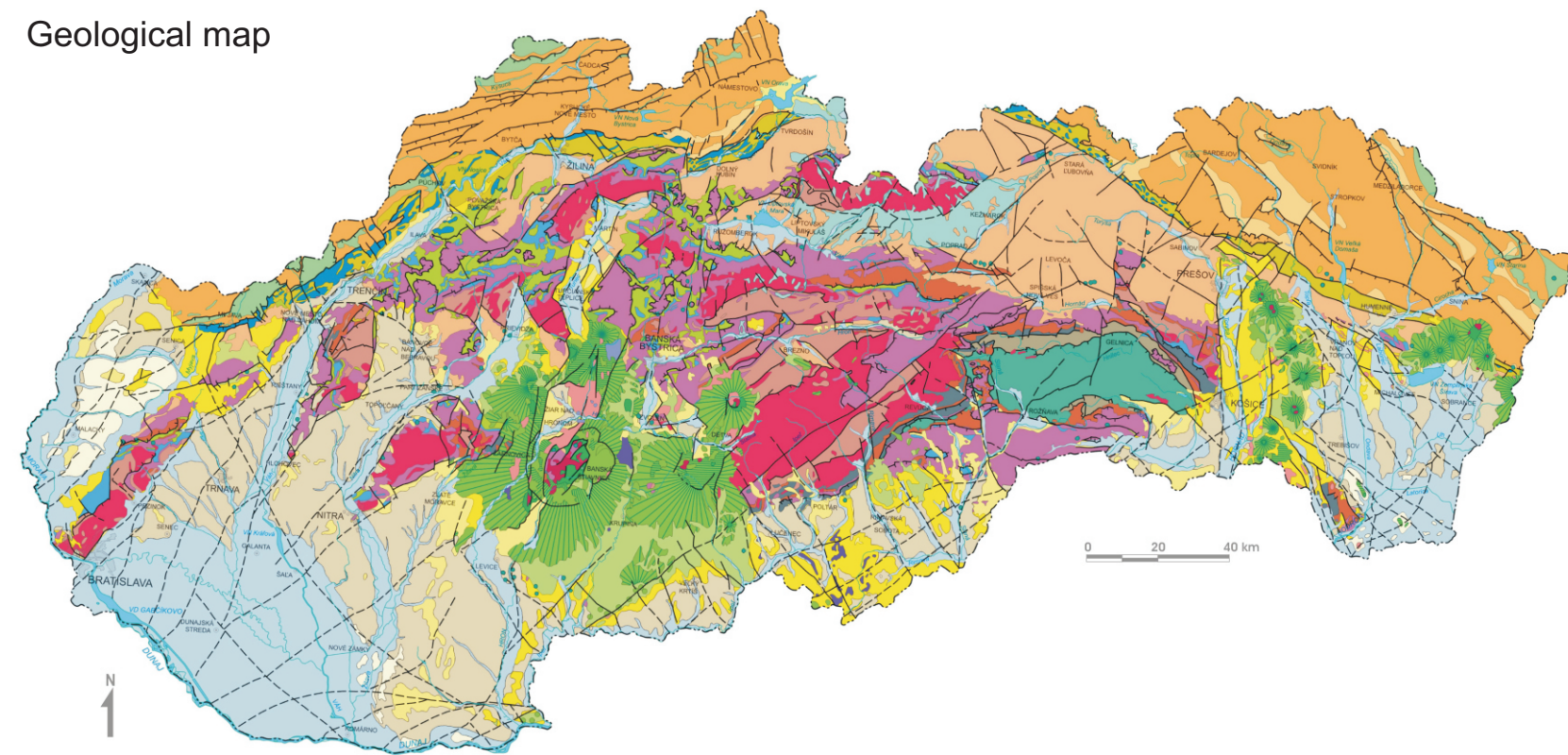


HEALTH INDICATORS



METHODS

Geological environment of the Slovak Republic was divided to 8 main geological units. Further datasets of environmental and health indicators were divided according to these geological units.



RESULTS and DISCUSSION

Health indicators

The average values of health indicators of the Slovak population classified according to geological structure (based on the municipal land registers) are listed in Table 1.

Table 1 shows considerable differences in the vast majority of health indicators between individual geological units. The distinction between the most favourable and the least favourable values of health indicators, in many cases, is very significant and very often exceed a level of 20%.

The geological environment of the Neogene volcanics (andesites and basalts) has been clearly documented as having the least favourable impact on the health of Slovak population, while Paleogene, Flysch geological environment (sandstones, shales, claystones) has the most favorable impact. The most significant differences between these two geological environments were observed especially for the following health indicators: SMRI6364 (cerebral infarction and strokes) more than 70%, SMRK (digestive system) 55%, REI (circulatory system) and REE (endocrine and metabolic system) almost 40%, REC (malignant neoplasms) more than 30%. These results can likely be associated with deficit contents of Ca and Mg in groundwater from the Neogene volcanics that are only about half the level of Ca and Mg in groundwaters of the Paleogene sediments.

The impact of the geological environment on the health of the population of the Slovak Republic can be listed in the following order of the geologic environments: Paleogene, Carbonatic-silicate Mesozoic, Carbonatic Mesozoic, Neogene, Quaternary, Crystalline, Paleozoic, volcanics (ranked from the most favourable to the least favourable).

Table 1 Health indicators for the population of the Slovak Republic according to geological units (mean values calculated for administrative units)

Geological unit	1	2	3	4	5	6	7	8	SR
Altitude	424.75	466.55	412.54	340.19	412.40	332.93	226.57	173.23	
No. of inhabitants	1489	2319	1341	1838	1437	1155	1072	1871	
LEM	66.42	67.05	68.37	67.49	68.59	65.88	67.85	67.86	67.44
LEW	75.81	75.85	77.04	77.35	78.15	75.58	76.82	75.15	77.07
A60+	15.26	15.87	16.82	14.79	13.64	16.88	17.64	15.84	15.38
A85+	0.80	0.85	0.97	0.82	0.74	0.97	1.07	0.86	0.84
BIR	12.03	9.93	10.41	10.32	13.18	10.15	11.22	10.12	10.58
GFR	54.44	43.78	47.48	45.11	59.02	45.96	51.75	44.49	46.15
LBW	8.64	6.50	5.24	5.49	6.31	6.58	7.37	6.67	7.55
SAR	67.12	59.76	62.59	61.65	77.11	58.95	60.24	58.55	62.98
CMm	13.29	13.50	13.92	12.29	11.25	15.44	15.31	13.71	14.76
CMw	10.22	9.87	10.40	9.31	8.38	11.74	11.82	10.51	9.07
SMRp	108.32	101.03	98.39	97.99	98.48	108.05	105.62	104.63	100.00
SMRw	109.60	102.50	100.22	97.63	99.27	111.07	106.84	104.47	100.00
SMRm	108.43	99.43	96.02	98.85	97.62	106.60	105.27	105.73	100.00
PPDm	33.73	34.18	31.55	33.16	34.02	32.19	30.12	32.22	33.67
PPDw	18.17	17.97	15.59	16.53	17.87	15.87	14.22	16.79	17.53
PPDncp	26.20	25.43	23.81	24.76	25.92	24.36	22.74	24.68	23.37
PYLL1m	4.95	5.06	4.60	4.99	5.44	4.68	4.29	4.72	4.68
PYLL1w	2.46	2.54	2.12	2.41	2.71	2.15	1.83	2.29	2.19
PYLL100	4360.96	4436.38	3985.16	3985.46	3874.38	4586.18	4040.81	4181.55	4033.00
PYLLC	1058.67	1001.67	982.93	927.37	908.76	1096.28	997.06	1102.35	1005.20
ReC	209.46	209.57	219.17	195.96	177.99	236.28	233.43	231.99	212.79
ReE	17.30	13.74	14.98	13.90	12.65	17.61	17.71	15.38	14.43
ReI	569.73	551.58	572.02	505.07	483.32	638.78	665.98	567.77	531.05
SMRC	101.78	96.34	96.95	95.18	95.03	102.91	99.37	106.96	100.00
SMRC1526	98.90	97.23	96.57	97.86	94.11	102.20	100.87	106.83	100.00
SMRC3039	101.43	95.30	99.03	92.00	97.37	102.36	106.43	109.80	100.00
SMRI2125	128.21	103.65	95.82	97.54	109.94	101.39	108.18	97.41	100.00
SMRI6364	84.78	119.47	102.53	121.31	72.61	125.53	120.72	112.39	100.00
SMRK	124.81	109.87	113.74	100.61	109.39	126.34	96.00	98.68	100.00
SMRJ	94.92	101.14	90.24	94.23	84.31	130.61	107.22	107.98	100.00
sum24neg	7462.11	7413.68	6933.59	6791.56	6584.24	7864.16	7179.47	7324.05	6957.83

Note: SR - average value for Slovak Republic, altitude - mean value [metres about sea level], No. of inhabitants - mean value for municipality

Environmental indicators (groundwater, soil)

Groundwater

The average values of environmental indicators (based on municipal land registers) for groundwaters are shown in Table 2.

The most significant differences in chemical composition of groundwaters between individual geological units are observed mainly for Ca and Mg contents, water hardness, HCO₃, T.D.S., SiO₂, Na and K contents in the case of silicate rocks (Neovolcanics, Crystalline complexes, Paleozoic rocks) and carbonate units (Paleogene, Carbonatic and Silicate-carbonatic Mesozoic complexes). We observe no significant differences in contents of potentially toxic elements between individual geological units. Their contents are relatively low, below the limit values for drinking waters.

Soil

The average values of environmental indicators (based on municipal land registers) for soils are shown in Table 3.

In majority of chemical elements, mainly macro-components as well as potentially risk elements there exist significant differences in content levels between individual geological units. Detail analysis of the impact of chemical elements on various health indicators will be realized in the future using statistical methods of nonlinear regression - neural networks and fuzzy cluster analysis.

Table 2 Environmental indicators - groundwaters, according to geological units (mean values calculated for administrative units-municipalities).

Geological unit	1	2	3	4	5	6	7	8
pH	7.18	6.98	7.53	7.47	7.50	7.16	7.25	7.24
TDS	302.27	242.70	496.12	586.79	524.64	439.73	767.13	874.19
CO ₃	1.98	1.98	1.81	2.06	2.05	1.95	2.36	2.52
Ca+Mg	1.68	1.30	3.00	3.45	3.02	2.11	4.26	4.78
Li	0.007	0.006	0.010	0.016	0.020	0.013	0.031	0.025
Na	8.53	7.44	7.44	12.79	12.74	16.09	25.99	34.46
K	4.59	3.71	4.32	8.32	6.22	9.47	11.75	19.81
Ca	43.15	35.41	84.64	99.86	86.53	56.13	107.59	120.99
Mg	14.70	10.05	21.69	23.27	19.67	17.14	38.40	42.86
Fe	0.144	0.154	0.295	0.362	0.355	0.246	0.388	0.466
Sr	0.192	0.090	0.093	0.114	0.089	0.210	0.177	0.270
Mn	0.072	0.037	0.041	0.057	0.063	0.122	0.138	0.201
NH ₄	0.074	0.082	0.077	0.058	0.072	0.100	0.092	0.137
F	0.11	0.09	0.10	0.12	0.11	0.11	0.17	0.17
Cl	13.18	10.27	14.21	21.24	17.14	21.66	46.57	58.50
SO ₄	45.65	34.48	50.30	65.36	62.72	49.70	89.91	119.83
NO ₃	0.07	0.08	0.04	0.08	0.10	0.09	0.10	0.16
NO ₂	18.02	14.82	17.80	21.72	16.19	26.44	62.46	69.36
PO ₄	0.10	0.09	0.09	0.10	0.05	0.37	0.33	0.37
HCO ₃	138.29	107.37	285.84	323.63	287.65	191.51	355.32	386.33
SiO ₂	13.72	15.95	9.61	12.34	11.26	41.72	22.98	18.17
Cr	0.00107	0.00093	0.00091	0.00090	0.00095	0.00234	0.00127	0.00157
Cu	0.00332	0.00185	0.00193	0.00256	0.00167	0.00242	0.00244	0.00351
Zn	0.12576	0.08212	0.10279	0.23097	0.13470	0.20241	0.35242	0.45639
As	0.00883	0.00256	0.00317	0.00135	0.00079	0.00241	0.00164	0.00161
Cd	0.00050	0.00119	0.00238	0.00052	0.00062	0.00127	0.00103	0.00094
Se	0.00083	0.00069	0.00069	0.00074	0.00068	0.00096	0.00130	0.00134
Pb	0.00142	0.00139	0.00142	0.00121	0.00125	0.00134	0.00146	0.00143
Hg	0.00015	0.00012	0.00015	0.00014	0.00013	0.00012	0.00012	0.00016
Ba	0.04953	0.06077	0.07130	0.08801	0.06656	0.09506	0.07867	0.09005
Al	0.03162	0.04989	0.02627	0.02122	0.02170	0.05330	0.03644	0.02596
Sb	0.00720	0.00049	0.00365	0.00034	0.00062	0.00025	0.00031	0.00028

Note: data in mg.l⁻¹, except of pH and Ca+Mg in mmol.l⁻¹

Table 3 Environmental indicators - soils, according to geological units (mean values calculated for administrative units-municipalities).

Geological unit	1	2	3	4	5	6	7	8
Al	7.34	7.01	5.74	5.79	5.63	6.50	5.64	5.75
As	62.25	15.56	20.36	11.44	8.93	10.13	10.64	8.30
B	96.65	53.18	72.65	81.31	68.03	46.51	63.17	62.14
Ba	473.07	507.31	355.39	376.74	369.32	428.53	383.16	392.31
Be	1.69	1.65	1.44	1.47	1.31	1.33	1.36	1.37
Bi	1.43	0.48	0.51	0.41	0.39	0.42	0.29	0.27
Ca	0.81	1.15	2.13	1.34	0.77	1.11	1.27	2.10
Cd	0.62	0.47	0.64	0.51	0.78	1.22	0.34	0.35
Ce	76.63	66.50	64.22	64.35	61.69	63.54	66.85	65.14
Co	11.90	15.30	14.48	11.53	11.42	12.29	10.26	11.00
Cr	48.40	70.40	85.08	87.10	110.68	63.15	86.23	85.52
Cu	90.50	23.99	28.87	35.47	22.82	22.33	19.39	22.24
F	378.36	374.23	416.63	357.63	312.27	265.16	313.76	329.68
Fe	3.21	3.00	2.68	2.65	2.52	3.23	2.56	2.66
Hg	1.66	0.27	0.25	0.47	0.20	0.20	0.11	0.08
K	2.05	1.87	1.66	1.73	1.74	1.55	1.64	1.67
Mg	0.74	0.92	1.25	0.89	0.67	0.67	0.73	1.01
Mn	0.10	0.08	0.08	0.08	0.08	0.09	0.07	0.07
Mo	0.73	0.72	0.87	0.63	0.84	0.58	0.60	0.54
Na	0.82	1.15	0.72	0.81	0.85	0.89	0.86	0.85
Ni	24.46	22.63	33.71	34.96	34.07	16.81	26.15	29.59
P	0.09	0.09	0.08	0.07	0.07	0.07	0.07	0.08
Pb	0.76	36.00	41.80	28.34	24.76	40.87	24.72	21.04
Sb	46.37	3.68	6.15	3.46	1.31	1.87	3.16	0.93
Se	0.15	0.15	0.15	0.18	0.18	0.13	0.13	0.16
Sn	5.96	4.52	4.32	4.86	5.23	4.16	4.78	4.43
Sr	85.85	139.91	89.73	92.38	88.49	113.21	96.72	110.72
V	85.84	84.33	77.54	79.59	77.21	98.08	71.92	75.06
W	1.26	1.05	1.03	0.88	0.85	1.08	0.85	0.85
Zn	77.65	81.67	83.93	74.21	71.71	86.76	84.45	69.93
pH _{soil}	5.38	5.37	6.42	6.30	5.71	5.98	6.46	6.89
pH _{KCl}	4.54	4.66	5.77	5.47	4.96	5.11	5.58	6.23
carbonates	0.73	1.03	4.19	2.68	0.97	1.12	1.33	4.13

Note: macroelements in %, microelements in mg.kg⁻¹

CONCLUSION

The results presented show that there are significant differences