# THE POTENTIAL IMPACT **OF GEOLOGICAL ENVIRONMENT** ON HEALTH STATUS OF RESIDENTS **OF THE SLOVAK REPUBLIC**





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

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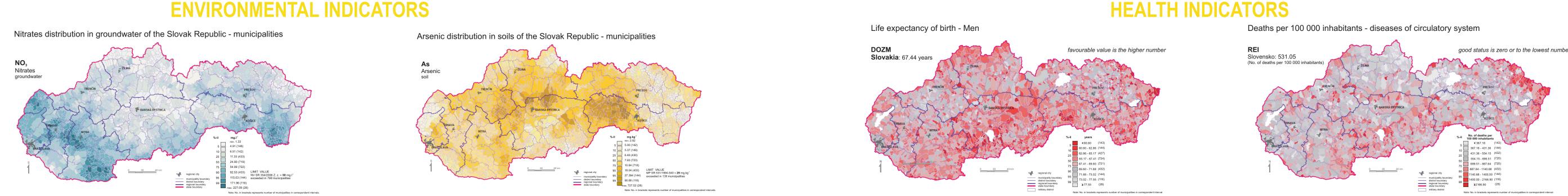
# INTRODUCTION

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.



# Nitrates distribution in groundwater of the Slovak Republic - municipalities NO₃ Nitrate





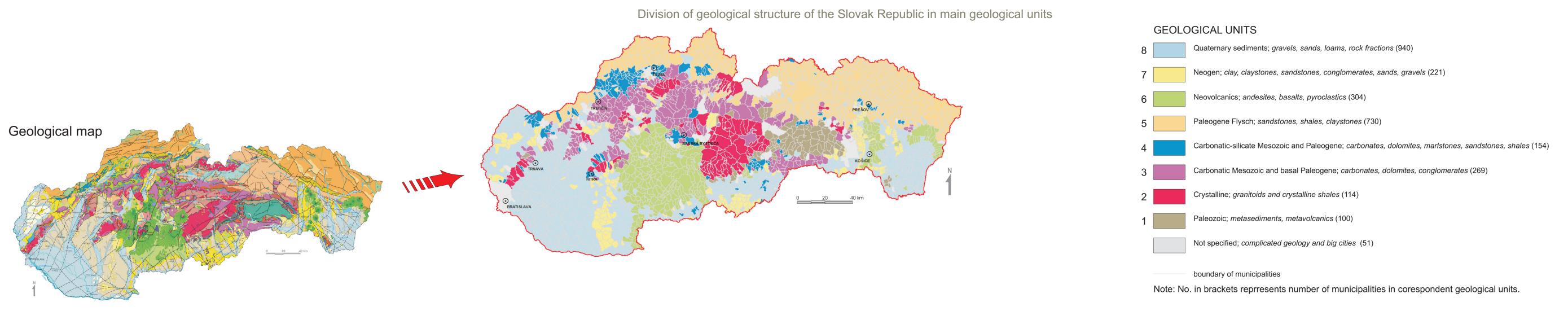
# MATERIAL

The evaluation of the impact of geological environment on the health status residents was based on datasets of environmental 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 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.

# **METHODS**

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



**RESULTS and DISCUSSION** 

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

# 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).

# 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, HCO<sub>3</sub>, T.D.S., SiO<sub>2</sub>, Na and K contents in the case of silicate rocks (Neovolcanics, Crystalline complexes, Paleozoic rocks) and carbonate units (Paleogene, Carbonatic and Silicate-carbonatic Mesosoic 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

analysis.

The average values of environmental indicators (based on *municipal land registers) for soils are shown in Table 3.* In majority of chemical elements, mainly macrocomponents 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

Geological unit		1	2	3	4	5	6	7	8	
Altitude	Contents	424.75	466.55	412.54	340.19	412.40	332.93	226.57	173.23	SR
No. of inhabitants		1,489	2,319	1,341	1,838	1,437	1,155	1,072	1,871	
LEm	Life expectancy at birth (Men)	66.42	67.05	68.37	67.49	68.59	65.88	67.85	67.86	67.44
LEw	Life expectancy at birth (Women)	75.81	75.85	77.04	77.35	78.15	75.58	76.82	75.15	77.07
A60+	Proportion of population at age 60 and more	15.26	15.87	16.82	14.79	13.64	16.88	17.64	15.84	15.38
A85+	Proportion of population at age 85 and more	0.80	0.85	0.97	0.82	0.74	0.97	1.07	0.86	0.84
BIR	Birth rate	12.03	9.93	10.41	10.32	13.18	10.15	11.22	10.12	10.58
GFR	General fertility rate	54.44	43.78	47.48	45.11	59.02	45.96	51.75	44.49	46.15
LBW	Low birth weight rate (LBW below 2500 g)	8.64	6.50	5.24	5.49	6.31	6.58	7.37	6.67	7.55
SAR	Spontaneous abortion ratio	67.12	59.76	62.59	61.65	77.11	58.95	60.24	58.55	62.98
CMm	Crude mortality rate (Men)	13.29	13.50	13.92	12.29	11.25	15.44	15.31	13.71	14.76
CMw	Crude mortality rate (Women)	10.22	9.87	10.40	9.31	8.38	11.74	11.82	10.51	9.07
SMRp	Indirect standardization: Standardized Mortality Ratio (Population)	108.32	101.03	98.39	97.99	98.48	108.05	105.62	104.63	100.00
SMRm	Indirect standardization: Standardized Mortality Ratio (Men)	109.60	102.50	100.22	97.63	99.27	111.07	106.84	104.47	100.00
SMRw	Indirect standardization: Standardized Mortality Ratio (Women)	108.43	99.43	96.02	98.85	97.62	106.60	105.27	105.73	100.00
PPDm	Proportion of prematerue deaths – M en (under 65)	33.73	34.18	31.55	33.16	34.02	32.19	30.12	32.22	33.67
PPDw	Proportion of prematerue deaths – Women (under 65)	18.17	17.97	15.59	16.53	17.87	15.87	14.22	16.79	17.53
PPDNCp	Proportion of prematerue deaths – natural causes (under 65)	26.20	25.43	23.81	24.76	25.92	24.36	22.74	24.68	23.37
PYLL1m	PYLL per 1 man death (Potential years of life lost)	4.95	5.06	4.60	4.99	5.44	4.68	4.29	4.72	4.68
PYLL1w	PYLL per 1 woman death	2.46	2.54	2.12	2.41	2.71	2.15	1.83	2.29	2.19
PYLL100	PYLL per 100.000 of population	4,360.96	4,436.38	3,985.16	3,985.46	3,874.38	4,586.18	4,040.81	4,181.55	4,033.00
PYLLC	PYLL due to malignant neoplasms per 100.000 of population	1,058.67	1,001.67	982.93	927.37	908.76	1,096.28	997.06	1,102.35	1,005.20
ReC	Deaths per 100, 000, malignant neoplasms	209.46	209.57	219.17	195.96	177.99	236.28	233.43	231.99	212.79
ReE	Deaths per 100.000, endocrine, nutirtional and metabolic diseases	17.30	13.74	14.98	13.90	12.65	17.61	17.71	15.38	14.43
Rel	Deaths per 100.000, diseases of the circulatory system	569.73	551.58	572.02	505.07	463.32	638.78	665.98	567.77	531.05
SMRC	Standardized Mortality Ratio – Malignant neoplasms	101.78	96.34	96.95	95.18	95.03	102.91	99.37	106.96	100.00
SMRC1526	Standardized Mortality Ratio – Malignant neoplasms of digestive organs	98.90	97.23	96.57	97.86	94.11	102.20	100.87	106.83	100.00
SMRC3039	Standardized Mortality Ratio – Malignant neoplasms of respiratory and intrathoracic organs	101.43	95.30	99.03	92.00	97.37	102.36	106.43	109.80	100.00
SMRI2125	Standardized Mortality Ratio – Ischaemic heart diseases (myocardial infarction and chronic ischaemic heart disease)	128.21	103.65	95.82	97.54	109.94	101.39	108.18	97.41	100.00
SMRI6364	Standardized Mortality Ratio – cerebral infarction and strokes	84.78	119.47	102.53	121.31	72.61	125.53	120.72	112.39	100.00
SMRJ	Standardized Mortality Ratio – Diseases of the respiratory system (no neoplasms)	124.81	109.87	113.74	100.61	109.39	126.34	96.00	98.68	100.00
SMRK	Standardized Mortality Ratio – Diseases of the digestive system (no neoplasms)	94.92	101.14	90.24	94.23	84.31	130.61	107.22	107.98	100.00
sum24neg	Sum of 24 negative indicators (LWB – SMRK)	7,462.11	7,413.69	6,933.59	6,791.56	6,584.24	7,864.16	7,179.47	7,324.05	6,957,83

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

Geological unit	1	2	3	4	5	6	7	8	Geological unit	1	2	3	4	5	6	7	8
-							/		AI	7.34	7.01	5.74	5.79	5.63	6.50	5.64	5.75
рН	7.18	6.98	7.53	7.47	7.50	7.16	7.25	7.24	As	62.25	15.56	20.36	11.44	8.93	10.13	10.64	8.30
TDS	302.27	242.70	496.12	586.79	524.64	439.73	767.13	874.19	В	96.65	53.18	72.65	81.31	68.03	46.51	63.17	62.14
	1.88	1.98	1.81	2.06	2.05	1.95	2.36	2.52	Ba	473.07	507.31	355.39	376.74	369.32	428.53	383.16	392.3
Ca+Mg	1.68	1.30	3.00	3.45	3.02	2.11	4.26	4.78	Be	1.69	1.65	1.44	1.47	1.31	1.33	1.36	1.37
Li	0.007	0.006	0.010	0.018	0.020	0.013	0.031	0.025	Bi	1.43	0.48	0.51	0.41	0.39	0.42	0.29	0.27
Na	8.53	7.44	7.44	12.79	12.74	16.09	25.99	34.46	Са	0.81	1.15	2.13	1.34	0.77	1.11	1.27	2.10
K	4.59	3.71	4.32	6.32	6.22	9.47	11.75	19.81	Cd	0.62	0.47	0.64	0.51	0.78	1.22	0.34	0.35
Ca	43.15	35.41	84.64	99.86	88.53	56.13	107.58	120.99	Се	76.63	68.50	64.22	64.35	61.69	63.54	66.85	65.14
Mg	14.70	10.05	21.69	23.27	19.67	17.14	38.40	42.86	Со	11.90	15.30	14.48	11.53	11.42	12.29	10.26	11.00
Sr -	0.144	0.154	0.295	0.362	0.355	0.246	0.388	0.466	Cr	48.40	70.40	85.08	87.10	110.68	63.15	86.23	85.52
Fe	0.192	0.090	0.093	0.114	0.089	0.210	0.177	0.270	Cu	90.50	23.99	28.87	35.47	22.82	22.33	19.39	22.24
Mn	0.072	0.037	0.041	0.057	0.063	0.122	0.138	0.201	F	378.36	374.23	416.63	357.63	312.27	265.16	313.76	329.6
NH <sub>4</sub>	0.074	0.082	0.077	0.068	0.072	0.100	0.092	0.137	Fe	3.21	3.00	2.68	2.65	2.52	3.23	2.56	2.66
F	0.11	0.09	0.10	0.12	0.11	0.11	0.17	0.17	Hg	1.66	0.27	0.25	0.47	0.20	0.20	0.11	0.08
CI	13.18	10.27	14.21	21.24	17.14	21.66	46.57	58.50	K	2.05	1.87	1.66	1.73	1.74	1.55	1.64	1.67
SO <sub>4</sub>	45.65	34.48	50.30	65.38	62.72	49.70	89.91	119.83	Mg	0.74	0.92	1.25	0.89	0.67	0.67	0.73	1.01
NO <sub>2</sub>	0.07	0.08	0.04	0.08	0.10	0.09	0.10	0.16	Mn	0.10	0.08	0.08	0.08	0.08	0.09	0.07	0.07
NO <sub>3</sub>	18.02	14.82	17.80	21.72	16.19	26.44	62.46	69.36	Мо	0.73	0.72	0.87	0.63	0.84	0.58	0.60	0.54
PO <sub>4</sub>	0.10	0.09	0.09	0.10	0.05	0.37	0.33	0.37	Na	0.82	1.15	0.72	0.81	0.85	0.89	0.86	0.85
HCO <sub>3</sub>	138.29	107.37	285.84	323.63	287.65	191.51	355.32	386.33	Ni	24.46	22.63	33.71	34.96	34.07	16.81	26.15	29.59
SiO <sub>2</sub>	13.72	15.95	9.61	12.34	11.26	41.72	22.98	19.17	Ρ	0.09	0.09	0.08	0.07	0.07	0.07	0.07	0.08
Cr	0.00107	0.00093	0.00091	0.00090	0.00095	0.00234	0.00127	0.00157	Pb	80.76	36.00	41.80	28.34	24.75	40.87	24.72	21.04
Cu	0.00332	0.00185	0.00193	0.00256	0.00167	0.00272	0.00244	0.00351	Sb	46.37	3.68	6.15	3.46	1.31	1.87	3.16	0.93
Zn	0.12576	0.08212	0.10279	0.23097	0.13470	0.23021	0.35242	0.45639	Se	0.15	0.15	0.15	0.18	0.18	0.13	0.13	0.16
As	0.00863	0.00256	0.00317	0.00135	0.00079	0.00241	0.00164	0.00161	Sn	5.96	4.52	4.32	4.86	5.23	4.16	4.78	4.43
Cd	0.00050	0.00119	0.00238	0.00052	0.00062	0.00127	0.00103	0.00094	Sr	85.85	139.91	89.73	92.38	88.49	113.21	96.72	110.7
Se	0.00063	0.00069	0.00069	0.00074	0.00068	0.00086	0.00130	0.00134	V	85.84	84.33	77.54	79.59	77.21	98.08	71.92	75.06
Pb	0.00142	0.00139	0.00142	0.00121	0.00125	0.00134	0.00146	0.00143	W	1.26	1.05	1.03	0.88	0.85	1.08	0.85	0.85
Hg	0.00015	0.00012	0.00015	0.00014	0.00013	0.00012	0.00012	0.00016	Zn	77.65	81.67	83.93	74.21	71.71	86.76	84.45	69.93
Ва	0.04953	0.06077	0.07130	0.09801	0.06656	0.05056	0.07867	0.09005	рН <sub>н20</sub>	5.38	5.37	6.42	6.30	5.71	5.98	6.46	6.89
ΑΙ	0.03162	0.04989	0.02627	0.02122	0.02170	0.05330	0.03644	0.02596	рН <sub>ксі</sub>	4.54	4.66	5.77	5.47	4.96	5.11	5.58	6.23
Sb	0.00720	0.00049	0.00365	0.00034	0.00062	0.00025	0.00031	0.00028	carbonates	0.73	1.03	4.19	2.68	0.97	1.12	1.33	4.13

# CONCLUSION

The results presented show that there are significant differences in health status of the population of the Slovak Republic in relation with diversity of geological structure and thus various geochemical backgrounds. Geological environment of Paleogene Flysch rocks (sandstones, shales, claystones) has been determined as the most favourable geologic unit for human health, while geological environment of Neogene volcanics (andesites, basalts) as the least favourable one. Overall, in terms of population health, silicate rocks - Neovolcanic rocks (andesites, basalts), Crystalline (mainly granites, migmatites and gneisses) and Paleozoic (metasediments, metavolcanics) are considered less favourable. On the contrary, with regard to human health carbonatic environments are seen as the most favourable.

Note: data in mg.l<sup>-1</sup>, except of pH and Ca+Mg in mmol.l<sup>-1</sup>

Note: macroelements in %, microelements in mg.kg<sup>-1</sup>



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