

# Historické dŕlní oblasti a jejich vliv na lidské zdraví

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**GEOHEALTH**

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



38. Česko-Slovenský hydrogeochemický seminář,  
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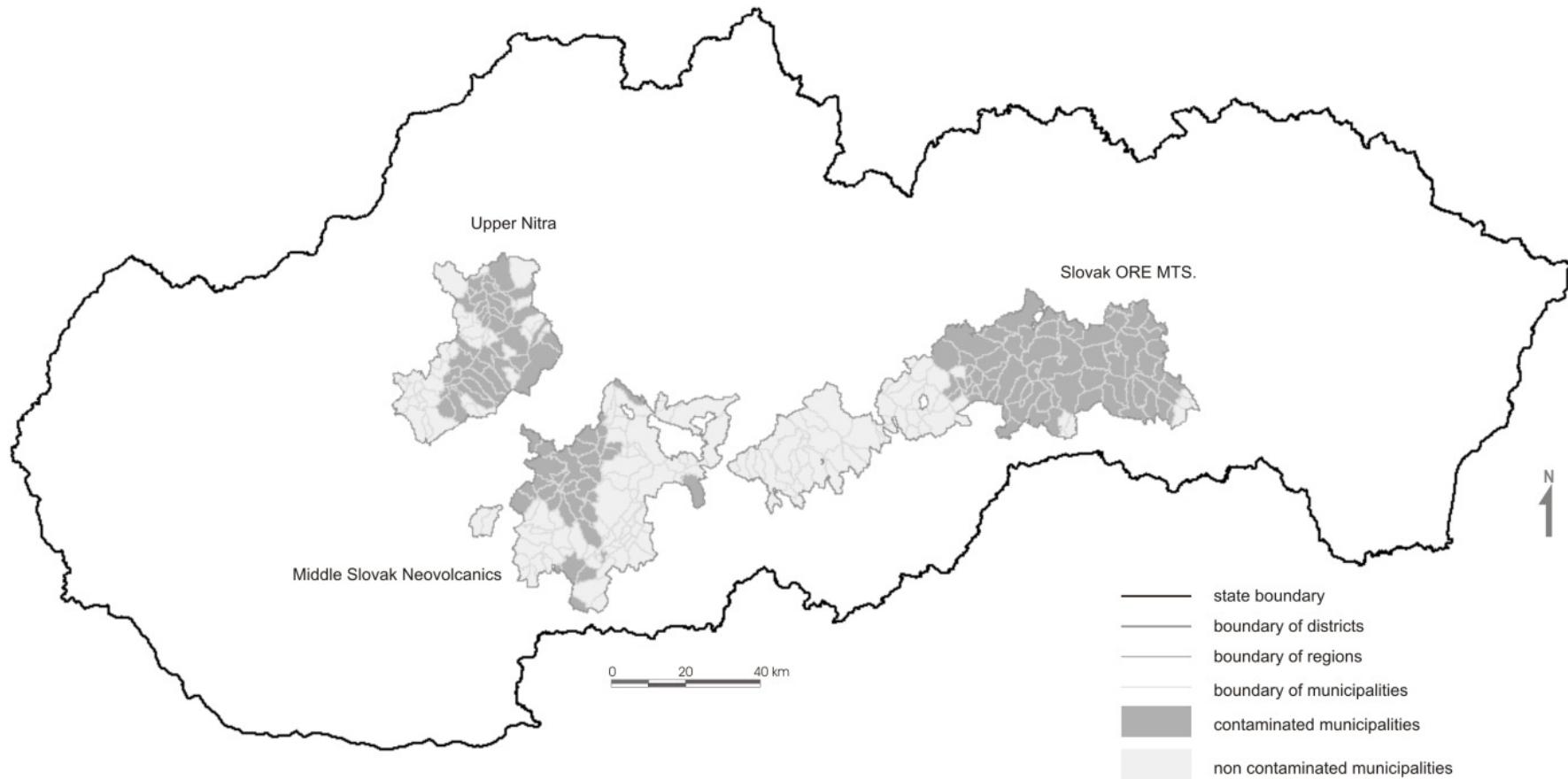
The main objective of this study was to assess how, and to what extent, the PTE contamination of the geological environment might influence the health status of residents living in the historical mining areas.

Impact of potentially toxic elements (PTE) on health status of population has been studied in three historical mining areas

# Middle Slovak Neovolcanics Slovak Ore Mts. Upper Nitra region



# Contaminated and non-contaminated areas of the Slovak Republic



# AREA DESCRIPTION

## Middle Slovak Neovolcanics

ore extraction from middle age Pb, Zn, Cu, As, Au,

neogene andesites, basalts and their pyroclastics

## Slovak Ore Mts.

ore extraction from middle age As, Sb, Pb, Zn, Cu, Hg, Au

paleozoic, metamorphic rocks (metavolcanics, metasediments) and various magmatic rocks

## Upper Nitra region

- brown coal extraction more 100 years As: 0.8-0.9 %, S: 2 %
- power plant from 1993 intensive filters, decrease of emissions about 98 %

tertiary sediments (sandstones, clays, silts) in depression surrounded core and volcanic mountains

# MATERIAL

Set of the environmental indicators (mainly PTE) for soils and ground/drinking water and health indicators (43) for each 138 contaminated and 155 non-contaminated municipalities (from Slovak national data, [www.geology.sk/geohealth](http://www.geology.sk/geohealth))

## ENVIRONMENTAL INDICATORS (from national geochemical databases)

- data were recalculated to mean values for each of evaluated municipality

## HEALTH INDICATORS (from Statistical office of the Slovak Republic)

- data represents 10 years mean value (1994-2003)
- data were recalculated and standardized for each of evaluated municipality)
- health indicators were compiled according to ICD 10th Revision ([www.nczisk.sk](http://www.nczisk.sk))

## Evaluated health indicators of the Slovak Republic

| No.  | Indicator | Description of indicator                         | Method of calculation  | Unit                                  | Mean SR |
|--|-----------|--|--|---------------------------------------|---------|
| <b>Demographic indicators describing age structure of municipalities</b> |           |  |  |                                       |         |
| 1  | LEp       | life expectancy at birth – population            | cumulative calculation of all years of life  |                                       | 72.60   |
| 2  | LEm       | life expectancy at birth – men                   | during lifetime / No. of living persons at   | years                                 | 67.44   |
| 3  | LEw       | life expectancy at birth – women                 | the beginning of the year  |                                       |         |
| 4  | A60+      | proportion of population at age 60 and more      | 100 x (number of people aged 60 and over / number of inhabitants)  | %                                     | 15.38   |
| <b>Crude mortality, premature</b>  |           |  |  |                                       |         |
| 5  | SMRp      | population                                       | indirect age-standardized mortality rate of  |                                       | 100     |
| 6  | SMRm      | men  | inhabitants to the Slovak standard   | %                                     | 100     |
| 7  | SMRw      | women  | (19 age groups)  |                                       | 100     |
| 8  | PYLL100   | potential years of lost life                     | 100, 000 x [the sum of the years of people up to the age of nearly 65 years (deaths at age between 1 to 64 years) / number of inhabitants] | years                                 | 4,033.0 |
| <b>Relative mortality for selected cause of death</b>                    |           |  |  |                                       |         |
| 9  | ReC00-C97 | malignant neoplasms                              |  |                                       | 212.79  |
| 10   | ReC15-C26 | malignant neoplasms of gastrointestinal system   |  |                                       | 76.14   |
| 11   | ReC16     | malignant neoplasms of stomach                   |  |                                       | 15.20   |
| 12   | ReC18-C20 | malignant neoplasms of colon and rectum          |  |                                       | 24.24   |
| 13   | ReC30-C39 | malignant neoplasms of respiratory system        |  |                                       | 45.19   |
| 14   | ReC50     | malignant neoplasms of breast                    |  |                                       | 24.80   |
| 15   | ReC64-C68 | malignant neoplasms of urinary system            |  |                                       | 11.25   |
| 16   | ReC81-C96 | malignant neoplasms of organs for haematopoiesis |  |                                       | 13.28   |
| 17   | ReC91-C95 | all leukemia                                     | 100 000 x [No. of deaths for selected  | No. of deaths per 100 000 inhabitants | 6.20    |
| 18   | ReC00-D48 | all neoplasms                                    | cause / number of inhabitants]   |                                       |         |
| 19   | ReE00-E99 | endocrine, nutritional and metabolic diseases    |  |                                       | 14.38   |
| 20   | ReI00-I99 | diseases of the circulatory system               |  |                                       | 531.05  |
| 21   | ReI21-I25 | ischaemic heart disease                          |  |                                       | 269.82  |
| 22   | ReI63-I64 | cerebral infarction and strokes                  |  |                                       | 63.57   |
| 23   | ReJ00-J99 | diseases of respiratory system                   |  |                                       | 58.08   |
| 24   | ReK00-K93 | diseases of the digestive system                 |  |                                       | 45.83   |
| 25   | ReN00-N99 | diseases of urinary and reproductive system      |  |                                       | 13.69   |

## Evaluated health indicators of the Slovak Republic

| No.   | Indicator   | Description of indicator                         | Method of calculation  | Unit  | Mean SR  |
|---|-------------|--|--|-------|----------|
| <b>Standardized mortality for selected cause of death</b>       |             |  |  |       |          |
| 26  | SMRC00-C97  | malignant neoplasms                              |  |       | 100      |
| 27  | SMRC15-C26  | malignant neoplasms of gastrointestinal system   |  |       | 100      |
| 28  | SMRC30-C39  | malignant neoplasms of respiratory system        |  |       | 100      |
| 29  | SMRC81-C96  | malignant neoplasms of organs for haematopoiesis |  |       | 100      |
| 30  | SMRE00-E99  | endocrine, nutritional and metabolic diseases    | indirect age-standardized mortality rate of inhabitants to the Slovak standard (19 age groups)   |       | 100      |
| 31  | SMRI00-I99  | diseases of the circulatory system               |  | %     | 100      |
| 32  | SMRI21-I25  | ischaemic heart disease                          |  |       | 100      |
| 33  | SMRI63-I64  | cerebral infarction and strokes                  |  |       | 100      |
| 34  | SMRJ00-J99  | diseases of respiratory system                   |  |       | 100      |
| 35  | SMRK00-K93  | diseases of the digestive system                 |  |       | 100      |
| 36  | SMRN00-N99  | diseases of urinary and reproductive system      |  |       | 100      |
| <b>Potential years of lost life for selected cause of death</b> |             |  |  |       |          |
| 37  | PYLLC00-C97 | malignant neoplasms                              |  |       | 1,005.20 |
| 38  | PYLLC15-C26 | malignant neoplasms of gastrointestinal system   |  |       | 242.26   |
| 39  | PYLLC30-C39 | malignant neoplasms of respiratory system        | 100, 000 x [the sum of the years of people up to the age of nearly 65 years (deaths at age between 1 to 64 years) / number of inhabitants] |       | 186.2    |
| 40  | PYLLI00-I99 | diseases of the circulatory system               |  | years | 866.19   |
| 41  | PYLLI21-I25 | ischaemic heart disease                          |  |       | 396.32   |
| 42  | PYLLJ00-J99 | diseases of respiratory system                   |  |       | 172.69   |
| 43  | PYLLK00-K93 | diseases of the digestive system                 |  |       | 334.80   |



# Methods

In historical mining regions health status of residents living in contaminated and non-contaminated areas was compared.

Compared areas:

- Similar geological structure
- Similar socioeconomic level of resident population
- Only difference – in PTE contents



Unemployment rates in assessed areas in 2001 and 2011

| Region                     | unemployment rate in % |       |                       |       |
|----------------------------|------------------------|-------|-----------------------|-------|
|                            | Contaminated area      |       | Non contaminated area |       |
|                            | 2001                   | 2011  | 2001                  | 2011  |
| Upper Nitra                | 19.09                  | 14.81 | 19.14                 | 15.20 |
| Slovak Ore Mts.            | 27.32                  | 25.65 | 32.20                 | 25.78 |
| Middle Slovak Neovolcanics | 25.90                  | 23.19 | 24.21                 | 24.86 |
| Slovak Republic            | 2001                   |       | 2011                  |       |
|                            | 19.2                   |       | 13.6                  |       |

Source: [www. statistics.sk](http://www.statistics.sk)

# Methods

Contaminated and non-contaminated areas were delineated based on PTE contents in **soils** (Slovak limits for soils)

PTE groundwater/drinking water contents were similar, relatively low and in major cases below the limit values for Slovak Drinking Water Standards

# Results

Selected values of environmental indicators in contaminated and non-contaminated areas of the Slovak Republic  
(mean values for all municipalities)

|                | MIDDLE SLOVAK NEOVOLCANICS |                       | UPPER NITRA       |                       | SLOVAK ORE MTS.   |                       |
|----------------|----------------------------|-----------------------|-------------------|-----------------------|-------------------|-----------------------|
|                | Contaminated area          | Non contaminated area | Contaminated area | Non contaminated area | Contaminated area | Non contaminated area |
| Soils          |                            |                       |                   |                       |                   |                       |
| As             | 11.03                      | 7.06                  | 32.38             | 16.90                 | 96.68             | 13.14                 |
| Cd             | 3.34                       | 0.60                  | 0.24              | 0.34                  | 0.79              | 0.31                  |
| Cu             | 35.67                      | 19.18                 | 19.15             | 17.91                 | 139.89            | 22.68                 |
| Hg             | 0.16                       | 0.08                  | 0.15              | 0.10                  | 3.03              | 0.18                  |
| Pb             | 91.42                      | 29.63                 | 37.65             | 29.95                 | 118.34            | 26.26                 |
| Sb             | 2.96                       | 1.53                  | 1.23              | 0.97                  | 76.79             | 2.36                  |
| Zn             | 134.14                     | 78.40                 | 88.32             | 72.75                 | 89.81             | 74.59                 |
| Ca             | 1.14                       | 0.96                  | 1.47              | 1.55                  | 0.65              | 0.91                  |
| Mg             | 0.73                       | 0.59                  | 0.95              | 0.91                  | 0.69              | 0.84                  |
| carbonate<br>s | 0.86                       | 1.21                  | 1.74              | 2.14                  | 0.62              | 0.22                  |
| Groundwater    |                            |                       |                   |                       |                   |                       |
| As             | 0.00194                    | 0.00160               | 0.02096           | 0.00194               | 0.01217           | 0.00165               |
| Cd             | 0.00139                    | 0.00286               | 0.00444           | 0.00818               | 0.00054           | 0.00205               |
| Cu             | 0.00263                    | 0.00239               | 0.00129           | 0.00169               | 0.00413           | 0.00112               |
| Hg             | 0.00014                    | 0.00012               | 0.00015           | 0.00014               | 0.00016           | 0.00013               |
| Pb             | 0.00198                    | 0.00106               | 0.00107           | 0.00193               | 0.00163           | 0.00104               |
| Sb             | 0.00024                    | 0.00021               | 0.00019           | 0.00023               | 0.00941           | 0.00048               |
| Zn             | 0.17592                    | 0.25344               | 0.20046           | 0.15462               | 0.12486           | 0.12066               |
| Ca             | 43.87                      | 48.98                 | 63.32             | 93.82                 | 38.33             | 33.02                 |
| Mg             | 11.75                      | 13.25                 | 18.65             | 25.72                 | 14.09             | 9.88                  |
| Ca+Mg          | 1.58                       | 1.77                  | 2.34              | 3.40                  | 1.54              | 1.23                  |

Contents of PTE in soils are significantly 2-5 x higher in contaminated areas

Characteristics of population health status  
in contaminated and non-contaminated areas  
(data recalculated according to number  
of inhabitants in respective municipalities)

|           | MIDDLE SLOVAK NEOVOLCANICS |           | SLOVAK ORE MTS. |           | UPPER NITRA |          |
|-----------|----------------------------|-----------|-----------------|-----------|-------------|----------|
|           | 1*                         | 2*        | 1*              | 2*        | 1*          | 2*       |
| LEp       | 71.10                      | 70.99     | 71.12           | 71.53     | 73.55       | 73.45    |
| LEm       | 65.78                      | 66.10     | 66.49           | 66.99     | 69.75       | 69.62    |
| LEw       | 75.96                      | 75.65     | 72.88           | 74.95     | 77.06       | 77.13    |
| A60+      | 18.16                      | 17.89     | 15.31           | 16.91     | 17.87       | 17.99    |
| SMRp      | 112.40                     | 112.15    | 112.25          | 110.32    | 94.98       | 94.38    |
| SMRm      | 122.67                     | 117.58    | 115.75          | 111.37    | 94.07       | 91.57    |
| SMRw      | 105.94                     | 107.21    | 110.60          | 109.88    | 94.74       | 96.03    |
| PYLL100   | 5,244.41                   | 5,049.83  | 4,527.48        | 4,985.29  | 3 485.95    | 3 504.16 |
| ReC       | 252.60                     | 240.31    | 211.78          | 229.03    | 223.96      | 238.11   |
| ReC1526   | 85.26                      | 96.23     | 70.73           | 72.94     | 77.28       | 94.21    |
| ReC16     | 14.24                      | 20.72     | 14.30           | 15.34     | 22.60       | 20.90    |
| ReC1820   | 27.41                      | 32.32     | 24.46           | 20.60     | 23.02       | 28.49    |
| ReC3039   | 55.44                      | 46.94     | 45.58           | 51.67     | 50.09       | 43.19    |
| ReC50     | 21.46                      | 29.31     | 24.51           | 33.53     | 23.87       | 24.96    |
| ReC6468   | 16.07                      | 8.46      | 12.02           | 13.40     | 9.60        | 10.98    |
| ReC8196   | 14.07                      | 13.98     | 12.75           | 15.26     | 11.66       | 12.74    |
| ReC9195   | 6.05                       | 8.11      | 6.13            | 6.74      | 4.78        | 5.21     |
| ReC00D48  | 241.58                     | 242.61    | 212.62          | 229.40    | 223.83      | 240.48   |
| ReE       | 21.52                      | 16.63     | 17.45           | 16.49     | 20.92       | 14.73    |
| ReI       | 760.28                     | 668.37    | 582.93          | 682.26    | 613.95      | 617.30   |
| ReI2125   | 392.94                     | 310.74    | 355.31          | 363.62    | 288.70      | 280.75   |
| ReI6364   | 141.29                     | 108.41    | 46.26           | 126.98    | 55.71       | 79.70    |
| ReJ       | 82.12                      | 101.82    | 73.29           | 79.76     | 52.40       | 49.87    |
| ReK       | 87.79                      | 74.58     | 42.05           | 48.67     | 52.40       | 42.30    |
| ReN       | 17.62                      | 15.99     | 11.57           | 17.83     | 12.21       | 10.66    |
| SMRC      | 103.88                     | 100.01    | 104.66          | 99.71     | 93.86       | 98.75    |
| SMRC1526  | 98.08                      | 112.33    | 97.17           | 88.23     | 90.88       | 107.90   |
| SMRC3039  | 114.40                     | 93.69     | 110.51          | 102.84    | 98.88       | 83.05    |
| SMRC8196  | 91.45                      | 92.29     | 97.83           | 110.76    | 79.44       | 87.30    |
| SMRE      | 119.57                     | 103.60    | 131.67          | 109.24    | 129.10      | 89.61    |
| SMRI      | 119.99                     | 108.75    | 114.98          | 116.24    | 98.25       | 98.33    |
| SMRI2125  | 100.30                     | 104.62    | 137.26          | 118.20    | 91.62       | 86.94    |
| SMRI6364  | 168.81                     | 140.90    | 74.89           | 174.76    | 75.50       | 102.84   |
| SMRJ      | 113.31                     | 146.33    | 132.39          | 129.35    | 77.81       | 72.34    |
| SMRK      | 127.85                     | 151.96    | 99.01           | 96.85     | 96.77       | 82.22    |
| SMRN      | 114.16                     | 101.85    | 89.87           | 118.10    | 78.32       | 63.89    |
| PYLLC     | 1,216.72                   | 1,101.53  | 1,062.55        | 1,126.65  | 925.65      | 975.03   |
| PYLLC1526 | 306.04                     | 277.58    | 220.23          | 272.70    | 201.33      | 280.05   |
| PYIIC3039 | 242.30                     | 227.34    | 200.19          | 232.48    | 193.05      | 151.50   |
| PYIII     | 1,170.12                   | 1,182.35  | 1,116.08        | 1,365.40  | 778.44      | 839.03   |
| PYLLI2125 | 578.20                     | 555.64    | 596.50          | 728.38    | 360.04      | 350.23   |
| PYLLJ     | 245.71                     | 286.85    | 272.24          | 266.66    | 74.51       | 71.90    |
| PYLLK     | 585.14                     | 596.79    | 391.31          | 415.26    | 351.55      | 219.86   |
| sum_neg   | 13,670,19                  | 13,137,34 | 11,679,16       | 13,012,17 | 9,431,74    | 9,461,49 |

Note: 1\* - Contaminated area  
2\* - Non contaminated area  
sum\_neg: SMRV - PYLLK

|                | MIDDLE SLOVAK NEOVOLCANICS |           | SLOVAK ORE MTS. |           | UPPER NITRA |          |
|----------------|----------------------------|-----------|-----------------|-----------|-------------|----------|
|                | 1*                         | 2*        | 1*              | 2*        | 1*          | 2*       |
| <b>ReC</b>     | 252.60                     | 240.31    | 211.78          | 229.03    | 223.96      | 238.11   |
| <b>ReI</b>     | 760.28                     | 668.37    | 582.93          | 682.26    | 613.95      | 617.30   |
| <b>ReJ</b>     | 82.12                      | 101.82    | 73.29           | 79.76     | 52.40       | 49.87    |
| <b>ReK</b>     | 87.79                      | 74.58     | 42.05           | 48.67     | 52.40       | 42.30    |
| <b>ReN</b>     | 17.62                      | 15.99     | 11.57           | 17.83     | 12.21       | 10.66    |
| <b>SMRC</b>    | 103.88                     | 100.01    | 104.66          | 99.71     | 93.86       | 98.75    |
| <b>SMRI</b>    | 119.99                     | 108.75    | 114.98          | 116.24    | 98.25       | 98.33    |
| <b>PYLLC</b>   | 1,216.72                   | 1,101.53  | 1,062.55        | 1,126.65  | 925.65      | 975.03   |
| <b>PYIII</b>   | 1,170.12                   | 1,182.35  | 1,116.08        | 1,365.40  | 778.44      | 839.03   |
| <b>sum_neg</b> | 13,670.19                  | 13,137.34 | 11,679.16       | 13,012.17 | 9,431.74    | 9,461.49 |

Note: 1\* - Contaminated area

2\* - Non contaminated area

sum\_neg: SMRV - PYLLK

# DISCUSSION

No significant differences between health indicators in contaminated and non-contaminated areas were observed in any of the tree regions

## Summary health indicators – sum\_neg

Middle Slovak Neovolcanics  
13,670 – 13,137

Upper Nitra region  
9,431 – 9,461

the same

Slovak Ore Mts.  
11,697 – 13,012  
It is in opposite (better situation is in contaminated area)

# GEOLOGICAL ENVIRONMENT



The most favorable



The most unfavorable

Middle Slovak Neovolcanics, Slovak Ore Mts. - built by silicate rock

Upper Nitra region: 40-45 % flysh sediments, 20 % carbonates  
20 % volcanic rocks, 20 % granitic rocks

# Contents of Mg and Ca

have determining impact on health status of Slovak residents

High contents – favorable status

Low contents – unfavorable status

In Upper Nitra region groundwater as well as soil contents of Ca, Mg are approximately twofold higher.

*Ca, Mg contents in drinking water vs. CVD and oncological mortality*

Mortality in the Slovak Republic

50 % CVD



30 % oncological





# Conclusion

We found no significant impairment of the health of the population living in the areas with higher PTE contamination compared to non-contaminated areas. Surprisingly, no significant differences between the health status of population living in contaminated areas and that living in non-contaminated areas were observed. Finally, we can conclude that if groundwater/drinking waters used for drinking purposes show no PTE contamination, the local population inhabiting these historical mining areas might be at much lower risk than has been, in general, reported so far.

# Thank you for your attention



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38. Česko-Slovenský hydrogeochemický seminář,  
Praha, 9. - 10. 10. 2014



# SEGH 2015

## THE LINKING BETWEEN ENVIRONMENT AND HEALTH

June/July 2015, State Geological Institute of Dionyz Stur, Bratislava, Slovak Republic

The International European Association Society for Geochemistry and Health  
in collaboration with the Slovak association of Geochemists,  
project GEOHEALTH is pleased to announce.

## 31<sup>th</sup> INTERNATIONAL CONFERENCE THE SOCIETY FOR ENVIRONMENTAL GEOCHEMISTRY AND HEALTH



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