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Soil monitoring system in Slovakia – knowledge and experiences

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Soil monitoring

is now a vital component, alongside soil maps and databases, in the quest for information about the soils of a particular region or country. The importance of a monitoring programme is that, if well constructed, it can provide information about how soils are changing with time and can be used to answer questions about whether the quality of a soil is improving, deteriorating or staying about the same under a particular use and management practice.

Thematic Strategy for Soil Protection, EC 2004

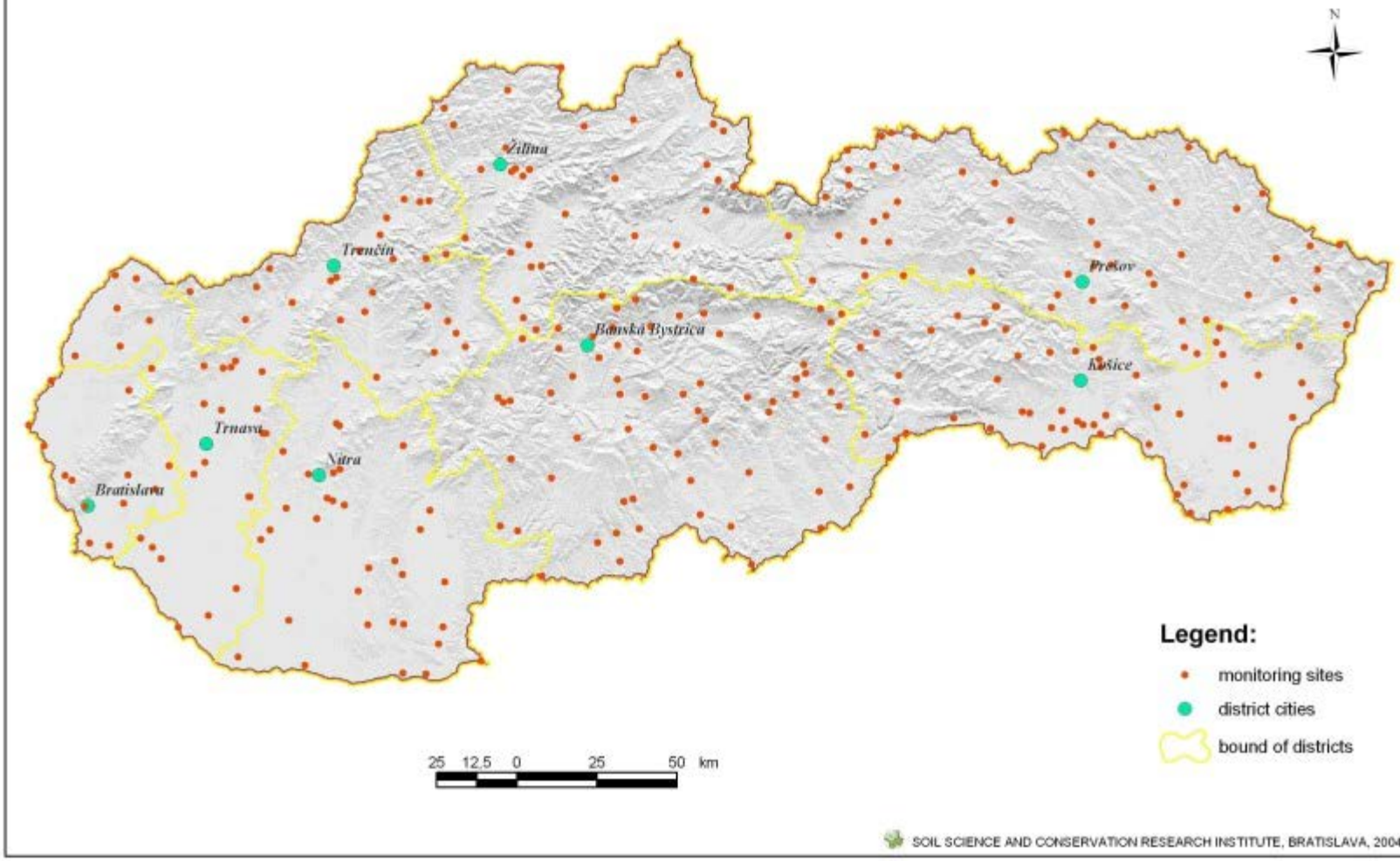
List of the most important resolutions relating to monitoring of environment and soil

- Recommendation of European Council (90)1 on european strategy of environment (1990) where the monitoring of all components of environment was recommended for member countries
- Resolution of the Slovak Government No 449 of May, 1992 with incumbent on Ministry of Slovak Commision for Environment to inform the Slovak Government about development of monitoring and information system realization on environment
- Resolution of the Slovak Government No 620 of September 7, 1993 where the monitoring of environment was passed
- Resolution of the Slovak Government No 7 of January, 2000 where the Conception on next construction and realization of monitoring and information system of environment was passed
- Resolution of the Slovak Government No 664 of August, 2000 where the next realization of monitoring of environment and soil was pased
- Conception of european soil policy and strategy of soil protection as well as sustainable land use was contained in proposal of European Commission (EC) on the 6-th Environmental action programme, which was accepted by European council and European parliament on the 22-nd of July, 2002, where one of the basic strategies is just soil and monitoring of its next development
- Act No 220/2004 Z.z. about protection of agricultural soil and land use, where in item 1 under § 2 and letter d, is given the need of monitoring of agricultural soil
- Importance of soil monitoring in EU is also based on significant european document (EU/COM (2002) 179 final
- On the basis of regulation from the 4-th operative meeting of Ministry for environment of Slovakia from the 13-th of May, 2005, the actual Conception of environment monitoring of Slovakia including soil was passed
- Ratified Conception of actualization and rationalization of environmental monitoring and accepted resolution No 54 from the 4-th operative meeting of Ministry of Environment of Slovakia from the 23-rd of April, 2007
- The need to secure reporting of information on environment monitoring in Slovakia in relation to EEA (European Environmental Agency) and to JRC (Joint Research Centre) in Ispra (Italy). The main aim is the supporting of reliable and independent information about environment including soil

Key points

- construction of soil monitoring network / grid
- identification of soil monitoring sites
- observation of parameters (according to threats to soil)
- harmonised nomenclature and methods of observation recommended by EC
- regular observation in time
- evaluation of actual state and development of soils and their prognosis
- proposals to soil protection and land use on the basis of obtained results

SOIL MONITORING NETWORK ON AGRICULTURAL SOILS IN SLOVAKIA



Soil monitoring system in Slovakia

main features:

- a part of monitoring of environment
- soil monitoring network is constructed on ecological principle (all main soil types and subtypes, soil substrates, climatic regions, polluted and non-polluted regions are included)
- number of monitoring sites: 318
- national sampling strategy: random sampling
- sampling depth: 0 – 10, 20 – 30 and 35 – 45 cm
- monitoring site area: 314 m^2
- sampling strategy: circle (r = 10 m)
- number of subsamples: 5
- disturbed/undisturbed: both
- samples quantities: 3000 – 5000 g
- repetition: 5 years

Site area

A „homogenous“ are for sampling is required. It is recommended to adopt a site area > 100 m^2. On the other hand, on the basis of meta-analysis of in-site variability, adopting areas > 1 ha would, generally, considerably increase the spatial variability.

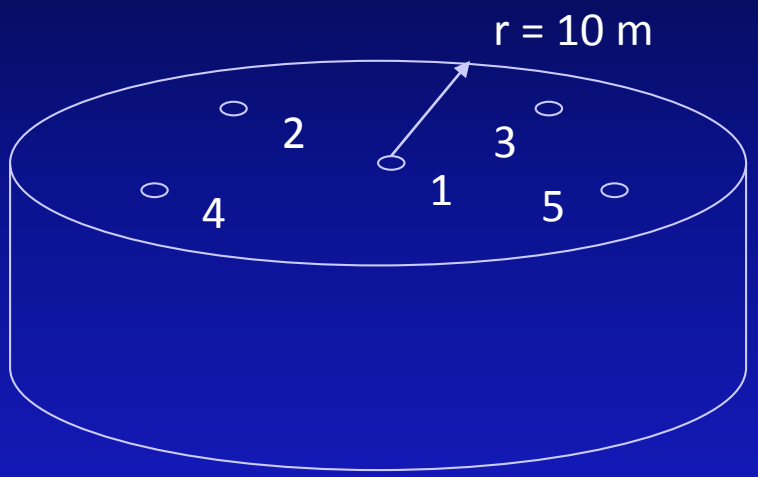
Identification of soil monitoring sites

All monitoring sites are geographically located using GPS (WGS 84). It is necessary for interpretations and creation of outputs using GIS which can be useful for management of soil protection and land use.

Configuration of sampling spots in soil monitoring system in Slovakia

Two types of sampling:

monitoring site area (topsoil)



monitoring site (soil profile)

place of sampling: in the spot 1 of monitoring site area

depth of sampling: arable land (0 – 10 and 35 – 45 cm)

grassland (0 – 10, 20 – 30 and 35 – 45 cm)

Observation of parameters according to threats to soil

- soil organic matter and biodiversity
- soil erosion
- soil contamination
- soil sealing
- soil compaction
- floods and landslides
- salinisation and sodification

Thematic Strategy for Soil Protection, 2004

Threat: **soil contamination**

Monitored indicators:

- arsenic (As)
- cadmium (Cd)
- chromium (Cr)
- copper (Cu)
- mercury (Hg)
- nickel (Ni)
- lead (Pb)
- zinc (Zn)
- cobalt (Co)
- selenium (Se)
- fluorine (F)

Total content (extracted with aqua regia) and bioavailable forms of risk elements are used (extracted with 1 $mol.dm^{-3}$ NH_4NO_3).

In addition, watersoluble fluorine is determined by ionselective electrode.

Threat: **Soil salinisation and sodification**

Monitored indicators:

- total content of salts
- CEC (cation exchange capacity)
- exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+})
- exchangeable anions (CO_3^{2-}, HCO_3^{-}, Cl^{-}, SO_4^{2-})
- EC (electrical conductivity)
- ESP (exchangeable sodium percentage)
- SAR (sodium adsorptium ratio)
- pH/H_2O

Threat: **Decline in soil organic matter**

Monitored indicators:

- Corg
- HA/FA
- Q^4_6

Fractional composition of HA:

- elementary analyses (C, H, N, O)
- ^{13}C NMR analyses (C_{alif}, C_{ar})

Threat: **Soil compaction**

Monitored indicators:

- bulk density
- porosity (P)
- max. capillar capacity (MCC)
- texture (according to FAO)

Threat: **Soil erosion**

Monitored indicators:

- ^{137}Cs
- Corg
- texture
- pH
- available nutrients (P and K)

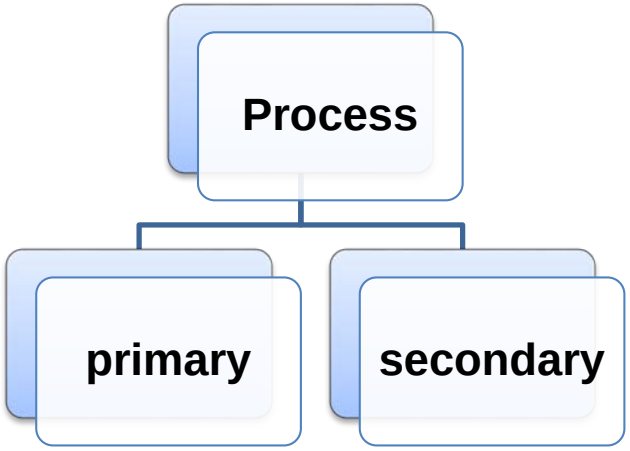
Obtained results (current state)

Salinization and sodification

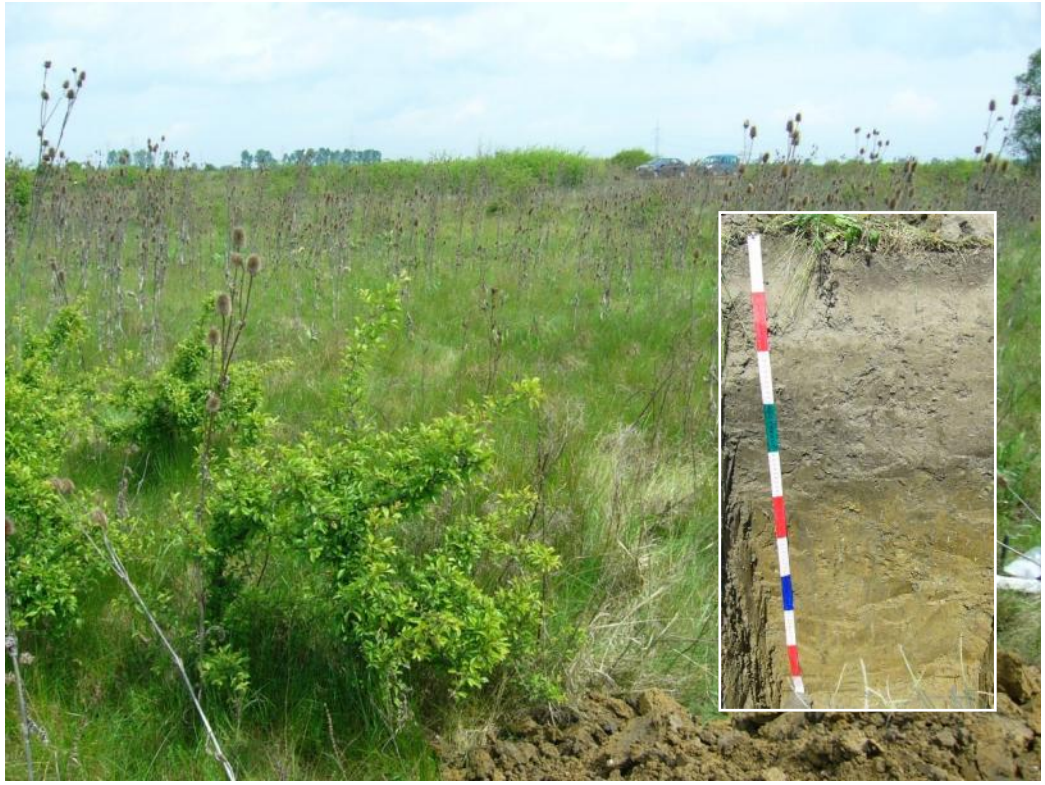
Salinization – process that leads to an excessive increase of water-soluble salts in the soil. The accumulated salts include sodium, potassium, magnesium and calcium, cloride, sulphate, carbonate and bicarbonate.

Sodification – accumulation of Na^+ in the solid and / or liquid phases of the soil as crystallised $NaHCO_3$ or Na_2CO_3 salts (salt´ efflorescens´), ions in the highly alkaline soil pollution (alkalization), or exchangeable ion in the soil absorption complex (exchangeable sodium percentage – ESP).

Eckelmann et al., 2006



SOIL SALINISATION AND SODIFICATION (Malé Raškovce-VSN lowland)



Depth (cm)	Total content of salts (%)	ESP (%)	SAR	ECe ($mS.m^{-1}$)	pH/H_2O
0-10	0.09	7.2	1.2	62	7.6
20-30	0.22	28.7	17.6	77	7.7
35-45	0.29	31.0	19.7	113	8.1
70-80	0.30	31.9	20.6	242	8.4

Processes of salinisation and sodification – actual state and development

- on the basis of obtained results of soil monitoring was indicated that processes of salinisation and sodification are running pararelly under conditions of Slovakia, but the process of sodification seems to be dominant

- concerning the creation, extension and development of salty soils relating to chemical composition of groundwater such risk is the most actual on the lower part of Žitný ostrov (island) between Zlatná na Ostrove and Komárno

- medium to strongly mineralised groundwater on Podunajská nížina (lowland) under evaporation water regime of soil and climate warming presents a potential threat to desertification of this area

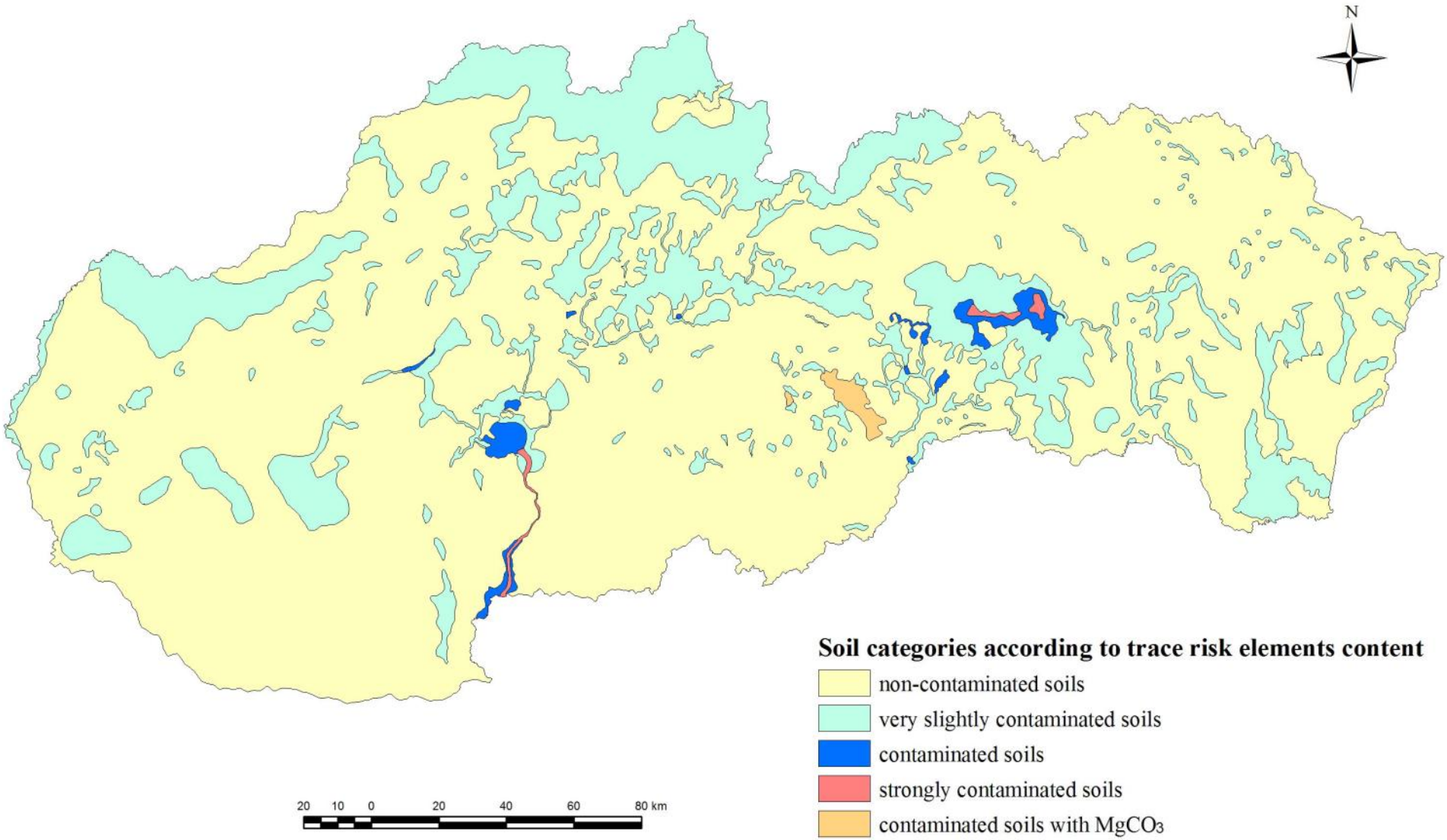
- secondary saline process seems to be more intensive opposite primary saline one (significant change in soil properties as well as in distribution of flora and fauna) also under conditions where these processes normally cannot developed

Soil contamination
Mean concentration of risk trace elements on agricultural soils of Slovakia (mg.kg^{-1})

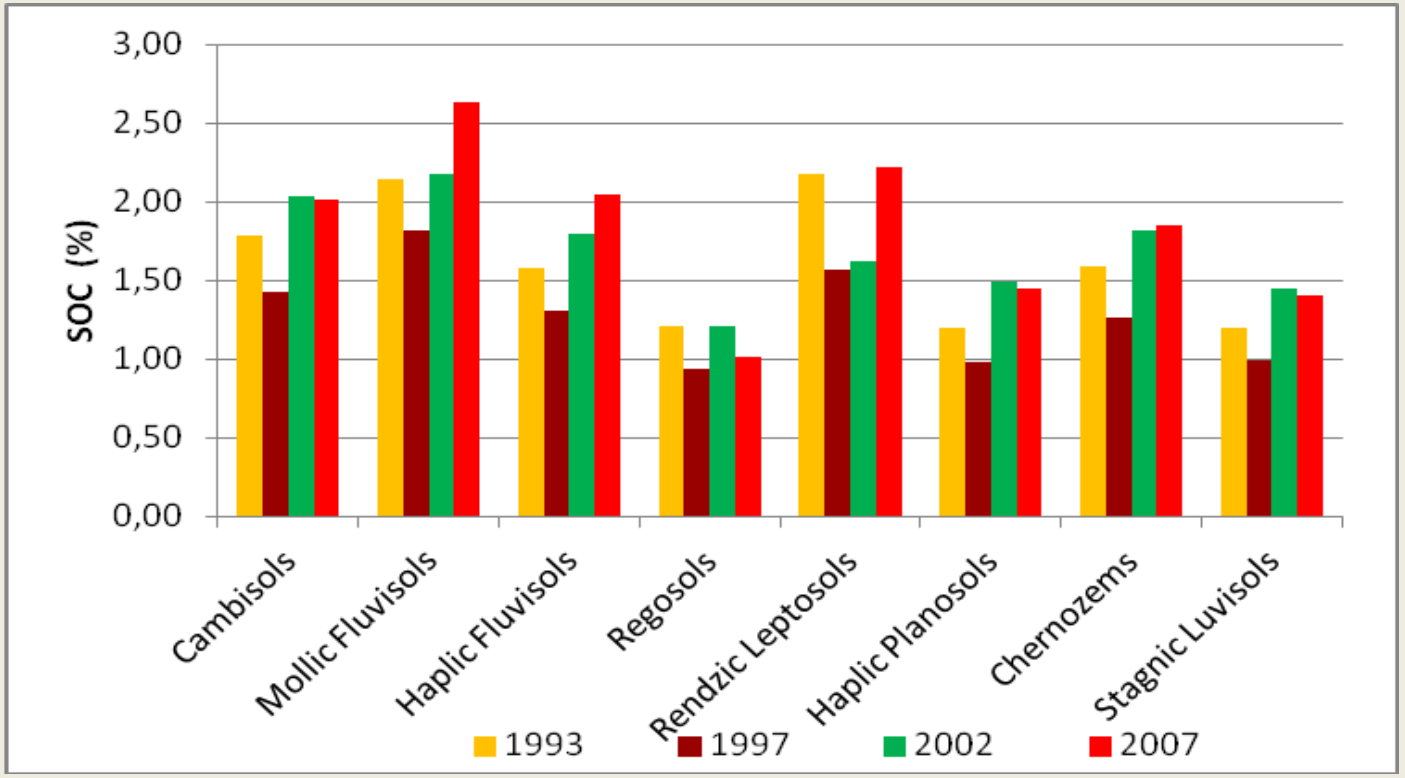
Risk elements / Soil types	As	Cd	Cr	Cu	Ni	Pb	Zn
ČM	1.05	0.15	2.41	10.99	7.38	11.82	9.33
HM	1.10	0.13	2.35	9.58	4.82	11.53	9.19
LM + PG	1.77	0.17	2.89	6.26	2.65	16.32	10.29
FM	3.11	**0.45**	5.03	17.47	6.93	**41.96**	33.98
ČA	1.51	0.22	3.60	13.13	5.93	15.81	15.60
KM	2.03	0.29	3.40	11.42	3.06	18.98	12.62
RA	0.72	**0.40**	3.48	9.48	6.45	22.93	22.43
RM	0.65	0.18	3.32	8.39	1.86	5.32	9.35

ČM – černozeme (Chernozems), HM – hnedozeme (Luvisols), LM – luvizeme (Albic Luvisols), PG – pseudogleje (Planosols), FM – fluvizeme (Fluvisols), ČA – čiernice (Mollic Fluvisols), KM – kambizeme (Cambisols), RA – rendziny (Rendzic Leptosols), RM – regozeme (Regosols)

Soil contamination categories in the Slovak Republic



Development of SOC in topsoil of main arable soils



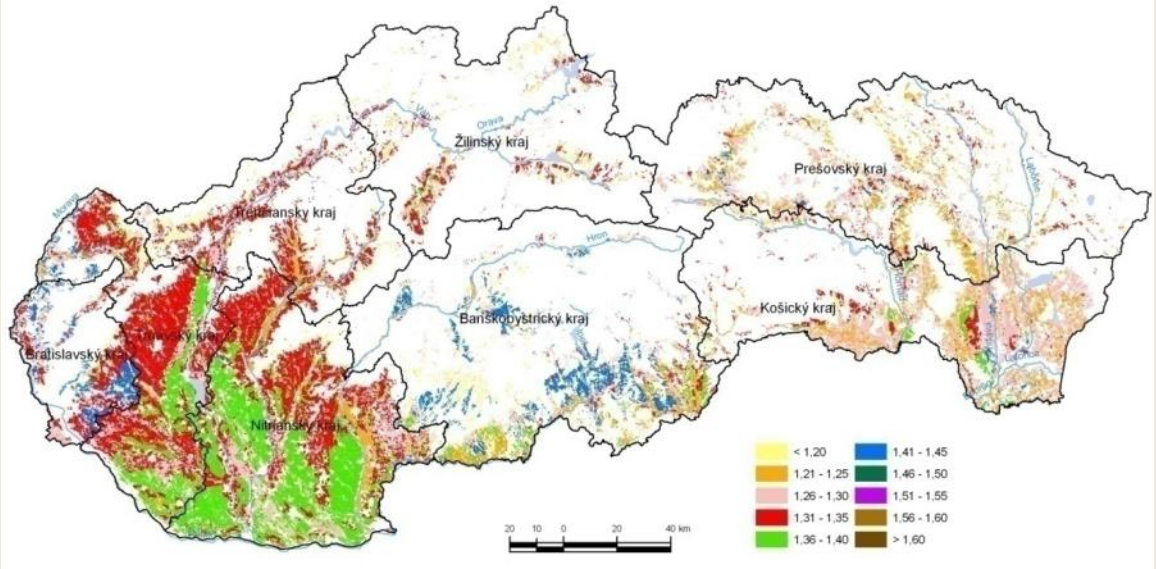
Content of macro- and micronutrients

- decrease of available macronutrients (especially phosphorus and potassium) meanly about 10 – 30 % on agricultural soils was indicated in comparison with 1993 year (starting of soil monitoring system in Slovakia)

- content of available magnesium is good to high on agricultural soils in Slovakia

- content of microelements (Cu, Zn, Mn) is medium to high on agricultural soils in Slovakia

Map of bulk density on topsoil of agricultural soils in Slovakia



Percentage of compacted monitoring sites according to soil types (mean values from 4 previous monitoring cycles)

Soil profile (depth)	**Soil texture**	**ČA**	**ČM**	**FM**	**HM**	**KM**	**PG**
Topsoil (0-10 cm)	sandy	17	-	-	-	-	-
	loamy	25	35	27	27	28	37
	clayey	45	63	38	31	36	35
Subsoil (30-35 cm)	sandy	67	-	-	-	-	-
	loamy	56	46	59	60	72	82
	clayey	72	67	70	90	81	87

Explanations: ČA – Mollic Fluvisol, ČM – Chernozem, FM – Fluvisol, HM – Luvisol, KM – Cambisol, PG – Planosol

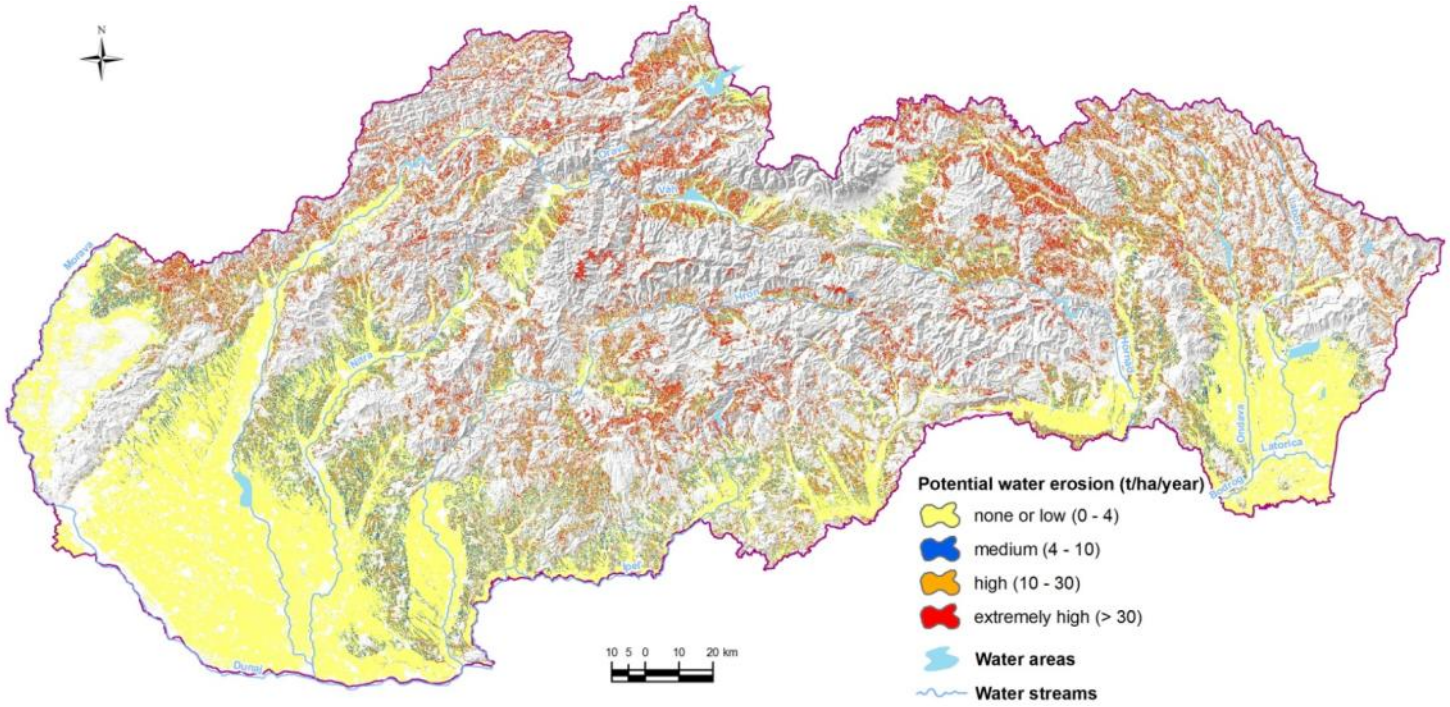
Soil erosion

is the wearing away of the land surface by physical sources such as rainfall, flowing water, wind, ice, temperature change or anthropogenic agents, etc.

Basic methods on soil erosion observation used in Slovakia:

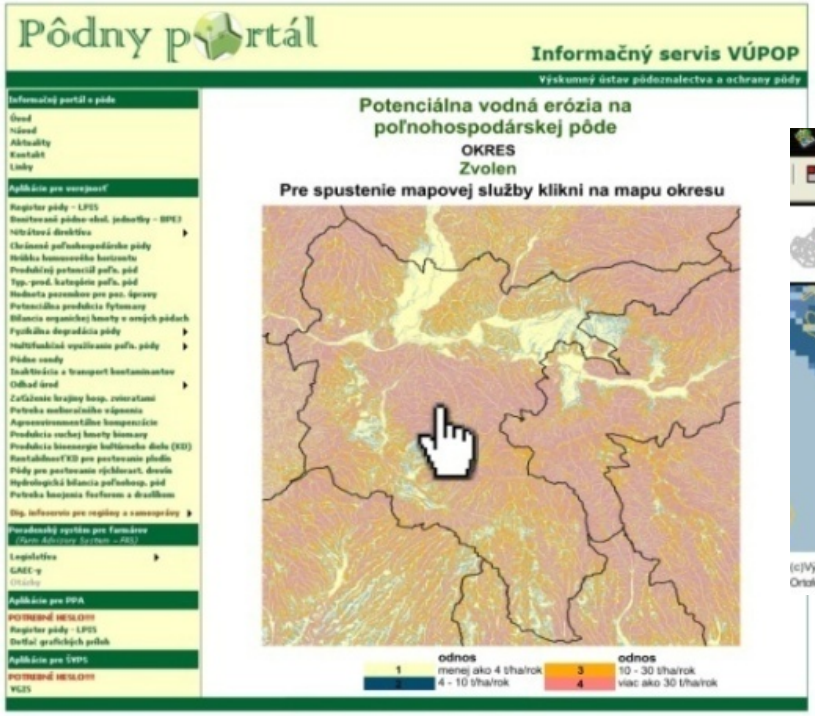
- comparison of various depth of diagnostic horizons and profile changes on selected soil transects
- intensity of recent erosion assessment (using ^{137}Cs)
- using of empirical model of Universal Soil Loss Equation (USLE) modified for the soil-climatic conditions of Slovakia (in GIS)

POTENTIAL WATER EROSION



Categories of erodibility (soil loss)	**Area in ha**	**% of agri. soils**
no, resp. low (0 – 4 t/ha/year)	1 454 925	60.35
medium (4 – 10 t/ha/year)	245 420	10.18
high (10 – 30 t/ha/year)	356 318	14.78
extremely high (more than 30 t/ha/year)	354 149	14.69
Total	**2 410 812**	**100**

The interactive and predictive erosive model was created for the farmers. They can find this model on www.podnemapy.sk. This application is very helpful for the information obtaining on soil erosion intensity and its area distribution, as well.

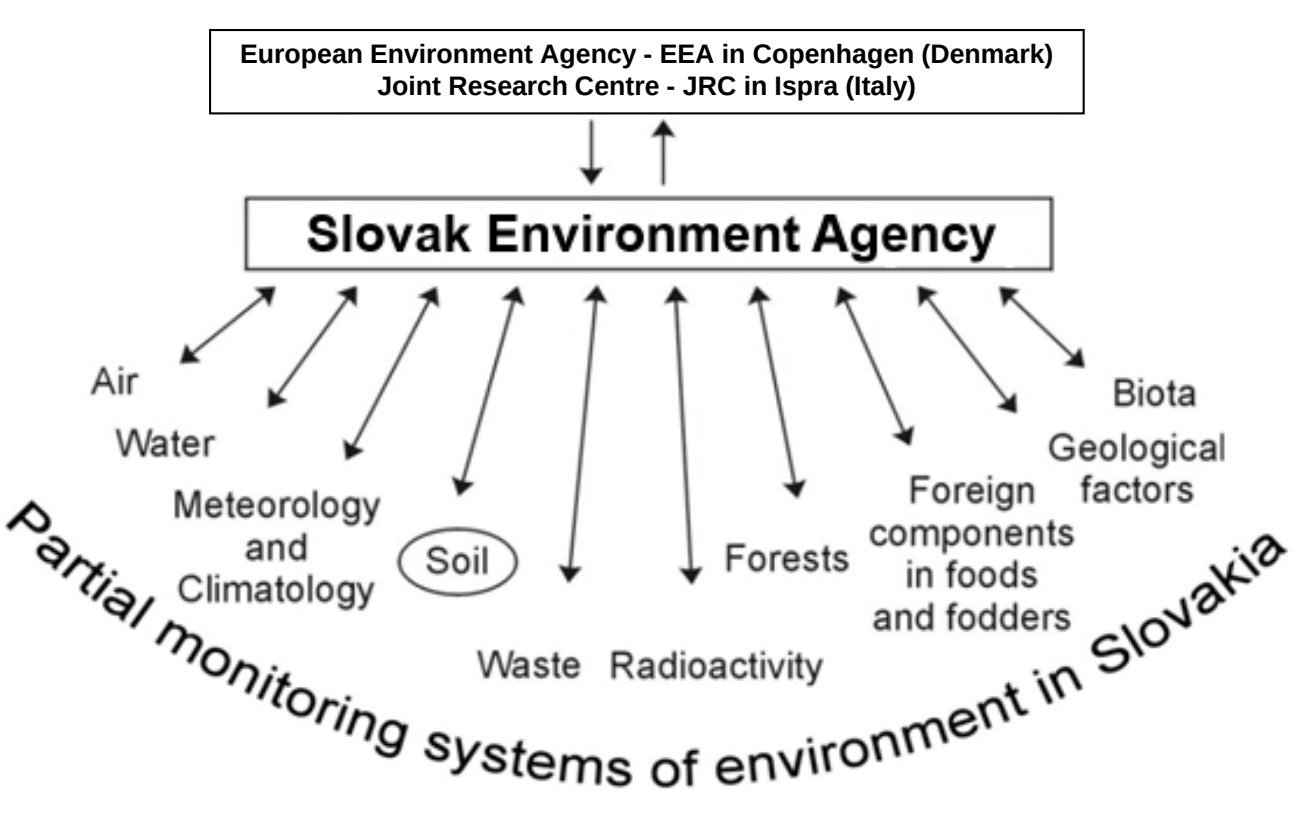


Soil portal – potential water erosion

On the basis of obtained results it was determined under conditions of Slovakia:

the most significant change:	soil erosion soil compaction
the significant change:	decline in soil organic matter and available nutrients (P, K)
slight to very slight change:	soil contamination, salinization and sodification

Implementation of soil monitoring system with monitoring of environment in Slovakia and EU



Spatial and attributive data from soil monitoring system of Slovakia are accesible for public on the pages: http://ism.enviroportal.sk/cms_poda, resp. http://envirozataze.enviroportal.sk/, http://envirozataze.enviroportal.sk/Mapa/, www.enviroportal.sk.

Soil monitoring database supports space for creation of next services in the framework of national infrastructure for complexed soil information. It is an important step to realization of INSPIRE Directive in Europe.

Structural harmonization of database and rebuilding the original structure of the geodatabase and moving on ORACLE platform are processing in this time.

Database of soil monitoring in Slovakia is developing at National Agricultural and Food Centre – Soil Science and Conservation Research Institute in Bratislava.

The role of soil monitoring for the protection of soil and land use

- identification of risk areas and their assessment
- prognosis of next development of soil parameters according to threats to soil
- a basic tool for protection of soils and sustainable land use
- creation of legislation
- evaluation of soils and environment (including recommendations and measures)


Thank you for your attention