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BANSKÁ BYSTRICA, SLOVAK REPUBLIC, 8 – 10 OCTOBER 2018

The activity has been implemented within the framework of national project
***Information and providing advice on improving the quality of environment in Slovakia**.*
The project is cofinanced by Cohesion Fund of the EU under Operational programme Quality of Environment.

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Current state of main risk elements in agricultural soils of Slovakia

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Introduction

One of the most important soil degradation processes is soil contamination. The regulation concerning agricultural soils is the Act n. 220/2004 on protection of agricultural soils and land use (MP SR, 2004) and updated version n. 59/2013 (MPRV SR, 2013) is a basic tool to increase protection against degradation of soils including contamination.

Background soils contain native heavy metals concentration plus an anthropogenic addition by the ubiquitous deposition resulting from diffuse heavy metal sources.

Current risk elements distribution in agricultural soils of Slovakia is evaluated in this presentation.

Methodology

Obtained results are evaluated on the basis of soil monitoring system in Slovakia. Soil monitoring network was constructed on ecological principles where main soil types, soil forming substrates, climatic regions, emission regions, protected areas, contaminated and non-contaminated regions as well as various land use are included. There are 318 monitoring sites on agricultural land in Slovakia.

The most important risk elements concerning soil contamination (Cd, Pb, Cu, Zn, Ni, Cr, Se, Co, As – extracted with aqua regia), Hg (total content – using AMA analyzer) and Fwatersoluble are included, as well. Topsoil and subsoil have been analysed and evaluated.

Results

Content of risk elements (mg.kg^{-1}) extracted with aqua regia in agricultural soils (0 – 10 cm) in Slovakia

Elements / Statistics	As	Cd	Co	Cr	Cu	Ni	Pb	Zn	Se	Hg^{1}
x	10.16	0.38	8.80	42.00	24.48	29.43	26.42	80.88	0.25	0.09
median	8.91	0.27	8.04	41.66	20.21	26.87	19.28	70.89	0.19	0.07
Xmin	1.00	0.07	1.00	0.99	0.39	0.24	3.45	19.80	0.04	0.01
Xmax	223.00	9.90	28.60	141.00	155.34	136.14	1238.00	1191.00	0.72	0.80
Sd	7.14	0.39	4.15	19.47	14.97	14.21	37.79	46.34	0.11	0.06
Vc (%)	61.35	83.36	49.08	48.91	59.36	48.67	100.46	48.48	50.08	66.50
n	318	318	318	318	318	318	318	318	318	318

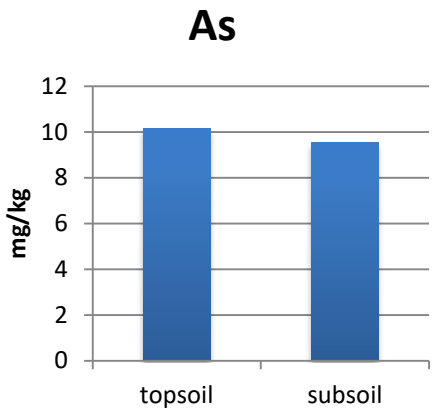
Explanations: x – arithmetic mean, Xmin – minimum value, Xmax – maximum value, Sd – standard deviation, Vc – coefficient of variability, n – frequency, Hg^{-1} – total content (AMA analyzer)

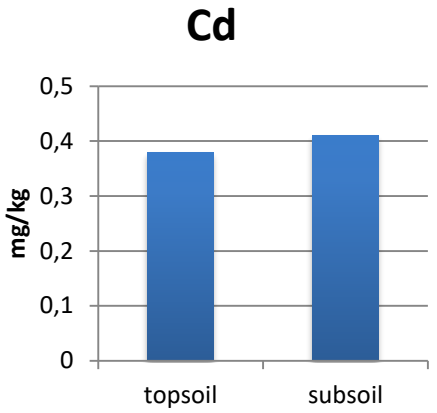
Content of risk elements (mg.kg^{-1}) extracted with aqua regia in agricultural soils (35 – 45 cm) of Slovakia

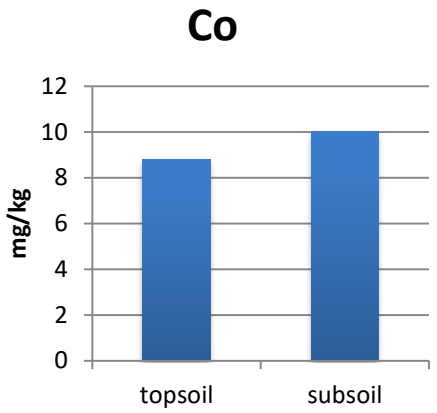
Elements / Statistics	As	Cd	Co	Cr	Cu	Ni	Pb	Zn	Se	Hg[1]
x	9.55	0.41	10.02	42.87	23.09	32.10	22.70	71.22	0.21	0.05
median	8.60	0.21	8.85	40.34	19.05	29.00	14.73	62.91	0.13	0.04
Xmin	0.77	0.01	1.00	1.99	1.33	0.29	4.10	3.80	0.02	0.01
Xmax	100.00	89.00	215.70	135.00	137.00	141.00	1941.00	1340.00	0.62	0.55
Sd	6.40	1.57	7.36	21.50	14.93	16.64	45.41	44.24	0.10	0.04
Vc (%)	65.26	191.75	66,97	56.60	60.85	56.05	121.39	53.83	43.93	69.85
n	318	318	318	318	318	318	318	318	318	318

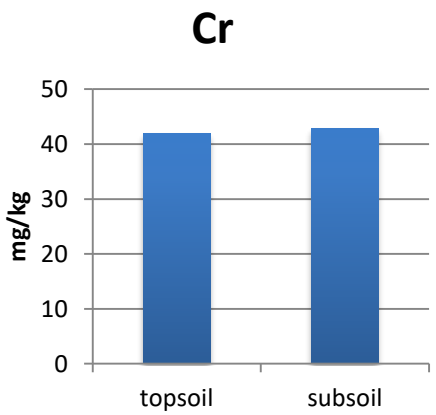
Explanations: x – arithmetic mean, Xmin – minimum value, Xmax – maximum value, Sd – standard deviation, Vc – coefficient of variability, n – frequency, Hg^{-1} – total content (AMA analyzer)

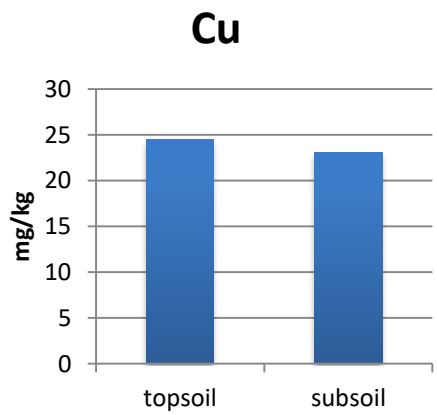
Distribution of risk elements in agricultural soils of Slovakia (extracted with aqua regia)

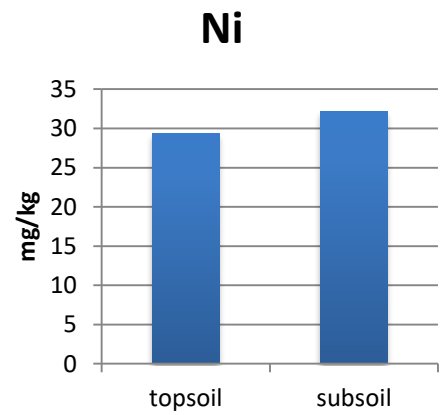




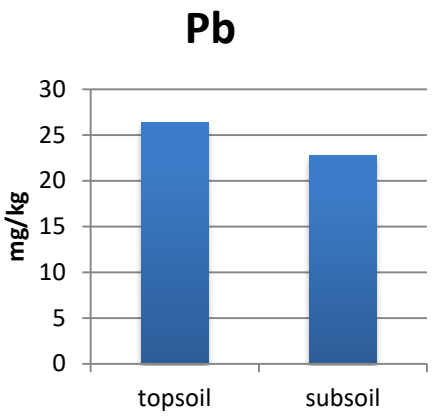


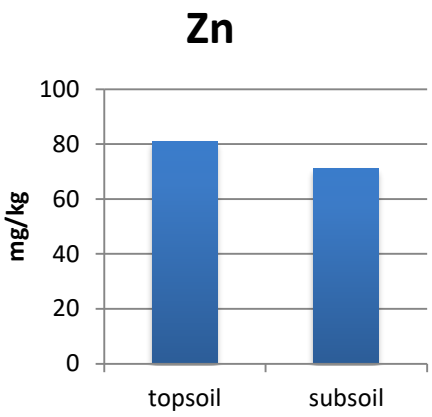


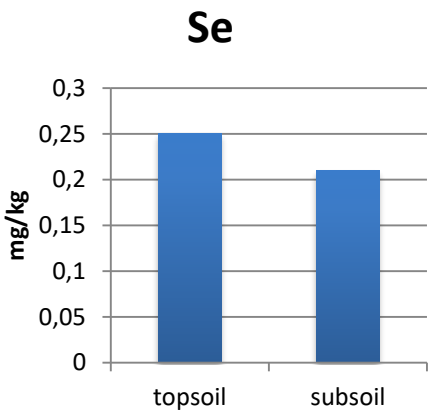


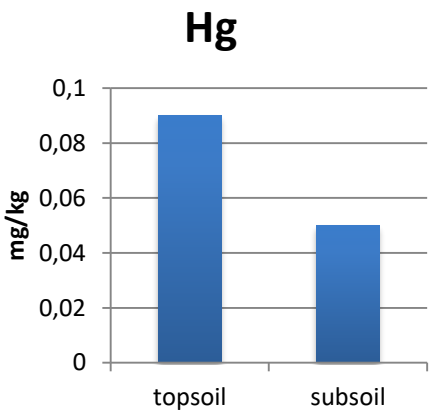


Distribution of risk elements in agricultural soils of Slovakia (extracted with aqua regia)







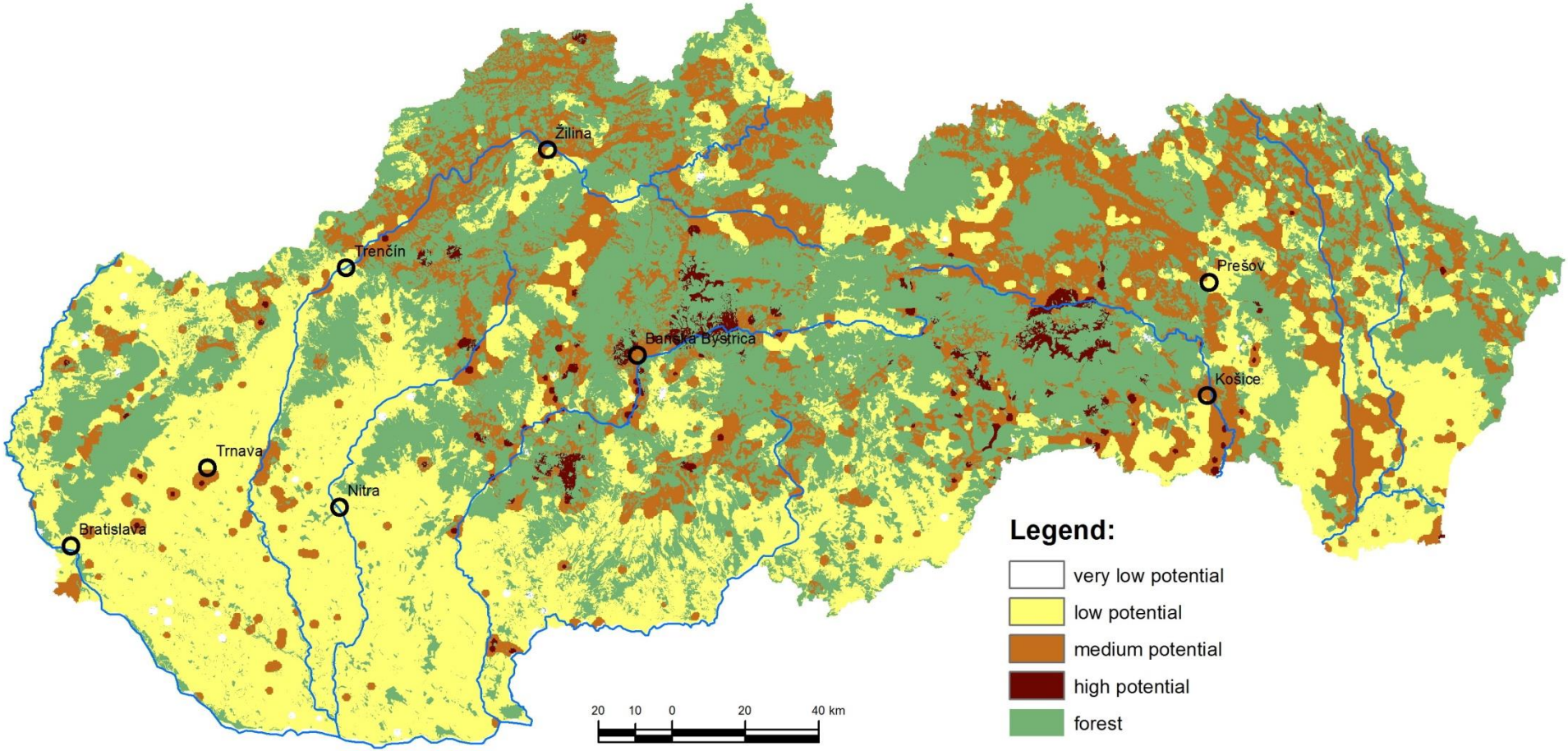


Average content of risk elements (mg.kg^{-1}) extracted with aqua regia in surface horizon (0 – 10 cm) of main soil types in Slovakia

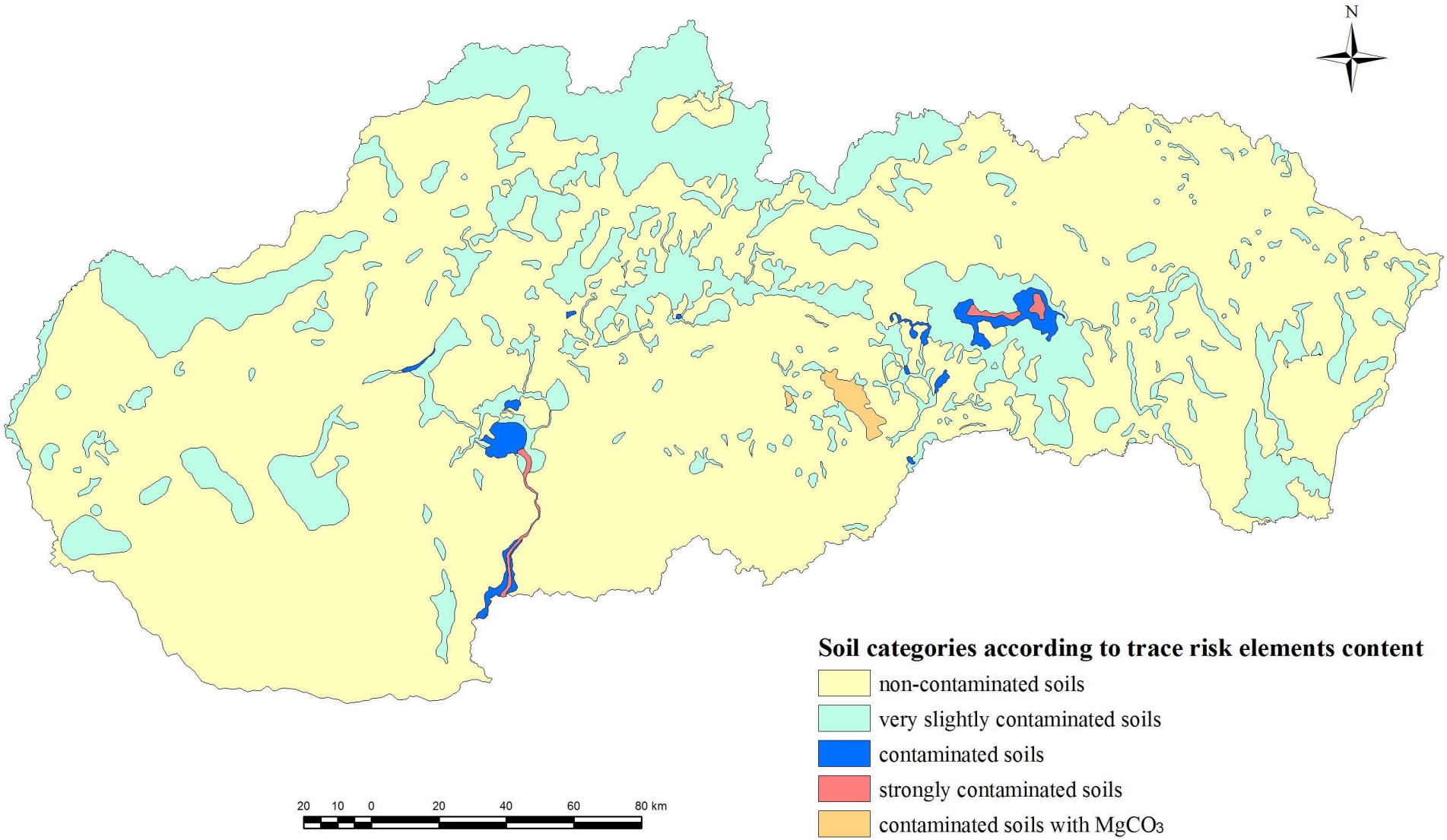
Soils	As	Cd	Co	Cr	Cu	Ni	Pb	Zn	Se	Hg[1]
FM	10.8	**0.7**	8.8	39.1	34.0	37.0	54.3	122.8	-	0.2
ČA	10.0	0.4	7.8	42.9	22.7	29.6	21.1	75.6	0.2	0.06
ČM	10.0	0.4	7.8	42.9	22.7	29.6	21.1	75.6	0.3	0.1
HM	9.2	0.2	10.0	41.5	22.9	32.6	19.7	68.8	0.1	0.05
LM+PG	9.9	0.3	9.7	42.8	17.0	23.3	24.2	66.7	0.2	0.07
KM	14.8	0.3	12.6	52.2	28.9	29.2	27.0	93.5	-	-
RM	3.4	0.1	2.0	19.5	17.0	12.0	7.7	41.0	0.3	0.03
RA	13.1	0.5	11.8	55.2	30.6	42.0	36.3	103.1	-	0.13

Explanations: FM – Haplic Fluvisols, ČA – Mollic Fluvisols, ČM – Chernozems, HM – Cutanic Luvisols, LM+PG – Albeluvisols and Planosols, KM – Cambisols, RM – Regosols, RA – Rendzic Leptosols, Hg^{-1} – total content (AMA analyzer)

Potential risk of soil loading by inorganic pollutants



Soil contamination categories in the Slovak Republic



Strongly polluted and secondary salined soils near waste deposits

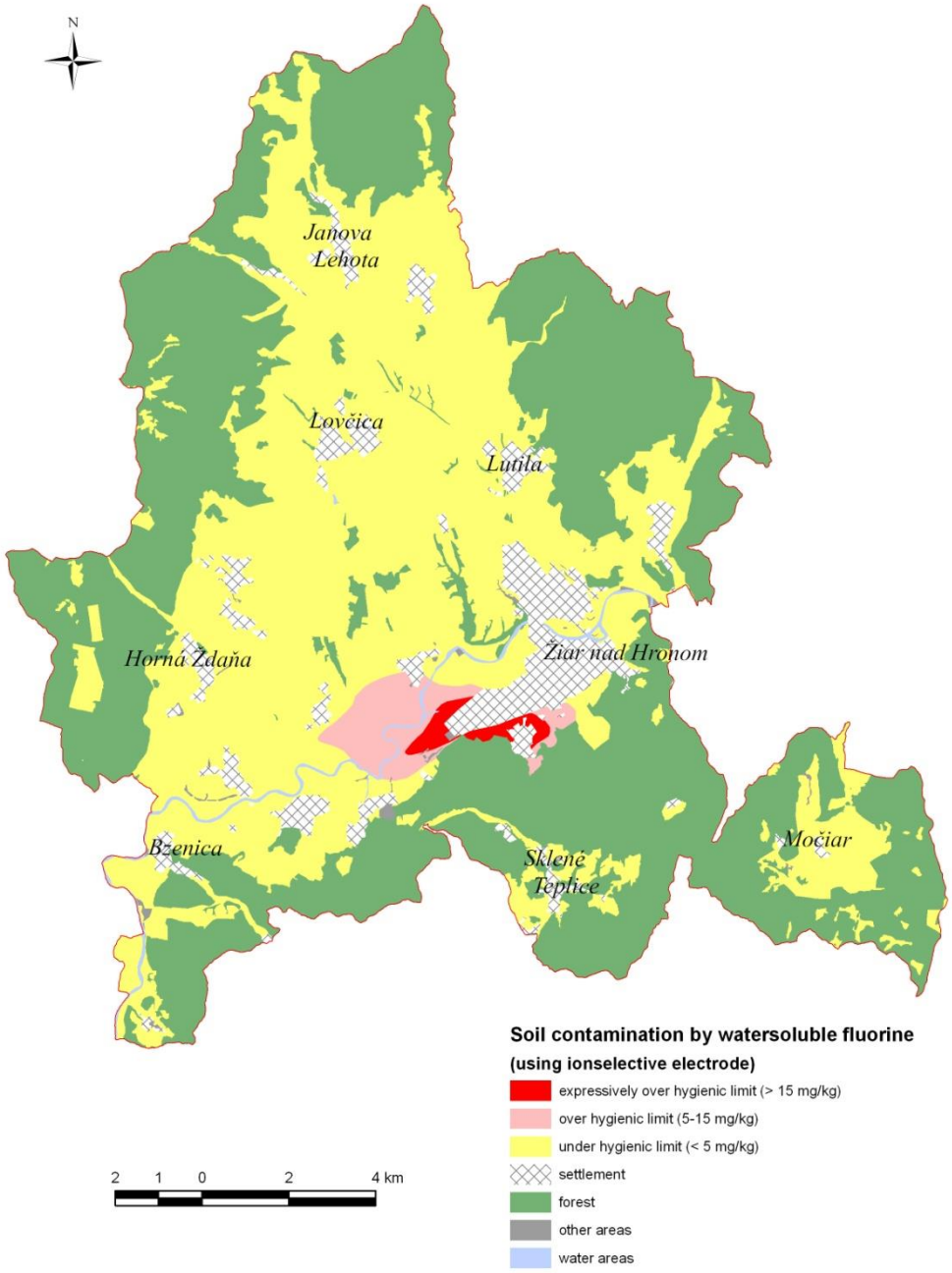
Distribution of risk elements in soil profile of Gleyic Fluvisol (Siltic, Toxic) (WRB 2014) (extracted with aqua regia) near aluminium waste deposits

Risk elements	Cd	Pb	Cu	Zn	Cr	Ni	As	Co	Se	Hg[1]
Topsoil (0 - 10 cm)	**1.5**	**129.0**	**95.5**	**258.0**	77.9	19.5	1.75	9.44	< 0.1	0.48
Subsoil (35 – 45 cm)	**0.95**	**102.0**	**140.0**	**157.0**	42.4	22.0	**64.0**	10.6	< 0.1	**0.58**

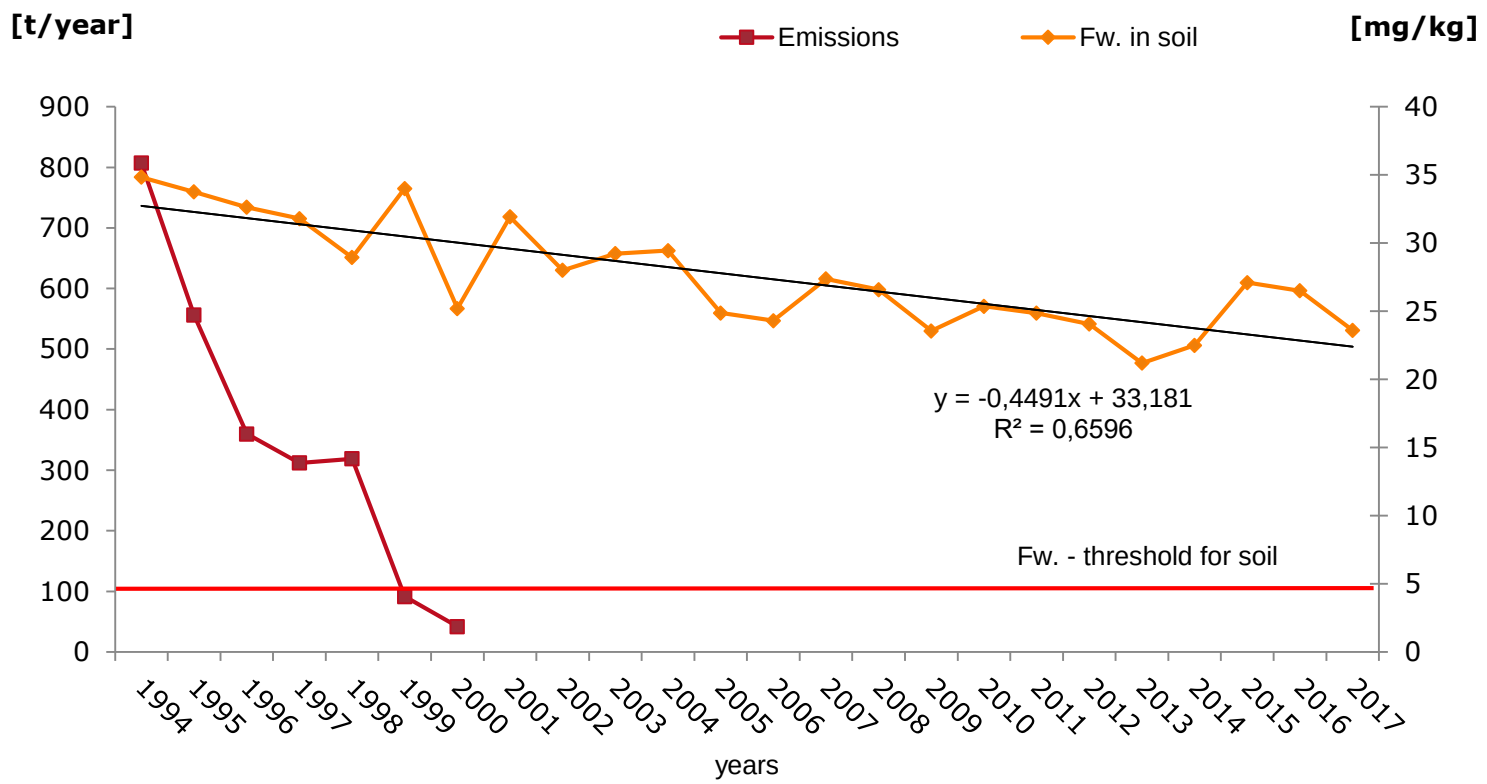
1 – total content (AMA analyzer)

Parameters of salinity

Depth (cm)	Total content of salts (%)	ESP (%)	SAR	ECe ($mS.m^{-1}$)	pH/H_2O
0-10	0.57	16.6	8.4	247	9.1
20-30	1.10	22.0	11.8	387	9.1
35-45	1.06	23.8	13.3	348	9.3
55 -65	0.93	46.9	37.5	382	9.2
75-85	1.31	51.9	44.8	359	9.3


N
Jaňova Lehota
Lovčica
Lutila
Horná Ždaňa
Žiar nad Hronom
Bzenica
Sklené Teplice
Močiar
2 1 0 2 4 km
Soil contamination by watersoluble fluorine
(using ionselective electrode)
expressively over hygienic limit (> 15 mg/kg)
over hygienic limit (5-15 mg/kg)
under hygienic limit (< 5 mg/kg)
settlement
forest
other areas
water areas

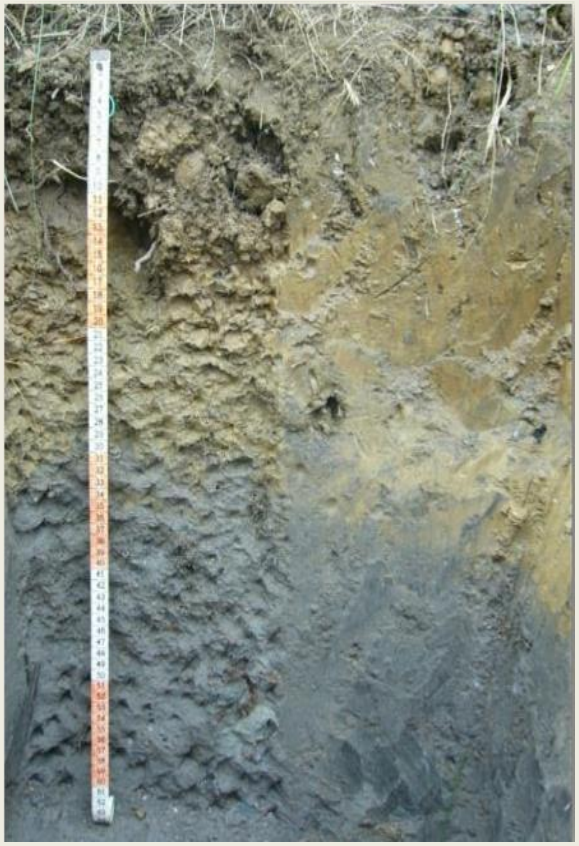
Development of fluorine on Planosol opposite Aluminium plant



Alkalization (Hačava Mg-smelter surroundings)

Depth cm	Mg $mg.kg^{-1}$	pH/KCl	P (Mehlich III.) $mg.kg^{-1}$	K (Mehlich III.) $mg.kg^{-1}$	Cox %	C_{HA}/C_{FA}	Q^4_6
0 – 10	**20 500**	**9.2**	27.77 (low)	118.85 (low)	1.28	0.42	4.0
20 – 30	**2 022**	**8.4**	21.83 (low)	110.89 (low)	-	-	-
35 – 45	**1 245**	**7.6**	27.12 (low)	90.41 (low)	-	-	-
60 - 70	**1 047**	**7.4**	27.87 (low)	80.17 (low)	-	-	-

Hidden soil pollution in Horná Nitra region



Hidden soil pollution on alluvial deposits of Štiavnica stream (Dvorníky)

Risk elements distribution of contaminated site on alluvial deposits of Štiavnica stream (Dvorníky)

Soil depth	Risk elements in mg.kg^{-1} (extracted with aqua regia)								
	Cd	Pb	Cu	Zn	As	Ni	Cr	Co	Hg[1]
0 – 10 cm	**9.94**	**1238.00**	**111.00**	**1191.00**	12.70	10.30	24.10	9.28	0.27
35 – 45 cm	**9.89**	**1941.00**	**137.00**	**1340.00**	14.30	5.35	15.30	14.00	0.10

1 – total content (AMA analyzer)

Conclusions

- in general, hygienic state of agricultural soils in Slovakia is relatively good;
- increased, resp. high to very concentration of risk elements was determined in old industrial zones and in zones influenced by mining activities as well as in areas influenced by geochemical anomalies (mostly mountain and submountain regions);
- increased concentration of some risk elements was measured in Fluvisols and Cambisols (Cd, Pb, Zn, Cu, Hg) in comparison with other soil types;
- the area of contaminated agricultural soils is less than 1 % of total area of soils in Slovakia;
- the lowest concentration of risk elements was determined in Regosols (situated mostly in the western part of Slovakia);
- soils which were polluted in the past, are polluted also at present and therefore it will be necessary to monitor them also in the future.


A nation that destroys its soils destroys itself
(Franklin Delano Roosevelt, 1937)
Thank you for your attention