• SOIL

Land use

♦ **Land Use on the basis of the Land Register's data**

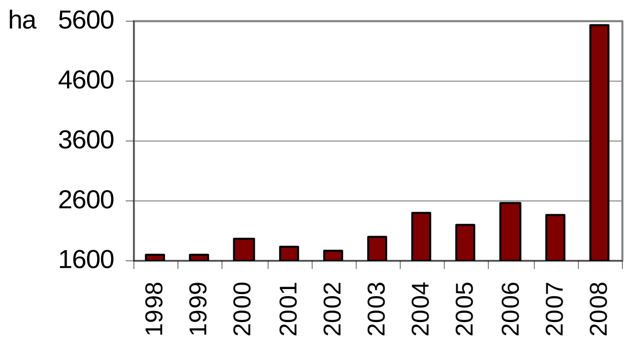
Land Use categories (state to the date 31st December 2008)

Land category	Area (ha)	% of total area
Agricultural land	2 423 478	49.42
Forest land	2 008 257	40.95
Water areas	94 575	1.93
Build-up land	229 059	4.67
Other land	148 335	3.03
Total area	**4 903 704**	**100.00**

Source: GCCA SR

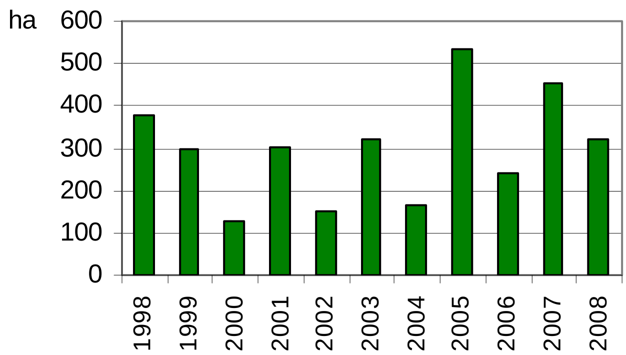
Anthropogenic pressure to use soil for purposes other than its primary production and environmental functions brings about its gradual decrease. In the years 1999-2008, **losses of agricultural soil to construction** grew on the year-year basis, mainly for public, house, and industrial construction purposes (3 190 ha in 2008).

Trend in agricultural soil loss including the losses of arable soil to forestland, non-agricultural and non-forested soil in the SR



Source: GCCA SR

Trend in forestland loss to agricultural soil, non-agricultural and non-forested soil in the SR



Source: GCCA SR

♦ **Changes to the land cover evaluated by comparing satellite images**

Changes to land cover in 1990, 2000, and 2006 were mapped on the basis of analysis of satellite images being part of the projects of CORINE1990, I&CLC2000, and GMES-Land 2006. Most significant changes to land cover involved:

- restitutions and changes to land ownership after 1989, with most changes shown especially in 1990-2000 in the north-west of Slovakia,
- natural catastrophes - tornadoes, forest fires (the wind calamity of 2004 in the High Tatra mountains),
- expansion of the traffic infrastructure and industrial parks,

- and activities related to anti-flood activities and energy production. (Gabčíkovo)

Total changes to land cover in 2000 - 2006 in Slovakia

Source: SEA

Soil properties

Information on state and trend in agricultural soil properties and their degradation may be obtained from the Partial Monitoring System - Soil (PMS-S) carried out by the Soil Science and Conservation Research Institute (SSCRI) and from the Agrochemical soil testing (AST) carried out by Central Controlling and Testing Institute in Agriculture (CCTIA). Information on state and trend in forest soil properties may be obtained from the Partial Monitoring System – Forests (PMS-F) carried out by the National Forest Centre – Forest Research Institute.

- **Chemical properties of soil**

Soil reaction

Trend in soil reaction (pH/H_2O) in the A-horizon of agricultural soil in Slovakia, based on the comparison of outcomes from three PMS-S cycles

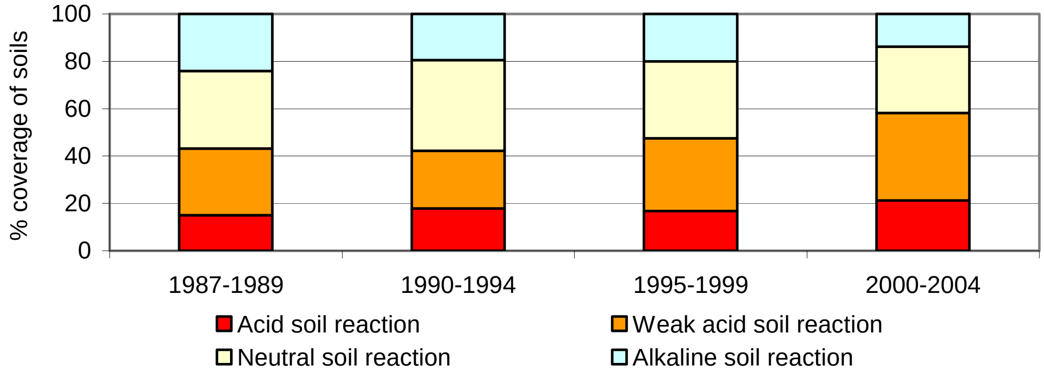
Main soil unit	1993	1997	2002	2007
Mollic Fluvisols AL	7.29	7.24	7.03	-
Fluvisols AL	7.13	6.95	6.84	-
Chernozems AL	7.28	7.31	7.22	7.14
Haplic Luvisols AL	6.71	6.85	6.90	-
Planosols AL	6.66	6.70	6.47	-
Planosols PG	6.31	6.24	6.13	-
Rendzic Leptosols AL	7.27	7.25	7.54	7.97
Rendzic Leptosols PG	7.17	7.18	6.57	7.27
Regosols AL	6.68	6.54	6.95	-
Cambisols AL	6.56	6.42	6.18	-

Cambisols PG	5.61	5.56	5.29	-
Solonchaks and Solonetz PG	8.29	7.88	8.45	-
Podzols PG	4.21	3.93	3.88	-

AL – Arable Land, PG – Permanent Grassland Source: SSCRI

Outcomes from agrochemical soil testing for the VIII. (1987-1989) through XI. (2000-2004) cycle show an **increase in the proportion of agricultural soil with acid** (+6.2 %) and **weak acid** (+8.8 %) **soil reaction.** On the other hand, a reduction was seen in the proportion agricultural soil with neutral (-4.7 %) and alkaline (-10.3 %) soil reaction.

Trend in agricultural soil reaction in the SR (in KCI) based on the outcomes from Agrochemical soil testing



Source: CCTIA

Most Slovak forestland is mildly to strongly acidic.

Trend in exchange soil reaction (pH/$CaCl_2$) in forest soil in the SR based on comparison of the PMS-F results

Depth	1988	1993	1998	2006
Upper humic horizon	-	4.8	4.7	4.7
0-10 cm	4.2	4.1	4.1	4.1
10-20 cm	-	3.9	4.0	4.0

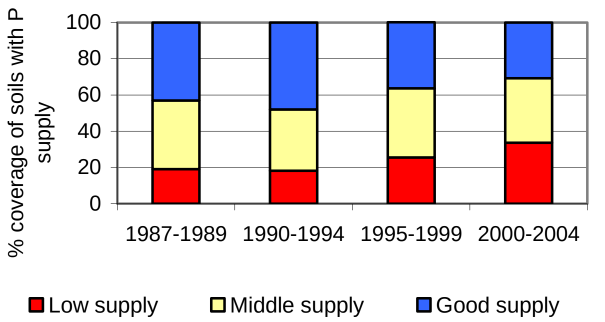
Source: NFC - FRI

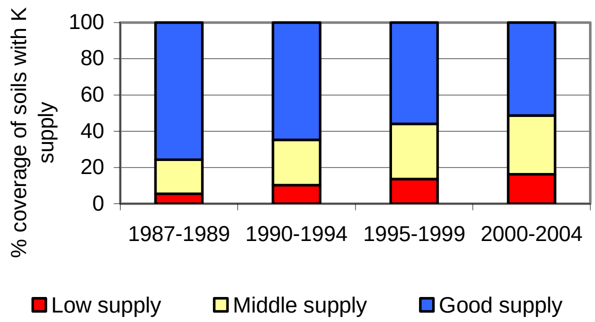
Available nutrients

During the period VIII. (1987-1989) through XI. (2000-2004) of Agrochemical soil testing there was an **increase in low supply of all three available nutrients (phosphorus, potassium, and magnesium).** In phosphorus, it was by 14.6 %, by 10.7 % in potassium, and by 5.3 % in magnesium. However; during this period, good supply of all three available nutrients were reduced (by 12.4 % in phosphorus, by 24.2 % in potassium, and by 12 % in magnesium), which, in terms of plant nutrition, is a negative tendency.

Trend in phosphorus content in agricultural soil in the SR based on outcomes of Agrochemical soil testing

Trend in potassium content in agricultural soil in the SR based on outcomes of Agrochemical soil testing

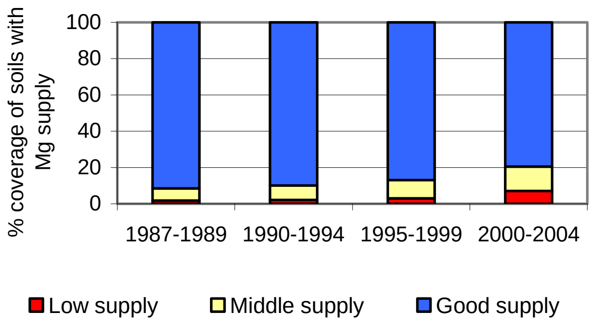




Source: CCTIA

Source: CCTIA

Trend in magnesium content in agricultural soil in the SR based on outcomes of Agrochemical soil testing



Source: CCTIA

Humus

Trend in humus content in the A-horizon of agricultural soil in the SR, based on the comparison of outcomes from three PMS-S cycles (%)

Main soil unit	1993	1997	2002	2007
Chernozems AL	2.74	2.17	3.12	3.19
Mollic Fluvisols AL	3.62	3.10	3.72	-
Fluvisols AL	2.71	2.24	3.03	-
Haplic Luvisols AL	2.07	1.72	2.59	-
Planosols and Luvisols AL	2.05	1.69	2.38	-
Planosols and Luvisols PG	3.79	3.45	5.12	-
Cambisols AL	3.05	2.45	3.45	4.29
Cambisols PG	5.52	4.14	6.55	6.09
Regosols AL	2.07	1.60	2.07	-
Rendzic Leptosols AL	3.74	2.76	3.14	3.83
Rendzic Leptosols PG	5.94	4.32	6.61	7.14
Andosols PG	10.91	12.48	16.55	15.71
Podzols PG	18.79	20.17	24.79	-

AL – Arable Land, PG – Permanent Grassland

Source: SSCRI

Note: Error in humus setting is app. 10%, i.e. 0.3 % of humus, for this reason, differences lower than 0.3 % may be attributed to analytical setting. In case of permanent grasslands differences between years may be caused by high heterogeneity of humus values between individual sites in the land, especially in case of lands above the upper forest border, and they are not statistically significant.

Changes to values in forest soil humus content in individual extraction cycles are shown in Table.

Trend in humus content in forest soil in the SR based on comparison of the PMS-F results

Soil horizon	% of humus		
	1993	1998	2006

Upper humic horizon	51.8	55.3	61.7
0-10 cm	9.55	9.79	8.60
10-20 cm	5.55	6.04	5.27

Source: NFC - FRI

♦ **Physical properties of soil**

The table shows changes to values of total porosity in the A-horizon of agricultural land during three PMS-S cycles.

Trend in overall porosity in the A-horizon of agricultural soils in the SR, based on the comparison of outcomes from three PMS-S cycles

Main soil unit	Volume %											
	Light soils				Medium heavy soils				Heavy soils			
	1993	1997	2002	2007	1993	1997	2002	2007	1993	1997	2002	2007
Chernozems	-	-	-	-	51.8	47.3	49.6	49.2	45.0	50.7	46.7	52.1
Mollic Fluvisols	54.0	46.8	42.3	-	46.4	49.5	51.4	-	53.5	48.8	47.3	-
Fluvisols	45.8	50.3	48.4	-	47.8	48.4	52.2	-	47.5	50.8	52.6	-
Haplic Luvisols	-	-	-	-	49.8	47.3	48.7	-	50.5	46.3	51.5	-
Planosols and Luvisols	-	-	-	-	46.0	46.8	49.6	-	50.8	47.6	52.0	-
Cambisols	32.7	45.5	45.5	-	40.2	48.3	52.5	51.3	51.9	51.6	51.8	49.5

Source: SSCRI

Soil degradation

Serious soil degradation includes contamination with heavy metals and organic pollutants, acidification, as well as alkalinization and soil salinization. Recently, soil degradation through desertification grows in significance.

♦ **Soil contamination by hazardous substances**

Load imposed on agricultural land types by hazardous substances - **diffuse contamination** is monitored directly within the partial monitoring system of **PMS - S** as well as its subsystem of the **Spatial soil contamination survey (SSCS).**

Outcomes of the II. **PMS -S** monitoring cycle with samples extracted in 1997 showed a slight improvement in the **sanitary condition of agricultural land types.** Apparent vertical migration of high-risk elements in the soil profile was detected (Kobza et al., 2002). Results from the III. cycle with samples extracted in 2002 showed that the **content of the majority of risk substances in selected agricultural land of Slovakia was below the limit**, especially in case of arsenic, chromium, copper, nickel, and zinc. In case of cadmium and lead, excessive limit values were recorded only in soils situated in higher altitudes, podzols, andosols, which may relate to remote transfer of emissions.

Soil samples extracted in the 4th extraction cycle were processed and analysed in 2008 (2007 being the year of extraction). Chemical analyses of monitored land types were completed in November 2008 for the types of andosols (PG), cambisols (PG and AL), rendzic leptosols (PG), and chernozems (AL).

Assessed were the basic statistical parameters (x_{min} - minimum value, x_{max} - maximum value, x_p - average value) of the monitored high-risk elements (As, Cd, Co, Cr, Ni, Pb, Zn).

Present condition in contamination of the analysed land types with samples extracted in 2007 was first time assessed on the basis of Annex 2 to Act No. 220/2004 Coll. on protection and exploitation of agricultural land as shown in the following table. Therefore, it is not possible to compare contaminations with the previous monitoring cycles assessed on the basis of laws that were in effect in the past.

Limit values of risk elements in the agricultural land types defined on the basis of the soil structure and value of soil reaction as well as the critical value of risk elements within the agricultural soil to plant relationship

Risk element	Limit values for risk elements in agricultural soil (in mg.kg^{-1} of dry matter, aqua regia decomposition, Hg total content)			Critical values for risk elements as they relate to the agricultural soil and plant (in mg.kg^{-1} of dry matter, in leachate of 1 mol/l amonnium nitrate, F in water leachate)
	Sandy, loam-sandy soil	Sand-loamy, loamy soil	Clay-loamy soil, clay	
Arsenic (As)	10	25	30	0.4
Cadmium (Cd)	0.4	0.7 (0.4)*	1 (0.7)*	0.1
Cobalt (Co)	15	15	20	-
Chromium (Cr)	50	70	90	-
Copper (Cu)	30	60	70	1
Mercury (Hg)	0.15	0.5	0.75	-
Nickel (Ni)	40	50 (40)*	60 (50)*	1.5
Lead (Pb)	25 (70)*	70	115 (70)**	0.1
Selenic (Se)	0.25	0.4	0.6	-
Zinc (Zn)	100	150 (100)*	200 (150)*	2
Fluorine (F)	400	550	600	5

Note: Supplied data apply to samples obtained in arable land types from the upper layer of 0.2 m and air-dried to reach constant weigh, * if pH (KCl) is less than 6, ** if pH (KCl) is less than 5,

Contents of risk elements for the soil types assessed in 2008 and extracted in 2007 are shown in the following tables.

Proportion of As, Cd, Co (in mg.kg^{-1} in aqua regia) in selected soils within the 4th extraction cycle (year of extraction - 2007)

Group of soils	Culture	Soil depth	As			Cd			Co		
			x_{min}	x_{max}	x_a	x_{min}	x_{max}	x_a	x_{min}	x_{max}	x_a
Andosols	PG	0-10	2.9	3.8	3.4	0.45	0.50	0.48	11.3	17.7	14.5
		35-45	1.2	1.3	1.2	0.01	0.22	0.11	12.9	17.8	15.4
Cambisols	PG	0-10	2.0	15.0	6.8	0.14	0.64	0.32	5.8	24.5	14.6
		35-45	1.5	10.2	4.6	0.01	0.17	0.07	6.9	25.3	16.7
Cambisols	AL	0-10	2.0	18.8	7.9	0.16	0.28	0.21	7.9	18.1	11.7
		35-45	2.0	17.0	8.6	0.02	0.13	0.07	10.4	15.8	13.0
Rendzic Leptosols	PG	0-10	2.3	28.8	13.3	0.11	1.87	0.62	1.1	24.0	12.7
		35-45	5.4	16.5	10.8	0.12	0.55	0.30	9.1	22.5	12.5
Rendzic Leptosols	AL	0-10	5.5	24.2	12.7	0.10	0.78	0.41	3.8	22.0	10.0
		35-45	5.6	20.7	12.7	0.06	0.65	0.27	2.9	19.2	8.9

Chernozems	Prevalent AL	0-10	6.6	14.9	9.5	0.03	0.38	0.18	6.6	10.9	8.8
		35-45	4.5	14.4	9.1	0.01	0.48	0.14	5.4	12.4	8.6

Source: SSCRI

Note: x_{min} – the minimum set value of a selected group, x_{mas} - the maximum set value of a selected group, x_2 average value of a selected group, AL - arable land, PG - permanent grassland

Contents of contaminating substances in soils of selected cadastre zones are monitored within the **Spatial soil contamination survey (SSCS).** Selections are made through soil analyses on the basis of detected increased contents of contaminants during the previous SSCS cycles. The file contains also outcomes from soil analyses in the cadastre zones included into the **Coordinated focus-specific monitoring (CFSM)** with monitoring of selected parameters of Pb, Cd, Cr, Ni, Hg, As, together with a number of other parameters required by the centre of coordination. Further, the file also contains soil samples from organic farming. 1,276 soil samples were analysed for inorganic and organic contaminants within the SSCS 2008

In case of forest soil, the most significant effect of their anthropogenic contamination involves accumulation of contaminants in upper humic horizon.

Content of risk elements in upper humic horizon of forest soil determined in aqua regia

Risk element		1993	1998	2006
Lead	Mean	61.8	38.4	30.5
	Maximum	300.4	234.8	180.5
Zinc	Mean	131.6	104.2	83.3
	Maximum	401.0	357.2	258.4
Copper	Mean	24.4	20.9	15.3
	Maximum	299.0	240.3	140.7
Cadmium	Mean	1.13	1.01	0.64
	Maximum	2.99	2.51	1.56

Source: NFC - FRI

♦ **Environmental burdens**

Besides diffuse contamination, other environmental burdens are also monitored in Slovakia. Environmental burden means a condition created by negative impacts of anthropogenic activities beyond the measure of the pollution criteria, on the components of environment such as ground water, soil, and rock. Consequences of environmental burdens on ecosystems or human health can be so critical that their sanation is necessary.

As a consequence of the task of Systematic identification of environmental burdens of the Slovak Republic in 2006 - 2008, the Register of environmental burdens in Slovakia included

- 878 probable environmental burdens, 124 of them of high risk, 600 of medium risk, and 154 of low risk sites. The most frequent sources of contamination of sites are municipal waste landfills (39%), industrial production and services (22 %), warehouse facilities of goods and merchandise, including petrol stations (12 %). Other activities such as mining (11 %), military activities (7 %), and transport (4 %) are among the most frequent causes of soil and ground water contamination.

- 257 environmental burdens, 95 of them of high risk, 134 of medium risk, and 28 of low risk sites.
- 684 sanated / recultivated sites. Most of the sanated sites include municipal waste landfills (47 %), warehouse facilities for goods and merchandise (37 %), and industrial production. (7 %).

The most frequent soil contaminants include mineral oils, aromatic hydrocarbons, and heavy metals. Other contaminants include chlorinated hydrocarbons, polycyclic aromatic hydrocarbons, phenols, and cyanides.

♦ Physical degradation

Erosion and soil compaction belong among the major phenomena of physical degradation in Slovakia.

Soil erosion

Water erosion is prevalent in Slovakia.

Agricultural land endangered by erosion in the SR

Erosion categories	Water erosion		Wind erosion	
	Land area in ha	% from Agricultural Land	Land area in ha	% from Agricultural Land
No erosion or slightly	1 357 390	56.01	2 291 157	94.54
Medium	230 473	9.51	55 253	2.28
Strong	354 555	14.63	45 805	1.89
Extremely strong	481 060	19.85	31 263	1.29
Total	**2 423 478**	**100.00**	**2 423 478**	**100.00**

Source: SSCRI

Soil compaction

Based on the results of the PMS-S for the years 1993-2002, there was an improving tendency in physical soil properties. This also suggests less dramatic compaction of heavy and medium heavy arable soil types. In case of subsoil, greater proportion of compacted sites was found. Heavy soil types show higher rate of compaction over the whole soil profile.

♦ Desertification

Desertification is becoming a major global issue, mainly as a consequence of the global climate change.

Processes of salinisation and sodification are included within soil monitoring to build a network of stationary monitoring sites. The network includes both weak and medium solonchaks and solonetz, as well as the typical solonetz soil types. Of the total number of 8 monitored sites, 6 are situated in the Podunajská plane. Anthropogenic soil sodification is measured in Central Slovakia by the exhausts from the aluminium production plant in Žiar nad Hronom. In the Eastern Slovakian Lowland, the monitoring network includes a typical solonetz in the cadastre area of Malé Raškovce.

Outcomes of the saline soils monitoring in 2008 and their analysis are, with the exception of small deviations, identical to the outcomes obtained for the previous years. The monitored area shows concurrent processes of salinisation and sodification, with sodification being more dominant. This is to a large degree shown by the Exchangeable Sodium Percentage (ESP) values of over 10% recorded in 2008 in the weak solonetz soils. There was a repeated detection of an apparent change of week solonetz soil to solonetz soil, or the first sodification level to the medium sodification level, respectively.

In terms of the risks associated with the formation, distribution and development of saline soils characterised by chemical composition of ground water, such risks are most probable in the lower territory of the Žitný ostrov area, in the Zlatná na Ostrove - Komárno zone. This is shown by higher values of electric conductivity (>200 $mS.m^{-1}$), high degree of ground water mineralization (>1 000 $mg.l^{-1}$), high sodium content (Na^{+} > 250 $mg.l^{-1}$), and high content of hydrocarbonate ions (HCO_3^{-} > 500 $mg.l^{-1}$), which indicates real conditions for the development of soda salinisation.

Medium and high mineralized ground water of the Podunajská plane with water evaporation of soils in the conditions of the ongoing climate warming represents a potential desertification threat to the territory.

Application of the sewage sludge and bottom sediments into the soil

Aplying the sewage sludge from waste water treatment plant to agricultural soil and forestland follows the provisions of the SR National Council **Act No. 188/2003 Coll. on application of sewage sludge and river bed sediments to soil**, **and on amendment to Act No. 223/2001 Coll. on waste and amendments to certain laws as amended.**

In 2008, the overall sludge production in the SR was 57 810 tons of dry matter. Of this volume, 38 368 tons (66.4 %) were used in soil processes, 10 766 tones were temporarily stored (18.6 %), and 8 676 tons (15.0 %) were landfilled. In 2008, there was **no direct application of waste water treatment sludge into agricultural soil**. 33 455 tons of sludge dry matter was used for compost production, while 4 913 tons of sludge dry matter were used for soil processes (reclamation of landfills, areas, etc.).