# Global Soil Change and Land Degradation in Conditions of Slovakia

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**Abstract**: Slovakia is situated in Central Europe of temperate climatic region. Climatic oscillations (greenhouse effect) as well as human activity in different economical conditions are more or less significant on global soil change and land degradation especially since 1990 year.

By the influence of global warming also in temperate climate regions the extension of more or less dry period is often indicated especially during last decade. Further also medium and strong mineralisation of groundwater has been confirmed. It can indicate the next development of alkaline and saline soils in the warmest regions of Slovakia referring to global climate change.

Soil acidification has developed particularly in soils developed mostly on acidic parent materials particularly under humid conditions. The decrease of humus content is remarkable in all arable soils.

In general, on the basis of obtained results it may be said that soils in Slovakia are not polluted. Not more than 0.4 % of soil cover is strongly polluted. The change of heavy metal content in soils is not significant during last decade.

The result of a soil global change depends to a great extent on its degree of reversibility. Finally, irreversible change is related to land degradation.

**Keywords**: soil monitoring, soil change, development of soil properties

## 1 Introduction

Slovakia in the twentieth century has been characterised by frequent and extensive change unfavourably impacting all aspects of the environment. Long-term continuing wasteful exploitation of natural resources, extensive pollution of the air, water, soil and land, release of pollutants into the environment, global climate change as well as agricultural activities – fertilisation, ploughing, deep loosening, irrigation, etc. have significant influence on global soil change. In addition, this problem is very actual in Slovakia where the socio-economical conditions have been changed after 1990 year.

In this paper the main soil properties development has been described during last decade. In the following text the partial results of national soil monitoring system concerning the soil acidification, alkalisation and salinisation, soil pollution, available nutrients and soil organic matter development as well as soil compaction are used.

## 2 Materials and methods

### 2.1 Soil sampling

The monitoring site is of circular shape with a radius of 10 m and on the area of 314 $m^2$. Soil sampling started in 1993 year. The standard depth of 0 m—0.10 m, 0.20 m-0.30 m and 0.35 m—0.45 m under grassland and forest as well as 0—0.10 m and 0.35 m—0.45 m in arable land is sampled. In this paper the results only from the topsoil are evaluated.

The basic soil monitoring is running in 5 years cycles, but more dynamic soil properties are monitored yearly.

### 2.2 Soil analysis

For basic chemical and physical analysis the following standard methods were used according to Fiala *et al.* (1999).

## 3 Results and discussion

### 3.1 Soil acidification, alkalisation and salinisation

According to obtained results the most soil sensitivity to soil acidification have acid soils as well as the soils on acid substrates (Dystric Cambisols, Podzols) oppossite carbonateous soils. It is in relation to fact that soil acidification is natural process and human activity can accelerate this process (Kobza, 1999). In addition, anthropogenic impact (e.g. acid rains) on soil acidification was not significant during measured period. The measured pH values between 1993 and 1997 years were practically without significant change.

Alkaline soils or Solonetzs contain above all $Na_2CO_3$, $NaHCO_3$ and $Na_2SiO_3$ opposite the saline soils or Solonchaks which contain mostly NaCl and $Na_2SO_4$ (Szabolcs, 1979). Alkalisation process is indicated with exchangeable sodium content in CEC (over 5%). One of the most important criteria for evaluation of salinisation process is electric conductivity ($EC_e$) more than 400 mS • $m^{-1}$.

Alkalisation and salinisation processes are running in natural conditions often in common (Fulajtár, in Kobza *et al.*, 1999) what is in relation to the next description. Increased content of exchangeable sodium (ESP) in deeper part of soil profiles in the warmest regions of Slovakia has been determined (in the subsoil mostly in the range 3%—9.5% ESP, in the topsoil only 1.4%—2.6% ESP). In addition, the values of $EC_e$ have been determined over 200 mS • $m^{-1}$ in the subsoil (slight salinisation process).

According to the results of Fulajtár, in Kobza, (1999) also medium and strong mineralisation of groundwater has been confirmed. These measured values (in soil and groundwater) indicate the next development of alkaline and saline soils in the warmest regions of Slovakia reffering to global climate change.

The other significant problem concerning the soil alkalisation and salinisation processes is secondary and anthropogenic impact. E.g. origin Eutric Fluvisols in the surroundings of alkaline red waste material in Žiar nad Hronom (Central Slovakia) have been changed on salines soils where pH (in 0.2 M KCl) was increased from 6—6.5 on 9—10 and ratio of sodium to calcium and magnesium (SAR) was also increased from 0.04—0.06 to 14.8—23.6 (Linkeš, 1986) during last 30—35 years. The next change of these parameters is not statistically significant during last decade.

Increase of pH values was also confirmed in the surroundings of magnesite factories (Hačava and Jelšava-Lubeník regions) where these values are running between 8 and 9 on originally acid and slightly acid soils. Content of available magnesium in the topsoil is between 7,000—9,000 mg • $kg^{-1}$ in the most polluted zone. Development of these parametres during monitoring period (since 1993 year) is without significant change (not more significant than their spatial variability).

Finally, it may be said that more or less change of measured parameters of alkalisation and salinisation in the topsoil has been caused by human impact and the slight change in the subsoil is probably mostly influenced by global climate change.

### 3.2 Soil pollution

Soil pollution can be caused by:

- the anthropogenic influence (industry, agriculture, municipal waste material, etc.)
- the influence of pedogeochemical anomalies
- the mixed influence (pedogeochemical anomalies and anthropogenic impact together).

In general, on the basis of obtained results it may be said that the agricultural soils in Slovakia are not polluted. Geometric mean of basic risk trace element content is lower than valid hygienic limit value in Slovakia (Ministry for Land Management, 1994). Maximum values of risk trace elements have been found mostly in regions with pedogeochemical anomalies occurrence, partly in industrial zones, respectively it is going about mixed influence (Kobza, 1999).

The significant change of pollutants (total content and 2M $HNO_3$ extractions) in soils has been not determined during last period. For the soil monitoring system the most available (mobile) forms of risk trace elements are significant, which can be transported by the root system into the plants and food chain. In addition, the watersoluble fluorine course in the most polluted soils in Žiar nad Hronom region (Central Slovakia) is given in Fig.1.

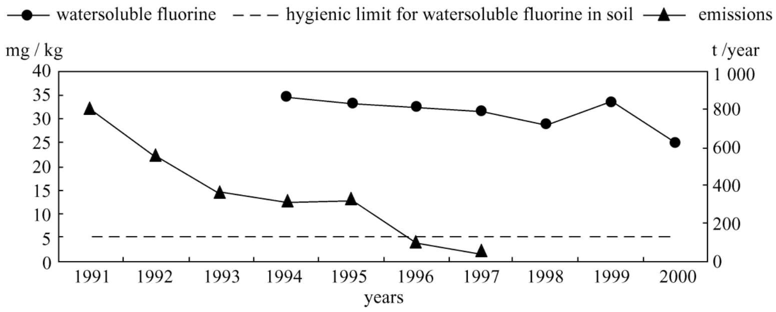


**Fig.1** Development of watersoluble fluorine in the topsoil of Dystric Planosol and F-emissions in the most polluted zone of Aluminium factory in Central Slovakia

Referring to Fig.1 the watersoluble fluorine course is more or less even – tempered without significant change during last period. Its content is high and it is running around 30 mg • $kg^{-1}$ (valid hygienic limit for Slovakia is only 5 mg • $kg^{-1}$ , Ministry for Land Management, 1994) during measured period. It is example of a fact that the soils can be rapidly polluted but with comparison of the air, water the natural decontamination of polluted soils is long-term process (Kobza *et al*., 2000).

### 3.3 Available nutrients development

Content of available nutrients phosphorus and potassium is one of the important parameters for soil fertility evaluation. Their supply in soils is in correlation to fertilisation level (Pirkl, Novozámský, 1966; Konovalov, Tichonova, 1970; Laszity Kadar, 1979; Hrtánek, 1980).

High fertilisation level has reflected good and very good supply of available nutrients in soils before 1990 year (Kobza, Styk, 1997). But later, economical conditions in Slovakia are rather different and fertilisers doses have been expressively decreased (from 220 kg NPK per ha before 1990 year to 40 kg—50 kg NPK per ha at present). Referring to this fact and on the basis of obtained results it may be said that the content of available phosphorus and potassium in agricultural soils has been decreased about 10%—30% since 1993 year (beginning of soil monitoring system realisation in Slovakia).

### 3.4 Soil organic matter development

Soil organic matter (SOM) performs very important position in soil fertility, which controls biological, chemical and physical properties. Change in climatic conditions and various anthropogenic interference into the soil can significantly influence on soil organic matter (Liang, Mac Kenzie, 1992; Kubát, Lipavský, 1996). The comparison of humus content and its main parameters is given in the following Table 1.

**Table 1 Comparison of soil organic matter parameters on arable land between 1993 and 1997 years**

| Soils | 1993 | | | 1997 | | |
|---|---|---|---|---|---|---|
| | humus [%] | $C_{HA}/C_{FA}$ | $Q^4_6$ | humus [%] | $C_{HA}/C_{FA}$ | $Q^4_6$ |
| Cambisols on acid rocks | 3.14 | 0.76 | 5.29 | 2.48* | 0.84 | 5.34 |
| Cambisols on volcano rocks | 2.93 | 0.63 | 5.44 | 2.41* | 0.83* | 5.08 |
| Cambisols on flysch | 2.98 | 0.80 | 4.88 | 2.31* | 0.92 | 4.91 |
| Rend□ic Leptosols | 3.50 | 0.95 | 4.91 | 2.64* | 0.89 | 4.70 |
| Cherno□ems | 2.81 | 1.70 | 4.03 | 2.16* | 1.55 | 3.97 |

*Statistical significant difference of the significant level $\alpha = 0.05$

According to obtained results on all compared soils the significant decrease of humus was determined in arable land (Barančíková, Kob□a, 1999). It is result of very poor manuring during last period. Qualitative parameters change is not statistically significant. Their difference in various soils exist (the highest $C_{HA}/C_{FA}$ ratio and the lowest $Q^4_6$ value in Cherno□ems opposite the lowest $C_{HA}/C_{FA}$ ratio and the highest $Q^4_6$ value in acid soils).

### 3.5 Soil compaction

Problem of soil compaction is generally related to the texture and cultivation of soils. The important physical properties as bulk density, porosity, maximum capillary water capacity, minimum air capacity have been monitored.

On the basis of obtained results it may be said that sandy soils have the low sensitivity to soil compaction. Clayey soils are typical with often unfavourable physical properties which can be caused by origin mechanical composition of these soils and anthropogenic impact (heavy machines usage), as well. The sensitivity of clayey soils to soil compaction is mixed (primary and secondary sensitivity).

Finally, the deterioration of physical properties was determined on the most cultivated and fertile soils as Cherno□ems and Haplic Luvisols since 1993 year (Houšková, in Kob□a *et al.*, 1999).

### 3.6 Soil erosion

Soil erosion is very serious problem. Intensity of soil erosion depends on silt fraction and soil organic matter content as well as on inclination and utilisation of field. Therefore soil erosion is more or less significant process. On the basis of obtained results the soil erosion was determined mostly in the range 6—17 $t \cdot ha^{-1}$ per year (medium and strong erosion). Only 3% of farming land is affected by strong and extremely strong erosion in Slovakia.

## 4 Conclusions

Global soil change in conditions of Slovakia is summarised in the following Table 2. In spite of the short – term observation (since 1993 year) some obtained results are already significant at present time. Global soil change depends on a composition of soil cover and on anthropogenic impact as well as on global climate change. The results of a soil global change depends to a great extent on its reversibility. The degree of reversibility or irreversibility of measured soil properties will be possible better to evaluate in the next soil monitoring process. Land degradation process is in relation to irreversible change of measured soil properties.

**Table 2 Global soil change in conditions of Slovakia since 1993 year**

| Fields of monitoring | Development tendency |
|---|---|
| Soil pollution | without significant change |
| Soil acidification | Slight tendency mostly on acid soils and substrates |
| Soil alkalisation and salinisation | primarily very slight process |
| Available nutrients P and K content | decrease mostly on cultivated and arable Soils about 10%—30 % (influence of low fertilisation level during last period) |
| Soil organic matter | decrease on cultivated and arable soils |
| Soil erosion | more or less running process |
| Soil compaction | deterioration of physical properties especially on Cherno□ems and Haplic Luvisols |
| Desertification (as a result of global climate change) | very slight and sporadically occurring phenomena in the most warm and dry regions of Slovakia for the time being (increase of groundwater mineralisation, resp. increase of groundwater level) |

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