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Transformation of salt-affected soils and their vegetation in Hungary as a result of human influences on soils and landscapes

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Summary

Although most of Hungarian lowland landscapes show a flat geomorphology a very high diversity of soils developed. The most important reason of this diversity is the everywhere presence of small elevation differences due to controlling runoff and groundwater levels.
In local level (southern Hortobágy) the typical elevation for developing accumulation horizons (86,5-87 meter above sea level), their intensity (ESP up to more than 70 %) and vertical position in profiles (closer than 50 cm to the surface) were established. With deviation (in both directions) from this surface level decreased the intense, and increased the vertical position of accumulation horizons. In the study area also strict human control on groundwater level was found, which could shift the accumulation horizons vertically. The process could reorganize of soil pattern also horizontally, also in larger scale.

Keywords: desalinization, secondary alkalization, changes of halophytic vegetation, accumulation horizon, salt affected soils

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Introduction

In Hungary more than 10% of the country is influenced by any form of alkalization processes, and on further 10% is the risk of secondary alkalization present. It is strictly related with climatic, geologic, hydrogeologic but also with anthropogenic factors.
Like in other regions of the world in Carpathian Basin could be also significant increase in frequency of extreme temperature and precipitation established (Bartholy – Pongrácz 2007), but no significant increase in annual mean temperatures were be pointed out for the last century (Domonkos – Tar 2003).
Even if we accept predictions of global warming, regarding the salt-affected soils in Hungary, human impacts affect probably more effective the landscape and soils, than climate change.
Relevant factors of alkalization are directed – intentionally or unintentionally – by human activities. Cultivation, drainage, water regulation, irrigation, amelioration affects significantly soil developing factors and processes.
Authors report about various soil transformation processes on saline and alkaline soils: a generalized trend could be hardly established. These various transformation phenomena of alkaline soils have an importance not only for agricultural production, but also for conservation directives and management practice for the natural halophytic communities on protected sites.

Changes of soil forming factors

Depth of the shallow alkaline groundwater is the most important factor controlling the development of salt affected soils. Since groundwater level stay mostly under anthropogenic control on local scale, the effects of it in accumulation or desalinization processes could hardly separate from regional functioning processes. Water regulations affected the whole Hungarian Plain and created the possibility of a sinking groundwater-level and desalinization of salt affected soils (Szabolcs 1989).
Rapid desalinization processes occurred only in sandy areas between Danube and Tisza rivers, where groundwater sinking until 3

meters in the last decades could be measured (Fig. 1.) (VITUKI 2006). Disappearing of former salt-lakes, lower frequency of salt crusts, transformation of solonchaks into solonetz, colonization of non-halophytic plants on former solonchak soils (Bagi 1989) and decreasing abundance of halophytic plants characterize these processes.

Despite of this the central Tisza region could be characterized by rising tendency of groundwater level. It could be an effect of not concreted, earth-constructed irrigation canals, water reservoirs and fishponds, and the very poor water permeability of soils. Rising groundwater together with its high sodium concentration could cause secondary alkalinization or salinization on local scale.

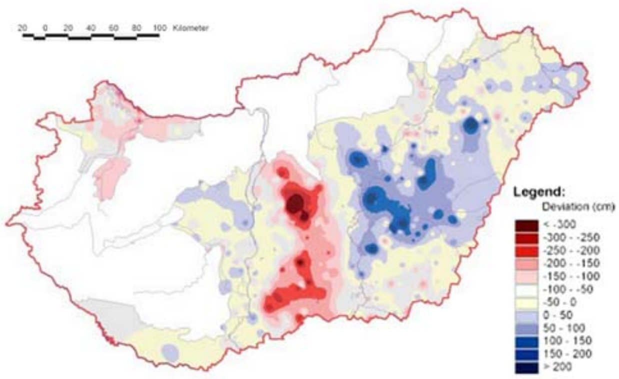

Fig. 1. Deviation of the average level of groundwater in the year 2003 from the average of years 1956-60 (VITUKI 2006)

As long term lysimeter experiments (Karuczka 1999) pointed out groundwater in surrounding of irrigated ploughlands could enriched by sodium, as result of the accumulation of sodium washed out by irrigation water. Although no significant increase of the total salt concentration was found in this case, because of well functioning drainage.

Based on analysis of data from 70 salt-affected profiles of “Soil Protection Information and Monitoring System” authors (Kovács et al. 2006) established generalized trends of actual soil development processes for different salt-affected soil types in the period between 1992 and 2000. Salt accumulation was characteristic for solonetzic meadow soils and solods, desalinization of the topsoil was typical in case of solonchaks, and no significant tendencies could be pointed out in case of solonetz soils.

Different risk of secondary alkalization by catena

Most important factor influencing the position of accumulation (natric, or rarely salic) horizon in the profile is the average level of alkaline groundwater. Since the elevation differences in large scale are very small, these differences appear also very close to each other in small scale. That means, that groundwater level which is influenced by rivers and undersurface water supply from surrounding hilly regions, could be situated in different depth below the surface depending on different geomorphologic elements. Soils in highest elevation (chernozems) were just as free from influence of salt accumulation like ones in deeper, from surface water out washed meadow soils. According surface elevation, groundwater level, position of accumulation horizon and genetic soil type a catena could be compiled (Fig. 2.). Most of Hungarian lowland landscapes show up a mosaic-like soil pattern composited from the members of this catena.

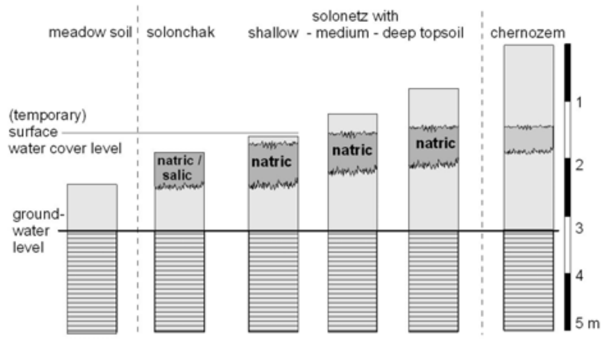

Fig. 2. A typical catena of Hungarian salt affected soils

This situation could be change if groundwater level changes because of any kind of human activity or climate change. Generally it is with sinking of groundwater level to reckon, but also a rising of it could be present on local scale. Vertically shifting of accumulation horizons could result a reorganization of soil pattern horizontally.

The risk of salinization or desalinization is different in different elevations by this catena. A groundwater sinking in case of solonetz soil sinking could cause desalinization, while it could result secondary alkalization in meadow soils.

Materials und Methods

To prove the importance of relative elevation in the development of soils accumulation horizons we analyzed data of 42 soil profiles situated on southern Hortobágy. The sampled area is about 50 km^2.

Profiles were sampled in each 10 cm. In each sample pH, organic matter, calcium-carbonate, exchangeable cations were measured. Absolute elevation (above sea level), genetic soil type (according to Hungarian classification system), maximal ESP of profile and its position (depth) in the profile were taken into consideration as profile characteristics.

In some cases, when locale changes of water regime, and former vegetation were well documented, occurrence or local extinction of halophytic plant species were registered. Changes of halophytic vegetation indicate vertically shifting of accumulation horizons.

Results

42 soil profiles were sorted in 5 classes by the elevation of the surface. Fig 3. shows the distribution of highest ESP values from each profile sorted by elevation classes. Highest ESP maxima could be measured in profiles of middle elevation. According the diagram surface elevation of 86,75 meter could be established as the most typical for developing soils having accumulation horizons in these region.

24 of the 42 profiles fulfilled the solonetzic criteria according the Hungarian soil classification system (ESP>15%), which could be characterized as profiles having accumulation horizon. They could be sorted in 4 of the above mentioned 5 elevation classes, while no higher than 15% ESP could be measured in the highest elevation class. 11 of these profiles were situated in middle elevation (86,5 - 87 m).

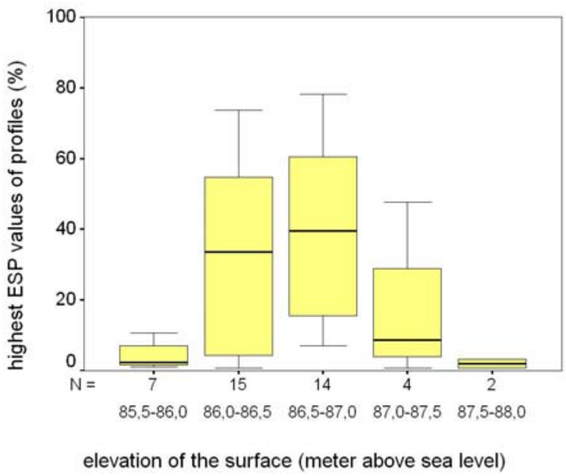

Fig. 3. Intense of accumulation in 42 profiles from southern Hortobágy sorted in classes by elevation of the surface

In success of developing of natural or cultivated vegetation has not only the intense of accumulation horizon (which characterize the ESP), but also the position of it an importance. A deep situated accumulation horizon influences only moderate the vegetation growth, while close to the surface it could be a very strong limiting factor.

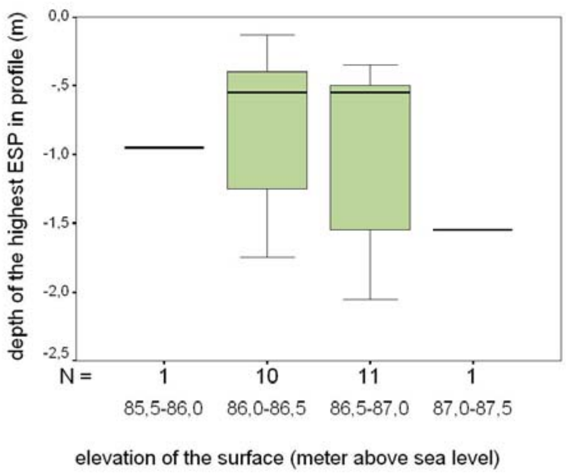

Fig. 4. Depth of accumulation maxima in cases of 24 profiles (having accumulation horizon) from southern Hortobágy sorted in classes by elevation of the surface

Fig. 4. contains data about position of the profiles accumulation horizon (depth of maximal ESP values below the surface). In two classes (86-86,5 and 86,5-87 m) there are profiles, which accumulation horizons are situated closer than 1 meter to the surface.

A Spearman's rank correlation between the maximum ESP values and the deviation of elevation of surface from 86,75 (where the highest ESP was found) in each profile were proved, where r_s= –0,491 and p=0,001.

The results mentioned above point to the importance of relative elevation of the surface in vertical position of accumulation horizons. Of course differ landscapes and regions in absolute elevation of most intense accumulation, which could be changed also by human impacts.

Vegetation as indicator of soil changes

As result of canalization of deep habitats covered by meadow soils sinking groundwater level and secondary salinization in the topsoil could be pointed out. The process was indicated by occurrence of halophytic plant species such as *Spergularia maritima* (All.) Chiov., *Aster tripolium* L. subsp. *pannonicum* (Jacq.) Soó, *Bupleurum tenuissimum* L. and *Atriplex hastata* L.

As result of setting fishponds stabilized a constant high groundwater level. Because of rising groundwater and its alkaline character a secondary alkalization appeared on former dry and only slightly alkaline habitats. Pedunculate oaks declined, cover of *Aster sedifolius* L. subsp. *sedifolius* decreased and the alkaline swamp character species (*Cirsium brachycephalum* Juratzka) occurred in this habitat.

In contrary of this in numerous sites of Hortobágy could be observed that thin vegetated microhabitat plots lose halophytic species (like *Camphorosma annua* Pall., *Suaeda pannonica* Beck.) while they became more dense vegetation cover mostly by *Artemisia santonicum* L. and *Festuca pseudovina* Hack. ex Wiesb. This could point to possible desalinization processes, which have to be proved basing on soil characteristics.

Discussion

Development of salt affected soils lies under control of changing groundwater level, which is significant influenced by human activities in Hungary. Despite of water regulations and decreasing aridity index of the country it could be hardly a general tendency established in soil development. Examples for both secondary alkalization and desalinization could be mentioned.

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