Dynamics of Salt Accumulation in the Danube Valley

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1 INTRODUCTION

Studies on salt-affected soils represent the frontline of soils researches (Letey, 1984) worldwide. The same is true in Hungary where research on salt accumulation started more than two hundred years ago (Ballenegger and Finály, 1963). Up to the present numerous studies have focused on salt-affected soils. Interestingly, although there are nine main soil types altogether in the country, only three of these main types have been described by monographs so far. In contrast, salt-affected soil types that cover less than one tenth of the territory of the country, are discussed by 20 books, out of which six are monographs.
Salt-affected soils are noted for their spatial and temporal variability (Wu et al., 2001). Similarly to the multiple scales of variability in space, temporal variability is also manifested at several period lengths. Not only salt accumulation shows changes in time, the attitude towards these soils have undergone great changes. For example in the greatest contiguous Central European salt-affected grasslands of the Hortobágy, paddy fields were built during the nineteen-sixties, but after a few years cultivation was stopped because of low yields. The grasslands became protected ten years later as a National Park and at present the abandoned paddy canals, dams and locks, roads are being removed.
Based on published data and our monitoring, the experiences gained on the dynamics of salt accumulation in the root zone in the area between the Danube and Tisza rivers are described in the subsequent sections. The studied grasslands have undergone long-term changes (Iványosi Szabó, 1993) in the course of 80 years, since the drainage of the wide marshlands along the River Danube. All three study sites are located in areas, which were strongly affected by the river either directly by floodwater or indirectly due to its influence on the groundwater level. The basic reason for the ongoing changes is the decrease in surface water, such as no floods and the sinking groundwater level (Bakacsi & Kuti, 1998, Rotárné Szalkai Á., 1994). Several factors, such as drainage of the area, increased groundwater use, afforestation and decreasing atmospheric precipitation, as well as higher air temperature promote these processes. Drastic changes have occurred in the vegetation cover already, the most notable is the shrinkage or disappearance of the saline lakes (Boros, 1999) and the drying and desalinization of the soils of the saline grasslands. Salt-affected habitats are quite sensitive to these changes, as the saline groundwater is the direct source of salts in the soil layers. As Várallyay (1966) emphasized, there are two main factors of salt accumulation in this region: the direct effect of weather (i. e. precipitation and evaporation) and the effect of groundwater level.

2. RESULTS

2.1 *Changes in soil salinity during the 33 years of observation*

In a saline-sodic spot changes in soil properties were followed by Harmati (2003), six times from 1951 on. Data collected for the check plot with continuous native grass vegetation of a long-term experiment were selected and data averaged for the 0-20 cm depth are discussed. Fig 1 shows that as time passed values of soil salinity, soda content and pH shifted significantly with a monotonous decrease. On the other hand the capillary water rise (height which was attained by water in glass tubes after 5 hours) showed increasing values with time. The correlation between the chemical parameters was statistically significant at the 0.05 level. Soda content showed a significant correlation with the other two chemical parameters at the 0.01 level. In the case of capillary rise - a traditional indicator of the speed of water movement in the soil - curves were fitted to the chemical parameters with correlation coefficients significant at 0.01 level.

Figure 1. Relationships between soil salinity (%), pH, soda content (%) and capillary rise (mm) of samples taken from the 0-20 cm layer of a grassland during 33 years of observation in (after Harmati, 2003)

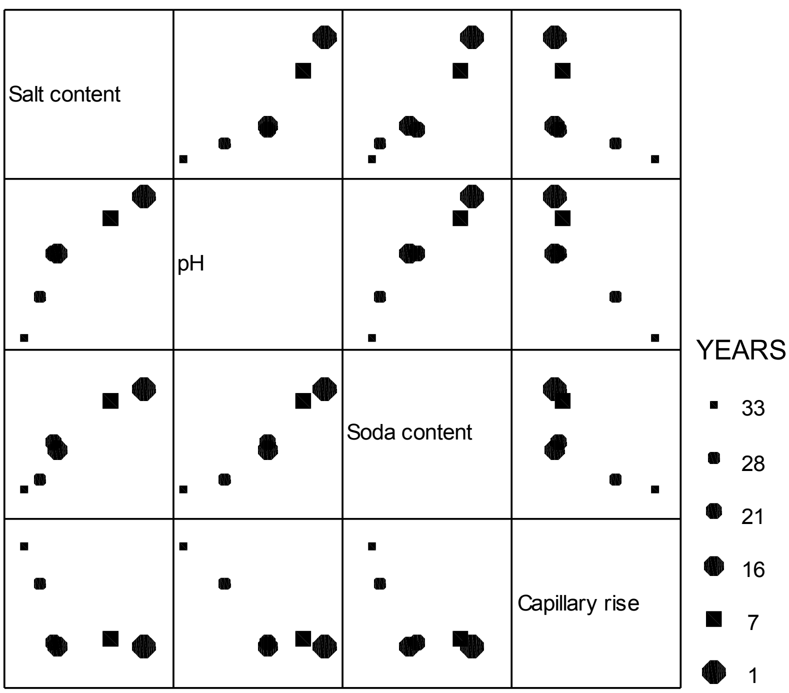


Table 1. Yearly mean air temperature and sum of precipitation during the monitoring

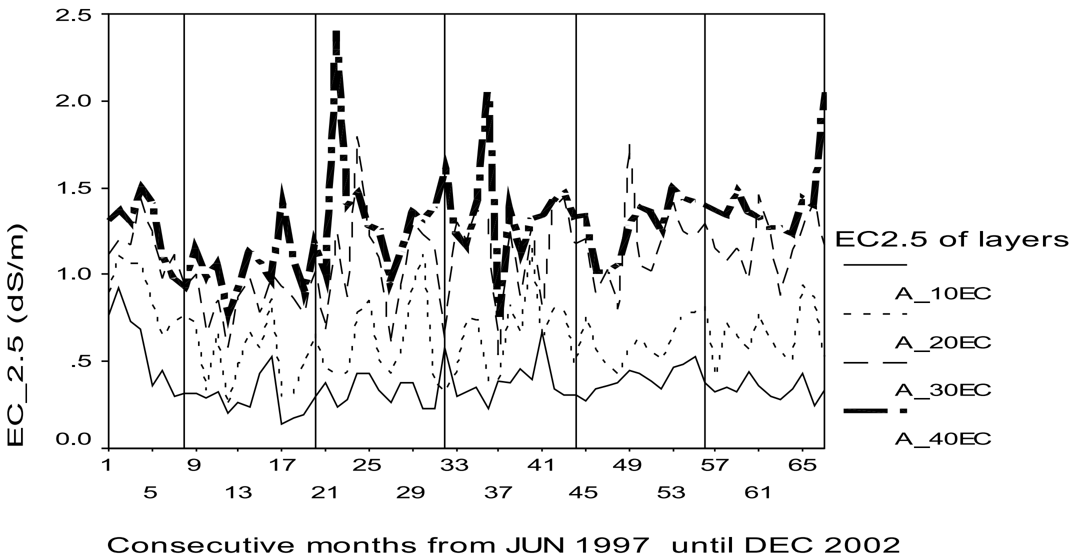
Year	Air temperature [°C]	Precipitation [mm]	Remark
1997	10.45	481	Observation starts in June
1998	10.98	596	
1999	11.21	830	
2000	11.71	332	
2001	10.70	594	
2002	11.79	464	Observation ends in December

2.2. *Monitoring changes during a five-year period at two sites*

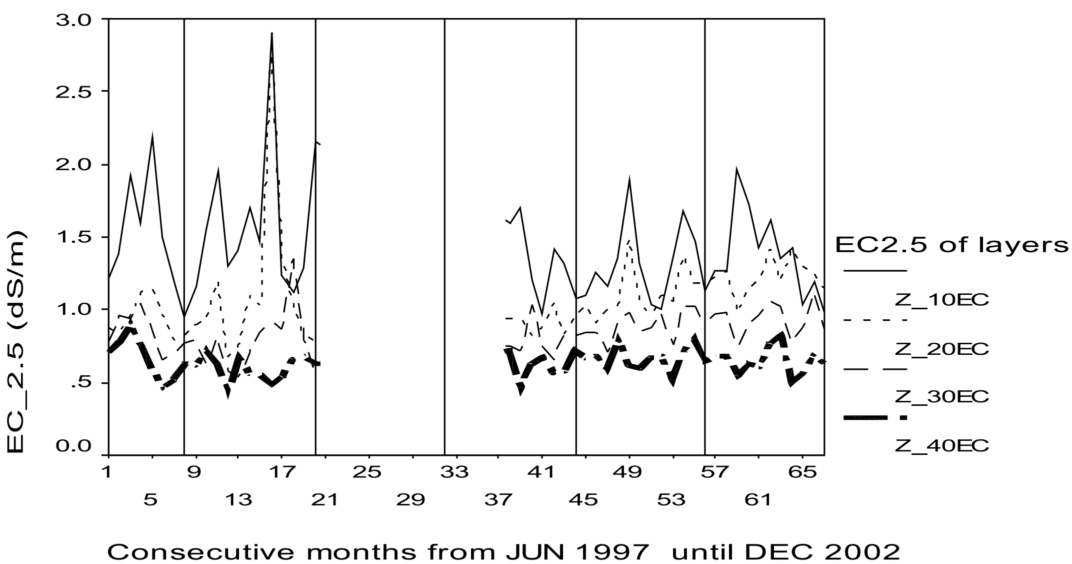
The monitoring consisted of 67 monthly observations of soil properties and species cover in a sodic ("Artemisia saline puszta" vegetation on "Solonetz" soil type) and a saline-sodic ("Pannonic Puccinellia limosa hollow" vegetation on "Solonchak" soil type) grassland. The sodic vegetation, located near to the 33-year long-term experiment is a result of gradual drying and groundwater sinkage. Right after the drainage of the original floodplain area first marsh, later meadow, subsequently semi vegetated salt-tolerant grass vegetation was characteristic. The saline-sodic vegetation is the result of the continuous drying of the lake and the shifting of the lake margin towards the bottom of the lake.

Figure 2. Changes in soil salinity ($EC_{2.5}$, EC of 1:2.5 soil: water suspension) in the four surface layers (0-10, 10-20, 20-30 and 30-40 cm) at a sodic site (a) and saline-sodic site (b)

a.) 1997 1998 1999 2000 2001 2002



b.) 1997 1998 1999 2000 2001 2002



At the sodic site, during the studied 67 months salinity increased in the 20-30 cm and 30-40 cm layers, while the average salinity of 0-40 cm depth did not show such a tendency (Fig 2). The difference between the 30-40 cm and 0-10 cm layers indicates the degree of leaching in the profile, that is the degree of the development of "Solonetz" soils. This showed significant correlation with the time elapsing at the 0.01 level. The transformation of soils from "Solonchak" (maximum of salinity is at the surface, Fig 1.b) into "Solonetz" (maximum of salinity is deeper, Fig 1.a) is going on at present. This is further evidenced by the statistically significant trend in the increase of pNa value at all four depths.

At the saline-sodic site there was a temporal tendency of decreasing pH and increasing pNa at all four depths (from 0-10 to 30-40 cm) significant at the 0.01 level, which can be related to the waterlogging of the site in 1999. The rise of the lake water level provided leaching water with low salinity, sodicity and alkalinity, consequently the soil pH and Na concentration decreased.

As compared to long-term meteorological data, the study period was warmer (Table 1) and represented extreme and close-to average years as well. There were significant tendencies in the changes in soil salinity, pointing to leaching and desalinization of the surface layers, the most typical process going on in the region.

3. CONCLUSIONS

The drop of the groundwater level resulted in the reduced acreage of salt-affected areas in the region between the Danube and Tisza rivers. This is evident in the area of sand dunes, but also noticeable in the Danube valley, which was an open floodplain 80 years ago. The transformation of soils from saline-sodic to sodic is taking place at present and the tendency seems to keep on. The desalinization, which could favor crop production is not welcome, as it promotes the spreading of undesirable weeds and threatens the stability of the protected salt-affected habitats.

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