Agrogeological Investigation on a Salt Affected Landscape in the Danube Valley, Hungary

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Introduction

Since the last decade, when the drop of the groundwater level was noticed on the Danube-Tisza Interfluve (MAJOR & NEPPEL, 1988; SZALAY & LÓCZY, 1992; KUTI, 1994), the research investigations of this region have become more intensive.

The Apajpuszta study area is located 40 km from the Danube, in the NS directed Danube Valley, with a hardly undulating landscape, bordered by sandy hills (120-140 m) from east. The other borders are artificial ones; the Átok canal from west, the Apaj road from north and the city of Kunszentmiklós from south. The southern part of the area is a nature conservation territory, being part of the Kiskunság National Park. The average elevation of the study area is 95.5 m above the Baltic Sea level, its surface is covered by salt affected soils. This area was many times the subject of different research investigations and mapping (SCHERF, 1935; SZABOLCS & JASSÓ, 1961; ERDÉLYI, 1967; VÁRALLYAY, 1967, 1968, 1993; VÁRALLYAY et al., 1985). The main goal of the recent experiment was to study interactions among the soil–parent material–groundwater systems (KUTI, 1994).

Geological Sampling Method

97 near-surface (5 m deep) boreholes were drilled in May 1987 in the framework of the Agrogeological Project of the Geological Institute of Hungary. The applied hole-net and the topographic features are shown in Figure 1.

Sampling was carried out in each distinguished stratum or at least for every 0.5 m layer down to 2 m depth, and every 1 m downwards in the boreholes, and once from the groundwater. All boreholes reached the groundwater table, at 0.4–2.0 m below the surface. The used sedimentological (grain size distribution) and chemical (carbonate and organic matter contents, chemical properties of groundwater) data were measured at the Geological Institute of Hungary.

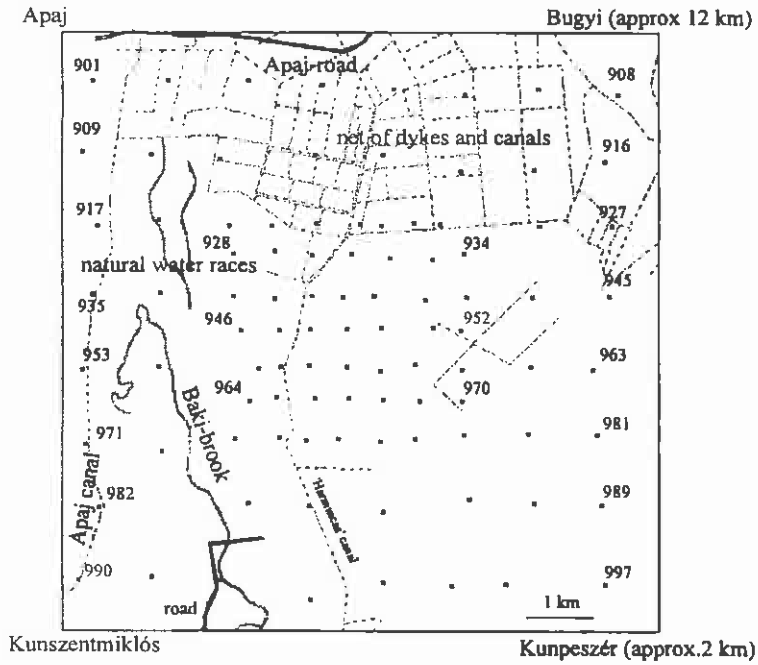

Figure 1
Main topographic features of the Apaj model area
(the nearest towns and some locations of boreholes are marked)

Chemical composition of the groudwater

Based on the measured components, the chemical composition of the groundwater can be characterized by the dominance of hydrocarbonates and sodium ions. Figure 2 shows a section where the highest salt content occurred (for the same series of boreholes which were used for the geological cross-section in Figure 3).

Geological and sedimentological structure

From the north peak of the Csepel Island to south a nearly 200 km long and 20-30 km wide strip of alluvial and floodplain terrace sediments have been spread along the Danube (RÓNAI, 1985). The river deposited its sediments from the mid-Pleistocene during the Holocene, up to the end of the last century (1870), when a large net of canals was established in the Danube Valley to control flood events. Holocene alluvial sediments are characteristic of the whole Apaj area. According to the description of a 104 m deep borehole in the Kunszentmiklós area, the thickness of the upper Quaternary gravel-sand sediments is about 25 m in this region.

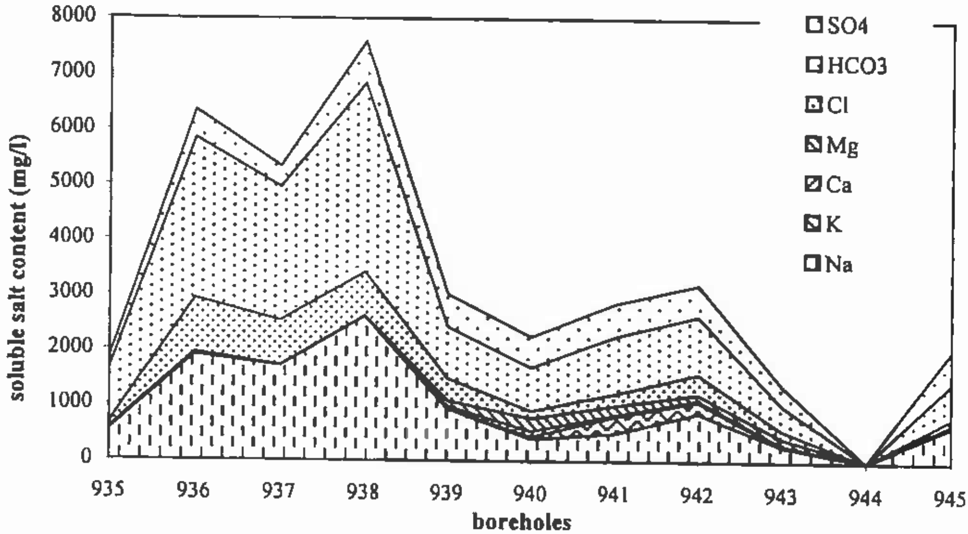

Figure 2
Chemical composition of the groundwater in a selected section (there are no data for borehole No. 944)

Based on the constructed cross-sections, the following structure of sediments was found in the Apajpuszta study area (Figure 3):

We can distinguish three different beds (group of layers) within the exposed alluvial floodplain sediment body. The lowest one is an alluvial gravelled sand layer; its gravel content is changeable, varying between 5-20%. It is usually exposed between 3.5-5 m; its largest thickness is 1.5 m, but many times it is indicated only.

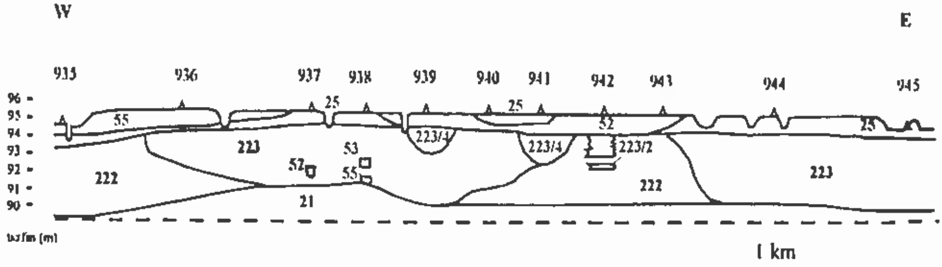

Figure 3
W-E cross-section of the study area. Legend: 55 clay, 53 clayey silt, 52 clayey sand, 25 sandy clay, 223/4 fine-small grained sand, 223 small grained sand, 223/2 medium-small grained sand, 222 medium grained sand, 21 gravelled sand

In the next layer sand is characteristic, without gravel and its clay content is also insignificant. Its average thickness is 2-4.5 m. The distances among the boreholes are larger than the presumable width of the river bed was, only some small lenses that are filled with fine grained clay-clayey silt sediments indicate the proximity of the ancient river branches.

The third, uppermost bed is a 0.5-0.8 m thick fine grained blanket, covering the surface, built from alternating layers of clay, clayey sand, sandy silty clay, etc. It probably resulted during the final stage of the filling process, when the fine grained floodplain sediments were dominant.

Vertical logs to classify the main sedimentological stuctures

Constructing and analyzing the vertical logs of boreholes, they can be classified into three main groups (Figure 4). For the characterization of the logs a clay+loam+silt/sand(+gravel) ratio was applied. Its changes in the profiles represent the variability of sediments that were transported and deposited by the river (some deposition by wind is possible).

Group „A": the clay+loam+silt/sand ratio has its maximum at the surface and becomes gradually coarser grained with depth. The ratio decreases without significant accumulation peaks.

Group „B": the clay+loam+silt/sand ratio has a maximum at the surface and has accumulation peak(s) deeper. The gradual change in grain size (the deeper the coarser) exists in general, but it is interrupted by fine grained layer(s).

Group „C": the clay+loam+silt/sand ratio has its maximum below the surface. Depending on other characteristic features its subtypes can be „AC" or „BC". There was a single borehole in which only sand, poor in fine grains was exposed and it was also added to this group. The identification of the members of group „C" is only based on the differences in the sand content in their top layers in comparison with the deeper parts.

Sampling the Uppermost 40 cm of the Soils

As it was mentioned above, the salt affected soils in the Danube Valley have many times been objects of various studies, but unfortunately only the western part of our study area has been involved in previous soil mapping projects. Because of the mosaic-like soil pattern in this area a larger scale sampling method would have been necessary than the geological one. Finally, however, only a relatively small-scale sampling was carried out to get some comprehensive information in the field of study.

In May 1994 the upper 40 cm layer of the soil was sampled equidistantly, at each 10 cm depth. Sampling tried to follow the original net of boreholes, but some differences occurred. Apart from the possible mistakes the results of the above-mentioned sampling were applied for the original net of holes. Nearly

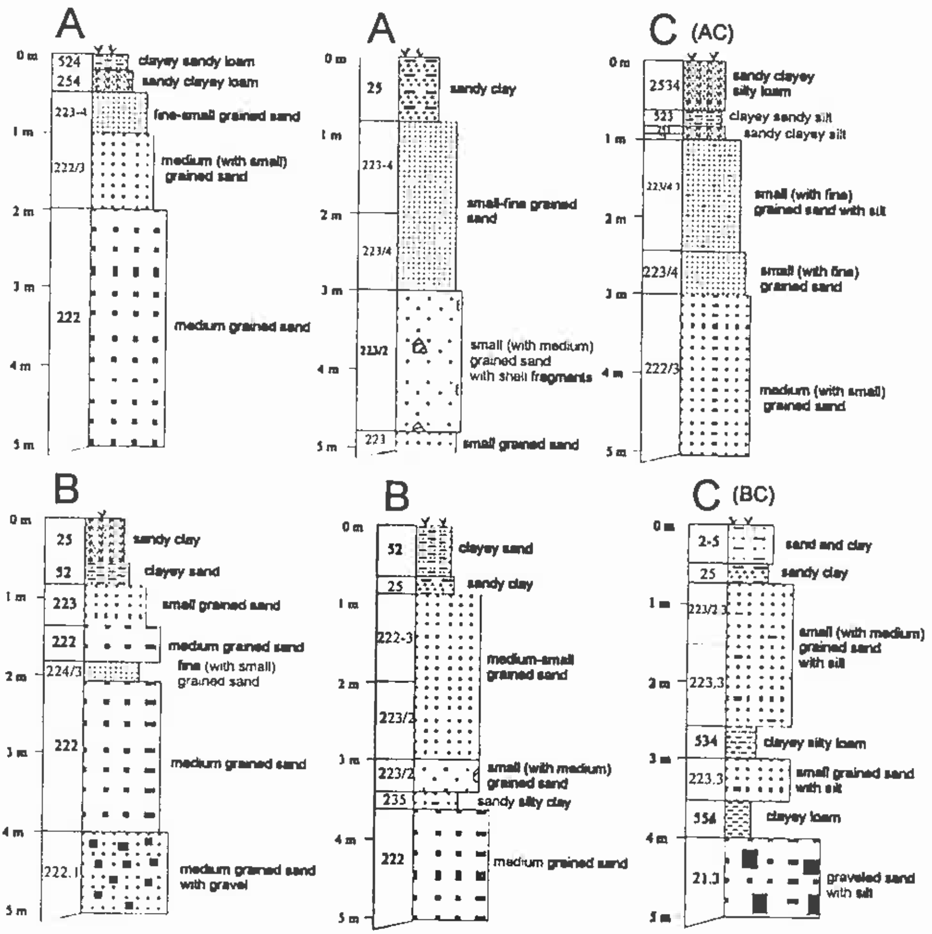

Figure 4
Basic types of vertical logs (A, B, C – with AC and BC subtypes) in the Apaj model area

400 samples were collected. Moisture content, EC and pH were measured. For their simple and immediate characterization EC and pH measurements were carried out in the laboratory using a 1:2.5 solid/liquid suspension, by adding 75 ml distilled water to 30 g soil.

Empirical separation of the samples, based on their settling velocity

Following measurements in laboratory, the suspensions were left undisturbed for a week. Some days later they were divided into two groups as a function of their settling velocity. The first group (p=0) can be characterized by fast settling leading to complete segregation of the solid and liquid phases within a few hours. The members of the other group settled slowly and – for more than 24 hours – the separation did not take place (peptized, p=1). In our case there are three main factors that may have a joint effect and result in the differences in the settling velocity:

1. the original grain size distribution of the sediments,
2. the grain size distribution, which was affected by leaching processes, leading to the transport and accumulation of the clay fraction in the B horizon,
3. the exchangeable sodium content on the colloid surfaces, which can keep the clay in dispersed form, obstruct their flocculation and fast settling.

Separation of the samples based on the EC, pH, empirical „p" and depth interval

Supposing that the measured EC correlates with the soluble salt content of the samples, the higher salt content causes higher EC values. The pH varies in a wide range, from neutral up to alkaline values. The higher pH value means that the concentration of H ions is lower in the soil solution. In this area the ground-water can be characterized by a high amount of hydrocarbonates, which means that the carbonate ions connected with H ions decrease the H ion concentration in the solution, while pH increases. The pH can also be higher if alkaline hy-

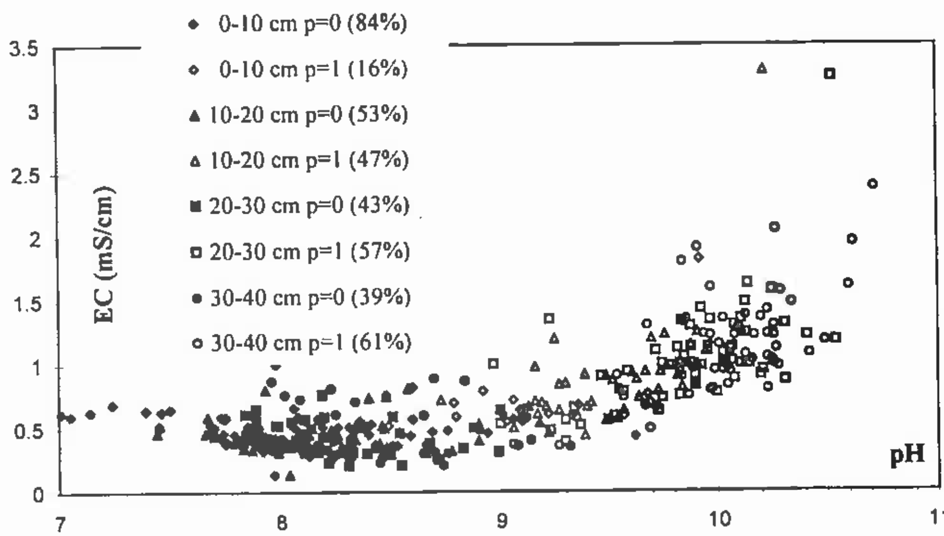

Figure 5

EC plotted against the pH values (The distribution percentage of the fast (p=0) and slowly (p=1) settled members of the samples were marked at each depth interval)

drolyzed sodium salts exist in the soil solution (SZABOLCS & JASSÓ, 1961). In Figure 5 we did not take into consideration differences based on the sedimentological feature of the samples. The pH clearly defines two subclasses as opposed to EC, which does not show such significant discrimination.

Figure 5 summarizes the measured EC plotted against the pH values, marking the distribution percentage of the fast (p=0) and slowly (p=1) settled members of the samples at each depth interval.

Figure 5 shows that the fast settling behaviour is characteristic in cases when the pH value is lower than 9-9.3 and EC is below 1 mS/cm. In this group the soluble salt content is low and stongly affected by the precipitated freshwater, and the presumable content of the exchangable sodium ions is not enough to keep the colloids in dispersed form for a long time in the suspension. From around pH 9, the EC value rises up to 3 mS/cm and the slow settling becomes characteristic.

The distribution percentage between the two sample groups – the fast settled and the samples suspending for a long time – in the same depth interval varies continuously from the uppermost 0-10 cm layer where fast separation is dominant (p=0=84%) to the deepest layer where its value drops to half (39%).

Separation of the samples based on their sedimentological log type

Figures 6 and 7 show the measured EC plotted against the pH values for different groups of samples. The basis of separation was their sedimentological

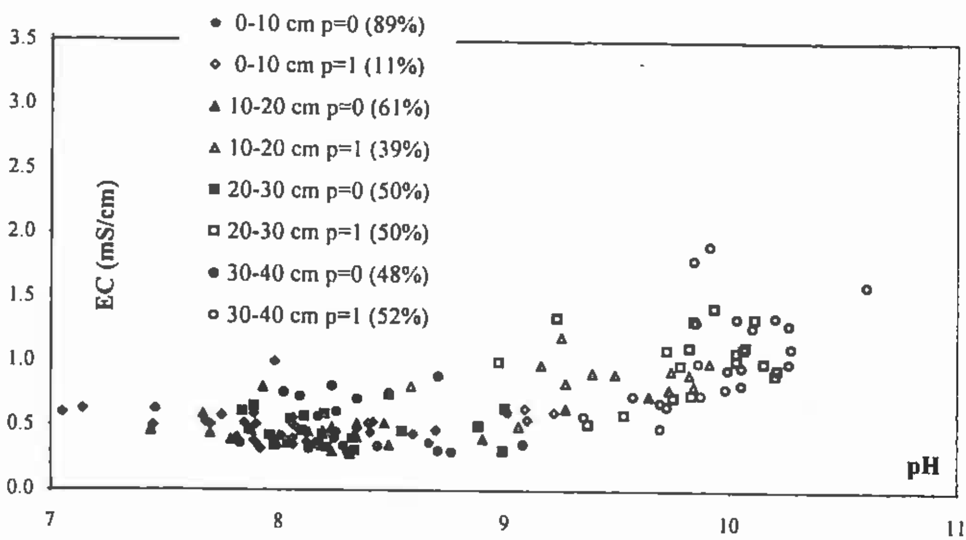

Figure 6

The EC plotted against the pH values for selected samples, according to their vertical log type. Group „C".

log type. There were 38 samples in the „C" group (Figure 6) and 58 in the „A and B" group (Figure 7).

Comparing the resulted scatter plots of the „C" and „A and B" type series of samples, the similarities are striking. Both of them are divided into two sub-

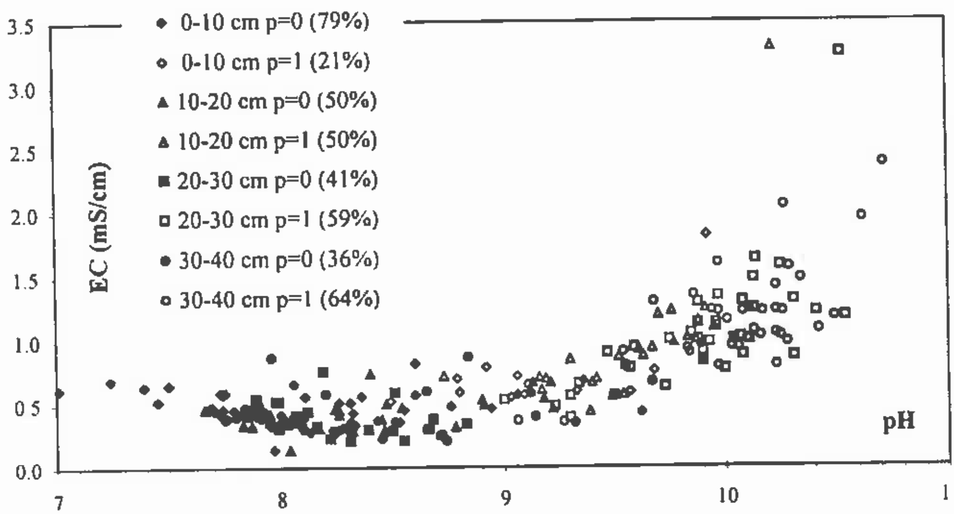

Figure 7

The EC plotted against the pH values for selected samples, according to their vertical log type. Groups „A and B".

groups according to their pH and settling behaviour. In the same depth intervals the distribution percentage of slowly settled samples was always a smaller value for Group „C" than in the case of „A and B" samples. In comparison with „A and B" log types, the "C" type usually has a higher sand content in the upper layer. The higher sand content means that if the sum of the colloid surface is smaller, the sodium has less possibility to contact and disperse them, so the settling behaviour will be determined mainly by the original grain size distribution of the sediments.

Comparing the 0-10 cm depth interval with the deeper layers a great difference was observed between them in their distribution percentage of non and strongly dispersed samples. This „jump" is due to the leaching process which can move the clay size particles down from the upper part of the profile, causing clay illuviation there, while the top layer loses a large amount of its clay content.

The EC and moisture content mean values

The EC mean values in Group „C" are always lower – in the same depth interval – than in the other group, which indicates differences in their salt content

(Table 1). Salt accumulation in the deeper part of the profiles is characteristic for Group „C" and „A and B", while the degree of accumulation is less in the „C" type.

The moisture content is always higher in the top 10 cm than lower down. From 10 to 40 cm depth the miosture content is more or less balanced, the differences are non-significant, being below 1%. The larger moisture content in the top layer may be due to the rainy weather at the time of sampling (Table 1).

Table 1

The EC and moisture content mean values for each depth interval according to the sedimentological log types

Depth interval	EC (mS/cm)		Moisture content (%)	
	"A and B"	"C"	"A or B"	"C"
0-10 cm	0.53	0.49	17.0	17.7
10-20 cm	0.67	0.59	15.2	15.8
20-30 cm	0.82	0.73	15.6	16.5
30-40 cm	0.89	0.82	15.6	16.6

Summary

The classification of the vertical logs based on their clay+loam+silt/sand ratio resulted in three main groups of the boreholes, marked „A", „B" (more clay size particles on the top), and „C" (less clay size particles on the top). Because of their textural similarity in the upper layers, groups „A" and „B" were handled together versus group „C". EC, pH and moisture content measurements were carried out on the collected soil samples. With the empirical classification of the suspensions – used for EC and pH – based on their settling velocity, two groups were established. In the fast settled group the settling behaviour was identified by the grain size distribution. Slow settling was due to the higher amount of exchangeable sodium, which dispersed the clay size particles.

Differences were observed between groups „A and B" and „C" in the trend of their EC distribution. In the deeper layer the same EC value was found for „C" type profiles as for the „A and B" group. In this area the evaporation rate, the depth and salt content of the groundwater determine salt accumulation in the profiles. The lesser salt accumulation in the „C" type may be due to its higher sand content and its lower capillary conductivity – due to which the salty groundwater does not rise to the upper layers –, than in the cases of "A or B" types.

From geological point of view the Apaj study area is quite homogeneous, while its soil cover is variable. For studying the sedimentological structure of this area, the geological sampling method was used successfully, the structure

of the sediment was well exposed. Using detailed sedimentological log types to classify the soil samples, some differences were displayed. As the mosaic-like soil pattern has a larger scale, the sedimentological „pattern" (based on small-scale data) has relation with the experienced settling velocity, the EC and pH values of the surface soil samples.

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