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Impact of environmental and climatic changes on a Protected Salt Plain in Danube valley, Hungary

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Introduction

This study aims to analyze the impact of meteorological (Bartholy et al, 2009) and environmental changes (Szabolcs, 1979; Várallyay, 1980) on groundwater levels and soil properties in the Upper Kiskunság Alluvial Plain (Hungary) and to monitor possible changes compare to the 1967 and 1979-80 soil-, and 1987 groundwater-level surveys (Figure 1).

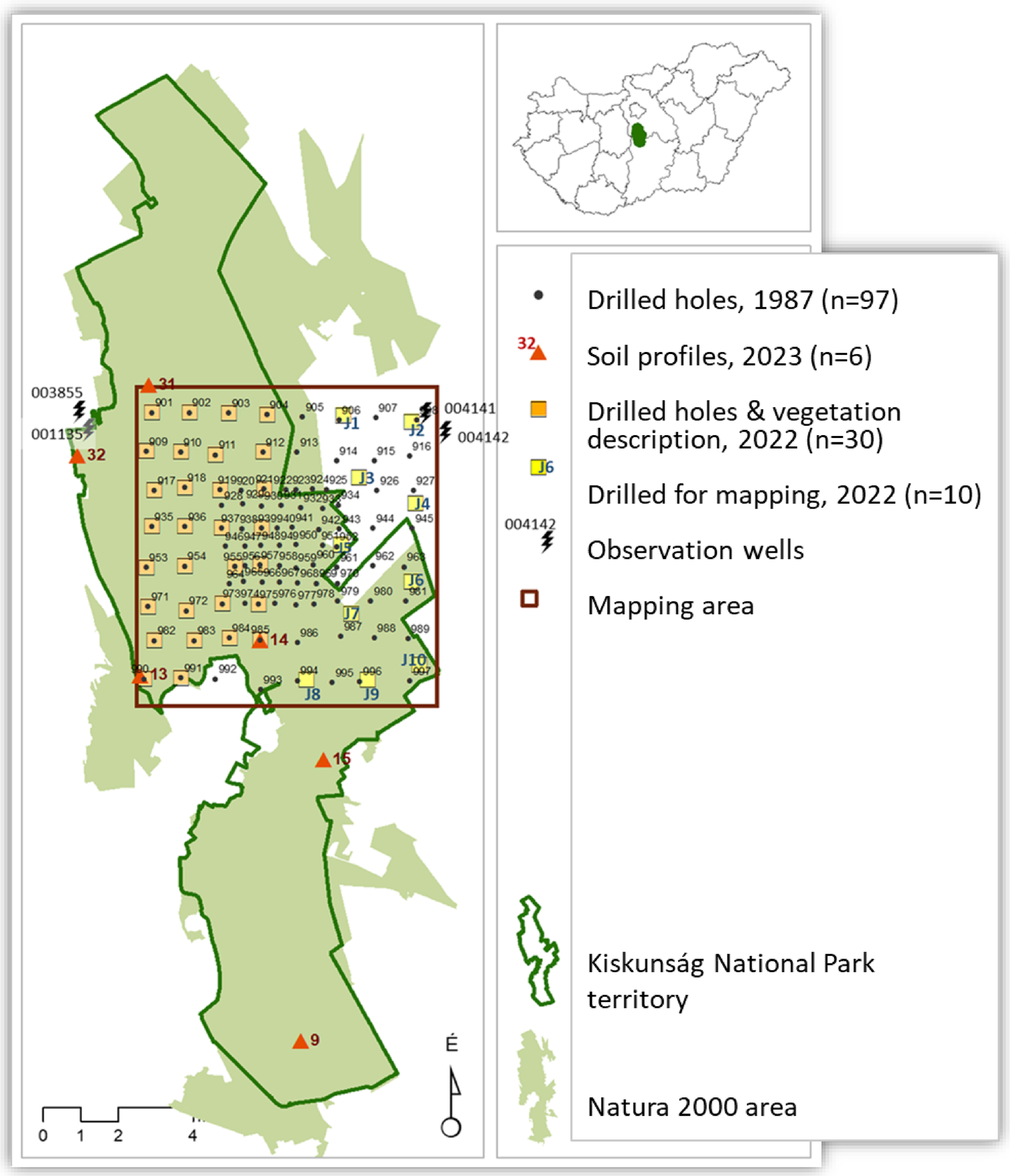

Figure 1: Study area, location of observation points

Methodology

During the data collection in 2022, 30 boreholes were drilled based on the previous survey grid (1987), measured groundwater depth and took soil- and groundwater samples.

Based on legacy maps from the 60's and 1979, six soil profile sites were detected, re-visited, and described (Figure 3).

The soil samples were subjected to basic laboratory analyses, and the water samples were used to determine the amount and composition of dissolved salt.

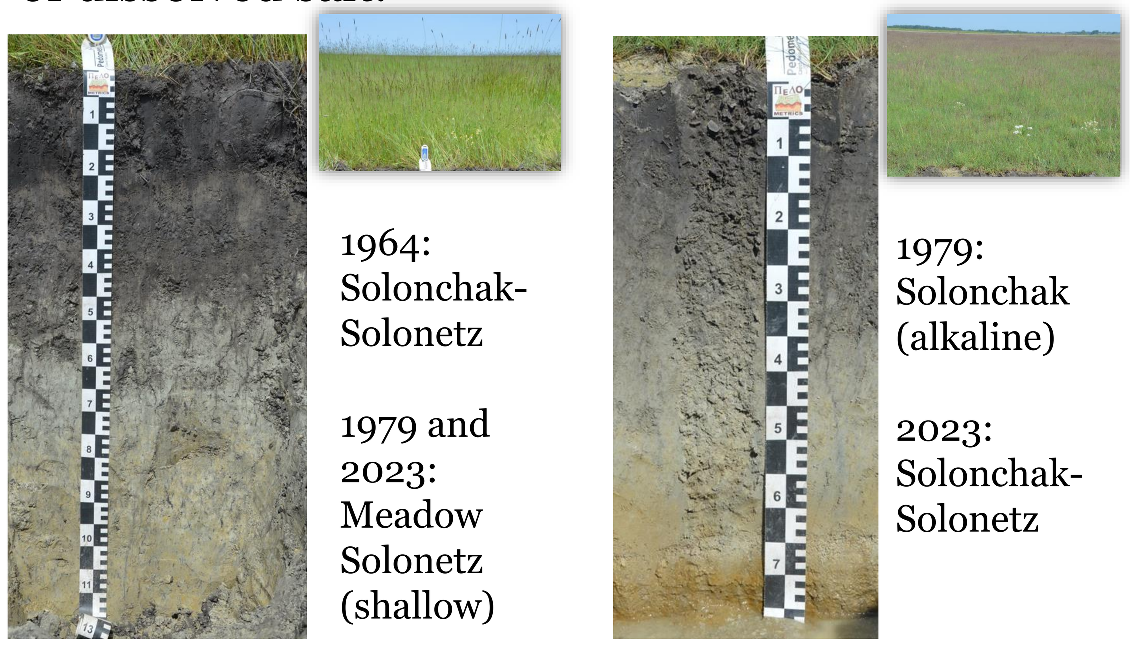

Figure 3: Profile-13 (left), Profile-31 (right), and their environment

Figure 3: Depth of groundwater level in 1987 (left) and 2022 (right), and their differences (mid-low)

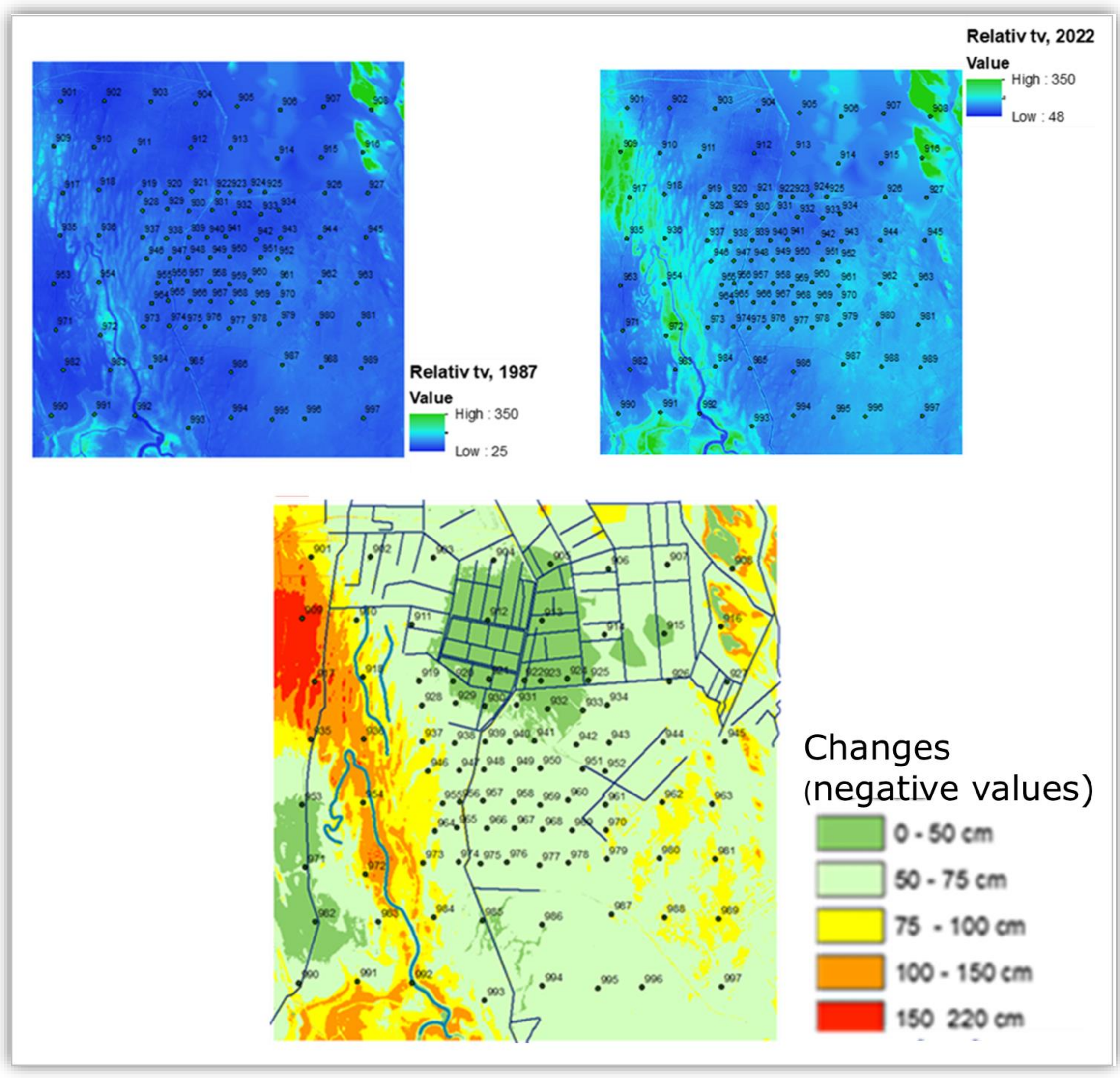

Table 1: Sampling depths and changes in **soil profile-13** (*means its data was substituted by the next borehole data, because of inland water) and **profile-31**, between 1964-2023.

Szelvény	Depth (cm) 1964	Depth (cm) 1979	Depth (cm) 1992	Depth (cm) 2023	particles SD, 1979: 2-0,05 mm (%)	particles SD, 1979: 0,05-0,002 mm (%)	particles SD, 1979: <0,002 mm (%)	particles SD, 2023: 2-0,05 mm (%)	particles SD, 2023: 0,05-0,002 mm (%)	particles SD, 2023: <0,002 mm (%)	990. fúrás (2023): agyag <0,002 mm (%)	pH H2O 1964	pH H2O 1979	pH H2O 1992	pH H2O 2023	pH H2O 990. fúrás (2023)
13*	0-1	0-5	0-5	0-5	9,20	42,50	48,30	41,03	49,13	9,85	56,57	7,53	7,70	8,44	7,68	8,10
	1-11	x	5-16	5-20	x	x	x	32,99	36,93	30,08		8,65	x	10,05	8,96	
	11-26	15-25	16-33	20-45	3,40	42,80	53,80	24,95	39,33	35,72	47,31	9,42	9,20	10,33	10,20	9,76
	26-43	33-45	33-47		2,40	44,80	52,80					9,27	9,80	10,33		
	43-70	58-68	47-70	45-75	2,80	56,00	41,20	14,90	42,30	42,80	45,25	9,08	9,90	10,39	10,43	10,21
	70-95	85-95	70-100	75-115	3,60	70,90	25,50	16,73	56,69	26,58	18,44	8,95	9,40	10,34	10,53	10,22
31	0-1	0-2	0-3	0-5	x	x	x	53,72	23,81	22,47		9,48	9,50	9,98	8,42	
	1-12	10-18	5-26	5-15	x	x	x	52,01	21,90	26,09		9,12	9,9	10,35	9,59	
	12-30		26-39	15-35				47,90	20,81	31,28		9,03		10,00	10,07	
	30-40	35-45	39-57	35-52	39,70	24,80	35,50	52,53	18,20	29,26		9,21	10,00	10,37	10,12	
	40-50	x	x	x	x	x	x	x	x	x		8,91		x	x	
	50-70	x	57-80	52-68	x	x	x	72,44	12,07	15,49		9,06	x	10,28	9,91	
	70-100	65-75		68-80	64,20	27,20	8,60	85,26	7,22	7,51		9,11	9,60		9,69	

Szelvény	Depth (cm) 1964	Depth (cm) 1979	Depth (cm) 1992	Depth (cm) 2023	$CaCO_3$ % 1964	$CaCO_3$ % 1979	$CaCO_3$ % 1992	$CaCO_3$ % 2023	$CaCO_3$ % 990. fúrás (2023)	Sum salt (m/m%) 1964	Sum salt (m/m%) 1979	Sum salt (m/m%) 1992	Sum salt (m/m%) 2023	Sum salt (m/m%) 990. fúrás (2023)	humusz (m/m%) 1979	humusz (m/m%) 2023	humusz (m/m%) 990. fúrás (2023)	Na^+ mmol/100g 1979	Na^+ mmol/100g 2023	Na^+ S% (ESP) 1979	Na^+ S% (ESP) 2023
13*	0-1	0-5	0-5	0-5	6,32	29,80	17,32	8,79		0,03	0,12	0,01	0,03	0,09	5,67	9,34		4,89	2,40	14,3	8,34
	1-11	x	5-16	5-20	9,64	x	32,17	18,39	25,72	0,17	x	0,17	0,08		x	1,62	3,15	x	5,07	x	16,8
	11-26	15-25	16-33	20-45	26,54	27,30	45,78	17,42	18,02	1,38	0,37	0,19	0,25	0,30	2,22	0,77	1,80	13,63	11,5	55	37,6
	26-43	33-45	33-47		48,46	33,50	40,01			0,85	0,70	0,20			1,27			12,88		48,9	
	43-70	58-68	47-70	45-75	26,54	54,50	32,17	31,33	34,82	0,45	0,50	0,20	0,40	0,40	x	x	0,36	10,24	14,7	46,5	41,0
	70-95	85-95	70-100	75-115	24,44	51,10	33,00	32,55	30,72	0,21	0,26	0,15	0,40	0,30	x	x	x	x	12,2	x	43,9
31	0-1	0-2	0-3	0-5	7,61	14,20	7,18	5,70		2,00	0,44	0,28	0,15		2,31	2,39		14,28	6,28	74	27,8
	1-12	10-18	5-26	5-15	9,72	19,4	6,07	7,08		1,15	0,32	0,35	0,2		0,95	1,15		8,17	9,65	38	32,7
	12-30		26-39	15-35	19,87		38,06	16,76		0,57		0,12	0,37			0,50			13,6		38,5
	30-40	35-45	39-57	35-52	29,60	42,80	37,21	32,15		0,35	0,28	0,07	0,19		x			6,67	8,06	37,3	22,6
	40-50	x	x	x	31,71		x	x		0,25		x	x								
	50-70	x	57-80	52-68	20,29	x	17,76	24,41		0,28	x	0,01	0,05		x			x	3,00	x	11,9
	70-100	65-75		68-80	19,87	29,40		18,72		0,24	0,05		<0,02		x			x		x	

Results and Discussion

Profile-13: In 1964, the maximum salt accumulation was in the 11-26 cm depth interval, with 1.38%. In 1979, the highest salinity (0.7%) was measured between 26 and 43 cm, and the maximum in 1992 was at this level and below, but with a salinity of only 0.2%. The 2023 recordings do not indicate a further decrease in the deeper layers (Table 1).

Profile-31: The pH was highest at the surface in 1964 (9.5), 10.0 in 1979 and 10.4 in 1992, typically at depths below 30 cm. In 1964, the maximum soil salinity was at the surface, with a peak of 2.0%, but it exceeded 0.24% throughout the depths studied, up to 100 cm.

The salt profile of the **Profile-31** described in 1979 was similar to the earlier one, but its maximum value was less than 0.5%. The results of the 1992 survey show that the salt profile has changed, with a trace of the beginning of the salt outflow, with the salt maximum no longer at the surface but in the 5-26 cm (0.35%), and the maximum at a deeper depth of 15-35 cm (0.37%) in the 2023 survey.

Maps produced by digital mapping tools show that the groundwater level decrease typically ranges between 50 and 75 cm, while in the northern, more densely canalized part, the decrease varies between 0 and 50 cm (Figure 3).

Conclusions

In 2022, the observed groundwater level was deeper than in 1987. The water table in the large central part of the study area was typically 50-75 cm lower in 2022 than in 1987.

No trend in the total dissolved salinity of the groundwater was observed over the study area.

Compared to 1979 survey, there was a change in the salt profile, a weakening of surface and near-surface salt accumulation, and an increase in meadow soil formation. In some cases, changes in soil type/subtype were observed in sections regularly surveyed since the 1960s.

The frost-free surface over the last decade, in addition to the low evapotranspiration in winter, is likely to favor water uptake and further surface outwash in the region.

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Acknowledgements

The research was funded by the Kiskunság National Park and the HUN-REN Agricultural Research Centre, Soil Science Institute. The authors would like to thank the staff of the National Park, especially Mile Orsolya for the guidance on the field and the botanical documentation.