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SALINIZATION AND ALKALIZATION AS DEGRADATION SOIL PROBLEM AT SOUTH PART OF DANUBE LOWLAND (SLOVAKIA)

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Abstract: The contribution deals with analysis of salinisation and alkalization processes of soil profile and with judgement of hazard coming out by these processes. The area, which has been investigated, is the south-eastern part of the Danube Lowland in Slovakia. It is a part of Rye Island – the most productive agricultural area of Slovakia. Groundwater is putting down as one of the most important aspect of soil salinisation and alkalization. It is known that these facts impact adversely on vegetation and crops, so there is a reason why it is important to solve this problem. The contribution used the monitoring data from the period of years 1989 – 2006. We collected soil samples and samples of mineralized groundwater at the area mentioned above. It was subsequently carried out their analysis to determine total dissolved solids (TDS), electrical conductivity (EC), pH, cation exchange capacity (CEC), sodium adsorption ratio (SAR). In selected locations, salt content and sodium exchange has reached the limit and slightly above-limit values. The results show that in all monitoring localities it is in motion both the process of salinisation, by indicated above-limit residue values and EC values, both alkalization process indicated by above-limit values of ESP and pH. In areas where ESP stands at 5-20%, alkalization is the dominant process. From groundwater quality indicators, monitored in the period 1989 - 2006 in selected locations, come out that during this period the groundwater quality decline in terms of salinisation and alkalization. Concentrations of majority of those indicators have increasing trend, as well as SAR and EC values.

Table 1. The relationship between conductivity and degree of salinity (Recommended Chemical Soil Test Procedures 1998).

	Degree of Salinity				
	Non-Saline	Slightly Saline	Mod. Saline	Strongly Saline	Very Strongly Saline
1:1 Method	(mS.cm^{-1})				
Coarse to Loamy Sand,	0-1,1	1,2-2,4	2,5-4,4	4,5-8,9	>9,0
Loamy Fine Sand to Loam	0-1,2	1,3-2,4	2,5-4,7	4,8-9,4	>9,5
Silt Loam to Clay Loam	0-1,3	1,4-2,5	2,6-5,0	5,1-10,0	>10,1
Silty Clay Loam to Clay	0-1,4	1,5-2,8	2,9-5,7	5,8-11,4	>11,5
Saturated Paste Method	(mS.cm^{-1})				
All textures	0-2,0	2,1-4,0	4,1-8,0	8,1-16,0	>16,1

Table 3. Evolution of salinization and alkalization in the soil profile in monitored localities 1 – 5 (1 – Mužla, 2 – Okoličná, 3 – Čalovec, 4 – Zlatná na Ostrove, 5 – Kameničná) in the time period 1989 - 2006.

loc.	Depth (cm)	Evap.res. (%) 1989 1999 2006	EC (mS.m^{-1}) 1989 1999 2006	pH/H_2O 1989 1999 2006	ESP (%) 1989 1999 2006
1	0 – 10	0,05 0,07 0,13	42 79 102	7,6 7,2 7,3	1,8 2,1 2,6
	10 – 30	0,08 0,09 0,10	69 53 73	7,8 7,5 7,3	2,5 2,7 3,5
	30 – 50	0,10 0,10 0,13	102 120 140	7,9 7,6 8,1	6,8 7,6 8,5
	50 - 100	0,12 0,15 0,20	210 255 310	7,8 8,0 8,1	7,9 8,2 9,2
2	0 – 10	0,10 0,08 0,15	36 68 95	7,2 7,3 7,2	1,4 1,8 1,9
	10 – 30	0,12 0,06 0,18	59 71 90	7,5 7,6 7,4	3,1 2,4 2,9
	30 – 50	0,15 0,11 0,19	61 108 113	7,4 8,0 7,9	2,7 2,9 8,6
	50 - 100	0,19 0,13 0,22	207 210 215	7,9 8,1 8,2	8,4 8,2 9,7
3	0 – 10	0,06 0,04 0,14	40 56 76	7,1 7,1 7,2	2,6 1,9 1,9
	10 – 30	0,08 0,11 0,17	48 62 70	7,2 7,3 7,4	3,7 3,9 4,2
	30 – 50	0,04 0,06 0,12	75 90 99	7,3 7,4 7,5	5,8 6,2 7,5
	50 - 100	0,05 0,10 0,16	155 180 199	7,5 7,6 7,7	8,3 8,7 9,1
4	0 – 10	0,04 0,11 0,11	51 30 67	7,5 7,3 7,6	1,2 1,1 0,9
	10 – 30	0,05 0,10 0,14	55 40 58	7,2 7,6 7,5	2,8 1,7 1,1
	30 – 50	0,04 0,03 0,10	119 83 115	7,8 8,0 7,5	9,6 7,3 8,2
	50 - 100	0,10 0,16 0,21	242 207 291	8,1 8,1 8,6	9,7 10,1 11,5
5	0 – 10	0,07 0,09 0,11	30 40 50	7,2 7,2 7,4	0,8 1,2 1,4
	10 – 30	0,13 0,14 0,15	57 49 80	7,1 7,3 7,5	1,0 2,5 3,9
	30 – 50	0,09 0,10 0,09	91 56 85	7,2 7,4 7,6	2,7 3,9 4,7
	50 - 100	0,11 0,12 0,16	120 126 170	7,8 7,5 7,9	5,6 8,8 9,5

Table 2. Basic charakteristics groundwater chemical composition of interested area.

	Basic statistical charakteristics groundwater chemical composition n=128				
	Mean	Median	Stand.Deviation	Min.	Max.
pH	7,32	7,30	0,40	5,76	9,89
TDS (mg.l^{-1})	643,0	641,5	265,1	49,2	1935,8
Ca+Mg (mmol.l^{-1})	3,561	3,536	1,721	0,120	13,021
Conductivity(µS.cm^{-1})	688,1	686,5	289,6	54,5	2200,0
Free CO_2 (mmol.l^{-1})	0,77	0,65	0,69	0,12	11,5
Na (mg.l^{-1})	21,06	15,20	23,11	1,10	260,00
K (mg.l^{-1})	5,53	2,10	11,31	0,05	114,00
NH_4 (mg.l^{-1})	0,068	0,025	0,300	0,025	6,900
Ca (mg.l^{-1})	91,93	89,78	44,49	2,40	352,70
Mg (mg.l^{-1})	30,81	28,58	18,82	0,50	114,55
Fe (mg.l^{-1})	0,075	0,005	0,345	0,005	6,547
Mn (mg.l^{-1})	0,069	0,007	0,195	0,003	2,931
Cl (mg.l^{-1})	22,69	17,37	18,52	1,06	89,00
SO_4 (mg.l^{-1})	70,70	42,88	91,87	0,30	1019,00
NO_3 (mg.l^{-1})	14,88	13,25	12,79	0,25	39,90
PO_4 (mg.l^{-1})	0,184	0,020	0,501	0,005	7,600
HCO_3(mg.l^{-1})	353,32	374,96	151,18	3,05	937,85

Fig. 1 . Specification of the interested area.

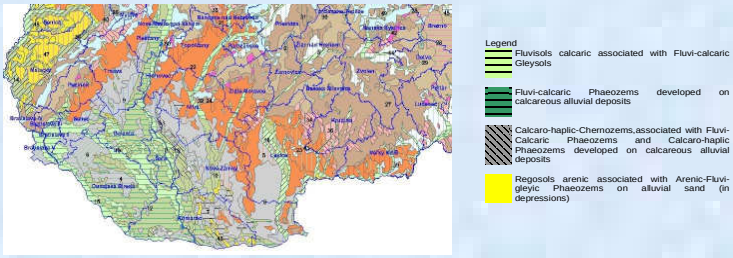

Fig.2 . Dominant soil groups of the interested area

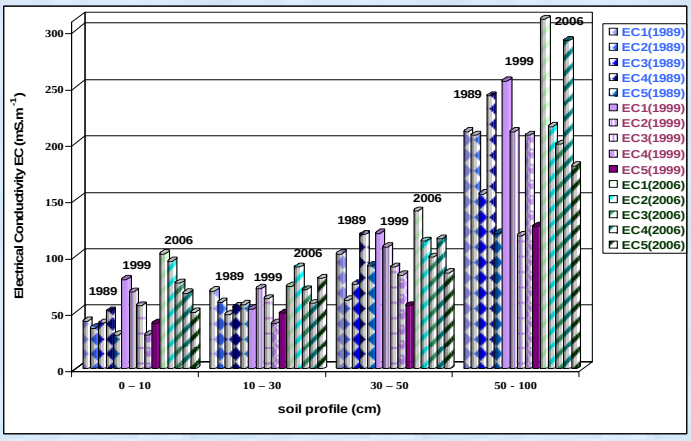

Fig.3. Electrical Conductivity of the soil profile in the most salt - affected localities : 1 – Mužla (EC1), 2 – Okoličná (EC2), 3 – Čalovec (EC3), 4 – Zlatná na Ostrove (EC4), 5 – Kameničná (EC5) in the time period 1989 - 2006.

The salt-affected soils occur in the south part and south-east part of Danube Lowland. The dry and warm summer climate, evaporation soil water regime and mineralized groundwater create here convenient conditions for development and spreading of the saline and alkaline soils.

Two processes in the development of the salt-affected soils can be recognised :

1. Process of salinization – is conditioned by presence of neutral sodium salts, mainly NaCl and Na_2SO_4. The indicators of salinization are dry evaporative rezidue > 0,2% and electrical conductivity of saturated soil extract EC > 400 mS.m^{-1}. Low stage of salinization is running EC 200 - 400 mS.m^{-1} or evaporative rezidue of salts 0,1-0,2 %. The result of salinization processes are middle saline soils and solonchaks.
2. Process of alkalization – is conditioned by presence of alkaline sodium salts, mainly Na_2CO_3, $NaHCO_3$, Na_2SiO_3. The indicators of alkalizaton are exchangeable sodium percentage ESP > 5 % and pH 8 or higher. The result of alkalization processes are middle alkaline soils and solonetz.

In natural conditions both of this processes are represented by different rate and the result is the mixture of both this processes, one of them is dominant.

Soil samples were taken from soil profiles from various depths (0-100 cm) for determination of the spatial variability of sodicity. The soils were air-dried and passed through a 2-mm sieve. Electrical conductivity (EC) and soluble ions (Na, Ca, Mg, K, SO_4 and Cl) were determined on saturated-paste extracts. The concentrations of Ca, Mg, Na and K were determined by atomic absorption spectroscopy (AAS); SO_4, Cl by ionselective electrode. The basis of the salinization impact model is the sodium adsorption ratio (SAR) – the relationship between Na^+, Ca^{2+} and Mg^{2+} concentrations:

$$SAR = \frac{Na}{\sqrt{Ca + Mg}}$$ (where Na, Ca, Mg are ionic concentrations are expressed in mol.l^{-1})

SAR is related to the exchangeable-Na ratio (ESP) of the soil by the following equation: $ESP = k_g\ SAR$ (where kg is Gapon selectivity coefficient).

Conclusions

Five localities with high-mineralized groundwater were monitored to judge salinity and alkality in the period 1989-2006. At the begginning of monitoring in localities 1 – 5 evaporative residues (salt content) reached the value 0,1 – 0,2 % in the bottom horizons, but in year 2006 this value has been spreading to whole soil profile and in the bottom horizons reached > 0,22 %. EC in localities 1,2,4 was > 200 mS.m-1 – that is the salinization potential for development of saline soils. Values of ESP in 2006 was higher than 11 % and pH in loc. 4 were measured higher 8,5 - so the alkalization is more marked and dominant there. The mentioned data allow us to declare that salinization and alkalization of soils start from the bottom of soil horizons through middle part of the soil profile up to the top horizons.

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