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CHARACTERISTICS OF WATER FROM FIRST AQUIFER BENEATH HYDROMORPHIC SOILS IN THE VOJVODINA PROVINCE

Jovica Vasin[1], Jordana Ninkov[1], Stanko Milić[1], Milorad Živanov[1], Branka Mijić[1], Dušana Banjac[1], Branislav Žeželj[2],

[1]Institute of Field and Vegetable Crops, Novi Sad, Serbia
[2]Meling doo, Serbia

Corresponding author: jovica.vasin@nsseme.com

Abstract
On the territory of the Vojvodina Province, the most common cause of soil salinization is the water in the first aquifer which is frequently saline and/or alkaline above the critical level. In this study, we analyzed water from the first aquifer sampled in locations classified as solonchaks in the soil map of Vojvodina (25 locations) and subsequently classified again into solonchak (5 locations), or reclassified into solonetz types of soil (9 locations) from the halomorphic order. The remaining eleven locations belonged to the soil types from the automorphic and hydromorphic order. Processes of desalinization and soil type change have occurred in these locations due to human activities (including the construction of drainage canals). But, based on salt or alkali levels above the critical and the quality of water in the first aquifer (especially high to very high sodium levels), it was concluded that there exists a serious risk of further continuous salinization and/or (especially) alkalization of the root zone of agricultural crops.

Keywords: critical (permissible) ground water level, salinization, alkalization, solonchaks, solonetz.

Introduction

One of the causes of salinization, i.e., accumulation of soluble salts in the topsoil due to the ascendent soil movement (ascendent movement prevails over descendent one in arid and semi-arid conditions), is the heavy mineralization of the shallow groundwater in the first aquifer. According to Miljković (1996) the immediate source of soluble salts is mineralized groundwater that rises by capillary movement and accumulates in the top layer of soil or on soil surface, thus causing the occurrence of salinization. The origin of salt is linked to the parent rocks that belong to aeolian, lacustrine and marine (paleogenic) sediments. Surface and ground waters seep through these rocks and dissolve the contained salts which mineralize the waters which become saline. The haloomorphic soil order includes soils whose profiles become waterlogged periodically or permanently due to surface or ground (most often) waters (Škorić et al. 1985). As the productivity of these soils is affected by ground water, it is important to examine ground water quality.

Material and methods

Sampling of water from the first aquifer was carried out in 25 locations whose soils had been classified as solonchaks in the soil map of Vojvodina R 1:50000 (Nejgebauer et al. 1971).Based on field and laboratory research the soils in these locations were reclassified in accordance with the current classification (Škorić et al. 1985). This paper presents the analyses of ground water from the following locations classified to belong to the order of halomorphic soils:

- solonchak type

in the locations of Trešnjevac (profile 14), Bački Brestovac (profile 16), Mali Stapar (profile 17), Kljajićevo (profile 18) and Rančevo (profile 21)

- solonetz type

in the locations of Žabalj1 (profile 1), Žabalj2 (profile 2), Despotovo (profile 3), Novi Bečej (profile 7), Ogar (profile 10), Kula (profile 11), Ruski Krstur (profile 12), Stanišić (profile 19) and Gornji Breg (profile 24). Ground water table was determined by digging a soil pit and probing from its bottom.Water quality was estimated on the basis of the following analyses: pH (potentiometrically), electrical conductivity - EC at 25°C (conductometrically), dry residue (evaporation at 105°C), ionic balance [HCO_3^- (titration with sulfuric acid in the presence of 1% solution of methyl orange), CO_3^{2-} (titration with sulfuric acid in the presence of 1% solution of phenolphthalein), SO_4^{2-} (gravimetrically, by precipitation with barium chloride), Cl^- (titration with a solution of silver nitrate in the presence of 5% potassium chromate), Ca^{2+} and Mg^{2+} contents (atomic absorption spectrophotometry), Na^+ and K^+ contents (atomic emission spectrophotometry)], sodium adsorption ratio to calcium and magnesium [SAR - sodium adsorption ratio (calculated)]. Based on the results of the analyses, water quality was determined and classified according to Stebler's irrigation coefficient, classification of US Salinity Laboratory, according to Nejgebauer and according to a modified FAO classification (Ayers and Westcot).

Results and discussion

Critical (permissible) ground water level is the depth at which ground water can have a detrimental effect on the soil. Based on the formula of Korda (quoted by Miljković, 2005) which takes into account the evaporation above the mean annual air temperature, critical ground water levels in the studied locations were found to be around 257-259 cm (Vasin, 2009). The results in Table 1 show that the first aquifer was above the critical level in all locations and that it represented a threat for the soils. The only exception were the locations of Žabalj2 (profile no. 2), and Ogar (profile no. 10) in which the ground water table was at a depth of 450 and 370 cm. The reaction of water from the first aquifer was alkaline and within a range considered as satisfactory, but for solonchack location near the limit of 8,5 pH unit (Ayers and Westcot 1985). The values of electrical conductivity (ECw) indicated a high salinity of ground water. All analyzed waters had high dry residue values, close, but somewhat lower values than the limit. That indicating their high mineralization. The chemical composition of groundwater (Table 2 and 3) was uniform and very low quality. Anion and cation sums were equal, corresponding to the rule. These sums for ground water beneath the soils from the hydromorphic order were slightly increased compared with the average for Bačka and Banat regions in the period 1959-1989 (Škorić, 1996). Among the cations in ground water, sodium ions were absolutely dominant. The negative effect of sodium is felt more by water-physical and chemical properties of soil than by agricultural plants. The other cations were present in the following order: magnesium, calcium and potassium. Bicarbonates were dominant anions in the analyzed ground waters. Water of such quality poses a risk of salinization and/or alkalization of soil in the root zone, especially when the ground water level stays above the critical level for an extended period. When ground water is above the critical level, salts may accumulate near soil surface on account of capillary movement, especially in the case of long spells without heavy rainfall. Ground waters beneath the soils of the halomorphic order (soil types solonchak and solonetz) tend to have poor quality score (on the vast majority of sites C4S4 class according to U.S. Salinity Laboratory, unsatisfactory and poor water according to Stebler, and unsuitable for irrigation according to Nejgebauer) (Table 4). Understandably, ground waters of such inferior quality are not used for irrigation, however, they pose a risk of salinization and alkalization of the upper part of the solum if they rise above the critical level. The data presented in Table 5 indicated that, according to the modified FAO classification (Ayers and Westcot, 1985), the risk of salinization of ground water is reduced if it is not already alkalized (if it has a low SAR value). Human action as a pedogenetic factor (construction of drainage canal systems, more dams and barrages on canals and rivers and drainage of waterlogged fields) caused desalinization and a change in soil type in the studied locations areas as compared with the situation encountered at the time when the soil map was made. However, because of a poor maintenance of the drainage systems, the ground water table has exceeded the critical level. In addition to the fact that the ground water quality is low (very saline and with a high sodium content) there is a serious risk of primary or even secondary salinization and alkalization of soil in the root zone of agricultural crops (seeds or natural vegetation of meadows), which may be reflected in reduced crop production potential.

Table 1. Characteristics of ground water in the studied locations

Soil type	Profile no	Depth, cm	pH	ECw, S/m	Dry residue,mg/l
Solonchak	14	170	8,88	2,84	2.213
	16	123	8,35	3,60	2.833
	17	160	8,31	4,48	1.264
	18	165	7,90	3,12	1.563
	21	130	8,90	2,07	1.352
	average	150	8,47	3,22	1.845
Solonetz	1	200	7,57	2,16	503
	2	450	7,57	1,03	551
	3	130	8,49	4,60	2.886
	7	140	8,19	5,71	2.668
	10	370	8,15	1,32	883
	11	130	8,47	2,52	1.815
	12	115	8,30	6,54	1.905
	19	115	8,13	3,26	2.245
	24	150	8,30	4,51	3.038
	average	200	8,13	3,52	1.833
Acceptable values in irrigation water			**6,0-8,5**	**0-3,00**	**0-2.000**

Table 2. Cationic balance of ground water in the analyzed locations

Soil type	Profile no.	Cations (meq/l)					SAR
		Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Sum	
Solonchak	14	0,19	0,28	0,02	33,08	33,57	68,2
	16	0,68	2,38	0,02	47,41	50,49	38,3
	17	0,17	0,24	0,02	26,82	27,25	59,2
	18	1,02	4,03	0,01	27,88	32,94	17,5
	21	0,11	0,24	0,01	29,66	30,02	70,9
	average	0,43	1,43	0,02	32,97	34,85	50,9
Solonetz	1	0,81	2,93	0,01	12,96	16,71	9,5
	2	3,94	1,85	0,07	4,24	10,10	2,5
	3	0,19	1,09	0,01	40,81	42,10	51,0
	7	1,29	3,60	0,01	32,08	36,98	20,5
	10	1,34	5,50	0,02	10,72	17,58	5,8
	11	0,26	0,85	0,28	27,54	28,93	37,0
	12	0,58	1,59	0,01	28,78	30,96	27,6
	19	0,31	0,63	0,01	43,31	44,26	63,2
	24	0,86	1,43	0,02	57,71	60,02	53,9
	average	1,06	2,16	0,05	28,68	31,96	30,1
Acceptable values in irrigation water		0-20	0-5	0-2	0-40	-	0-15

Table 3. Anionic balance of ground water in the analyzed locations

Soil type	Profile no.	Anions (meq/l)				
		CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Sum
Solonchak	14	0,75	30,65	2,55	2,77	36,72
	16	3,46	29,36	5,84	8,90	47,56
	17	2,94	17,02	1,17	1,13	22,26
	18	0,68	23,06	1,24	3,61	28,59
	21	3,64	16,09	1,50	1,23	22,46
	average	2,29	23,24	2,46	3,53	31,52
Solonetz	1	0,00	6,86	1,90	0,07	8,83
	2	0,00	10,74	1,06	0,67	12,47
	3	0,42	12,08	1,37	0,54	14,41
	7	0,00	19,26	13,68	6,14	39,08
	10	0,00	14,30	1,11	1,34	16,75
	11	0,00	24,03	3,72	5,22	32,97
	12	0,00	22,46	10,87	1,01	34,34
	19	3,84	29,51	8,37	3,53	45,25
	24	4,24	30,39	3,25	10,63	48,51
	average	0,94	18,85	5,04	3,24	28,07
Acceptable values in irrigation water		**0-0,1**	**0-10**	**0-30**	**0-20**	**-**

Table 4. Water quality assessment

Soil type	Profile no.	Water class (according to US Salinity Laboratory)	Stebler's classification		Water class according to Nejgebauer	
			Irrigation coeff.	Rated as	Irrigation coeff.	Rated as
solonchak	14	C4S4 - very high salinity, very high Na content	1,20	poor	IV b	unsuitable
	16	C4S4 - very high salinity, very high Na content	0,30	poor	IV d,e	unsuitable
	17	C4S4 - very high salinity, very high Na content	1,04	poor	IV b	unsuitable
	18	C4S4 - very high salinity, very high Na content	2,50	unsatisfactory	IV b	unsuitable
	21	C3S4 - salty, very high Na content	0,62	poor	IV d,e	unsuitable
	average	C4S4 - very high salinity, very high Na content	1,13	poor	IV b	unsuitable
solonetz	1	C3S2 - salty, medium Na content	1,41	unsatisfactory	IV b	unsuitable
	2	C3S1 - salty, small Na content	7,14	satisfactory	III b	additional examination
	3	C4S4 - very high salinity, very high Na content	0,95	poor	IV d,e	unsuitable
	7	C4S4 - very high salinity, very high Na content	3,21	unsatisfactory	IV b	unsuitable
	10	C3S2 - salty, medium Na content	0,98	poor	IV b	unsuitable
	11	C4S4 - very high salinity, very high Na content	1,39	unsatisfactory	IV b	unsuitable
	12	C4S4 - very high salinity, very high Na content	0,79	poor	IV b	unsuitable
	19	C4S4 - very high salinity, very high Na content	4,53	unsatisfactory	IV d,e	unsuitable
	24	C4S4 - very high salinity, very high Na content	7,14	satisfactory	III b	additional examination
	average	C4S4 - very high salinity, very high Na content	3,06	unsatisfactory	IV b	unsuitable

Table 5. Water quality assessment according to a modified FAO classification (*Ayers and Westcot*, 1985)

Soil type	Profile no.	Restricted use of water for irrigation according to:		
		Ecw dS/m	Dry residue, mg/l	SAR to Ecw ratio
Solonchak	14	moderate	possible	possible
	16	possible	possible	moderate
	17	possible	moderate	moderate
	18	possible	moderate	no
	21	moderate	moderate	possible
	average	possible	moderate	moderate
Solonetz	1	moderate	moderate	no
	2	moderate	moderate	moderate
	3	possible	possible	moderate
	7	possible	possible	no
	10	moderate	moderate	no
	11	moderate	moderate	possible
	12	possible	moderate	no
	19	possible	possible	moderate
	24	possible	possible	moderate
	average	possible	moderate	moderate

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References

1. Ayers, R. S., Westcot, D. W. (1985): Water quality for agriculture. FAO Irrigation and Drainage Paper, 29. Rev.1. FAO, Rome.
2. Miljković, N. (1996): Osnovi pedologije, Univerzitet u Novom Sadu, Prirodno-matematički fakultet, Institut za geografiju, Novi Sad.
3. Miljković, N. (2005): Meliorativna pedologija, Univerzitet u Novom Sadu, Poljoprivredni fakultet, Departman za uređenje voda, JVP «Vode Vojvodine», Novi Sad.
4. Nejgebauer V., Živković B., Tanasijević Đ., Miljković N. (1971): Pedološka karta Vojvodine R 1 : 50.000, Institut za poljoprivredna istraživanja, Novi Sad.
5. Škorić, A., Filipovski, G., Ćirić, M. (1985): Klasifikacija zemljišta Jugoslavije, Akademija nauka i umjetnosti Bosne i Hercegovine, Posebna izdanja, knjiga LXXVIII, Sarajevo.
6. Vasin, J. (2009): "Solončaci Vojvodine - karakteristike i savremena klasifikacija", doktorska disertacija. Univerzitet u Novom Sadu, Poljoprivredni fakultet u Novom Sadu.