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Prof. Dr Snežana Šerbula

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PREFACE

Today's growing environmental and ecological imbalances require a multidisciplinary approach in finding adequate sustainable solutions. That is why environmental and ecological issues are at the focus of the 27th International Conference Ecological Truth and Environmental Research 2019 (EcoTER'19), which will be held at Bor Lake, Serbia, 18-21 June 2019. On behalf of the Organizing Committee, it is a great honor and pleasure to wish all the participants a warm welcome to the Conference.

The EcoTER'19 is organized by the University of Belgrade, Technical faculty in Bor, and co-organized by the University of Banja Luka, Faculty of Technology, University of Montenegro, Faculty of Metallurgy and Technology – Podgorica, University of Zagreb, Faculty of Metallurgy – Sisak, University of Pristina, Faculty of Technical Sciences – Kosovska Mitrovica and the Association of Young Researchers, Bor.

The primary goal of EcoTER'19 is to bring together academics, researchers, and industry engineers to exchange their experiences, expertise and ideas, and also to consider possibilities for collaborative research.

These proceedings include 105 papers from authors coming from universities, research institutes and industries in 15 countries: Russia, Belarus, Turkey, Kazakhstan, Czech Republic, Portugal, Sweden, Switzerland, Slovenia, Bulgaria, Croatia, Bosnia and Herzegovina, North Macedonia, Montenegro, and Serbia.

The support of the donor and their willingness and ability to cooperate has been of great importance for the success of EcoTER'19. The Organizing Committee would like to extend their appreciation and gratitude to the donor of the Conference for their donation and support.

We would like to thank all the authors who have contributed to these proceedings, and also to the members of the scientific and organizing committees, reviewers, speakers, chairpersons and all the Conference participants for their support to EcoTER'19. Sincere thanks to all the people who have contributed to the successful organization of EcoTER'19.

On behalf of the 27th EcoTER Organizing Committee,

Snežana Šerbula, PhD Full Professor

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THE QUALITY OF IRRIGATION WATER AND ASSESMENT OF ITS USE IN TOPLICA DISTRICT

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Abstract

In the area of Toplica district in 2018, samples of irrigation water were sampled at 34 locations. Water quality assessment for irrigation was carried out using the traditional classifications by Stebler, Nejgebauer and the classification of the US Laboratory for saline soils and by the more recent FAO and RSC classifications. Following parameters were assessed: pH value - potentiometric; EC - electroconductivity - electrochemical; dry residue - thermogravimetric; ionic balance: CO_3^{2-}; HCO_3^-; Cl^- -volumetric. The acid-available fraction of heavy metals and other microelements (As, B, Cd, Cr, Cu, Fe, Ni, Pb, Zn) and SO_4^{2-}; Ca^{2+}; Mg^{2+} preparation and reading on the ICP-OES method EPA 200.7; Content K^+, Na^+ - plamenephotometric; SAR (Sodium Adsorpcio Ratio) - using calculation. In all tested water samples, the contents of the tested microelements and heavy metals were below the maximum permissible concentrations, except in one sample, number 29 from location no. 21 where an increased concentration of boron (B) content was determined. The reason for this phenomenon was probably related to the contamination of the accumulation due to the spillage of the fertilizers with high concentration of this element, were stored directly beside the water intake.

Keywords: classifications, quality, water, irrigation, contamination

INTRODUCTION

Irrigation is an agro-technical measure that allows stable yields of cultivated plants to be achieved and in this way satisfies the ever-growing needs for food due to population growth. Therefore, in many areas of the world without irrigation, agricultural production would not be possible and it is necessary to pay special attention to available water resources, both in quantity and quality [1]. Inadequate quality of irrigation water can significantly reduce the expected economic yield of agricultural production [2,3]. Water quality is a term used to describe the physical, chemical and biological parameters of water characteristics and defines the suitability for a specific purpose [4]. The application of water of inadequate quality can result in decay of soil structure, slower plant growth, deformation of the fruit, and in some cases the complete absence of plant growth. In order to overcome this, specific indicators for assessing the quality of water for irrigation have been adopted. Those indicators are a set of parameters that are widely accepted and used in the decision-making process [5].

Irrigation means the use of water from natural and artificial sources. Natural sources are from the waters and lakes, and artificial can be wells and artificial lakes. In addition, the source of water for irrigation can be wastewater from the settlement, from production and industrial capacities [6]. Water of inadequate quality can affect the salinity, alkalization and deterioration of water-physical properties of the soil [7,8].

It is very important to assess the risk of salinization of irrigation water source of any agricultural land in order to achieve maximum yields of cultivated crops [9]. For the assessment of the quality of water for irrigation, there are traditional and modern methods and classifications. None of them can be considered absolutely applicable to all conditions in plant production [10]. They are mainly based on the estimation of the total amounts of salt in water, relative to the concentration of Na^+ ion on the ion content Ca^{2+} and Mg^{2+}, the presence of the Cl and B salts and the electrical conductivity.

MATERIALS AND METHODS

Description of the area of research and methodology of sampling

Toplica district is located in the basins of the river Toplica and Kosanica, in the south of the Republic of Serbia in the central Balkan region (Figure 1). The research area in which research has been conducted extends from 42°52'-43°24' north latitude and from 20°55'to 21°49' east longitude and covers an area of approximately 2. 231 km^2.

The irrigation water sampling site coordinates are presented together with results of the analysis in Table 2. At the sites where research was conducted, the drip irrigation system is applied at nine locations; in eight places plants are irrigated by artificial rain, and within the three parcels it is planned to use some of the irrigation methods in the following period. 34 samples of irrigation water were sampled, 24 from wells, three from streams, four from artificial reservoirs, and three from lake.

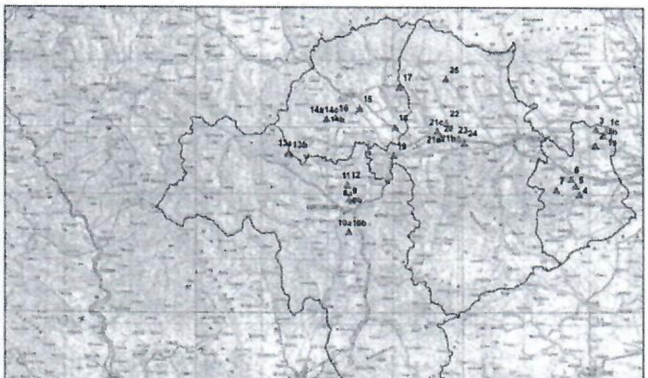

Figure 1 *Location map with selected sample sites*

Research methods

In the irrigation water samples, the following parameters were determined: pH - potentiometric (SRPS H.Z1.111: 1987) [11], electrical conductivity (EC) - (SRPS EN 27888: 1993) - electrometric [12]; the total dissolved solids content (TDS) - gravimetric [13]; CO_3^{2-}; HCO_3^-; Cl-volumetric, K^+; Na^+ - plamenfotometric (APHA) [14]. The content of heavy metals and other toxic elements (As, B, Cd, Cr, Cu, Fe, Ni, Pb, Zn) and SO_4^{2-}; Ca^{2+}; Mg^{2+}

were determined by EPA method 200.7, [15] on the ICAP 6300 ICP optical emission spectrometer (ICP-OES); (SAR) - by calculating [16].

RESULTS AND DISCUSSION

In relation to the Stebler classification, based on the estimation of the irrigation coefficient determined by the content of Na^+, Cl^-, SO_4^{2-}, all the tested irrigation water samples are of good quality, which means that they can be used without special measures to prevent the accumulation of harmful salts in the soil. 88.23% of the samples were with good water quality, 8.82% of satisfactory quality and 2.95% water were of unsatisfactory quality.

Based on the Nejgebauer classification [17], which takes into account the total amount of salt in irrigation water in interaction with the concentration of Na^+ with Ca^{2+} and Mg^{2+}, of the tested samples 55.9% belonged to the Ia class, in which the dry residue is below 700 mg l^{-1}, and the ratio (Ca+Mg) : (Na+K) is > 3, and 32.4% was in Ib class, where the dry residue is less than 700 mg l^{-1}, and the ratio (Ca+Mg): >3. These are impeccable water with ameliorative characteristics of flushing salt marsh. IIa (2.9%) class, where the dry residue is less than 700 mg l^{-1}, and the ratio (Ca+Mg): Na> 1 and IIIb (8.8%) class, where the dry residue is less than 700-3000 mg l^{-1}, and the ratio (Ca+Mg): Na> 1.

Experts from the University of Riverside, USA [18] made the largest contribution to the study of irrigation water quality and its classification as regards the benefits of irrigation of agricultural crops, and it is applied worldwide. The basis for assessing the method is EC and SAR. In the tested water samples for irrigation, the C1-S1 class belongs to 11.7% of the tested samples with characteristic that EC≤0.250 dS m^{-1}; SAR 0-10. These are waters where there is a small risk of dredging / alkalization, or water suitable for irrigation. 35.4% of the tested samples belong to the class C2-S1 class of water, in which the EC values range from 0.250 to 0.750 dS m^{-1} and can be used for irrigation of plants with a mean salt tolerance. The remaining 50.0% of the tested samples belonged to the class C3-S1, in which the EC values range from 0.750 to 2.250 dS m^{-1}, and their use requires the application of special measures in the prevention of soil depletion. 2.9 % belonged to the class C4-S1 (S4-highly salinated - high danger of salinization of soil (EC from 2.25 to 4 dSm^{-1}); S1-(SAR 0-10) - water with low content of Na, with low risk of salinization.

Modified FAO classification [19], analyzes in detail the influence of dissolved salt in irrigation water and its impact on the water-physical properties of the soil, primarily on infiltration. It takes into account the risk of sedimentation, based on the amount of electrical conductivity (EC) and salt concentration in the test sample (TDS).

Table 1 shows the values of the parameters on the basis of which the irrigation water samples were estimated in relation to the above classification. It was found that 35.3% of the samples belonged to the class of drinking water and irrigation (EC <0.7dS m^{-1}, TDS <500 mg l^{-1}), 61.8% of the samples belonged to the class for irrigation (EC: 0.7-2 dS m^{-1}; TDS 500-1500 mg l^{-1}), and 2.9 % - to the class for primarily drainage and ground water (EC: 2-10 dS m^{-1}; TDS 1500-7000 mg l^{-1}).

An additional estimate using the possible influence of some elements dissolved in irrigation water, analyzing Na^+ effects through different relationships with other tested substances (Na_2CO_3) was determined on the basis of the RSC-Residual Sodium Carbonate classification [10]. Based on this classification, 91.2% of the tested irrigation water samples belonged to the class of good waters (RSC <1.25) and 2.9% water - to the class with usability limit (RSC = 1.25-2.50); 5.9 % of the water samples were with poor quality (RSC>2.50).

The obtained values of the content of the studied microelements and heavy metals are shown in Table 1, and the interpretation was carried out on the basis of the limit values in the Ordinance on the permitted quantities of hazardous and harmful substances in soil and irrigation water [20] and the literature data [18] (*).

***Table 1** Maximum permitted levels (MAC) of hazardous and harmful substances in irrigation water*

Element	As	B	Cd	Cr	Cu	Fe*	Ni	Pb	Zn	Hg
					(mg l^{-1})					
MAC	to 0.05	to 1.0	to 0.01	to 0.5	to 0.1	to 5	to 0.1	to 0.1	to 1.0	to 0.001

In all tested water samples, the content of the tested microelements and heavy metals were below the maximum permissible values, except in one sample, number 29 from location No. 21 where an increased concentration of boron (B) content was determined. The reason for this phenomenon was probably related to the contamination of the accumulation due to the spillage of the fertilizers with high concentration of this element, were stored directly beside the water intake.

***Table 2** Chemical and physical properties of water samples for irrigation*

N°	Coordinate X	Coordinate Y	pH	EC (dSm^{-1})	TDS (mg l^{-1})	SAR (mg l^{-1})	As (mg l^{-1})	B (mg l^{-1})	Cd (mg l^{-1})	Cr (mg l^{-1})	Cu (mg l^{-1})	Fe (mg l^{-1})	Ni (mg l^{-1})	Pb (mg l^{-1})	Zn (mg l^{-1})
1	562174	4787965	7.1	0.76	380	0.31	bdl	0.0203	bdl	bdl	0.0297	bdl	bdl	bdl	0.2228
2	562178	4787952	7.1	0.919	459	0.49	bdl	0.0183	bdl	bdl	bdl	bdl	bdl	bdl	bdl
3	562535	4788642	7.4	0.856	428	0.74	bdl	0.0786	bdl	0.0161	bdl	bdl	bdl	bdl	bdl
4	560901	4786541	7.4	0.835	418	1.03	bdl	0.0631	bdl	bdl	bdl	bdl	bdl	bdl	bdl
5	560946	4788855	7.2	0.532	268	0.63	bdl	0.0321	bdl	bdl	bdl	bdl	bdl	bdl	0.0094
6	558452	4779163—	7.4	0.688	344	0.91	bdl	0.0073	bdl	bdl	bdl	bdl	bdl	bdl	bdl
7	557868	4780465	7	0.751	375	0.77	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
8	557171	4781405	7	0.229	115	0.47	bdl	bdl	bdl	bdl	bdl	0.0827	bdl	bdl	0.0136
9	554978	4779802	7.3	0.913	457	0.93	bdl	0.0119	bdl	bdl	bdl	bdl	bdl	bdl	bdl
10	523836	4777919	7.3	0.916	458	0.58	bdl	0.0855	bdl	bdl	bdl	bdl	bdl	bdl	0.3722
11	523303	4778327	7.6	0.866	433	0.61	bdl	0.0994	bdl	bdl	bdl	bdl	bdl	bdl	bdl
12	523303	4778294	7.8	0.488	244	0.13	bdl	0.0647	bdl	bdl	bdl	bdl	bdl	bdl	bdl
13	523275	4773241	8.1	0.124	62	0.15	bdl	bdl	bdl	bdl	bdl	0.0214	bdl	bdl	bdl
14	523216	4773229	7.8	0.38	190	0.24	bdl	0.0053	bdl	bdl	bdl	bdl	bdl	bdl	bdl
15	523068	4780447	7.5	1.12	581	1.32	bdl	0.0166	bdl	bdl	bdl	bdl	bdl	bdl	0.0124
16	523034	4780570	7.9	0.989	494	1.08	bdl	0.1244	bdl	bdl	bdl	0.088	bdl	bdl	bdl
17	514124	4785377	7.6	0.714	357	0.01	bdl	bdl	bdl	bdl	bdl	0.011	bdl	bdl	0.0083
18	514223	4785177	7.9	0.623	311	0.05	bdl	bdl	bdl	bdl	bdl	0.0157	bdl	bdl	bdl
19	519905	4790324	8.7	0.501	250	0.05	0.0082	0.0225	bdl	bdl	bdl	0.1167	bdl	bdl	bdl
20	519888	4790318	7.6	0.855	427	1.04	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.0742
21	519897	4790339	7.6	0.878	439	0.43	bdl	0.028	bdl	bdl	bdl	bdl	bdl	bdl	0.0389
22	524991	4791914	7.4	0.952	476	0.72	bdl	0.0413	bdl	bdl	bdl	bdl	bdl	bdl	0.0098
23	521234	4790539	7.3	0.41	205	0.84	bdl	0.0244	bdl	bdl	bdl	bdl	bdl	bdl	0.0156
24	531080	4795050	7.5	0.626	312	0.09	bdl	bdl	bdl	bdl	0.0128	bdl	bdl	bdl	0.0547
25	530412	4789145	8.3	1.06	531	0.76	0.0164	0.2643	bdl	bdl	bdl	0.0245	bdl	bdl	bdl
26	530190	4784978	8.9	0.513	257	0.52	bdl	0.036	bdl	bdl	bdl	bdl	bdl	bdl	bdl
27	537328	4787548	7.4	0.74	370	1.05	bdl	0.1614	bdl	bdl	bdl	0.0169	bdl	bdl	0.0151
28	536939	4788514	7.3	2.26	1130	2.51	bdl	0.1216	bdl	bdl	bdl	bdl	bdl	bdl	0.0089
29	536909	4788548	8.3	1.73	869	6.89	bdl	1.683	bdl	bdl	bdl	0.064	bdl	bdl	bdl
30	536879	4788485	7.6	1.2	580	1.58	0.0076	0.0889	bdl	0.0095	bdl	bdl	bdl	bdl	0.0403
31	538266	4789799	7.8	0.54	272	0.36	bdl	0.0355	bdl	bdl	bdl	bdl	bdl	bdl	bdl
32	540137	4787341	7.5	1.44	722	2.22	bdl	0.2407	bdl	bdl	bdl	0.0595	bdl	bdl	0.0281
33	540997	4786817	7.7	0.616	308	0.46	bdl	0.0457	bdl	bdl	bdl	bdl	bdl	bdl	0.1645
34	538212	4796190	7.8	0.482	241	0.13	bdl	bdl	bdl	bdl	0.0252	bdl	bdl	bdl	0.1235

bdl - below detection limit

CONCLUSION

Based on the obtained and analyzed results of the quality study of irrigation water, it can be concluded that water from sampling sites can be used mostly without restrictions to irrigate cultivated crops and there is no risk to have a negative impact on the structure of the soil on which it is applied. Special attention should be paid at locations where irrigation water didn't meet the criteria for applicability, the irrigation measures could be applied with restriction because the use of contaminated water can damage the structure of the agricultural soil.

At the location where increased content of (B) boron was determined, it is necessary to implement measures for cleaning and washing water intake, and if the results after implementation of those measures do not give satisfactory results, it is necessary to relocate the water intake location.

Nevertheless, the irrigation water and soil tests should be carried out periodically in order to prevent the creation of a rupture and breakdown of the structure.

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