

## **WATER QUALITY OF THE DRINA RIVER AS A SOURCE OF IRRIGATION IN AGRICULTURE**

Radmila PIVIC<sup>1</sup>, Dragana JOSIC<sup>1</sup>, Zoran DINIC<sup>1</sup>, Zeljko DZELETOVIC<sup>2</sup>, Jelena MAKSIMOVIC<sup>1</sup>, Aleksandra STANOJKOVIC SEBIC<sup>1</sup>

<sup>1</sup>Institute of Soil Science, Belgrade, Serbia

<sup>2</sup>Institute for Application of Nuclear energy, Zemun, Serbia

\*Corresponding Author: drradmila@pivic.com

### **Abstract**

The paper presents the results of testing the quality of water for irrigation during the summer season in 2013, in the basin of the Drina River, that flows through Serbia from Salaš Crnobarski to Bajina Bašta (Bušinsko polje), in three monitoring cycles on 12 selected sites belonging to agricultural area under irrigation. It was established that the quality of the surface water corresponded to the standards for irrigation according to temperature, pH, conductivity (EC<sub>w</sub>), total dissolved solids (TDS), ion balance: Ca<sup>2+</sup>, Mg<sup>2+</sup>, K<sup>+</sup>, Na<sup>+</sup>, chlorides (Cl<sup>-</sup>), sulfates (SO<sub>4</sub><sup>2-</sup>), Sodium Adsorption Ratio (SAR).

Based on the presented and analyzed results of testing of the quality of water for irrigation, it can be concluded that the tested samples of water for irrigation of crops and soils are adequate for usage to the certain limitations and the need for frequent checks of water quality during the summer months in relation to classification of Neugebauer and Stebler, which provide a rough assessment of the usability of water for irrigation without assessing the impact of the water used on the plant and equipment and modern classification of FAO, U.S. Salinity Laboratory, RSC-Residual Sodium Carbonate.

**Key words:** *water, quality, irrigation, agriculture*

### **Introduction**

The scope of the research conducted in this paper is the study of quality of irrigation water from the River Drina, complies with the requirements of FAO and U.S. Salinity Laboratory classification (Doneen and Westcot, 1988; U.S. Salinity Laboratory Staff, 1954), designed for usability evaluation of irrigation water. Irrigation means the artificial watering the soil in order to wet the rhizosphere layer at a time when the amount of available soil moisture is insufficient to meet the optimum energy crops. Irrigation is a hydro-reclamation measure that aims to improve the physical properties of the soil by adding water to achieve optimum moisture during the growing season and thus achieve optimum yield. It may be applied during part of the growing season or during the whole growing season. Irrigation of cultivated plants on agricultural soil involves the use of water of appropriate physical, chemical and biological properties, so it is very important to examine the quality of water used for its intended purpose in order to assess the impact on soil and plants. Intensification of irrigation depends primarily on the provision to the required amount of water of adequate quality.

Anthropogenic impacts and natural processes can affect the quality of surface waters and threaten their use as drinking water, and for use in industry, agriculture, and for other purposes (Carpenter et al., 1998; Jarvie et al., 1998; Simeonova et al., 2003).

The aim of this study is to assess the current water quality of the River Drina in order to be used for irrigation of agricultural soil near the streams and highlight the pollution risk. Pollution risks are mainly the direct consequence of the discharge of waste water from industrial plants, agricultural intensification or anthropogenic factors.

The major pollutants of surface water in the country are industrial enterprises, farms and settlements with sewage systems, without built facilities for waste water treatment, and such with acting, but technically outdated (Konstandinova et al., 2013).

Agricultural lands used for intensive agriculture and fertilized with nitrogen and phosphate, treated with pesticides, and manure from livestock farms are one of the major sources of diffuse pollution (mainly nitrogen, phosphorus and biodegradable organics).

### Description of the study area

In geographical terms, the basin of Drina River in the flow through Republic of Serbia lies between 43°00' and 44°52' of north latitude and 19°15' and 19°20' of east longitude (Figure 1).

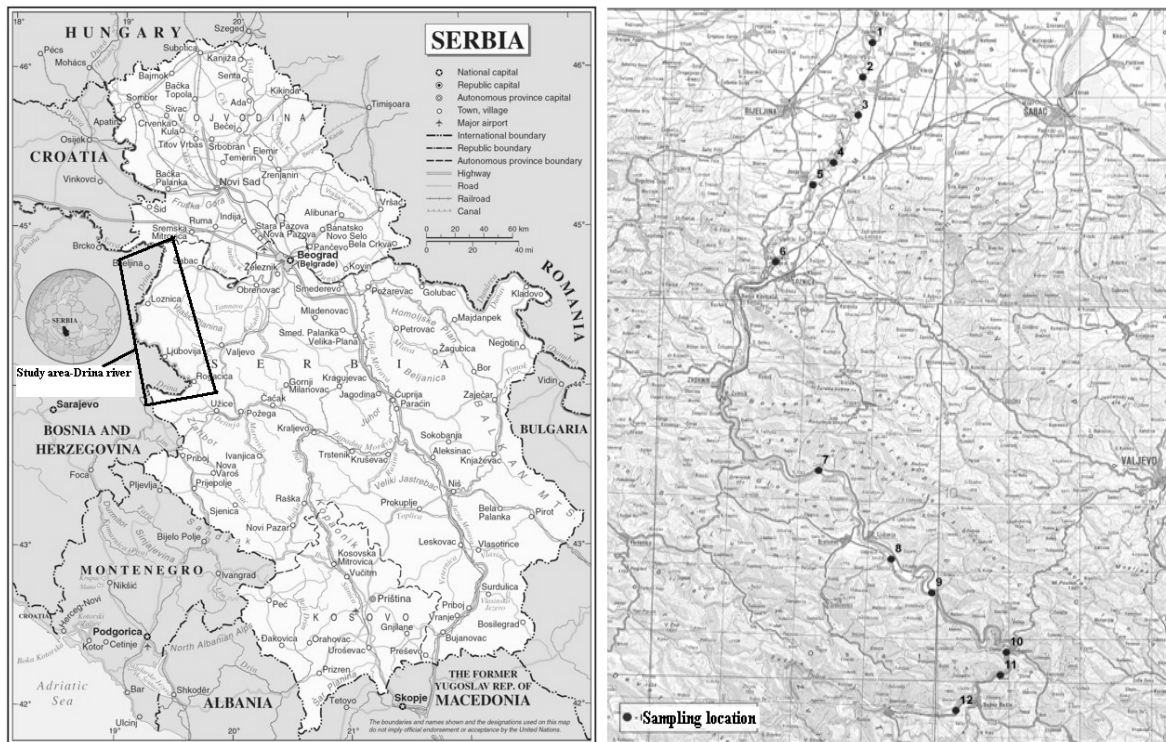


Figure 1. Location map of Drina valley with selected sample sites.

The Drina is a 346 km long international river, which forms large portion of the border between Bosnia and Herzegovina and Serbia. It is the longest tributary of the Sava River and the longest karst river in the Dinaric Alps which belongs to the Danube river watershed

<http://sh.wikipedia.org/wiki/Drina>

River Drina basin covers the southwestern and western part of Serbia, the northern part of Montenegro and the eastern part of Bosnia and Herzegovina. Direction of its flow is from south to north and has a lot of tributaries. Water regime of the River Drina belongs to the typical modes of type snow-rain, with the primary peak of the water level in April and a secondary peak in December. Most of the stream is running through the mountains, while the entire upper stream is located in the high mountains of the Dinaric Alps, creating conditions that heavy precipitation and snows melting are leading to high flows. Decline of River Drina flow is very high, almost 2000 meters for less than 350 km of length, (spring is at about 2000 meters above sea level, while the confluence is on 80 meters above sea level). With an average flow of 395 m<sup>3</sup> / s at the confluence, Drina is richest tributary of the River Sava.

Soils suitable for irrigation are primarily alluvial soils along the River Drina and meadow soils that are heavier texture from alluvium. Water physical properties of the soil along the Drina are very heterogeneous composition. Represented are applied gravel, sandy gravel, sandy, loamy and clay composition. All of these can be irrigated land varying amounts of

water. The basic soil types in the river basin are Fluvisols, Eutric Cambisols and Distic Cambisols.

### Sampling and collection of water samples

A total of 36 water samples were collected from 12 (twelve) sampling points. Water samples were collected in three cycles of sampling, in July, August and September 2013, using 2000 ml plastic bottles. The sampling bottles for heavy metal determination were pre-soaked overnight with 10% HCl, then, rinsed with distilled water and also rinsed using river water before sample collection. Sampling bottles for the determination of physicochemical parameters were cleaned and rinsed using distilled water only. Preservation of water samples was done by adding 2 drops of concentrated HNO<sub>3</sub> to each water sample before storage below 4°C until it was analyzed.

### Analytical methods

The measured parameters were determined by the following methods: temperature is determined *in situ* by a calibrated thermometer, pH -potentiometric (SRPS H.Z1.111:1987), electrical conductivity (EC<sub>w</sub>)- conductimetric (SRPS EN 27888:1993), total dissolved solids (TDS)-gravimetric (Greenberg et al., 1998), Cl<sup>-</sup> - volumetric, K<sup>+</sup>; Na<sup>+</sup> - plamenfotometric (APHA, 1992). Sodium Adsorption Ratio (SAR)- calculation (Rhoads et al., 1992). SO<sub>4</sub><sup>2-</sup>; Ca<sup>2+</sup>; Mg<sup>2+</sup> was determined using EPA 200.7 methods, as well as an ICAP 6300 ICP optical emission spectrometer (ICP-OES).

### Results and discussion

The seasonal and annual averages of physicochemical characteristics are given in Table 1. The **pH** is an important factor that determines the suitability of water for a variety of purposes, inter alia, for irrigation. All tested samples showed pH values from neutral to slightly alkaline (Figure 2).

**Conductivity** is a measure of the ability of an aqueous solution to carry an electric current. Increasing levels of conductivity and cations are the products of decomposition and mineralization of organic materials (Begum and Harikrishnarai, 2008). The aqueous salt solution and dissociated are broken down into positive and negative ions. Electrical conductivity in natural waters is generally with values less than usual. Measurement of the conductivity is performed at a specific temperature and it corresponds to the presence of dissolved salts. These are most commonly sodium chloride, and may be present, and sodium sulphate, calcium chloride, calcium sulfate, magnesium chloride, etc. Salts dissolved in the water influence on increase of the water conductivity values. In all three cycles of analyzing the water from Drina River (Figure 2), according to FAO classification, the samples belong to a class of water for drinking and irrigation, and as well to a class for irrigation water. By classification of U.S. Salinity Laboratory, all of the samples belong to the C2 S1 class of water, where EC<sub>w</sub> values range from 0.250 to 0.750 dSm<sup>-1</sup> and, as such, it can be used for irrigation of the plants with medium tolerance to salt.

Table 1 Average value of the water quality parameters of irrigation water, along with the standard limits by irrigation water US and FAO and by Republic of Serbia

Parameters/ Dimension	Mean±STDEV (n=36)	Standard limits		
		US Duncan et al., 2000	FAO Ayers et al., 1994	R. Serbia Official Gazette, 1994/2012
Temperature(°C)	20.2±2.57			30
pH	8.17±0.17	6.0-9.0	6.5-8.4	
Ecw 25°C (dSm <sup>-1</sup> )	0.22±0.01		<0.7	<1.0 <sup>#</sup>
TDS (mg l <sup>-1</sup> )	282.88±126.36		0-2000	
SAR	0.09±0.03	5.7	0-15 <sup>°</sup>	
Cl <sup>-</sup> (mg l <sup>-1</sup> )	0.30±0.07		0-30 <sup>°</sup>	50 <sup>#</sup>
SO <sub>4</sub> <sup>2-</sup> (mg l <sup>-1</sup> )	0.20±0.05		0-20 <sup>°</sup>	50 <sup>#</sup>
Ca <sup>2+</sup> (mg l <sup>-1</sup> )	2.75±0.15	20-60	0-20 <sup>°</sup>	
Mg <sup>2+</sup> (mg l <sup>-1</sup> )	0.43±0.06		0-20 <sup>°</sup>	
K <sup>+</sup> (mg l <sup>-1</sup> )	0.07±0.02	5-20	0-2 <sup>°</sup>	
Na <sup>+</sup> (mg l <sup>-1</sup> )	0.11±0.04		0-40 <sup>°</sup>	

\*References (listed below in reference list); bdl-below detection limit

<sup>°</sup> - in me/l = mill equivalent per liter (mg/l ÷ equivalent weight = me/l); in SI units, 1 me/l= 1 mill mol /liter adjusted for electron charge.

**Total dissolved solids (TDS)** are an important characteristic for determination of the quality of water for irrigation because it expresses the total concentration of soluble salts in water. Dissolved solids in water include all inorganic salts, silica and soluble organic matter (Atekwana et al., 2004; Ahipathy and Puttaiah, 2006). Pure water must be free from most suspended particles, which are responsible for turbidity. TDS was the highest in summer due to evaporation and reduced inflow which contributed to an increase in concentration, and had the minimum value in the rainy season, due to the increased entry of rain and a corresponding reduction in concentration at all locations (Figure 3).

**Chlorides and sulfates** are among the basic components found in fresh water. Some of the anthropogenic sources of chlorides in surface water are agricultural activities (organic and mineral fertilizers), sewage, landfill leakage, industrial wastewaters etc. Scientific investigations proved that water with chloride concentrations > 150 mg l<sup>-1</sup> are inappropriate for irrigation due to their toxicity to crops (Konstandinova et al., 2013; Szykiewicz et al., 2008). Sulfates distribution in surface and ground waters is principally controlled by dissolution processes and precipitation of mineral and amorphous solid phases, dissolved oxygen concentration, atmospheric precipitation, biological interactions, point and non-point pollution sources (Hudak et al., 2003; Souligny et al., 2002). Concentration of chlorides, sulfates, Ca and Mg in observed samples are in recommended values. (Table 1).

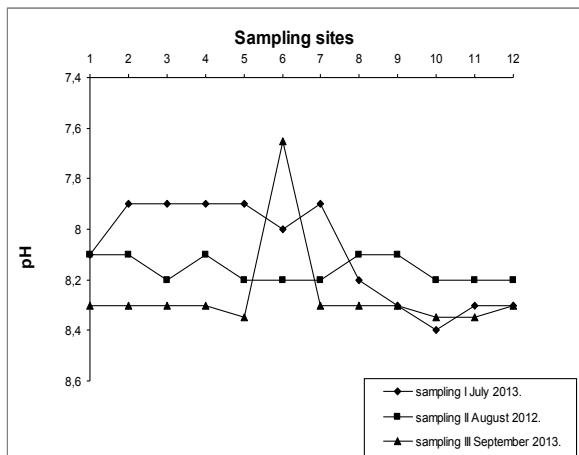


Figure 2. pH value of the tested water samples in batches of monitoring

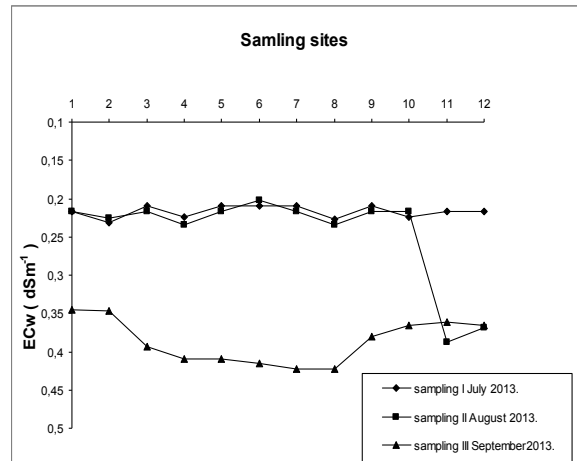


Figure 3. ECw value of the tested water samples in batches of monitoring

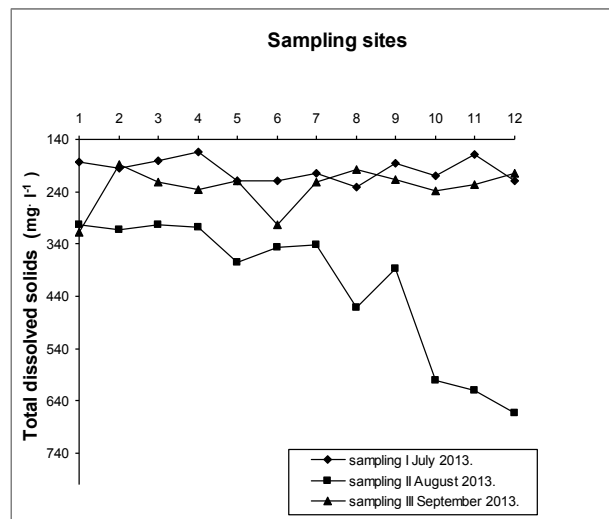


Figure 4. TDS value of the tested water samples in batches of monitoring

In all three cycles of analyzing the water from Drina, according to FAO classification, the samples belong to a class of water for drinking and irrigation, and as well to a class for irrigation water.

By classification of U.S. Salinity Laboratory, all of the samples belong to the C2 S1 class of water, where ECw values range from 0.250 to 0.750 dSm<sup>-1</sup> and, as such, it can be used for irrigation of the plants with medium tolerance to salt.

Sodium adsorption ratio of irrigation water, SAR (showed in Table 1) is used to determine whether sodium (Na) levels of water will cause soil structure to deteriorate. Unadjusted SAR considers only Na, Ca, and Mg (Ayers et al., 1994).

Analysis of water quality for irrigation of the Drina in all cycles of monitoring shows that water samples according to the classification of FAO belong to a class of water for drinking and irrigation. According to the classification of U.S. Salinity Laboratory analyzed samples belong to class C2-S1 (C2-medium saltwater-medium risk of soil salinization (ECw from 0.250 to 0.750 dS m<sup>-1</sup>). Moderately saline water can be used for plants with medium tolerance to salt and only if the conditions for flushing salts from the upper soil layers. The water could be irrigated relatively permeable soil without special measures for combating

salinization. S1 (SAR 0-10) - Water from the low-sodium has a low risk of alkalization. It is suitable for irrigation of all types of soils.

According to the classification of Neugebauer, tested samples of the River Drina, belong to the Ia class of water with low salt concentration and a very favorable ratio of divalent cations to the sum of Na and K, or only for Na. These waters are excellent for irrigation.

By classification of Stebler, tested water samples from the River Drina, are classified as good water for irrigation (can be used without special measures for the accumulation of harmful salts in the soil), and sample no. 8 in the first cycle; samples No.1-12 in the second test cycle; samples No.1-3, 5-11 of the third test cycle, which belong to the class of satisfactory water (It takes measures to prevent salinization, except for land with good drainage characteristics).

By classification RSC Residual Sodium Carbonate, all of the tested samples are belonging to the class of good water.

### Conclusion

Based on the obtained and analyzed results of testing the quality of water for irrigation from the Drina River, it can be concluded that it can be used for irrigation of crops and soil according all presented classification for irrigation water with restrictions and frequent quality checks during the summer months.

### Acknowledgment

This research was financially supported by the Ministry of Education and Science, Republic of Serbia [Project TR 37006]

### References

- APHA(1992): Standard methods for the examination of water and wastewater. In A.E. Greenberg, A.E., Clesceri, L.S. and Eato, A.D. (Eds.) American Public Health Association, 18th ed., Washington, U.S.A.
- Ahipathy, M.V., Puttaiah, E.T. (2006): Ecological characteristics of Vrishabhavathy River in Bangalore (India) *Environ Geol* 49: 1217–1222.
- Atekwana, E.A., Atekwana Estella A., Rowe, R.S., Werkema, D.D. Jr., Legall, F.D. (2004): The relationship of total dissolved solids measurements to bulk electrical conductivity in an aquifer contaminated with hydrocarbon, *J Appl Geophys* 56: 281–294.
- Ayers, R.S., Westcot, D.W. (1994): *Water Quality for Agriculture, Irrigation and Drainage paper 29, Rev.1, 174 p.* (Food and Agriculture Organization of the United Nation, Rome, Italy, Reprinted)
- Begum, A., Harikrishna R. (2008): Study on the Quality of Water in Some Streams of Cauvery River. *J. Chem.* 2, 377-384.
- Carpenter S.R., Caraco N.F., Correll D.L., Howarth R.W., Sharpley A.N., Smith V.H. (1998): Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecol Appl* 8(3):559–68.
- Determination of electrical conductivity SRPS EN 27888:1993.
- Doneen L.D. and D.W. Westcot D.W. (1988): *FAO.Irrigation practice and water management Irrigation and Drainage Paper 1, Rev. 1.* FAO , Rome. 71 pp.
- Duncan, R.R., Carow, R.N., Huck, M. (2000): *USGA Green Section Record, September/October, pp.14-24.*
- <ftp://ftp.fao.org/agl/aglw/docs/idp57.pdf> U.S. Salinity Laboratory Staff (1954)
- [http://water.epa.gov/scitech/methods/cwa/bioindicators/upload/2007\\_07\\_10\\_methods\\_method\\_200\\_7.pdf](http://water.epa.gov/scitech/methods/cwa/bioindicators/upload/2007_07_10_methods_method_200_7.pdf)
- <http://sh.wikipedia.org/wiki/Drina>
- Hudak, P. F. and Sanmanee, S. (2003): Spatial patterns of nitrate, chloride, sulfate, and fluoride concentrations in the Woodbine aquifer of North-Central Texas. *Environmental Monitoring and Assessment*, 82: 311-320.

- Jarvie H.P., Whitton B.A., Neal C. (1998): Nitrogen and phosphorus in east coast British rivers: speciation, sources and biological significance. *Sci Total Environ* 210–211:79–109.
- Konstandinova G., Georgieva N., Yaneva Z., Petkov G., Todorova M., Miteva Ch.(2013): Tundzha River water quality as a source for irrigation in agriculture *Bulgarian Journal of Agricultural Science*, 19 (No 4), 635-643 Agricultural Academy.
- Measurement of pH - Potentiometric method SRPS H.Z1.111:1987.
- Official Gazette of Republic Serbia, 23/94, (1994) and #50/2012, (2012).
- Rhoads, J.D., Akandiah, A. M. Maghali A.M.(1992): The use of saline waters for crop production. *FAO Irrigation & Drainage Paper*, No.48.
- Souligny, A. E. and Hollabaugh, C.L. (2002): Sulfate concentration of surface and groundwater of the piedmont of West Georgia: Variations with rock type, land usage, flow characteristics, and human activities. *North-Central Section (36th) and Southeastern Section (51st)*, GSA Joint Annual Meeting, 3-5 April, pp.56-72.
- Szynkiewicz, A., Modelska, M., Jedrysek, M.O. and Mastalerz, M. (2008): The effect of acid rain and altitude on concentration,  $\delta^{34}\text{S}$ , and  $\delta^{18}\text{O}$  of sulfate in the water from Sudety Mountains, Poland. *Chemical Geology*, 249: 36–51
- Simeonova, V, Stratis, J.A., Samara, C., Zachariadis, G., Voutsas, D., Anthemidis, A., Sofoniou, M., Kouimtzis, T., 2003. Assessment of the surface water quality in Northern Greece. *Water Research* 37: 4119–4124.