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"Agrosym 2024"

Jahorina, October 10-13, 2024

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PREFACE

Dear colleagues,

It is with great pleasure that I introduce the *Book of Proceedings* for the 15th International Scientific Agricultural Symposium "AGROSYM 2024." I trust that you will find it a valuable resource in your work. This year, around 800 contributions have been accepted for inclusion in the *Book of Abstracts*. The themes of AGROSYM 2024 span the full spectrum of agricultural sciences, divided into seven key sessions: 1) Plant Production, 2) Plant Protection and Food Safety, 3) Organic Agriculture, 4) Environmental Protection and Natural Resource Management, 5) Animal Husbandry, 6) Rural Development and Agro-Economy, and 7) Forestry and Agroforestry.

There is growing consensus among scholars and practitioners that technological innovations have the potential to boost agricultural production, enhance supply stability, and reduce the environmental impact of farming. Technology has been especially pivotal in increasing the productivity of annual crops such as maize, rice, soybeans, wheat, and cotton. However, with trees having longer growth cycles, breeding programs for these crops require more time. New plant breeding techniques promise improvements in productivity, but they have sparked an ongoing academic debate regarding their advantages and drawbacks.

While much of the focus in the past has been on the production side of agriculture (e.g., productivity and efficiency), there is an increasing emphasis today on the consumption side and the intermediate stages of the food chain, such as processing and distribution. This shift is driving the transition toward a "farm-to-fork" approach. Globally, consumers are sending clearer signals about their preferences for higher quality, healthier, safer, and more flavorful products. In response, many agri-food companies are exploring innovative ways to gain greater control over production processes and ensure the quality and safety of final products. Furthermore, changes in investment strategies hold the potential to reduce the environmental and social costs of agriculture. It has become increasingly clear to investors that companies that prioritize sustainability and social responsibility tend to yield better long-term returns.

Agri-food systems are at the heart of global discussions surrounding sustainable development and the achievement of the United Nations Sustainable Development Goals (SDGs) by 2030. These systems are deeply connected to numerous global challenges, including climate change, poverty, food insecurity, biodiversity loss, resource depletion, and ecosystem degradation. A key goal of the sustainable agriculture movement is to create farming systems that mitigate or eliminate the environmental harms associated with industrial agriculture. Additionally, it is critical to improve the resilience of food systems to crises, shocks, and pandemics.

I would like to extend my heartfelt thanks to all the authors, reviewers, and colleagues who contributed to the editing of the *Book of Abstracts*. Special thanks are due to our co-organizers and partners for their unwavering collaboration and comprehensive support throughout this endeavor.

Dušan Kovačević

East Sarajevo, 10 October 2024
Prof. Dušan Kovačević, PhD
Editor in Chief, President of the Scientific Committee of AGROSYM 2024

CONTENT

EVALUATING CORROSION AND INCRUSTATION RISKS IN SELECTED WELLS IN DANUBE ALLUVIUM

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Abstract

The determination of corrosion and incrustation risks in drainage wells is crucial for the maintenance of water extraction infrastructure, ensuring the required efficiency in groundwater levels maintaining, and safeguarding the functionality and longevity of water extraction systems. Analytical methods have long been established for assessing water aggressiveness, providing insights into the groundwater environment susceptibility to corrosion or incrustation of underground structures. The assessment of groundwater aggressiveness is facilitated by the Langelier (LSI) and Ryznar indices (RSI), while Johnson's Classification aids in understanding incrustation phenomena. Based on conducted groundwater sampling campaign in 2021, for four drainage wells in Danube alluvium, the risks of chemical corrosion and incrustation were calculated. Revealed results indicated that groundwater was characterised with oxygen level of 2.5 mg/l – 3.75 mg/l and redox values in range of 362 mV to 583 mV, with very variable iron content. Based on the negative LSI values, examined groundwater from B-1, B-2, and B-4 is undersaturated and tends to dissolve calcium carbonate. The calculated indices for B-3 suggest mild incrustation tendencies, indicating a propensity for carbonate precipitation. Groundwater in zone B-4 stood out as highly corrosive. Saturation indices indicated groundwater tendencies towards either calcium carbonate dissolution or precipitation. The choice of construction materials significantly influences corrosion susceptibility, necessitating pre-emptive measures. Understanding groundwater behavior regarding scaling and corrosion is pivotal for effective prevention and maintenance planning. By implementing tailored strategies, such as pH adjustment and corrosion-resistant coatings, the detrimental effects of scaling and corrosion can be mitigated, ensuring the longevity of drainage well systems and minimizing operational costs. Regular monitoring of groundwater chemistry enables timely interventions, fostering sustainable water management practices.

Keywords: *groundwater, corrosion, incrustation, Langelier, Ryznar.*

Introduction

The most common processes that contribute to the inevitable reduction in yield, known as "well aging," after long-term exploitation, are corrosion and incrustation-chemical scaling. The inclination of water towards either can significantly impact the transmission and distribution of water, influencing both economic considerations and public health concerns (Derakhshannia et al., 2020; Lodha et al., 2023; Mokhtari et al., 2010). Corrosion represents a set of chemicals, electrochemical, and biochemical processes that lead to damage and physical degradation of well construction. The basic precondition for the occurrence of corrosion of well construction metal parts is high mineralization, as well as the activity of microorganisms in water, especially sulfate-reducing bacteria. Favorable factors for the formation and development of corrosion include increased acidity of groundwater, increased content of dissolved oxygen (>2 mg/l), sulfides (>1 mg/l), and humic acids (>50 mg/l), presence of organic acids, low water hardness, and increased mineralization (>1000 mg/l). Incrustation or

chemical scaling is the process of depositing insoluble materials in the pre-filter zone of the well or in the well's filtration construction itself; it distinguishes mechanical, chemical, biochemical, and biological scaling. Chemical scaling is the process of forming precipitates through chemical reactions, usually in the form of scale on the filtration construction and in the pre-filter zone of the well. Favorable factors for the formation and development of incrustation include increased alkalinity of groundwater, increased content of bicarbonates (>300 mg/l), iron (>2 mg/l), and manganese (>1 mg/l), and oxygen content below the aerobic boundary of the environment (<0.5 mg/l). Pumping of groundwater leads to disturbance of the natural chemical equilibrium of groundwater as a result of hydrodynamic disturbances in the aquifer, contact of groundwater with atmospheric oxygen, loss of dissolved gases, and deposition of corresponding substances. Filtration and pre-filter zone scaling are conditioned by disturbances in the carbonate equilibrium of water and redox processes in the narrow zone of the well. In order to predict examined groundwater aggressiveness, the Langelier and Ryznar number were calculated, and Johnson's Classification were estimated.

Materials and methods

The settlement of Vinci in Serbia is located on the right bank of the Danube River. Situated in the coastal area, Vinci occupies terrain elevations ranging from 70 to 75 meters above sea level (mnm), with the majority of the settlement positioned between 71 and 73 mnm. The lower-lying section of the settlement, below 72 mnm, lies adjacent to the Danube River, extending westward towards the "Vinci" water source (supplying the Golubac municipality), and partly towards the north and northwest, reaching the lower terrains of the Vinci-Požarevac drainage system.

In 1994, a drainage system consisting of a total of 4 operational wells (B-1 to B-4) with their own pumps and outlets into the Danube River was constructed to protect the lowest parts of the terrain in the developed area of the Vinci settlement (Figure 1). Following their construction, the wells were equipped with hydraulic and electrical equipment and put into operation. The primary role of this drainage system is to safeguard the lower coastal area of the Vinci settlement from the increased Danube levels. For these wells the Langelier and Ryznar indices were calculated as well as Johnson's Classification was determined.

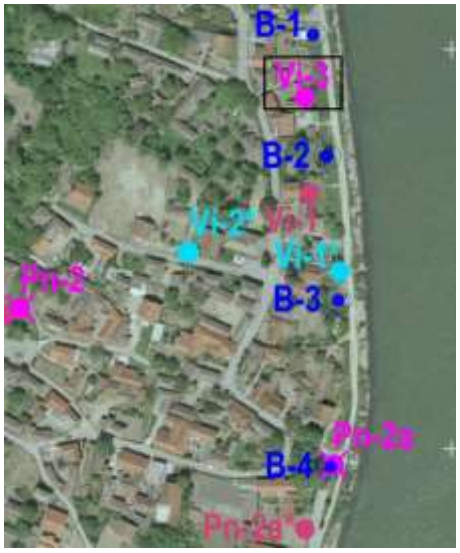

Figure 1 The locations of the monitored wells

The Langelier index and Ryznar number

The Ryznar Stability Index (RSI) is a parameter used to assess the scaling potential and corrosiveness of water (Ryznar, 1944). It helps determine whether water tends to form scale (such as calcium carbonate deposits) or if it is corrosive. The Ryznar index is calculated using water analysis data, including parameters like pH, conductivity, total dissolved solids (TDS), calcium concentration, bicarbonate concentration, and water temperature. Calculated pHS value, corresponds to the equilibrium state in the solution of carbonate compounds. The pHS value represents the hydrogen ion index corresponding to the equilibrium saturation of groundwater with carbonic acid compounds. The pH value reflects the real concentration of hydrogen ions in groundwater when measured directly on-site. Conversely, pH values obtained in laboratory settings typically register higher than those measured directly on-site. In light of analyzed literature data (Shankar, 2014), a practical formula has been proposed to calculate pHS values as follows (Eq.1):

$$pH_S = 9,92 - \frac{t\left[{}^0C\right]}{40} - \log\left[Ca^{++}(mg/l)\right] - \log\left[HCO_3^{-}(mg/ekv/l)\right] + 0,2\log\left[S.O.(mg/l)\right]$$

(1)

t - temperature of groundwater (°C),

S.O. - dry residue (mg/l)

In terms of the stability of carbonate systems in water, the Ryznar criterion or number is introduced, expressed as:

RSI=2pHS−pH

RSI has only positive values, and the higher the values, the more corrosive the water is (Table 1).

Table 1. Ryznar index and water tendency towards incrustation or corrosion

RSI value	Indication of water aggressiveness
4-5	Highly incrustive
5-6	Mildly incrustive
6-7	Mildly incrustive or corrosive
7-7.5	Corrosive
7.5-9	Highly corrosive
>9	Extremely corrosive

The Ryznar index complements the Langelier Saturation Index (LSI), which also assesses water scaling potential. While Ryznar gives an indication of water aggressiveness, the LSI considers both scale and corrosion potential (Eq. 2).

LSI=pH−pHS

(2)

If the measured pH value is less than the calculated pHs value (LSI < 0), the concentration of dissolved CO_2 in groundwater is above equilibrium, and groundwater can dissolve carbonate compounds. If, however, the pH value is greater than the calculated pHs value (LSI > 0), the concentration of dissolved CO_2 in groundwater is below equilibrium, and calcium carbonate can precipitate from groundwater.

Values of LSI can be interpreted as follows:

- Positive value: water tends to precipitate calcium carbonate.
- Zero: water is in equilibrium.
- Negative value: water is undersaturated, tends to dissolve calcium carbonate.

Johnson's Classification is relevant to incrustation processes. This classification helps in understanding the propensity of groundwater to form incrustations, which can be valuable for various applications, including water supply management and infrastructure maintenance. According to Johnson's Classification the process of incrustation occurs in groundwater with the following characteristics: the water is alkaline, i.e., pH is > 7.5, carbonate content in water exceeds 300 mg/L, indicating the potential for calcium carbonate precipitation. The iron content in water is greater than 2 mg/L. The process of iron precipitation from water is intensified by biological processes - the action of iron bacteria. The manganese content in water is over 1 mg/L.

Results and Discussion

Considering the results of water quality testing, pH values ranged from a minimum of 7.16 in zone B-1 to a maximum of 7.62 in zone B-4, ranging from neutral to slightly alkaline values (Table 2). Carbonates were not detected, except in zone B-4, manganese content was >1 mg/L, and iron content varied widely, from 0.3 mg/l to even 5.42 mg/l (in B-2 and B-4). Along with high manganese values in groundwater in all four examined zones, microbial-mediated precipitation of iron and manganese and the formation of iron and manganese incrustations (iron and manganese oxide-hydroxides) are likely. Based on the negative values of LSI calculated according to the above relation, groundwater in the zones of hydro-technical facilities B-1, B-2, B-3, and B-4 is undersaturated and tends to dissolve calcium carbonate. The LSI value in zone B-3, according to the parameters calculated from measurements conducted in 2021, tends towards carbonate precipitation (Table 3). Based on the Ryznar number, groundwater in zones B-1 and B-2 fell within the range of corrosive waters, while zone B-3 exhibited characteristics of both weakly incrustive and corrosive waters. Groundwater in zone B-4 stood out as highly corrosive.

Table 2. Selected groundwater quality parameters

Sampling site / **Parameter**	**Unit**	**B-1**	**B-2**	**B-3**	**B-4**
pH вредност		7.16	7.23	7.62	7.53
Ec	µS/cm	499	488	583	362
Eh	mV	371.5	394.2	363	389.9
DO	mgO_2/l	2.5	3.59	3.75	2.96
Iron (II)	mg/l	0.72	0.4	0.21	0.26
Iron	mg/l	2.77	5.42	0.72	0.3
NH_4	mgN/l	1.36	0.72	1.02	0.14
NO_2	mgN/l	0.006	0.054	0.038	0.028
NO_3	mgN/l	0.15	0.81	0.62	2.83
Cl	mg/l	17.6	17.44	17.49	11.07
SO_4	mg/l	3.33	15.5	18.35	25.47
H_2S	mg/l	<0.04	<0.04	<0.04	<0.04
TOC	mg/l	2.48	1.98	3.8	3.89
OP	mgP/l	0.218	0.34	0.08	0.262
TDS	mg/l	322	302	360	243
Total hardness	mg $CaCO_3/l$	222.4	233.4	275.4	151.3

Table 3. Saturation indices in groundwater

Well	**Redox (mV)**	**LSI**	**Ryznar**
B-1	371.5	-0.1	7.4
B-2	394.2	-0.08	7.4
B-3	363	0.42	6.8
B-4	389.9	-0.10	7.7

Several factors contribute to the corrosion of well materials. High mineralization levels in groundwater, along with the presence of dissolved gases and organic matter, can accelerate corrosion processes. Additionally, the pH level of the groundwater plays a crucial role, as acidic conditions can promote the dissolution of metallic components. Common materials used in well construction, such as steel, cast iron, and galvanized steel, are prone to corrosion if not adequately protected. Corrosion can lead to structural deterioration, leakage, and ultimately, the failure of the well system. Therefore, it is essential to select corrosion-resistant materials or apply protective coatings to extend the lifespan of wells and ensure the reliability of groundwater supply systems. Furthermore, proper design and construction practices, along with regular inspection and maintenance, are essential for mitigating corrosion risks in well infrastructure. By understanding the factors influencing corrosion and employing appropriate preventive measures, the integrity and functionality of well systems can be preserved, ensuring the sustainable management of groundwater resources.

Conclusion

Understanding the groundwater potential for chemical scaling and corrosion is important from several aspects: managing prevention of scaling, corrosion control, and maintenance planning. Groundwater with high mineral content, particularly calcium carbonate, can lead to scaling in drainage well systems. This scaling can clog pipes, reduce flow rates, and interfere with the operation of pumps and other equipment. By knowing the groundwater potential, appropriate measures can be taken to mitigate scaling, such as adjusting pH levels or installing filtration systems. By assessing the potential for corrosion based on groundwater characteristics such as pH, dissolved oxygen content, and mineral content, protective measures like corrosion-resistant coatings or cathodic protection systems can be implemented to prolong the lifespan of drainage well infrastructure. Understanding the potential for chemical precipitation and corrosion allows for proactive maintenance planning. Regular monitoring of groundwater chemistry parameters can help identify changes over time, allowing for timely interventions to prevent or mitigate scaling and corrosion issues. This proactive approach can minimize downtime, reduce repair costs, and ensure the efficient operation of drainage well systems.

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