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Water Source Analysis for Birra Peja: Focus on Physicochemical Attributes

Arsim Elshani[1], Indrit Loshi[1*], Kastriot Pehlivani[1], Afrore Zhara[2]

[1] Department of Food Technology, Agribusiness Faculty, University of Haxhi Zeka, Uck No.1, 30000 Peja, Kosovo

[2] Beer Production, j.s.c. Birra Peja, Nexhdet Basha 160, 30000 Peja, Kosovo

[*] Correspondent author's email: indrit.loshi@unhz.eu

ABSTRACT

The study aims to determine whether the physicochemical attributes of different water sources, including the karstic spring of Radavc and three boreholes, meet the established brewing water quality standards and guidelines. This investigation also seeks to understand how the mineral composition of the water may impact the flavor profile and brewing efficiency of the beer produced by the brewery. In essence, the problem revolves around ensuring the availability of high-quality water for beer production and optimizing brewing processes based on water characteristics. These results indicate that the water from the Drini Bardhë source exhibits superior quality compared to the well water. Specifically, the Drini Bardhë water displays favourable pH levels and mineral content suitable for drinking water. However, the well water samples exhibit higher iron concentrations, potentially impacting the taste of the final products. Despite this, all samples show low levels of total coliforms, meeting the World Health Organization's safety standards for consumption and production processes. Overall, this study emphasizes the significance of understanding the physicochemical attributes of water sources for breweries like Birra Peja. By tailoring water treatment and modification approaches based on these attributes, breweries can enhance brewing efficiency, consistency, and the final product's sensory characteristics. This research contributes to the broader knowledge of water quality's role in the brewing industry and provides valuable insights for optimizing beer production processes.

Keywords: beer production, brewing practices, physicochemical analysis, Radavc karstic spring, water quality.

INTRODUCTION

The scientific problem addressed in this study lies in the crucial role that water quality plays in industrial processes, particularly in beverage production. With a specific emphasis on the brewing industry, where water serves as a primary ingredient, the composition of the water used profoundly influences the overall quality of the beer produced. Two primary sources of water for brewing exist: surface water and groundwater, each with distinct characteristics. Surface water typically has lower mineral content but higher organic matter levels, while groundwater tends to exhibit higher mineral concentrations but lower organic matter content (Brewing Water, 2016).

For Birra Peja, a brewery committed to delivering exceptional products, maintaining the excellence of its offerings hinges on the quality of the water employed in its production processes. Consequently, this study sets out to conduct an exhaustive physicochemical analysis of the water sources surrounding Birra Peja, with a specific focus on the karstic spring of Radavc, renowned as the brewery's primary water source.

The scientific purpose of this research aligns with analogous studies conducted in related industries (Eßlinger, 2009; Briggs et al., 2004; Lewis et al., 2002). The objective is to comprehensively assess the physicochemical properties of the water, yielding a comprehensive understanding of its composition, including critical factors like mineral content, pH levels, and organic matter concentration. Drawing parallels with prior research establishes a robust foundation for evaluating the water's suitability for brewing purposes (Pehlivani et al., 2023; Elshani et al., 2022; Musliu et al., 2018).

By directing attention to the Radavc karstic spring, which serves as the brewery's principal water source, this research seeks to illuminate the specific characteristics of this crucial water supply. Such an analysis can provide valuable insights into how the unique properties of the spring may impact the quality of the final product, thus deepening our understanding of the intricate relationship between water composition and beer excellence. In essence, this study endeavour's to scientifically justify the importance of assessing and optimizing water quality for Birra Peja's brewing processes, contributing to the broader knowledge of water's role in the brewing industry.

MATERIALS AND METHODS

Study area, geological and hydrogeological conditions

The research was conducted in the karstic spring of Radavc, which is also the source of the Drini Bardhë River. The spring is located at the contact of Triassic limestone and diabase-cherty rock formation in the village of Radac, north of Peja, Zhleb Mount. The karst limestone massif, comprising synclines with an SSW-NNE orientation, forms the western end of the Dukagjini plain and extends approximately 7.5 km in length and up to 1.2 km in width. While the exact location of the water source of the Drini i Bardhe River is not precisely known (Fig. 1) it is believed to be in the mountainous area of Zhleb, Montenegro [MAFRD 2022]. Moreover, it is speculated that a significant portion of Sushica River water is lost underground and reemerges at the source of Drini i Bardhe, indicating a potential connection between the two water sources and the karst reservoir [Kadriu et al., 2017] (Fig. 2).

Boreholes:

To ensure a reliable water supply for the Birra Peja brewery, three boreholes were drilled around the Peja area to extract water. Table1 presents the essential data related to these boreholes, along with the water extraction rates [Kadriu et al., 2017]. Despite this supplementary water source, the main supplier for Birra Peja remains the city water, which draws from the Drini i Bardhë source [MAFRD, 2022].

Physicochemical analysis:

The standard methods used for testing various parameters include BS EN, ISO, and EPA methods. The tested parameters include smell, colour, taste, hardness, free chlorine, chlorides, hazy, pH value, conductivity, sulphates, ammonia, nitrites, nitrates, consumption index $KMnO_4$ (O_2), and various heavy metal concentrations (Zinc, Copper, Cadmium, Lead, Cobalt, Nickel, Sodium,

Figure 1. Rivers in Kosovo

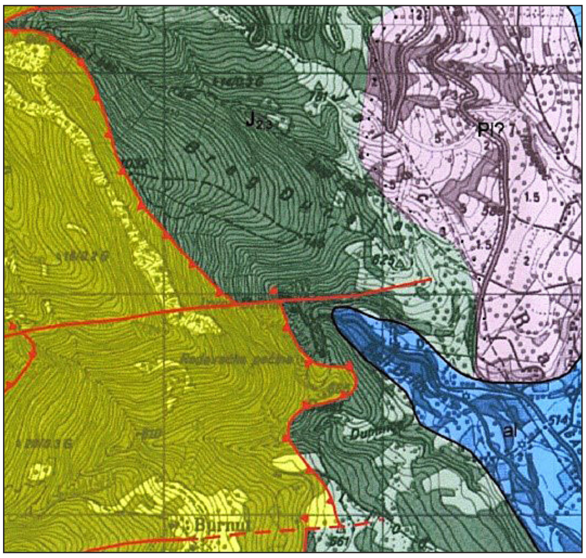

Figure 2. Hydrogeological conditions at the source of Drini i Bardhë

Table 1. Data of drillings for water

The well, No.	Drilling depth, m	Diameter, mm	Drilling thickness, mm	Extraction of water, l/s
Bunari I	97	300	225	11
Bunari II	99	240	200	6
Bunari III	92	240	200	6
From city	--	--	--	550

Potassium, Magnesium, Aluminium, Calcium, Chrome, Manganese, Arsen, Selenium, Antimony, Mercury, Iron, Silver).

Data analysis

The results of the chemical analysis were presented in tables, including measurements, reference values, and the obtained results for each parameter. The comparison between the water from the Drini Bardhë source, the three boreholes, and the city water supply was done to assess the water quality.

The materials and methods employed in this research aimed to assess the water quality in the study area, specifically focusing on the physicochemical characteristics of water from different sources. The data obtained from the analysis were crucial for making informed decisions about water management practices in the context of beverage production at Birra Peja.

RESULTS AND DISCUSSIONS

The results of the comprehensive physicochemical analysis conducted as part of this investigation have been systematically structured and meticulously compiled in Tables 2 through 9. These tables serve as essential tools for facilitating an extensive reference and assessment of the acquired findings. The data presented in these tables offer a detailed insight into the various parameters studied, enabling a comprehensive understanding of the water characteristics derived from the Radavc karstic spring, the boreholes surrounding the Peja brewery, and the municipal water supply system.

Physicochemical analysis

The physicochemical analysis included parameters such as smell, colour, taste, hardness, free chlorine, chlorides, hazy, pH value, conductivity, sulphates, ammonia, nitrites, nitrates, consumption index $KMnO_4$ (O_2), and

Table 2. Periodic physicochemical analysis of the well water of the Bunari I

Tested parameters	Standard methods	Measurement range		Results
		Unit	Value	
Smell	BS EN 1508:1999		–	No
Colour	ISO 7887:1994	°Co–Pt	–	No
Taste	BS EN 1508:1999		–	No
Hardness	ISO 6059:1984	d°H	01–50	15.45
Free chlorine (residual)	ISO 7393-1:2000	mg/l	0.018–1.5	0.00
Chlorides	ISO 9297:1989	mg/l	5–250	9.21
Hazy	ISO 7027:1999	NTU	0.01–1000	0.00
pH value	ISO 10523:2008		1.0–14.0	7.45
Conductivity	ISO 27888:1985	μS/cm	0.01–1999	298
Sulphates SO_4	ISO 9280:2000	mg/l	10–250	26.9
Ammonia NH_4	ISO 7150-5:1986	mg/l	0.01–30	0.026
Nitrites NO_2	ISO 6777:1984	mg/l	0.002–1.00	0.0033
Nitrates NO_3	ISO 7890-2:1988	mg/l	0.2–20.0	3.36
Consumption index KM_nO_4 (O_2)	ISO 8467:1993	mg/l	0.5–10	1.36

Table 3. Periodic physicochemical analysis of the water of the Bunari I well, with standard methods

Tested parameters Standard methods (EPA 6020A)	Measurement range value (mg/l)	Reference values (mg/l)	Results (mg/l)
Zinc (Zn)	0.03–3.0	3.0	0.000
Copper (Cu)	0.200–4.0	2.0	0.0001
Cadmium (Cd)	0.0005–0.010	0.005	0.000
Lead (Pb)	0.001–0.100	0.01	0.0002
Cobalt (Co)	0.0001–0.01	–	0.00004
Nickel (Ni)	0.001–0.050	0.02	0.0001
Sodium (Na)	0.050–0.500	200	1.5369
Potassium (K)	0.050–1.000	12	0.4315
Magnesium (Mg)	0.050–10000	–	3.2422
Aluminium (Al)	0.010–1.000	0.2	0.000
Calcium (Ca)	0.050–1.000	–	4.9972
Chrome (Cr)	0.005–0.500	0.05	0.0003
Manganese (Mn)	0.001–1.000	0.05	0.00005
Arsen (As)	0.001–0.050	0.01	0.0002
Selenium (Se)	0.001–0.050	0.01	0.00002
Antimony (Sb)	0.001–0.010	0.005	0.00003
Mercury (Hg)	0.0002–0.010	0.001	0.0001
Iron (Fe)	0.010–1.000	0.2	0.000008
Silver (Ag)	0.005–0.100	–	0.000

Table 4. Periodic physicochemical analysis of the well water of the Bunari II

Tested parameters	Standard methods	Measurement range		Results
		Unit	Value	
Smell	BS EN 1508:1999		–	No
Colour	ISO 7887:1994	°Co–Pt	–	No
Taste	BS EN 1508:1999		–	No
Hardness	ISO 6059:1984	d°H	01–50	17.13
Free chlorine (residual)	ISO 7393-1:2000	mg/l	0.018–1.5	0.00
Chlorides	ISO 9297:1989	mg/l	5–250	14.18
Hazy	ISO 7027:1999	NTU	0.01–1000	0.00
pH value	ISO 10523:2008		1.0–14.0	7.34
Conductivity	ISO 27888:1985	µS/cm	0.01–1999	417
Sulphates SO_4	ISO 9280:2000	mg/l	10–250	49.3
Ammonia NH_4	ISO 7150-5:1986	mg/l	0.01–30	0.039
Nitrites NO_2	ISO 6777:1984	mg/l	0.002–1.00	0.0033
Nitrates NO_3	ISO 7890-2:1988	mg/l	0.2–20.0	11.34
Consumption index KM_nO_4 (O_2)	ISO 8467:1993	mg/l	0.5–10	0.48

various heavy metal concentrations (Zinc, Copper, Cadmium, Lead, Cobalt, Nickel, Sodium, Potassium, Magnesium, Aluminium, Calcium, Chrome, Manganese, Arsen, Selenium, Antimony, Mercury, Iron, Silver). The pH values of all water samples were found to be within the permissible range for drinking water, and the mineral content was also within acceptable limits [Szalinska & Dobyrn 2018; Council Directive 98/83/EC].

Water quality comparison

The results showed that the water from the Drini Bardhë source had better physicochemical characteristics compared to the water from the

Table 5. Periodic physicochemical analysis of the water of the Bunari II well, with standard methods

Tested parameters Standard methods (EPA 6020A)	Measurement range value (mg/l)	Reference value (mg/l)	Results (mg/l)
Zinc (Zn)	0.03–3.0	3.0	0.0039
Copper (Cu)	0.200–4.0	2.0	0.00008
Cadmium (Cd)	0.0005–0.010	0.005	0.000
Lead (Pb)	0.001–0.100	0.01	0.00009
Cobalt (Co)	0.0001–0.01	–	0.00009
Nickel (Ni)	0.001–0.050	0.02	0.0003
Sodium (Na)	0.050–0.500	200	5.6291
Potassium (K)	0.050–1.000	12	10.0084
Magnesium (Mg)	0.050–10000	–	5.2324
Aluminium (Al)	0.010–1.000	0.2	0.00008
Calcium (Ca)	0.050–1.000	–	6.9686
Chrome (Cr)	0.005–0.500	0.05	0.0004
Manganese (Mn)	0.001–1.000	0.05	0.0003
Arsen (As)	0.001–0.050	0.01	0.0001
Selenium (Se)	0.001–0.050	0.01	0.0001
Antimony (Sb)	0.001–0.010	0.005	0.00002
Mercury (Hg)	0.0002–0.010	0.001	0.0001
Iron (Fe)	0.010–1.000	0.2	0.0001
Silver (Ag)	0.005–0.100	–	0.000

Table 6. Periodic physicochemical analysis of the well water of the Bunari III

Tested parameters	Standard methods	Measurement range		Results
		Unit	Value	
Smell	BS EN 1508:1999		–	No
Colour	ISO 7887:1994	°Co-Pt	–	No
Taste	BS EN 1508:1999		–	No
Hardness	ISO 6059:1984	d°H	01–50	6.90
Free chlorine (residual)	ISO 7393-1:2000	mg/l	0.018–1.5	0.002
Chlorides	ISO 9297:1989	mg/l	5–250	12.0
Hazy	ISO 7027:1999	NTU	0.01–1000	0.000
pH value	ISO 10523:2008		1.0–14.0	7.28
Conductivity	ISO 27888:1985	μS/cm	0.01–1999	500
Sulphates SO_4	ISO 9280:2000	mg/l	10–250	10.0
Ammonia NH_4	ISO 7150-5:1986	mg/l	0.01–30	0.039
Nitrites NO_2	ISO 6777:1984	mg/l	0.002–1.00	0.065
Nitrates NO_3	ISO 7890-2:1988	mg/l	0.2–20.0	13.4
Consumption index KM_nO_4 (O_2)	ISO 8467:1993	mg/l	0.5–10	0.96

three boreholes. Specifically, the water from the Drini Bardhë source had better taste and hardness compared to the borehole water. The strength of the water from the Drini Bardhë source was approximately 10 German degrees, while the borehole water had strengths ranging from 6.9 to 17.45 German degrees. This indicates that the water from the Drini Bardhë source is more suitable for consumption and use in the production process [Bodík & Kubaská 2013; Council Directive 98/83/EC; Nagaraju et al., 2016; Szalinska & Dobyrn 2018].

Heavy metal concentrations

The concentrations of heavy metals in all water samples were within acceptable limits, except

Table 7. Periodic physicochemical analysis of the water of the Bunari III well, with standard methods

Tested parameters Standard methods (EPA 6020A)	Measurement range value (mg/l)	Reference values (mg/l)	Results (mg/l)
Zinc (Zn)	0.03–3.0	3.0	0.0134
Copper (Cu)	0.200–4.0	2.0	0.00102
Cadmium (Cd)	0.0005–0.010	0.005	0.000
Lead (Pb)	0.001–0.100	0.01	0.0002
Cobalt (Co)	0.0001–0.01	–	0.00004
Nickel (Ni)	0.001–0.050	0.02	0.0001
Sodium (Na)	0.050–0.500	200	1.5369
Potassium (K)	0.050–1.000	12	0.4315
Magnesium (Mg)	0.050–10000	–	11.242
Aluminium (Al)	0.010–1.000	0.2	0.00475
Calcium (Ca)	0.050–1.000	–	89.40
Chrome (Cr)	0.005–0.500	0.05	0.00307
Manganese (Mn)	0.001–1.000	0.05	0.00045
Arsen (As)	0.001–0.050	0.01	0.0002
Selenium (Se)	0.001–0.050	0.01	0.00002
Antimony (Sb)	0.001–0.010	0.005	0.00047
Mercury (Hg)	0.0002–0.010	0.001	0.0001
Iron (Fe)	0.010–1.000	0.2	0.000008
Silver (Ag)	0.005–0.100	–	0.000

Table 8. Periodic physicochemical analysis of the well water of the city water

Tested parameters	Standard methods	Measurement range		Results
		Unit	Value	
Smell	BS EN 1508:1999		–	No
Colour	ISO 7887:1994	°Co-Pt	–	No
Taste	BS EN 1508:1999		–	No
Hardness	ISO 6059:1984	d°H	0.1–50	10.75
Free chlorine (residual)	ISO 7393-1:2000	mg/l	0.018–1.5	0.00
Chlorides	ISO 9297:1989	mg/l	5–250	11.34
Hazy	ISO 7027:1999	NTU	0.01–1000	0.00
pH value	ISO 10523:2008		1.0–14.0	7.71
Conductivity	ISO 27888:1985	μS/cm	0.01–1999	340
Sulphates SO_4	ISO 9280:2000	mg/l	10–250	60.82
Ammonia NH_4	ISO 7150-5:1986	mg/l	0.01–30	0.039
Nitrites NO_2	ISO 6777:1984	mg/l	0.002–1.0	0.00
Nitrates NO_3	ISO 7890-2:1988	mg/l	0.2–20.0	5.88
Consumption index KM_nO_4 (O_2)	ISO 8467:1993	mg/l	0.5–10	0.64

for iron, which was found to be higher than the permissible level in the well water. High iron content can negatively affect the taste of the final products. Birra Peja needs to consider appropriate treatment methods to reduce iron levels in the well water [Canbay & Doğantürk 2016; Demaku et al., 2011; Fulekar & Dave 2007; Fulekar et al., 2007; Nagajyoti 2010; Rauret, 1997; Smołka-Danielowska 2006]

Overall, the Results and Discussions section highlights the water quality differences between the Drini Bardhë source and the

Table 9. Periodic physicochemical analysis of the water of the city water, with standard methods

Tested parameters Standard methods (EPA 6020A)	Measurement range value (mg/l)	Reference values (mg/l)	Results (mg/l)
Zinc (Zn)	0.03–3.0	3.0	0.000
Copper (Cu)	0.200–4.0	2.0	0.00008
Cadmium (Cd)	0.0005–0.010	0.005	0.000
Lead (Pb)	0.001–0.100	0.01	0.0001
Cobalt (Co)	0.0001–0.01	–	0.00004
Nickel (Ni)	0.001–0.050	0.02	0.0001
Sodium (Na)	0.050–0.500	200	2.2639
Potassium (K)	0.050–1.000	12	0.4898
Magnesium (Mg)	0.050–10000	–	3.7464
Aluminium (Al)	0.010–1.000	0.2	0.000
Calcium (Ca)	0.050–1.000	–	5.3021
Chrome (Cr)	0.005–0.500	0.05	0.0002
Manganese (Mn)	0.001–1.000	0.05	0.0001
Arsen (As)	0.001–0.050	0.01	0.00006
Selenium (Se)	0.001–0.050	0.01	0.00007
Antimony (Sb)	0.001–0.010	0.005	0.00002
Mercury (Hg)	0.0002–0.010	0.001	0.0001
Iron (Fe)	0.010–1.000	0.2	0.000
Silver (Ag)	0.005–0.100	–	0.000

boreholes, emphasizing the importance of water quality management for beverage production. The results provide valuable insights for Birra Peja to make informed decisions and implement necessary measures for ensuring water quality and product safety.

CONCLUSIONS

The scientific problem addressed in this study lies in the evaluation of the physicochemical characteristics of water from various sources, including the karstic spring of Radavc, boreholes around the Peja brewery, and the city water supply. While the determination of water quality for production purposes is not a novel concept in itself, the specific context of this research, which focuses on Birra Peja's water sources and their suitability for brewing, presents a unique scientific challenge.

The water from the Drini Bardhë source demonstrated superior physicochemical attributes compared to the water from the boreholes. Notably, the Drini Bardhë source exhibited better taste and hardness properties, with a strength of approximately 10 German degrees. On the other hand, the borehole water exhibited strengths ranging from 6.9 to 17.45 German degrees, indicating potential variations in water quality among different sources.

While the mineral content and pH values of all water samples were within permissible ranges for drinking water, it was observed that the iron concentration in well water exceeded acceptable levels. This finding highlights the need for effective treatment strategies to address elevated iron content, which could adversely affect the taste of final products. The concentration of total coliforms in all samples remained below the limits established by the World Health Organization, indicating the safety of the water for consumption and production use.

The results underscore the crucial role of water quality management in beverage production. For Birra Peja, ensuring adherence to the standards set by the World Health Organization is imperative to guarantee the safety and quality of the products. The findings from this study provide valuable insights that can guide decisions related to sourcing and utilizing water for production processes.

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