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Assessment the water quality of wells used for drinking water of Pristina district, Kosovo

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Abstract. Water quality is a necessary condition when water is planned to be used. In this sense, the assessment and recognition of its quality takes on special importance. This paper deals with the quality of well water in the city of Pristina. To achieve the goal in this work, during the months of August and September of 2022, water samples were taken in four wells to analyze the physical, chemical, and microbiological parameters of the water. The research work and the results obtained showed that; the water wells analyzed from the four samples showed no signs of turbidity and the presence of chlorine. The values for temperature, pH, total hardness, dissolved oxygen, nitrites, nitrates, sulfates, manganese, and ammonia were found to be within the limit values as determined by Administrative Instruction No. 10/2021, while iron showed higher values (above the allowed values). The high values of the parameters in the water make it unusable for use, while the use of polluted water causes health problems for the community. Therefore, permanent monitoring of the quality and quantity of water used for public consumption should be a high priority for policymakers and drinking water service providers.

Key words: water quality, physicochemical properties, Pristina-Kosovo, biological parameters.

Introduction

Water is a necessity for all living species on Earth and serves several purposes in the natural world. It is a clear, tasteless, and odorless liquid that covers 71% of the Earth's surface. According to Rasca et al. (2020), water is a one-of-a-kind chemical that is essential to the survival of all living beings. It is the foundation of life and is required for all species to survive, from single-celled organisms to sophisticated multicellular organisms like humans. It is a solvent capable of dissolving a wide range of compounds, making it an important component of many biological operations (Hlordzi et al., 2020). It also has a high specific heat capacity, which means it can absorb and release a big quantity of heat without dramatically altering temperature. This feature aids in the regulation of the Earth's atmosphere's temperature and is critical for the existence of many living creatures (Schveitzer et al., 2013).

Water is necessary for human activities such as agriculture, manufacturing, and transportation, in addition to its natural purposes. It is utilized for irrigation, animal watering, and other agricultural purposes. It is also utilized in industrial activities like as cooling, cleaning, and manufacturing (Wang et al., 2021). Water is utilized in transportation for shipping, pleasure, and fishing. Despite the importance of water, many people throughout the world still lack access to clean and safe water (Yap, 2011). World Health Organization (2019) estimates that around 2.2 billion people do not have access to safe drinking water and 4.2 billion do not have access to acceptable sanitation facilities.

Water shortage is a developing problem in some regions of the world, and appropriate water resource management is becoming increasingly crucial (Braga et al., 2022; Flura, 2016).

The chemical, physical, and biological properties of water are referred to as its quality (Akhtar et al., 2021; Manikannan et al., 2011). Temperature, pH, dissolved oxygen, turbidity, total dissolved solids, and salinity are physico-chemical parameters of water, whereas biological parameters include the presence of microorganisms such as bacteria, viruses, and protozoa (Goshtasbi et al., 2022; Sonila Kane, 2015). These factors are critical for establishing water quality and whether it is safe for drinking or other uses. Water quality is affected by both natural and human influences. Natural variables such as rainfall, climate, and geology may all have an impact on water quality (Liu et al., 2015; Williams & Benson, 2010). Heavy rains, for example, can produce flooding and wash contaminants into rivers, lakes, and groundwater. Agriculture, urbanization and industrialization are all examples of human activities that can have a substantial influence on water quality (Kolarevic et al., 2011; Norshila Abu Bakar, 2020). These activities can bring contaminants into water sources, such as chemicals, heavy metals, and pathogens, rendering it unsuitable for ingestion and other purposes (Chinedu & Nwinyi, 2011; Driga & Drigas, 2019).

Biological parameters such as the presence of microorganisms in water can also affect water quality. Microorganisms such as bacteria, viruses, and protozoa can cause waterborne diseases such as cholera, typhoid, and dysentery (Imoobe & Koye, 2011; Meme et al., 2014). The presence of these microorganisms can be influenced by physicochemical parameters such as temperature, pH, and dissolved oxygen (Olah et al., 2011; Manikannan et al., 2011). For example, high temperatures can encourage the growth of certain bacteria, while low dissolved oxygen levels can reduce the ability of aquatic organisms to fight off infections (Chinedu & Nwinyi, 2011; Proshad et al., 2018).

Human activities can also have an impact on the effect of biological factors on water quality. Large numbers of pathogens can be introduced into water bodies by agricultural runoff and sewage, rendering them unsuitable for food and other purposes (Norshila Abu Bakar, 2020; Prest et al., 2016). Furthermore, industrial operations can bring contaminants into water bodies, such as heavy metals and chemicals, affecting the growth and survival of aquatic creatures (Hazra, 2021; Scown et al., 2011).

The main goal of this study is to evaluate the quality of well water used for drinking purposes in the Pristina district of Kosovo by analyzing its physicochemical and microbiological parameters. This research aims to identify potential contaminants and assess compliance with established water quality standards. The study highlights critical issues such as iron exceeding permissible limits and microbiological contamination, which may pose health risks.

Materials and methods

Study area

The study area - the city of Pristina, is located in the central part of the Republic of Kosovo, at the coordinates 42°40′0" North and 21°10'0" East. The area of the Municipality of Pristina is about 523 km^2, the elevation is 652 m and it has 198,897 inhabitants. Residents are supplied with drinking water from the public system and from private drilled and dug wells. The wells are not constructed according to hygienic and sanitary rules and are exposed to various pollutants. The study area has a geological construction of rock formations.

The entire study was conducted in different areas of Pristina, Kosovo. Water samples were collected from water wells 4 times during the year 2022 (Fig. 1).

Water wells quality parameters include: turbidity (Turb.), color (Co-Pt), Smell (sm.), free chlorine (FCl), pH, ammonium (NH^{4+}), nitrites (NO_2^-), nitrates (NO_3^-), total phosphorus (TP), iron (Fe), Manganese (Mn), conductivity (Cond.), chlorides (Cl^-), sulfates (SO_4^{2-}), and bacteria such as: Coliform, Live bacteria, Enterococci and *Escherichia coli* (Table 1.)

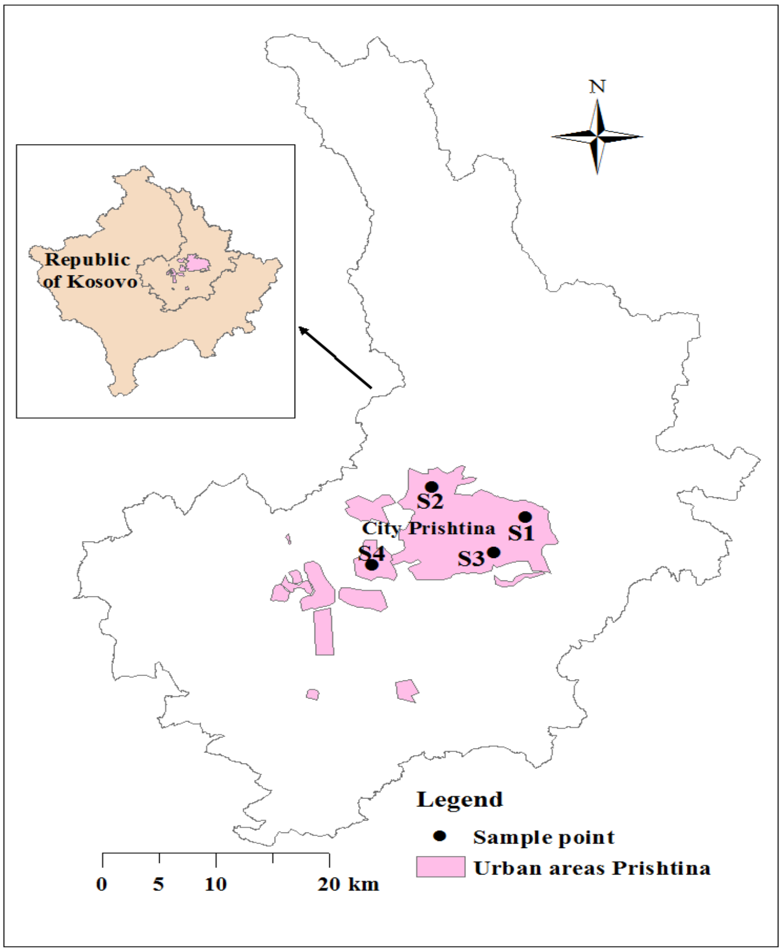

Fig. 1. Location of investigated area

Table 1. Physicochemical and microbiological parameters and analytical methods in water wells in Pristina

Parameters	Meaning	Unit	Analytical methods
Turb.	Turbidity	NTU	ISO 7027:2001
Co-Pt	Color	/	ISO 7887:2001
Sm.	Smell	/	EN 2892-15
FCl	Free chlorine	mg/l	ISO 7393-1:2000
pH	pH	/	ISO 10523:2008
NH_4^+	Ammonium	mg/l	ISO 7150-5:1984
NO_2^-	Nitrites	mg/l	ISO 7890-3:1988
NO_3^-	Nitrates	mg/l	ISO 7890-2:1988
Oxidation	O_2 consumption	mg/l	ISO 11885:2007
Fe	Iron	mg/l	SMWW 3500 Fe-B
Mn	Manganese	mg/l	ISO 6333:1986
Cond.	Conductivity	µS/cm	ISO 27888:2001
Cl^-	Chlorides	mg/l	ISO 9297:2000
SO_4^{2-}	Sulfates	mg/l	ISO 15923-1:2013
Coliform	Total coliform bacteria	cfu/ml	ISO 9388-1:2003
Live bact.	Total live bacteria	cfu/ml	ISO 6222:1999
Enterococci	Enterococci bacteria	cfu/ml	ISO 7899-2:2000
Escherichia coli	*Escherichia coli* bacteria	cfu/ml	ISO 9388-1:2003

Chemical analysis

All samples were tested in the laboratories of Institute for Public Health Pristina, and "KUR Pristina", Pristina, Kosovo, both accredited by the General Directorate for Accreditation of Kosovo to the requirements of standard ISO/IEC 17025. General requirements for the competence of testing and calibration laboratories (DAK). Laboratories were well-equipped and staffed by knowledgeable individuals. Standard Methods for the Examination of water were used to test all parameters in accordance with Kosovo legislation (Administrative Instruction 10/21). Water is sampled using standard techniques based on ISO 5667-6:2014 water quality - sampling. Bottles containing water wells are closed and placed in the refrigerator before being delivered to the lab for examination.

Water samples are transported using established techniques (ISO 5667-5:2006).

Results and Discussion

Because of the probable presence of numerous pollutants, the quality of subsurface water in Pristina, Kosovo, is a worry. The city is located in an area with a lot of mining and industrial activity, which can lead to the release of different contaminants into ground water sources. Natural activities such as mineral leaching from neighboring geological formations can also have an impact on the quality of Pristina's water wells. The geological nature of the land can also influence on the water quality. Regular monitoring and testing of physicochemical and biological characteristics are required to assure the safety of Pristina's water wells.

Water quality reflects its physico-chemical and microbiological properties. As a result, it was critical to investigate its physicochemical and microbiological properties. The first sample was taken on 1 August, well -1 (S1) 2022. The second sample was taken on 5 August, well - 2 (S2) 2022. The third sample was taken on 12 August well - 3, (S3) 2022. And the fourth sample was taken on 15 September, well - 4 (S4), 2022.

Free chlorine in drinking water plays a crucial role in ensuring that the water is safe to drink. It kills harmful microorganisms that can cause illnesses such as cholera, typhoid fever, and dysentery. The amount of free chlorine in drinking water is carefully regulated to ensure that it is effective in killing pathogens but not so high that it poses a risk to human health. While chlorine can sometimes affect the taste and odor of drinking water, its use has greatly improved public health by reducing the incidence of waterborne diseases. Table 2 demonstrates that the free chlorine number in all samples is 0. The chlorides levels in the water are within acceptable norms, with sample 3 having the lowest chlorides levels of about 2.5 mg/L and sample 4 having the highest number of 69 mg/L.

Turbidity refers to the level of cloudiness or haziness in water, caused by suspended particles such as silt, sediment, and organic matter. High levels of turbidity in drinking water can be a concern as it can interfere with disinfection processes, making it more difficult to kill harmful microorganisms. Additionally, high turbidity can affect the taste, odor, and appearance of the water. As you can see in Table 2, the turbidity value number in all samples is 0.

Manganese is a naturally occurring element that can be found in rocks, soil, and groundwater. In small amounts, manganese is essential for human health, but high levels of manganese in drinking water can cause health problems. Exposure to high levels of manganese over a long period of time can cause neurological problems, particularly in children. Additionally, high levels of manganese can give the water an unpleasant metallic taste and stain fixtures and laundry. Water treatment plants can remove manganese through processes such as oxidation, filtration, and ion exchange. Regular testing of drinking water for manganese levels is recommended to ensure that it is safe for consumption. Manganese levels are 0.01 mg/L in samples 2, 3, and 4, and 0.009 mg/L in sample 1, which is within acceptable limits.

Iron is a common element found in soil, rocks, and groundwater. In low concentrations, iron in drinking water is not harmful to human health and can even be beneficial, as it is an important nutrient for the body. However, high levels of iron in drinking water can cause problems. Iron can promote the growth of certain bacteria in water systems, which can cause problems with taste, odor, and color (Fig. 2). Unfortunately, the value of Iron in all four samples is higher than the permitted value, with the highest value being 0.02 mg/L in the fourth sample and the lowest value being 0.01 mg/L in samples 1 and 2.

Table 2. The results of water wells quality characteristics in water wells in Pristina

Parameters	Meaning	Unit	Max. range allowed	S1	S2	S3	S4
FCl	Free chlorine	mg/l	0.5	0.0	0.0	0.0	0.0
Turb.	Turbidity	NTU	< 0.5	0.0	0.0	0.0	0.0
Mn	Manganese	mg/l	11	0.009	0.01	0.01	0.01
Fe	Iron	mg/l	0.001	0.01	0.01	0.035	0.02
NH_4^+	Ammonium	mg/l	0.5	0.013	0.013	0.039	0.065
NO_2^-	Nitrites	mg/l	0.5	0.036	0.036	0.039	0.169
Oxidation	O_2 consumption	mg/l	20	1.2	0.8	0.8	0.96
Hardness	Hardness of water	d0H	120	13.8	1.7	1.7	20.16
SO_4^{2-}	Sulfates	mg/l	400	131	12.76	10.8	32
NO_3^-	Nitrates	mg/l	50	19.7	31.0	17.0	6.93
Cl^-	Chlorides	mg/l	250	27.9	36.1	2.5	69
pH	pH	/	9.5	7.80	5.48	4.49	7.52
Cond.	Conductivity	µS/cm	600	753	7.36	7.89	8.70
Sm.	Smell	/	no	no	no	no	no
Co-Pt	Color	/	10	0.0	0.0	0.0	0.0
Coliform	Total coliform bacteria	cfu/ml	100	50	0.0	>300	>300
Live bact.	Total live bacteria	cfu/ml	300	0.0	10	>300	>300
Enterococci	Enterococci bacteria	cfu/ml	0.0	0.0	0.0	0.0	0.0
Escherichia coli	*Escherichia coli* bacteria	cfu/ml	0.0	50	0	10	50

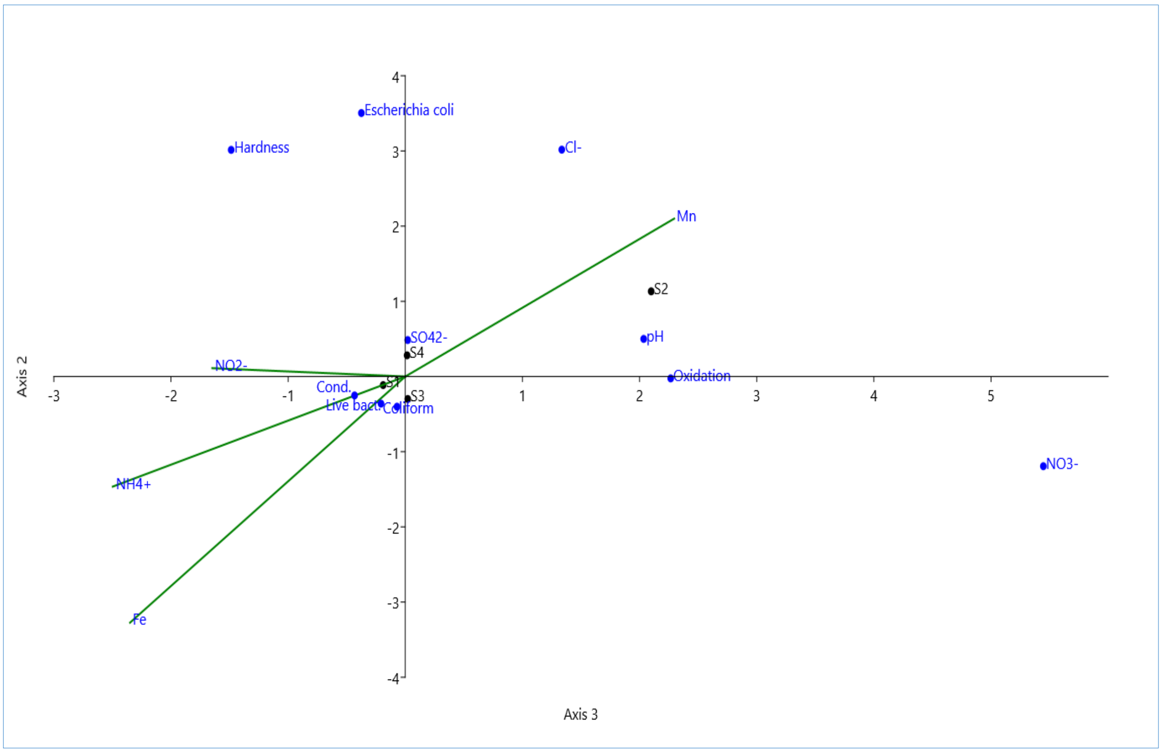

Fig. 1. Ordination plot of canonical correspondence analysis (CCA) for physicochemical parameters and bacteria

Ammonium is a common source of nitrogen in soil and is also found in surface and groundwater. In low concentrations, ammonium in drinking water is not harmful to human health. However, high levels of ammonium in drinking water can be toxic and cause health problems. Exposure to high levels of ammonium can cause nausea, vomiting, and diarrhea. In addition, ammonium can react with chlorine used in water treatment, forming harmful disinfection byproducts. The ammonium values are within the permitted ranges, as shown in Table 2, with samples 1 and 2 having the lowest ammonium values of about 0.013 mg/L and sample 4 having the highest value of 0.065 mg/L.

Nitrites are nitrogen compounds present in surface and groundwater as a consequence of agricultural and industrial operations. Nitrites in drinking water are not detrimental to human health at low amounts. High amounts of nitrites in drinking water, on the other hand, can be toxic, particularly to babies and young children. As shown in Table 2, the nitrite values are within the allowed limits, with samples 1 and 2 having the lowest ammonium values of about 0.036 mg/L and sample 4 having the highest value of 0.169 mg/L. Water nitrate levels are within acceptable norms, with sample 4 having the lowest ammonium level of about 6.93 mg/L and sample 2 having the maximum level of 31 mg/L.

The O_2 consumption values are within the permitted ranges, with samples 2 and 3 having the lowest ammonium values of about 0.8 mg/L and sample 1 having the maximum value of 1.2 mg/L. The hardness of water values is within the permitted ranges, as shown in Table 2, with samples 2 and 3 having the lowest ammonium values of about 1.7 d0H and sample 4 having the highest value of 20.16 d0H.

Sulfates are a type of dissolved salt that can be found in groundwater and surface water. In low concentrations, sulfates in drinking water are not harmful to human health, and in fact, can be beneficial as they aid in digestion and help with the absorption of nutrients. However, high levels of sulfates in drinking water can cause diarrhea and dehydration, especially in infants and young children. Water sulfates are within acceptable ranges, with sample 3 having the lowest ammonium value of about 10.8 mg/L and sample 1 having the maximum value of 131 mg/L.

Conductivity refers to the ability of water to conduct an electrical current, which is affected by the number of dissolved solids, such as salts and minerals, in the water. Conductivity is often used as a measure of water quality, as high conductivity can indicate the presence of pollutants or excessive levels of dissolved minerals. In drinking water, high conductivity can affect the taste and odor of the water and can also lead to scaling in pipes and appliances. The conductivity of water values in sample 1 is above the allowed value which is 753 µS/cm, while for the other samples the conductivity values are within the allowed limits, where samples 2 have the lowest conductivity values of about 7.36 µS/cm (Fig. 3). All analyzed samples have neither color nor smell.

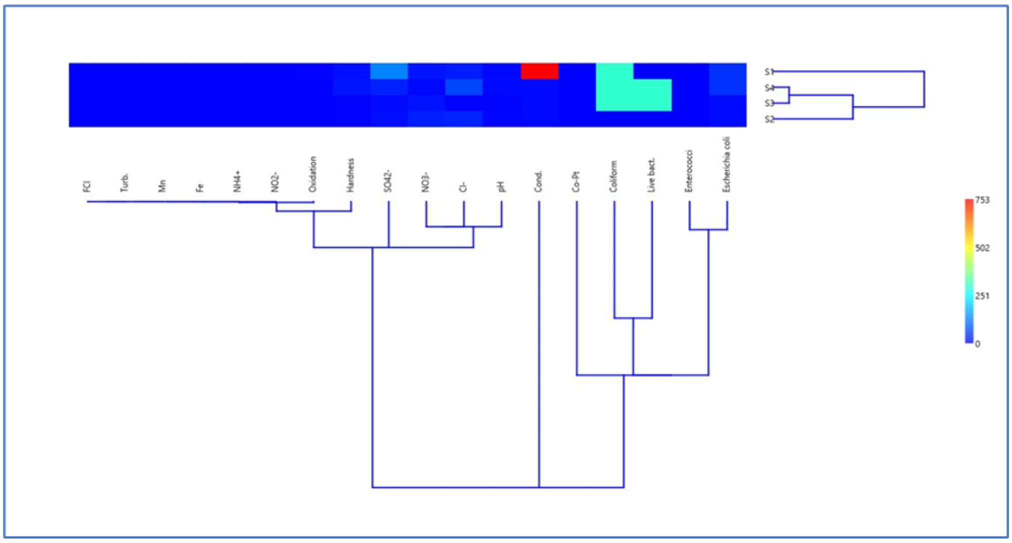

Fig. 2. Hierarchical clustering – Heat map between parameters and location.

Problems with the transmission of pathogenic *E. coli* from water have been documented from the use of water for recreation and from contaminated drinking water. Drinking water supplies are the source of contamination from rainwater runoff that contained cattle excrement. Therefore, conventional testing for total coliform bacteria and *E. coli* gives a good chance of detecting these indicator organisms of faecal contamination.

Based on the results of our analysis, it can be seen that *Escherichia coli*, as an indicator of water contaminated with feces, was found to be present in S1 and S4 with 50 cfu/ml; S3=10 cfu/ml while in the bacteriological aspect S2 had no presence of these bacteria. While on the other hand, it can be seen that sampling points S1 and S2 are within the required standard, while S3 and S4 have exceedances of the presence of coliform bacteria, the values are over 300 cfu/ml. Regarding live bacteria, it can be seen that have exceed the reference values in S3 and S4, while on the other hand point S2 is within the allowed limits and S4 the presence of live bacteria was not recorded. In all stations S1-S4, we did not have the presence of Enterococci bacteria, the results are comparable to authors such as (Wekesa & Otieno, 2022; WHO, 2019; Perveen & Haque, 2023) (Fig. 4).

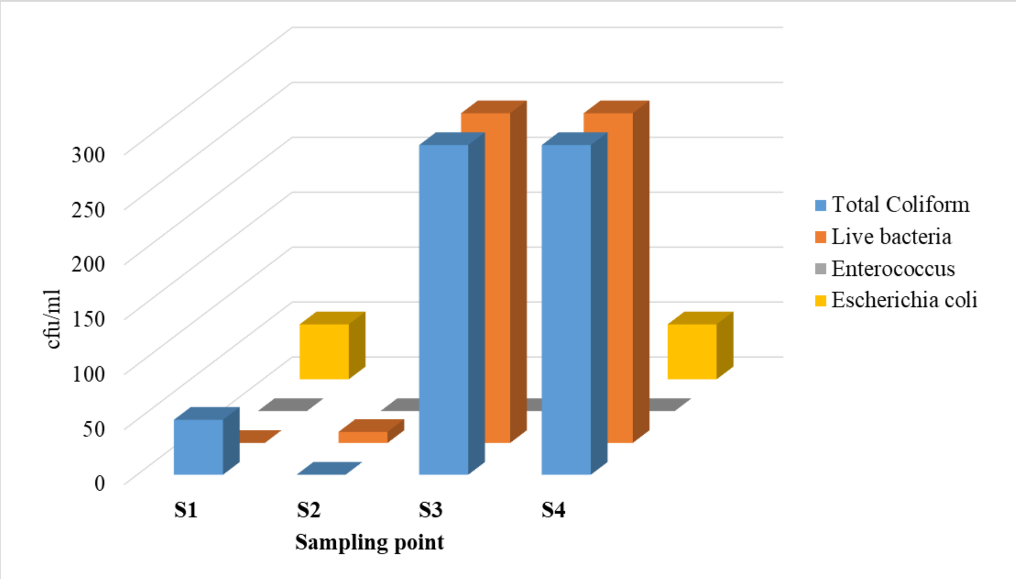

Fig. 3. Comparative results of microbiological parameters in water wells

Conclusions

The physicochemical and microbiological properties of water play a significant role in determining its quality, and it is essential to monitor them regularly. This study conducted on water samples taken on four different months in August and September 2022 revealed that the free chlorine level in all samples was 0, indicating that the water was not effectively disinfected against harmful microorganisms. However, the chloride levels were within acceptable norms, and the turbidity value in all samples was 0, indicating that the water was clear and free of suspended particles.

Regular testing of drinking water for manganese, iron, and ammonium levels is crucial to ensure that it is safe for consumption. The results show that the manganese levels are within acceptable limits, while the iron levels are higher than the permitted value. Therefore, regular testing and treatment of water are necessary to ensure that iron levels are kept within acceptable limits. Additionally, the ammonium values are within the permitted ranges, but high levels of ammonium can be toxic and cause health problems, and thus continuous monitoring is essential to prevent any adverse health effects.

The results of the water analysis indicate that most of the parameters tested are within the acceptable limits for safe drinking water. However, there are some areas of concern, particularly regarding iron and conductivity levels in sample 1. High levels of iron can promote the growth of bacteria in water systems, causing taste, odor, and color problems. Similarly, high conductivity levels can indicate the presence of pollutants or excessive levels of dissolved minerals, leading to scaling in pipes and appliances. These issues should be addressed to ensure that the water is safe and meets the required standards.

Based on the microbiological analysis, it can be seen that the waters of Prishtina's wells have a bacterial load. In station S3 and S4 we have excesses of coliform bacteria and live bacteria. While in S1, S2 and S3 we have excesses of *E. coli*. Stations S1, S2, S3 and S4 are free of bacterial load of Enteroccoci bacteria.

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