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Research of the Drinking Water Quality in Wells and Fountains of Villages in Gjakova Municipality in Kosovo

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Abstract

It is known that the issue of obtaining sufficient drinking water, this vital element without which there can be no life on earth, as in the past also today is and remains a serious concern for humanity in general. Therefore, the purpose of this paper is to study the drinking water quality in villages Hereç, Gërçinë and Damjan in Gjakova Municipality. Water was tested for organoleptic, physico-chemical, and microbiological parameters, and sensory methods and analytical techniques, classical and instrumental ones were aplied. The results of the analysis are compared with the standard values of the EU Directive 98/83 on the quality of water for human consumption. The obtained results prove that the drinking water is contaminated with Mn, with 0.059mg / l in the villages Herec, in Gercine 0.052mg / l and in Damjan with a concentration of 0.07mg / l. Meanwhile, we have encountered microbial contamination in two sampling sites in Gercine and in one sampling site in Damjan. Therefore, the evidence for the presence of Mn and microbial contamination, justify the aim of this work.

Keywords: Drinking waters, Gjakova villages, Analysis, Contamination, Manganese, Microbial contamination

1 Introduction

The issue of acquiring sufficient drinking water in many settlements in Kosovo, as in many other countries in the world, has been and remains the basic problem for organizing the life quality in the geographical space where humans wish to construct and organize their settlements. In this context, springs were largely responsible for determining the sites of ancient settlements (1). Water is the main natural resource and essential human need without which life on earth is unthinkable. Water is a major natural source and basic human need for life. In recent decades, groundwater has become an essential resource due to its purity and availability (2).

Lack of sufficient drinking water, both in the past and now, often, not only it has caused major demographic movements around the world, but there have also been cases of sporadic conflicts and major wars for controlling and owning sufficient water resources. Even today, in many Kosovo settlements, lack of water has created new demographic realities, as with the increase of population, insufficient water reservoirs have affected the population movement from one settlement to another, i.e. from Hasi region to Gjilan area, as well as in many other areas in Kosovo lacking water. Yet, springs are still an important groundwater source since they are easily accessible and usually provide clean drinking water (3). Dug wells are distributed all over the rural and semi urban areas, mostly as private wells associated with single family homesteads (4). Gjakova with its surrounding, our object of study, is located between geographic latitude 42022' and geographic longitude 20026', on the left shore of Erenik River, east of Çabrat Plateau, on both sides of Krena River, at an average altitude of 365 m. The average temperature in July is 21.50C, and in January -90C. Summer months are dry, and winters are wet. The average precipitation is 959.3 mm (5). The physico-chemical quality of drinking water is also based on hydrogeological criteria. These criteria relate to the type of water layer feeding, the composition and structure of the terrain, the level of protection of the water layer etc (6).

World Health Organization (WHO) 1993 documented that 80% of pathogenic diseases in human beings are caused by contaminated water and the valuation of water quality in developing countries has become a critical problem in last few years (7). The purpose of this study is to assess the water quality in villages Hereç, Gërçinë and Damjan of Gjakova Municipality, based on the physico-chemical and microbiological parameters, which justifies the drinking water quality.

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2 Material and methods

Samples for analysis were taken in three different villages of Gjakova Municipality, in December 2019, the analyzed water was taken from springs and wells in these villages and the analyses were done at the K.R.U. "Gjakova" JSC filtering station labs. The sampling points and labeling of drinking water samples from wells and springs together with the geographical coordinates of the water samples for analyses are presented in Table 1, whereas the geographic position of sample points (monitoring network) is presented in Figure 1.

Table 1: Sampling location, geographic code, and coordinates

Location	Location code	Sample code	Geographic coordinates Latitude	Longitude	Altitude (m)
Hereç	1	1 – 1k	42°28'27" N	20°21'43" E	508
		1 – 2k	42°27' 54" N	20°21'4" E	
		1 – 3p	42°28' 27" N	20°21'32" E	
		1 – 4p	42°27' 54" N	20°21'5" E	
Gërçinë	2	2 – 1k	42°17' 49" N	20°29'30" E	508
		2 – 2k	42°17' 47" N	20°29'25" E	
		2 – 3p	42°17' 46" N	20°29'22" E	
		2 – 4p	42°17' 48" N	20°29'24" E	
Damjan	3	3 – 1k	42°17' 40" N	20°30'58" E	346
		3 – 2k	42°17' 58" N	20°31' 6" E	
		3 – 3p	42°17' 57" N	20°31' 6" E	
		3 – 4p	42°17' 57" N	20°31' 1" E	

Explanation: samples marked with k are taken from springs, whereas, samples marked with p are taken from wells.

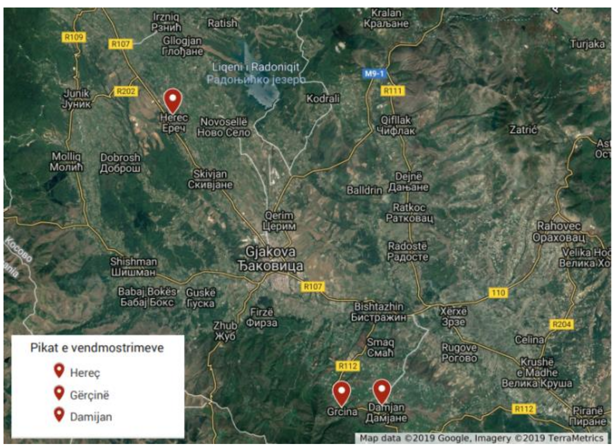

Figure 1: Monitoring network

Sampling is of special importance because it is causally related with the accuracy of the final results, therefore extra care should be taken while sampling. The mode of sampling, the amount of sample taken and the mode of transport and the maximum time that the sample can stay before chemical analysis is conducted, have been made in accordance with the method's ISO 5667: 1,3,11 (8-10). Their conservation was done in compliance with the conservation procedure of the American Public Health Association, 2005 (11).

During this research, the sensory method was applied to determine the organoleptic parameters such as: smell, taste, and color. Whereas, at the analysis lab the electrochemical method - pH value, electrical conductivity and dissolved O_2; nephelometric method - turbidity; spectrophotometric method - ammonia, nitrites, nitrates and Al; and volumetric (titrimetric) method - $KMnO_4$ expenditure, water hardness, free chlorine, Cl- and Ca chlorides were used to determine the physico-chemical parameters. The table results show the standard methods applied for the analysis of each parameter (Tables 2, 3 and 4). The microbiological analysis, determining the general number of live bacteria with PCA, was performed pursuant to the EN ISO 6222:1999 standard (12).

3 Results and discussions

During the experimenting part, the organoleptic, physico-chemical, and microbiological parameters of water from springs and wells in Hereç, Gërçinë and Damjan villages in Gjakova Municipality was determined. In total 12 samples of drinking water from wells and springs in these villages were taken. The results of the organoleptic, physico-chemical, and microbiological parameters are presented in Tables 2, 3 and 4, whereas, the microbiological parameters in Table 5.

Table 2: Analysis results of organoleptic and physico-chemical parameters of the water in village Hereç

Water analysis results: Hereç Analysis date: 07/12/2019				Sample code			
Parameters	Standard method	Unit	Direc. 98/83/EC	1-1k	1-2k	1-3p	1-4p
Color	Sensory method	-	None	None	None	None	None
Smell	Sensory method	-	None	None	None	None	None
Taste	Sensory method	-	None	None	None	None	None
Temperature	ISO 10523:2012	^0C	8-12	9	8	9	10
Turbidity	ISO 7027:1999	NTU	0-1	0.76	0.13	0.10	0.31
Free chloride Cl_2	ISO 73931:2000	mg/l	0.2-0.5	0.01	0.01	0.02	0.01
pH	ISO 10523:2008	-	6.5-9.5	7.0	6.9	6.6	6.6
$KMnO_4$ expenditure	ISO 8467:1993	mg/l	0-8	1.40	1.40	1.24	1.88
Conductivity	ISO 7888:1985	μS/cm	2500	324	319	133	358
Hardness	ISO 6059:1984	°dH	30	11.2	11.48	4.48	9.1
Cl^- chlorides	ISO 9297:1989	mg/l	250	10.95	10.56	8.58	11.54
Dissolved O_2	ISO 5814:2012	mg/l	>5	8.32	7.98	7.02	7.45
Ca	ISO 6059:1984	mg/l	200	30.26	25.05	15.03	30.46
NH_3	ISO 71505:1986	mg/l	0.5	0,010	0.05	0.05	0.05
NO_2^-	ISO 6777:1984	mg/l	0.5	0,003	0,002	0,002	0,010
Fe	ISO 6333:1986	mg/l	0.2	0.05	0.04	0.05	0.07
Mn	ISO 6333:1986	mg/l	0.05	0,028	0,022	0,022	0,059
PO_4^{3-}	EN ISO 6878:2004	mg/l	3.0	0.09	0.11	0.10	0.14

The results show the quality of drinking water in villages Hereç, Gërçinë and Damjan. The assessment of the water quality was performed based on referring values of Directive 98/83/EC (13) on the quality of water intended for human consumption, which is in correlation with Administrative Instruction 12/2016 of Kosovo (14) and WHO standards (15) on the quality of drinking water. In relation to the organoleptic and physico-chemical aspect, color, smell, and taste result with satisfactory levels pursuant to Directive 98/83/EC, excluding sample 3-4p, which contained a metallic smell and taste.

Table 3: Analysis results of organoleptic and physico-chemical parameters of the water in village Gërçinë.

Water analysis results: Gërçinë Analysis date: 07/12/2019				Sample code			
Parameters	Standard method	Unit	Direc. 98/83/EC	2-1k	2-2k	2-3p	2-4p
Color	Sensory method	-	None	None	None	None	None
Smell	Sensory method	-	None	None	None	None	None
Taste	Sensory method	-	None	None	None	None	None
Temperature	ISO 10523:2012	^{0}C	8-12	9	9	10	10
Turbidity	ISO 7027:1999	NTU	0-1	0.71	0.79	0.80	0.1
Free chloride Cl_2	ISO 73931:2000	mg/l	0.2-0.5	0.32	0.31	0.02	0.04
pH	ISO 10523:2008	-	6.5-9.5	7.6	7.3	7.0	7.1
$KMnO_4$ expenditure	ISO 8467:1993	mg/l	0-8	1.12	1.18	1.68	1.12
Conductivity	ISO 7888:1985	µS/cm	2500	197	203	820	763
Hardness	ISO 6059:1984	^{0}dH	30	6.3	7.2	19.1	18.3
Cl^- chlorides	ISO 9297:1989	mg/l	250	8.50	9.10	76.57	50.33
Dissolved O_2	ISO 5814:2012	mg/l	>5	8.71	8.32	5.32	6.02
Ca	ISO 6059:1984	mg/l	200	28.05	29.10	156.3	101.2
NH_3	ISO 71505:1986	mg/l	0.5	0.30	0.40	0.03	0.04
NO_2^-	ISO 6777:1984	mg/l	0.5	0.12	0.13	0.01	0.01
Fe	ISO 6333:1986	mg/l	0.2	0.05	0.06	0.18	0.17
Mn	ISO 6333:1986	mg/l	0.05	0.02	0.02	0,052	0.02
PO_4^{3-}	EN ISO 6878:2004	mg/l	3.0	0.05	0.05	0.06	0.06

When the pH is acidic and below pH 6.5, water can have a bitter, metallic taste. When the pH is more basic than pH 8.5, then water can have a slippery feel and soda taste (16), it also causes the reduction of the efficiency of hypochlorite treatment for the drinking water disinfection (17). pH levels let us understand that all values were within the permitted limits, although the water in village Hereç was more acidic, especially in wells with variations from 6.6 to 7, whereas, in village Damjan, in sample point 3-4p it resulted in 6.2 (presented in Figure 2). One of the important characteristics of the water system is temperature, because it impacts strongly in the content of the dissolved oxygen, in the activity of the water biotic and the speed of many chemical reactions (18). In all analyzed samples the temperature followed by permitted values at a relation of 8-10^0 C.

Table 4: Analysis results of organoleptic and physico-chemical parameters of the water in village Damjan

Water analysis results: Damjan Analysis date: 07/12/2019				Sample code			
Parameters	Standard method	Unit	Direc. 98/83/EC	3-1k	3-2k	3-3p	3-4p
Color	Sensory method	-	None	None	None	None	None
Smell	Sensory method	-	None	None	None	None	Metallic
Taste	Sensory method	-	None	None	None	None	None
Temperature	ISO 10523:2012	^{0}C	8-12	9	9	10	9
Turbidity	ISO 7027:1999	NTU	0-1	0.62	0.89	0.11	1.43
Free chloride Cl_2	ISO 73931:2000	mg/l	0.2-0.5	0.3	0.3	0.05	0.06
pH	ISO 10523:2008	-	6.5-9.5	7.4	7.3	6.9	6.2
$KMnO_4$ expenditure	ISO 8467:1993	mg/l	0-8	1.28	1.42	1.29	1.92
Conductivity	ISO 7888:1985	µS/cm	2500	399	406	327	262
Hardness	ISO 6059:1984	^{0}dH	30	11.88	11.02	9.52	5.60
Cl^- chlorides	ISO 9297:1989	mg/l	250	10.63	10.58	11.34	17.72
Dissolved O_2	ISO 5814:2012	mg/l	>5	7.82	7.90	6.44	6.80
Ca	ISO 6059:1984	mg/l	200	58.11	54.20	44.08	23.04
NH_3	ISO 71505:1986	mg/l	0.5	0,010	0,010	0.09	0,015
NO_2^-	ISO 6777:1984	mg/l	0.5	0,004	0,004	0,003	0,005
Fe	ISO 6333:1986	mg/l	0.2	0.05	0.05	0.05	0.06
Mn	ISO 6333:1986	mg/l	0.05	0,047	0,032	0,010	0.07
PO_4^{3-}	EN ISO 6878:2004	mg/l	3.0	0.05	0.05	0.12	0.26

Table 5: Microbiological analysis results of water in villages Hereç, Gërçinë and Damjan.

Sample	otal number of living bacteria in 1ml at 37°C, cfu/ml according to ISO 6222:1999	resence/absence of coliforms
1-1k	$1.1x10^2$	Negative
1-2k	90	Negative
1-3p	$3.8x10^2$	Negative
1-4p	$3.5x10^2$	Negative
2-1k	60	Negative
2-2k	80	Negative
2-3p	$6.5x10^2$	Positive
2-4p	$7.1x10^2$	Positive
3-1k	80	Negative
3-2k	70	Negative
3-3p	$6.8x10^2$	Negative
3-4p	$1x10^3$	Positive

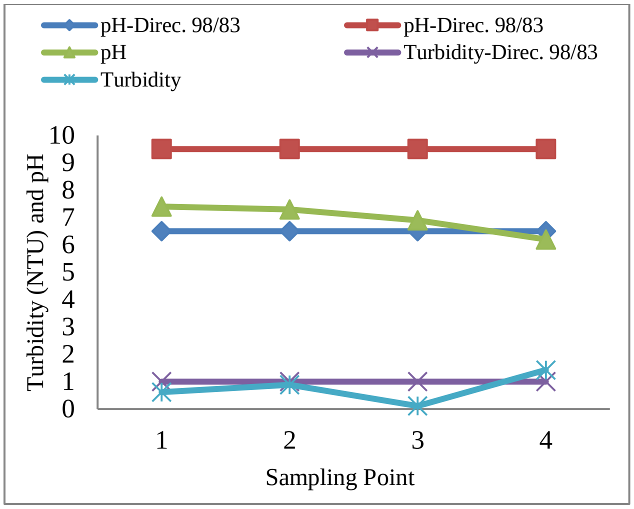

Figure 2: Turbidity and pH

With the exception of the sample 3-4p, where an increased value than the allowable level of 1.43 NTU was encountered, turbulence in other sampling sites resulted within the reference values. In general, the water of wells had lower turbidity than springs (presented in Figure 2). The situation with the free chlorine (Cl_2) in village Hereç results with low levels, both in spring water and in wells, because the water there is not treated with chlorine. Whereas, in Gërçinë and Damjan the amount of free chlorine results to be compatible with the referring values, because in comparison to well waters, the water in these springs is monitored by K.R.U. "Gjakova", namely it is treated with chlorine. Chlorine is not dangerous to humans in low concentration levels but, in high concentration levels it causes cardiovascular problems and it gives a bitter taste to the water (19). $KMnO_4$ expenditure has been in correlation with the values foreseen pursuant to Directive 98/83/EC. Electrical conductivity reflects the ability of an aqueous to conduct electrical current that depends on the presence and total concentration of ions, their mobility and valance and on the temperature (20). In relation to conductivity, the samples have shown relatively low levels, excluding the water from wells in Gërçinë village, where it has resulted with higher levels at the value of 820μS/cm at sample point 2-3p, but without exceeding the referring values.

The water hardness usually goes in correlation with conductivity, therefore, the hardness as also resulted with a presence of higher values in the wells of village Gërçinë, but in compliance with the referring values. Hardness varies substantially with the presence of limestone and dolomite in the local geology (21). There are data that drinking hard water has a positive effect on cardiovascular diseases (22). Chlorides (Cl-) in water samples were within the permitted values pursuant to EU standards (1998). Chloride, Cl- occurs naturally in fresh, estuarine, or salt water from dissolution of rocks and minerals. In freshwater, its concentration is commonly less than 10 mg/l (23).

Dissolved oxygen (DO) in our research results within referring values. DO is the most important water quality variable determining the health status of an aquatic ecosystem (24). Even the presence of calcium (Ca) results within the referring values. Calcium is an essential element for our organism and our needs for it are 0.7 up to 2 g/per day. Calcium plays important roles in bone structure, heart function, muscle contraction, nerve impulse transmission and blood clotting, while calcium deficiency can cause osteoporosis (22). In all the analyzed samples ammonia (NH_3) followed the permitted values pursuant to EU standards (1998). Ammonia (NH_4^+), in the environment originates from metabolic, agricultural, and industrial processes and from disinfection with chloramines. Ammonia in drinking-water is not of immediate health relevance, and therefore no health-based guideline value is proposed (25).

In the analyzed samples in this paper the maximum value of nitrites (NO_2^-) at 0.13 mg/l was encountered at sample point 2-2k, which is within the acceptable limits. Nitrites are present in groundwater due to the spread of bacteria from faecal contamination, agricultural production, poor sewage network, presence of animal stalls near water well (26). The concentration of iron (Fe) in water samples of Gërçinë village, at sample point 2-3p results at 0.18mg/l, and at point 2-4p at 0.17mg/l thus getting close to the permitted limits at 0.2mg/l. Iron is essential element for good health because it transports oxygen in blood. The shortage of iron causes disease called anaemia and prolonged consumption of drinking water with high concentration of iron may lead to liver disease called as haermosiderosis (27). Manganese usually occurs together with iron and is widely distributed in soil, sedimentary rocks, and water. Manganese is an element essential to the proper functioning of both humans and animals, as it is required for the functioning of many cellular enzymes (28). In comparison to Fe, the concentration of manganese (Mn) in the analyzed waters of these villages results to be present above the referring values. While the referring value for manganese is 0.05 mg/l, in Hereç village sample point 1-4p the referring value for this metal is exceeded at 0.059 mg/l; in Gërçinë village sample point 2-3p at 0.052 mg/l and in Damjan village sample point 3-4p has a more significant excess at 0.07 mg/l (presented in Figure 3).

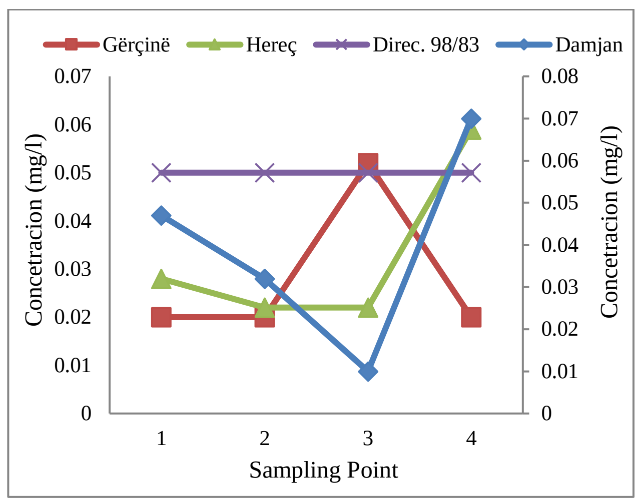

Figure 3: Mn concentration

The presence of phosphates (PO_4^{3-}) in the analyzed samples of water varied between 0.05-0.26 mg/l, namely they are within the permitted values. According to McCutheon et al, higher concentration of phosphate in water than 0.1 mg/L is an indication of pollution (29). In the microbiological sense the water of Gërçinë village wells, in sample points 2-3p and 2-4p, and in

Damjan sample point 3-4p, have shown unsatisfactory results, because there is microbiological pollution, as we have also encountered the presence of coliforms. Therefore, drinking water can be contaminated with these pathogenic bacteria and this is an issue of great concern (7). In our opinion, this is a result of the failure to observe protective sanitary measures, because in the vicinity of water wells were animal stables, poor sewerage networks, toilets, etc. According to Conboy & Goss the well type, depth and the grounds hydrological group have proven to be important in determining the bacterial pollution (30).

4 Conclusions

During the research work in this paper samples were taken from three different villages: Hereç, Gërçinë and Damjan Gjakova Municipality. We have analyzed the organoleptic, physico-chemical, and microbiological parameters. After the analyses we have compared the results with the permitted values pursuant to Directive 98/83/EC and we have reached the following conclusions:

The water in two wells in village Damjan is not suitable for consumption, because sample 3- 4p shows high manganese levels as well as high NTU values and as such they cause microbiological pollution, which is also proven by the microbiological analysis. The microbiological analysis has yielded positive results on the presence of coliforms and the presence of the later shows the potential presence of pathogenic organisms, which is why the water is considered unsuitable for drinking. We have a similar situation with samples 2-3p and 2-4p of the water from the well in Gërçinë village, wherein we noticed microbial pollution, whereas, sample 2-3p in addition to the microbial pollution also shows manganese presence above the permitted levels. Also, in village Hereç, in sample point 1-4p we have encountered the excess of referring manganese values. In relation to the other water samples, they are all at satisfactory levels as they are within the permitted limits pursuant to Directive 98/83/EC. Based on this conclusion we recommend that both wells in Gërçinë village and the well with the code 3-4p in Damjan village are disinfected and in the meantime the inhabitants are instructed to not use the water for drinking. Therefore, it is up to the responsible institutions in the future to search for the causes of manganese and coliform bacteria pollution, in order to undertake the preventive measures for their rehabilitation and repairing.

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Ethical issue

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Authors’ contribution

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing

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