PHYSICO-CHEMICAL AND BACTERIOLOGICAL EVALUATION FROM GROUNDWATERS OF PUKA CITY

Nevila Bushati[1,2,*], Anila Neziri[2], Arlind Mustafa[3]

[1]University of Shkodra, Faculty of Natural Sciences, Water Research for Shkodra Region, Albania;*
[2]University of Shkodra, Faculty of Natural Sciences, Department of Biology-Chemistry, Albania;*
[3]Health Care Service Operator, Environmental Health Specialist, Pukë, Albania;

[*]Corresponding Author Nevila Bushati, e-mail: nevila.bushati@unishk.edu.al;

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ABSTRACT

The municipality of Puka in Albania has rich underground aquifers and results in many sites with natural water resources meeting water needs. According to data available from the General Directorate of Water Supply and Sewerage in 2015, out of 5,724 urban residents Puka Municipality, only 2747 were connected to the water supply network (1,105 connections), while in rural areas, out of about 12,000 inhabitants, only 2,350 were connected to the network (523 connections), the rest of the population use artisanal wells and drilling. The main purpose of this paper was to evaluate the quality of wells and drilling waters based on physico-chemical and microbiological parameters. In terms of physico-chemical results, pH, ammonia, nitrate, nitrite, organic matter, calcium, magnesium, total hardness, chlorides, bicarbonates and silicon have resulted in low levels, within the norms allowed by national and international standards. Water samples from drilling and wells were collected according to European recommendations and WHO legislation. The level of bacterial contamination was higher in summer months compared to other months. Drinking water results higher polluted in the second period of sampling July-August 2019. Bacteriological results show that during the period April-May, there was a lower bacterial loading on the wells in the drinking water from wells and drilling waters with *Escherichia coli* and *Streptococcus faecalis.*

Key words: wells, drillings, ph, ammonia, nitrates, nitrites, organic matter, calcium, bicarbonates, Escherichia coli, Streptococcus faecalis etc.

INTRODUCTION

Puka is a small Municipality in Albania, with about 5,600 inhabitants. Puka Municipality is the center of the Puka District Prefecture in Albania. Puka is located in a rugged mountainous terrain in the northwestern part of Albania. Puka district is bordered with Tropoja and Has to the north, with Kukës to the east, with Mirdita to the south and with Lezha and Shkodra to the west. Groundwater is relatively abundant in Albania and well distributed over the country. Groundwater resources are Albania's major source of drinking water, 70% of the main cities are supplied by wells (Final Report, 2007). Groundwater represents an important source of drinking water and its quality is currently threatened by a combination of bacteriological and chemical contamination (Pedley, S. and Howard, G. 1997). The water supply network of the Municipality of Puka limits only a part of the Municipality, which serves

only for urban areas. Water supply for all users and activities are done from groundwaters and not by surface waters (lakes, rivers). In particular, in Puka city there exist two water reservoirs and an extensive network, which does not cover the daily needs of the inhabitants and one part of it is very old (SDC, 2008). Regarding the outflows from the water supply system (which are estimated to be the same as the inflows), there is no forecast for their processing and are usually discharged uncontrollably as part of the sewage network in rivers, lakes, etc. In general, detailed data on water demand and consumption for all different categories of users are missing, both in terms of organized networks and private drilling (Mustafa, 2019). There is also a water network in the settlements of the administrative units of Gjegjan, Kçirë and Qelëz. Contamination of a private well can affect not only the residents of the house, but also the immediate families using the same catchment or aquifer. The well water can be contaminated in two ways: 1) the aquifer from which the water is drawn is polluted or 2) the contaminated surface water enters the well (Bakalli M. 2013). Ground water is not 100 percent pure water. Because it collects in the tiny pore spaces within sediments and in the fractures within bedrock, ground water always contains some dissolved minerals (www.water and health.org). *Escherichia coli* and *Streptococcus faecalis* provide clear evidence of fecal contamination. In most communities, the main risk to human health stems from faecal contamination (WHO, 1997).

MATERIAL AND METHODS

The study for bacteriological and physico-chemical parameters was conducted in Puka municipality with samples taken from water supply, drilling and wells waters. Sampling procedure for drinking waters was done in accordance with standard methods (STASH 2639:1989) for the examination of drinking water, (APHA 1998, 2001) for its quality (WHO 1986, 1996). Water samples for physico-chemical and bacteriological analysis were taken through sterile bottles in 10 points of Puka Municipality from watersupply, wells and drilling waters. The water was taken directly from the wells in bottles from 250 mL. (STASH 2639:1989; ISO, 7393/2:1995) were obtained in glass bottles according to the preservation method of samples for chemical analysis of nitrates and ammonia suitable for strong chemical compound (Çullaj, 2005). In this study are analyzed some physico-chemical indicators of drinking water such as; *temperature, pH, nitrates, nitrite, ammonia, calcium, magnesium, total hardness, bicarbonate, carbonate, chloride, silica and organic matter*. Water quality assessment for physico-chemical parameters was performed in accordance with Albanian standards (STASH 3904:1997 and EPA recommendations. European recommendations and WHO (World Health Organization) helped in a standard bacteriological analysis, ISO 8199, (1987); ISO 8199, (1988); ISO 5667-2, (1995). The presence of *Escherichia coli* in different water samples was determined by MPN method. A 10 mL of sample was inoculated into three tubes each consisting of double strengths tubes, 1mL was put into the first three single – strength tubes, and 0.1 mL sample into each of the other three tubes, all containing lactose broth medium. The tubes were incubated at 44°C for 24–48 h. In addition, gas accumulation in Durham tubes was observed and the Most Probable Number was determined by means of MPN index. Standard Methods for the Examination of Water and Wastewater 20th Edition and ISO 9308-1, recommended use of membrane filtration method, where incubation temperature is 44ºC and incubation time 48 hours. An appropriate volume of a water sample (100 mL water) was filtered through a 0.45-µm pore size nitrocellulose membrane filter that retains the bacteria present in the sample and was than transfered in *Slanetz-Bartley Agar* plates.

Table 1. Geographical Coordinates of Sampling Stations.

Nr	Sampling stations	Geographical coordinates
1	Neighborhood "Zezaj"	42.04601,19.90597
2	Memaj "Rrapë"	42.04263,19.94408
3	Center "Rrapë"	42.04411, 19.96801
4	Neighborhood "Qarret"	42.05377, 19.83713
5	Memaj	42.03964, 19.9458
6	Neighborhood "Lacaj"	42.04031, 19.89478
7	Entrance of Puka city	42.04714, 19.89072
8	Neighborhood "Shkjau" Qarret	42.0517, 19.83628
9	Qarret	42.05372, 19.83715
10	Rrapë	42.04599, 19.96753

RESULTS AND DISCUSSION

During the investigations done for the period April-May 2019, the boreholes with numbers 1, 2, 4 and 8 resulted with higher levels of ammonia and carbonates (table. nr.2), as well as in the period of July-August 2019 the points 1,2,3,4 and 8 of the boreholes were over the permitted norms (table. nr.2). Meanwhile the values of physico-chemical indicators of water supply deposits resulted within the allowed norms according the standards in both periods (April-May and July-August 2019). The value of pH, ammonia, nitrates and nitrite, organic matter, calcium, magnesium, total hardness, chlorides, bicarbonates and silicon can all be achieved at the appropriate level, within the standards allowed by standards and more. At the period April-May, the values of ammonia and carbonates at points 1,2,4 and 8 of the wells were outside the permitted normal range, while at the period of July-August the values of ammonia and carbonates at points 1,2, The wells 3,4 and 8 limit the normal permitted (table. nr.2). The values of the physico-chemical indicators of water supply depots result within the norms allowed by the standards in both periods (April-May, July-August), (table. nr.2). Bacteriological results show that during the months April-May 2019 there was a bacteriological loading in the drinking waters at wells points 1, 2, 4 and 8 (table. nr.3). Bacteriological loading for *Escherichia coli* varied from 10-16 CFU/100 mL water, meanwhile the bacteriological loading for *Streptococcus faecalis* varied from 8-16 CFU/100 mL water (table. nr.3). During the months July-August 2019, there was identified bacteriological loading in wells and drilling waters at the points 1,2,3,4 and 8, the bacteriological loading for *Escherichia coli* varied from 8-18 CFU/100 mL and the values for *Streptococcus faecalis* varied from 8-24 CFU/100 mL (table. nr.3). The level of bacteriological loading results higher in summer months compared to the other months of the year. From the comparison of the two periods April-May and July-August, the drinking water results with higher bacteriological loading at the second period July-August. During April-May and July-August drinking water results clear at all points. Statistical processing was conducted by Minitab 17 Statistical program. The results of our study are presented with histograms and probability plot. The figure nr.1 represents histogram for bacteriological results of wells-drilling waters for the period April-May 2019. The standard deviation for *Escherichia coli* was around 7.543 and the mean values was 5.7 and the p-value results <0.005, figure.nr.1. The standard deviation for *Streptococcus faecalis* was around 8.262 and the mean values was 5.6 and the p-value results <0.005, figure.nr.1. The figure nr.2 represents histogram for bacteriological results of wells-drilling waters for the period July-August 2019. The standard deviation for *Escherichia coli* was around 7.997 and the mean values was 7.2 and the p-value results <0.005, figure.nr.2. The standard deviation for *Streptococcus faecalis* was around 8.954 and the mean values was 7.2 and the p-value results 0.017, figure 2.

Table 2. Physico-chemical results of wells-drilling waters for the period April-May 2019.

Points	Temp	pH	Ammonia (NH_4^-)	Nitrite (NO_2^-)	Nitrate (NO_3^-)	Organic matter	Chlorure (Cl^-)	Calcium (Ca_2^+)	Magnesium (Mg_2^+)	Total hardness (°GJ)	Bicarbonates (HCO_3)	Carbonates (CO_3)	Silica (SiO_2)
1	7°	6.5	Trace	0	20	-	-	35	12.8	5.6 °GJ	201	3	0
2	7°	7	Trace	0	25.1	-	-	9	9.7	3.5 °GJ	152	3	0
3	6°	5	0	0	22.3	-	-	22	11.3	4.06 °GJ	231.8	3	0
4	6°	7	Trace	0	19.6	-	-	9.4	10.2	3.5 °GJ	152	3	0
5	6°	6.5	0	0	11.4	-	-	16	6.5	2.66 °GJ	140.3	0	0
6	7°	5.5	0	0	10.8	1.12	23	15	7.9	3.92 °GJ	109.8	0	0
7	7°	7	0	0	14.8	-	26	-	-	-	231.8	0	0
8	6°	6	Trace	0	21.5	-	23	-	-	-	103.7	6	0
9	7°	6.5	0	0	10.7	1.84	-	-	-	-	-	0	0
10	7°	5.5	0	0	12.5	-	-	26	11.4	4.48 °GJ	250.1	0	0

Table 3. Bacteriological results of wells-drilling waters for the period April-May 2019.

Nr	Bacterial index	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Norms	Methods of analyses
1	*Escherichia coli* CFU/100 mL	16	16	0	10	0	0	0	15	0	0	0/100ml water	ISO9308-3:2003
2	*Streptococcus faecalis* CFU/100 mL	8	20	0	8	0	0	0	20	0	0	0/100ml water	ISO 7899-2:2000

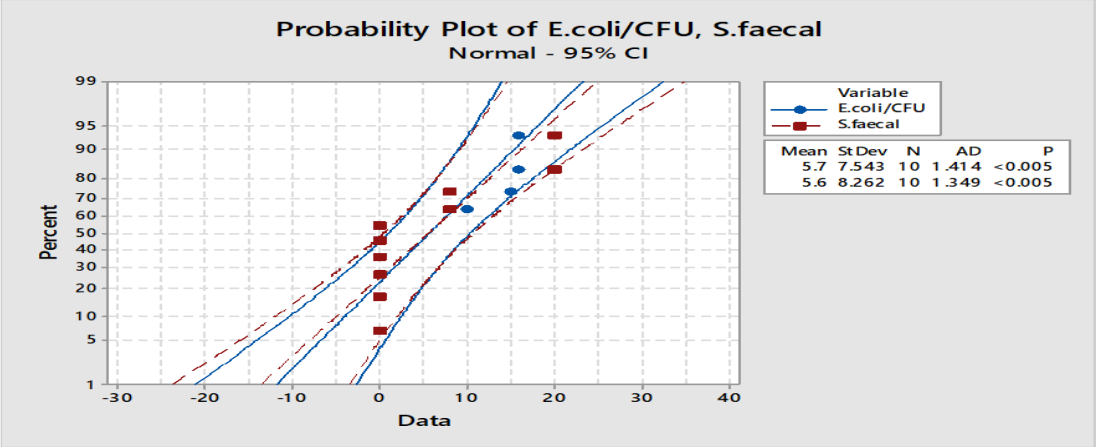

Figure 1. Histogram for bacteriological results of wells-drilling waters for the period April-May 2019.

Table 4. Physico-chemical results of wells-drilling waters for the period July-August 2019.

Point	Temp	pH	Ammonia (NH_4^-)	Nitrite (NO_2^-)	Nitrate (NO_3^-)	Organic matter	Chlorure (Cl^-)	Calcium (Ca_2^+)	Magnesium (Mg_2^+)	Total hardness (°GJ)	Bicarbonates (HCO_3)	Carbonates (CO_3)	Silica (SiO_2)
1	14°	6.9	Trace	0	26	-	-	23	5.5	4.48 °GJ	-	3	0
2	12°	6.9	Trace	0	27.3	-	-	25	3.04	2.8 °GJ	-	3	0
3	11°	6.8	Trace	0	25.3	-	-	16	6.5	2.66 °GJ	-	3	0
4	12°	7.1	Trace	0	20.7	-	-	18	10.3	3.5 °GJ	-	6	0
5	12°	6.5	0	0	13.4	-	-	15	6.4	2.66 °GJ	-	0	0
6	13°	6.8	0	0	12.9	-	-	15	8.8	3.92 °GJ	-	0	0
7	11.5°	7	0	0	14.8	-	-	-	-	-	-	0	0
8	11°	6.8	Trace	0	21.5	-	-	-	-	-	-	3	0
9	11°	6.5	0	0	10.7	-	-	-	-	-	-	0	0
10	10°	6.9	0	0	12.5	-	-	-	-	-	-	0	0

Table 5. Bacteriological results of wells-drilling waters for the period July-August 2019.

Nr	Bacterial index	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Norms	Methods of analyses
1	*Escherichia coli* CFU/100 mL	18	16	8	15	0	0	0	15	0	0	0/100ml water	ISO9308-3:2003
2	*Streptococcus faecalis* CFU/100 mL	8	24	10	10	0	0	0	20	0	0	0/100ml water	ISO 7899-2:2000

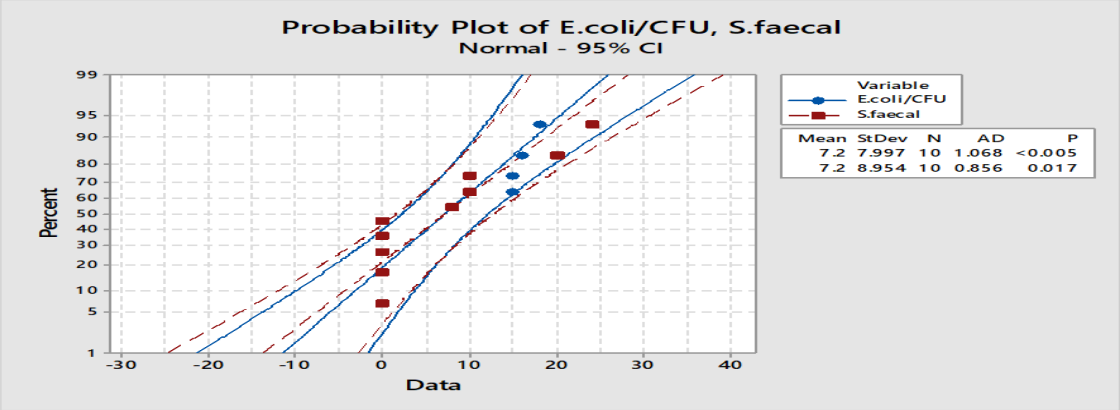

Figure 2. Histogram for bacteriological results of wells-drilling waters for the period July-August 2019.

Table 6. Physico-chemical results of water supply for the period April-May 2019.

Points	Temp	pH	Ammonia (NH_4^-)	Nitrite (NO_2^-)	Nitrate (NO_3^-)	Organic matter	Chlorure (Cl^-)	Calcium (Ca_2^+)	Magnesium (Mg_2^+)	Total hardness (°GJ)	Bicarbonates (HCO_3)	Carbonates (CO_3)	Silica (SiO_2)
1	11°	6.5	0	0	9.1	0.65	5.5	8.2	10.3	3.9 °GJ	-	0	0
2	11°	6.5	0	0	10.2	0.27	-	8	3.04	1.82°GJ	-	0	0
3	12°	6.8	0	0	9.9	0.44	9.6	7.1	10.2	3.9 °GJ	-	0	0
4	12°	6.8	0	0	9.4	0.44	12.4	7.1	10.4	3.8 °GJ	-	0	0
5	12°	6.7	0	0	11.2	0.88	4.6	7.3	8,4	3.9 °GJ	-	0	0
6	6.5°	6.5	0	0	8.5	0.41	5.7	5,9	7.9	3.8 °GJ	-	0	0
7	6.5°	6.5	0	0	8.8	0.43	8	4	12.6	3.36°GJ	-	0	0
8	13.5°	6,5	0	0	12.5	0.45	10	6.2	9.1	3.8 °GJ	-	0	0
9	7°	7.1	0	0	11.2	-	10	6.2	9.4	3.8 °GJ	-	0	0
10	9°	6,5	0	0	14.8	-	-	6.9	9.4	3.9 °GJ	-	0	0

Table 7. Bacteriological results of water supply for the period April-May 2019.

Nr	Bacterial index	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Norms	Methods of analyses
1	*Escherichia coli* CFU/100 mL	0	0	0	0	0	0	0	0	0	0	0/100ml water	ISO9308-3:2003
2	*Streptococcus faecalis* CFU/100 mL	0	0	0	0	0	0	0	0	0	0	0/100ml water	ISO 7899-2:2000

Table 8. Physico-chemical results of water supply for the period July-August 2019.

Points	Temp	pH	Ammonia (NH_4^-)	Nitrite (NO_2^-)	Nitrate (NO_3^-)	Organic matter	Chlorure (Cl^-)	Calcium (Ca_2^+)	Magnesium (Mg_2^+)	Total hardness (°GJ)	Bicarbonates (HCO_3)	Carbonates (CO_3)	Silica (SiO_2)
1	15°	7.2	0	0	8.9	0.44	7.9	5.9	18.8	3.8 °GJ	110.2	0	0
2	13.5°	7.2	0	0	8.8	0.48	-	9	9.7	3.5 °GJ	85.4	0	0
3	15°	7,2	0	0	10.9	0.96	23	4	17	4.48 °GJ	152.5	0	0
4	15°	7.2	0	0	10.4	0.48	23	3	16.4	4.2 °GJ	152	0	0
5	15°	7.2	0	0	12.8	1.12	26.6	4	16.8	4.34 °GJ	176.9	0	0
6	8°	6.5	0	0	8.5	0.48	19.5	3	5	1.54 °GJ	85.4	0	0
7	8°	6.5	0	0	7.3	0.64	12.4	7	11	3.5 °GJ	146.4	0	0
8	15.5°	7.2	0	0	13.7	-	23	6	15	4.2 °GJ	170.8	0	0
9	-	7.2	0	0	9.1	1.27	16	11	5.5	2.8 °GJ	128.8	0	0
10	11°	7.2	0	0	11.8	1.36	-	23	8.5	5.18 °GJ	-	0	0

Table 9. Bacteriological results of water supply for the period July-August 2019.

Nr	Bacterial index	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Norms	Methods of analyses
1	*Escherichia coli* CFU/100 mL	0	0	0	0	0	0	0	0	0	0	0/100ml water	ISO9308-3:2003
2	*Streptococcus faecalis* CFU/100 mL	0	0	0	0	0	0	0	0	0	0	0/100ml water	ISO 7899-2:2000

CONCLUSIONS

- The bacteriological and physico-chemical data aims providing some assessment to water quality of Puka Municipality. The level of bacteriological loading was higher in second period of water sampling for well and drilling waters. From the comparison of two periods April-May and July-August, the water from wells and drilling water result with higher loading at the second period July-August. Meanwhile the quality of watersupply was very good. No samples resulted with bacteriological loading in water resorvoir.
- Inhabitants of Puka municipality that use wells and drilling waters as their source of water should be educated of the possible risks of wells and drilling waters that are used for human consumption. The private houses which mainly use wells and drilling waters should be disinfected with chlorine and analysed every time that they suspect for the presence of bacteria. According to 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. *The main requirement concerning the quality of water for public use* is that they must be "healthy" to use.

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