DRINKING WATER QUALITY IN RURAL REGIONS OF DIFFERENT HYDROGRAPHIC AREAS

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ABSTRACT: Drinking water quality in rural regions of different hydrographic areas
Drinking water researches were conducted in rural regions of different hydrographic areas. In regions of Lijevče polje population mainly use for drinking water from the wells and water pumps, while in Eastern Herzegovina use water from springs and by capping groundwater. Water analysis form chosen locality was conducted four times during a year by season aspects on chosen springs. Results show that the water Vrijeka spring (Eastern Herzegovina) satisfies basic physicochemical and microbiological criteria for water that is used for drinking. Water from the well in village Berek (Lijevče) is not safe for the health because it is slightly acidic, muddy and has increased concentration of orthophosphates and suspended substances, while the water on the Trošelji locality correspond to the drinking water, by monitored criteria.

Key words: water quality, physicochemical, microbiological

INTRODUCTION

In rural regions of Lijevče polje is not installed water supply network so the local population mainly use for drinking water from the well and water pumps due to the existence of underground aquifers. Since it is a region where intensive agriculture is presented and where they use different fertilizers and pesticides, and the fact that there is not developed sewage system but beside the houses there are cesspools that gradually outflow in surrounding grounds, there is a real danger that undesirable substances, by surface waters, reach underground water that local population use for water supply. Population in rural areas in Eastern Herzegovina use for drinking water mainly from spring and by capping underground water, whose level significantly varies throughout the year. For this area is characteristic that in autumn and winter period heavy precipitation in significant rate raise water level causing flooding of entire fields, while in summer period appears drought, the water level is increasing and small springs and water flows dry up totally.

MATERIAL AND METHODS

For analyzing drinking water in rural regions of Lijevče polje are chosen the well in Berek village and water pump in Trošelji village. In the area of Eastern Herzegovina is conducted the analysis of water quality from the spring of the river Vrijeka which is used for water supply by local population. Taking the samples for physicochemical and microbiological analysis is conducted four times in a year. In area of Lijevče polje samples were collected once in April, June, September and November 2010., and in Eastern Herzegovina were collected in March, July and September 2010 and in January 2011. Water samples are collected in sterile dishes in aseptic terms by prescribed procedure (KARAKAŠEVIĆ, 1967; ŠKUNCA-MILANOVIĆ et al., 1990). On the spot were determined water and air temperature, pH values, electroconductivity, concentration of dissolved oxygen, oxygen saturation, turbidity i flow (Dalmacija, 2000). Through plankton net is filtered by 100 liters water for determining presence of algae. Then, samples are transported on ice on temperature of +4°C. Chemical analysis of water was conducted within 12 hours from the moment collecting, and seeding for microbiological analysis is conducted within 24 h. Using spectrophotometer HACH DR2800 concentrations of dissolved ammonia, nitrates, nitrites, orthophosphates, sulfates, iron and manganese are determined, so as total suspended substances. Concentration of ammonia was determined using Nessler reagent. Nitrites were determined using method with sulfanilic acid, nitrates by reduction of cadmium, and sulfates are determined using barium chromate reagent. For determination of orthophosphates is used method with ascorbic acid, for determination of manganese concentration is used PAN method, and for iron is used method with fenantrolin. Total suspended substances are determined photometrically. Number of individual group of bacteria is determined by indirect breeding methods (HRIBAR, 1978; MCKANE et al., 1996; PETROVIĆ et al., 1998; ŠKUNCA-MILANOVIĆ et al., 1990). Determination of total bacteria count is conducted on substrate for total count after 5 days incubation at temperature 22-26°C. Psihrophilic heterotrophs were determined on agar after 72 hours incubation at 22°C., while mesophilic heterotrophs were determined on the same substrate after 48 hours incubation at 37°C. Facultative oligotrophs were determined on ten times diluted agar after incubation at 26°C lasting 7 days. Total coliphorms was determined using method of most likely number after 48 hour of incubation at temperature of 37°C on McConkey substrate. Confirmatory test for fecal coliphorms was done on endo-agar substrate after incubation of 48 hour at 44°, as well as on McConkey substrate after 48 hours of incubation at 44°C. For determination of presence of *Pseudomonas aeruginosa* cetrimide agar is used. Presence of genus *Salmonella* i *Shigella* was determined on SS agar substrate, while for isolation of *Clostridium* species were used chromogenic substrate for clostridium isolation and TSN agar. Enterococcus species were isolated on Simons-citrate agar and azide dekstroze agar (APHA-AWWA-WPCF, 1998), and for Streptococcus species is used Slanetz-Bartley agar. For determination of algae presence in water microscope Leica DM1000 is used.

RESULTS

Well is Berek village is located on 45˚02'33" North, 17˚13'76" East and it has an altitude of 114 m. The highest water temperature was measured in July and was 17.2° (*Tab.1*). In September in water was recorded a low concentration of dissolved oxygen,

only 5.15 mgO_2/l which corresponds oxygen saturation of 54% and it is near lower limit that is recomended for drinking water. In all samples water was slightly acidic. Just in November pH value 6.8 was recorded which represents lower limit for drinking water, while in other samples pH values was under allowed limit. Acidic waters are often corrosive and can cause dissolution of copper and lead from water pipes which then reach drinking water and give it metal taste (Dalmacija et al., 2004). Values of electroconductivity were very high in every tested sample that indicates higher ion concentration in water which can be consequence of its low pH value. In April were recorded high values of turbidity (13.61 NTU) and concentration of suspended substances (6 mg/l), while in June, September and November values of both of this parameters were in normal range

Table 1. Physicochemical characteristics of water from the Berek well

	21.04.2010	9.6.2010	28.9.2010	16.11.2010
air temperature (˚C)	18	25	18	15
water temperature (˚C)	15.2	17.2	17.1	13.7
concentration of dissolved O_2 (mg/l)	-	6.83	5.15	6.28
saturation (%)	-	70.4	54.0	61.5
pH	6.45	6.53	6.75	6.80
electroconductivity (µS/cm)	695	709	745	702
turbidity (NTU)	13.61	1.01	0.56	0.47
ammonium nitrogen (mg/l)	0.01	0.07	0.02	0.02
nitrate nitrogen (mg/l)	3.2	0.5	2.1	2.7
nitrite nitrogen (mg/l)	0.003	0.002	0.005	0.000
sulfates (mg/l)	37	33	38	30
orthophosphates (mg/l)	0.17	0.27	0.12	0.06
suspended substances (mg/l)	6	0.5	0	1
iron (mg/l)	0.04	0.01	0.04	0.03
manganese (mg/l)	0.010	0.026	0.011	0.010

Suspended substances that cause turbidity can cause heavy metals, toxic organic components and pesticides, and also give water unpleasant look that gives negative impression to the consumers (DALMACIJA et al., 2004). Recorded concentrations of ammonium, nitrates, nitrites, sulfates, iron and manganese in water were in the prescribed range by the Rulebook. However, orthophosphates were above the permitted limit, in two of four samples, and in June was recorded 0.27 mg/l which was almost two times higher than permitted value. Number of aerobic psihrophilic heterotrophs was in every sample lower than maximum permitted 300 col/ml. The highest number of bacteria in water was recorded in September (347 col/ml) and the lowest in November (60 col/ml). Potential pathogenic mesophilic bacteria in April were not even recorded, and in June there was 80 col/ml which was in the prescribed range by the Rulebook (SLUŽBENI GLASNIK REPUBLIKE SRPSKE, 40/03). However, in June, September and November in water were recorded total number of coliphorms, among them in June and September were isolated fecal coliphorms. *Escherichia coli*, fecal Streptococcus and Enterococcus were isolated, which has high resistance and can resist negative conditions so their presence in water is used as indicator of older fecal pollution (ŠKUNCA-MILOVANOVIĆ et al., 1990).

Table 2. Microbiological characteristics of water from the Berek well

	21.04.2010	9.6.2010	28.9.2010	16.11.2010
total bacteria count (kol/ml)	100	285	347	60
aerobic heterotrophic psihrophilic	40	66	170	60
facultative oligotrophic bacteria (col/ml)	61	195	330	57
aerobic mesophilic bacteria (col/ml)	0	80	30	30
total coliphorm bacteria count (col/ml)	0	10	23	9
fecal coliphorm bacteria (col/ml)	0	4	5	0
Escherichia col (col/ml)	0	2	5	0
Proteus species (col/ml)	0	0	0	0
Salmonella and *Shigella* (col/ml)	0	0	0	0
sulfite-reducting Clostridium in 100 ml	0	0	0	0
Pseudomonas aeruginosa (col/ml)	0	0	0	0
fecal Strepotococcus and Enterococcus	0	present	present	0
Algae	0	0	0	0

Based on these results it can be concluded that water from the well in Berek locality beside that it is slightly acidic and contains orthophosphates and suspended substances, comes in contact with waste fecal substances and it is not health safe.
Water pump in Trošelji village is located on 45˚03'49" North and 17˚21'12" East. Results of physicochemical water analysis are presented in *Table 3*.

Table 3. Physicochemical characteristics of water from Trošelji locality

	21.04.2010	9.6.2010.	28.9.2010	16.11.2010.
air temperature (˚C)	18	25	19	17
water temperature (˚C)	12.7	12.0	17.8	15.1
concentration of dissolved O_2 (mg/l)	-	14.62	8.17	8.11
saturation (%)	-	135.4	86.9	81.8
pH	6.65	7.32	7.32	7.74
electroconductivity (µS/cm)	623	612	717	733
turbidity (NTU)	1.29	0.77	0.42	0.76
ammonium nitrogen (mg/l)	0.06	0.00	0.02	0.05
nitrate nitrogen (mg/l)	1.0	4.9	4.2	4.1
nitrite nitrogen (mg/l)	0.001	0.001	0.004	0.010
sulfates (mg/l)	14	13	15	18
orthophosphates (mg/l)	0.01	0.14	0.10	0.15
suspended substances (mg/l)	2	0	0	1
iron (mg/l)	0.00	0.00	0.03	0.02
manganese (mg/l)	0.006	0.010	0.004	0.009

Water is rich with dissolved oxygen and in June was recorded oversaturation of 135.4%. In April is recorded slightly lower pH value (6.65) than it is predicted for drinking water, but in the next three months pH values were in the normal range. The highest value of turbidity is recorded in April what it was 1.29 NTU which corresponds to water that can be used for water supply to 5000 inhabitants. In the same sample suspended substances were present with 2 mg/l, while in June and September they were not even recorded. Total bacteria count on this locality did not go beyond 300 col/ml which was registered in September (*Table 4*). Then, the highest psihrophilic heterotrophic count was registered 150 col/ml, which is in the prescribed range for drinking water. Aerobic mesophilic bacteria was isolated in April, June and November, but their count was in the range prescribed by the Rulebook (SLUŽBENI GLASNIK REPUBLIKE SRPSKE, 40/03) and among them are not isolated total or fecal coliphorms.

Table 4. Microbiological characteristics of water from Trošelji locality

	21.04.2010	9.6.2010	28.9.10	16.11.2010
total bacteria count (kol/ml)	52	65	300	15
aerobic heterotrophic psihrophilic bacteria	15	30	150	13
facultative oligotrophic bacteria (col/ml)	32	80	55	30
aerobic mesophilic bacteria (col/ml)	13	10	0	9
total coliphorm bacteria count (col/ml)	0	0	0	0
fecal coliphorm bacteria (col/ml)	0	0	0	0
Escherichia coli (col/ml)	0	0	0	0
Proteus species (col/ml)	0	0	0	0
Salmonella and *Shigella* (col/ml)	0	0	0	0
sulfite-reducting Clostridium in 100 ml	0	0	0	0
Pseudomonas aeruginosa (col/ml)	0	0	0	0
fecal Strepotococcus and Enterococcus	0	0	0	0
Algae	0	0	0	0

Based on all observed physicochemical and microbiological parameters it can be concluded that water from the water pump from Trošelji locality satisfies basic hygienic and sanitary conditions and can be used for drinking.
The highest recorded water temperature from the spring of the river Vrijeka was 11.2° (*Table 5*) and since it is not significantly increased during warm summer months it can be concluded that temperature of this spring correspond to drinking water. Water is slightly alkaline without significant variation in pH values during the year. The lowest values of concentation of dissolved electrolytes was recorded in January (398 μS/cm) when the spring has much water, while in summer period in time of drought recorded the highest concentration of electroliytes in water (550 μS/cm).

Table 5. Physicochemical characteristics of water from the spring of river Vrijeka

	23.03.2010	04.07.2010	01.09.2010	19.01.2011
air temperature (˚C)	14.0	21.0	17.1	10
water temperature (˚C)	11.0	10.5	11.2	9.9
concentration of dissolved O_2 (mg/l)	-	8.73	9.15	10.19
saturation (%)	-	82.3	88.4	94.5
pH	7.60	7.65	7.71	7.68
electroconductivity (μS/cm)	438	484	550	398
turbidity (NTU)	0.89	0.81	1.99	1.41
ammonium nitrogen (mg/l)	0.00	0.01	0.00	0
nitrate nitrogen (mg/l)	0.6	0.6	0.4	0.5
nitrite nitrogen (mg/l)	0.000	0.001	0.000	0.011
sulfates (mg/l)	0	0	0	0
orthophosphates (mg/l)	0.35	0.15	0.00	0.15
suspended substances (mg/l)	2	1	0	1

In September and in January were recorded slightly increades values of water turbiditz, but they were in allowed range to use as water supply to 5000 inhabitants. Recorded concentrations of ammonium, nitrate and nitrite were far below maximum allowed concentrations, and sulfates were not even recorded. In March is recorded increased concentration of orthophosphates (0.35 mg/l), also in water was recorded slightly more suspended substances and before taking the samples the weather was rainy, probably because of the washing away the surrounding soil caused slightly muddy water and bringing orthophosphates. Considering that in June concentration of orthophosphates was significantly decreased, and in September they were not even recorded and as all other parameters during the whole year were in allowed range for drinking water

(SLUŽBENI GLASNIK REPUBLIKE SRPSKE, 40/03), it can be concluded that in physicochemical aspect water from spring of river Vrijeka can be used for drinking.
As regards to bacteriological analysis total bacteria count correspond the count of facultative oligoptophs which are adapted to survive in areas with very low concentration of organic substances (*Table 6*).

Table 6. Microbiological characteristics of water from the spring of river Vrijeka

	23.03.201	04.07.2010	01.09.20	19.01.20101
total bacteria count (kol/ml)	195	100	244	20
aerobic heterotrophic psihrophilic bacteria (col/ml)	24	100	215	20
facultative oligotrophic bacteria (col/ml)	130	100	250	66
aerobic mesophilic bacteria (col/ml)	0	2	95	0
total coliphorm bacteria count (col/ml)	0	0	0	0
fecal coliphorm bacteria (col/ml)	0	0	0	0
Escherichia coli (col/ml)	0	0	0	0
Proteus species (col/ml)	0	0	0	0
Salmonella and *Shigella* (col/ml)	0	0	0	0
sulfite-reducting Clostridium in 100 ml	0	0	0	0
Pseudomonas aeruginos (col/ml)	0	0	0	0
fecal Strepotococcus and Enterococcus (col/ml)	0	0	0	0
Algae	0	0	0	0

Their count, also the count of psihrophilic aerobic bacteria in every analysis do not pass 300 col/ml which is the upper limit for drinking water. Potentially patogenic aerobic mesophilic bacteria in January and in March were not ever recorded, and in July were present with just 2 col/ml. Their count in September significanlty increased (95 col/ml), but they were still in the range prescribed by Rulebook (SLUŽBENI GLASNIK REPUBLIKE SRPSKE, 40/03). Total coliphorm bacteria were recorded only in March, but their count were in allowed range. Among present total coliphorms fecal bacteria were not found. Based on monitored physicochemical and microbiological characteristics it can be concluded that water from the spring of the river Vrijeka satisfies conditions prescribed by the Rulebook (Službeni glasnik Republike Srpske, 40/03) for the water that can be used as water supply to 5000 inhabitants.

CONCLUSION

By monitornig physicochemical caracteristics of chosen springs in the area of Lijevče polje and Eastern Herzegovina, it is noticed that springs in Eastern Herzegovina contain very low concentration of dissolved sulfates. Vrijeka did not even have sulfates. Monitored springs in Eastern Herzegovina have also slightly lower concentrations of nitrate nitrogen. Also, it is evident that water from chosen springs have slightly lower pH values and significantly higher values of electroconductivity. Water from the well in Berek village is not health safe because it is slighty acidic, turbid and has increased concentration of orthophosphates and suspended substances. Presence of total and fecal coliphorms, Escherichia, fecal Streptococcus and Enterococcus shows that water from the well comes in contact with waste fecal substances and as such can not be used for drinking. Water on Trošelji locality and from spring of river Vrijeka satisfy basic physicochemical and microbiological criteria set for drinking water.

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