DE GRUYTER OPEN

DOI: 10.1515/sspjce-2016-0004

Monitoring of water quality of selected wells in Brno district

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Abstract

The article deals with two wells in the country of Brno-district (Brčálka well and Well Olšová). The aim of work was monitoring of elementary parameters of water at regular monthly intervals to measure: water temperature, pH values, solubility oxygen and spring yield. According to the client's requirements (Lesy města Brno) laboratory analyzes of selected parameters were done twice a year and their results were compared with Ministry of Health Decree no. 252/2004 Coll.. These parameters: nitrate, chemical oxygen demand (COD), calcium and magnesium and its values are presented in graphs, for ammonium ions and nitrite in the table. Graphical interpretation of spring yields dependence on the monthly total rainfall and dependence of water temperature on ambient temperature was utilized. The most important features of wells include a water source, a landmark in the landscape, aesthetic element or resting and relaxing place. Maintaining wells is important in terms of future generations.

Key words: COD, pH values, spring yield, water temperature, well

1 Introduction

The usefulness of groundwater for drinking of irrigation depends largely on its quality, which is largely related to the type and location of the aquifer. Water from igneous and metamorphic rocks is generally of excellent quality for drinking. The quality of water in sedimentary rocks varies. Ground water is generally of higher quality than surface water. Groundwater is usually higher in dissolved minerals salts such as Na, Ca, Mg and K cations with anions of Cl, SO_4 and CHO_3. If such salts exceed 1000 (mg/L), the water is considered as saline. High concentrations of dissolved mineral salts can limit the use of groundwater for drinking because of its laxative effects. Unconsolidated deposits and other aquifers with high hydraulic conductivities such as limestone caverns and lava tubes can become contaminated from biological sources of they are close to surface sources of pollution [1]. The first wells were built in the first half of the 20th century as a source of drinking water for farmers and foresters.

In the second half of the 20th century, their devastation was caused and some of them disappeared due to soil ameliorative interventions and cause of earth-unfriendly influence of human intervention [2]. Existence of heavy metals or other chemical elements ion or microbial activity in the soils and water are described also in [3,4]. Locations of wells and springs considering the soil type and geological conditions have an impact on not only on the infiltration of rainwater but also on the subsidizing source and its properties. These problems deal with e.g. [5,6,7,8] in their work. According to [9] groundwater means all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.

Ground water in aquifers between layers of poorly permeable rock, such as clay or shale, may be confined under pressure. If such a confined aquifer is tapped by a well, water will rise above the top of the aquifer and may even flow from the well onto the land surface. Water confined in this way is said to be under artesian pressure, and the aquifer is called an artesian aquifer.

A spring is a water resource formed when the side of a hill, a valley bottom or other excavation intersects a flowing body of groundwater at or below the local water table, below which the subsurface material is saturated with water. Springs may be formed in any sort of rock. Small ones are found in many places. When weak carbonic acid (formed by rainwater percolating through organic matter in the soil) enters these fractures it dissolves bedrock. When it reaches a horizontal crack or a layer of non-dissolving rock such as sandstone or shale, it begins to cut sideways. As the process continues, the water hollows out more rock, eventually admitting an airspace, at which point the spring stream can be considered a cave. This process is supposed to take tens to hundreds of thousands of years to complete [10]. There are different kinds of springs and they may be classified according to the geologic formation from which they obtain their water, such as limestone springs or lava-rock springs; or according to the amount of water they discharge-large or small; or according to the temperature of the water-hot, warm, or cold; or by the forces causing the spring-gravity or artesian flow [11].

The wells of the forest springs are mostly natural. Adjusted springs have pipes of various sizes, which spring water flows out. Sometimes wells have artificially created lake with a pipe or a gutter outlet [12].

2 Material and Methods

Selected monitored wells which parameters are presented in this paper are administrated by Lesy města Brna (The Forests of The City of Brno, Corp.). In cooperation with this company we chose ten wells for the monitoring and measurements. Wells are located north of Brno city. In this article are presented results of measurements of two wells: spring Brčálka and Olšová spring. Field research and measurements took place from April 2014 to March 2015. In the first phase we defined wells for the research (in cooperation with The Forests of The City of Brno, Corp.). Together with the workers of the corporation the initial reconnaissance of the springs and their surroundings started. Key data were obtained by self-field measurements and by observation and evaluation of the laboratory analyzes of water from the springs. GPS device Trimble Juno ST program TerraSync was used for getting the exact position of each spring. Measurements were carried out each month from May 2014 to March 2015. By apparatus Multi 340i pH values, water temperature and solubility of oxygen were measured. Next, the air temperature was measured. Measurements of spring yield was done by direct measurement i.e. by capturing water flowing from the spring into the measuring jug – the graduated cylinder of 1L, for springs with lower spring yield the graduated cylinder of 500 ml or 250 ml respectively.

In October 2014 and February 2015, water samples were taken for laboratory testing of water quality (processed by Brněnské vodárny a kanalizace (Water supply and treatment, Corp.)). Water quality was assessed according to the Ministry of Health Decree No. 252/2004 Coll., laying down hygienic requirements for drinking water, hot water and the frequency and scope of drinking water control [13].
Physico-chemical analyses were done and parameters as: ammonium ions, nitrate, nitrite, chemical oxygen demands by permanganate (COD (Mn)), calcium and magnesium were determined. In the next parts the location and description of the current status of wells is described.

All mapped wells are located on the land which is intense for forestry function and has undergone some technological modification. These two wells are in good condition and are situated in the South region in the Brno district.

2.1 Spring Brčálka

Spring Brčálka (Figure 1) is situated in cadastral area of Lelekovice city at altitude 368 m a.s.l. (GPS coordinates N 49° 17' 51.00", E 16° 34' 59.88"). Brčálka well is located in the northern part of the village Lelekovice, on direction to observation tower Babí Lom, near the retention reservoir. Spring is also known as „Za rybníčkem“.

Figure 1: Spring Brčálka [14]

It is located in the river basin Ponávka. Most likely it is a shallow detected flow spring. The well is natural and often used by people from the surrounding. The entire structure is made of natural quarry stone from which the outlet pipe comes out. Face of the well is adjusted with low cement mortar stone wall. Water flows through steel pipe to the area reinforced by stones; afterwards it flows through the furrow on the right side of the path. Above the drain pipe is placed granite slab on which is the inscription: Brčálka - this fountain was renewed for thirsty wayfarer by the Green Party in 2006. Pipe is covered with hemispherical colonies of red algae, along with tiny diatoms genus *Achnanthes* [15].

2.2 Olšová spring

Spring Olšová depicted in Figure 2 is located north of the village Lelekovice approximately 800 m from the village. Well is located at the eastern foot of the Babí Lom at the altitude 430 m a.s.l. (GPS coordinates N 49° 18' 16.92", E 16° 34' 55.86"). Spring is also known as „U silničky“.

Figure 2: Olšová spring [14]

Well was built in the late 80s of the 20th century. This spring is very volatile flows throughout the year. Spring yield is in range from 0.8 to 60 L/min. After intensive rain the flow increase several fold. The unsteadiness of the flow warns against using the water without boiling it. Dissolved solids and conductivity varies depending on the abundance of spring [15].

Just as spring Brčálka, Olšová is also natural appearance spring and is built of quarried stone on cement mortar. Spring is diverted into the spring reservoirs into which can be taking a look through a steel door on the side of the stone structures of the well. From there water flows thought the outlet pipe to the area reinforced by stones. Water in the form of concentrated runoff is diverted thought the furrow and culvert under the road to the recipient of Zahumenský creek. This spring also belongs to the river basin Ponávka. Based on the regular monthly monitoring of the spring can be concluded that this is spring with considerably fluctuating flow throughout the year. Environment around the wells is clean and tidy. There is no considerable existence of waterlogging of the sites of concentrated runoff. Next, water drained via culvert into the creek. Near the wells is located information boards introduce history and natural surroundings to visitors and says that water is "perhaps still drinkable."

3 Results and Discussion

Both wells in the forest city of Brno were monitored for one year. Measurement of selected parameters has begun in May 2014. These parameters of water were monitored each month: water temperature, pH, solubility of oxygen and spring yield. Complex laboratory analysis were done twice a year and investigated parameters were: ammonium, nitrate, nitrite, COD(Mn), calcium and magnesium. Measurements of values of springs yield and water temperature were necessary for examination the dependence on rainfall and ambient temperature respectively. The values of investigated water from the selected springs obtained from laboratory analyzes were compared with the values according to Decree no. 252/2004 Coll. [13].

The water temperatures of both springs measured during the period from May 2014 - March 2015 were monitored and are presented in Figure 3. In May spring Olšová was dry, so measurement of water temperature was not underway.

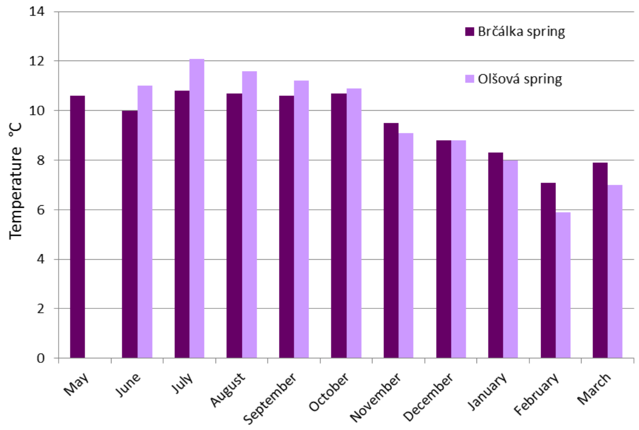

Figure 3: Water temperature in monitored period

Figure 3 represents the temperature of water in the selected springs measured at regular monthly intervals. Brčálka spring showed very similar temperatures in period from July – October while in case of Olšová spring the trend of water temperature is decreasing. In next months (till March) the course of the temperature values decreases for both springs. The highest differences in temperature were recorded in July (Δt=1.3 °C) and February (Δt=1.2 °C).

Measured pH values for each month are depicted in Figure 4.

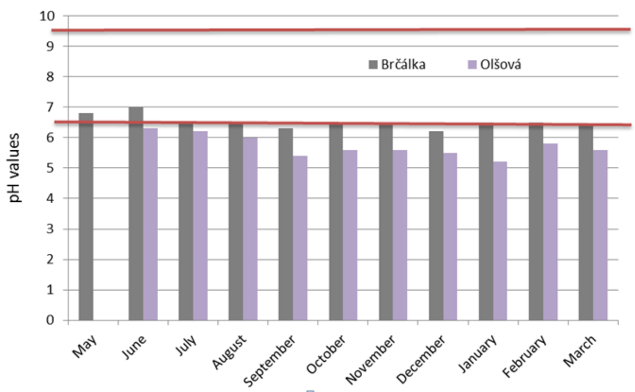

Figure 4: The pH values of water of selected springs

The pH values for Brčálka well are mostly about 6.5. Well Olšová has pH values lower than the lowest limit (6.5) for drinking water requirements according to Decree no. 252/2004 Coll. [13]. Values of pH values defined in [13] are in range from 6.5 to 9.5 and shown in Figure 4.

Solubility of oxygen in mg/L is depicted in Figure 5 for spring Brčálka and Olšová spring.

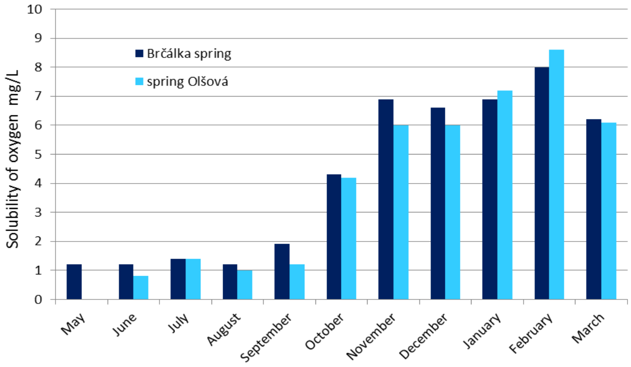

Figure 5: Solubility of oxygen in monitored springs

Concentration of oxygen depends on temperature of water and on atmospheric pressure. As it is obvious from the Figure 5, during the summer months (June 2014-September 2015) the values are significantly lower than during the autumn and winter period (October 2014-March 2015).

In Figure 6 spring yield during 11 months is presented. Water flow is expressed in L/s for Brčálka spring and also for spring Olšová.

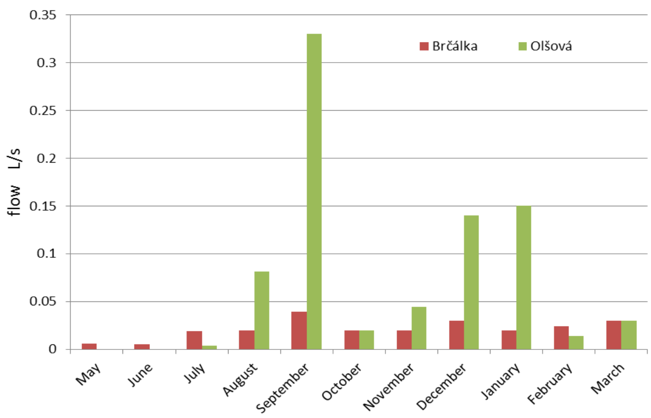

Figure 6: Springs yield of monitored springs

Spring Olšová had no flow rate during May and June, very low during July and then during the September, December and January significantly exceed the values for Brčálka spring (Figure 6). Spring yield of Brčálka spring shows stable flows.

Concentrations of selected indicators were measured twice during the evaluated period, once in October 2014 and Once in February 2015. Measured concentrations of nitrates, COD(Mn), calcium and magnesium in springs are expressed in Figure 7 in mg/L.

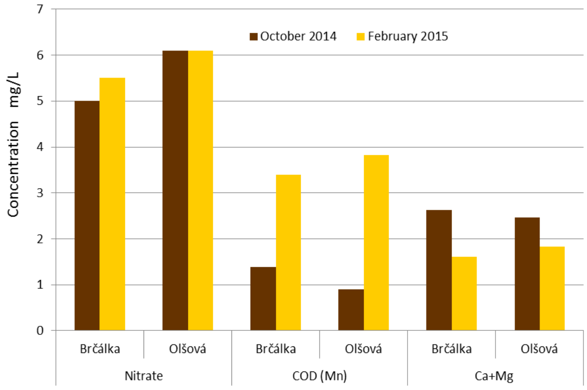

Figure 7: Concentrations of nitrates, COD(Mn) and calcium + magnesium

Measurement of ammonium ions and nitrite in October 2014 and in February 2015 was determined. Because of range of values the results are not presented via graphs, results are listed in Table 1. The limit value for nitrate according to Decree no. 252/2004 Coll. is 50 mg/L, for COD it is 3 mg/L and recommended content of calcium and magnesium is in range from 2 – 3.5 mg/L. For itrate the measured values are so the values are not even close to this limit but in case of COD(Mn) the limit value was exceeded for both springs in February 2015. Values of Ca+Mg were under limit values (in October 2014) and in recommended range for February 2015.

Ammonium ions and nitrites in the spring water are presented in Table 1.

Table 1: Concentration of ammonium ions and nitrite in both wells

Well	Ammonium ions [mg/L]		Nitrite [mg/L]	
	October 2014	February 2015	October 2014	February 2015
Brčálka	<0.01	<0.01	<0.012	<0.012
Olšová	0.01	0.02	<0.012	<0.012

The values of nitrites were in minor amount of less than 0.012 mg/L. The limit value of nitrites according to Decree no. 252/2004 Coll. is 0.50 mg/L, so the values are not even close to this limit. The same limit is for ammonium ions (0.50 mg/L) but also all values were below this limit (Tab. 1).

Dependencies of spring yield on monthly rainfall of selected wells measured during the period from May 2014 till March 2015 is shown in Figure 8.

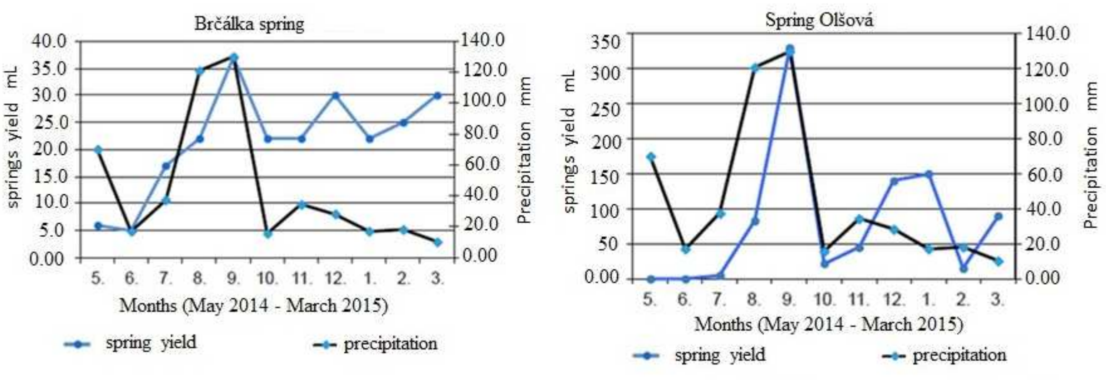

Figure 8: Dependencies of spring yield of Brčálka (a), Olšová spring (b) on monthly rainfall

From Figure 8 shows evident dependency of spring yield on precipitation. We can conclude that Brčálka spring is deeper underpinning because it shows more stable yield than Olšová spring where the spring yield fell again very quickly after the rainfall is reduced. Olšová spring is therefore more dependent on rainfall than Brčálka spring.

Similar trend of direct proportion of spring yield and precipitation is visible in Figure 8 for both springs till September (Brčálka) and till November (Olšová). After this period the indirect proportion started.
Figure 9 presented dependencies of water temperature of selected wells on ambient temperature determined during period from May 2014 till March 2015.

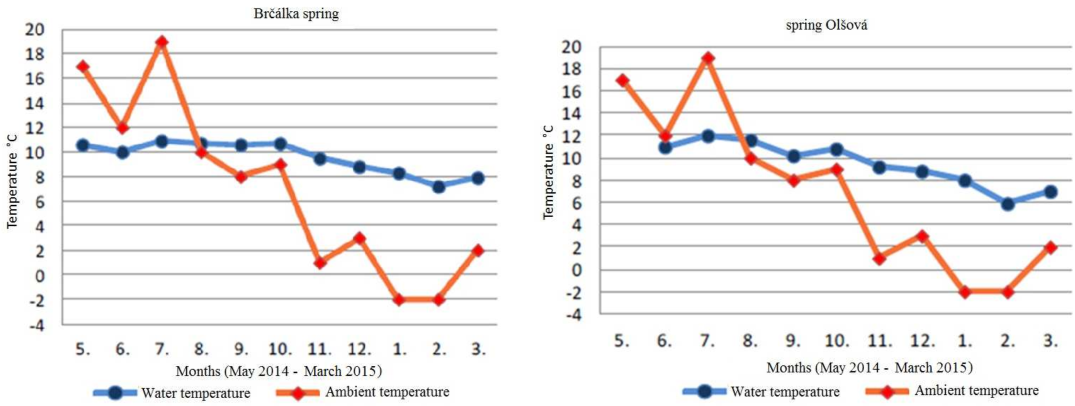

Figure 9: Dependencies of water temperature of the Brčálka spring (a) and spring Olšová (b) on ambient temperature

Dependence of water tempterature on ambient temperature is depicted in Figure 9. Well Brčálka envinces relative constant temperature of water and is less depencence on ambient temperature compared with Olšová well.

4 Conclusion

The water quality of the individual springs often fluctuates, and therefore it is difficult to say that well water is drinking unequivocally. It is important constant monitoring of water and inform about water quality e.g. through information boards etc. If the spring whose water is not potable is adjusted to drinkable, it is important to establish an information board, which will announce this information to visitors of the forest.

The article deals with the springs and wells in the county of Brno-district. The area of interest was the northern part of the Brno-country district near Lelekovice and Veverská Bítýška.
The aim of work was monitoring the selected wells at regular monthly intervals to measure the elementary parameters of water. Each month, following parameters were determined: water temperature, pH values, solubility oxygen and spring yield. The water temperature at any monitored wells even in the winter does not fall below 5 °C. The pH values for Brčálka well are mostly about 6.5. Well Olšová has pH values lower than the bottom limit (6.5) for drinking water requirements according to [13]. Spring Olšová had no flow rate in May and June 2014. The most fluctuated flows (highly dependent on rainfall) had Olšová spring (in

May and June had no flow rate). Brčálka well had relatively stable flows, which were higher in September December 2014 and March 2015). The limit value for nitrate according to Decree no. 252/2004 Coll. is 50 mg/L, for COD it is 3 mg/L and recommended content of calcium and magnesium is in range from 2 – 3.5 mg/L.

According to the client's requirements (Lesy města Brno) laboratory analyzes of selected parameters were done twice a year and their results were compared with Decree no. 252/2004 Coll. [13]. These parameters: nitrate, chemical oxygen demand (COD (Mn)), calcium and magnesium and its values are presented in graphs, for ammonium ions and nitrite the table was used. Graphical interpretation of spring yields dependence on the monthly total rainfall and dependence of water temperature on ambient temperature was again utilized.
Concluding the paper, it has to be noted that the quality of water in wells is dependent on many factors. According to measurements presented in the paper, Brčálka well is in good technical condition, spring yield was more/less stable and water flow was not very fluctuated. Also Olšová spring has natural character as the first well, but the water flows were significantly unstable and dependent on rainfall. It leads to lower water quality for drinking purposes. Water did not fulfil requirements according to [13] in parameters pH values and COD.

Based on two comprehensive analyzes for the water in the springs it cannot be declared that the source is permanently drinking. Especially here, where the source is shallow captured, the quality is very variable and depending on rainfall, pollution of the environment and the agricultural activities of the wider area.
Decree 252/2004 Coll. does not address to the control of the wells for drinking purpose. The Decree determines the frequency of controls for water pipelines and wells as individual water supply and also the quality control of water "dispenser" - drinking water tank. Springs and wells in are not the subject of the decree [13].

Wells in the landscape have many roles. Among the most important features include a water source, a landmark in the landscape, aesthetic element or resting and relaxing place. People are increasingly aware of the importance of the wells in the country. They seem more interested in them and care for them. This is demonstrated by the formation of the National Registry of springs and wells, where each year a growing number of springs entered into evidence. Maintaining wells is also important in terms of future generations.

Acknowledgements

The article contains photographs by Ing. Ema Stehnová, who also participated in the fieldwork and they are a part of the diploma thesis called "Sledování pramenných vývěrů ve správě Lesů města Brna v severní části okresu Brno venkov" (*Monitoring water springs in management of Lesy města Brna in the northern part of district Brno venkov).*

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