

**FIZIČKO-HEMIJSKI PARAMETRI IZVORA
VODOSNABDEVANJA U SKOPLJU**

Scientific paper

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APSTRAKT: Snabdevanje vodom hemijski i mikrobiološki zdravom vodom je od suštinskog značaja za opstanak ljudi u urbanim sredinama i uopšte. Resursi koji ispunjavaju ove kriterijume su ograničeni i pod velikim pritiskom urbanizacije, industrijskih aktivnosti i izgradnje objekata svih vrsta. Nepoštovanje osnovnih principa zaštite životne sredine može značajno ugroziti kvalitet resursa koji se koristi ili bi se koristio za vodosnabdevanje stanovništva. Uslovi, uticaji i stepen otpornosti jednog resursa za vodosnabdevanje određuju se nizom hidroloških, hidrogeoloških, geoloških, litoloških, meteoroloških i drugih parametara koji, kada se objedine, treba da karakterišu resurs, ili u našem slučaju izvor Rašče. U cilju sprovođenja mera koje proizilaze iz složenih istraživanja, formiraju se zaštitne zone koje treba da garantuju bezbednost vodosnabdevanja stanovništva. To podrazumeva poštovanje i sprovođenje određenih mera i aktivnosti u skladu sa prethodno definisanim karakteristikama istraživanja. Suština je očuvanje kvaliteta i bezbednosti izvora sada i u budućnosti. Zbog toga je neophodno dosledno primenjivati propisana pravila i procedure u skladu sa zaštitnim zonama. Praćenje kvaliteta i količine izvora je primarni zadatak kako bi se tačno utvrdilo stanje i, po potrebi, predložile nove mere zaštite, što na kraju uključuje i reviziju zaštitnih zona, u cilju očuvanja postojećeg stanja kvaliteta i količine izvora. Dobijene vrednosti izmerenih fizičko-hemijskih parametara prikazane su kao minimalne, maksimalne i prosečne vrednosti na nivou godišnjih posmatranja.

Ključne reči: zaštitne zone, fizikohemijski parametri, kvalitet, vodosnabdevanje

**PHYSICOCHEMICAL PARAMETERS OF
THE WATER SUPPLY SOURCES IN SKOPJE**

Građanska uprava

ABSTRACT: Water supply with chemical and microbiological healthy water is essential for the survival of human in urban areas and in general. The resources that meet these criteria are limited and under great pressure from urbanization, industrial activities, assigning objects of all kinds. Failure to respect the basic principles of environmental protection can significantly threaten the quality of a resource that is used or would be used for water supply of the population. The conditions, the impacts, the degree of resistance to one resource for water supply are determined by a series of hydrological, hydrogeological, geological, lithological, meteorological and other parameters that collected in one should characterize the resource or in our case the spring Rasce. In order to implement the measures arising from complex research, protection zones are created that should guarantee the population safety of water supply. This involves respecting and implementing certain measures and activities in accordance with the characteristics previously defined by the research. The bottom line is to maintain the quality and security of the source now and in the future. It is therefore necessary to consistently implement the prescribed rules and procedures in accordance with the protection zones. Monitoring the quality and quantity of the source is the primary task in order to be able to determine the situation accurately and if necessary, propose new protection measures, which ultimately includes the revision of the protection zones, in order to maintain the existing status with the quality and quantity of the source. The obtained values of measured physical and chemical parameters are shown as minimum, maximum and average values at the level of annual observations.

Keywords: protection zones, physicochemical parameters, quality, water supply

1. INTRODUCTION

The rapid development of industrial production, the growth of the global population, and the increasingly pronounced demands of modern people for a more comfortable and better life are daily confronting humanity with the need for large quantities of water for various purposes: industry, agriculture, domestic use, etc. All of this has led to an extremely critical situation regarding the increasingly scarce sources available to meet water demands [1].

As a measure of water consumption, the so-called “specific water consumption” is used, which is obtained by dividing the total water consumption by the number of inhabitants. It is estimated that water consumption in households alone is around 250 liters per day. In order to reduce water consumption in industry (for example, 400–800 m³ of water are required to produce 1 ton of paper, while processing 1 ton of wool requires about 1000 m³ of water), recirculation of treated wastewater is applied, sometimes reaching 90–95%.

Water is undoubtedly the main component in the diet of humans and all living organisms. Therefore, having access to clean, unpolluted, and safe drinking water is a great privilege. For this reason, in the realization of the socio-economic development of the Republic of Macedonia, water supply rightfully occupies one of the most important places. Considering the importance of water for human life, planning the development of water management is an integral and inseparable part of overall socio-economic development planning. The development of water management generally takes place in three directions: regulation of water regimes, utilization of water resources, and protection of water resources.

2. RASCHE SPRING

The Rasche Spring is located 15 km west of Skopje, more precisely at the southeastern foothills of Zheden Mountain, near the village of Rasche, at an elevation of 299.68 meters above sea level. It represents the main source of water supply for the population and industry of the Skopje region and supports the vital functions of 25% of the population in North Macedonia.

Numerous and complex investigations have been carried out by various institutions to determine the origin of the water and the mechanisms of recharge of the Rasche Spring, resulting in several hypotheses (Spatial Plan of the Protection Zones of the Rasche Spring Region, 2002) [2–4].

According to the Spatial Plan of the protection zones of the Rasche Spring region, and based on all hydrological, geological, meteorological, and isotopic studies, it has been established that the water originates as follows: 70% from Shar Mountains, 20% from Zheden Mountain, and 10% from the Vardar River.

As a result of long-term research and the synthesis of knowledge regarding the recharge of the Rasche Spring, the boundaries of the protection zones have been defined, along with the corresponding protection measures [5]. Three protection zones have been established:

- The first zone – the area of the Zheden massif, the Rasche Spring with intake structures 1 and 2, and the area enclosed by a physical fence;
- The second zone – the area of Lower Polog, which is in direct connection with the Zheden massif; and
- The third zone – the area of Upper Polog, including part of the Mavrovo Hydrosystem and the foothills of the Shar Mountains.

The water is physically, chemically, and bacteriologically clean, without the need for any treatment. In accordance with the requirements of the applicable regulations (Rulebook on the Safety of Drinking Water, Official Gazette of the Republic of Macedonia No. 46/2008), preventive disinfection of the water is carried out using chlorine gas. Residual chlorine in the water, with a concentration of 0.2 to 0.5 mg/l, ensures long-term protection of the water from contamination.

3. QUANTITATIVE CHARACTERISTICS OF THE WATER SUPPLY OF THE CITY OF SKOPJE

The water supply of the City of Skopje is mainly provided by the waters from the spring Rasche 1 and the intake structure Rasche 2, which are collected at the Kondovo chlorination station. The delivered water quantities meet the needs of the population and industry for most of the year. Under favorable hydrological conditions, there is no need to use the reserve sources; however, in hydrologically unfavorable years, the reserve water supply sources are brought into operation, namely the wells in the Nerezi well field and the Lepenec well field. The available capacities are presented in Table 1.

Tabela 1: Sources of water, intake structures, pumping stations, and well fields

	Installed capacity (m ³ /s)	Exploited capacity (m ³ /s)
Rasche 1	4,00	2,00-4,00
Rasche 2	2,0	1,00
Zhelezara pipeline	1,2	1,2
Nerezi well field	0,76	0,57
Lepenec well field	0,69	0,69
Total	8,65	5,46-4,46

The quantities of produced water are presented below in a table 2, expressed by years. From the attached table, it can be concluded that the system is relatively constant. The slight annual variations are the result of hydrological and hydrometeorological conditions, as well as the demographic situation in the city, but the system continuously supplies the required amount of water [6].

Tabela 2: Water production by years

Year	Produced water in m ³
2010	99.234.707
2011	97.804.551
2012	98.800.832
2013	97.514.677
2014	92.793.925
2015	94.419.411
2016	102.812.617

Due to the extremely unfavorable hydrological conditions and the sudden demographic boom, an increased consumption is noticeable in 2016. This trend continues in the following years, but the system continues to meet all needs.

4. QUALITATIVE CHARACTERISTICS OF THE WATER SUPPLY OF THE CITY OF SKOPJE

Analyses of the physicochemical characteristics were performed on water samples taken in accordance with the prescribed methodology and standard procedures, as well as the Regulation on Water Safety. The samples for analysis were taken from the Rasche 1 and Rasche 2 intakes, as well as from the critical control point Kondovo. The measurements were carried out in the laboratories of the Sanitary Control Center at the Public Enterprise “Water Supply and Sewerage” Skopje. The obtained results are presented graphically and refer to a period of 10 months.

The pH value is within the permitted limits. Values above 7 indicate a slightly alkaline medium in the water, which is in balance with the pH of the human organism. At the Rasche 1 spring, a slightly higher pH value is observed, i.e., a higher alkalinity of the water, Figure 1.

COD expressed through the consumption of KMnO_4 is below the maximum permitted level. The low consumption value is due to the very low presence of organic substances, i.e., pollutants, and the karst nature of the area in which the springs are located. A slightly increased amount of KMnO_4 consumption is observed at Rasche 2, which is the result of the different nature of the intake compared to the Rasche 1 spring, Figure 2.

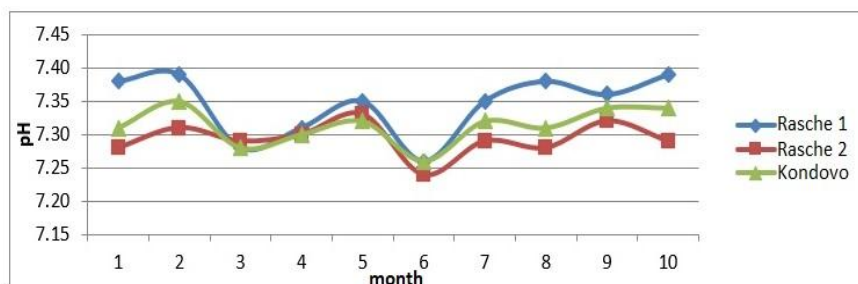


Figure 1: Graphical representation of pH in water

The concentration of nitrates is constant throughout the year, with Rasche 2 showing a slightly higher presence compared to the other two sources during the entire year. This is the result of the fact that in the vicinity of this source there are agricultural areas where both natural fertilizers and fertilizers of various types are used, Figure 3.

The concentration of sulfates is significantly increased in the month of September, when rainfall occurs and soil leaching takes place due to the mineralogical characteristics of the soil in contact with the water resource; however, the amounts remain low and far below the permissible limits recommended by health authorities, Figure 4.

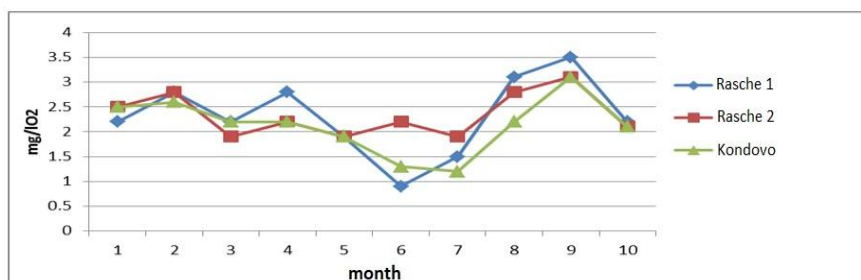


Figure 2: Graphical representation of COD expressed through KMnO_4 consumption in water

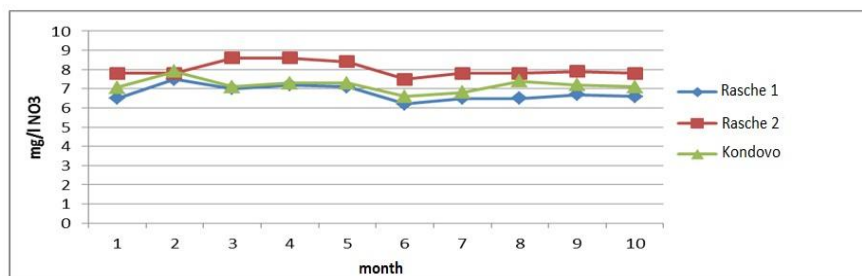


Figure 3: Graphical representation of nitrates in water

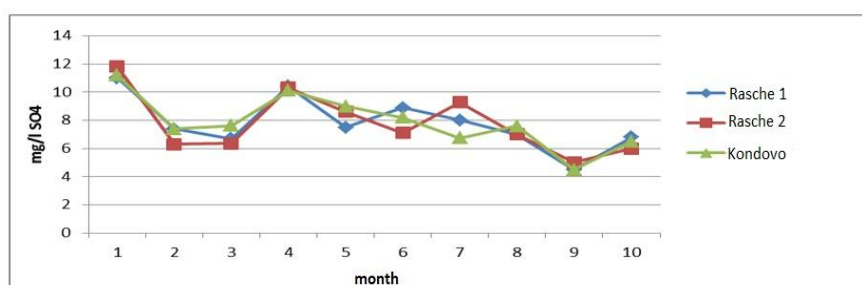


Figure 4: Graphical representation of sulfates in water

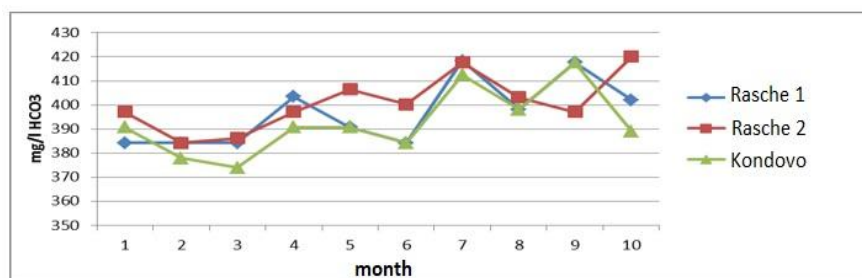


Figure 5: Graphical representation of bicarbonates in water

The concentration of bicarbonates is variable within the range of 370 to 420 mg/l and shows fluctuating values throughout the year. The variations are more pronounced at Rasche 1 and Kondovo, while at Rasche 2 they are more moderate. This is a key characteristic of the water, as the presence of bicarbonates gives the water its characteristic palatability, Figure 5.

Sodium is present in the water in small amounts. A concentration below 10 mg/l makes the water suitable for consumption and even for dietary use. This is in accordance with the regulation on mineral waters, according to which waters with less than 50 mg/l are recommended for diets, Figure 6.

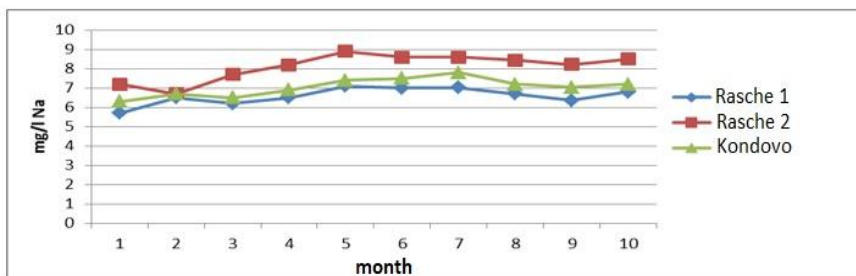


Figure 6: Graphical representation of sodium in water

Chlorides are constant and are a result of the mineral composition of the soil with which the water comes into contact as it travels through the Polog Valley and the Zheden massif. The recorded concentration is within low limits and is one of the characteristics of this water resource, Figure 7.

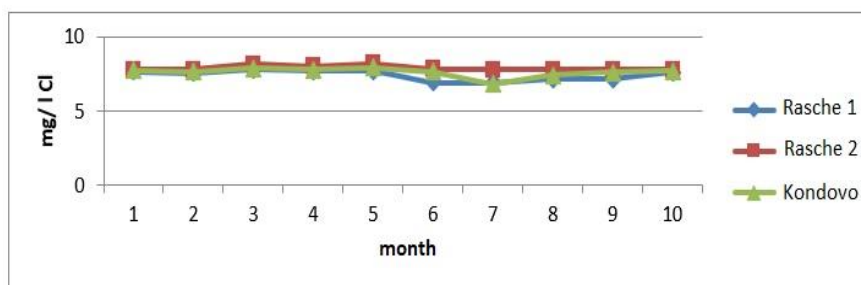


Figure 7: Graphical representation of chlorides in water

Despite the potential risk from HEK Jugohrom and the landfill, which emit hexavalent chromium, its presence is trace and continuously controlled. The slight variations are in the microgram range, within the limits of analytical error, Figure 8.

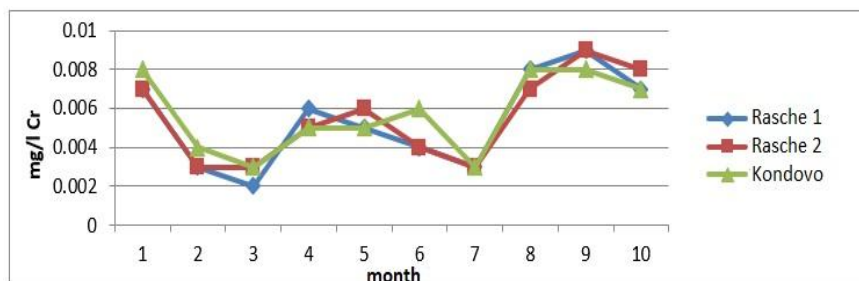


Figure 8: Graphical representation of chromium in water

5. CONCLUSION

Based on the processed literature data as well as the conducted analyses of water quantities and water quality from a chemical aspect, it can be concluded that: the water from the Rasche 1, Rasche 2, and Kondovo sources is calcium bicarbonate water; the low sodium content is desirable, including for use by sensitive individuals and users following diets; the low nitrate content makes the water suitable from a health perspective, including for users with a faster metabolism; the low values of permanganate consumption indicate that the water is not organically loaded; the waters show consistency in composition with insignificant variations even under variable hydrological conditions; and the water quantities are sufficient to meet all the needs of the population of the City of Skopje.

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