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DRINKING WATER QUALITY OF SEVERAL PRIVATE WELLS AND PUBLIC SPRINGS FROM COVASNA AND SUCEAVA COUNTIES (ROMANIA) AND THE SEASONAL FLUCTUATION OF THEIR CHEMICAL QUALITY PARAMETERS

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Abstract

A total of 80 water samples were collected from several private wells (Sita Buzăului village – Covasna County) and public springs (Vatra Dornei area – Suceava County), during five sampling campaigns (November 2016, January – April 2017). The wells had a higher content of dissolved ions than the springs, while nickel was slightly higher in springs than in wells, due to the more acidic pH. The levels of the analyzed parameters were lower during January and February 2017 than in March 2017. Based on the water quality index, 75% of the investigated water sources can be classified as excellent quality status, 19% correspond to good status, while 6% have a poor water quality.

***Key words**: Covasna County, drinking water quality, groundwater, Suceava County, water quality index*

INTRODUCTION

Water is one of the most important resources on the Earth and in some areas, especially the rural ones, the groundwater from wells and springs is the only drinking water source and therefore it is very important to be constantly monitored in order to assess its quality [2], [12], [14], [16]. In the last decades, the contamination of underground water caused by human activities (mainly rural) has become an important problem for many European countries [13]. Animal sewages, pesticides, fertilizers, or irrigations salts can infiltrate into the soil and contaminate the underground water, changing its chemical composition and quality and making it a vulnerable source [11], [13]. Groundwater pollution is associated with several unpleasant aspects such as taste, odor, color, hardness and the presence of dangerous/toxic chemical compounds or pathogenic organisms [3].
The objectives of the present study were: (1) to investigate the quality of several drinking waters sampled from nine private wells (Covasna County – Romania) and seven public springs (Suceava County – Romania); and (2) to evaluate the monthly/seasonal fluctuations of water quality parameters.

MATERIALS AND METHODS

During November 2016, January – April 2017, a total of 80 water samples were collected from nine different wells located in Sita Buzăului village (Covasna County – Central E of Romania) and from seven natural springs located in Vatra Dornei city (Suceava County – N of Romania) (Fig.1). The analyzed water sources are used for drinking, cooking, washing and agricultural purposes.
The analysed physico-chemical parameters were: pH, electrical conductivity (EC), oxido-reduction potential (ORP), total dissolved solids (TDS) and salinity and they were measured *in situ*, using a portable multiparameter (WTW multi350i, Germany).
The waters used for dissolved ions and nickel analysis were sampled in polyethylene containers of 500 ml and transported to the

laboratory in cold (4°C) and dark conditions, where they were filtered through 0.20 µm pore syringe filters in order to remove the impurities, while the samples used for cations and nickel analyses were acidified with HNO_3 (65%) [4], [6], [15].

Fig. 1. Location of the investigated areas.
Source: Own determination.

The dissolved ions (NO_2^-, NO_3^-, Br^-, F^-, Cl^-, PO_4^{3-}, SO_4^{2-}, Li^+, Na^+, NH_4^+, K^+, Mg^{2+} and Ca^{2+}) were analyzed by ion chromatography (IC 1500 Dionex system, SUA), while the nickel was analyzed by atomic absorption spectrometry (ZeeNIT 700 system, Analytik Jena, Germany) equipped with a single-element hollow cathode lamp, an air-acetylene burner and a graphite furnace.
The overall quality of the investigated water sources was evaluated by calculating the water quality index (WQI), based on the fallowing equation [1], [7], [8], [17], [18], [20]:

$$WQI = \frac{\sum_{i=1}^{n} q_i \cdot W_i}{\sum_{i=1}^{n} W_i};$$

$$W_i = \frac{k}{S_i} = \frac{\frac{1}{\sum \frac{1}{S_i}}}{S_i} \quad ; \quad q_i = \frac{V_a - V_i}{S_i - V_i} \cdot 100$$

where: "W_i is weightage factor; k is a constant value; S_i is the standard value of the i^th^ water quality parameter; n is the total number of water quality parameters; q_i is the quality rating for the i^th^ water quality parameter; V_a represents the analysed value of the i^th^ water quality parameter determinate experimentally; V_i is the ideal value of the i^th^ water quality (V_i for pH = 7 and for the other parameter the Vi value is 0" [1], [7], [8], [17], [18], [20]. The standard values (S_i) of the investigated parameters were the maximum permissible limits imposed by national legislation (Law 458/2002) and international legislation (BC Health Act Safe Drinking Water Regulation – BC Reg 230/92 Canada; World Health Organisation – WHO 1996).

RESULTS AND DISCUSSIONS

The obtained results are summarized in Fig. 2 and Fig. 3. The natural springs proved to be more acidic (pH between 5.0 and 7.5) than the wells (pH between 6.1 and 7.2) [15]. A total of 69% from the analysed spring samples, respectively 15% from the wells samples, had a more acidic pH than the limits regulated by national legislation for drinking water (6.5 – 9.5) [9]. The redox potential was inversely correlated with the pH, having values between -32.1 and 33.1 mV for wells and between -41.2 and 116.2 mV for spring samples. The electrical conductivity (EC), total dissolved solids (TDS) and salinity levels were considerably higher in the wells (147 – 1242 µS/cm for EC, 94 – 788 mg/L for TDS and 0 – 0.6 ‰ for salinity) sampled from Sita Buzăului area than for the springs (54.1 – 201.1 µS/cm for EC, 35.1– 129.1 mg/L for TDS and 0 ‰ for salinity) sampled from Vatra Dornei area (Fig. 2).
These values reflect the presence of relatively high amounts of dissolved inorganic and organic salts in the wells. However, the EC for all the samples was within the national limit (2500 µS/cm) for drinking water [9].
High levels of EC can usually indicate the presence of calcium, magnesium, sodium, and potassium cations and carbonate, hydrogencarbonate, chloride, sulfate, and nitrate anions [19]. High levels of dissolved solids, may affect water taste [19]. The waters from all the springs and seven wells had the TDS < 300 mg/L, which give an excellent taste, while two of the wells (W3 and W9) had the TDS level between 600 and 900 mg/L, which lead to a fair water taste [19]. Generally, water with TDS concentrations below 1000 mg/L is usually acceptable to consumers, although TDS > 500 mg/L may

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induce a specific taste and may lead to excessive scaling in water pipes, heaters, boilers, etc. [19].

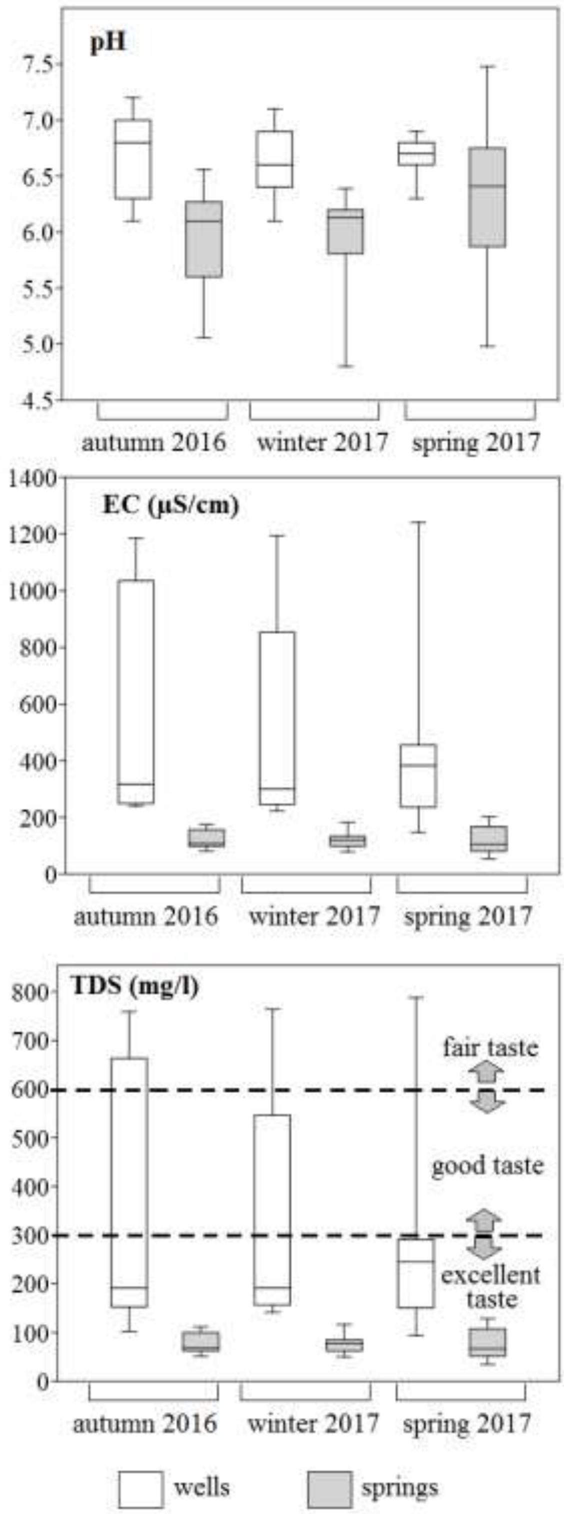

Fig. 2. Seasonal fluctuation of pH, EC and TDS for the investigated wells and springs.
Source: Own determination.

The results indicated that both wells and spring waters had a relatively constant composition, with no significant monthly fluctuations. The waters sampled during February and April 2017 were slightly acidic, while the waters sampled in January and February 2017 had lower levels of EC, TDS and salinity compared to those registered in March 2017. These fluctuations can be correlated with the higher amounts of precipitations from March which enhanced the salts dissolution.

As it is shown in Fig. 3, the concentrations of dissolved ions were considerably higher in wells than in springs. The fallowing ions were not detected in the analyzed samples: Li^{+}, NH_4^{+}, NO_2^{-}, F^{-} and PO_4^{3-}. The levels of Cl^{-} (1.5 – 181.3 mg/L for wells and 0.5 – 13.1 mg/L for springs), SO_4^{2-} (2.5 – 43.8 mg/L for wells and 3.1 – 18.1 mg/L for springs) and Na^{+} (1.1 – 58.4 mg/L for wells and 3.1 – 9.1 mg/L for springs) were within the limits (250 mg/L for Cl^{-} and SO_4^{2-}, and 200 mg/L for Na^{+}) imposed by national legislation for drinking water [9]. The nitrate content from spring waters (0.1 – 16.5 mg/L) was considerably lower than for wells (1.1 – 146.1 mg/l). A total of 22% from the wells samples had NO_3^{-} content above the national limit (50 mg/l).

High amounts of calcium were registered in some of the analyzed well samples (12.8 – 212.7 mg/L), which may be correlated with the presence of limestone and dolomite [5], [10] in the local geology. High levels of Ca^{2+} and Mg^{2+} may lead to high levels of hardness and can cause a bitter or salty taste and a slimy mouth feel [5], [10]. Well waters proved to have relatively high levels of potassium (up to 44.5 mg/l) (Fig. 3). Spring samples had higher nickel content (4.4 – 19.2 µg/L) than wells (5.2 – 16.1 µg/L), fact that can be correlated with the more acidic pH of spring [15], which enhance the heavy metals solubility. In all the analyzed samples, nickel concentrations were within the national limit (20 µg/L) for drinking water [9].

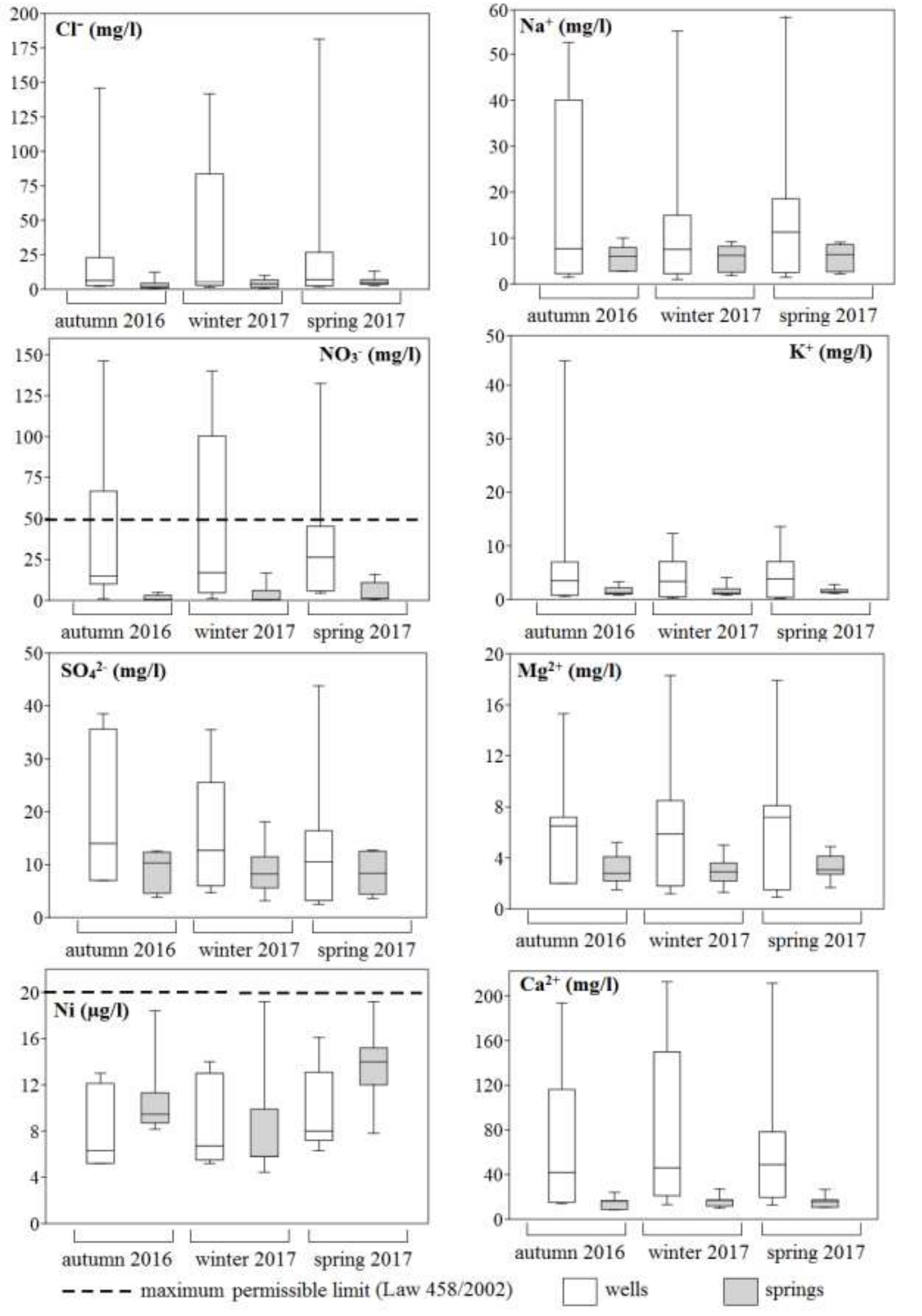

Fig. 3. The concentration of dissolved ions and nickel for both the investigated wells (Sita Buzăului) and springs (Vatra Dornei).
Source: Own determination

The concentrations of both dissolved ions and nickel were lower during January and February 2017 than in March 2017. These fluctuations can be correlated with the higher amounts of precipitations from March which enhanced the salts dissolution [15].

As it is shown in Fig. 4, the WQI had higher values for well water (2.4 – 69.1) than for spring water (4.6 – 18.7). A total of 75% of the investigated water sources had the WQI < 25, which correspond to an excellent quality status, while 19% of the water sources had the WQI between 25 and 50, which correspond to a good quality status. Only one well (W3), had the WQI between 50 and 75, being classified as poor water quality. This indicates that, with the exception of well W3, the overall chemical quality of the investigated water sources is suitable for drinking, cooking, agricultural or recreational purposes and do not represent a risk for consumers health.

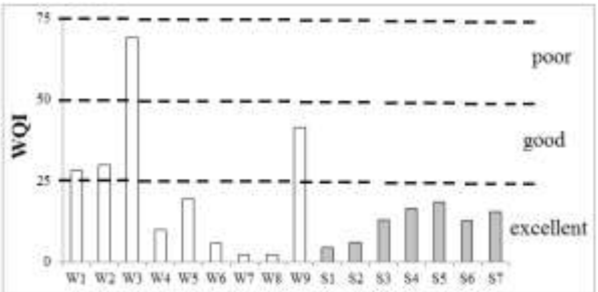

Fig. 4. Water quality status for the analysed wells (W) and springs (S), based on WQI value.
Source: Own determination

CONCLUSIONS

Some of the analysed waters proved to have a more acidic pH than the national limits. All the analyzed waters had the levels for Cl^-, SO_4^{2-} and Na^+ within the limits imposed by national legislation for drinking water. The nitrate content from wells exceeded the national limits for 22% of the samples.

The nickel content was within the national limit for drinking water, being higher in springs due to the more acidic pH.

The levels of the analyzed quality parameters were lower during January and February 2017 than in March 2017, when the high amounts of precipitations enhanced the salts dissolution.

Based on WQI, the overall chemical quality of most of the investigated water sources correspond to excellent and good status, being suitable for drinking, cooking, agricultural or recreational purposes.

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