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A BASELINE ASSESSMENT OF WATER QUALITY FROM PRIVATE WELLS LOCATED IN CONSTANTA COUNTY AND RISK IMPLICATIONS FOR COMMUNITY HEALTH

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Abstract

The aim of the research was to evaluate the quality of drinking water from five private wells (W1-W5) located in Negresti-Cobadin, Constanta County, Romania. The evaluation consisted in determination of some specific parameters as pH, electrical conductivity (EC), total hardness (TH), ammonium, nitrate and nitrite concentrations and oxidisability index. The results were compared with quality standards for drinking water imposed by Council Directive 98/83/EC and also with Romanian legislation. The pH, EC, nitrite and ammonium levels for all water samples are within recommended ranges. The TH values are higher and range between 27.41 and 47.14 mg CaO/L. Concerning nitrate levels, it is noteworthy to mention that excepting W4 sampling point, all water samples exceeded (as average) maximum admitted level. Oxidisability parameter indicates for wells W1-W4 values were below 5 mg O₂/L, meanwhile in the case of W5 found value exceeded slightly limit value.

Keywords: *conductivity, nitrate, nitrite, pollution, water.*

Introduction

Protecting the quality of drinking water is a major challenge considering that the presence of undesirable pollutants may be unacceptable due to their health effects and decrease of water quality. Among the contaminants of water, nitrate and nitrite species occupy an important place and is a common problem in many parts of the world and it is generated by agriculture (fertilizers and manure), domestic activities, municipal wastewater and sludge, septic systems (Scaeteanu et al 2014). The main manifestation of high nitrate levels in drinking water or food is methemoglobinemia, which appears mainly to babies or to elder people (Santamaria 2006).

Given that drinking water quality is an actual and astringent problem and the presence of some chemical species above limits are harmful for human health, it was evaluated some specific parameters (pH, electrical conductivity (EC), total hardness (TH), nitrate, nitrite, ammonium, oxidisability) for well water samples collected from Negresti-Cobadin, Constanta County, Romania, during 2016-2017.

Measurement of various water quality parameters provides information to facilitate protection of the community health, to investigate and identify pollution sources. Monitoring long-term trends in source water quality leads to prepare for future challenges of regulations.

Materials and Methods

Water samples were collected from five wells (labelled **W1-W5**) located in Negresti-Cobadin, Constanta County, Romania. The samples were collected from wells during three sampling campaigns: **S1** (October 2016), **S2** (January 2017) and **S3** (April 2017). Selected wells represent sources of drinking water and are used also for domestic usage as cooking, washing, etc. It was analyzed 15 water samples in triplicate (5 wells x 3 sampling moments) and the results are average of the determinations. All samples were collected in polyethylene bottles rinsed with sample water before collection and were carried to the laboratory where were stored at 4°C to avoid possible degradation of chemical species that are present in water. Chemical analyses were conducted within 48 hours of collection. A presentation of the analyses, methods and apparatus used for analytical determination of the subjected parameters are presented elsewhere (Scaeteanu & Madjar 2017).

The experiment was designed as a bifactorial one and the studied factors are: **A factor** - the location and **B factor** - the sampling moment.

Results and Discussion

The obtained results (as average of determinations) are presented in Table 1.

Table 1. The average values of the quality parameters for well water

Well	pH	EC μS/cm	TH (mg CaO/L)	NO ₃ ⁻ mg/L	NO ₂ ⁻ mg/L	Oxidisability mg O ₂ /L
W1	7.12	1343	28.33	64.23	0.048	2.52
W2	7.25	1505	32.10	145.31	0.082	2.37
W3	7.21	1274	30.90	50.46	0.020	1.89
W4	7.04	1124	27.41	19.55	0.019	2.16
W5	7.18	2207	47.14	235.56	0.110	5.22
Limits	6.5-9.5*	2500*	min.5* 20-30**	50*	0.5*	5*

*According to Official Journal of the European Communities, Council Directive 98/83/EC (1998) and to Law no. 458/2002 (2011); **STAS 1342/1991

The influence of location (A factor) and sampling moment (B factor) on pH value from water samples collected from Negresti –Cobadin, Constanta County

The average of the determinations for pH parameter is between 7.04 and 7.25, these values being within limits imposed by legislation (6.5-9.5). There are no significant differences between W2, W3 and W5 sampling points and significant as against W1 and W4. The results of the analyses indicate a neutral to slightly alkaline reaction for analyzed water samples. The influence of the sampling moment on pH average values indicates significant differences with the highest value in S3 moment (7.64).

Similar pH values for well water collected from Patarlagele and Paltinis villages, Buzau County (Senila et al 2017) and Maneciu-Ungureni, Prahova County (Scaeteanu & Madjar 2017) were reported. According to literature, drinking water should be almost neutral with pH values between 6.8-8.5 (Cohl et al 2014).

Table 2. The influence of location (A factor) and sampling moment (B factor) on pH value from water samples

B A	S1	S2	S3	Average A
W1	a6.80b	a7.20a	b7.37a	b7.12
W2	a6.85c	a7.15b	a7.75a	a7.25
W3	b6.64c	a7.27b	a7.72a	a7.21
W4	b6.54c	b6.95b	a7.63a	b7.04
W5	b6.60c	a7.22b	a7.74a	a7.18
Average B	6.69c	7.16b	7.64a	

Average A: LSD 5% = 0.10* ; LSD 1% = 0.15; LSD 0.1% = 0.23

Average B: LSD 5% = 0.08* ; LSD 1% = 0.11; LSD 0.1% = 0.16

¹B constant A variable: LSD 5% = 0.18* ; LSD 1% = 0.25; LSD 0.1% = 0.35

²A constant B variable: LSD 5% = 0.19* ; LSD 1% = 0.26; LSD 0.1% = 0.36

There were made interpretations by LSD 5% indicated in the table by "**"

¹Means with different letters in a column (in front of data) are significant different.

²Means with different letters in a row (in back of data) are significant different.

The influence of location (A factor) and sampling moment (B factor) on EC value from water samples collected from Negresti –Cobadin, Constanta County

The average values of EC ($\mu\text{S}/\text{cm}$) for analyzed water samples indicate significant differences for all sampling points, the highest average value being encountered for W5 (2207 $\mu\text{S}/\text{cm}$), but lower than maximum admitted limit (2500 $\mu\text{S}/\text{cm}$).

Table 3. The influence of location (A factor) and sampling moment (B factor) on EC ($\mu\text{S}/\text{cm}$) value from water samples

B A	S1	S2	S3	Average A
W1	c1366a	c1375a	c1288b	c1343
W2	b1472b	b1545a	b1497b	b1505
W3	d1288a	d1295a	d1239b	d1274
W4	e1129a	e1109b	e1135a	e1124
W5	a1733b	a1748b	a3140a	a2207
Average B	1398c	1414b	1660a	

Average A: LSD 5% = 10.44* $\mu\text{S}/\text{cm}$; LSD 1% = 15.19 $\mu\text{S}/\text{cm}$; LSD 0.1% = 22.83 $\mu\text{S}/\text{cm}$

Average B: LSD 5% = 9.73* $\mu\text{S}/\text{cm}$; LSD 1% = 13.27 $\mu\text{S}/\text{cm}$; LSD 0.1% = 17.95 $\mu\text{S}/\text{cm}$

¹B constant A variable: LSD 5% = 19* $\mu\text{S}/\text{cm}$; LSD 1% = 27 $\mu\text{S}/\text{cm}$; LSD 0.1% = 37 $\mu\text{S}/\text{cm}$

²A constant B variable: LSD 5% = 22* $\mu\text{S}/\text{cm}$; LSD 1% = 30 $\mu\text{S}/\text{cm}$; LSD 0.1% = 40 $\mu\text{S}/\text{cm}$

There were made interpretations by LSD 5% indicated in the table by "**"

¹Means with different letters in a column (in front of data) are significant different.

²Means with different letters in a row (in back of data) are significant different.

Significant differences are given by sampling moment, but with average values lower than 2000 $\mu\text{S}/\text{cm}$, excepting S3 sampling moment for W5 sampling point (3140 $\mu\text{S}/\text{cm}$). Similar results were reported for well water collected from Buzău County (Senila et al 2017), meanwhile much lower values for EC were found for water samples collected Prahova County (Scaeteanu & Madjar 2017).

The influence of location (A factor) and sampling moment (B factor) on TH value from water samples collected from Negresti –Cobadin, Constanta County

The values for TH parameter is between 28.33 and 47.14 mg CaO/L, higher than the minimum value of 5 mg CaO/L imposed by legislation (Law no. 458/2002 2011), with no significant differences between W1, W2, W3 and W4 but with significant differences as against W5. The influence of the sampling moment on TH average values indicates significant differences, the highest value being encountered in S3 for W5 (67.08 mg CaO/L), 2.23 times higher than recommended value of 30 mg CaO/L. This result is concordance with slightly alkaline reaction of water samples. Drinking water with high total hardness may produce nephrolithiasis, influence iron absorption or produce laxative effects. Also, the degree of water hardness is correlated with aesthetic acceptability by consumers (WHO 2011).

Table 4. The influence of location (A factor) and sampling moment (B factor) on TH (mg CaO/L) value from water samples

B				
A	S1	S2	S3	Average A
W1	a37.63a	a28.00b	c19.37c	b28.33
W2	a43.45a	a27.32b	b25.53b	b32.10
W3	a40.76a	b23.96b	b28.00b	b30.90
W4	a38.08a	b19.26b	b24.91b	b27.41
W5	a40.32b	a34.03c	a67.08a	a47.14
Average B	40.05a	28.51c	32.98b	

Average A: LSD 5%= 5.14* mgCaO/L; LSD 1%=7.49 mgCaO/L; LSD 0.1%=11.25 mgCaO/L
 Average B: LSD 5%= 3.64* mgCaO/L; LSD 1%=4.97 mgCaO/L; LSD 0.1%=6.73 mgCaO/L
¹B constant A variable: LSD 5%= 7.68* mgCaO/L; LSD 1%=10.73 mgCaO/L; LSD 0.1%=15.10 mgCaO/L
²A constant B variable: LSD 5%= 8.15* mgCaO/L; LSD 1%=11.12 mgCaO/L; LSD 0.1%=15.05 mgCaO/L

There were made interpretations by LSD 5% indicated in the table by “*”

¹Means with different letters in a column (in front of data) are significant different.

²Means with different letters in a row (in back of data) are significant different.

The influence of location (A factor) and sampling moment (B factor) on nitrate levels from water samples collected from Negresti –Cobadin, Constanta County

The average content for nitrate in water samples indicate significant differences with concentrations higher than limit value of 50 mg/L for four sampling points (W1, W2, W3, W4). The highest average value is 235.56 mg/L for W5, this being 4.71 times higher than maximum admitted level. The influence of sampling moment on average values indicates significant differences with concentrations that exceed the limit value. The highest concentration is 141.30 mg/L for S3, for this sampling moment being found also the value 400.17 mg/L for W5, 8 times higher than maximum admitted level. The lowest concentrations are recorded for W4, with an average of 19.55 mg/L and the sample collected at S3 present the lowest nitrate level of 16.90 mg/L.

A study developed in Romania during 2009 (Tudor & Staicu 2009) revealed that 58% from reported cases of infant methemoglobinemy appeared when consumed

well water was 101-500 mg /L nitrate-contaminated. Also, 20% of cases were reported when nitrate levels were between 0-50 mg/L.

Table 5. The influence of location (A factor) and sampling moment (B factor) on nitrate levels (mg/L) value from water samples

B A	S1	S2	S3	Average A
W1	c61.10b	c76.35a	c55.25c	c64.23
W2	b110.83c	b139.78b	b185.34a	b145.31
W3	d51.05a	d51.49a	d48.86b	d50.46
W4	e21.32a	e20.44a	e16.90b	e19.55
W5	a158.23b	a148.29c	a400.17a	a235.56
Average B	80.51c	87.27b	141.30a	

Average A: LSD 5%= 2.35* mg/L; LSD 1%=3.43 mg/L; LSD 0.1%=5.15 mg/L.
 Average B: LSD 5%= 0.65* mg/L; LSD 1%=0.88 mg/L; LSD 0.1%=1.20 mg/L.
¹B constant A variable: LSD 5%= 2.07* mg/L; LSD 1%=2.97 mg/L; LSD 0.1%=4.38 mg/L.
²A constant B variable: LSD 5%= 1.45* mg/L; LSD 1%=1.98 mg/L; LSD 0.1%=2.68 mg/L.

There were made interpretations by LSD 5% indicated in the table by "a,b,c"

¹Means with different letters in a column (in front of data) are significant different.

²Means with different letters in a row (in back of data) are significant different.

The influence of location (A factor) and sampling moment (B factor) on nitrite levels from water samples collected from Negresti –Cobadin, Constanta County

The influence of location on nitrite concentrations indicates no significant differences between W3 and W4 and significant as against the other locations. The found values are between 0.019-0.110 and are below limit value of 0.5 mg/L. The influence of sampling moment an average values present significant differences with values that are below limit value, the highest concentration (0.169 mg/L) being found in the case of W5 at S3 sampling moment.

Having in view the cumulative hazardous effect of the simultaneous presence nitrate and nitrite in drinking water according to Council Directive 98/83/EC, there must be ensured the relation: $[\text{nitrate}]/50 + [\text{nitrite}]/3 \leq 1$, where the square brackets represent the concentrations in mg/L for both species. The results in our study conducted to the following values: 1.30 for W1, 2.93 for W2, 1.01 for W3, 0.39 for W4, 4.74 for W5. As it may be observed, for W1, W2, W3 and W5 the calculated parameter exceeded the limit value, the highest value being found in the case of the well with highest nitrate and nitrite levels.

There are many studies that deal with nitrate and nitrite levels found in well water collected from different areas in Romania. Extreme values of nitrate, higher than 300 mg/L were reported for Matca (Galati County), Sahateni (Buzau County) and Clinчени (Ilfov County) (Pele et al 2010). Concerning nitrite, values above 0.5 mg/L were detected in well water from Matca (Pele et al 2010). Also, in well water from Ozun village (Covasna) nitrate levels exceeded the limit value even 3 times, meanwhile nitrite concentrations were within safe limit (Raduly & Farkas 2017).

Table 6. The influence of location (A factor) and sampling moment (B factor) on nitrite levels (mg/L) value from water samples

B A	S1	S2	S3	Average A
W1	b0.074a	b0.050b	d0.020c	c0.048
W2	c0.038c	a0.074b	b0.134a	b0.082
W3	e0.010b	c0.023a	c0.028a	d0.020
W4	d0.029a	c0.018b	e0.011c	d0.019
W5	a0.109b	b0.053c	a0.169a	a0.110
Average B	0.052b	0.044c	0.072a	

Average A: LSD 5%= 0.005* mg/L; LSD 1%=0.007 mg/L; LSD 0.1%=0.011 mg/L.

Average B: LSD 5%= 0.002* mg/L; LSD 1%=0.003 mg/L; LSD 0.1%=0.004 mg/L.

¹B constant A variable: LSD 5%= 0.005* mg/L; LSD 1%=0.008 mg/L; LSD 0.1%=0.012 mg/L.

²A constant B variable: LSD 5%= 0.005* mg/L; LSD 1%=0.0071 mg/L; LSD 0.1%=0.0103 mg/L.

There were made interpretations by LSD 5% indicated in the table by “**”

¹Means with different letters in a column (in front of data) are significant different.

²Means with different letters in a row (in back of data) are significant different.

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The influence of location (A factor) and sampling moment (B factor) on oxidisability (mg O₂/L) from water samples collected from Negresti –Cobadin, Constanta County Oxidisability parameter indicates water pollution and is expressed as amount of oxygen that oxidize organic species. Clean water usually has oxidisability between 2-4 mg O₂/L (Cohl et al 2014).

Table 7. The influence of location (A factor) and sampling moment (B factor) on oxidisability parameter (mg/L) from water samples

There were made interpretations by LSD 5% indicated in the table by “**”

B A	S1	S2	S3	Average A
W1	b2.16b	b2.80a	b2.61a	b2.52
W2	b2.08c	c2.32b	b2.70a	b2.37
W3	c1.92a	d2.00a	c1.76b	d1.89
W4	c1.84b	b2.80a	c1.84b	c2.16
W5	a4.40b	a3.20c	a8.07a	a5.22
Average B	2.48c	2.62b	3.40a	

Average A: LSD 5%= 0.15* mg O₂/L; LSD 1%=0.22 mg O₂/L; LSD 0.1%=0.34 mg O₂/L

Average B: LSD 5%= 0.10* mg O₂/L ; LSD 1%=0.13 mg O₂/L ; LSD 0.1%=0.18 mg O₂/L

¹B constant A variable: LSD 5%= 0.21* mg O₂/L; LSD 1%=0.30 mg O₂/L; LSD 0.1%=0.43 mg O₂/L

²A constant B variable: LSD 5%= 0.22* mg O₂/L; LSD 1%=0.30 mg O₂/L; LSD 0.1%=0.41 mg O₂/L

¹Means with different letters in a column (in front of data) are significant different.

²Means with different letters in a row (in back of data) are significant different.

The average values for oxidisability parameter indicate no significant differences for W1 and W2 and significant as against W3, W4 and W5 with values between 1.89-5.22 mg O₂/L. For one well was found a slightly higher value (5.22 mg O₂/L) than limit (5 mg O₂/L). The influence of the sampling moment on average values indicates significant differences with values lower than imposed limit. The highest value is found for W5 at S3 (8.07 mg O₂/L), 1.61 times higher than limit value. The lowest values were encountered for W3 (1.89 mg O₂/L, as average), the sample collected from W3 at S3 presenting the lowest oxidisability value (1.76 mg O₂/L).

Conclusions

The main objective of the research was to monitor water quality parameters such as pH, electrical conductivity (EC), total hardness (TH), oxidisability, nitrate, nitrite and ammonium concentrations in wells located in Negresti-Cobadin, Constanta County during 3 sampling campaigns (during 2016-2017) from 5 wells. The results of the analyses led to the conclusions presented below:

The pH and EC for all water samples are within recommended ranges, 6.5-9.5 pH units and 2500 μ S/cm, respectively.

The TH values are higher and range between 27.41 and 47.14 mgCaO/L (as average), these values being often encountered for well water.

Violations of the parametric value for nitrate (50 mg/L) imposed by European and Romanian legislation were detected for a large number of water samples (73.33% from total). Excepting W4 sampling point, all water samples exceeded (as average) maximum admitted level. For W5 the found value was 4.71 times higher than limit value.

Nitrite levels were below maximum admitted level, the highest average concentration (for W5) being 4.54 times lower than limit value (0.5 mg/L).

Ammonium levels for all sampling points and sampling moments were below detection limit of the method.

Oxidisability parameter for wells W1-W4 presented values below 5 mg O₂/L, meanwhile in the case of W5 found value exceeded slightly limit value (5.22 mg O₂/L, as average).

As a general conclusion, the values of some subjected parameters (pH, conductivity) are similar with those already reported for other areas (Maneciu-Ungureni, Prahova County, Patarlagele and Paltinis villages, Buzau County). Nitrate contents of W1-W4 analyzed water samples are similar with those found for water collected from Clincheni, meanwhile for W5 nitrate concentrations are comparable with those found for some wells located in Sahateni. The identified values of nitrite are similar with those reported for Branesti but higher than those from Sahateni. Oxidisability parameter determined in this study presents values higher than those reported for Maneciu-Ungureni, Prahova County (1.33-2.61 mgO₂/L).

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