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# STUDY OF RURAL GROUNDWATER QUALITY IN BRESTEA VILLAGE, ROMANIA

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***Abstract***

*Water is a social requirement and an important factor in the ecological balance. Water from wells is good for direct consumption if the soil is not contaminated. The quality of drinking water is regulated by Law no. 458/2002 (transposing the Directive 98/83/EC on the quality of drinking water). The aim of this paper was to assess the physico-chemical qualities of groundwaters from Brestea village, commune Denta, Timis County. The water samples were taken in 2015 from 10 functional wells. For the source whose physical and chemical parameters have exceeded the limit values, the monthly monitoring of the water quality (microbiological and physico-chemical properties) has been performed for 2 years. At the same time, the pH of the soil near the water sources was also measured. The results highlighted a good connection between the microorganisms from water and the nitrite, nitrate and ammonium content of water. The information can be further used to identify and eliminate the specific pollutants, areas and pollution sources.*

***Keywords***: *groundwater quality, rural area, wells.*

## INTRODUCTION

In the past, people had a real cult of fountains with rich springs and good water that meant health. Besides the fountains from private households, each locality also has public fountains recognized as having "good water". Clean normal water is a standard necessity of life (Sandeep et al., 2014; Salagean et al 2015). Drinking water must be health providing, clean, without microorganisms, parasites or substances which, by number or concentration, can be a potential hazard for human and animal health (Todoran et al., 2010; Sandu et al., 2015; SAMUEL et al., 2017).

In the world, the underground waters are one of the most important resource, taking into account that unlike surface waters they are usually less polluted or even unpolluted. Therefore, underground waters may be made potable using minimal measures, sometimes using only disinfection, or without any treatment (Negrea et al., 2009).

In rural areas that don't have distribution of potable water through public supply systems, the wells that represent sources of groundwater are very important. This water is not treated and is often subjected to chemical and microbiological pollution from anthropogenic sources (Jamshidzadeh et al., 2007). The ground water in rural areas can be polluted as a result of farming activities (Pivic et al., 2017). The quality of the drinking water drawn in wells can be affected especially for those wells that are placed in the valleys, and at insufficient distance from the stables (Muntean et al., 2006; Navarro et al., 2007; Salagean et al 2015).

Water quality assessment is made by measuring of certain parameters (physical, chemical and microbiological) whose limits are defined legally (Calisevici et al., 2011).

In this context, the aim of the present paper is to investigate the quality of water from the wells of Breștea village, Timis County, Romania. The results of the study showed that the values of physico-chemical and microbiological parameters of waters from wells were in some cases above the limit values for drinking water.

## MATERIALS AND METHODS

Figure 1 shows the map of the Brestea village and the locations of the wells from which water samples were taken.


Figure 1. The map of wells from Brestea, Denta commune, Timis County

The water from 10 wells located in Brestea village, Denta commune, Timis County and the soil near the water source were analysed in March 2015. Subsequently, for 2 years, the source no. 8 has been monitored.

For **pH measurement**, an InoLab pH-meter was used. Water samples were analysed directly. The following procedure was used for the soil samples: the samples were dried for 7 days at 40°C, sieved to less than 2 mm in a plastic sieve and ground to a fine powder using an agate ball mill. Soil samples, treated as describe above, were mixed with potassium chloride solution 1 $mol \cdot L^{-1}$ in a 1:5 (g:ml) ratio and shacked for 15 min before measuring (SR ISO 10390, 2015).

**Determination of permanganate index**

25 ml of water sample is heated in a boiling water-bath with a known amount of potassium permanganate (20 mmol / l) and 5 ml sulfuric acid for a fixed period time (10 min). The principle consist in reducing part of the permanganate by oxidizable material in the sample and determining the consumed permanganate by addition of an excess of oxalate solution (5 ml), followed by titration with permanganate (ISO 8467, 1993).

**The rapid spectrophotometric methods for determination of ammonium, nitrates and nitrites:** The Spectroquant® NOVA 60 photometer (SQ) and the SQ specific kits (with reagents and reaction tubes) were used (Comitet omologare metode, 2004).

**Ammonium:** spectrophotometric kit for 0.010-2 mg/l $NH_4$-N or 0.01-2.58 mg/l domain. 0.5 ml of sample is droped in the reaction tube and homogenised. A dose of $NH_4$-1K is added. In high alkaline solutions, the nitrogen ammonia is present almost totally as ammonia, reacts with hypochlorite ions forming monochloramine, which reacts with substitute fenol and forms a blue indocarbolitic derivative.

**Nitrates:** spectrophotometric kit for 1.0-50.0 $mg/dm^3$ $NO_3$-N or 2.2–79.7 $mg/dm^3$ $NO^-_3$ domain. 0.5 ml of test is putted in the tube. 1 ml of $NO_3$-1K is added, The mix is shacked for a minute and let aside for 10 minutes. In sulphuric acid solution nitrate ions react with a derivative of benzoic acid to form a red nitro compound.

**Nitrites**: spectrophotometric kit for 0.02 – 1.00 $mg/dm^3$ $NO_2$-N or 0.07-3.28 $NO_2$ for a 10 mm tube. 5 ml of sample are mixed with $NO_2$ reagent and shake until total dissolution. In acid solution, nitrite ions react with the sulphanilic acid resulting diazonium compound; it reacts with N-1-naftiletilendiamine dihydro-chloride forming a violet red nitro compound.

**Determination of iron:** 5 ml of sample is mixed with 3 drops of $Fe^{-1}$ reagent and homogenized. The iron content is measured spectrophotometrically.

**Determination of total number of bacteria growing at 37°C** (SR EN ISO 6222, 2004; SR EN ISO 8199:2008)

The method consists in inoculation by including 1-2 ml of sample or decimal dilutions ($10^{-1}$ and $10^{-2}$) into a Petri plate in 10-15 $cm^3$ nutritive gellose (melted and cooled at 45°C); after the solidification of the gellose, the plates are incubated at 37±2°C for 44±4 h. All the colonies are counted, both those at the surface and the ones within the gellose.

## RESULTS AND DISCUSSIONS

The results of the physico-chemical analyses of water and soil samples are presented in figures 2 to 8.

The results revealed exceeding of pH limits in samples 3 and 7, of ammonium ions in sample 8 and of iron ions in samples 8, 9 and 10.

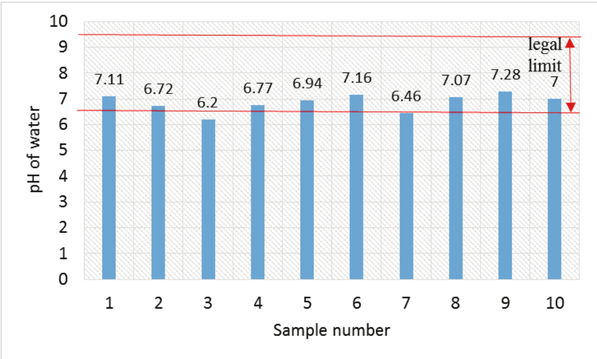


Figure 2. pH values of waters sampled from 10 wells

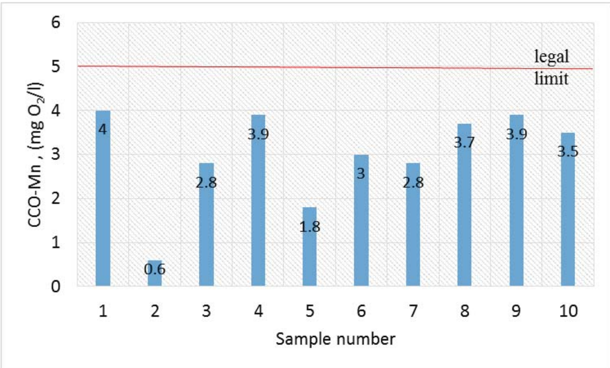


Figure 3. CCO-Mn of waters studied

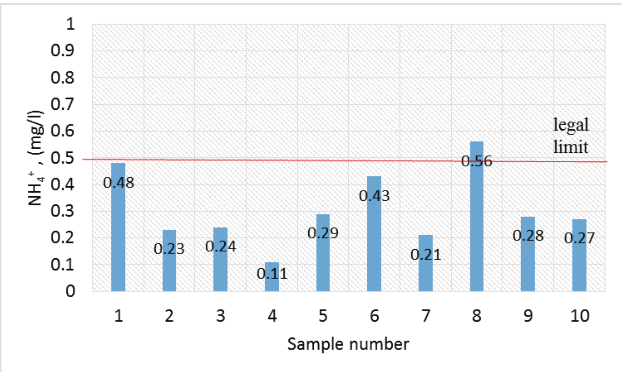


Figure 4. $NH_4^+$ in waters studied

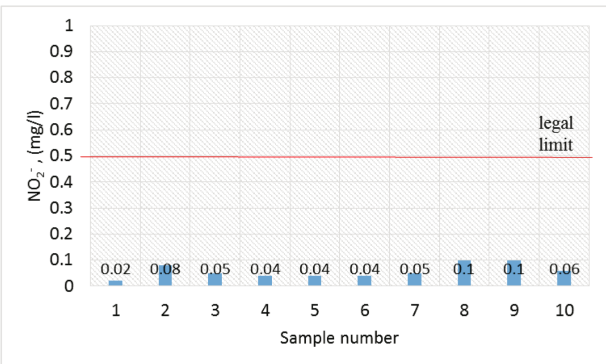


Figure 5. $NO_2^-$ in waters studied

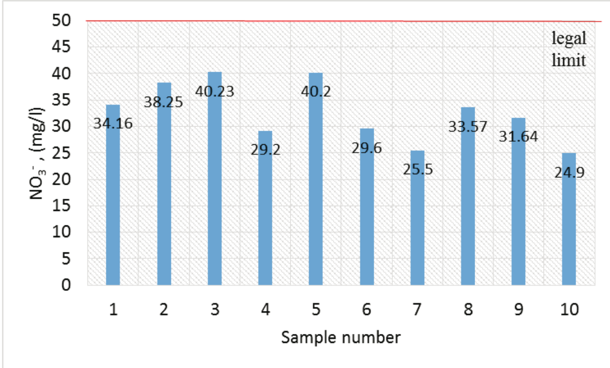


Figure 6. $NO_3^-$ in waters studied

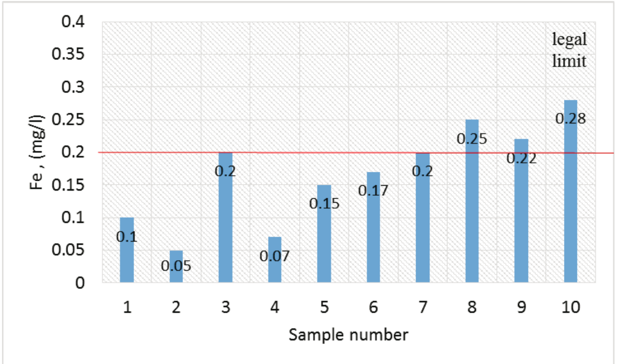


Figure 7. Fe concentration in waters studied

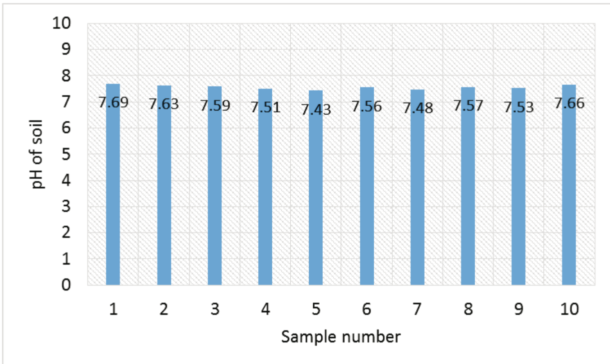


Figure 8. pH of soil near the wells

It has also been found that the characteristics of water from wells located in different areas (upstream, downstream, centre of the locality) are very close. This information are useful for detecting specific pollutants, areas and sources of pollution (households, livestock units, uncontrolled fertilization of agricultural lands, polluting industries, etc.).

In order to identify the parameters that increase the microbiological content of the water from a well, the source number 8, with the higher content of ammonium, was chosen for the study. Every month, for two years (between April 2015 and April 2017), samples of water were taken and analysed in terms of colony-forming units (CFU/ml) and $NH_4^+$, $NO_2^-$ and $NO_3^-$ content. The results are presented in table 1.

Table 1. Time variation of physico-chemical and microbiological parameters of water sampled from source number 8

| Time (month) | CFU/ml | $NH_4^+$ (mg/l) | $NO_2^-$ (mg/l) | $NO_3^-$ (mg/l) |
|---|---|---|---|---|
| 0 | 42 | 0.56 | 0.1 | 33.57 |
| 1 | 58 | 0.29 | 0.20 | 32.14 |
| 2 | 74 | 0.37 | 0.25 | 46.28 |
| 3 | 83 | 0.41 | 0.30 | 47.75 |
| 4 | 102 | 0.50 | 0.38 | 47.86 |
| 5 | 134 | 0.54 | 0.27 | 47.48 |
| 6 | 158 | 0.60 | 0.38 | 49.44 |
| 7 | 175 | 0.68 | 0.42 | 54.35 |
| 8 | 148 | 0.57 | 0.30 | 58.78 |
| 9 | 149 | 0.60 | 0.36 | 55.85 |
| 10 | 134 | 0.75 | 0.30 | 41.51 |
| 11 | 84 | 0.41 | 0.24 | 34.43 |
| 12 | 72 | 0.36 | 0.20 | 32.84 |
| 13 | 70 | 0.35 | 0.17 | 42.42 |
| 14 | 77 | 0.38 | 0.18 | 36.45 |
| 15 | 85 | 0.42 | 0.30 | 40.19 |
| 16 | 92 | 0.45 | 0.27 | 42.65 |
| 17 | 90 | 0.44 | 0.21 | 42.26 |
| 18 | 112 | 0.55 | 0.27 | 45.64 |
| 19 | 116 | 0.57 | 0.26 | 44.25 |
| 20 | 141 | 0.64 | 0.40 | 48.72 |
| 21 | 138 | 0.68 | 0.34 | 45.12 |
| 22 | 118 | 0.58 | 0.30 | 37.13 |
| 23 | 94 | 0.46 | 0.27 | 38.42 |
| 24 | 91 | 0.45 | 0.25 | 36.72 |

Law no. 311/2004 which completes the Law no. 458/2002 (republished) on the quality of drinking water, harmonized with European Union legislation - Council Directive 98/83/EC on the quality of water intended for human consumption require a maximum CFU / ml limit of 20 for drinking water.

The Romanian legislation no longer specifies limits for the water from wells (regulations are for drinking water only) and the maximum allowed for CFU is "lowered" from 300 to 20 colonies. The method used for determination is similar to that from STAS 3001. Nitrogen, nutrient of great importance in aquatic ecosystems, enter in several ways and is found in water in many forms: molecular nitrogen, nitrogen oxides, ammonia, ammonium, nitrites and nitrates. Consequently, nitrogen biochemistry involves the consideration of all nitrogen oxidation states, from 5 to 0 and -3. (Lupea, 2003).

In ecosystem, nitrogen enters in the biogeo-chemical cycle, determined by a complex of interactional factors from aquatic ecosystems. Algae can use the free nitrogen from water and salts ammonia and after their exhaustion even the nitrate (Botnariuc et Vădineanu, 1982).

*Statistical analysis.* The experimental results have suggested the existence of a time dependence between the microbial load of water and the various forms of nitrogen in water.

For an accurate description of that dependence, it was proposed a polynomial equation of first degree expressed by equation 1 (Borse, 1997; Todinca et Geanta, 1999; Elnashaie et Uhlig, 2007).

$$y = a_0 + a_1 \cdot x_1 + a_2 \cdot x_2 \qquad (1)$$

where: $a_0$, $a_1$, $a_2$ are the coefficients of equation; y is the colony-forming units (CFU/ml); $x_1$ is the time (months) ; $x_2$ is the nitrogen form in water: a) $NH_4^+$ (mg/l), b) $NO_3^-$ (mg/l), c) $NO_2^-$ (mg/l).

By using MATLAB 7.2 (R2006a), the experimental data were processed and analysed.

The equation of mathematical statistical models are presented in Table 2.

Table 2. Equations of statistical mathematical models

| Case | Equations of statistical mathematical models |
|---|---|
| a) | $y = -11.3685 + 0.1176 \cdot x_1 + 228.8617 \cdot x_2$ |
| b) | $y = -78.2547 + 1.3205 \cdot x_1 + 3.8782 \cdot x_2$ |
| c) | $y = -0.4578 + 0.3211 \cdot x_1 + 368.8026 \cdot x_2$ |

The equations are valid on the range of studied values. For the validation of the model were used the following indicators of adequacy (table 3).

Table 3. Indicators of adequacy of statistical models determined

| Case | Variance, $\sigma^2$ | Indicator of the precision of the model, $R^2$ | Correlation coefficient, R |
|---|---|---|---|
| a) | 20.5663 | 0.6397 | 0.7998 |
| b) | 19.9572 | 0.6607 | 0.8129 |
| c) | 18.7352 | 0.7010 | 0.8373 |

The values from table 3 are indicating a satisfactory correlation between the determined statistical model and experimental data. This confirms the fact that mathematical equations describe with sufficient accuracy the CFU evolution in time as a function of some nitrogen compounds.

## CONCLUSIONS

The results of the study evidence that anthropogenic pollution affects the quality of water from wells located in Brestea village. The water supply number 8 is physico-chemical and microbiological polluted in any season. There is also a diffuse microbiological pollution, which indicates that the ground water is polluted and the natural purification does not succeed. The water source exceeds frequently the limits allowed by legislation for total number of bacteria. It is clear that all activities taking place on the surface have an impact on groundwater quality.

The study shows that the risk due to consumption of water from wells in Brestea village is reduced, but not completely.

The equations of statistical models can be used to approximate the microbiological growth in water from wells knowing the time of the year when the sample was collected and its content of ammonium ion, nitrates or nitrites. The values of adequacy indicators revealed a satisfactory prediction capacity of mathematical statistical models. Also, the model predictions can constitute a control criterion for assessing groundwater quality.

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