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Drinking water quality assessment of rural wells from Aiud Area

Diana I. Călin, and Cristina Roşu

Faculty of Environmental Sciences, Babeş-Bolyai University, Cluj-Napoca, Romania. Corresponding author: D. I. Călin, dia_calin@yahoo.com

Abstract. The present paper presents the assessment of physico-chemical quality of drinking water coming from rural wells of Aiud area (villages: Măgina, Livezile, Poiana Aiudului, Vălişoara). Water quality was evaluated through a research project conducted over a period of eight months (October 2009 - May 2010). It consisted of a monthly monitoring of water physico-chemical characteristics of 27 drinking wells from the villages mentioned above. There were monitored monthly in the laboratory the following parameters: pH, temperature, oxidation-reduction potential, electric conductivity, total dissolved solids, salinity, using WTW Multi-parameter inolab 720. In April and May, at the parameters mentioned above were added chemical measurements for the following indicators: Ca^{2+}, Na^{+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, PO_4^{3-}, HCO_3^{-}, which analysis were performed with Dionex Ion Chromatograph System 2100. The results of the chemical analysis were processed using the following methods: linear regression, Pearson correlation coefficient (r) and water quality index (WQI). This monitoring project was initiated from the premise of a problematic quality of well waters, based on the well known contamination vulnerability of the drinking water in Romania, but the results of this study proved the opposite: the water from the monitored wells had a proper quality for drinking.
Key words: underground water, well water, water quality index, drinking water.

Rezumat. Lucrarea de faţă prezintă evaluarea fizico-chimică a calităţii apei de consum ce provine din fântânile din zona rurală a oraşului Aiud (Măgina, Livezile, Poiana Aiudului, Vălişoara). S-a evaluat calitatea apei de consum în urma unui proiect de cercetare desfăşurat pe o durată de 8 luni (octombrie 2009 - mai 2010). Acesta a constat într-o monitorizare lunară a caracteristicilor fizico-chimice ale apei din cele 27 de fântâni din perimetrul rural menţionat mai sus. S-au monitorizat lunar în laborator următorii parametrii: pH, temperatura, potenţialul de oxido-reducere, conductivitatea electrică, substanţele total dizolvate, salinitatea, utilizând multiparametrul WTW inolab 720. În lunile aprilie şi mai, la parametrii menţionaţi mai sus, s-au adăugat măsurători pentru următorii indicatori chimici: Ca^{2+}, Na^{+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, PO_4^{3-}, HCO_3^{-}, măsurători care au fost realizate cu ion-cromatograful Dionex Sistem 2100. Rezultatele analizelor chimice s-au interpretat pe baza următoarelor metode: regresie liniară, coeficientul de corelaţie Pearson (r) şi indicele de calitate al apei WQI. În elaborarea acestui proiect de monitorizare s-a plecat de la premisa unei probleme în ceea ce priveşte calitatea apei de băut din România, însă rezultatele acestui studiu s-au dovedit a fi unele pozitive: apa din fântânile monitorizate are o calitate bună pentru consum.
Cuvinte cheie: apă subterană, apă de fântână, indicele de calitate al apei, apă de băut.

Introduction. Access to safe drinking water is a basic human right, a primary requirement for development and civilization and an essential element for ensuring public health and quality of life.

According to WHO guidelines, access to a safe drinking water source represents the availability of at least 20 liters of water per person per day, up to 1 km radius of the user's home. In Romania, 43% of the population doesn't have access to safe drinking water sources. According to the Sustainable Development Index (SDI), in the EU, Romania has the worst infrastructure in this field, with the lowest score, 5.6 on a scale from 1 to 10, of which the average is 9.8 in the EU (Popovici et al 2008 p.48; Nan 2009; Mănescu et al 2006).

The statistics show that only 67% of the Romania's population benefits of drinking water distributed through the public system. A percentage of 90% of the urban population is connected to drinking water supply systems, while only 30% of the rural population benefits of this service (Popovici et al 2008; Nan 2009).

In the rural areas, 7 million inhabitants (67% of the rural population) procure their drinking water from wells (Samwell 2003). These waters are often polluted with nitrates, microorganisms and pesticides due to the poor management of waste, outdoor latrines, inadequate designed septic tanks and agricultural activities. Consumption of contaminated water can cause serious health problems. Between 1985 and 1996, in Romania there were 2913 cases of Baby Blue Desease, of which 102 were fatal (Popovici et al 2008). In the report "Assessment of the acute infantile methemoglobine cases generated from well water consume", Anca Tudor says that in 2007, there were 128 infantile cases of methemoglobine in Romania, of which 3 had been fatal. Three of the 128 ill children were from Alba county, the same county in which we conducted the present study (Tudor 2007).

Study purpose. Our purpose was the physico-chemical quality assessment of drinking water from 27 wells of the rural area located in the North-Western side of Aiud town (Măgina, Livezile, Poiana Aiudului, Vălişoara).

Specific objective. The objective was monthly monitoring of physico-chemical characteristics of underground-water coming from 27 drinking wells from the rural area Măgina, Livezile, Poiana Aiudului and Vălişoara for a period of eight months.

Study area. The rural area selected for the present study is represented by the next villages: Măgina, Livezile, Poiana Aiudului and Vălişoara. These villages are located on the North-West side of Aiud town, in Alba County, Romania, on the county road DJ 107 Aiud - Buru, between 46^{0}20'28" to 46^{0}23'33" North latitude and 23^{0}33'39" to 23^{0} 39'52" East longitude (see Figure 1).

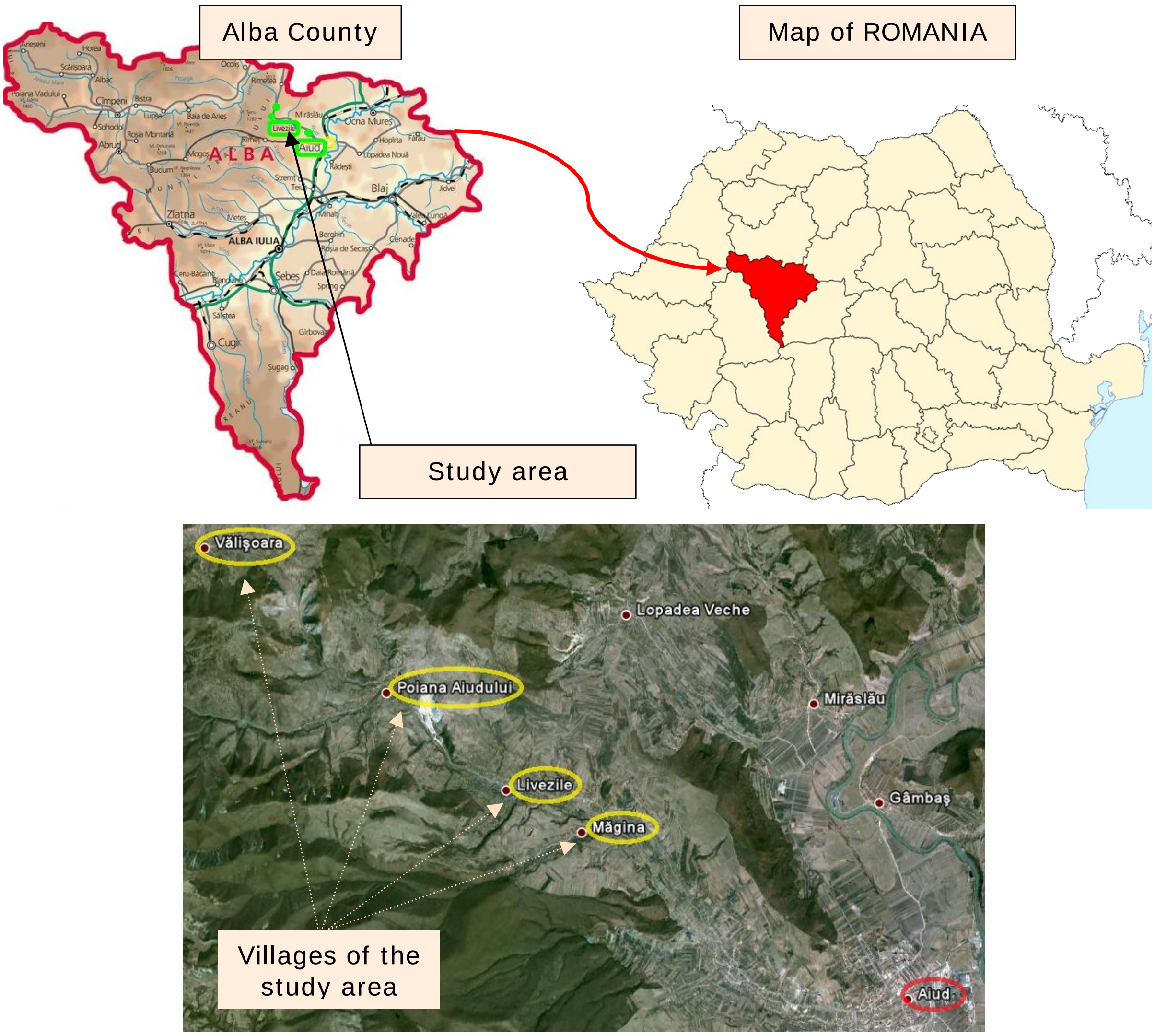

Figure 1. Location of the study area.

The study area is situated on the East side of Trascău Mountain. Thus, there is a hilly relief, with an altitude that varies from 320 meters in the East up to 520 meters in the West (Măgina 320m, Livezile 335-350m, Poiana Aiudului 380-420m, Vălişoara 520m).

Aiudel River is flowing through these villages, which in Aiud joints into Mureş river. Geologically, the majority of the area contains chalk, known as a very permeable rock that gives a high vulnerability for groundwater contamination (Muresan 2003). These villages are characterized by a temperate continental climate, with specific features of hilly areas climate in Măgina and Livezile, and mountains influences on the local climate in Poiana Aiudului and Vălişoara. The multi-annual average temperature in Măgina and Livezile 7.5°C, while in Poiana and Vălişoara is 6.5^{0}C. The measured rainfall in the area has a multi-annual mean of 577 mm.

A percentage of 60.9% of the villages surface is covered by forest, while only 36% of the land is used in agricultural activities and less than 5% is arable land, fact that involves a low risk for groundwater pollution through agricultural practices. There are no industrial activities in these villages.

The inhabitants of this villages have no access to a safe drinking water supply system, thus they are using drinking water coming from public or private wells.

Material and Method. The following materials were used for water sampling and analysing processes:

- 27 sterile polyethylene (PE) containers - 100 mL;
- Hanna electronic thermometer for in-situ measurements;
- Eset Garmin GPS;
- WTW inolab 720 Multi-parameter;
- Dionex Ion Chromatography System 2100.

Selection of the sampling wells. In this project we opted for a uniform distribution of the sampling wells on the each village area. We selected 27 representative wells with the following distribution: 5 in Măgina, 6 in Livezile, 7 in Poiana Aiudului and 9 in Vălişoara (see Figure 1 for the village locations).

Monitoring period. We conducted this monitoring project for a period of eight months. We collected well water samples monthly from October to May, except March. The hydrologists recommend a maximum of four annual water samples for an aquifer, but in karst aquifers Makela & Meybeck (1996) recommend a monthly monitoring due to the high permeability of this rocks.

Monthly monitored parameters: pH, T, ORP, EC, TDS, salinity. In April and May, we added the following chemical parameters: Ca^{2+}, Na^{+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, PO_4^{3-}, HCO_3^{-}.

Water sampling. The sampling process is a very important stage in assessing the water physco-chemical characteristics. The precision of this process is a significant determinant of the results accuracy. In carrying out this activity, we followed the methodology recommended by the "General guide for underground-water sampling SR ISO 5667-11".

We collected the water samples into 27 sterile polyethylene containers. During the field work we carried the samples in a portable heat-resistant bag, and then we kept them in the refrigerator no longer than 72 hours until the laboratory analysis were done.
During the 8 months research project, we have collected and analyzed a total of 196 water samples. The number of samples collected in every village is shown on the next page in Figure 2.

Mapping the water sampling locations (wells). To execute subsequent maps of the water sampling points, we identified the geographic coordinates of each well using Garmin GPS Eset. Once we had this coordinates, we realized the maps using ArcGis (see Figures 3 and 4).

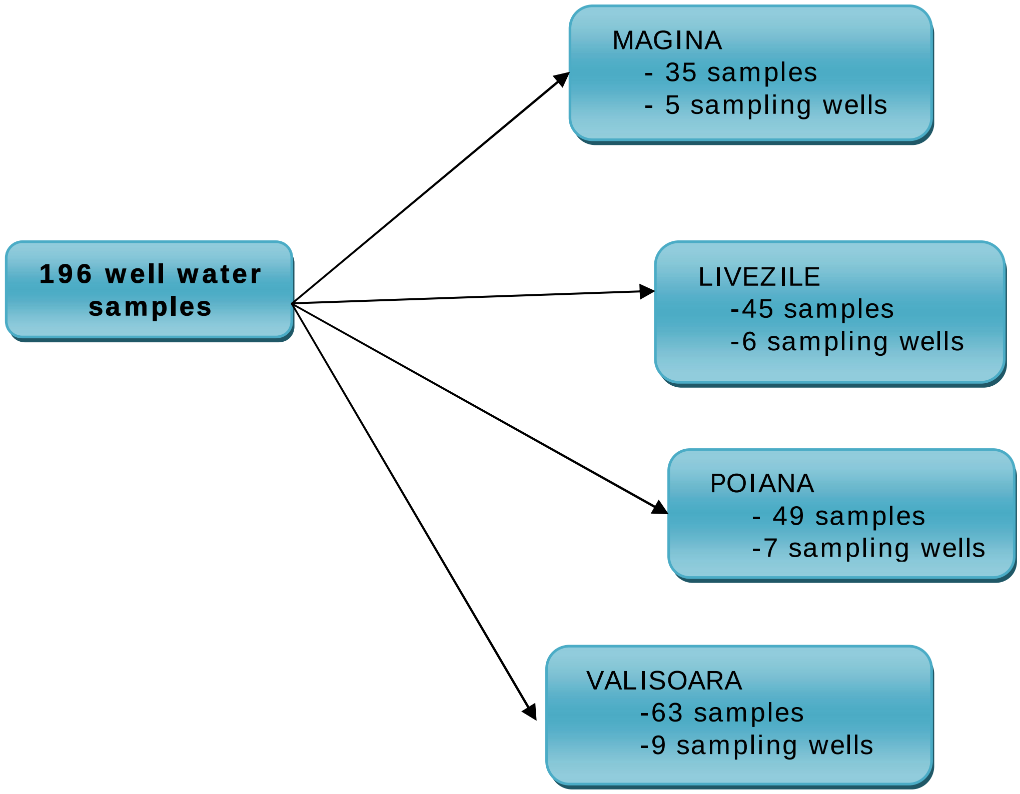

Figure 2. The total number of water samples.

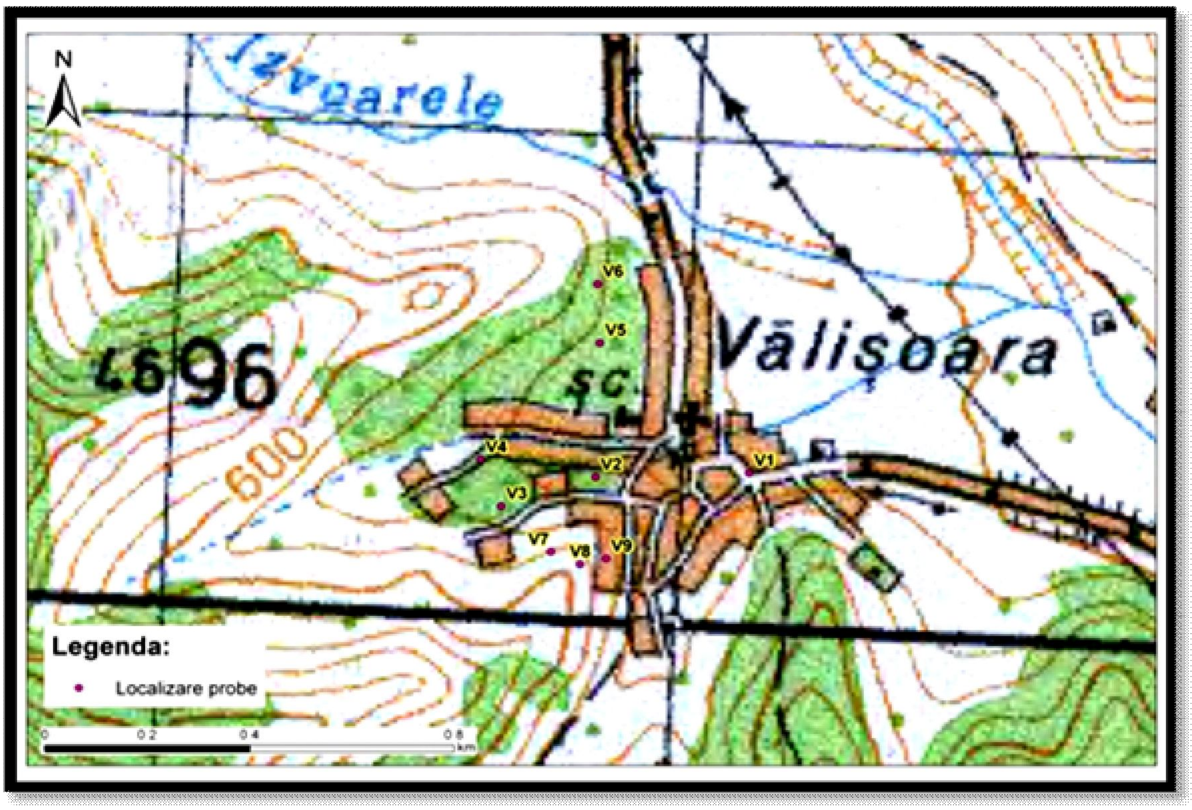

Figure 3. Underground water sampling location (wells, marked: ●) in Vălişoara village.

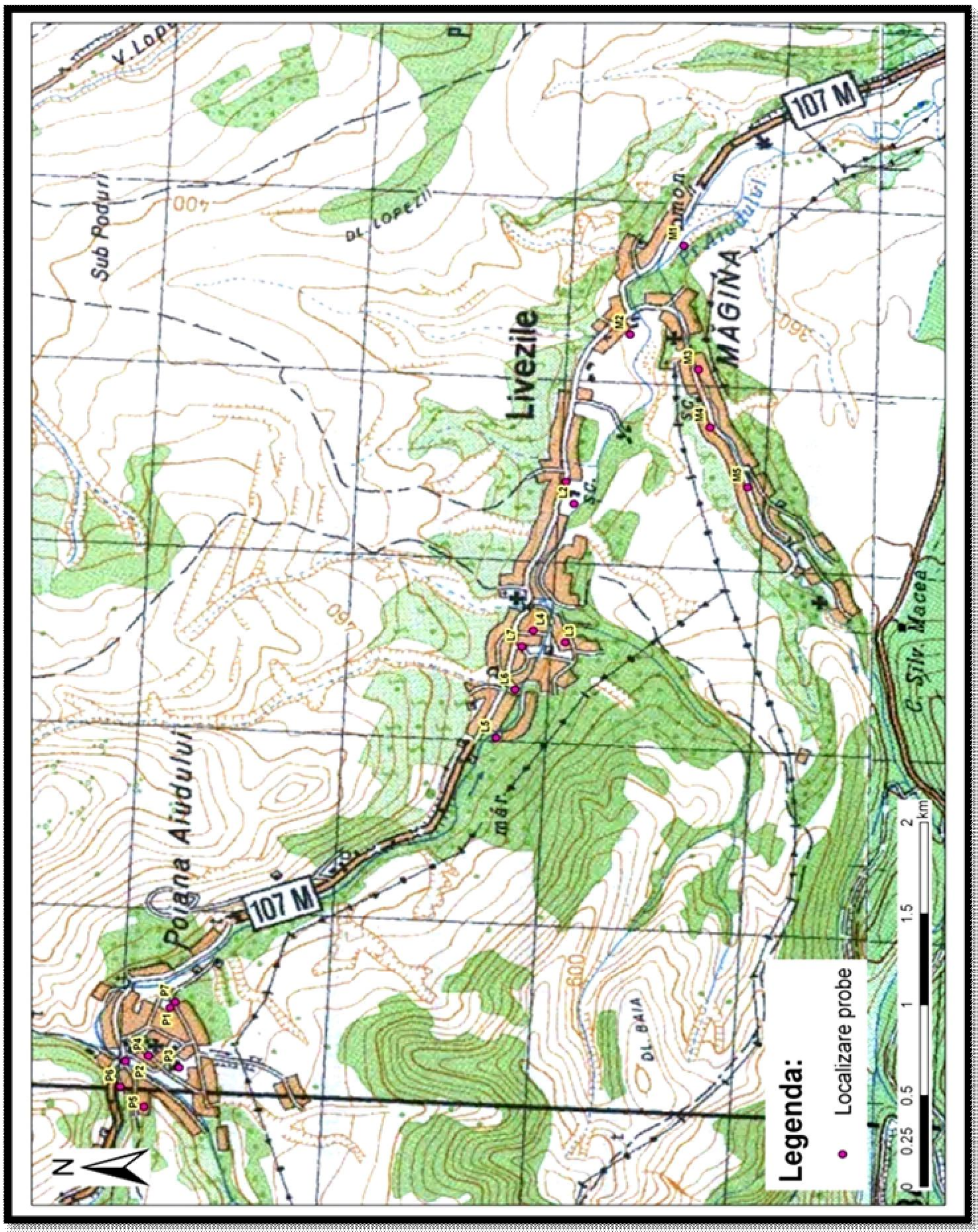

Figure 4. Underground-water sampling locations (wells, marked: ●)
from Măgina, Livezile and Poiana.

Laboratory analysis. Using WTW multi-parameter inolab 720 were determined the physico-chemical parameters (pH, ORP, EC, TDS, salinity), but only after calibrating the device with standard buffer solutions for pH and electric conductivity. WTW inolab 720 functioning is based on sensors, one is measuring pH, ORP and the other one measures EC, TDS and salinity.

For analyzing the chemical parameters (Ca^{2+}, Na^{+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, PO_4^{3-}, HCO_3^{-}), it was used Dionex Ion Chromatograph System 2100 (ICS-2100). The ICS-2100 system is the first Reagent-Free™ ion chromatography system with electrolytic sample preparation and eluent generation capabilities designed to perform all types of electrolytically IC separations using conductivity detection.

Water Quality Assessment. The Water Quality Index aims at assessing the quality of water from a source through a single numerical value, calculated on the basis of one system which translates all the constituents and their concentrations present in a sample into a single value. This is a very effective method that allows you to compare the quality of various water samples based on the indicator values of each sample (Rajendra et al 2009). To calculate the water quality indices we followed the methodology presented by Rajendra and Ramakrishnaiah in their studies.

Results and Discussion. The physico-chemical parameters monitored during the eight months, the maximum admissible concentrations permitted by legislation (Romanian legislation -458/2002 completed by 311/2004, WHO, EPA US) and the minimum and the maximum concentrations determined in the well water samples are shown in the table below:

Table 1

Extreme values determined for the monitored parameters

Physico-chemical parameters	Drinking well water MIN	MAX	Maximum admissible concentrations
pH	6.76	8.93	6.5-9.5
ORP, mV	-537	14.3	650 (WHO)
EC, µS/cm	251	1834	2500 (RO)
TDS, mg/L	125	917	500 (RO)
Salinity, ‰	0	0.7	0.2 (EPA)
Ca^{2+}, mg/L	19	217	200 (RO)
Mg^{2+}, mg/L	3	32	50 (RO)
Na^{+}, mg/L	2	108	200 (RO)
Cl^{-}, mg/L	5	219	250 (RO)
SO_4^{2-}, mg/L	5	114	250 (RO)
NO_3^{-}, mg/L	5	14	50 (RO)
PO_4^{3-}, mg/L	0.05	0.21	1(EPA)
HCO_3^{-} , mg/L	83	409	900 (EPA)

From a total of 192 well water samples collected, 55.72% had exceeded the maximum admissible concentration values allowed for the following parameters: TDS, salinity and Ca^{2+}.

A percentage of 22.39% of all the samples exceeded 500 mg/l for TDS, the EPA standard. Almost half of the samples (49.47%) were characterized by salinity higher than 0 ‰ .

The concentration of the chemical elements presented in the table above was determined in the last two months of monitoring (April and May), as from the 192 water samples, a total of 54 have undergone complete set of analyses. The calcium ions were the only chemical elements that exceeded the maximum admissible concentration. There have been two exceeded of the maximum admissible concentration for Ca^{2+} for 2 samples from different wells (M4, M5) in April.

None of the monitored parameters have shown major variations in different water sample collected from the same well. Well water properties remained relatively constant during the 8 months of monitoring. No relevant seasonal influences on the water quality have been noticed. The water samples which have exceeded the maximum admissible concentration for certain parameters have retained the trend throughout the period of monitoring for the every single well.

Of the 27 wells monitored, eight didn't have any exceeded of the accepted maximum admissible concentrations for any parameter during the eight months of monitoring.

In situ temperature ranged from 7.3^{0}C to 14.8^{0}C, with an average of 10.7^{0}C, during the sampling process in the 8 months of monitoring. The pH measured presented oscillations between 6.76 and 8.93, with an averaged of 7.79. The ORP's values ranged between -537mV and +14.3mV, with an average of -187.17 mV. The electric conductivity measured in the laboratory for groundwater samples presented variations between 251 µS/cm and 1834 µS/cm, with an average of 842.41 µS/cm. The TDS values ranged from 125 mg/L to 917 mg/L, but with an average of 422.11 mg/L, smaller than the maximum value allowed. The salinity presented variations between 0 and 0.7 ‰, with an average of 0.172 ‰.

Calcium concentrations ranged from 19 mg/L to 217 mg/L, with an average of 82.96 mg/L. The sodium ranged from 2 mg/L to 108 mg/L, with an average of 29.31 mg/L. The magnesium ranged from 3 mg/L to 32 mg/L, with an average concentration of 10.88 mg/L. Sulfate concentrations have ranged between 5 and 141 mg/L, with an average concentration of 54.79 mg/L. The chlorine ion presented variations between 5 mg/L and 219 mg/L, with an average of 45.66 mg/L. The phosphate concentration ranged between 0.05 and 0.21mg/L, with an average of 0.0985 mg/L. The nitrate had concentrations that ranged between 5 mg/L and 14 mg/L, whose average was 9.96mg/L. Hydrogen carbonate concentrations varied between 83 and 409 mg/L, with an average of 244.11 mg/L.

The representative values of the physico-chemical parameters determined in the water samples from each village are presented by a normal statistical interpretation in the Table 2.

Compared with the well water quality from the other monitored villages, Măgina has a higher percentage of wells with improper water quality according to analyzed parameters. There were registered exceeded of the maximum admissible concentrations for the parameters in all the sampling points monitored. Three of the five monitored wells from Măgina exceeded the maximum admissible concentrations for TDS and salinity monthly. These wells are built on Aiudel river shore, at an average distance of 16.6 m. Thus we admit the possibility of a good communication between the river water and the groundwater that supplies the wells. This can be an explanation of the poorer quality of the well water from this village compared to the upstream area.

The well water from Livezile presented exceeded only for salinity and in only two sources of the six monitored in this village.

In Poiana Aiudului five of the seven monitored wells exceeded the TDS or salinity maximum admissible concentrations.

In Vălişoara, six of the nine monitored wells had water with a higher salinity than 0 ‰ and the water collected from 2 wells exceeded the maximum permissible for TDS.

Following this physico-chemical assessment, we found out that the well water monitored has only one qualitative problem: a too high content of salts. According to the experts in medicine, a salinity that exceeds the concentration of 0.2 ‰ in drinking water is a long term hazard for the consumers with kidney and cardiovascular problems (Vermesan et al 2007).

The analysis results were processed using the following methods:

- Linear regression;
- Calculating the Pearson correlation coefficient (r);
- Computing the water quality index WQI.

Correlation and regression analysis for the chemical and physical parameters monitored. Correlation is a statistical method which analyzes the possible relationships between two or more variables taken from the same group of objects, which has the index **r** the correlation coefficient.

Correlation coefficient is a quantitative value that describes the relationship between two or more variables. This coefficient **r** varies between two extreme values: 1 (perfect positive correlation) and -1 (perfect negative correlation).

Table 2

Normal statistics for water quality parameters of groundwater samples

	MIN	MAX	Mean	Standard deviation	Median
MAGINA					
pH	7.09	8.53	7.671714	0.31517	7.71
ORP	-90.2	-1.8	-38.8657	19.50211	-41.6
EC	542	1834	1213.829	376.4619	1180
TDS	271	**917**	606.5857	188.3287	589.5
SAL	0	**0.7**	0.377143	0.215687	0.4
LIVEZILE					
pH	6.95	8.18	7.732222	0.377431	7.82
ORP	-66.7	3.5	-41.9467	21.64005	-46.3
EC	490	1046	662.3111	163.7381	772.7381
TDS	225	**523**	329.9778	82.80789	305
SAL	0	**0.3**	0.06	0.089484	0
POIANA					
pH	6.76	8.59	7.830408	0.475289	7.96
ORP	-91.6	14.3	-45.0729	27.9188	-53.6
EC	377	1496	868.0612	305.2336	899
TDS	188.5	**747.5**	433.8163	152.4791	450
SAL	0	**0.6**	0.183673	0.174818	0.2
VALISOARA					
pH	6.82	8.93	7.930984	0.447276	7.9
ORP	-537	10.4	-61.2867	64.79977	-52.3
EC	251	1120	626.2857	201.9373	633
TDS	125	**637**	318.0952	108.7533	316.5
SAL	0	**0.3**	0.069841	0.097773	0

For measuring the correlation between the physico-chemical parameters monitored, we opted for calculating simple Pearson correlation coefficient using Excel program.

We did the correlation matrices for the monitored parameters of the well water from each village in order to highlight the relationship between them. Calculating the correlation coefficient for each village, we used the local monthly average of each parameter monitored throughout the eight months of study.

Tables 3, 4, 5, 6 present the correlation matrices **r** Pearson for the physico-chemical parameters monitored in Măgina, Livezile, Poiana Aiudului and Vălişoara.

We found a significant positive correlation between TDS and EC in all four villages ($r > 0.9$) between salinity and EC, salinity and TDS in Poiana and significant negative correlation between pH and ORP in Livezile and Poiana, between pH and TDS in Vălişoara.

Table 3

Pearson correlation matrices for the water parameters monitored in Măgina

Parameters	pH	EC	TDS	ORP	Salinity
pH	1				
EC	0.46	1			
TDS	0.47	**0.99**	1		
ORP	-0.38	-0.8	0.75	1	
salinity	0.4119	0.752	0.751	-0.6	1

Table 4

Pearson correlation matrices for the water parameters monitored in Livezile

Parameters	pH	Ec	TDS	ORP	salinity
pH	1				
EC	-0.47	1			
TDS	-0.49	**0.98**	1		
ORP	**-0.99**	0.495	-0.8	1	
salinity	-0.64	0.843	0.82	0.65	1

Table 5

Pearson correlation matrices for the water parameters monitored in Poiana

Parameters	pH	Ec	TDS	ORP	salinity
pH	1				
EC	0.01	1			
TDS	0.004	**0.99**	1		
ORP	**-0.968**	0.049	0.057	1	
salinity	0.169	**0.932**	**0.93**	0.24	1

Table 6

Pearson correlation matrices for the water parameters monitored in Vălişoara

Parameters	pH	Ec	TDS	ORP	salinity
pH	1				
EC	-0.79	1			
TDS	**-0.90**	**0.91**	1		
ORP	-0.782	0.742	0.828	1	
salinity	-0.869	0.878	0.846	0.695	1

Regression analysis. Regression method purpose is to predict the values of one variable through correlated with the values of other variables on the basis of the regression equation.

Applying the regression analysis for the well water samples, we obtained the regression equations for all the physico-chemical parameters, the correlation coefficient **r** and the coefficient of determination R^2. We obtained a strong correlation between the following parameters: TDS – EC, ORP – pH, salinity - EC, salinity - TDS, TDS – pH, which is highlighted by the following graphs:

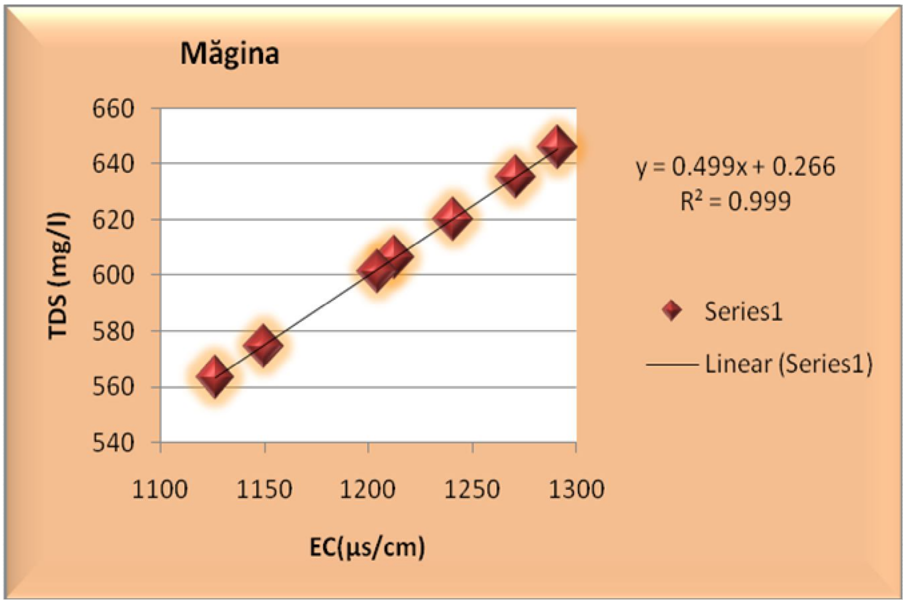

Figure 5. Linear regression between EC and TDS, Măgina samples.

The above chart shows a very strong dependence between the values of EC and TDS, highlighted by the perfect right of recourse, and by the coefficient of determination R^2 value. The same can be said about the chart below, only that this one analysis two other variables, ORP and pH, between which there is a strong relation of dependency.

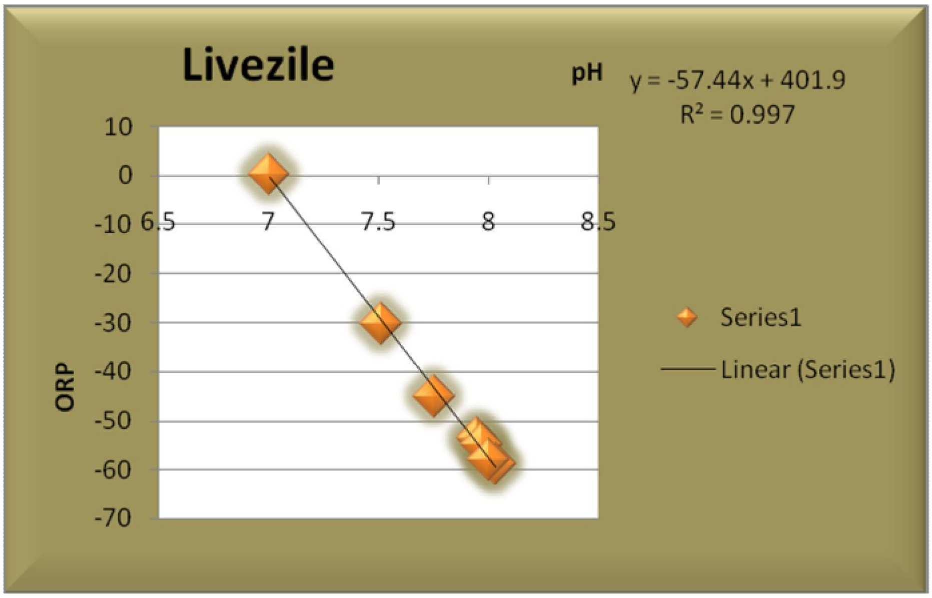

Figure 6. Linear regression chart of ORP and pH, Livezile samples.

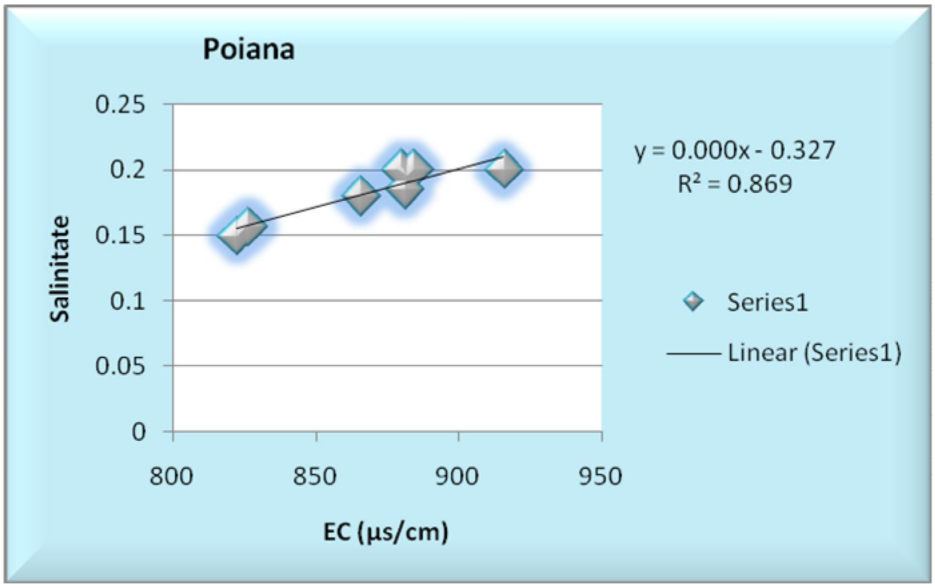

Figure 7. Linear regression chart for salinity and EC, Poiana samples.

The analysis results of the water samples collected during the eight months of monitoring in Poiana village, that were subjected to linear regression analysis demonstrate a strong dependence between the values of the following parameters: salinity and electric conductivity, salinity and TDS. This relationship between the mentioned parameters is illustrated by figure 7 and 8. Taking in account the strong correlation between EC and TDS, any variable that is dependent on TDS is clearly dependent on EC.

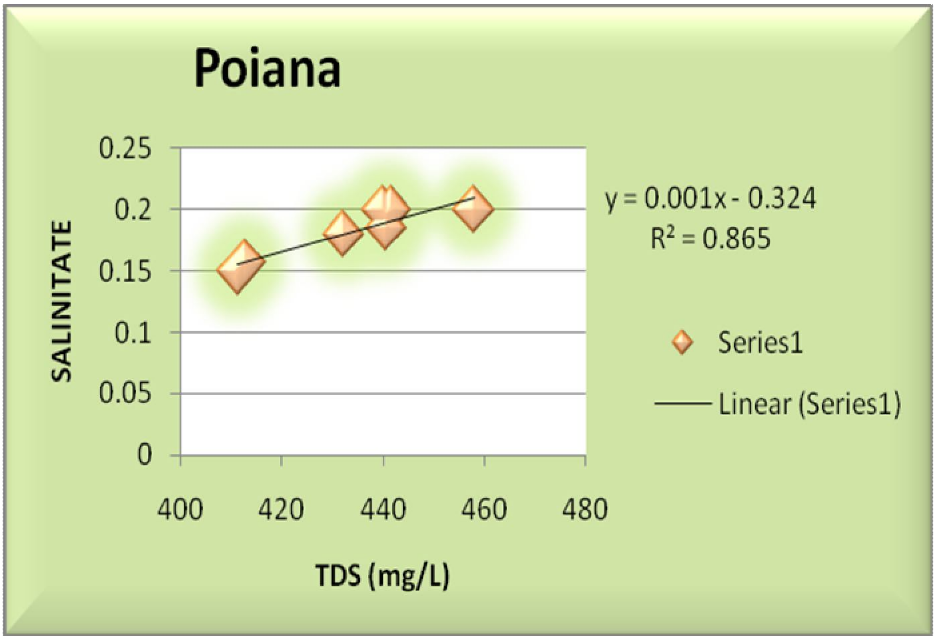

Figure 8. Linear regression graph between salinity and TDS, Poiana.

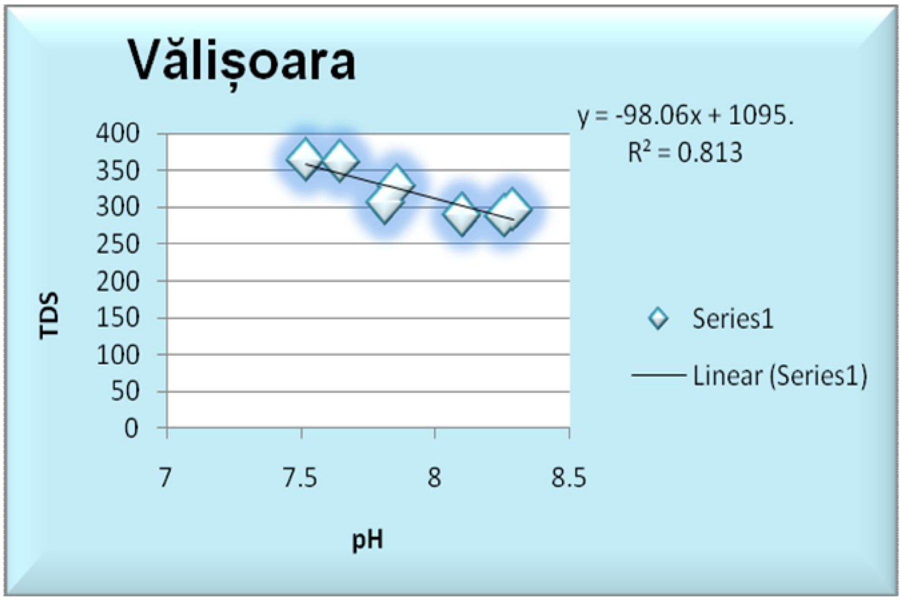

Figure 9. Linear regression graph of TDS and pH Vălişoara.

The TDS and pH are two other parameters between which we determined a strong correlation. We obtained this result from the regression analysis for the water samples collected in Vălişoara village. The above chart shows very clear the relationship between those two parameters.

Water quality index (WQI). We calculated WQI for all water sources monitored in April and May. To calculate the water quality indices we used the following key parameters of the ones monitored:

- May: pH, EC, TDS, Ca^{2+}, Na^{+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, PO_4^{3-}
- April: pH, EC, TDS, Ca^{2+}, Na^{+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, HCO_3^{-}

In order to calculate WQI, we followed three steps. The first step consisted in assigning a weight value (w_i) for each parameter according to its relative importance in the overall quality of water for drinking purposes (Tables 7-8). The maximum weight of 5 has been assigned to the parameter nitrate due to its major importance in water quality assessment. Like Ramakrishnaiah, we assigned a minimum weight of 1 for magnesium because it does not pose any danger to human health (Ramakrishnaiah et al 2009).

The second step was to calculate the relative weight (**W_i**) using the formulas from Rajendra and Ramakrishnaiah's studies. The calculated relative weights (**W_i**) are presented in Tables 7-8.

Table 7

Relative weights of physico-chemical parameters-April

Physico-chemical parameters	Maximum admissible concentration	Weight (w_i)	Relative weight (W_i)
pH	6.5 – 8.5	4	0.125
EC, µS/cm	2500 (RO)	3	0.093
TDS, mg/L	500 (EPA)	3	0.093
Ca^{2+}, mg/L	200 (RO)	2	0.062
Mg^{2+}, mg/L	50 (RO)	2	0.062
Na^{+}, mg/L	200 (RO)	2	0.062
Cl^{-}, mg/L	250 (RO)	3	0.093
SO_4^{2-}, mg/L	250 (RO)	4	0.125
NO_3^{-}, mg/L	50 (RO)	5	0.156
PO_4^{3-}, mg/L	1 (RO)	4	0.125

Table 8

Relative weights of physico-chemical parameters-May

Physico-chemical parameters	Maximum admissible concentrations	Weight (w_i)	Relative weight (W_i)
pH	6.5 – 8.5	4	0.16
EC, µS/cm	2500 (RO)	3	0.1 2
TDS, mg/L	500 (EPA)	3	0.12
Ca^{2+}, mg/L	200 (RO)	2	0.08
Mg^{2+}, mg/L	50 (RO)	2	0.08
Na^{+}, mg/L	200 (RO)	2	0.08
Cl^{-}, mg/L	250 (RO)	3	0.12
SO_4^{2-}, mg/L	250 (RO)	4	0.16
HCO_3^{-} , mg/L	900 (EPA)	1	0.04

WQI calculated values are divided into five quality levels: from unsuitable water for drinking to excellent water (Rajendra et al 2009; Ramakrishnaiah et al 2009).

The computed values of WQI in April and May range from 19.255 to 63.79.

51 of the 54 samples for which we calculated WQI, were classified as having an excellent quality, and the other three samples have good quality water. On April all the well water samples had an excellent quality, while on May three of the 27 monitored wells had good water for drinking, and those remaining still had excellent water for drinking. In Table 9 are presented the water quality classes based on the WQI values and the percentage and number of samples belonging to different classes of quality.

Table 9

Water quality classification based on WQI values

WQI value	Water quality	Samples number APRIL	P%	Samples number MAY	P%
< 50	Excellent	27	100	24	88.8
50 – 100	Good water	0	0	3	11.1
100 – 200	Poor water	0	0	0	0
200 – 300	Very poor water	0	0	0	0
> 300	Unsuitable water for drinking	0	0	0	0

Conclusions. This research approached a sensitive issue, if we take in account the high vulnerability of well water to contamination. The analysis results demonstrated that the well water from the study area has a proper quality for drinking.

The residents of the villages Măgina, Livezile, Poiana Aiudului and Vălişoara do not have access to a drinking water supply system, thus they use well water for drinking purpose. The drinking well water quality was assessed by analyzing 192 water samples, of which a percentage of 22.39% were strongly mineralized (TDS > 500 mg/L). Electric conductivity is a direct function of the total dissolved solids, fact that was also demonstrated by the regression analysis, but even though the electric conductivity was within the acceptable limits for all samples. 44.47% of the water samples have exceeded the salinity of 0 ‰ and 2 samples exceeded the permissible limit for calcium. A constant consumption of water characterized by a higher salinity than 0 ‰ is a potential health risk, especially for people suffering of kidney and cardiovascular diseases.

Despite the fact that these underground waters have a high vulnerability to contamination because they are coming from karst aquifers, there have been no exceeded of the maximum concentration allowed for nitrates, all samples had a lower concentration than 50 mg/L. In some locations, the wells are built at a shorter distance than 15 m from the latrine or animal manure, but even in these cases the water quality was not affected. The only explication that can be given are the natural attenuation processes that may occur into soil, layer which serves as a good filter. One advantage for the good quality of the groundwater from the study area is the low intensity of farming practices(less than 5% of the total area of these villages is used as arable land).

Compared to the water from other villages, in Măgina we found high salinity of water. An explanation of this fact can be the intense communication between the groundwater body and Aiudel River in this village.

The analysis results indicate us low concentrations of calcium, magnesium, sodium and chlorine ion in all the water samples (except for 2 samples), which presents an advantage for the people suffering of cardiovascular disease.

WQI values assigned an excellent quality for drinking to all the water samples collected on April. On May, only 88.8% of the monitored wells had excellent water for drinking and the remaining 11.11% had good water. Undoubtedly, this seasonal quality changes are due to the groundwater dynamic, that were influenced by the large volume of precipitation that fall down on May.

Taking all into account, we conclude that the rural area Măgina, Livezile, Poiana Aiudului and Vălişoara has a proper groundwater for drinking from the analyzed parameters point of view and consume of that water does not pose health risks for the consumers.

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Authors:
Diana Ioana Călin, Babeş-Bolyai University, Faculty of Environmental Sciences, Romania, EU, Cluj-Napoca 400294, 30 Fântânele Street, dia_calin@yahoo.com
Cristina Roşu, Babeş-Bolyai University, Faculty of Environmental Sciences, Romania, EU, Cluj-Napoca 400294, 30 Fântânele Street, crisrosu@yahoo.com
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