QUALITY OF DRINKING WATER SUPPLIES IN ALMAŞU RURAL AREA (SALAJ COUNTY, ROMANIA)

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Abstract: The groundwater sources used for drinking water in rural areas (Almaşu commune) are often affected by natural contamination (the presence of natural chemical compounds in the water source), or artificial pollution resulted from the use of fertilizers and pesticides (chemical contamination) and uncontrolled discharges of domestic waste (microbiological contamination). Almaşu is the biggest commune of Sălaj County and is located in the southern part of the Almas River Basin, in N-W of Romania. The aim of this study is to determine the quality of water from households'wellsand from the local water supply system (recently put into use) from Almaşu village. This paper presents astudy regarding the quality of the water supplies used by the local population for drinking and food preparation; identification of possible contamination; the information of population regarding the quality of the drinking water and the possible risks when inappropriate water is used. The results regarding the main physico-chemical parameters (pH, redox potential, total dissolved solids, electrical conductivity and total hardness) shown that all the values are relatively low and below the maximum concentration level according the Romanian legislation. The values for salinity are between 0.20 – 0.80 ‰. The major anions (F^-, Cl^-, NO_2^{2-}, Br^-, NO_3^{3-}, PO_4^{3-}, SO_4^{2-}) were analyzed and the majority of water samples from wells have high levels of sulfate (values between 147- 260.46 mg/l) andnitrate (values between 136.54 - 334.07 mg/l). The results show that the quality of water from the distribution system is superior to the water from wells.

Keywords: drinking water, underground water, nitrate, contamination, Almaşu village.

1. INTRODUCTION

The purpose of this study is to present drinking water pollution from Almaşu village (Sălaj County – Romania). Also, one of the plans is to inform the population about the quality of drinking water, to expose the cases where is a contamination of drinking water. Lots of people from this rural area don't know the quality of the water they drink, and they don't understand the importance of the quality of drinking water on the human health.

The chosen area (Almaşu village) for this study is located in Sălaj County in the north-west part of the country. In this area weren't made before studies regarding the quality of drinking water. In rural area Almaşu were carried works for the execution of the water supply systems of the commune, with the help of European Programs, this works were completed in 2013. Until now only a part of the population is connected to the water supply of the village and from those who are connected many often use the water from wells, foreconomic reasons.

Water quality has become an increasing, environmental and social constraint for our society and in the last decade's groundwater pollution has become a growing problem, and in especially in rural areas (the population from rural areas uses as a primary source of drinking water the groundwater). Seven million people from rural areas of Romania use as drinking water source wells and often these wells are polluted with nitrates, bacteria and pesticides (Samwel, 2004).

The quality of drinking water is a permanent concern in our country, because of the high level of nitrites and nitrates found in some places, manly in rural areas. The studies regarding only water quality in villages are less frequent. A study in some UK villages

on water pollution has shown that ammonium and phosphates are the dominant pollutants and that nitrite has values above those considered dangerous to fish (0.1 mg/l), and low concentrations of nitrate (Withers et al., 2011). The level of nitrates and nitrites in some wells from Serbia´s southeast Pannonian Basin is generally small, the presence of the ammonium ion was found to have the most significant impact on groundwater quality (Polomčić et al., 2014). In the study made by Briciu & Oprea-Gancevici (2011) in rural areas from Dragomirna Plateau (Romania) –only 13 samples from 423 have concentration of nitrate exceeding the CMA (50 mg/l).

Several eastern European countries reported high levels of nitrate contamination in a large proportion in private wells; in Romania, for example, 20% of 2,000 wells had nitrate levels higher than 23 mg/L as nitrate-N (Jedrychowski et al., 1997).

Studies made in the south-east of the Romania, have shown that the villages near Bucharest have concentration of nitrates in wells below the value 50 mg/l, but in the villages were the agriculture is the main source of activity (from the southern part of the country), the level of nitrates increase around 200 mg/l (Pele et al., 2010).

Contamination of drinking water by nitrate is usually associated with pollution resulted from human activities in especially the agriculture do to the use of commercial fertilizers, as well as from human and animal waste. Many households have their well in the near of this source of pollution. Nitrates are highly soluble, and in time they can accumulate in groundwater which can be used as source of drinking water (Chiritescu, 2015).

Approximately 98% of nitrogen in soil is organic nitrogen which is not taken by the plants. The rest of the nitrogen that may be used by plants is formed by nitrate and ammonium (Hope et al., 2005). Almost 50-70% of the artificial nitrogen, which comes from the fertilizers, is consumed by plants, a part (2-20%) evaporates into the atmosphere, 15-25% form compounds with organic materials in soil, and the rest of 2-10% is transported to surface and groundwater (Kurt et al., 2012).

The anthropic activities altered the nitrogen cycle dramatically over the last half-century, and as a result, nitrate is steadily accumulating in our water resources. Since 1950, the globally human nitrogen production has increased rapidly and currently exceeds nitrogen fixed by natural sources by about 30% (Fields, 2004; Ward et al., 2005).

The contamination of drinking water with nitrate may increase cancer risk, because nitrate is endogenously reduced to nitrite and subsequent nitrosation reactions give rise to N-nitroso compounds

and these are considered highly carcinogenic (Weyer et al., 2001). In addition to the endogenous production of nitrate, is an increasing evidence for the beneficial role of this pathway in human health. Are some studies which shows its importance in protecting against oral and gastrointestinal diseases (Duncan et al., 1997) and also for its role in vascular fitness and exerting antihypertensive effects (Bryan & Loscalzo, 2011; Carlstrom et al., 2011; Lansley et al., 2011; Montenegro et al., 2011; Tang et al., 2011; Zhu et al., 2011).

Studies shows that nitrite appeared to cause fetotoxicity in rats at drinking-water concentrations equivalent to 200 and 300 mg of sodium nitrite per kilogram of body weight per day, causing increased maternal metHb levels, but teratogenic effects were not observed in reported studies in mice and rats. When nitrate levels in drinking-water exceed 50 mg/l, drinking-water will be the major source of total nitrate intake, especially for infants. Cases of methaemoglobinaemia related to lower intakes of nitrate appear to be restricted to infants. In infants under the age of 3 months, the conversion of nitrate to nitrite and metHb formation is high (Speijers et al., 1989; FAO/WHO, 1996).

In the below table are given some indication regarding the level of nitrates in drinking water and the possible effect on human.

Table 1. Level of nitrate in drinking water and effect on human health (source: Daniels &Mesner, 2010)

Nitrate Level, mg/l	Interpretation
0-10	Safe for humans and livestock. However, concentrations of more than 4 mg/l are an indicator of possible pollution sources and could cause environmental problems.
11-20	Generally safe for human adults. Not safe for infants because their digestive systems cannot absorb and excrete nitrate.
21-40	Should not be used as a drinking water source but short-term use acceptable for adults and all livestock unless food or feed sources are very high in nitrates.
41-100	Risky for adults and young livestock. Probably acceptable for mature livestock if feed is low in nitrates.
Over 100	Should not be used as drinking water for humans or livestock.

2. MATERIALS AND METHODS

The water samples were collected from different water sources from Almaşu commune, Sălaj County, Romania. Were taken and analyzed samples from six private wells from Almaşu village (codes: WA.3, WA.5, WA.6, WA.7, WA.8, WA.9)

(see figure 1);one sample from the spring which is the source for the local water supply in Almaşu village (before the treatment process), the springing take place in Stana village (WA.1); one sample from an another spring from Stana village (WA.2); one sample from the local water supply of Almaşu village (WA.4). The water sources for the distribution system of Almaşu village is located in an area were pollution is minimal. The water from the local water supply is sanitized before to be used by the population.

The main physico-chemical parameters of water (pH, temperature (T), redox potential (ORP), electrical conductivity (EC), total dissolved solids (TDS) and salinity (S), were analyzed at the sampling place. It is important to determine these parameters at the sampling place, because until this are transported to the laboratory, the values may decrease or increase, and because of the physical and biological processes which take place into the sample. Analyses were carried out using a Multiparameter WTW 720 Series (InoLab). The pH electrode used in determination present internal temperature compensation.

Using the complexometric titration method (with EDTA in presence of Eriochrome -T indicator) the total hardness of waters was determined.

The turbidity of the drinking water samples was measured using a WTW turbidimeter.

The water samples for the anions determination were taken in polyethylene bottles and transported into the lab and stored at 4˚C. Were analyzed 7 anions (F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}) with DIONEX ICS 1500 Ion Chromatography.

The samples were filtered through a 0.45 µm millipore filter and diluted with ultrapure water in function by the conductivity of the sample (to a maximum of 100 µS/cm). The samplings take place in March 2016.

3. RESULTS AND DISCUSSIONS

For this study, we have selected to analyze different groundwater sources used for drinking in Almaşu commune, to be able to compare the quality of water from private wells and of water from the local water supply, which has also as source groundwater.
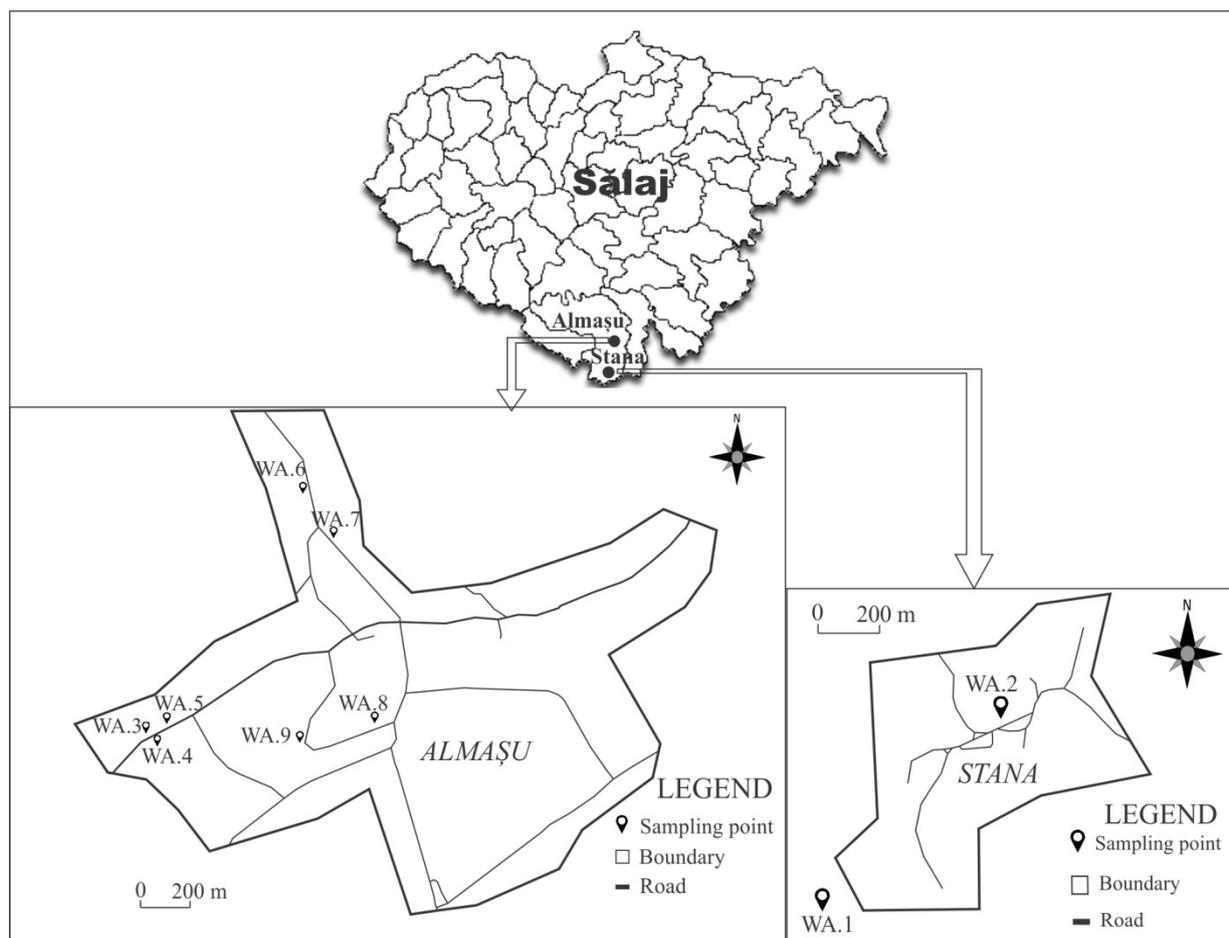

Figure 1. Location of the sampling points: Sample WA.1 spring -source of the water supply; WA.2 – spring Stana; WA.3, WA.5, WA.6, WA.7, WA.8, WA.9 – private wells; WA.4 - local water supply

In the table 2 are presented the results regarding the main physico-chemical parameters of the analyzed drinking water samples.

The value of pH in all the analyzed samples is around the value of 7. The negative values of ORP indicate a reducing medium, these waters are preferred for consumption due to the high anti-oxidant value, and can assist the body in the fight against oxygen free radicals.

All the analyzed groundwater sources are shallow, in this area water passes through or over mineral deposits such as limestone (Petrescu & Mészáros, 1987); because of this the water hardness is significant. The average value for total hardness in the wells waters is 45 °d (German degrees) and in the water sample from the distribution system the value is 33 °d, these values indicates that the analyzed waters are very hard.

Also, the geological substrate gives the high value for TDS in water samples from wells; all the samples from wells exceed the limit given by USEPA of 500 mg/l. In terms of salinity, 7 from 9 drinking water samples exceed the maximum permissible limit imposed by USEPA (0.2 ‰). The water from the distribution system doesn't exceed the 0.2‰ value for salinity. The drinking waters with a high salinity can have negative effects on human health in particularly on children and old people.

In the period, we take the samples (March 2016) the turbidity of all waters was below the 0.1 NTU value, but in some periods the turbidity of drinking waters grows, particularly in raining days, and a high turbidity represent a health concern (source of pathogens).

The chromatographic analysis identifies 4 anions from 7 (which the device can measure), the NO_2^-, Br^-, PO_4^{3-} anions had values below the detection limit (LOD). The detection limit for these anions is 0.02 mg/l. The concentration of the measured anions can be observed in figure 3.

Regarding the fluoride and chloride concentrations, all the samples have concentrations below the maximum concentration level (MCL) given by the Romanian legislation. All the analyzed water samples from wells exceed the MCL (in Romania: 50 mg/l) for nitrates, the water from the distribution system has small nitrates concentration, below the MCL. The USEPA: MCL for NO_3^- is 10 mg/l. These high concentrations of nitrates are a real concern for the people who consume these waters. The highest level for nitrates (334.07 mg/l) was identified in sample WA.3, which has a value of 6.6 times higher than the MCL.

Two drinking water samples (WA.2 and WA.6) from wells exceed the limit for sulfates of 50 mg/l, the concentration of sulfates in the water from the local supply is low.

4. CONCLUSIONS

In this study, we analyzed water samples from the local distribution system of Almaşu village and water samples from private wells (Almaşu village) and from the point of analyzed parameters we can say that the quality of water from the distribution system is superior to the water from wells. The source of the water from the distribution system is underground (spring), this spring occurs in an area where the human activity is minimal and there are no anthropogenic sources of pollution.

A real concern for the local population is represented by the very high concentration of nitrates in the water from wells, almost seven times higher than the maximum concentration level permitted by the Romanian legislation (law 311/2004) for drinking water. This high level of nitrates has a negative effect on human health in especially on young children's and old people.

Table 2. Physico-chemical parameters of drinking waters

| Sample code	pH	ORP (mv)	EC (μS/cm)	TDS (mg/l)	S (‰)
WA.1	7.2	-35.80	620.00	397.00	0.20
WA.2	7.19	-31.10	912.00	584.00	**0.40**
WA.3	7.39	-41.40	1342.00	859.00	**0.60**
WA.4	7.05	-22.00	712.00	455.00	**0.20**
WA.5	7.98	-76.50	1364.00	874.00	**0.60**
WA.6	7.01	-10.20	1399.00	895.00	**0.60**
WA.7	7.04	-16.70	1638.00	1048.00	**0.80**
WA.8	7.14	-25.60	1470.00	943.00	**0.60**
WA.9	7.15	-26.30	1370.00	887.00	**0.50**
MCL*/ **	*6.5-9.5		* 2500	** 500	** 0.2
* MCL- maximum concentration level – according to Law no. 311 /2004 – Romania ** USEPA maximum permisible limit					
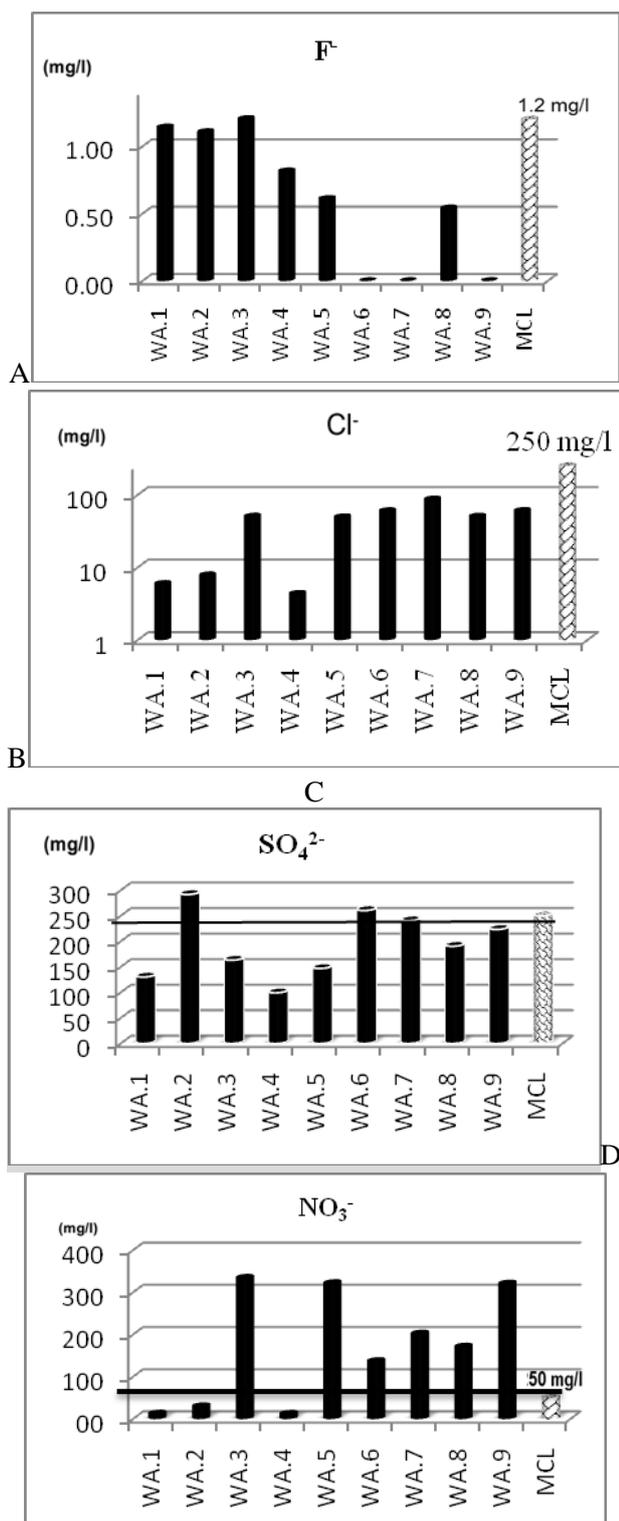
Figure 3. The concentration of the identified anions in drinking water A: F^-, B: Cl^-, C: SO_4^{2-}, D: NO_3^-

Most of the population from this area uses water for consumption from their private well without being concern by the quality of this water. After we obtained the results, we informed the people who consume the analyzed waters about these results, after this they take into consideration to use another water source for consumption, in specially those families who have small children's.

Because we found high concentrations of nitrates in drinking water, we want to extend this research and to analyze more fountains. We want to carry out an information campaign about the quality of drinking water in this village and the importance of clean drinking water consumption. We want to bring to the population attention the risks which involve a long time use ofheavily contaminated water with nitrates. Taking into account thatin the village there is a drinking water network with a much better quality than in the wells, the population has an alternative.

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