RESEARCH ON THE QUALITY OF WATER CONSUMED BY RURAL AREAS INHABITANTS OF BIHOR COUNTY

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Abstract

This paper is a study on the water quality used by rural areas inhabitants of Bihor county. The areas surveyed were selected on the basis of their landform. Based on the research and information provided to us by the Cris Waters Drainage Area Body, our study highlights some qualitative and quantitative aspects concerning water supply in rural areas.

Key words: water supply systems, springs, wells, manganese, nitrites.

INTRODUCTION

Water supply to rural areas embeds several features in comparison with the status of water supply of cities. In rural area water plants capacity – if exist – is weaker but too often people are supplied with water from wells, springs or fountains. Until 2015, the entire territory of Romania should comply fully with the provisions of the European Directive 98/83/EC on the quality of water intended for human consumption. These provisions target the localities where there are already water supply systems but also the settlements inhabited by >50 people and which should have access to drinking water of appropriate quality.

According to data provided by the National Institute of Public Health published in 2011 (Activity report, 2011), in Bihor county there were identified 112 small water supply areas. These areas are divided into three categories, depending on the volume of water supplied each day, or if such volume is not known, according to the population supplied. Thus, of the 112 water supply areas:

- 71 are classified in the 1st category (10-100 m^3/day supply);
- 32 are classified in the 2nd category (100-400 m^3/day supply);
- 9 are classified in the 3rd category (400-1000 m^3/day supply).

MATERIAL AND METHOD

Rural areas studied in our paper work were systematized according to landforms criterion. For each of the three landforms categories encountered throughout the county, we decided to choose some examples

that can potentially be extrapolated. Some of the information was taken from reports of Cris Waters Drainage Area Body (Report water quality, 2010). When we had not found data on quality of wells or springs water, we collected some samples and we carried out our own laboratory tests.

Bihor county landscape is structured in three main geomorphological units as follows:

a) The highest geological landform lies in the east, and includes the Bihor, Codru-Moma, Padurea Craiului and Vladeasa massif mountains;
b) The mid altitude geology landform encloses lower peaks of Codru-Moma, Padurea Craiului and Plopis massif mountains;
c) The lowest level is the Cris Plain located in the western part of the county.

Regarding the mountainous area we chose to study water quality within the karst areas of the county i.e. supply water quality in Padurea Craiului mountains. For the hills, we decided to describe in terms of water quality one of the village circumscribed to Sarbi commune which has roughly 4,500 inhabitants. The commune is located in the northeastern part of the county of Bihor at the contact area between Barcaului Plain and Oradea Hills. As for the plain area, we studied water quality used by the rural population of those Oradea city neighboring rural localities spread along the banks of Crisul Repede river i.e. Biharia, Osorhei, Alparea, Fughiu, Santandrei, Palota, Girisu de Cris, Tarian, Nojorid. We investigate also the situation in the Tinca village, settlement of Tinca commune enclosed in the Campia de Vest Plain which is, at its turn, a geographical subunit of Miersig Plain.

For the most cases where the quality of power supply is not in accordance with the legal provisions in force we put forward some alternatives. The water parameters we analyzed in the laboratory were as follows: hardness, alkalinity, pH, electrical conductivity, amount of dissolved salts, turbidity, dissolved iron, manganese and nitrites. Sampling and analysis methods are those provided by standard ISO 5667-11 Groundwater sampling and standardized methods in force for determining each parameter.

RESULTS AND DISCUSSION

1. Mountainous area

Depending on the size of the karst areas, the water accumulation in the Padurea Craiului Mountains is periodic and the amount of water oscillates. Rainwater accumulated in carbonate deposits are discharged through various springs. Their waters are captured and channeled to local

residents by means of centralized or individual water supply systems built individually by villagers or together by several families.

Water quality is relatively good food in this area. A series of studies were undertaken to highlight the weak points of water in the region. According to the studies carried out previously, the Cris Waters Drainage Area Body (Ravbar, Goldscheider, 2007) assesses the groundwater protection against pollution sources as being unsatisfactory. Intrinsic vulnerability due to hydrogeological factors and the deposits covering the area cover is quite high. Fortunately specific vulnerability is small because the area is unpolluted, with no active industrial plants. The main economic activity of the people is farming i.e. livestock breeding, potato and maize planting.

Water supply system of Bratca commune inhabitants is both centralized as well as individual i.e. from groundwater. The water trunk that feeds the communities surveyed is the trunk ROCR02 (Zece Hotare, Padurea Craiului Mountains). Regarding the spring water quality within the surveyed area one can make the following statements: the carbon species possibly present in water are carbonic acid and bicarbonate: pH ranges between 6.3 and 7 makes it impossible for the presence of carbonates; the degree of water mineralization in the region is low but falls within the drinkability terms; nitrates concentrations are below 10 mg/l, well below the maximum permissible concentrations stated in the Law on drinking water, i.e. 50mg/l.

Specifically water supply of Bratca village is mixed: Bratca settlement and Beznea village have a centralized water supply system by capturing a spring located on the left bank of the Bratcuta valley. The villages of Damis, Lorau, Ponoara and Valea Crisului do not posses centralized water supply system. In these villages water supply is ensured by twofold: local water supply systems that capture nearby springs and wells. The centralized system was developed in 1971 and undergoing amelioration. The ’70s system facility no longer meets the current requirements. Spring is disturbed during rainfall and water insoluble substances providing turbidity to water are a good support for the pathogens. This could endanger health condition of humans, especially since the water is not subject to any disinfection process. Water distribution system consists of parts made of easily corrodible metals. For this reason frequent interruptions occur in water supply to the population. These disruptions can favor the penetration of pollutants in the water plant with negative consequences on human health (Moglia et al., 2006).

2. Hill area

Of the 7 villages of Sarbi commune, located in the hills area surveyed, only in Sarbi village there is a centralized water supply system. In 2012 the amount of RON 1.66 mil was allocated by rural water supply sub-program for the water supply of the following villages Chioag, Almasu Mic, Fegernic Nou, Sarcau. We did not find information on groundwater quality for this area. For this reason we run a series of physical and chemical tests in the Hydrochemistry and Hydrology laboratory of our faculty. We chose to study the quality of water used by Burzuc village inhabitants. In this village there are three springs namely Ciorgau, Bora and Izvorul Nuci. Most people in the village (70%) are supplied with water from the Ciorgau spring, by carrying water individually each household in containers of various capacities i.e. buckets, cans, etc.

The results of the laboratory analyses and the maximum rated values permitted by the provisions of the *Law on potable water* in force are shown in the Table 1 below.

Table 1

Parameters set for the two springs

No.	**Indicators**	**U.M.**	**Ciorgau spring water**	**Hill spring water**	**Maximum rated value**
1	Hardness	° germ.	20.16	33.6	5 (minimum)
2	Alcalnity	mg/l	451.4	585.6	Not regulated
3	pH		7	7.5	6.6-9.5
4	Electrical conductivity	ms/cm	0.63	1.03	2.5
5	Total dissolved salts	g/l	0.32	0.514	Not regulated
6	Turbidity	NTU	**7.**0	0	5
7	Fe dissolved	mg/l	0.1	0.16	0.2
8	Manganese	mg/l	0.**7**	absent	0.05
9	Nitrites	mg/l	0.1	0.05	0.50

Besides indicators determined we studied the two water samples appearance. Ciorgau spring water is turbid, while the hill spring water is clear. The difference in appearance is perfectly explained by the presence of manganese in Ciorgau water spring. In the presence of oxygen, manganese move to higher oxidation forms. Combinations with some chemical substances from water result in insoluble compounds that can be observed with the naked eye and confers slight turbidity to water. From the table one may notice that the turbidity of the water samples exceeds the maximum rated values. The concentration of manganese in groundwater outlet from soil (from the spring on site) is much higher than the one determined in the

laboratory. A part of the manganese is already fixed as insoluble combinations, and our method only allows determination of the concentration of soluble manganese. The same reasoning is applicable to iron.

Even though it is not a toxic substance, manganese can have certain effects on health. Apart from these effects this metal may become a problem in the water for consumption purposes due to its slow oxidation and depositing throughout water distribution pipelines.

3. Plain area

3.1. Oradea neighbouring rural localities spread throughout the Crisul Repede river banks i.e.: Biharia, Osorhei, Alparea, Fughiu, Santandrei, Palota, Girisu de Cris, Tarian, Nojorid.

Except for Osorhei, Alparea and Fughiu settlements which water supply is the Water plant no. 5 Oradea, the remaining localities are being supplied with drinking water from groundwater. Groundwater sources in the area are characterized by a rather various physical – chemical content. Therefore they require, where appropriate, additional treatment in order to comply with the maximum rated values for drinking water quality provided by law.

In the rural settlements of Santandrei, Tarian, Nojorid, Biharia, there are centralized water supply systems which serve only a relatively small of inhabitants. Wells are deep, but are generally old and the flow is insufficient. Water wells in Biharia and Santandrei comply with the drinking water requirements. For Tarian drilling analyzes do not fall within the drinkability rated values for: ammonium (0.53 mg/l NH_4 as against 0.5 mg/l NH_4 allowed value), iron (0.686 mg/l Fe as against to 0.2 mg/l allowed value), turbidity (8.3 NTU as against 5 NTU allowed) and petroleum compounds. As for Nojorid drill, the water source and network analyses do not comply in terms of physical and chemical content for the following compounds: ammonia and nitrites, coliform bacteria, faecal streptococci (i.e. 1.72 mg/l NH_4 as against 0.5 mg/l NH_4 admissible, 1.04 mg/l NO_2 as against 0.5 mg/l NO_2 allowed by legal provisions in force).

3.2. Tinca commune

Tinca village was classified as the vulnerable area to nitrates pollution from historical sources as a result of breeding animals (livestock) in the currently disused animal farms. Tinca commune has drinking water supply network spread on length of 21.2 km. Water distribution network is supplied with the water captured through a drain located on the bank of the Crisul Repede river. Central water supply covers 50% of the settlement population. The remaining 50% is supplied from individual or public wells.

There are ongoing workings to extend the water supply network for Girisul Negru and Belfir localities, extending the sewerage network and the building of a wastewater treatment plant. The quality of water supplied this commune inhabitants is different. Water supplied by the water supply centralized system is of good quality because after drainage filtration, the water is treated with chlorine and distributed to households. Throughout the village, the quality of water extracted from wells water is poor. Nitrites concentration is 4-5 times higher than the maximum rated values in the drinking water. Locals' wells are not sited and constructed in accordance with regulations in force. The depth of the wells is often too low (<10m depth), and the distance from the stable or toilet is not appropriate. The vast majority of stables have no waterproof floor and the septic tanks have no concrete walls (Rotz et al., 2013). We determined in laboratory the nitrites and nitrates concentrations for four water samples collected from four wells located within the Tinca settlement area. The test results are present at Table 2 bellow.

Table 2

Wells nitrites and nitrates concentration as determined by laboratory test

No.	Indicators	U.M.	Sample 1	Sample 2	Sample 3	Sample 4	Maximum rated value
1.	Nitrites	Mg/l	**4.05**	**6.32**	**4.03**	**4.52**	**0.5**
2.	Nitrates	Mg/l	1.80	2.67	1.98	2.05	50

CONCLUSIONS

In rural areas of Bihor county there are both centralized and local water supply systems. Water flow supplied by centralized facilities and the length of facilities ensuring water transportation do not cover yet the entire area.

The water supply source even for the water supply centralized systems is often groundwater. Water extraction is made by deep water drillings which are usually antique, the vast majority of cases dating back from the '70s. Sometimes the water source of a centralized water supply system is a water spring. Water quality is different depending on the geographical area. For the water supply systems located in mountainous area the water quality is generally good. The absence of major sources of pollution is the main reason such good condition of water in the mountains. In mountainous area where karst is dominant, the main problem is the variability of water flows as well as the fact that during rainy periods the water become turbid, inducing the possibility of biological pollution.

Both in mountainous and the hills areas there are many cases of exceeding the maximum rated concentrations allowed by law for manganese

and iron in the drinking water. This is attributed to natural geological conditions. The presence of two metals increases water turbidity which hampers water usability. Manganese is becoming increasingly accused in the occurrence of neurological disorders in both adults and children (Guilarte et al., 2006).

For plains areas the main pollutants are inorganic nitrogen compounds i.e. ammonia and nitrite, but also the coliform bacteria and fecal streptococci. Pollution is caused by excessive use of fertilizers on agricultural land.

Both in terms of quantity and quality of water supply there are problems in terms of water supply for rural residents. It seems there are two solutions to this problem. One of the solutions is the connection, where possible, of rural water distribution network to the neighboring urban network (Shannon et al., 2008). The second one is drilling new water drillings or desand the already drilled ones but which are facing problems and proper treatment of water in order to bring water drillings to the legal standards in terms of drinkability. Water treatment consists most often in disinfection, but may also require deferrization and demanganisation procedures. However these procedures can be expensive, therefore it is preferable the construction of water supply systems to serve several settlements which are constituents of a micro-region (Moglia, 2011; Moglia et al., 2011).

As for water supply by means of wells a solution at hand is the appropriate construction of animal housing and storage facilities for farmyard manure. They should be endowed with waterproof floor. Another solution to avoid water contamination is the construction of septic tanks sealed with concrete walls. A modern solution which can be applied to large rural settlements would be the implementation a system for the collection and composting of farmyard manure and the use of compost to fertilize farming land rationally.

REFERENCES

1. Guilarte T.R., McGlothan J.L., Degaonkar M., Ming-Kai C., Barker B., Syversen T., Schneider J.S., 2006, Evidence for Cortical Dysfunction and Widespread Manganese Accumulation in the Nonhuman Primate Brain following Chronic Manganese Exposure, *Toxicological Sciences,* 94(2), pp. 351-358.
2. Moglia M., 2011, Water Management in the developing Town: a complex Systems perspective, Thesis for: PhD, Advisor: Pascal Perez, Stewart Burn, Andrew Walker.
3. Moglia M., Burn S., Meddings S., 2006, Decision Support for Water pipeline renewal prioritisation, *Electronic Journal of Information Technology in Construction*, 11 (Special Issue Decision Support Systems for Infrastructure Management), pp. 237-256.

4. Moglia M., Alexander K.S., Sharma A., 2011, Discussion of the Enabling Environments for Decentralised Water System, *Water Science and Technology*, 63 (10), pp. 2331-2339.
5. Ravbar N., Goldscheider N., 2007, Proposed methodology of vulnerability and contamination risk mapping for the protection of karst aquifers in Slovenia, *Acta Carsologica*, 36: 3, pp. 461-475.
6. Rotz C.A., Montes F., Hafner S.D., Heber A.J., Grant R.H., 2013, Ammonia Emission Model for Whole Farm Evaluation of Dairy Production Systems, Doi:10.2134/Jeq2013.04.0121.
7. Shannon M.A., Bohn P.W., Elimelech M., Georgiadis J.G., Marin˜as B.J., Mayes A.M., 2008, Science and technology for water purification in the coming decades, *NATURE*jVol 452j20, pp. 301-310.
8. * * *, 1998, Directiva 98/83/CE a Consiliului Europei din 3 noiembrie 1998 privind calitatea apei destinate consumului uman, cu modificările ulterioare (European Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, as amended).
9. * * *, 2010, Buletin de calitate a apelor Bazinul hidrografic CRISURI - Tr. III (Report water quality basin CRISURI - Tr. III).
10. * * *, 2011, Raport de activitate "Sanatate in relatie cu mediul" – Institutul național de Sănătate Publică (Activity report "Health in relation to the environment" – National Institute of Public Health).