GROUNDWATER SOURCES IN THE CONTEXT OF RURAL DEVELOPMENT – CASE STUDIES

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Abstract: *Groundwater sources used for drinking water in rural areas are affected by natural contamination (natural chemical compounds present in raw water source), or artificial pollution resulted from the use of fertilizers and pesticides (chemical contamination) and uncontrolled discharges of domestic waste (microbiological contamination). In this study it were analyzed three central water supply systems from Romania rural localities with raw water sources bacteriologically or chemically contaminated. Water quality analyses showed changes in water distributed to the population by identifying microbiological contamination or high levels of nitrates concentrations. This paper aims to discuss the groundwater sources for drinking water threatened by their location in rural areas of developing agro-zoo-technical domestic or industrial activities. Identification of hazards and contamination in critical points must be the basis of risk assessment in drinking water supplied for the population.*

Cuvinte cheie: *surse de apă subterană, nitraţi, contaminare microbiologică, sănătate umană*

Rezumat: *Sursele de apă subterană, utilizate pentru apa potabilă în zonele rurale sunt afectate fie de contaminarea naturală (prezenţa compuşilor chimici naturali în sursa de apă), fie artificială rezultată din utilizarea fertilizatorilor şi pesticidelor (contaminare chimică) sau deversarea necontrolată a deşeurilor menajere (contaminare microbiologică). În acest studiu s-au supus monitorizării sistemele centrale de aprovizionare cu apă din 3 localităţi rurale din România cu surse de apa brută contaminate microbiologic sau chimic. Analizele au arătat modificarea calităţii apei distribuite către populaţie prin identificarea contaminării microbiologice, sau prin nivele crescute ale concentraţiei de nitraţi. Această lucrare îşi propune analiza surselor subterane de apă potabilă ameninţate de amplasarea lor în zonele rurale din dezvoltarea activităţilor agro-zootehnice domestice sau industriale. Identificarea pericolelor şi a contaminării în puncte critice, trebuie să stea la baza evaluării riscurilor în aprovizionarea cu apă potabilă a populaţiei.*

INTRODUCTION

The main problems linked to water resources worldwide are: loss of potential freshwater supply sources, water quality degradation and pollution of water and sources (due to land use, land cover modifications, extraction activities, application of pesticides or developing human communities). Water pollution represents alteration of the physical, chemical and biological characteristics of water, caused directly or indirectly by human activities. A contaminant in the ground will move with the geology characteristics and many times contributes at increasing of the same contaminant (nitrates, metals) or bacterial flora, naturally present in the water. Soils are often considered to be near the perfect filters against the transportation of bacterial pathogens through the subsoil to groundwater.(1)

In order to get potable water from groundwater sources, usually it is used only disinfection methods. In Romania the maximum admitted limits for microbiological parameters and chemical substances in drinking water are regulated by Law no. 458(rl)/2002 (2), which transposes 98/83/EC Directive on drinking water. The target for microbiological quality must be zero germs/100 water ml, except for number of colonies at 220 C and 370 C, which may be 100 colonies, respectively 20 colonies per ml. Regarding the maximum allowable concentration for nitrates in drinking water, these should not exceed 50 mg/l, and 0.5 mg/l for nitrites.

PURPOSE

The aim of the this study is to present three case studies focused on groundwater sources quality for drinking water in rural areas of developing agro-zoo-technical activities.

METHODS

There were chosen, as case studies, central water supply systems in rural localities with distinct characteristics regarding location and catchment: Geoagiu Bai locality-Hunedoara County, Luna locality–Cluj County and Rogova locality–Mehedinti County. Several samples of water were collected and analyzed from the source (raw water) and from the distribution system during 2009-2011. Because in the first place was inspected the water source, treatment plants, and anterior data showed constant changes of several water quality parameters, the analysis were carried out on that parameters which exceeded the maximum allowable concentrations required by the legislation in force. During the study period, the analysis were performed for microbiological components (total

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coliforms and theromotolerant coliform bacteria – according to SR EN ISO 9308-1/2004, fecal streptococci – according to SR EN ISO 7899-2/2002), and for chemical parameters (nitrates, nitrites and ammonium) on a spectrophotometer with molecular absorption using national standards. For nitrates the analysis were performed according to SR ISO 7890-3/2000, for nitrites according to SR EN 26777/2006, and for ammonium SR ISO 7150-1/2001.

RESULTS

1. Case study – Geoagiu Băi village

The raw water source for Geoagiu Bai locality is „Fântâna Rece" spring, with a flow rate of about 0.2 l/sec. The water catchment is located between two households (house, yard, backyard farms) at a distance between 7 and 10 meters. The catchment chamber is in an advanced stage of degradation. From the catchment location water is transported in two tanks placed in series where it is chlorinated manually (adding sodium hypochlorite once per day). In 2010, results showed a minimal bacterial contamination because the water was not chlorinated. Then, analyses performed in November 2011 showed adequate results chemically but again not bacteriologically (table no. 1).

Table no. 1. Results water „Fântâna Rece" Spring – at catchment - 23.11.2011

Indicator	**Sample**	**Law 458/2002**	
	Spring water	**CMA value**	**UM**
Nitrates	10,5	**CMA ALLOWABLE VALUE**	mg/l
Nitrites	< 0,005	50	mg/l
Ammonium	< 0,005	0,5	mg NH_4^+/l
No colonies at 37oC	**3**	0,5	**UFC/ml**
No colonies at 22oC	**24**	**undetectable at 100 ml**	**UFC/ml**
Total Coliforms	**3**	**undetectable at 100 ml**	**/100 ml**
Thermotolerant coliform bacteria– E.coli	ABSENT	0	/100 ml
Fecal streptococci	ABSENT	CMA ALLOWABLE VALUE	/100 ml

The presence of total coliforms suggests a possible fecal contamination of the water which, in our case was not confirmed. In this situation we presume that the bacteriological contamination of water was not due to the households or human activities.

2. Case study – Luna locality

Source of raw water for the water treatment plant in Luna locality is the groundwater collected by a drain consisting of 6 drillings being surrounded by agricultural land, exploited for cereal crops. Due to the small depth of the drillings and soil structure and location in agricultural farms area, the supplied water layer is very vulnerable to pollution. The water treatment plant provides currently water for human consumption (drinking water) for Luna locality. The treatment process of treating water consists in denitrification and then chlorination of raw water. Before our investigations, the measurements of nitrates concentrations in the central water supply consistently showed high values, and the few recorded values below 50 mg/l are due to the flow changes at the source (table no. 2). Values were similar at collector basin, the reservoir and network, the highest concentrations being above 60 mg/l, value recorded inclusively in the water distribution network, because at that time the denitrification filters did not function properly.

The same situation was found during our study nitrates at high levels exceeding the allowable standard, the highest value of 71.4 mg/l being measured in the reservoir (table no. 3). Again, the denitrification filters was not properly functioning because the lack of maintenance (washing).

Table no. 3. Nitrates concentrations (mg/l) in the water supply system Luna - 2010

	25.03.10	10.05.10	7.06.10	12.07.10	6.08.10
Collector chamber	60.62	67.55	59.82	64.7	68.23
School reservoir	64.03	64.85	55.91	71.4	67.76

3. Case study – Rogova locality

Rogova locality is located in Mehedinti County and because of the average depth of the drilling and soil structure, and also of the location in the area of former and actual livestock farms, the water catchment layer is vulnerable to pollution. The process used to disinfect the raw water is chlorination. Before our investigation period, samples collected from the raw water at Rogova water treatment plant showed very high values for nitrates, with an average of 211.63 mg/l while ammonium and nitrites had fluctuations below the maximum allowed concentration (table no. 4).

Table no. 2. Nitrates concentrations (mg/l) in the central water supply system Luna - 2009

Collector basin	27.02.09	27.03.09	23.04.09	04.05.09	01.06.09	06.07.09	10.07.09	03.08.09	07.09.09	05.10.09
	59.63	37.89	**52.43**	35.22	**61.68**	**51.57**	**55.92**	**54.39**	**52.04**	**56.04**
School network	15.01.09	27.02.09	15.06.09							
	62.66	**62.77**	31.32							

Table no. 4 Concentrations of ammonium, nitrates and nitrites in the raw water at Rogova water treatment plant 2010-2011

	Drilling		
	Ammonium (mg/l)	**Nitrates (mg/l)**	**Nitrites (mg/l)**
20.01.10	-	73	0.02
14.05.10	0.019	259	0.004
01.07.10	0.018	234.1	0.003
22.07.10	0.019	276.6	0.003
12.08.10	0.003	231.42	0.001
28.10.10	0.052	225.42	0.003
09.12.10	0.009	177.52	0.013
12.01.11	0.04	216	0.002
Average	0.02	211.6325	0.006125

Table no. 5 shows that the nitrates values from this sampling point were between 141-275 mg/l. A seasonal evolution of the nitrates concentration was observed; the maximum values measured being recorded after snowmelt and during summer months with high rainfalls.

Table no. 5. Concentrations of ammonium, nitrates and nitrites (mg/l) in the network water –Rogova 2010-2011

	14.5.10	**27.5.10**	**22.7.10**	**12.8.10**	**26.8.10**	**9.9.10**	**29.9.10**	**7.10.10**	**28.10.10**	**9.12.10**	
Ammoni	0.2	0.049	0.025	0.003	0.59	0.13	0.13	0.014	0.084	0.008	
Nitrates	**260.63**	**275.04**	243.4	242.71	239.26	198.7	198.7	232.32	219.58	172.1	
Nitrites	0.006	0.006	0.003	0.002	0.003	0.009	0.009	0.002	0.004	0.004	
	12.1.11	**3.2.11**	**10.3.11**	**7.4.11**	**5.5.11**	**2.6.11**	**7.7.11**	**3.8.11**	**7.9.11**	**5.10.11**	**9.11.11**
Amoniu	0.025	0.004	0.008	0.076	0.025	0.074	0.013	0.003	0.002	0.002	0.003
Nitrates	217.34	231.2	238.5	**260.31**	201.21	223.16	162.79	227.98	141.12	141.98	181.4
Nitrites	0.003	0.004	0.004	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.002

DISCUSSIONS

The great majority of evident water-related health problems are the result of microbial contamination and an appreciable number of serious health concerns may occur as a result of the chemical contamination of drinking water.(3) At "Fântâna Rece" (spring) water source bacteriological contamination risks were identified, although existing data do not confirm the contamination component of fecal nature. It is required to increase the chlorine dose and to rehabilitate the water distribution network. Due to agricultural practices, oxidation-reduction reactions, and nitrogen cycle leads to transformation and speciation of nitrogen in nitrate (NO_3).(4) Cronin et al., 2007 (5) shows that nitrate is a particular concern at elevated concentrations this is linked to potentially serious health problems. For Luna locality, the aquifer water quality is influenced by the rainfall regime and agricultural practices in the area, and the chemical and physical structure of the soil. In the distribution network the major problem occurred was represented by contamination with nitrates as a consequence of water source quality and improper treatment. The presence of nitrates in the water source of Luna is of mixed origin, clearly predominantly telluric and pronounced anthropogenic due to agricultural practices in the area. The nitrates values measured in the water from the central distribution system Rogova are very high considering that in the years before measurements were performed no cases of methemoglobinaemia in infants were recorded. For infants and pregnant women the water consumption from the network or other sources with nitrates concentration above 50 mg/l is prohibited. Abu Naser et al, in 2007 (6) performed a cross-sectional study to determine the factors associated with high methaemoglobin levels in infants and the relationship with nitrate concentration in drinking water and the results emphasize the importance of the choice of a suitable source of water for infants. But, epidemiologic studies that have evaluated dietary sources of nitrate have not provided evidence for a positive association with cancer.(7)

CONCLUSIONS

In order to reach the safe drinking water criteria, a water source requires sanitary protection of the catchment area, a proper treatment and monitoring. Even if drinking water does not meet quality parameters in chemical terms (nitrates are highly toxic for infants), it is preferable to continue supplying the community with disinfected water and the risk communication process, instead of drinking water consumption from unmonitored or untreated sources, even for a predetermined period of time. Identification of hazards and contamination in critical points must be the basis of risk assessment in drinking water which supplies the population.

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