DISINFECTION BYPRODUCTS IN DRINKING WATER FROM RURAL CENTRAL SYSTEM WATER SUPPLY

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Abstract: *Identification of chlorination byproducts and their potential health hazards has created a major issue in balancing chemical toxicity with risks from pathogenic microbes. This paper evaluates rural central systems water supply established in the period 2006-2012 related to disinfection efficiency and the levels of disinfection by-products (trihalomethanes), correlated with other chemical/bacteriological parameters of the water. The results of our study emphasis that the quality of treated water has been in accordance to Romanian water law, only some of them having nitrates, ammonia and bacteria levels over CMA's were residual free chlorine level below CMA's. Disinfection by products levels in treated water samples were low, except by chloroform. A significant statistically correlation (p=0.05) was observed between the chloroform and residual chlorine level in the water.*

Cuvinte cheie:
trihalometani, apa potabilă, zone rurale

Rezumat: *Identificarea produșilor secundari clorinării și riscurile potențiale ale acestora pentru sănătate a creat o problemă majoră în echilibrul dintre toxicitatea chimică cu pericolele legate de microbi patogeni. Această lucrare evaluează sistemele centralizate de alimentare cu apă din mediul rural, create în perioada 2006-2012, cu privire la eficiența dezinfecției, a produșilor secundari dezinfecției (trihalometani), corelat cu alți parametri chimici și bacteriologici din apă. Rezultatele studiului accentuează faptul că apele au fost, în general, conforme calitativ cu legislația românească, numai unele dintre probe având atât nitrați, amoniac și conținut bacterian peste CMA, cât și clor rezidual liber, mai redus decât limita admisă. Probele de apă tratată au avut un conținut scăzut de produși secundari dezinfecției, cu excepția cloroformului, existând o corelație semnificativă statistic (p = 0,05) între acesta și nivelul de clor rezidual în apă.*

INTRODUCTION

According to World Health Organization (WHO) 2000 report, 87% of the European rural population is supplied with drinking water from public systems. In contrast, the drinking water supplied by the central water system is very low in Romanian rural areas. The majority of the water is obtained mostly from groundwater, which is generally treated only by chlorine disinfection.

Several epidemiological studies have reported the associations between the ingestion of chlorinated drinking water in excess and the presence of CBPs with the risk of bladder and rectal cancer followed by mortality, as well as spontaneous abortions.(4)

The published data in Romania (2,3,5) showed that total THMs levels in the urban water distribution networks are below the CMA (100 µg/l); sometimes they can exceed the limit. Regardless of the THM levels, higher number of cancer cases can appear in long-term exposed populations.(3) Meanwhile, there is no published data about the presence of THMs and their compounds concentrations in drinking water from rural central systems supply in Romania.

PURPOSE

This paper evaluates the disinfection efficiency and the levels of THMs in 16 rural water treatment stations (WTS) that were established in the years 2006-2012.

METHODS

22 water samples were collected from 16 rural WTS in 3 counties (Alba, Cluj, Hunedoara) (13 groundwater source, 3 surface water source). 13 WTS processed water only by disinfection with chlorine while 3 WTS underwent pretreatment (filtration only or decantation and filtration) before chlorination. The water samples were processed and analyzed in order to characterize the following chemical parameters: ammonium content (SR ISO 7150-1:2001), nitrates (SR ISO 7890-3:2000) and free residual chlorine (Standard Methods 4500-Cl) by colorimetric test. Determination of total THM and their compound concentrations were performed by gas chromatography (Shimadzu GC Solution) with electron capture detector (GC-ECD). The analysis was performed using the headspace technique. The microbiological parameters analyzed were: Coliform bacteria, E. coli (ISO9308-1), Fecal Streptococcus (STAS 3001/1991, ISO 7899-2), Colony counts 22^0C (STAS 3001/91, ENISO 6222). Statistical data processing and graphics execution were performed using Microsoft Excel 5.0 program. Student's "t" test, "p" value, and the Pearson-Bravais correlation coefficient "r" were the statistical analyses used to verify any statistical differences.

RESULTS AND DISCUSSIONS

The results obtained by laboratory analysis of the 22 treated water samples have revealed that: 3 (13.6%) water samples had high ammonium and nitrate contents; 5 samples

(23%) identified the presence of Coliforms bacteria; and 3 (13.6%) water samples contained developed colony counts 22 °C greater than the CMA limit (figure no. 1).

**Figure no. 1. Chemical and bacteriological nonconformed water samples (%)**
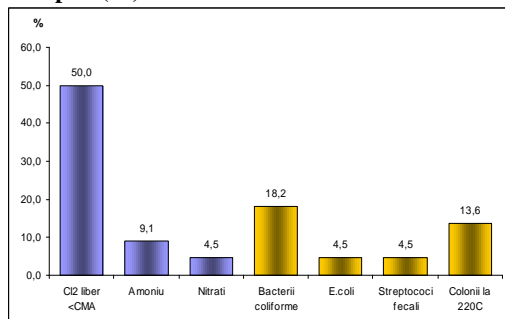
Free residual chlorine concentration showed the common deficiencies in water disinfection process, so that only 10 of the water samples had the free residual chlorine level < 0.5 mg/l. In addition, the parameters of the chemical and microbiological specimens exceeded the CMA regulation. Total THM's identified in 21 treated water samples had concentrations below CMA (100 µg/l), with levels ranging from 2.45 - 44.91 µg/l. Depending on the levels of free residual chlorine, the water samples were divided into two categories: category 1 for free residual chlorine concentration ≤ 0.5 mg/l and category 2 for free residual chlorine concentration > 0.5 mg/l.

Table no. 1. Total THMs and Average Compounds Levels in Chlorinated Water

Sample's category		Total THMs (µg/l)	Chloroform (µg/l)	Bromodichloro methane (µg/l)	Dibromochloro methane (µg/l)	Tribromo methane (µg/l)
Free chlorine (mg/l) ≤ 0,5	mean	10.52	5.04	2.69	2.07	0.80
	st. dev.	9.70	3.62	3.11	2.97	0.94
	%		47.93	25.53	19.70	7.63
Free chlorine (mg/l) > 0,5	mean	27.75	16.73	7.08	3.72	0.21
	st. dev.	12.39	10.87	2.52	1.30	0.53
	%		60.31	25.52	13.41	0.76
"t" test	t	-3.45	-3.10	-3.58	-1.71	1.82
	p	0.004	0.01	0.002	0.11	0.09

Figure no. 2. Regresions Free chloraine and Chloroform, Bromdichloromethane
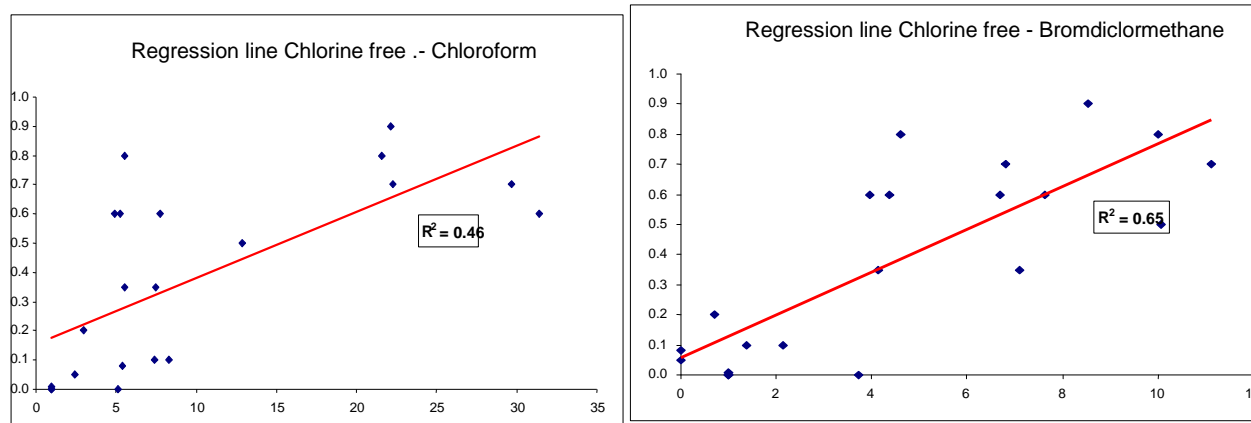
Total THMs and compounds concentrations were higher in category 2 water samples. Statistical significant differences were also noticed (p=0.01-0.002) only for total THMs, chloroform and bromodichloromethane in category 2 samples (table no. 1).

The distribution analyses of the THMs compounds showed the highest percentage of chloroform (47.93% and 60.31%) for both water category 1 and 2, respectively. It was followed by bromodichloromethane, dibromochloromethane and tribromomethane. The Pearson-Bravais correlation ("r") (figure no. 2) demonstrated positive association and statistical

significance between THM concentrations and free residual chlorine level > 0.5 mg/l.

The presence of an increased level of free residual chlorine in the treated water is an important factor for an enhanced generation of DBP, even in low levels of oxidizable organic matter.(5) Unlike the United States, which has conducted extensive assessment on DBP occurrence under different water treatment methods, little is relatively known about the occurrence and the levels of DBPs in Europe, with the exception of a few places such as Poland, Finland, Spain, the United Kingdom, Greece and Italy.(4)

CONCLUSIONS

The results of our study demonstrated that the quality of treated water is in accordance to Romanian water law. Some water samples contained higher levels of nitrates, ammonia and bacteria than the CMA limit, while the residual free chlorine levels were below that of the CMA. Our study revealed low levels of DBP, with chloroform being the predominant species. A significant correlation was observed between chloroform and residual chlorine levels in water. Public health concerns such as bladder and rectal cancer developments in humans living in rural areas may arise from drinking this kind of water, which stemmed from the insufficient and inefficient water treatment of the central water supply system.

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