GENERAL CONSIDERATIONS IN SUPERVISION OF QUALITY OF DRINKING WATER IN BIHOR COUNTY - IDENTIFICATION OF ARSEN CONTAMINATION AND COMMUNICATION OF THE IMPACT ON HEALTH

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Abstract

Arsenic has a negative impact on health caused by constant consumption of contaminated drinking water. Long-term exposure to arsenic determine the appearance of various diseases.

High arsenic in water, a public health issue, warrants water quality monitoring and risk communication campaigns for local decision-makers and populations.

Between 2009 and 2017, Arsenic was a concern for the Bihor Public Health Department specialists, both in monitoring the quality of water distributed to the population and in informing the population about the risk they are exposed to. The monitoring of the drinking water quality by the Bihor Public Health Directorate, ensures the fulfillment of the legal obligation to monitor the quality of the drinking water distributed to the population. In the monitoring of drinking water quality, the sampling is performed by specialists, samples are analyzed by high performance methods, the non-conforming values being communicated to the local authorities together with the indication to take all necessary measures to ensure compliance with the provisions of the legislation in force, and to the National Public Health Institute, to assess the health risk of constant consumption of arsenic-contaminated water.

The results, communicated to the representatives of the local authorities and the family doctors, represented a major argument in launching the specific Information - Education - Communication (IEC) Campaign with partners: 17 local authorities in which potable water presented values of arsenic above the permissible limit.

This issue was debated with representatives of the public institutions responsible for water quality monitoring, at local, national and cross-border level - with Hungarian partners.

Actions undertaken are an important element for risk communities, aiming at assessing the state of solving this problem and / or facilitating the liaison between representatives of local authorities and suppliers of specific equipment for identifying solutions to reduce arsenic in water.

Key words: drinking water, arsen, risk, public health

INTRODUCTION

The Romanian health legislation states that: "... drinking water must be free of micro-organisms, parasites or substances which by number or concentration can constitute a potential danger to human health" (Water Law 458/2002 with modifications and completions).

Arsenic, a chemical element that is naturally found in air, water, soil, has effects and a negative impact on health. The highest risk of arsenic accumulation in the human body is caused by constant consumption of contaminated water, followed by the consumption of contaminated food and smoking. Long-term exposure to arsenic causes various disorders such as skin problems (Hughes et al., 2011; Karagas et al., 2001; IARC, 2012; Leonardi et al., 2012), internal organs disorders (bladder, kidney and lung cancer), cardiovascular diseases, respiratory diseases, diabetes, etc. (Negrea P. et al., 2017).

The Drinking Water Directive (DWD), (Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption) - obliges European Union(EU) Member States to monitor drinking water in order to provide consumers with adequate and up-to-date information on its quality, monitoring the quality of drinking water being a priority of the European Commission. Monitoring of drinking water quality in Romania is ensured by the producer, distributor and the public health authority.

The monitoring of the quality of drinking water by the Bihor Public Health Directorate provided to the population of Bihor County, shows if the following physical and chemical indicators: ammonia, arsenic, nitrite, nitrate, taste, odor, turbidity, sodium, total hardness, pH, oxidisability, iron, lead, free residual chlorine and cadmium, are in compliance with the legislation in force. European studies involving our country have shown the existence of regions within the EU Member States where the arsenic values of natural origin, in deep water, exceed the established standard of 10 μg / l. (Leonardi et al., 2012, Lindberg et al., 2006).

In the Panonic Basin, the area most affected by arsenic contamination of natural water resources (Figure 1), approximately 500,000 people living in Hungary and Romania are exposed to increased levels of arsenic in drinking water (Lindberg AL et. al., 2006, Negrea AG, 2017). According to Smedley & Kinninburgh (2002), the arsenic-threatened area in Romania and Hungary is 110,000 square kilometers and the maximum level of arsenic in water in Romania was 150 μg/l (maximum concentration permitted by the World Health Organization. The most affected counties are Arad, Bihor and Timiş.

Fig. 1.Arsenic contamination of natural water resources inPanonic Basin

High level of arsenic in water is a public health issue that justifies the implementation of an action plan for communicating risk to local decision-makers and populations.

MATERIAL AND METHOD

Between 2009 and 2017, Arsenic, as a health problem mainly due to contaminated water consumption, was a concern for the Bihor Public Health Department specialists, for monitoring the quality of water distributed to the population and informing the population about the risk posed by contaminated water consumption and the identification of feasible alternatives and solutions for improving the quality of water consumed.

Surveillance of the quality of drinking water distributed to the population is carried out in accordance with the legal framework for the implementation of the methodologies developed by the National Institute of Public Health. This legislation is represented by Romanian Government Decisions for the approval of the National Health Programs and by Orders of the Minister of Health for the approval of the Technical Norms for the implementation of the National Public Health Programs.

Therefore, within the National Program of Public Health Monitoring of the determinants of living and working environment - PN II, Objective A: Protecting public health by preventing illnesses associated with determinants of life and work environment, Specific area 1: Protecting health and preventing illnesses associated with risk factors in the environment, the following are stipulated as activities: monitoring the quality of drinking water distributed in a centralized system in large supply areas; fountain water and artesian water monitoring; drinking water quality control - small systems. The methodologies

of these activities ensure the fulfillment of the obligation to monitor the quality of the drinking water distributed, according to the provisions of the Drinking Water Quality Law No. 458/2002 republished, Romanian Government Order no. 22/2017 and Romanian Government Decision No. 974/2004 with subsequent amendments and completions.

Determination of arsenic in water samples was performed by:

1. Semi-quantitative method - Arsenic test - colorimetric method with bands, Merck kit - RENAR approved method, method used until its replacement in 2011 with atomic absorption spectroscopy (AAS) with graphite furnace, using Atomic Absorption Spectrometer Analytik Jena ContrAA 700.

2. Atomic Absorption Spectroscopy (AAS) with graphite furnace using the Analytik Jena ContrAA 700 Atomic Absorption Spectrometer, with which the Laboratory of Diagnosis and Investigation in Public Health - Sanitary Chemistry and Toxicology from the Bihor Public Health Department is equipped.

Atomic absorption spectrometry is based on the ability of free atoms to absorb light. The AAS spectrometer measures the absorbance of a cavity cathode lamp which specific to each element (Arsenic 193,696 nm), absorbance that is directly proportional to the concentration of metal in the sample and is read on the calibration curve previously plotted (Figure 2). For arsenic analysis wer established working conditions in order to achieve a high sensitivity of the method.

Water samples were taken in water sample containers, bottles from polypropylene, polyethylene or fluorinated ethylene propylene (FEP). Material for containers and lids must not contain or lose any analyte. Only chemical substances and solutions of the highest purity were used for sample and solutions preparation. Water samples were preserved by treatment with 65% Merck Nitric Acid Extra-pure Acid. A small sample is placed in the autosampler. Work schedule has been established using Aspect CS software. Interferences are eliminated with matrix modifiers. A small drop of the sample is pipetted into the graphite tube. By increasing the temperature gradually the sample is dried by electric heating, is pyrolyzed and atomized. If the concentrations are outside the linearity range, the spectrometer alone makes the necessary dilutions indicated in the program. The software automatically calculates the determined concentration. The results are expressed as mass of analyte per liter of water (μg / l). As a result, the very low detection limits make the graphite furnace AAS a high performance method for element analysis.

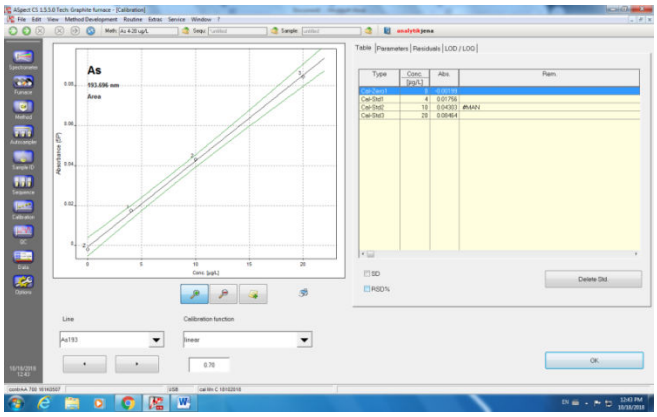

Fig. 2.Calibration Curve

Following the monitoring of drinking water quality, which revealed non-compliant values of the arsenic parameter,a Information – Education – Communication (IEC) Campaign was implemented. The elaboration of the IEC campaign methodology was carried out in compliance with the legal provisions, respectively the Government Decisions for the approval of the National Health Programs and by Orders of the Minister of Health for the approval of the Technical Norms for the implementation of the National Public Health Programs.

Thus, within the National Program for Evaluation and Promotion of Health and Health Education 1. Evaluation and Promotion of Health and Health Education Subprogramme; Specific domain: 1. Interventions for a healthy lifestyle; 1.2. Organizing and conducting IEC interventions for local specific health priorities, the IEC Campaign *"Local Specific Public Health Issues - Preventing Consumption of drinking water with high Arsen levels"* was carried out.

The campaign methodology was conducted in accordance with the operational procedure of the Bihor Public Health Directorate: *Providing information to the population on disease prevention and promotion of health.*

RESULTS AND DISCUSSION

During 2012-2017, in the framework of the audit monitoring for the arsenic parametercarried out by Bihor Public Health Directorate, using Atomic Absorption Spectroscopy, the registered values were distributed as shown in Figure 3.

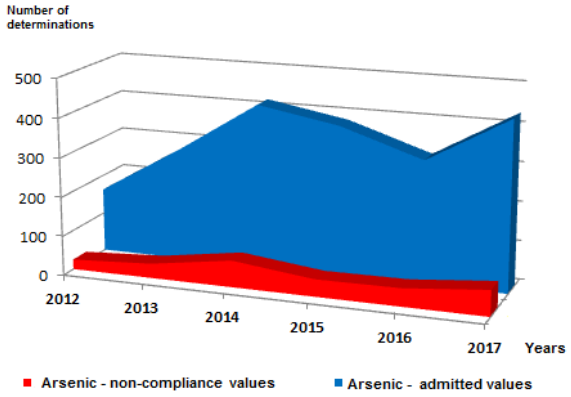

Fig. 3.Arsenic parameter valuesas part of audit monitoring during 2012-2017

The detected values recorded constant exceedances over the admitted value,for the following localities: Abrămuţ, Adoni, Ant, Avram Iancu, Batăr, Boiu, Budusläu, Ciumeghiu, Cociuba Mare, Cubulcut, Curtuişeni, Diosig, Galospetreu, Ghiorac, Madras, Marghita, Niuved, Olsig, Otomani, Petid, Petreu, Săcueni, Sălacea, Sălard, Salonta, Sanniob, Sântimreu, Şimian, Talpoş, Tamasda, Tulca, Valea lui Mihai (Figure 4). The highest exceedances were recorded in Avram Iancu, Ciumeghiu, Diosig, Sântimreu and some values exceeded 10 times the admissible value.

Fig. 4. Areasin Bihor County with non-compliant values for arsenic parameter for water

The values of the arsenic parameter from water samplescollected by specialists and analysed in the Sanitary Chemistry Laboratory of the Bihor Public Health Department during 2009 -2011, were sent to the National Public Health Institute - the Regional Public Health Center of Cluj Napoca, for the risk assessment regarding the health impact of constant consumption of arsenic-contaminated water. The risk evaluation for the health of the population exposed to increased concentrations of arsenic in drinking water, established in 2012 by the specialist from the Regional Public Health Center of Cluj Napoca, was achieved by the so-called "Incremental Lifetime Cancer Risk" (ILCR), which is the increase in the risk of life-long cancer caused by exposure to a substance with a carcinogenic potential.

According to the United States Environmental Protection Agency (USEPA), for values of ILCR < $1x10^{-6}$ (1E-06), cancer risks can be considered negligible, while for values exceeding $1x10^{-4}$ (1E-04) the risks are considered to be sufficiently high to require remedial action to be taken in order to protect health. The risk calculations were based on monitoring data for arsenic concentrations in drinking water for four age groups reported over a three-year period. The ILCR values obtained for the population exposed to arsenic concentrations in drinking water were between 2.99E-05 ($2.99x10^{-5}$) and 4.47E-04 ($4.47x10^{-4}$).

Increased concentrations of arsenic in drinking water are a risk factor in cutaneous cancer and internal cancers. The values obtained for the localities in Bihor county show that the risk increases directly in proportion to the dose and inversely proportional to the age of the consumer (Table 1).

The results, received from the National Public Health Institute regarding the risk assessment and the health impact of the constant consumption of arsenic contaminated water, were communicated to representatives of local authorities and family doctors from the localities concerned and were a major argument in launching the specific IEC Campaign.

In September - October 2012, the IEC Campaign – addressed to Local Public Health Issues - Preventing Consumption of Drinking Water with High Levels of Arsenic, under the slogan: "Arsenic - a Health Risk", was organized, having as partners 17 local authorities to which belong the following cities and the communes: Tamaşda, Batăr, Săcueni, Cubulcut, Olosig, Salacea, Buduslău, Curtuişeni, Văşad, Diosig, Ciumeghiu, Ghiorac, Sniobob, Valea lui Mihai, Cociuba Mare, Şimian, Gepiu.

Table1

Cancer risks ILCR

	0-2 ani	2-6 ani	6-16 ani	16-30 ani
Budusläu	2,31E-04	1,15E-04	1,02E-04	5,28E-05
Curtuişeni	3,08E-04	1,54E-04	1,37E-04	7,04E-05
Văşad	1,21E-04	6,54E-05	5,82E-05	2,99E-05
Ciumeghiu	2,50E-04	1,27E-04	1,13E-04	5,81E-05
Ghiorac	2,92E-04	1,46E-04	1,30E-04	6,70E-05
Diosig Z1	1,54E-04	7,70E-05	6,84E-05	3,52E-05
Diosig Z2	3,69E-04	1,84E-04	1,64E-04	8,45E-05
Diosig Z3	3,85E-04	1,92E-04	1,71E-04	8,80E-05
Gepiu Z2	2,00E-04	1,00E-04	8,90E-05	4,57E-05
Cociuba Mare	2,38E-04	1,19E-04	1,06E-04	5,46E-05
Săcueni Z1	2,31E-04	1,15E-04	1,02E-04	5,28E-05
Săcueni Z2	2,50E-04	1,27E-04	1,13E-04	5,81E-05
Olosig	1,69E-04	8,47E-05	7,53E-05	3,87E-05
Cubulcut	4,47E-04	2,23E-04	1,98E-04	1,02E-04
Sălacea	2,46E-04	1,23E-04	1,09E-04	5,63E-05
Otomani	2,31E-04	1,15E-04	1,02E-04	5,28E-05
Şimian	2,15E-04	1,07E-04	9,58E-05	4,93E-05
Tămaşda	3,08E-04	1,54E-04	1,37E-04	7,04E-05
Valea lui Mihai	1,38E-04	6,93E-05	6,16E-05	3,17E-05
Sînlob	2,38E-04	1,19E-04	1,06E-04	5,45E-05

The target group was composed of representatives of the local authorities and the general population from the localities where drinking water presented values of arsenic above the allowed limit.

Activities: conceiving, editing and printing informative and educational material: flyer "Arsenic - a health risk" - 3000 pcs.; identifying and contacting the water sources responsible persons within the Town Halls of the localities concerned; actions of IEC with representatives of local authorities and with inhabitants from the 17 localities; actions to distribute informative and educational materials in listed localities.

Resources used - human resources: DSP specialists; material resources: power point presentations, printed information and education materials: flyer "Arsenic - a health risk".

Results: - 1 working meeting with the water sources responsible persons within the Mayor Halls; 17 actions of IEC in designated localities / 199 persons directly informed; 17 actions for distributing information-education materials; 3000 pcs. flyer "Arsenal - a health risk" distributed.

This health issue has been extensively discussed in working meetings, roundtables, local scientific events, together with representatives of Bihor's Sanitary-Veterinary and Food Safety Directorate, Bihor Environmental Protection Agency, Crişuri Basin Water Administration, specialists from the

Public Health Departments of Arad and Timiş and cross-border with representatives of Békés Public Health Directorate (Hungary), Prefecture of Békés County (Hungary).

The activity of public health specialists of the Bihor Public Health Directorate was an important social marketing element for the risk communities, the local meeting with local decision-makers continuing after the completion of the IEC Campaign in 2012.

CONCLUSIONS

During audit monitoring for the arsenic parameter in water,carried out by Bihor Public Health Directorate, exceedances over the admitted value were registered in 2 areas from Bihor County: North – West (Săcueni - Marghita - Valea lui Mihai region) and South – West (Salonta region).The highest exceedances were recorded in Avram Iancu, Ciumeghiu, Diosig, Sântimreu and some values exceeded 10 times the admissible value.

The risk assessment and the health impact of the constant consumption of arsenic contaminated water evaluated by National Public Health Institute - the Regional Public Health Center of Cluj Napoca,showed that the increased concentrations of arsenic in drinking water are a risk factor in cutaneous cancer and internal cancers. The values obtained for the localities in Bihor county,show that the risk increases directly in proportion to the dose and inversely proportional to the age of the consumer.

Following revealed non-compliant values of the arsenic parameter, it is necessary to:

- continue monitoring of drinking water quality
- present incidental legislation and encourage open dialogue with local authorities to "raise awareness" about the importance of the issue and the impact on public health
- assess the stage of solving the problem on improving water quality, along with the indication of taking all necessary measures to ensure compliance with the provisions of the legislation in force
- give priority to corrective actions for parameters whose exceedance represents a danger to human health (even closing water sources with non – compliance parameters)
- facilitate liaison between representatives of local authorities and suppliers of specific equipment to identify solutions to reduce arsenic in water
- carry out information - education - communication campaigns

- cooperate and agree partnerships with local / national / cross-border institutions for research and for impact evaluation of high arsenic level on public health and environment

REFERENCES

1. Cavar S., Klapec T., Grubešic R.J., Valek M., 2005, High exposure to arsenic from drinking water at several localities in eastern Croatia. Sci. Total Environ. 339, pp. 277–282
2. Chappell W.R., Abernathy C.O., Calderon R.L. (Eds.), 2001, Arsenic Exposure and Health Effects IV. Elsevier
3. Csalagovitis I.,1999, Arsenic-bearing Artesian Waters of Hungary. Ann. Rep. Geological Institute of Hungary, 1992–1993/II, pp. 85–92
4. Commity Decision from 18 December 2014 for modification of Decision 2000/532/CE for establishing the list of of wastes according to Directive 2008/98 / EC of the European Parliament and of the Council 2014/955/UE;
5. Drinking Water Quality Law No. 458/2002 republished with subsequent amendments and completions:
6. Gurzau E.S., Gurzau A.E.,2001, Arsenic in drinking water from groundwater in Transylvania, Romania. In: Chappell WR, Abernathy CO, Calderon RL, editors. Arsenic exposure and health effects IV. Amsterdam: Elsevier Science, pp.181-185
7. Leonardi G, Vahter M , Clemens F , Goessler W , Gurzau E , Hemminki K , Hough R , Koppova K , Kumar R , Rudnai P , Surdu S , Fletcher T, 2012, Inorganic arsenic and basal cell carcinoma in areas of Hungary, Romania, and Slovakia: a case-control study,
8. Lindberg A.L., Goessler W., Gurzau E., Koppova K., Rudnai P., Kumar R., Fletcher T., Leonardi G., Slotova K, Gheorghiu E., Vahter M.,2006, Arsenic exposure in Hungary, Romania and Slovakia, J Environ Monit., 8(1), pp.203-210
9. Orders of the Minister of Health for the approval of the Technical Norms for the implementation of the National Public Health Programs during 2009-2017;
10. Romanian Government Decisions for the approval of the National Health Programs during 2009-2017;
11. http://www.sickkids.ca/PGPR/Symposia-and-Workshops/Oct-2007-china/arsenic-pollution/index.html, Arsenic Pollution: Global Distribution – Evaluation and Monitoring
12. http://www.who.int/ipcs/features/arsenic.pdf, World Health Organization, 2010. Preventing Disease through Healthy Environmentse Exposure to Lead: a Major Public Health Concern. WHO, Geneva
13. http://www.who.int/mediacentre/factsheets/fs372/en/, Arsenic, 2016
14. http://www.who.int/water_sanitation_health/dwq/chemicals/arsenic.pdf?ua=1, Arsenic in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality