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RISKS IN THE CONSUMPTION OF DRINKING WATER POLLUTED WITH NITRATES

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Key words: *drinking water, pollution, nitrate / nitrite, methemoglobinemia*

INTRODUCTION

In the current context of general pollution, knowing the effects of water pollution with nitrates/nitrites constitutes, on the one hand, a message favourable to the waters, often severely polluted, and, on the other hand, a means of raising awareness on the medical problems posed by chemical pollution.

Raising awareness is necessary especially in our country where water supply systems, especially in rural areas, are mostly poor and nitrate poisoning is often reported [4, 5].

Nitrates represent the salts of nitric acids and are found in air, soil, water and food (especially in plant products) [10]. The origin of nitrates in water may be natural, the soil is rich in nitrogen salts, a situation encountered in our country [11]. In nature, in the areas where human intervention was made, nitrates are found in the soil in quantities between 0-2.5 mg/L –according to EPA (United States Environmental Protection Agency), WHO (World Health Organisation) and IARC (International Agency for Research on Cancer). When the level of nitrates in the soil exceeds 2.5 mg/L, the excess is due to pollution, which indicates that the area was affected by human activities [8]. Most of the nitrates reach water by pollution with organic substances containing nitrogen and which by biodegradation become ammonia, nitrite and finally nitrate state. Nitrates can also reach water as a result of industrial pollution, especially due to agricultural use of nitrogen fertilizers (ammonium nitrate) [9].

However, it was found that nitrates are not toxic, except for the cases when they are reduced to nitrites, known as toxic to blood by combining with hemoglobin and forming methemoglobin, which leads to phenomena such as asphyxia by hypoxemia and subsequent hypoxia. Methemoglobinemia primarily affects newborn babies, berastfeeding women and old people. The ones who suffer from this disease present mouth and limbs cianosis, breathing difficulties, asohixia and anxiety. The disease manifests clinically when the level of methemoglobin reaches 10% of normal hemoglobin [12], whereas at more than 70% leads to death [1]. The symptoms are correlated with the percentage of hemoglobin blocked.

The reduction of the nitrate to nitrite can be exogenously achieved in water even in summer when the temperature rises above 20˚ C and the water contains reducing germs. But most commonly it occurs by endogenous reduction in the body in the digestive tract by microbial action in general and especially *Enterobacteriaceae* (coliform flora), which can be done within three hours of ingestion. In addition, the conversion of nitrate to nitrite is produced by cooking and food preparation, etc.

Nitrates decrease overall body strength and polluted water consumption with this substance can trigger methemoglobinemia or "blue disease" which manifests itself in a feeling of suffocation and can even lead to death of infants and children. In addition, nitrates in water can cause miscarriages and male infertility. Annually, there are around 100 cases of poisoning with nitrates and nitrites. This type of pollution is particularly dangerous when it comes from many sources - in most cases, even in households, people are not aware of the danger to which they are exposed. The disease is found almost exclusively in infants in the first year of life if they are fed artificially, which is explained by the fact that, in his first months, the child preserves fetal hemoglobin, and as the need for water is greater than in adults, the amount of nitrate per unit of body weight is also higher [14].

The continuous intake of nitrates from water and from some foods also lead to chronic poisoning, which is far more extensive than acute poisoning and has more serious consequences in the long term. Due to its insidious symptomatology and a possible association with other disorders, it usually goes unnoticed and this just gives it a much greater severity than acute poisoning.

Chronic poisoning in children is manifested by a progressive decrease in body resistance especially against biological aggressors (for infectious diseases) and even ordinary actions such as breathing, causing a delay in the physical development. Reputed authors argue that the nitrates also have an inhibiting effect on the uptake of iodine in the thyroid, which, under conditions of a lack of iodine in water and

food, may constitute an important factor in maintaining a high morbidity and thyreopathic endemic dystrophy (goiter).

Last but not least, a very long-term risk of the presence of nitrates in water is the possibility of forming, through a series of complex processes of nitrosamines, substances with a high carcinogenic and teratogenic potential (especially in the colon). Nitrites are considered responsible for gastric cancer, because of the nitrosamines they form under certain conditions ("tertiary nitrate toxicity"). Manufacturers and distributors of drinking water are required to perform quality control monitoring of water supplied [11].

Nitrates present already acknowledged toxic effects, but the interest in their toxicity has been manifested since 1945, when Hunter Comly signaled a few cases of methemoglobinemia („blue baby syndrome") in some children who consumed contaminated water. Between 1945 and 1970, reference literature reported about 2000 cases of methemoglobinemia [13]. The cases presented poisonings which appeared at three-year olds who consumed levels exceeding 100 mg nitrates/L.

In Hungary, between 1975 and 1977, there were reported 190 cases of methemoglobinemia as a result of the consumption of contaminated water, 94% of them being registered in children under three months. The concentrations of nitrates in the water exceeded 100 mg/L in 92% of cases and ranged between 40 and 100 mg/L for 8% of the cases reported [15]. In a national report [12], it was indicated that most cases (48%of the total) of methemoglobinemia manifested at children aged between one month and 3 months.

According to the same study, 58% of all cases appeared when concentrations ranged between 101 and 500 mg nitrates/L water.

The same study reported [12] that, in our country, most cases of infantile methemoglobinemia registered in 2000 (453 cases), followed by a decrease in the number of cases to the point that, in 2009, there were only 89 cases reported. The peak was in 2000–2005, in the East of Romania, where were reported no less than 844 cases of infantile methemoglobinemia, the most numerous being in Iasi (284) [7].

Monitoring of drinking water in Bacau, during 2006 - 2014

The monitoring of the drinking water quality is conducted within the framework established by transposing the requirements of European directives and by implementing them national and local level. By means of control monitoring performed periodically, the organoleptic and microbiological quality of drinking water produced and distributed and the effectiveness of treatment processes are verified, with emphasis on the disinfection technology used to determine if the drinking water is adequate or not in terms of the values of the relevant legally specified parameters [2, 3].

Laboratory findings highlight the water quality of wells, pumps and sources legally verified in terms of physical-chemical and bacteriological parameters.

Water samples collected from local plants presented a rate of 59.5% poor bacteriological indicators and 41.9% - poor physico-chemical parameters. Water quality was affected by pollution, and improper operation of local water supply facilities.

MATERIAL AND METHODS

There have been investigated a number of 93 cases of acute nitrate poisoning in children of different sexes and ages, in urban and rural areas of Bacau County.

The investigations were performed at the Public Health Department of Bacau, within the national prevention program for *evaluating cases of acute infantile methemoglobinemia caused by water from the well* for a period of nine years (2006-2014). For the determination of nitrate / nitrite in water was used the colorimetric method with indigo carmine and reading by spectrophotometer at λ = 410 nm using 1 cm path length cuvette. The extinction value was read from the calibration curve. For patients, there was used the photometric dosage by means of the analyzer of urine strips - Labu Reader - strips with 10 parameters.

From the data collected, we found existing morbidity cases of acute nitrite poisoning in rural areas of Bacau.

For each case of acute poisoning with nitrite was completed the *reporting sheet for cases of infant methemoglobinemia caused by well (fountain) water*, according to the methodology submitted by the Institute of Public Health Bucharest.

From the records to which we had access, we took the nominal list of cases of acute poisoning with nitrates (children's place of residence, age, sex, etc.) for the time period studied (2006-2014).

For the same period, there was conducted water quality monitoring for the water supplied to the population through a centralized system and local facilities. Drinking water was supplied through a centralized system within the parameters of quality, according to Law 458/2002 [4].

The statistical interpretation of the results obtained during the 9-year study is represented graphically in the following section.

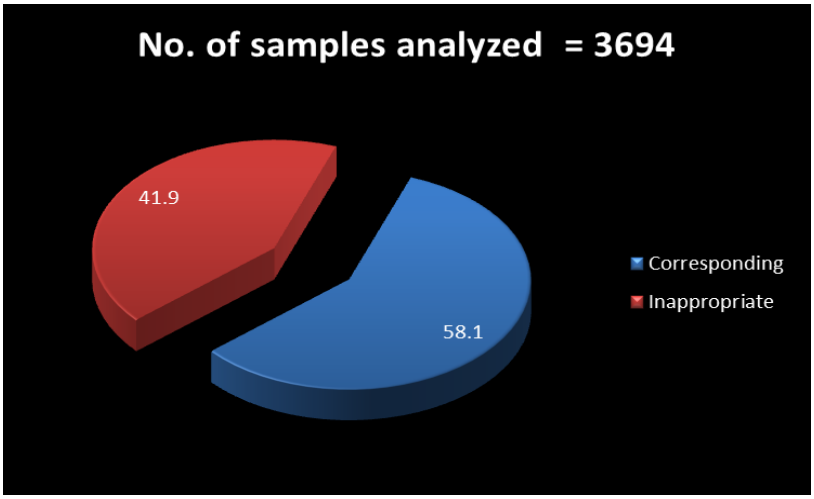

Figure 1. Representation of the percentage of physical-chemical results

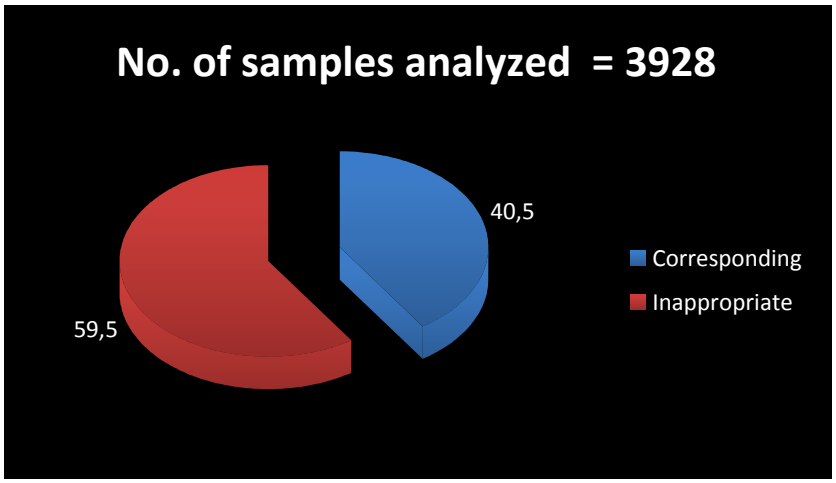

Figure 2. Representation of the percentage of bacteriological results

RESULTS AND DISCUSSIONS

Nitrates and their concentration represent a global preoccupation and the reduction of pollution with nitrates is a tendency which is more and more undergoing in many countries. Thus, in the EU, the safe nitrate level for nitrates in drinking water is 50 mg/L. The Directive on Nitrates issued in 1991 (91/676/CEE) s one of the first EU laws destined to control underground and groundwater pollution with nitrates from agricultural sources by promoting good agricultural practices.

This normative document proved efficient given that, between 2004 and 2007, the nitrate levels in ground waters remained constant or decreased to 70% in the localities monitored [17]. In surface waters, the nitrate content is lower (0–18 mg/L), but they can reach higher concentrations as a result of fertilization and contamination of some areas with animal waste [16]. Water pollution with nitrates occurs primarily in intensive farming areas where nitrogenous fertilizers are frequently applied. A relevant example is the situation indicated by Pele et al. Concerning the high levels of nitrates in good water [6].The epidemiological situation of the years investigated is shown in the following graph

The dynamics of the cases of acute nitrate poisoning confirmed over the nine-year study indicates an annual decrease in the number of cases, which shows more efficiency in the application of preventive measures, involving local and rural health services in achieving the objectives of the territorial health program. The age distribution of the 93 cases shows that the highest percentage (44.95%) was recorded during 1-3 months of life, age peculiarities thus creating conditions for the emergence of acute nitrate poisoning in children. Children are more sensitive in the first months of life due to the persistence of fetal hemoglobin (more oxidisable than adult hemoglobin) and insufficient enzyme methemoglobin reduction.

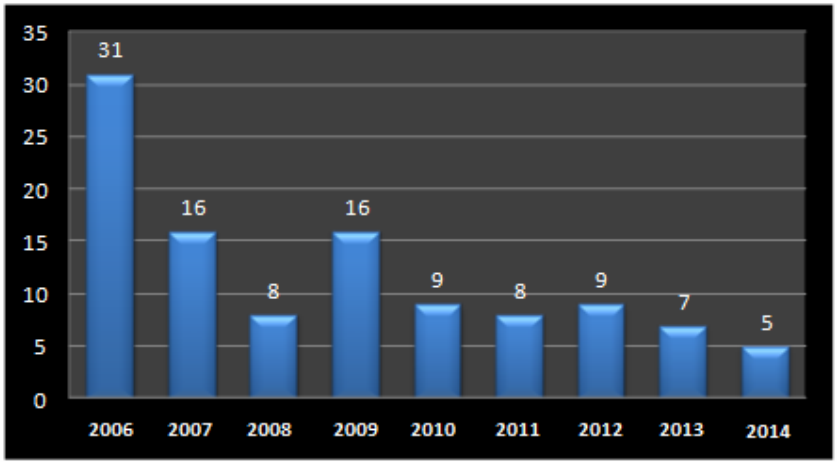

Figure 3. Number of nitrate poisoning cases recorded in Bacau in 2006-2014

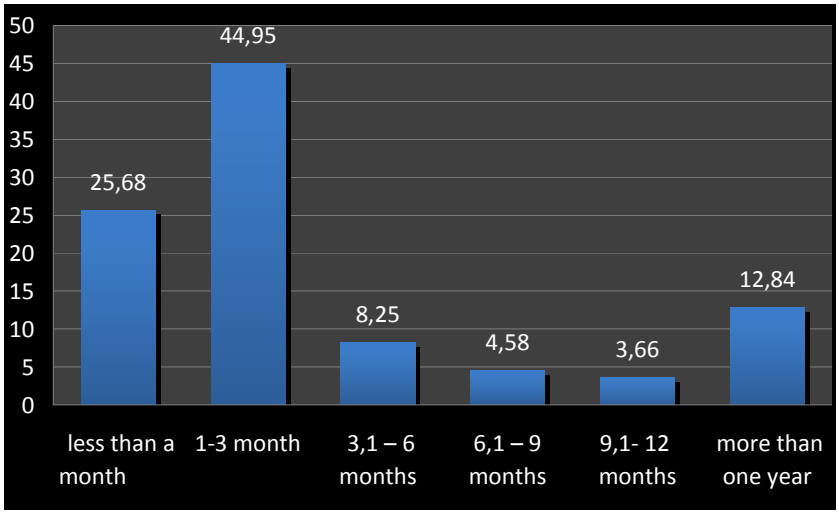

Figure 4. Representation of the percentage of cases of acute poisoning with nitrates by age.

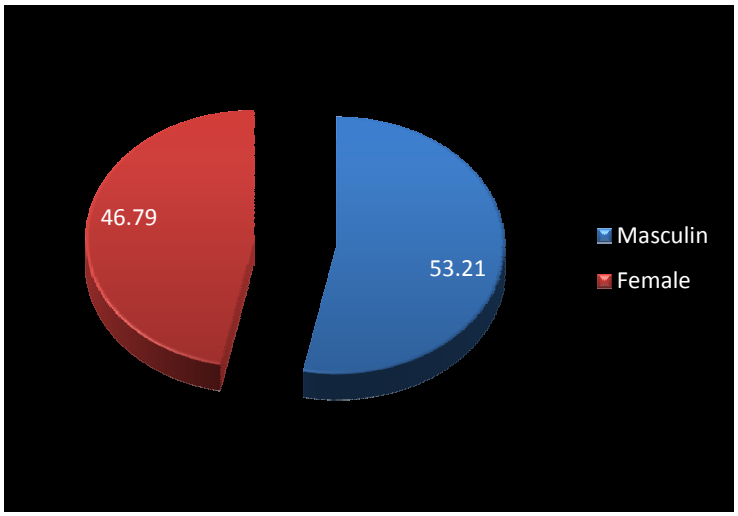

Figure 5. Representation of the percentage of cases of acute poisoning with nitrates by sex.

By gender, more than half of the cases of acute nitrate poisoning were reported in boys (53.21%) – which is actually the usual proportion of males each year, not found in the literature data.

Most cases of acute nitrate poisoning were recorded in the second and third quarters of the year (when the water chemical pollution has been increased due to microorganisms involved in ammonification-nitrification processes, carried out with maximum intensity in summer). The bacteriological contamination of water during this period increased the number of digestive disorders and, hence, that of nitrate poisoning cases.

The distribution by residence shows that most cases (95.42%) occurred in rural areas. This is due to water supply systems - in mostly poor - rural inconsistent values of the parameters analyzed in the control of water quality monitoring are witnesses of this.

The distribution of the cases of acute poisoning with nitrates in terms of the source of water supply shows that 89.91% of cases are due to consumption of good water and only 10.09% of the cases involved the distribution center network. It, therefore, confirms the theory that good water is the main source that generates acute nitrate poisoning.

Regarding the distribution of cases of acute poisoning with nitrates after the way of feeding children, there is a high percentage of cases for children who were fed artificially (73.39%). Cooking for artificial nutrition necessarily involved the use of water, which does not fall within the parameters of quality and trigger those acute nitrate poisoning cases.

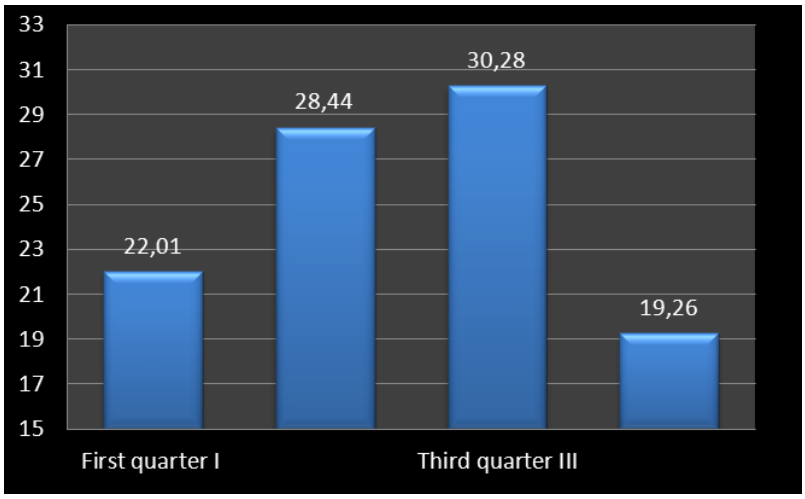

Figure 6. Representation of the percentage of cases of acute poisoning with nitrates, depending on the occurrence

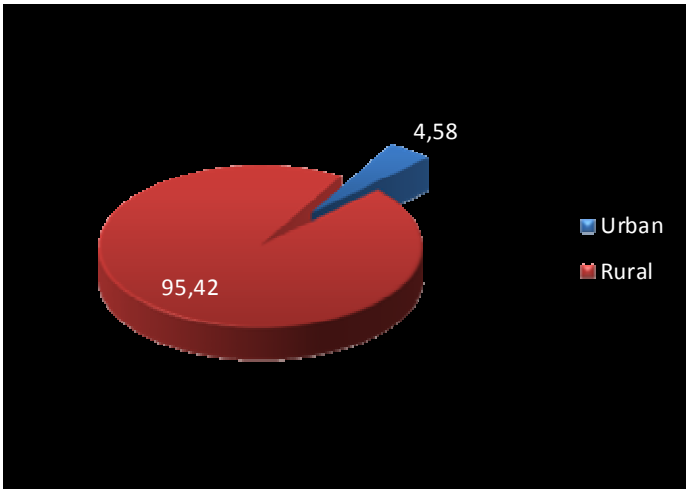

Figure 7. Representation of the percentage of cases of acute poisoning with nitrates, by residence

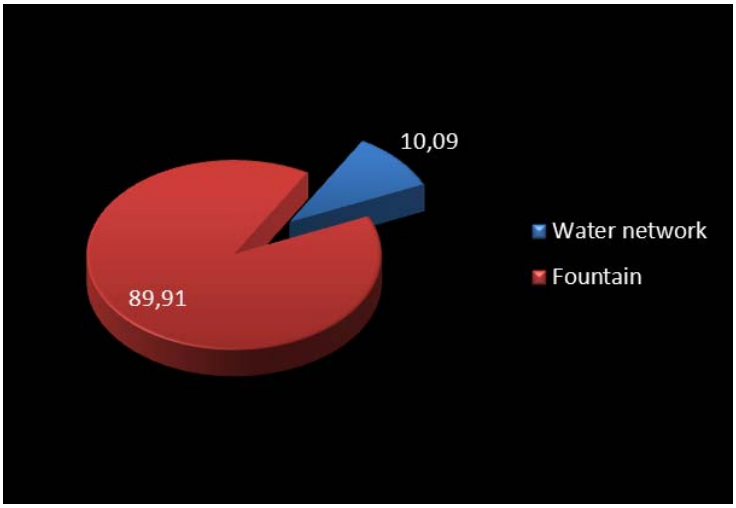

Figure 8. Representation of the percentage of cases of acute poisoning with nitrates, according to water source

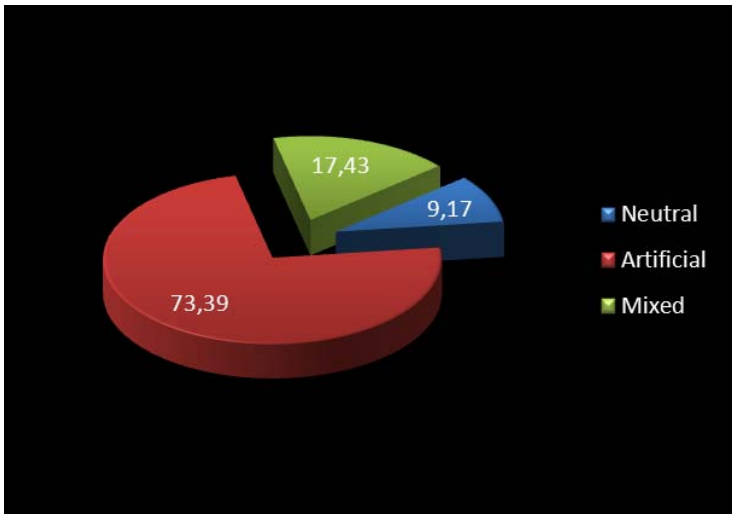

Figure 9. Representation of the percentage of cases of acute nitrate poisoning in relation to children's way of feeding

More than half of the cases of acute poisoning with nitrates (49.54%) during the period 2006 to 2014 were associated with digestive diseases, namely acute diarrheal disease (BDA). Digestive disorders are conditions favorable to producing and passing through blood and tissues of large quantities of nitrite.

The distribution of cases of acute poisoning with nitrates also reveals a higher percentage of cases of poisoning associated with respiratory diseases – 41.28%. It is known that diseases of the upper respiratory tract, the proliferation of nasopharynx flora and its ascension in areas proximal to the intestine enhances the toxicity of nitrates.

The situation of acute nitrate poisoning in Bacau County during 2006-2014 is presented in Table 1, where 2. 93 cases of acute nitrate poisoning are indicated as found in 48 localities of Bacau County (of which 4 urban).

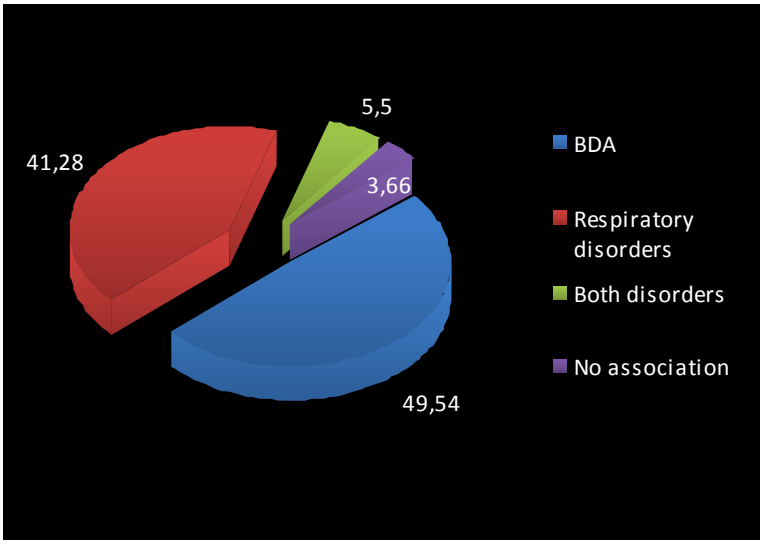

Figure 10. Representation of the percentage of cases of acute nitrate poisoning as a result of the association with BDA and /or respiratory disorders

Table 1. Situation of acute nitrate poisoning in Bacau in the period 2006-2014

Number of cases	Number of localities
No cases	**45 localities**
1 case	**22 localities**: Oneşti, Moineşti, Coţofăneşti, Sărata, Ştefan cel Mare, Răcăciuni, Parava, Căiuţi, Bogdăneşti, Helegiu, Bârsneşti, Bucium, Tamaşi, Asău, Huruieşti, Dealu Morii, Filipeni, Hemeiuşi, Oituz, Stănişeşti, Săuceşti, Dofteana.
with 2 cases	**15 localities**: Gârleni, Vultureni, Plopana, Răchitoasa, Buhuşi, Motoşeni, Ungureni, Cleja, Gioseni, Buhoci, Bereşti Bistriţa, Tg. Trotuş, Colonesti, Odobeşti, Faraoani.
with 3 cases	**6 localities:** Bacău, Sascut, Blăgeşti, Dămieneşti, Secuieni, Luizi Călugăra
with 4 cases	**2 localities:** Gura Văii, Pânceşti
with 5 cases	**3 localities:** Horgeşti, Corbasca, Parincea

Table 2. The statistical summary of cases of poisoning / localities

Number of cases	Number of localities	Urban	Rural
0	45	4	41
1	22	2	20
2	15	1	14
3	6	1	5
4	2	-	2
5	3	-	3
Total cases 93	Total localities 48	Total urban 4	Total rural 44

CONCLUSIONS

The territorial distribution shows that, in some localities, only one case of acute poisoning was registered during this period, but there were towns with more than 3 cases. The villages of Horgeşti, Parincea Corbasca registered 5 cases along the nine years, whereas the second risk group included Pancesti and Gura Vaii with 4 cases of poisoning.

The distribution by residence shows that most cases (95.42%) occurred in rural areas. This is mostly due to deficient water supply systems.

The distribution of cases of acute poisoning with nitrite depending on the source of water supply shows that 89.91% of cases are due to consumption of good water and only 10.09% of the cases involved the central water supply network. It, therefore, confirms the theory that well water is the main source that generates acute nitrate poisoning.

The dynamics of acute nitrate poisoning cases confirmed throughout the nine-year study indicates an annual decrease in the number of cases, which suggests efficient preventive measures by involving local government and health services in rural areas in achieving the objectives of the territorial health program called *Disease prevention through the monitoring of causal factors in the living environment.*

Findings and results certify that nitrates affect not only the environment but also human health and in, some cases, they can cause very serious problems.

In Moldavia, old and recent studies have shown environmental pollution, especially water with higher or lower concentrations of nitrate and Bacau County is no exception to this almost global situation. As a result, important segments of the population are quasi-permanently exposed to water contaminated with nitrates from local water facilities, besides having an additional intake through food.

ABSTRACT

We investigated a number of 93 cases of acute nitrate poisoning in children of different sexes and ages, in urban and rural areas of Bacau County. The investigations were performed at the Public Health Department of Bacau, within the frame of the national prevention program for evaluating cases of acute infantile methemoglobinemia caused by water from well sources, over a period of nine years (2006-2014). For the determination of nitrates/nitrites in water was used the colorimetric method with indigo carmine and reading spectrophotometer. For patients, there was used the photometric dosage by means of the analyzer of urine strips - Labu Reader - strips with 10 parameters.

The territorial distribution shows that, in some localities, during this period, there was only one case of acute poisoning. However, there were villages with more than 3 cases, respectively Horgeşti, Parincea, Corbasca with cases in these nine years, whereas the second risk group included Pancesti and Gura Vaii with 4 cases of poisoning. The dynamics of acute nitrate poisoning cases confirmed throughout the nine-year study indicates an annual decrease in the number of cases, which suggests efficient preventive measures by involving local government and health services in rural areas in achieving the objectives of the territorial health program called *Disease prevention through the monitoring of causal factors in the living environment.*

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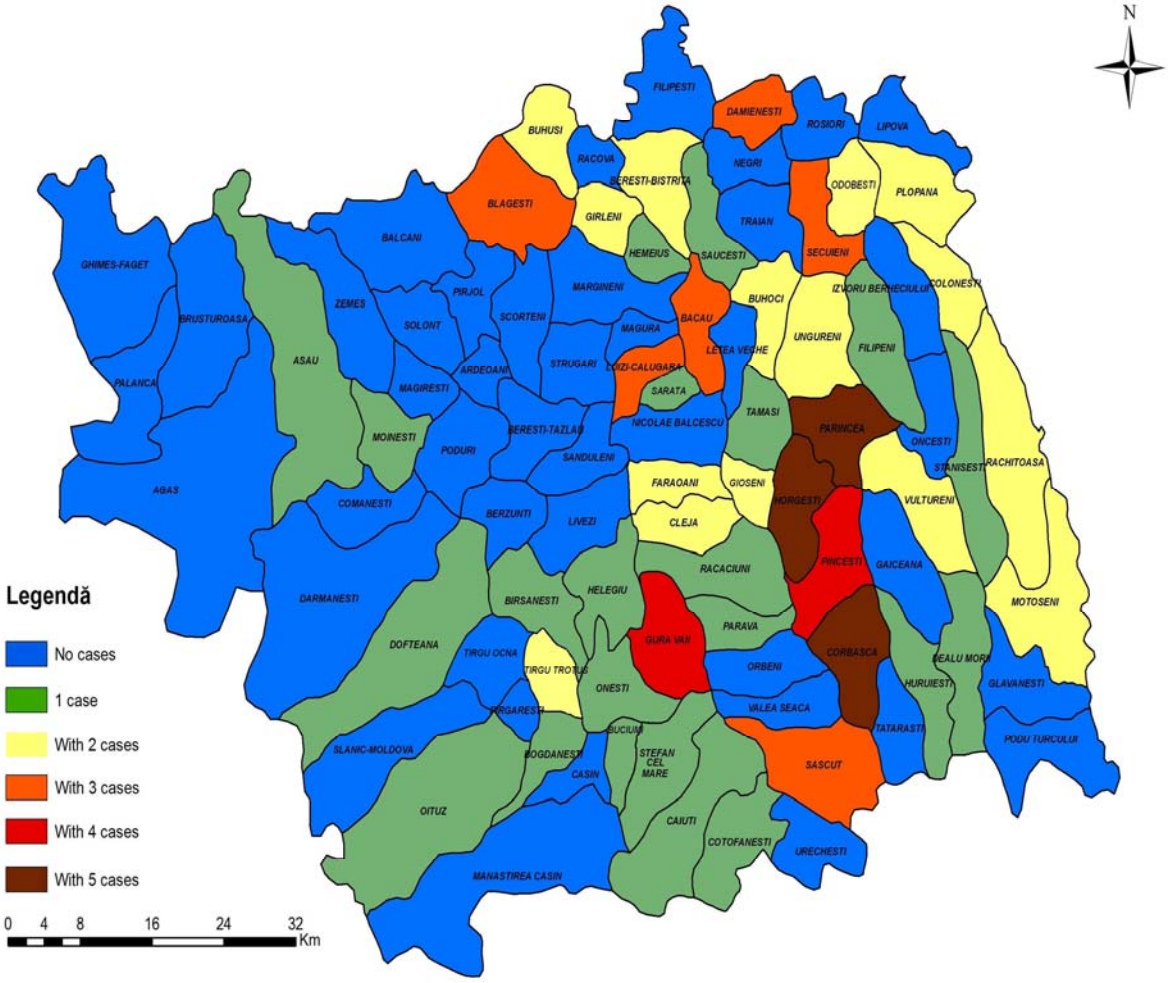

Fig.11. The territorial distribution of acute poisoning with nitrites in Bacau county during 2006-2014