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Assessment of Ammonia, Nitrates and Nitrites in Water Consumed by Animals in Local Households

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Abstract

The aim of this paper was to assess the quality of the water consumed by animals in rural households in terms of ammonia, nitrates and nitrites concentration. Thirty-seven water samples were collected from different sources (15 wells, 9 springs and 13 rivers and streams), all from Transylvania. The results were compared with the drinking water standards of the Law 7/2023 and statistically processed with the SPSS program, version 17. Significant differences ($p < 0.05$) were observed for ammonia, nitrites and nitrates. Ammonia concentration was significantly higher ($p < 0.05$) in rivers and streams than in wells and springs. For this parameter, no significant differences were observed between wells and springs ($p > 0.05$). Nitrites had a significantly higher concentration ($p < 0.05$) in wells and rivers and streams than in springs, while nitrates had a significantly higher value in wells ($p < 0.05$).

Keywords: watering; drinking water; nitrates, nitrites, animals.

1. Introduction

Water is one of the fundamental components of living matter. Along with air and food, water is one of the main factors of the environment, which deeply influences all living things. Being an essential nutrient for life, the interest regarding the quantity and quality of water is very intense throughout the world. The availability and quality of water is very important for numerous functions, such as thermoregulation, feed consumption, enzymatic reactions, excretion and other functions [17].

The most common sources of both nitrate and nitrite in water include agricultural activities (inorganic fertilizers and manure), wastewater treatment, nitrogenous waste products from humans and discharges from industrial processes and motor vehicles [13, 14, 7, 23]. In addition, water with a certain content of nitrates and low oxygen concentration during stagnation in galvanized steel pipes can chemically lead to the formation of nitrites - *Nitrosomas* bacteria are responsible.

In soil, fertilizers containing inorganic nitrogen and wastes containing organic nitrogen are first decomposed to give ammonia, which is then oxidized to nitrate and nitrite. The third stage of nitrogen cycle is called nitrification. During this stage the ammonia in the soil is converted into nitrites, NO_2^-, and nitrates, NO_3^-. In this way nitrates are used by plants and animals that consume green food during their growth. It is also known that the excess of nitrates can end up in the water sources intended for animal consumption, especially in underground water [21, 24]. There are many examples that indicate that certain plants are used to prevent excess nitrates from entering water sources. Thus, in a study it was shown that poplars (*Populus italica*) can be used to prevent nitrates from reaching the water during the winter. In the same study, it was highlighted that *Lolium perenne* L. can keep up to 84% of the amount of nitrates. Cultivating this plant on the banks of a river can stop nitrates from reaching the river [9]. On the other hand, the free ammonia that reaches the pipe system is an important factor in nitrification and this can lead to a decrease in the quality of water consumed by animals [22, 18].

In ruminants and herbivores, the nitrates that reach the digestive tract are transformed into nitrites by bacteria. Nitrites are easily absorbed in the body and are ten times more toxic than nitrates [22, 18].

Nitrates are not very toxic, and their toxicity does not only come from the water source. It has been observed along the way that high concentrations of nitrates in water usually appear during droughts, when the water level drops and the amount of nitrates increases. The greatest difficulty is represented by the total amount of nitrates (from both water and food), which can reach higher values than the maximum allowed limit [25].

For beef cows, nitrites are considered toxic, but not nitrates. Nitrites from the digestive tract reach the blood and transform hemoglobin into methemoglobin, which decreases oxygen transport and can even lead to the death of the animal [10]. The aim of this paper was to assess the quality of the water consumed by animals in rural households in terms of ammonia, nitrates and nitrites concentration.

2. Material and Method

Thirty-seven water samples were collected and analyzed from different sources (well - 15 samples; spring - 9 samples; stream, river - 13 samples), from households located in rural areas of Transylvania were watered (Cluj, Alba, Bistrita-Nasaud, Hunedoara counties). The water samples for ammonia, nitrates and nitrites exam were collected according to Popescu S., 2008 [16]. At the time of collection, the container was rinsed with water from the source.

The collection of water samples was performed differently depending on the source, as follows: (i) from wells- with the bucket lowered under the water table; (ii) from the spring, stream, river - from the place where the animals are watered. The water quality was appreciated based on chemical parameters (nitrites and nitrates).

Determination of ammonia, nitrates and nitrites in water samples. The studied parameters were assessed by the colorimetric method using a photometer – HI 83200 HANNA and the following powder reagents were used: HI 93728-0 - for nitrates determination, HI 93707-0 – for nitrites determination and HI 93700A-0 + HI 93700B-0 for ammonia determination. All the measurement procedures were carried out in accordance with the description made by the manufacturer [11].

The results were compared to the values set out by Law 7/2023 [15].

The obtained data were statistically processed with the SPSS program, version 17. The descriptive statistical indicators (mean, standard error of the mean, median, minimum, and maximum) were calculated for the determined parameters. The Kruskal-Wallis test was used to compare the results. Differences were considered significant if $P < 0.05$.

3. Results and Discussions

One of the chemical indicators, namely nitrites, was not identified above the allowed value (0.5 mg/L) in any collected sample. Higher concentrations were recorded in two water samples (from the well and the stream) (Table1). Increased values of nitrites or nitrates in water can cause poisoning in animals, nitrites being more harmful [2].

Nitrates, the second chemical parameter determined, were not present in water samples from rivers or streams, and in most samples, the amount identified was insignificant or close to zero. The maximum allowed value (50 mg/L) was recorded in two samples from the wells (Table 1). In sample number 12 there is a significant number of nitrates, but it is within the standard.

In all samples taken from wells, springs, rivers and streams, the value of ammonia tends to zero, being within acceptable limits. Three samples (Table 1) had the amount of ammonia close to the maximum allowed value (0.5 mg/L). Ammonia is the result of the breakdown of organic and inorganic matter from nitrogen-based fertilizers in water. The presence of ammonia in the water means recent faecal contamination.

In another study it is highlighted that an increased concentration of nitrates in the drinking water of broiler chickens causes a decrease in growth [3]. According to another research, a concentration 2-3 times higher than the allowed value causes reproductive problems in adult cows, and developmental delays in heifers [8].

Table1. Ammonia, nitrites and nitrates in water samples

Sample	Ammonia (mg/L)	Nitrites (mg/L)	Nitrates (mg/L)	Sample	Ammonia (mg/L)	Nitrites (mg/L)	Nitrates (mg/L)
W 1	0	0.17	1,8	S 20	0	0	0
W 2	0.1	0.02	17	S 21	0	0.005	13.29
W 3	0.19	0.05	1,9	S 22	0	0.005	8.86
W 4	0	0.01	0	S 23	0	0.005	0
W 5	0	0.015	21	S24	0	0.01	12.9
W 6	0	0.04	37	SR25	0.4	0.03	0
W 7	0	0.005	28	SR 26	0	0.03	0
W 8	0	0.15	8	SR 27	0.01	0.07	0
W 9	0.2	0	0	SR 28	0.01	0.07	0
W 10	0	0.015	50	SR 29	0.1	0.30	0
W 11	0	0.03	50	SR 30	0.01	0.2	0
W 12	0	0.5	40	SR 31	0.4	0.5	0
W 13	0	0	0	SR 32	0	0.15	0
W 14	0.4	0	0	SR 33	0	0	0
W15	0	0.3	0	SR 34	0.04	0.04	0
S16	0	0.12	3.5	SR 35	0.09	0.03	0
S 17	0.1	0.05	0	SR 36	0.03	0.03	0
S 18	0	0	0	SR37	0.14	0.01	0
S 19	0.3	0	0				

W-water samples from well; S- water samples from spring; SR – water samples from stream, river

In dairy cows, the concentration of nitrates above 180 mg/L in drinking water did not increase the concentration of nitrates eliminated through milk [12].

Table 2 presents descriptive statistical indicators for the evaluated parameters and the significance of the difference in relation to the source of the water (well - W, spring - S, rivers and streams - SR). Significant differences ($p < 0.05$) were observed for ammonia, nitrites and nitrates. Ammonia concentration was significantly higher ($p < 0.05$) in RS than in W and S. For this parameter, no significant differences were observed between W and S ($p > 0.05$). Nitrites had a significantly higher concentration ($p < 0.05$) in E and SR than in S, while nitrates had a significantly higher value in W ($p < 0.05$).

Table 2. Descriptive statistical indicators for the evaluated parameters

Issue		Parameter		
		Ammonia (mg/L)	Nitrites (mg/L)	Nitrates (mg/L)
W	Mean ±SE	0.05±0.03	0.1±0.04	15.75±4.95
	Median	0^a	0.03^a	8^a
	Min-Max	0-0,4	0-0.5	0-50
S	Mean ±SE	0.04± 0.03	0.02±0.01	4.28±1.93
	Median	0^a	$0{,}005^b$	0^b
	Min-Max	0-0,3	0-0.12	0-13.29
SR	Mean ±SE	0.09±0.04	0	0.09±0.03
	Median	0.03^b	0^b	0.06
	Min-Max	0-0.4	0	0-0.25

The existence of nitrates in the water supply can impact the well-being and productivity of animals, with the extent of the influence varying depending on the concentration of nitrates and the species of the animals. According to the research of Grant, the nitrate concentrations exceeding 100-150 mg/L of drinking water can cause reproductive disturbances in mature cows and replacement heifers, which will show lower growing rates, but usually there are no significant milk production alterations at moderately raised nitrate levels in the drinking water [8]. Other studies [6] took water samples from 128 dairy cattle farms in the State of Iowa in order to assess the water quality effects on the productive performances of dairy cows. His study's results indicate that high nitrate concentrations in drinking water cause longer calving intervals. Seerly et al., 1996, concluded that drinking water containing about 300 mg/L nitrates does not affect the health of swine and ovine [19]. In one study was reported, similarly, no morbidity in pregnant sows after the consumption over a 6 weeks period of water with a nitrate content of approximate 1300 mg/L [1]. On the other hand, no effects were observed on newborns or young piglets drinking water with nitrates exceeding 2000 mg/L [20]. A national level monitoring of the swine farms in the United States showed no connection between the health or performance of the animals and the drinking of water containing more than 460 mg/L nitrates [5]. There is also the possibility that cultivated fodder with a large amount of nitrates can lead to high concentrations of nitrates in the water source. Thus, in his study on poultry, Bergsrund, 1990, suggested that water containing more than 20mg/L nitrates can have negative effects on their growth, but also on the egg production [4].

4. Conclusions

The comparative analysis of the three water sources (well, spring, rivers and streams) showed significant differences ($p<0.05$) for all studied parameters. That is why it is important that the water sources must be in accordance with the hygienic requirements to maintain the native quality of underground and surface water.

References

[1] Anderson D.M., S.C. Stothers, 1978, Effects of saline water high in sulphates, chlorides and nitrates on the performance of young weanling pigs, Journal of Animal Science, 47, 900-907.

[2] ANZECC, Australian and New Zealand Environment and Conservation Council., 2000, Water Quality Guidelines, http://www.mfe.govt.nz/publications/water/anzecc-water-quality-guide-02.

[3] Barton T.L., 1996, Relevance of water quality to broiler and turkey performance, Poultry Science, 75(7), 854-6.

[4] Bergsrund F., L. James, 1990, Water Quality for Livestock and Poultry, Minnesota Extension Service.

[5] Bruning-Fan, C. S., J.B. Kaneene, J.W. Lloyd, A.D. Stein, B. Thacker, H.S. Hurd, 1996, Associations between drinking-water nitrate and the productivity and health of farrowing swine, Preventive Veterinary Medicine, 26, 33-46.

[6] Ensley S.M., 2000, Relationship of Drinking Water Quality to production and Reproduction in Dairy Herds, PhD Dissertation, Iowa State University.

[7] Environment Canada, 2003, Canadian water quality guidelines for the protection of aquatic life: nitrate ion, Ottawa (ON): Environment Canada, Water Policy and Coordination Directorate, National Guidelines and Standards Office.

[8] Grant R., 1996, Water quality and requirements for dairy cattle, University Nebraska NebGuide G93-1138-A.

[9] Haycock, N. E., and Pinay, G. 1993. Groundwater nitrate dynamics in grass and poplar vegetated riparian buffer strips during the winter, J. Environ. Qual. 22, 273–8.

[10] Herring A., 2014. Beef cattle production systems: Wallingford, Oxfordshire; Boston, MA: CABI, https:// hannainst.ro/.

[11] Kammerer M.L., H. Pinault, H. Pouliquen, 1992, Nitrate content of milk. Relationship with its concentration in drinking water (in French), Annales de Recherches Veterinaires, 23, 131- 138.

[12] Keeney D.R., J.L. Hatfield, 2008, The nitrogen cycle, historical perspective, and current and potential future concerns, In: Hatfield JL, Follett RF, editors. Nitrogen in the environment: sources, problems, and management. San Diego (CA): Elsevier Inc.

[13] Kirmeyer G.J., L.H. Odell, J. Jacangelo, A. Wilczak, R. Wolfe, 1995, Nitrification occurrence and control in chloraminated water systems, Denver (CO): American Water Works Association Research Foundation and American Water Works Association.

[14] Law 7/2023, Law Regarding the Drinking Water Quality, in: The Official Journal of Romania, part I, 63/25th of January 2023.

[15] Popescu S., C. Borda, 2008, Water hygiene. In: Animal hygiene and environmental protection, Student handbook for practical lessons, Ed. Napoca Star, 53-87.

[16] Popkin B.M., K.E. D'Anci, I.H. Rosenberg, 2010, Water, hydration, and health, Nutr. Rev., 68(8), 439-58.

[17] Rashid N.S., S.M. Praveena, A.Z. Aris, 2015, Drinking Water Assessment on Ammonia Exposure Through Tap Water in Kampung Sungai Sekamat, Kajang, Procedia Environmental Sciences, 30, 354-357.

[18] Seerley R.W., H.G. Young, J.F. Fredrickson, 1996, A progress report on the performance of growing finishing swine under different environmental conditions, South Dakota Agicultural Experiment Station, AS Series 66-20.

[19] Sorensen M.T., B.B. Jensen, H.D. Poulsen, 1994, Nitrate and pig manure in drinking water to early weaned piglets and growing pigs, Livestock Production Science, 39, 223-227.

[20] USEPA, 1987, Estimated national occurrence and exposure to nitrate and nitrite in public drinking water supplies, Washington (DC): United States Environmental Protection Agency, Office of Drinking Water.

[21] USEPA, 2002, Nitrification. Prepared for Standards and Risk Management Division, Office of Groundwater and Drinking Water, U.S. Environmental Protection Agency, Washington, DC.

[22] USEPA, 2006, Basic information about nitrate in drinking water, Washington (DC), United States Environmental Protection Agency.

[23] Van Duijvenboden W., A.J.C.M. Matthijsen, 1989, ntegrated criteria document nitrate, Bilthoven: National Institute for Public Health and the Environment (RIVM Report No. 758473012).

[24] Wright C.L., 2007, Management of water quality for beef cattle, Vet. Clin Food Anim 23, 91-103.