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Assessing the Water Quality for Animal Consumption in Rural Households via Indicator Parameters

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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 Transylvania in terms of indicator parameters, such as pH, chlorides, iron, sulfates, temporary hardness and organic matter. The water samples were collected from three different sources: 15 samples from wells, 9 samples from springs and 13 samples from rivers and streams. The results were compared with the drinking water standards outlined in Law 7/2023] and were subjected to statistical analysis using the SPSS program, version 17. Significant differences ($p < 0.05$) were observed for sulfates, pH, organic matter. The amount of sulfates was significantly higher ($p < 0.05$) in wells than in springs and rivers and streams. The pH was significantly higher ($p < 0.05$) in rivers and streams compared to wells and springs. Organic substances had significantly higher concentrations ($p < 0.05$) in wells than in springs and streams and rivers.

Keywords: animals, drinking water, indicator, parameters, watering.

1. Introduction

Global water quality varies from place to place, influenced by environmental factors and geographical locations. Numerous microbiological, chemical and indicator parameters are interconnected to characterize water quality [3, 8]. Groundwater, including wells, and surface water, such as rivers and streams, play vital roles as sources of drinking water for both humans and animals. Water pollution stands as a significant contributor to the spread of diseases and the transmission of infections among organisms that rely on it [2].

The pH level of water can affect animal health differently depending on the species. For example, in ruminants, drinking water with a pH lower than 5.5 could lead to metabolic acidosis, while alkaline water with a pH above 8.5 may increase the risk of metabolic alkalosis.

Iron is an element found in the Earth's crust, but at the same time, it is widely distributed in the biosphere. In the context of water for animals, iron is typically seen as an issue that primarily affects water lines, rather than posing a toxicological concern. High levels of iron can affect the taste of water, and thus reduce water intake, and have adverse effects on metabolism of several essential micronutrients [12].

Sulfate is present in nearly all forms of water. Sulfate gives water a bitter taste, but animals can adapt to it. It's advisable to dilute water with elevated sulfate levels, especially for weanling pigs and animals not accustomed to it [4]. Chloride is naturally present in groundwater, streams, and lakes. However, the detection of relatively high chloride concentrations in freshwater (approximately 250 mg/L or higher) could suggest contamination from wastewater sources [5, 10].

The presence of turbidity in drinking water is visually unappealing and gives the water an unattractive appearance [10].

Water quality has substantial effects on the welfare and productivity of an animal and therefore it is important that the drinking water consumed by animals to be periodically analyzed. In this context, the aim of this paper was to assess the quality of the water consumed by animals in rural households in Transylvania in terms of indicator parameters, such as pH, chlorides, iron, sulfates, temporary hardness and organic matter.

2. Material and method

The study was conducted over a period of 4 months in a rural environment in Transylvania (Alba, Bistrița-Năsăud, Cluj, Hunedoara counties). During this time, water samples were collected from various sources located in households: well - 15 samples; spring - 9 samples; stream, river - 13 samples. The water samples for assessing indicator parameters were collected following the recommendations made by Popescu, 2008 [17]. With each sample collection, the container was rinsed with water from the source. Water samples were collected in clean, colorless plastic or glass containers with stoppers. Water samples were collected differently depending on the water source: (a) wells: samples were taken using a bucket submerged below the water surface; (b) springs, streams, rivers: samples were collected from the area where animals are watered.

Water samples were transported to the laboratory to be analyzed within 4-6 hours of collection. The samples were accompanied by a note in which the following data were mentioned: the water source type and its location; time and date of water sample was collection; the species of animals consuming the water and their number (where possible); the technical and hygienic condition of the water source – the material used for water troughs, the method of water withdrawal**,** the hygiene of the facilities and the surrounding area of the watering site; air temperature at the time of collection; weather information during the collection and two to three days prior to the water samples collection.

The water quality was appreciated based on indicators parameters: iron, sulfates, chlorides, temporary hardness, organic substances and pH of the water. The information about indicator parameters and their determination methods is presented in Table 1.

Table 1. Summary of methods used to determine individual chemical parameters

No.	Parameter	Parametric value	Measure unit	Method	References
1	Odour	Acceptable to consumers and no abnormal change	-	The odour is determined using the operator's sense of smell.	[17]
2	Colour	Acceptable to consumers and no abnormal change	-	Indicative	[17]
3	Turbidity	Acceptable to consumers and no abnormal change	-	Indicative	[17]
4	pH	≥ 6.5 and ≤ 9.5	pH units	pH Meter	[11]
5	Iron	200	µg/L	Photocolorimetry	[11]
6	Sulfates	250	mg/L	Photocolorimetry	[11]
7	Chlorides	250	mg/L	Mohr's Method	[17]
8	Temporary hardness	≥5	German degree (°dH)	Titration	[17]
9	Organic substances	5	mg O_2/L	$KMnO_4$	[17]

The results obtained were compared with the values recommended by Law 7/2023 [13].

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

Of the 37 samples analyzed, 3 showed slight changes in odour (one from the well, two from surface water) and 5 had different degrees of turbidity (surface water).

Iron exceeded the maximum allowed concentration (0.2 mg/L) in samples 1, 3 and 14 – from the well and in samples 25, 26 and 29 – from rivers and streams (Table 2, and Table 4).

In most samples from the spring, iron had a value close to zero; only in two samples the iron concentration slightly exceeded the standard, respectively in samples 18 and 23 (Table 3).

Iron detected in samples above the allowed value does not endanger the health of the animals, but changes the color and taste of the water, the animals refusing to consume it. An increased amount of iron can affect the pipe system by reducing the circulating volume due to accumulations [1].

Table 2. The results of the water samples from wells

Sample	Iron (mg/L)	Sulfates (mg/L)	Organic substances (mg O_2/L)	Chlorides (mg/Ll)	Temporary hardness (German degree) (°dH)	pH
1	0.77	250	2.56	26	21	6.84
2	0.1	67	2.8	62	8.96	6.82
3	0.43	62	1.67	33	15.5	6.92
4	0	73	0.4	122	20.44	7.27
5	0	48	2.53	92	22.68	6.9
6	0	54	4.87	144	21.28	6.48
7	0	61	5.43	84	23.24	6.37
8	0	21	7.35	16	33.32	7.4
9	0	29	6.95	206	21.28	7.2
10	0	178	5.83	152	26.60	7.42
11	0	123	5.67	147	27.16	7.14
12	0	198	5.83	48	28.84	7.15
13	0	27	5.99	32	29.40	7.5
14	2.50	16	5.78	18	28	7.36
15	0	43	6.71	22	13.44	7.1

The amount of sulfates was low in all water samples, falling within acceptable limits (250 mg/L). The first sample had the maximum allowed amount, three samples from the well (10, 11 and 12), two from the springs (samples 23 and 24) and four samples from rivers and streams (27, 28, 29 and 30) had a significant amount of sulfates, but within acceptable limits (Tables 2, 3, 4). In a study conducted by Loneragan, 2001, in cattle, it is shown that an increased amount of sulfates in the water decreases the volume ingested by the animals and the carcass weight at slaughter is low [14].

The same study shows that over time, the animals get used to the modified water, but the side effects of such consumption do not disappear. After ingesting water with a sulfate concentration exceeding 1000 mg/L, the volume of hydrogen sulfide increases in the rumen.

High levels of sulfates in drinking water lead to nutritional deficiencies [18], and 0.22% of sulfates in the feed causes a deterioration of carcasses over time [14].

The amounts of chlorides were double or even triple compared to the maximum allowed limit (250 mg/L) in three samples from springs (Table 3) and only a single sample from the river (Table 4). Similar results were reported in other studies [18, 19, 20]; in the study conducted in the USA they showed that over 40% of the examined water samples contained chlorides in concentrations that exceeded the maximum allowed limit. Chlorines can reach the water by polluting the water with sewage, with industrial residues or by dissolving in the soil [17]. According to a study by Chen and Balnave, 2001, Isa Brown laying hens can consume water with a concentration of 2g/L of NaCl without any adverse effects on their health [6].

In another study conducted by Damron, 1998, the quality of eggs was tested when laying hens consumed water with different concentrations of sodium chloride (NaCl): 0, 200, 400, 600 and 800 ppm NaCl. The quality of the eggs was not affected by any of the NaCl concentrations in the drinking water [7].

Analyzing the organic substances, it was found that in most water samples from the wells (67.67%) the maximum allowed concentration (5 mg O_2/L) was exceeded; only in the first 5 samples out of 15, the amount of oxygen per liter was according to the standard. River or stream water is the only category where all samples comply with the norms regarding the concentration of organic substances (Table 4). In the samples collected from the springs, 7 out of 9 samples fall within the standard (Table 3). The presence of organic substances in concentrations much higher than the allowed values indicates the existence of water pollution factors at the source level.

Table 3. The results of the water samples from springs

Sample	Iron (mg/L)	Sulfates (mg/L)	Organic substances (mg O_2/L)	Chlorides (mg/L)	Temporary hardness (German degree) (°dH)	pH
16	0.05	5	2.4	15	12.6	7.16
17	0	6	0.54	22	14.5	6.45
18	0.25	18	1.99	29	71.12	5.93
29	0	24	6.15	18	20.44	7.1
20	0	14	5.59	10	22.12	6.9
21	0	21	4.7	653	22	6.9
22	0	19	1.6	635	16.8	7
23	0.25	124	2.15	445	41.16	7.45
24	0	170	1.27	31	10.36	7.1

Most of the water samples are non-compliant in terms of temporary hardness, with values exceeding two or three times the permissible limit (10 German degrees). Out of 37 samples, only 6 (16.22%) have hardness below the maximum limit (Tables 2 and 4). Fortunately, this parameter does not change the well-being of the animals, as they consume hard water without effects on production or the amount ingested [15, 18]. However, a study in turkeys conducted by Martino, 2018, shows that high water hardness, complemented by low salinity, represents a major risk in infection with *Campylobacter coli* and *C. Jejuni* [16].

Table 4. The results of the water samples from rivers and streams

Sample	Iron (mg/L)	Sulfates (mg/L)	Organic substances (mg O_2/L)	Chlorides (mg/L)	Temporary hardness (German degree) (°dH)	pH
25	0.25	87	2.87	71	21.84	6.31
26	0.25	72	3.67	48	22.68	6.42
27	0	180	2.79	48	32.76	8.58
28	0	162	2.95	47	33.32	8.52
29	0.25	194	4.82	61	41.44	8.62
30	0	143	2.39	53	32.2	8.55
31	0.1	26	3.27	260	33.6	8.7
32	0	2	1.91	27	14.7	8.57
33	0	3	0.63	17	7	6.95
34	0	0	2.95	19	3.36	8.01
35	0.17	5	2.79	19	3.64	8.26
36	0.06	0	3.03	20	3.92	8.37
37	0.07	5	3.03	20	3.36	8.23

Regarding the chemical reaction of water (pH), most of the collected water samples are compliant (6.5 - 9.5). However, values below the lower limit of the range were recorded in 6 samples (6, 7, 17, 18, 25 and 26). In general, the pH was higher in samples from rivers and streams (Table 4).

In the analyzed samples there was no value exceeding the upper limit of the range. Consumption of water with modified pH compared to water quality requirements can be important for animal health.

For example, Grant, 1993, showed that water with a pH below 5.5 can cause problems in farm animals such as reduced milk production, low milk fat percentage, reduced growth rates, infectious and metabolic diseases and a decrease in fertility [9].

Table 5 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 sulfates, pH, organic matter in water from different sources (well, spring, rivers, and streams).

The amount of sulfates was significantly higher ($p < 0.05$) in W than in S and SR. The pH was significantly higher ($p < 0.05$) in SR compared to W and S.

Organic substances had significantly higher concentrations ($p < 0.05$) in W than in S and SR.

Table 5. Descriptive statistical indicators for the evaluated parameters

		PARAMETER					
		Iron (mg/L)	Sulfates (mg/L)	Chlorides (mg/L)	Temporary hardness (German degree)	pH	Organic substances (mg O_2/L)
W	Mean±SE	0.29±0.19	80.23±19.45	65.08±13.32	22.56±1.93	7.02±0.09	4.43±0.6
	Median	0	61^a	48	22.68	7.1^a	5.43^a
	Min-Max	0-2.5	16-250	16-147	8.96-33.32	6.37-7.50	0.4-7.35
S	Mean±SE	0.06±0.04	44.55±19.85	206.44±94.8	25.68±6.42	6.89±0.15	2.93±0.67
	Median	0	19^b	29	20.44	7^a	2.15^b
	Min-Max	0-0.25	5-170	10-653	10.36-71.12	5.93-7.45	0.54-6.15
SR	Mean±SE	0.09±0.03	67.61±21.30	54.61±17.86	19.52±3.94	8.01±0.24	2.85±0.26
	Median	0.06	26^b	47	21.84	8.37^b	2.95^b
	Min-Max	0-0.25	0-194	17-260	3.36-41.44	6.31-8.70	0.63-4.82

4. Conclusions

The evaluation of the three water sources (wells, springs, rivers, and streams) revealed significant differences ($p<0.05$) for pH, organic substances and sulfates. The design of water sources, as well as their exploitation, present hygiene deficiencies in most cases; consequently, the water becomes contaminated either during transportation or at the watering site, with negative consequences for animal health and production. Therefore, we recommend placing water sources at specified distances from various sources of pollution.

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