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Agriculture and Environment

Water quality assessment from own source at poultry farm located in rural region in South Bulgaria

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Abstract. *The aim of the study was to investigate and assess the quality of water, obtained from own well source at a poultry farm (with capacity 13 350 hens and turkeys), situated in rural area in South Bulgaria, on the basis of organoleptic (smell, color, visibility, taste), physical (temperature) and chemical (pH, permanganate oxidation, hardness, chlorides, ammonia, nitrates, nitrites) indices. It was found that the quality of water corresponded to the norms concerning the organoleptic (smell – 0 ball, norm up to 2 ball; color - 5°, norm up to 15°; visibility - over 60 cm thickness of water plast, norm at least 30 cm; taste - no flavor, norm no flavor), physical (temperature – 13.5-16.8 °C, norm 6-16 °C) and chemical (pH 6.80÷7.15, norm 6.5-9.5; oxidizability 0.24÷0.72 mg O_2/l, norm up to 5.0 mg O_2/l; hardness 6.49÷7.55 mg Σqv/l, norm up to 12.0 mg Σqv/l; chlorides 162.0÷197.0 mg/l, norm up to 250.0 mg/l and nitrites 0.0÷0.021 mg/l, norm up to 0.5 mg/l) indices. The most significant deviation from quality standards were observed regarding the concentration of ammonia (0.01÷0.6, norm up to 0.5 mg/l) and nitrates (58.0÷110.0 mg/l, norm up to 50.0 mg/l).*

Keywords: poultry farm, water, indices, assessment, quality

Introduction

The water is an indispensable resource for livestock production systems. It is necessary to meet potable, technological and sanitary needs of the animals bred and staff of the farm. Therefore, the water in the farm must comply with the regulated requirements for quality. Water for livestock farms is provided from different sources (surface waters – dams, rivers, lakes and groundwaters – wells) and with different systems of water supply (central or local) (Netsov and Petkov, 1994). Local supply from own wells is mainly used in small farms. Sometimes the water from these sources can be hazardous to human and animal health in the farm because there are potential opportunities for its contamination with dangerous substances and microorganisms (Nielsen, 1991). The contamination of surface and groundwaters is essentially determined by the pollution of general nature – air, water, soil. In this connection Apostolov and Krasteva (2003) consider that livestock farms are major polluters of water and water sources, particularly in the areas around them.

Manure and wastewater from livestock farms consist mainly of organic compounds, microorganisms and pathogenic forms of the parasite, which under certain conditions can become a serious environmental problem for the quality of water resources around the farm (Vasilev, 2001; Fewtrell and Bartram, 2001). According to data of Iliev et al. (2004), Mihaylova (2009), Georgieva et al., (2010, 2011) and the Annual Report on State of Environment in Bulgaria (2010), in many regions of the country ground water contains excessive amounts of nitrates, especially in areas with intensive farming and plant production. Most commonly underground waters (springs, wells, drainage wells) are polluted in zones of arable agricultural lands or near settlements, industrial plants and animal farms (Karagul et al., 2004). Studies in dairy (Kostadinova et al., 2003) and pig farms (Petkov, 2004) in the country indicate that water quality derived from own drill wells normally meets the regulated standards. But there are risks, determined by the simultaneous influence of available concentrations of nitrites and nitrates as well as the ingress of pathogenic microorganisms in the water.

The aim of the study was to investigate and assess the water quality from own source at a poultry farm, located in rural area in South Bulgaria, on the basis of organoleptic, physical and chemical indices and its suitability to be used for drinking and production purposes on the farm.

Material and methods

Study area. The study was carried out in a poultry farm at the Hybrid Center for Poultry Science at the Institute of Animal Science, Kostinbrod, Stara Zagora branch for the period from September 2008 to June 2009. The farm is located at the southern part of the village of Malko Kadievo, situated 9 kilometers east of Stara Zagora (central region of South Bulgaria) on an area of 230 dka. There are 10 buildings for turkeys and laying hens on the territory of the farm, a hatchery, warehouses and administrative offices. The total number of birds in the farm (hens and turkeys) in the survey period was 13 350. The farm has closed production cycle. It owns 50 acres of land for cereal production – wheat and barley. This land is fertilized with organic manure (obtained from birds) and mineral fertilizers.

The water in the farm for drinking and technological purposes is supplied from own well drilling with depth 15 m. The well is located 20 m east of the production buildings and 70 m from the manure storage place. The water for watering the birds in the buildings is provided by the groove troughs with manual adjusting of the amount of water lodged.

Sampling. Water samples for analysis were taken monthly from the water source, in glass bottles, strictly according to Bulgarian State Standard (BSS) ISO 5667-5 Water Quality. The total number of

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water samples taken was 10. All they were analyzed in the research laboratory ECOLAB at the Department of Applied Ecology and Animal Hygiene, Faculty of Agriculture, Trakia University, Stara Zagora, Bulgaria.

Investigated indices and methods of analysis. For the purposes of the study the following indices of the water were investigated and the following methods for their analysis were used:

A. Organoleptic indices

- Smell - descriptive in balls by intensity of the smell, BSS 17.1.4.01-77;
- Color – visual in color degrees by platinum-cobalt scale, BSS 17.1.4.01-77;
- Visibility – in cm by method of Snellen, BSS 8451-77;
- Taste - organoleptic (descriptive), BSS 8451-77.

B. Physico-chemical indices

- Temperature (°C) - with mercury thermometer, BSS 8451-77;
- Active reaction (pH), BSS EN ISO 10523;
- Permanganate oxidation (mg O_2/l), BSS EN ISO 8467:01;
- Total hardness (mg Σqv/l), BSS EN ISO 6059;
- Chloride content (mg/l), BSS 17.1.4.27;
- Content of ammonium nitrogen (mg/l), BSS ISO 7150-1;
- Content of nitrite nitrogen (mg/l), BSS ISO 7890-3;
- Content of nitrate nitrogen (mg/l), BSS EN 26777.

Assessment of water quality. Ecological quality assessment of the tasted water samples was made by comparing the obtained results with statutory norms for different indicators in Regulation № 1/2007 on the study, use and protection of groundwater and Regulation № 9/2001 on water quality intended for drinking purposes.

Results and discussion

Organoleptic indices. All water samples analyzed for organoleptic indices corresponded to statutory requirements: smell – water was with no smell (0 ball, at norm up to 2 ball); color of the water (expressed in degrees of color) was 5° (at norm up to 15° or acceptable for consumers); visibility of water (water layer thickness in cm) was over 60 cm, (at norm at least 30 cm); taste – the water was with no flavor (at norm – no flavor).

Physic-chemical indices. Results for the studied physico-chemical indices of water are presented in Table 1.

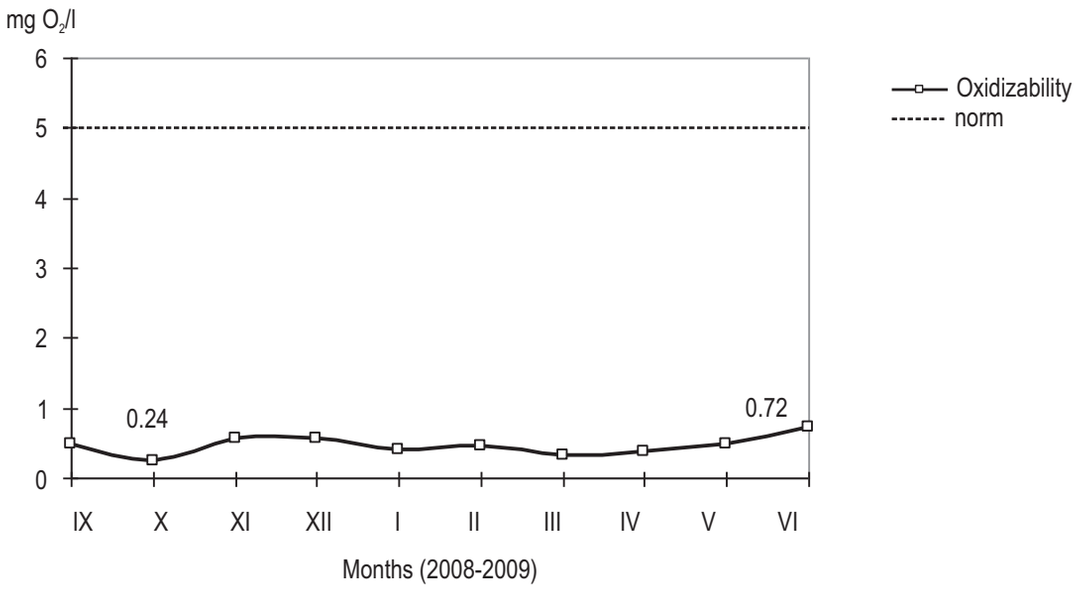
Temperature (°C). The average water temperature during the study period was 14.6 °C (Table 1). Water temperature was with the lowest values during December, January and February – 13.5 °C. The highest values were recorded in September (16.7 °C) and October (16.8 °C). These values slightly exceed the permissible limit (16 °C). Variation in the values of that index was in a narrow range (C_v = 8.2%) and gives reason to think that water comes from a deep underground zone with relatively constant temperature. This presupposes that it is cleaner and with better quality. The water temperature throughout most of the period was consistent with the requirements (6-16 °C). It is considered that in this temperature range water satisfies best the thirst, has a refreshing effect and stimulates the functions of the digestive tract.

Active reaction (pH). The active reaction of the sampled water varied in the range from 6.80 in October to 7.15 in March (Table 1). The average value of index for the period was 6.93. Slight fluctuations in the values of this indicator were observed (C_v=1.7%). The measured values were in the optimal range 6.5 – 9.5 stipulated in Regulation № 9/2001 and Regulation № 1/2007.

Table1. Physical and chemical indices of water

Month and year	Physical and chemical indices of water							
	Tempe-rature T, °C	pH	Oxidizability by KMnO4 mg O_2/l	Total hardness mg Σqv/l	Chlorides mg/l	Ammonia mg/l	Nitrites mg/l	Nitrates mg/l
09.2008	16.7	6.97	0.48	7.22	192.0	0.014	-	58.0
10.2008	16.8	6.80	0.24	6.77	191.0	0.019	0.016	59.4
11.2008	13.8	6.82	0.56	7.18	193.0	0.036	0.012	65.0
12.2008	13.5	6.81	0.56	7.14	190.0	0.062	0.017	67.0
01.2009	13.5	6.87	0.40	7.34	197.0	0.046	0.014	67.0
02.2009	13.5	6.82	0.46	7.38	195.0	0.048	0.014	64.0
03.2009	14.0	7.15	0.32	7.10	180,0	0.059	0.014	64.0
04.2009	14.8	7.00	0.38	6.49	190.0	0.062	0.019	75.0
05.2009	14.0	7.05	0.48	7.55	162.0	0.600	0.021	87.0
06.2009	15.0	7.03	0.72	7.26	162.0	0.510	-	110.0
Average for the period	14.6	6.93	0.46	7.14	185.2	0.15	0.016	71.6
SE	±0.40	±0.04	±0.04	±0.10	±4.12	±0.06	±0.00	±4.53
CV, %	8.2	1.7	28.8	4.1	6.7	141.2	50	21
min	13.5	6.8	0.24	6.49	162	0.01	-	58
max	16.8	7.15	0.72	7.55	197	0.6	0.021	110
Standard*	6 - 16	6.5 - 9.5	5.0	12.0	250	0.5		

* According Regulation № 9/2009 and Regulation № 1/2007



Firgure 1. Oxidizability of water by $KMnO_4$(mg O/l)

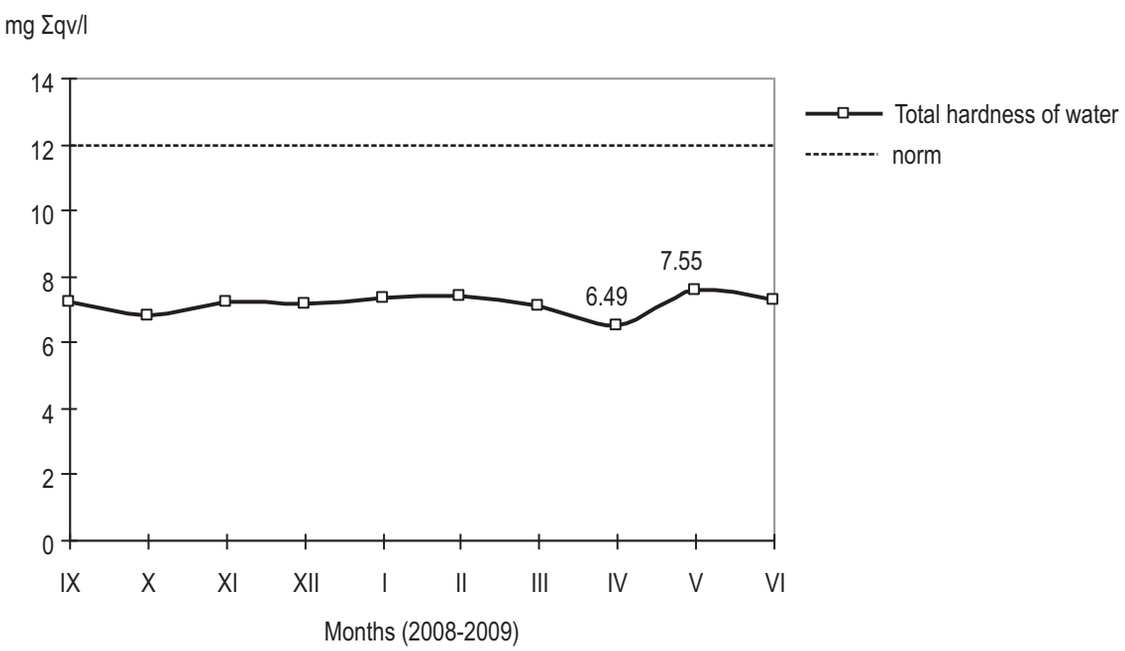
Permanganate oxidation (mg O_2/l). The values of this index were in the range from 0.24 mgO_2/l in October to 0,72 mgO_2/l in June, with average content for the period – 0.46 mgO_2/l. Despite the moderate variation in the indicator values (C_v = 28.8%), the established quantities were over 10 times lower than the permissible limit - 5.0 mgO_2/l (Table 1, Figure 1).

Total hardness (mg Σqv/l). Water hardness was the lowest in April – 6.49 mgΣqv/l, and the highest in May – 7.55 mgΣqv/l, average for the period 7.14 mg Σqv/l. The values of the index fluctuated in a relatively narrow range (C_v=4.1%). On this index water meets the requirements as established results were lower than the permissible level for hardness of water – up to 12.0 mg Σqv/l (Figure 2).

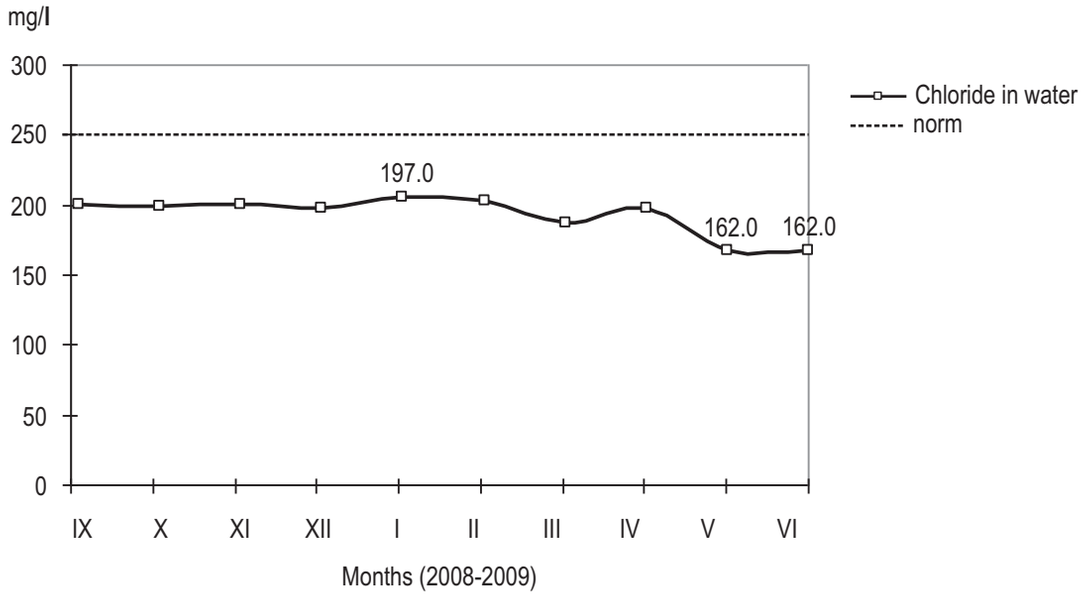
Chloride content (mg/l). Concentrations of chloride in water sampled were relatively high – from 162.0 mg/l in May and June to 197.0 mg/l in January, on average 185.2 mg/l. At the same time the index values varied in a narrow range (C_v = 6.7%). All established concentrations were in the norm - up to 250 mg/l (Figure 3).

Content of ammonium nitrogen (mg/l). The content of ammonium ions in the water ranged widely (C_v=141.2%). The lowest concentration (0.014 mg/l) of ammonium ions was measured in September and the highest, exceeding the permissible level 0.5 mg/l, was recorded in May (0.60 mg/l) and June (0.51 mg/l), (Figure 4).

Content of nitrite nitrogen (mg/l). During the survey period low concentrations of nitrite were found in the water – from 0.012 to 0.021 mg/l, on average 0.016 mg/l. The nitrite content in the tested



Firgure 2. Total hardness of water, mg Σqv/l



Firgure 3. Chloride content in water, mg /l

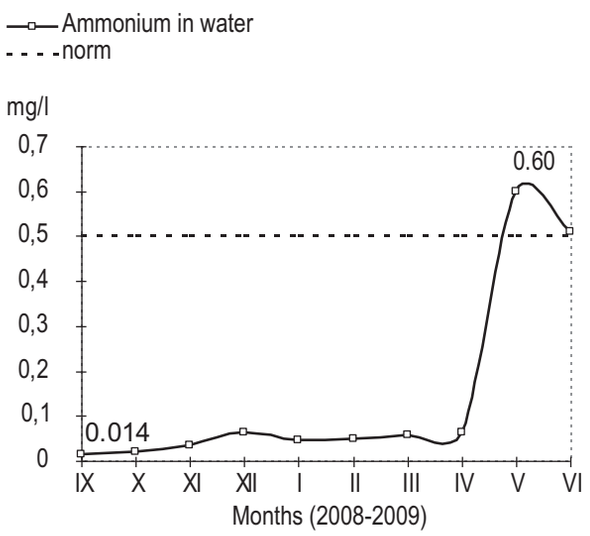


Figure 4. Content of ammonium in water, mg /l

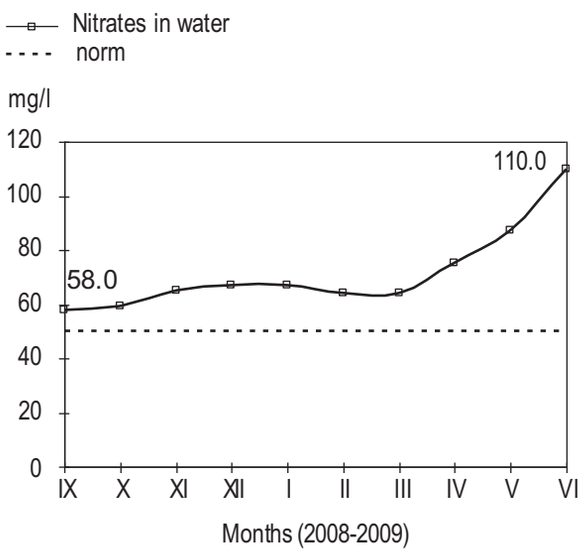


Figure 5. Content of nitrates in water, mg /l

water was not found in September and June. The quantity of nitrite in water varied significantly during the different months of the controlled period (C_v=50.0%). All values were much lower than the limit boundary (0.5 mg/l).

Content of nitrate nitrogen (mg/l). Nitrate content ranged from 58.0 mg/l in September to 110.0 mg/l in June, on average 71.6 mg/l (Figure 5). A clear trend of increase in nitrate levels was observed at the end of the reference period. Nitrates content in all water samples exceeded the maximum permissible concentration – 50.0 mg/l.

Assessment of water quality on the simultaneous presence of nitrates and nitrites in water. In 8 of 10 months (since October 2008 to May 2009) of the investigation period simultaneous presence of nitrates and nitrites was established in the water. In accordance with Regulation № 9 (2001) it an assessment of the water quality on this complex index was made for the relevant months of the surveyed period. The results are presented in Table 2.

Sums of the ratios of the actual concentrations of nitrites (NO_2^-) and nitrates (NO_3^-) in the water for different months, attributed to the limit concentration (LC) of each substance ranged from 1.16 in September to 2.20 in June, an average for the period 1.46. The calculated values for this complex index were higher than one (>1.00), i.e. all they exceed the permitted limit. These results indicate that there is a potential health risk via synergetic action of nitrites and nitrates in the water for the birds raised and the farm staff.

The presence of ammonia, nitrites and nitrates in groundwater is a criterion for water pollution with nitrogenous organic substances. It is likely that contamination of groundwater is from the farm as manure removed from the buildings is stored on the ground near the production buildings. In spring months, when the environment temperature is higher, more intensive are the processes of ammonification of organic matter in manure and the levels of ammonia, nitrites and nitrates in groundwater increase. Consequently, one option to reduce pollution of groundwater on the territory of the livestock farm is manure to be stored in waterproofing

Table 2. Water quality assessment on base of the simultaneous presence of nitrates and nitrites

Month and year of sampling	Ratio (NO_2^-)* / LC_1**	Ratio (NO_3^-)* / LC_2***	C ≤ 1****
09.2008	-	1.16	1.16
10.2008	0.032	1.19	1.22
11.2008	0.024	1.30	1.32
12.2008	0.034	1.34	1.37
01.2009	0.028	1.34	1.37
02.2009	0.028	1.28	1.31
03.2009	0.028	1.28	1.31
04.2009	0.038	1.50	1.54
05.2009	0.042	1.74	1.78
06.2009	-	2.20	2.20
Average for the period	0.032	1.43	1.46

* Nitrites (NO_2^-) and nitrates (NO_3^-) content in the water (mg/l, Table 1); ** LC_1 – Limit concentration of nitrites in the water – 0,50 mg/l;
*** LC_2 – Limit concentration of nitrates in the water – 50 mg/l; **** $(NO_2^-)/LC_1 + (NO_3^-)/LC_2 \leq 1$ (Regulation № 1/2007);

area, especially when this water is used to meet the drinking and technological needs of the farm. It is also necessary at least twice a year to conduct own monitoring of the water, permanently to control its quality.

Conclusion

The quality of water from own water source in the studied poultry farm meets the statutory standards of the investigated organoleptic (odor, color, visibility and taste), physical (temperature) and the following chemical indicators: pH, permanganate oxidation, total hardness, chlorides and nitrates. Deviation from the quality standard was demonstrated for the concentration of nitrate level, where all reported values were higher than the permissible maximum level 50,0 mg/l and for ammonia – for the last two months of the investigated period. A trend is observed for increasing the concentration of ammonium ions in water in the spring months that at the established relatively high levels of nitrates and chlorides in water can be assumed as an indicator of organic pollution, a result from the adverse effects of the production activities on the poultry farm.

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Regulation № 9 of 16.03.2001 on the quality of water intended for drinking (SG, No.30/2001).

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