Original Article

Assessment of Bacteria and Physicochemical Parameters in Poultry Drinking Water in Skikda Region, Algeria

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ABSTRACT

Background: Water is an essential nutrient for animals; preserving its good quality is fundamental for healthy birds living in flocks.

Objectives: This study aims to evaluate poultry water's microbiological and physicochemical quality among farms in the Skikda region of Algeria.

Methods: Fifteen samples were collected from 15 locations of both broiler and layer farms from March 2019 to May 2019. The samples, such as total coliforms, fecal coliforms, fecal streptococci, and *Salmonella*, were processed for bacterial analysis. The same samples were also monitored for the physicochemical parameters and heavy metals.

Results: The diverse contaminations of the total coliforms, the fecal coliforms, and the streptococci were noticed at 53%, 13%, and 20% of samples, respectively. Our analysis showed the absence of *Salmonella* in all samples. The results for the totality of samples were satisfactory regarding pH, nitrate, chloride, copper dosage, cadmium, and lead. The study showed higher levels for physicochemical parameters like hardness (69.30±71.93 °f), alkalinity (53.3507±61.1743), nitrates (0.7076±1.1605), and heavy metals such as iron (0.1568±0.2035), cadmium (0.0056±0.0119) and nickel (0.0256±0.0512).

Conclusion: The water quality at these poultry farms is far from satisfactory and presents diverse contaminations by the coliforms and the streptococci. Also, some physicochemical properties and heavy metal levels were abnormal.

Keywords: Bacteriology, Heavy metal, Physical chemistry, Poultry, Water

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Introduction

Water, an essential element for life, is used for several purposes in poultry farming. These uses include hydrating birds, regulating body temperature, aiding digestion, therapeutic vectors (medicaments and vaccines), and as a vehicle of antiseptics. It is also important for the quality of the product and the productiveness of breeding. Unfortunately, stockbreeders often do not pay enough attention. The success of poultry farms largely depends on the quality of the drinking water distributed to the birds. Monitoring water consumption daily is a reliable measure of broiler performance. Therefore, quantitative and qualitative water analyses should be performed regularly because of their impact on the health and welfare of birds (Bobinienė et al., 2014).

In well-controlled farming conditions, the harmful effects of poor-quality water can pass unnoticed, but in poorly controlled conditions, the effects can manifest first on the health and production of the poultry (Amaral, 2004; Sheikh, 2019; Swelum et al., 2021). The effectiveness of antibiotic therapy can also be impacted as diseases can be transmitted to the flock through drinking water, mainly from water contaminated by pathogenic organisms. These pathogens generally originate from other animal species and man, such as in the case of *Salmonella* and *Escherichia coli*, respectively (Swelum et al., 2021; Levantesi et al., 2012; Cabral, 2010; Amaral, 2004).

Water is an essential nutrient for birds; preserving its quality is fundamental for healthy birds to live in flocks. It was established that a bird can survive several weeks without food but only a few days without water. Broilers drink a great deal of water; a critical fact that producers may not be aware of is that food and water consumption are very closely related; for example, a 2.3 kg broiler will consume approximately 8.2 kg of water, compared to 4.6 kg of food (Lacy, 2002; Tabler, 2003). In addition to being a vital nutrient, water is involved in many aspects of poultry metabolism, including body temperature control, digestion and absorption of food, transport of nutrients, and the elimination of liquid via urine from the body (Bobinienė et al., 2014).

Drinking water comes from two main sources: Surface water and groundwater. In the poultry industry, several water sources are used as safe drinking water in poultry farms, including tap water, filter water, roof tank water, and groundwater (Saleh et al., 2023). Water with adequate physical, chemical, and microbiological quality is paramount. Since many birds have access to the same water source, quality problems will affect many animals. Poor quality water can cause many therapeutic failures and be a factor predisposing to reduce the effectiveness of vaccines and medications administered (Amaral, 2004; Swelum et al., 2021).

Agricultural production, such as livestock farming, is an important economic activity, and it is a major consumer of water for hydration and facility cleaning. Limited data is available concerning the levels and conditions of water used in livestock farms. This study aims to provide insight into the quality of the drinking water used in some poultry farms in the Skikda region, northeastern Algeria, which has been previously revealed by several studies in other countries, such as Morocco and Libya (El Allaoui et al., 2016; Kassem Agha et al., 2022).

This study aimed to assess the physicochemical and bacteriological quality of the water used as drinking water for poultry and its impact on the health and production of birds.

Materials and Methods

Study area

The present study was conducted in 15 poultry farms from March 2019 to May 2019. These poultry farms were further categorized into 7 broiler farms, 7 laying hen farms, and 1 turkey farm in Skikda Province, Algeria. The province is exposed to Mediterranean climatological impact and contains 330 poultry farms registered with agricultural services. The studied farms' breeding capacity varied to 3500 birds for broiler farms and 5000 birds for laying hen and turkey farms. Given the importance of the number of farms and the technical and economic constraints of the survey, we limited ourselves to a few municipalities. The choice of poultry farms selection was guided by the manager's acceptance to cooperate and their easy accessibility.

Data collection and sampling conditions

Each farm was visited once for the sampling. Water samples were taken randomly from 5 drinking troughs used for the poultry. Samples were collected using a sterile syringe and emptied into sterile 100-mL bottles. The samples were collected under rigid conditions to avoid any accidental contamination.

All samples were placed on ice packs and transported to the laboratory within 2 hours. Samples were treated on the same day or kept in the refrigerator overnight. The organization of sampling in farms is shown in Table 1.

All samples were labeled and numbered correctly to facilitate the analysis and avoid errors. All bottles were accompanied by a data sheet, making the possibility of helpful information for the laboratory, such as the date and nature of the sample, information on livestock, and water supply. All information was collected in a livestock questionnaire.

Along with collecting samples for physical, chemical, and microbiological analyses, the farmers in this study completed a multiple-choice questionnaire validated by the authors of this paper that covered a variety of factors affecting water quality. The epidemiological questionnaire contained 30 closed-ended questions. The latter was related to the location and conception of the rearing buildings, the broiler rearing characteristics, such as equipment, environmental conditions, biosecurity measures, origin of chicks and feed, farm staff, vaccination programs, and use of antibiotics.

Bacteriological analysis

A total of 15 samples taken from 15 poultry farms were the subject of a bacteriological study aimed at counting total coliforms, fecal and streptococci, and the search for *Salmonella*.

Bacteriological analyses were performed according to the standard protocols.

For the isolation of *Salmonella*, this study used the protocol of the International Organization for Standardization for detection of *Salmonella* spp. in animal feces and in environmental samples from the primary production stage: Using buffered peptone water broth (Fluka, Sigma Aldrich, France) for pre-enrichment solution, Muller-Kauffmann tetrathionate/novobiocin broth (AES Chemunex Combourg, France), and Rappaport-Vassiliadis broth (Merck Darmstadt, Germany) for enrichment, XLD (Fluka analytical Steinheim, Switzerland) and Hektoen agar (Pasteur Institute of Algeria) for isolation (ISO, 2007).

Enumeration of *E. Coli* and coliform bacteria was done according to the AFNOR NF EN ISO 9308-3 standard (March 1999) in surface and wastewater. This process was carried out in a liquid medium on BCPL (bee collected pollen load) (Pasteur Institute of Algeria) and indole mannitol medium (Schubert medium) (Pasteur Institute of Algeria) using a general method by seeding in most probable number (MPN) liquid medium (search and enumeration of coliforms and thermo-tolerant coliforms) (AFNOR, 1999a). The formation of a red ring on the surface of the positive tube (Schubert medium) after adding Kovacs reagent (Pasteur Institute of Algeria) shows the presence of *E. Coli*.

The enumeration of fecal streptococci was carried out according to the standard of the miniaturized method (MPN) by inoculation in ROTHE medium (glucose broth with sodium azide) (Pasteur Institute of Algeria) and E.V.A (LYTSKI) (Pasteur Institute of Algeria), using two tests (presumptive and confirmatory tests) (NF EN ISO 7899-1 March 1999/T 90-432). The final reading was also approved according to the prescriptions of MPN tables standard methods, 1989 (AFNOR, 1999b).

Physicochemical and heavy metals analysis

The physicochemical analysis was conducted in the technical laboratory of the GL1K complex, Sonatrach of Skikda, according to the methods approved by Rodier et al. (2016). An electronic pH meter was used to measure the pH. The measurement of heavy metals, such as iron (Fe), lead (Pb), copper (Cu), cadmium (Cd), and nickel (Ni), were taken by atomic absorption spectrophotometry (Thermo Fisher Scientific Inc, Waltham, Massachusetts, États-Unis) (Rodier et al., 2016).

Determination of chlorides (argentometry)

pH of the sample must be adjusted to 8.3, and the titration will be done using a silver nitrate solution (Pasteur Institute of Algeria) in the presence of the potassium chromate (K_2CrO_4) indicator (Pasteur Institute of Algeria); we titrate until the color brick red.

Determination of alkalimetric titer and full alkalimetric titer

The relative values of alkalimetric titer and full alkalimetric titer allow us to know the qualities of hydroxides and carbonates or alkaline earth bicarbonates in water. Alkalinity was measured using a titrated solution of sulfuric acid H_2SO_4 (Pasteur Institute of Algeria) in the presence of 50% phenolphthalein (Pasteur Institute of Algeria) (alkalimetric titer) or methyl orange (Pasteur Institute of Algeria) (full alkalimetric titer).

Table 1. Origin and nature of samples studied

N° of Samples	Origin of Samples	Type of Farm
P1	Water well	Laying chicken
P2	Water well	Laying chicken
P3	Water well	Laying chicken
P4	Water well	Broiler chicken
P5	Water well	Laying chicken
P6	Water well	Broiler chicken
P7	Water well	Laying chicken
P8	Public water network	Broiler chicken
P9	Public water network	Turkey
P10	Water well	Laying chicken
P11	Water well	Laying chicken
P12	Water well	Broiler chicken
P13	Water well	Broiler chicken
P14	Water source	Broiler chicken
P15	Water well	Broiler chicken

Hardness (total hydrometric titer)

The hardness of a water sample was measured directly by titration with 0.01 M solution of ethylenediaminetetraacetic acid (EDTA) (Pasteur Institute of Algeria) using EBT (Eriochrome Black T) (Pasteur Institute of Algeria) as an indicator.

Determination of nitrates and nitrites

The nitrate concentrations were determined by a UV-visible spectrophotometer. The concentration of the nitrate ion was proportional to the intensity of the coloring. The samples were processed at 0-50 ppm and a wavelength of 410 Nm.

A certain volume of potassium permanganate ($KMnO_4$) (Pasteur Institute of Algeria) was added to the sample and analyzed in an acidic medium to determine nitrites. Nitrite ions (NO^{2-}) only react with the permanganate ions. The solution was heated to complete the reaction. An excess amount of permanganate was measured by adding sodium oxalate, which was titrated with a standard solution of potassium permanganate.

Determination of heavy metals

The content of heavy metals (iron, lead, copper, cadmium, and nickel) was measured by atomic absorption spectrophotometry after preparation of the samples by taking 100 mL of the sample and reducing the pH to 2.3 with an acidic solution.

Statistical analyses

The data collected was processed using SPSS software, version 22 to obtain each studied parameter's arrhythmic means and standard deviations.

The chi-square test was applied to find the association between physiochemical parameters and bacterial types. Data were transformed by applying the test of normality, and an independent samples t-test was applied for physiochemical parameters of two sites (layer and broiler sites). The independent samples t-test was also applied to notice a significant difference in average concentrations of metals at P>0.050 between two sites (layer and broiler sites).

Table 2. Mean bacterial count (CFU mL-1) water samples

Bacterium	Mean±SD
CT (UFC/mL)	167.9±379
CF (UFC/mL)	17.13±54.48
SF (UFC/mL)	131.1±296.56
Salmonella (UFC/mL)	0

Abbreviations: CT: Total coliforms; CF: Faecal coliforms; SF: Faecal streptococci.

Results

Epidemiological results

Of 15 poultry houses studied, 11 poultry farm buildings were located near towns, and the water supply was mainly from individual water sources.

For the broiler breeding, the cleaning of the drinking troughs was only carried out at the end of the breeding strip, when the breeding building was empty (the crawl space), and during the preparation for the establishment of a new breeding strip. It was also noticed that the broiler chickens raised on farms are of various breeds such as ISA, COBB500, Arbor-Acres aged 49-52 days at slaughter weighing 3-3.2 kg on average, with a consumption index varying between 4.8 kg up to 5.5 kg/bird. Drinking troughs were cleaned weekly for laying hen farms for most poultry houses studied. The daily consumption varies between 100 g/d to 110 g/d, with an average production of 140 egg plates/d during 22 months.

For turkey farms, we observed the application of hygiene measures to the strict minimum (absence of footbaths and rare cleaning of drinkers), and the slaughter weight reached an average weight of 20 kg at ages varying from 4 to 5 months.

The pathologies noted for all the species studied are mycoplasmosis, respiratory diseases, hemorrhagic enteritis, and coccidiosis.

Microbiological results

The microbial load of total coliforms (TC), fecal coliforms (FC), and fecal streptococci (FS) were expressed in CFU, referring to the Mac Grady MPN table.

The results of the average microbial load of bacteria are shown in Table 2, showing higher levels of TC, followed by FS and FC.

Results of physicochemical parameters and heavy metals analyses

The physicochemical parameters and heavy metals results were compared to the allowed values described by the Official Journal of the Algerian Republic (JORA, 2011) and the World Health Organization (WHO) guidelines (WHO, 2017). These results showed high averages for hardness (69.30±71.93 mg/L), alkalinity (53.35±61.17 mg/L), chloride level (0.3501±0.43 mg/L), iron (0.15±0.20 mg/L), and cadmium (0.0056±0.0119 mg/L) (Table 3).

Statistical results

A significant association ($P<0.05$) was present between physiochemical parameters and bacterial types (TC, FC, and FS) of the two sites (layer and broiler sites).

Regarding the microbial analysis of both sites, non-significant results were noticed between the microbes of the two sites.

Concerning physiochemical parameters, a non-significant difference was noticed between pH ($P=0.733$), total hydrometric titer ($P=0.951$), and NO_3 ($P=0.790$). On the other hand, a significant difference was noticed for NO^{2-} ($P=0.034$), total alkalinity ($P=0.041$), and Cl ($P=0.019$).

No significant ($P>0.05$) difference was present in average concentrations of metals between the two sites (layer and broiler sites).

Discussion

Examining the values and the distribution of the physicochemical and bacteriological parameters of the drinking water of the poultry buildings of Skikda gives us important information about the drinking water quality in this region.

Table 3. Mean±SD of the physico-chemical analysis of the drinking water of the poultry farm buildings studied

Settings	Mean±SD	Limit Values
pH	7.07±0.44	≥6.5et ≤9
THT	69.30±71.93	20
TAC	53.35±0.39	50
NO^{2-}	0.70±1.16	0.2
NO_3	2.61±4.28	50
Cl	0.35±0.35	500
Fe	0.156±0.203	0.3
Cu	0.059±0.11	2
Cd	0.0056±0.0119	0.003
Ni	0.02±0.05	0.07
Pb	0	0

Abbreviations: THT: Hardness (°f); TAC: Alkalinity (˚f); NO^{2-}: Nitrites (mg/L); NO_3: Nitrate (mg/L); Cl: Chloride (mg/L); Fe: Iron (mg/L); Cu: Copper (mg/L); Cd: Cadmium (mg/L); Ni: Nickel (mg/L); Pb: Lead.

In this study, we recorded various contaminations by total coliforms, fecal coliforms, and streptococci, which were 53%, 13%, and 20%, respectively. The analysis showed the absence of *Salmonella* in all the samples analyzed. Above all, we noted that 9 samples from 5 laying hen farms and 4 broiler farms showed high loads of total coliforms. Nevertheless, we noted low contamination in total and fecal coliforms in the P8 and P9. Our results corroborate those of Eufrásia et al. (2022), who noted contamination of 40% for total coliforms and 15% for *E. coli*. Jafari et al. (2006) reported in their study of drinking water in broiler farms in Iran that the number of microorganisms in birds' drinking water should be 100 CFU/mL for total bacteria and 50 CFU/mL for coliforms. Our results also corroborated those of Amaral et al. (2001), who reported that samples from the water sources and reservoirs were contaminated by *E. Coli* in 10 broiler and laying hen farms, verifying fecal pollution of the samples. Also, Kassem Agha et al. (2022) reported that coliform counts and *E. coli* were present in 91% and 50% of drinking water used in 35 broiler farms in Libya.

Fecal coliform was also detected in the majority of samples from drinking water from wells, indicating the occurrence of fecal contamination that could be due to free access of wild and domestic animals to the superficial water sources, disposal of animal excreta and dead carcasses, and even the drainage of human's sewage from the rural villages. Although superficial water sources are more susceptible to fecal contamination, underground water is also susceptible to this pollution (Amaral, 2004). Surface water quality is subject to frequent, dramatic changes in microbial quality due to various activities in a watershed. These changes are caused by the discharges of municipal raw waters or treated effluents at specified point source locations into receiving waters (river, lake) or by stormwater runoff into the drainage basin at nonpoint locations all over the watershed.

The birds are smaller and precocious animals, and their lower resistance may cause them to be more susceptible to infections, mainly caused by pathogens of intestinal origin that might be present in water with fecal pollution (Amaral, 2004). Drinking water is important in transmitting some bacterial, viral, and protozoan diseases that are among the most common poultry diseases. Conventional antimicrobials (antibiotics) have been used in livestock production, including poultry, as a preventive measure against or for treating infectious bacterial diseases.

Interventions in poultry production can be assured by the administration of antibiotics in feed or drinking water. Food and Drug Administration (FDA) approved using antibiotics as animal additives without prescription. European Union (EU) countries also approved their regulations on using those substances in animal production. Unfortunately, the use or misuse of these compounds has led to the development and dissemination of antimicrobial drug resistance, which is currently a serious public health concern (Abreu et al., 2023).

Important factors to prevent waterborne diseases in broiler production are the protection of supply sources, water disinfection, and the quality control of microbiological, chemical, and physical characteristics. Also, using organic acids as food additives creates an acidic environment in the digestive tract system by lowering the pH in the intestinal tract, which prevents the development of pathogens and microorganisms (AL-Tamimy et al., 2022). Water is essential for birds; therefore, preserving its quality is fundamental for good flock performance. The farmer may prevent many diseases in bird flocks by controlling the quality of the ingested water, resulting in decreased costs and increased profit, two essential aims of animal production nowadays. Many factors increase the risk of occurrence of waterborne diseases.

First is the inadequate disposal of organic and inorganic residues from agriculture and livestock production. The deprivation of concern regarding the quality control of the water given to animals results in the low-quality water availability to birds. There is a general belief that water sources in rural areas are of good quality and can be used as drinking water for humans and animals, regardless of whether they have been submitted to adequate water treatment (Amaral, 2004).

All the results of the samples were of satisfactory quality in pH, nitrate, chlorides, copper, cadmium, and lead. However, we noted high rates for specific physicochemical parameters: Hardness (69.30±71.93 ˚f), alkalinity (53.3507±61.1743 ˚f), nitrite (0.7076±1.1605 mg/L), and heavy metals such as iron (0.1568±0.2035 mg/L), cadmium (0.0056±0.0119 mg/L), and nickel (0.0256±0.0512 mg/L).

The pH of natural water depends on the underlying geological formation of the land. It can also be influenced by the oxygenation of the source (El Allaoui et al., 2016). Our results are corroborated by those of Khan et al. (2013), who reported that the pH of drinking water is equivalent to 7.5, which results in the best performance and better economics. Moreover, low pH water is aggressive and can dissolve metal pipes, releasing lead, copper, and other minerals into the water (Watkins et al., 2004). Also, Veeramani et al. (2003) reported better performance of broilers offered drinking water with acidic pH and poor performance on offering alkaline drinking water. According to the WHO recommendations, the source, raw water temperature, treatment, and chemical or biological processes in the distribution system influence the dissolved oxygen content of water. Depleting dissolved oxygen in water supplies can encourage the microbial reduction of nitrate to nitrite and sulfate to sulfide. It can also increase the concentration of ferrous iron in the solution, with subsequent discoloration at the tap when the water is aerated (WHO, 2017).

Water hardness is a measurement of the amount of salt in the water, primarily divalent ions like magnesium, calcium, and iron, representing the total amount of divalent salts (Saleh et al., 2023). Of 15 samples, 11 showed values exceeding the safe limit (20 ˚f) (73.3%). These samples come from laying hen farm buildings (n=6), broiler farms (n=4), and 1 turkey farm whose water supply is mainly from wells. Our results corroborate those Eufrásia et al. (2022) reported in their study on the drinking water and original tap water of small-layer farmers in Southern Mozambique. On the other hand, they noted a lower rate in borehole water (37.5%) in the same study. Also, Lekehal et al. (2016) noted an average of 55.2±27.8 ˚f in their study conducted in the Batna region, Algeria, with rates varying from 63 to 78 ˚f. This high hardness interferes with the intestinal absorption of trace and macro elements; it promotes intestinal irritation, pecking, and cannibalism and causes scaling of the watering equipment. That is why its high rate was evidence of heavy contamination and drew attention to frequent cleaning and disinfection (El Allaoui et al., 2016; Saleh et al., 2023). Also, hardness in drinking water can induce an unpleasant taste, reduce water consumption, and decrease egg production in layer farming (Cardozo et al., 2015).

Regarding alkalinity, the results of our study revealed that 8 samples analyzed from 6 laying hen farms and 2 broiler farms represent a content exceeding the standard recommended by the limit values of the Algerian official journal (JORA, 2011). Alkalinity is related to water hardness. These two parameters exceeded the recommended standard, which reflects poor water quality and provides a favorable environment for the development of bacteria.

Seven samples represent nitrite levels higher than the standard JORA (2011) recommended. Our results contradict those El Allaoui et al. (2016) reported, who noted an average of 0.049 mg/L of nitrite in the analyzed water.

Nitrite is a natural ion present everywhere in the environment. It is a product of nitrogen oxidation by microorganisms in plants, soil, or water (AFSSA, 2011). Traces of nitrites in water are often linked to pipes where corrosion is significant (AFSSA, 2001). The nitrate results revealed that all the concentrations of the samples analyzed comply with the standards. This finding could be because the study was conducted in spring, characterized by a mild climate, less rain, and fewer storms with drier soils. Several studies have shown that nitrate levels are high in winter and low in summer (AFSSA, 2011). Rainfall from agricultural soils, particularly in winter or following major storms shortly after fertilizer application, is a significant source of nitrates to surface waters. Sources of nitrate in groundwater and surface water include agrochemicals, surface runoff from irrigated lands, septic tanks, leakage from drainage networks, livestock wastes, manure storage, landfills, urban fertilizer use, industrial wastewater, sludge disposal, etc. Over-fertilization leaves traces of nutrients in the soil even after harvesting (Brindha et al., 2017). The presence of nitrates in drinking water can alter the functions of thyroid hormones, which can harm the growth rate (Lekehal, 2016). Analysis of the water in the study area revealed normal amounts of chlorides ranging from 0.056 mg/L in P6 and 0.63135 mg/L in P1 and P3. According to certain studies, the diet that was deficient in both $Na+$ and $Cl-$ resulted in decreased feed and water consumption and impaired growth performance (Jiang et al., 2019). The dosage of trace elements was important in our study. Indeed, it should be noted that the major part of the trace elements (95% to 99%) are ingested in quantities generally more than the needs of the animal to accelerate growth and in the manufacture of foods such as margin of safety, can constitute a risk for the environment, mainly because of their phytotoxicity in the regions of intensive poultry production. It also highlights the importance of controlling the levels of trace elements in poultry feed to limit releases, particularly of heavy metals, into the environment.

The results concerning the levels of iron and copper in the water analyzed showed that most of the values of these parameters comply with the limit values. According to some authors, the dietary addition of Fe in the finisher phase improved meat quality and increased body weight of chicks and average daily feed intake in Ross and Yellow broilers (Lin et al., 2020)

Also, in broilers, copper intake above nutritional requirements (8 mg Cu/kg) may improve growth performance as an alternative to antibiotic growth promoters (National Research Council, 1994; Nguyen et al., 2022); however, high levels of copper cause its accumulates in the liver, and, consequently, contributes to the increased concentration of droppings, thereby leading to adverse effects on nutrient utilization (Yang et al., 2018). Copper in the drinking water supply usually arises from the corrosive action of water leaching copper from copper pipes in buildings. High dissolved oxygen levels have sometimes been shown to accelerate copper corrosion (WHO, 2017).

The high amount of trace elements in our study can be explained by the phytotoxicity of soils and the toxicity of water wells, which are the main water source for most farms studied. However, the ultra-trace elements analyzed in our study are cadmium, nickel, and lead. Two samples (P1 and P2) show levels slightly exceeding the recommended standard for cadmium. According to the I.N.R.A (2001) study, a cadmium deficiency slows the growth of chickens. By comparing our analysis results for nickel with the recommended standards, we notice a high rate for the P12 sample. Excess nickel leads to poor growth and anemia. Water pollution is an undesirable change in water's physical and chemical properties. Numerous factors, including hardness, pH, and total dissolved solids, affect water consumption in chicken farms. Minerals and salts at high concentrations in animal drinking water produce physiological abnormalities in broilers, resulting in loss of the broilers' health, growth, feed intake, and immune status (Saleh et al., 2023). Due to the negative effect of chemical residues on the nutritional value of bird carcasses, medicinal plants are used to improve the quality and growth of this industry (Sabah Abdulameer et al., 2022).

Conclusion

Based on this study, the water quality was far from satisfactory, and coliforms, streptococci, certain physicochemical parameters, and heavy metals were observed in various contaminations. The quality of drinking water in poultry farms has a considerable influence on the success of a farm and its profitability. The results of the physicochemical analysis of the water showed that pH, nitrates, chloride, and some heavy metals such as copper and lead were below the permissible levels and safe for poultry consumption. However, the problem lies in the total hardness and alkalinity levels, of nitrites, iron, cadmium, and nickel, which were above the standards. These results may impact the solubility of antibiotics used as vaccines for poultry. Water contamination can have an impact on the health of poultry through certain respiratory or digestive diseases. The causes of this pollution are multiple; among them, we can cite the poor protection of wells, the poor design of septic tanks, and the presence of sources of pollution, such as deposits of poultry manure near the wells. In light of this study, it was recommended that water quality in poultry farming be improved, the breeder be advised to protect the wells against contamination, and drinking water purification stations be installed. In addition, the cleaning and disinfection of poultry buildings and silos at the end of each band must be carried out rigorously to prevent the passage of pathogens between two successive bands. Finally, to correct the noncompliant physicochemical parameters, the breeder can acidify the water (pH correction), safeguard it with softeners (correction of the hardness), and carry out denitrification (correction of the presence of nitrites and nitrates).

Ethical Considerations

Compliance with ethical guidelines

This article is based on water samples with no human or animal sample, there were no ethical considerations to be considered in this research.

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Authors' contributions

Conceptualisation: Djeffal Samia and Omar Bouaziz; Study design: Samia Djeffal and Bouaziz Omar; Samples collections: Iness Boucebaine and Merième Belmeguenai; Data interpretation: Samia Djeffal, Hind Houssou, and Yasmeen Roheela; Writing the original draft: Samia Djeffal, Hind Houssou, and Yasmeen Roheela; Review and editing: Hind Houssou, Yasmeen Roheela; Supervision: Samia Djeffal.

Conflict of interest

The authors declared no conflict of interest.

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