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Physicochemical and Microbiological Assessment of Drinking Water in Selected Poultry Farms in Kabul Province, Afghanistan

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ABSTRACT

Poultry is a vital sector and an important source of income for many families in Afghanistan. Water quality is a key factor affecting poultry health and productivity. This cross-sectional study aimed to assess the physicochemical and microbiological quality of water sources used in poultry farms in Kabul Province. Water samples were collected from 20 poultry farms and analyzed for total coliforms (TC), faecal coliforms (FC) (Escherichia coli), pH, total dissolved solids, electrical conductivity, chlorine concentration, and turbidity. The results showed that TC and FC levels exceeded acceptable limits (>50 CFU/100 mL) in 65% and 10% of primary water sources, respectively. The median TC and FC values in primary water sources were 63 CFU/100 mL (range: 0–317) and 4.5 CFU/100 mL (range: 0–14), respectively. In secondary water sources, TC and FC exceeded permissible limits in 75% and 55% of samples, with median values of 266 and 84 CFU/100 mL, respectively. Significant differences in TC and E. coli levels were observed between primary and secondary water sources ($p < 0.05$), and among physicochemical parameters; turbidity and electrical conductivity exceeded recommended standards. A significant positive correlation was found between TC and FC ($r = 0.603$; $p < 0.05$), while both showed a significant negative correlation with chlorine levels ($p < 0.05$). These findings highlight substantial health risks associated with poultry farm water sources and underscore the need for improved water management practices to ensure safe, sustainable poultry production in Kabul Province.

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INTRODUCTION

Globally, the animal husbandry sector represents a multi-billion-dollar industry. Between 2008 and 2017, global per capita poultry consumption increased by 16% (Hubbard et al., 2020). Poultry is one of the primary animal species utilized in industrial livestock production. Poultry products constitute a significant part of the global diet, providing consumers with affordable, high-quality protein within a short production cycle. In addition, poultry management and production are generally more straightforward and cost-effective than those of other livestock species (Markos, 2016). Therefore, the poultry industry plays a crucial role in food security, contributing significantly to the world's meat supply and 92% of egg production. In 2021, global poultry meat production reached an estimated 137.8 million tons, up 1.32% from the previous year (Gržinić et al., 2023).

Water is an essential nutrient for all living organisms and plays a critical role in poultry health and production (Do Amaral, 2004). Surface water and groundwater are the primary sources of water for poultry farms (Houssou et al., 2025). In poultry, water serves multiple functions, including hydration, digestion, nutrient absorption, excretion of waste via urine, body temperature regulation, administration of medicaments and vaccines, and cleaning and disinfection of poultry facilities (Parker & Brown, 2003). The water content of a bird's body ranges from 60% to 85%, depending on age, and approximately 65% of an egg's composition is water. Broiler chickens, in particular, require higher water intake than other poultry types. For instance, a broiler chicken weighing 2.3 kg consumes approximately 8.2 liters of water and only 4.6 kg of feed. While birds can survive for a specific period without feed, they can survive only a few hours without water (Umar et al., 2014). Therefore, the success of poultry farming is largely dependent on the quality and availability of water in the farms (Houssou et al., 2025).

Although natural water is generally clean, it is increasingly difficult to find water that has not been contaminated by humans or animals, particularly in developing countries (Do Amaral, 2004). Globally, approximately 663 million people rely on unsafe drinking water sources, and nearly 1.8 billion people consume contaminated potable water. In Afghanistan, 52% of the population lacks access to safe drinking water (Hamdard et al., 2020), and access to clean water remains a significant challenge in Kabul city (Habib, 2014).

Water-borne diseases are a significant concern in poultry production, including bacterial, viral, and protozoal infections that severely affect poultry health and productivity (Do Amaral, 2004). Among these, coliform bacteria are widely distributed in poultry farms and are commonly used as indicators of water quality (Pal, 2014). Coliform bacteria belong to the Enterobacteriaceae family and include the genera Citrobacter, Enterobacter, Escherichia, Hafnia, Klebsiella, Serratia, and Yersinia (Coetzee et al., 2000). They are rod-shaped, non-spore-forming, gram-negative, oxidase-negative, and either aerobic or facultative anaerobic bacteria (Niyoyitungiye et al., 2020). These bacteria can cause a wide range of infections in humans, mammals, poultry, and fish (Green & Goldman, 2021), and their presence often indicates poor biosecurity and hygiene practices on farms (Elmberg et al., 2017).

Afghanistan is an agricultural country, with approximately 80% of the population engaged in agriculture and livestock production, and the majority residing in rural areas (Muradi & Boz, 2018). Livestock farming, particularly poultry, serves as an important source of income for many households, especially for women. Recent data indicate promising growth in Afghanistan's poultry sector, with investment of approximately one billion dollars. The country has nearly achieved self-sufficiency in poultry meat production (Samadi & Zadran, 2023; Zrawar et al., 2023). Despite its importance, high morbidity and mortality rates in Afghan poultry farms severely affect productivity and threaten the sustainability of the industry (Khatami, 2023). These challenges may be attributed to multiple factors, including infectious and parasitic diseases, metabolic disorders, inadequate biosecurity practices, poor management, and other related issues (Samadi & Zadran, 2023; Addis et al., 2014). Among these factors, poor-quality water sources represent a significant threat to poultry health and productivity (Do Amaral, 2004; Zrawar et al., 2023). Although numerous small- to large-scale broiler farms exist in Kabul Province, the quality of drinking water in these farms has not been previously evaluated. Therefore, the main objective of this study was;

- To investigate the physicochemical and microbiological parameters of water sources in poultry farms in Kabul Province.

MATERIALS AND METHODS

This cross-sectional study was designed to evaluate drinking water quality at poultry farms and associated factors in Kabul Province, Afghanistan. The study design is described below.

Study Area

This study was conducted in selected poultry farms of Kabul Province. According to an older census (2003), the province had 345,497 chickens, 1,505 ducks, 3,342 turkeys, 57,713 cattle, 91,994 sheep, 97,140 goats, 16,300 donkeys, 356 camels, and 491 horses (FAO, 2008). Based on the latest data from the Ministry of Agriculture, Irrigation and Livestock (MAIL), there are 151 registered and active poultry farms in Kabul Province, comprising 146 broiler farms and 5 layer farms.

Sample Size and Sampling Design

Of the 151 poultry farms, 20 were conveniently selected from seven districts of Kabul Province, including northern districts (Deh Sabz, Mirbacha Kot, and Kalakan), southern districts (Chahar Asyab and Bagrami), eastern districts (Khak-e-Jabar and Bagrami), and the western district (Paghman).

Water Sample Collection

Two water samples were collected from each selected farm: one from the primary water source (well, tanker, or tap) and another from the secondary source (drinkers). Prior to collection from the primary sources, the outlet pipe was cleaned with water, then ethanol, and allowed to run at maximum pressure for approximately 3 minutes. Approximately 500 ml of water was collected from the outlet pipe and transferred to drinkers using sterile syringes. All samples were stored in an icebox and transported to the laboratory of the Ministry of Rural Rehabilitation and Development (MRRD) within 24 hours for analysis.

Microbiological Assessment

Total coliforms (TC) and fecal coliforms (*E. coli*, FC) were evaluated using the membrane filtration technique, following the procedures described by Hamdard et al. (2020) and Rompré et al. (2002). The procedure for enumerating and detecting TC and *E. coli* involved several steps .For sample filtration, 100 mL of homogenized water was passed through a sterile 0.45 µm membrane filter using a membrane filtration unit sterilized with ethanol. For total coliform detection, M-lauryl sulfate broth (MLSB) media was prepared by dissolving 1.28 g of powdered media in 25 mL of distilled water in a plastic tube. An absorbent pad was placed in a metallic Petri dish and saturated with MLSB medium. The membrane filter was placed face-up on the MLSB-saturated pad. For fecal coliform (E. coli) detection, the same materials and procedure were used, except ECO compact dry media (ECO; NISSUI PHARMACEUTICAL CO., LTD, Japan) was used instead of MLSB. The ECO media was first saturated with 1 mL of sample water, and the membrane filter was placed face-up on the ECO-saturated medium. The MLSB plates were incubated at 37°C, whereas ECO plates were incubated at 44 ± 0.5°C for 24 hours. After incubation, colonies were counted on both media. Total coliform colonies appeared smooth, pink to reddish, whereas *E. coli* colonies appeared blue. The same procedure was applied to both primary and secondary water source samples.

Physicochemical Assessment

The physicochemical properties of water samples, including clarity, color, turbidity, pH, electrical conductivity, temperature, and acidity/alkalinity, were assessed following previously described methods (Hamdard et al., 2020). Clarity and color were visually evaluated; turbidity was measured in nephelometric turbidity units (NTU) using a turbidimeter; and pH, electrical conductivity, and temperature were measured using a pH meter, a conductivity meter, and a thermometer, respectively.

Questionnaire-based Data Collection

A structured questionnaire was used to identify potential risk factors associated with water source contamination in the studied poultry farms. The questionnaire collected demographic information, farm characteristics, water source type, farm hygiene, environmental conditions, and accessibility.

Data Analysis

Laboratory and questionnaire data were analyzed using SPSS version 25 (IBM, USA). Descriptive statistics, including measures of central tendency, dispersion, and frequency tables, were calculated. Spearman's correlation, Kruskal-Wallis, and Mann-Whitney U tests were used to evaluate correlations and compare variables.

FINDINGS

The study revealed important aspects of water quality in poultry farms in Kabul Province and the associated factors, as follows.

Demographic information of the farms and their water sources

Based on the results, wells were the primary water source for 90% of the studied poultry farms in Kabul province, while only two farms used tap water and tankers. On 85% of the farms, wells were located on the farm; of these, 55.55% had wells 50-100 meters deep, while the remaining wells were up to 200 meters deep. Sixty-five percent of the farms were located 10-100 meters from residential areas, 20% were 100 to 1000 meters away, and 15% were more than 1000 meters away from residential areas. Additionally, 45% of the studied farms were situated within 10-500-meters of other poultry farms. Water dams were present near 45% of the farms, and in 55% of the farms, poultry waste storage was within 100 meters of the water sources. Regarding dead bird management, 55% of the farm managers reported discarding carcasses near the farms, while 35% buried them. Further details are presented in **Error! Reference source not found.**.

Mortality of the birds in the studied poultry farms

Data from previous production cycles showed that 15% of the farms experienced <5% mortality, 40% reported 5-10% mortality, and 35% lost 11-20% of their birds. In the current production cycle, mortality was lower: 65% of the farms reported <5% mortality, while 30% experienced 11-20% mortality. Vaccination practices varied on the studied farms: 45% of the farmers administered the infectious bursal disease vaccine, while 35% administered vaccines for infectious bronchitis and Newcastle disease.

Physical and hygienic conditions of primary water sources

On 85% of farms, the primary water source was clear, while on 15% it had a foul smell and taste. Hygiene around the water source was good in 75% of the farms. Most farms (95%) lacked a protocol for monitoring waterborne diseases, and none had previously tested water quality. Only 10% of the farms added chlorine to their primary water sources (Table 1).

Table 1. *Demographic Characteristics of Studied Poultry Farms Regarding Water Sources, Farm Location, and Dead Bird Management in Kabul Province, October 2023.*

Variables	Categories	Frequency	Percent
Primary Water Source of the Farm	Well	18	90
	Tap	1	5

Variables	Categories	Frequency	Percent
	Tanker	1	5
Depth of Wells as Primary Water Source (meters)	50	6	33.33
	50-100	4	20.22
	100-150	6	33.33
	150-200	2	11.12
Location of Water Reservoir	In the farm	17	85
	10-50 meter outside the farm	3	15
Physical Condition of Water Sources	Transparent	17	85
	Bad taste	1	5
	Bad smell and sour taste	2	10
Hygiene Conditions Around Primary Water Sources	In good hygienic conditions	15	75
	Dirty	3	15
Water Management Protocol for Monitoring and Preventing Waterborne Diseases	No	19	95
	Yes	1	5
Water Quality Testing Conducted	No	20	100
	Yes	0	0
Chlorination of Primary Water Sources	No	18	90
	Yes	2	10
Distance from Farm to Residential Areas (meters)	10-100 m	13	65
	100-500 m	2	10
	500-1000 m	2	10
	>1000 m	3	15
Distance from another poultry farm	10-100m	5	25
	100-200m	1	5
	200-500m	3	15
	>500m	11	55
Presence of Water Dams or Standing Water Near the Farm	10-100m	2	10
	100-200m	1	5
	200-500m	1	5
	>1000m	5	25
	No dam present	11	55
Farm Waste Storage Distance from Water Source (meters)."	1-10m	3	15
	10-50m	3	15
	50-100m	5	25
	>100m	9	45
Method of Dead Chicken Carcass Disposal	Dropped near the farm	11	55
	Bury	7	35
	Burning	2	10

Chemical Profile of Water Sources

Four chemical parameters, including pH, electrical conductivity (EC), total dissolved solids (TDS), and turbidity, were evaluated (Table 3). Mean pH values for primary and secondary water sources were 7.38 and 6.94 (range: 5–8), respectively ($p < 0.05$). Median EC values were similar between the two sources ($p > 0.05$). Median turbidity was 0.25 NTU for primary and 0.8 NTU for secondary sources ($p < 0.05$). Median TDS values in the primary and secondary water samples were 295 mg/L and 315 mg/L, respectively ($p > 0.05$). These parameters varied by farm location (Tables 5 and 6).

Bacterial profile of water sources

In primary water sources, total coliform (TC) was undetectable in 10% of farms, and in 25% of farms, TC levels were below the maximum allowable value (≤50 CFU/100 mL; range: 3–38). Fecal coliform (FC) was undetectable in 35% of samples, and in 55% of farms, FC was ≤50 CFU/100 mL (range: 2–26). The median and mean of TC in primary water sources were 63 and 107.3 CFU/100 mL, respectively (range: 0–317), while FC levels were 4.5 and 14 CFU/100 mL (range: 0–85) (Table 3).

In secondary water sources, TC was undetectable in 15% of farms, and in 10% of farms, TC was ≤50 CFU/100 mL (range: 41–45). FC was undetectable in 25% of samples, and in 20% of farms, FC was ≤50 CFU/100 mL (range: 4–35). Median TC level in secondary water sources was 266 CFU/100 mL, while FC level was 84 CFU/100 ml. Differences between primary and secondary water sources for TC and FC were statistically significant ($p < 0.05$) (Tables 2 and 3).

Table 2. *Frequency Distribution of Total Coliform and Fecal Coliform (CFU/100 mL) in Primary and Secondary Water Sources of Selected Poultry Farms, Oct 2023.*

Sample sources	Total coliform CFU/100 ml				Fecal coliform CFU/100 ml			
	CFU/100 ml	**Frequency**	**Percent**	**Cumulative Percent**	**CFU/100 ml**	**Frequency**	**Percent**	**Cumulative Percent**
Primary	0	2	10.0	10.0	0	7	35.0	35.0
	3	1	5.0	15.0	2	1	5.0	40.0
	5	1	5.0	20.0	3	2	10.0	50.0
	30	2	10.0	30.0	6	1	5.0	55.0
	38	1	5.0	35.0	7	1	5.0	60.0
	50	1	5.0	40.0	10	1	5.0	65.0
	60	1	5.0	45.0	15	1	5.0	70.0
	62	1	5.0	50.0	16	1	5.0	75.0
	64	1	5.0	55.0	20	1	5.0	80.0
	86	1	5.0	60.0	23	1	5.0	85.0
	120	1	5.0	65.0	26	1	5.0	90.0
	139	1	5.0	70.0	64	1	5.0	95.0
	150	1	5.0	75.0	85	1	5.0	100.0
	184	1	5.0	80.0	Total	20	100.0	
	240	1	5.0	85.0				
	260	1	5.0	90.0				
	308	1	5.0	95.0				
	317	1	5.0	100.0				
	Total	20	100.0					

Sample sources	Total coliform CFU/100 ml				Fecal coliform CFU/100 ml			
	CFU/100 ml	Frequency	Percent	Cumulative Percent	CFU/100 ml	Frequency	Percent	Cumulative Percent
Secondary	0	3	15.0	15.0	0	5	25.0	25.0
	41	1	5.0	20.0	4	2	10.0	35.0
	45	1	5.0	25.0	16	1	5.0	40.0
	84	1	5.0	30.0	35	1	5.0	45.0
	180	1	5.0	35.0	80	1	5.0	50.0
	210	1	5.0	40.0	88	1	5.0	55.0
	211	1	5.0	45.0	120	1	5.0	60.0
	248	1	5.0	50.0	160	1	5.0	65.0
	284	1	5.0	55.0	220	1	5.0	70.0
	324	1	5.0	60.0	240	1	5.0	75.0
	372	1	5.0	65.0	320	2	10.0	85.0
	444	1	5.0	70.0	330	1	5.0	90.0
	450	1	5.0	75.0	380	1	5.0	95.0
	510	1	5.0	80.0	490	1	5.0	100.0
	516	1	5.0	85.0	Total	20	100.0	
	520	1	5.0	90.0				
	600	1	5.0	95.0				
	750	1	5.0	100.0				
	Total	20	100.0					

Based on farm location, the highest proportion of farms with zero TC in primary water samples was in the northern part of Kabul Province (25%), followed by the west (12.5%) and east (10%), while all farms in the south had detectable TC. For FC, 33.3% of northern farms had zero counts, compared with 30% in the south, 30% in the east, and 25% in the west. Median TC in primary water sources in the north was 45 CFU/100 mL (range: 0–240), and median FC was 6 CFU/100 mL (range: 0–26) (Table 4). A similar pattern was observed in other regions, though western farms showed higher contamination. Secondary water samples from eastern farms had the highest TC counts, while western farms' secondary water was most contaminated with *E. coli* (Table 4).

Table 3. Microbial and Physiochemical Properties of Primary and Secondary Water Sources in Studied Poultry Farms of Kabul Province, October 2023.

Tested Parameters	Normal Range	Reference	Categories	Median	Mean	SD*	Min*	Max*	*p-value*
pH	6.5 - 8.5	Halls, 2008	Primary	7.3	7.38	0.343	7	8	0.015
			Secondary	7.15	6.94	0.554	5	8	
EC*/µS/cm	≤ 400 µS/cm	Osei et al., 2019	Primary	615	730.5	333.805	380	1700	0.715
			Secondary	615	779.25	401.957	380	1790	
Turbidity /NTU	≤ 5 NTU		Primary	0.25	2.58	6.799	0	26	0.008
			Secondary	0.8	3.34	8.161	0	30	
TDS* mg/L	≤ 500 mg/L		Primary	295	359	167.549	180	850	0.645
			Secondary	315	389.5	200.636	180	890	
TC*/100ml	Max allowable level (50 CFU/100 ml)	Jafari et al., 2006	Primary	63	107.3	103.892	0	317	0.014
			Secondary	266	289.46	224.84	0	750	
FC*/100ml			Primary	4.5	14	22.588	0	85	0.015
			Secondary	84	140.35	156.591	0	490	

*EC: Electrical conductivity; TDS: Total dissolved solids; TC: Total coliform; FC: Fecal coliform; SD: Standard deviation; min: Minimum; max: Maximum

Table 4.*Total Coliform and Fecal Coliform (CFU/100 mL) in Primary Water Sources by Location of Studied Poultry Farms in Kabul Province, October 2023.*

	Measures	**North**		**South**		**East**		**West**	
		TC*	**FC***	**TC**	**FC**	**TC**	**FC**	**TC**	**FC**
Primary water sources	Mean	78.17	9.67	108.2	6.8	94.4	19	166	23.25
	Median	45	6	64	3	50	3	135.00	14.5
	Std. Deviation	94.616	11.13	109.459	8.044	126.239	37.007	98.211	28.86
	Std. Error	38.627	4.544	48.951	3.597	56.456	16.55	49.105	14.43
	Minimum	0	0	3	0	5	0	86	0
	Maximum	240	26	260	16	317	85	308	64
Secondary water sources	Mean	235.2	115.7	302.4	103.8	330	162.8	304.03	195
	Median	166	42	211	35	444	88	348	230
	Std. Deviation	276.38	190.8	221.12	137.27	229.89	179.43	219.17	136.991
	Std. Error of Mean	112.83	77.6	98.9	61.89	102.81	80.244	109.56	68.5
	Minimum	0	0	41	0	0	0	0	0
	Maximum	750	490	600	320	516	380	520	320

*TC: Total coliform FC: Fecal coliform

Table 5. *Physicochemical Profile of Primary Water Sources in Poultry Farms of Kabul Province by Location, October 2023.*

	East					West					North					South				
Measures	**TDS mg/L**	**pH**	**EC µS/cm**	**Temp °C**	**Turb. NTU**	**TDS mg/L**	**pH**	**EC µS/cm**	**Temp °C**	**Turb. NTU**	**TDS mg/L**	**pH**	**EC µS/cm**	**Temp °C**	**Turb. NTU**	**TDS mg/L**	**pH**	**EC µS/cm**	**Temp °C**	**Turb. NTU**
Median	350	7.4	710	18	0.8	255	7.4	525	13	0.5	275	7.2	555	16	0.1	480	7.5	970	17	0.2
Mean	448	7.6	906	17.8	4.5	267.5	7.4	537.5	13.3	0.5	303.3	7.22	623.33	16.2	0.1	410	7.42	838	16.2	5.32
Std. Deviation	230.7	0.503	456.9	0.84	7.63	68.1	0.351	117.01	.500	0.13	122.093	0.2	246.793	0.753	0.1	178.5	0.31	355.98	1.643	11.561
Minimum	290	7	590	17	0	200	7	410	13	0	190	7	400	15	0	180	7	380	14	0
Maximum	850	8	1700	19	18	360	8	690	14	1	540	8	1100	17	0	610	8	1240	18	26

TDS: Total dissolved solids; pH: Potential of Hydrogen; EC: Electrical conductivity; Temp: Temperature Celsius; Turb: Turbidity

Table 6. *Physicochemical Profile of Secondary Water Sources in Poultry Farms of Kabul Province by Location, October 2023.*

	East				West				North				South			
Measures	**TDS mg/L**	**pH**	**E.C µS/cm**	**Turb. NTU**	**TDS mg/L**	**pH**	**E.C µS/cm**	**Turb. NTU**	**TDS mg/L**	**pH**	**E.C µS/cm**	**Turb. NTU**	**TDS mg/L**	**pH**	**E.C µS/cm**	**Turb. NTU**
Median	355	6.7	730	0.8	275	6.1	545	0.9	275	7.6	555	0.4	510	7.4	1045	0.80
Mean	477	6.7	934	5.64	286.3	7	557.5	0.83	358.33	6.9	726.7	0.42	422	7.4	865	6.6
Std. Deviation	242.631	0.901	494.601	10.28	69.7	0.29	117.011	0.171	239.79	0.4	478.943	0.232	183.1	0.1	365.21	13.2
Minimum	310	5	600	1	215	7	430	1	190	6	400	0	180	7	380	0
Maximum	890	8	1790	24	380	7	710	1	840	7	1690	1	620	8	1260	30

TDS: Total dissolved solids; pH: Potential of Hydrogen; EC: Electrical conductivity; Turb: Turbidity

Association between laboratory results and farm demographics

Spearman's rho correlation was used to assess associations between farm demographics, microbial contamination, and water physicochemical properties. In primary water sources, TC and FC were positively correlated ($r = 0.603$, $p < 0.05$). TC and chlorine levels were negatively correlated ($r = -0.532$, $p < 0.05$), and a medium negative correlation was observed between FC and chlorine ($r = -0.413$, $p > 0.05$). In secondary water sources, FC and chlorine were negatively correlated ($r = -0.549$, $p < 0.05$), as were TC and chlorine ($r = -0.621$, $p < 0.05$) (Table 7).

Analysis of physicochemical parameters showed that pH was significantly affected by water reservoir location ($p = 0.026$) and the presence of standing water ($p = 0.033$). FC levels were significantly influenced by farm structure ($p = 0.029$) and proximity to public roads ($p = 0.021$). TDS varied significantly with the presence of standing water ($p = 0.023$), and EC was significantly affected by the distance from farm waste storage to water sources ($p = 0.048$) (Table 8).

Table 7.*Correlation Between Total Coliforms (TC), Fecal Coliforms (FC), and Chlorine Levels in Primary and Secondary Water Sources of Selected Poultry Farms in Kabul Province, October 2023.*

Water sources	**Variable**	**Correlation Coefficient**	***P-value***
Primary	Fecal coliform & total coliform	0.603^{**}	0.005
	Total coliform & chlorine /mg/L	-0.532^{*}	0.019
	Fecal coliform & chlorine/mg/L	-0.413	0.079
Secondary			
	Fecal coliform & chlorine /mg/L	-0.549^{*}	0.012
	Total coliform & chlorine /mg/L	-0.621^{**}	0.003

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).

Table 8.*Association between Physicochemical Profiles of Poultry Farm Water Sources, Environmental Factors, and Farm Characteristics in Kabul Province, October 2023.*

Variables	**Comparison Variables**	**Variable categories**	**N**	**Mean Rank**	**Sum of Ranks**	***p-value***
pH	Water reservoir location	Inside the farm	17	9.29	158	0.026
		Outside the farm	3	17.33	52	
	Presence of standing water	≤ 500m	4	5	20	0.033
		≥ 501	16	11.88	190	
FC	Farm structure	Concrete	7	6.64	46.5	0.029
		Raw	13	12.58	163.5	
	Public roads	≤ 500	7	14.57	102	0.021
		≥ 501	13	8.31	1108	
TDS		≤ 500m	4	16.5	66	
		≥ 501	16	9	144	
	Presence of standing water	≤ 500m	4	16.5	66	0.023
		≥ 501	16	9	144	
EC	Distance of farm waste storage from water sources	≤ 100	11	12.86	141.5	0.048
		≥ 101	9	7.61	68.5	

DISCUSSION

In the present study, the microbiological and physicochemical quality of water sources in poultry farms in Kabul Province was evaluated. To the authors' knowledge, this is the first study to assess poultry farm water quality in this region. The results indicated that 90% of the primary water sources were contaminated with total coliforms (TC), while 65% were contaminated with fecal coliforms (FC). Similarly, TC and FC were detected in 85% and 75% of secondary water sources, respectively. In contrast, 75% of the primary water sources and 90% of the secondary water sources were within the allowable limit (>50 CFU/100 mL) for TC and FC, respectively. These findings indicate substantial fecal contamination of poultry farm water sources. Such contamination may result from unrestricted access of domestic and wild animals to water sources, improper disposal of animal waste, or leakage of human sewage into poultry water supplies (Jafari et al., 2006). Importantly, specific microbial pathogens, including *Escherichia coli*, can form biofilms in farm water distribution systems, pipes, drinkers, equipment, and consumables, thereby prolonging contamination in the farm environment (de Oliveira Branco et al., 2016). Although most coliform bacteria, such as *Escherichia*, *Klebsiella*, *Enterobacter*, *Citrobacter*, *Hafnia*, and *Serratia*, excluding pathogenic strains of *E. coli*, may not directly cause severe disease in poultry, their presence in drinking water indicates fecal contamination and the potential presence of other significant poultry and zoonotic pathogens, including *Salmonella* spp. and *Campylobacter* spp. (Do Amaral, 2004). Furthermore, avian pathogenic *E. coli* (APEC) strains cause severe disease in poultry, leading to high mortality rates, reduced production, and substantial economic losses. These strains are associated with conditions such as airsacculitis, peritonitis, and cellulitis, resulting in significant morbidity and mortality within flocks (Joseph et al., 2023). In addition, numerous studies have reported antimicrobial resistance among coliform bacteria, posing serious threats to poultry health, productivity, and public health (Shawish et al., 2020).

Comparable findings have been reported by researchers in various regions worldwide, including Afghanistan's neighbouring countries such as Iran, Pakistan, and India (Balan et al., 2012; Jafari et al., 2006; Nedelkova et al., 2019; Saboor et al., 2021; Zaman et al., 2012). Jafari et al. (2006) evaluated total coliform levels in water sources from 20 poultry farms in Iran and reported that 50% of the samples exceeded the maximum allowable limit of 50 CFU/100 mL. Moreover, fecal coliforms were detected in all tested samples. Similarly, Zaman et al. (2012) analyzed 50 water samples collected from tanks and drinkers in three broiler farms in Khyber Pakhtunkhwa, Pakistan. They found that 72% of the samples were contaminated with *E. coli*, with 44% of drinkers testing positive. These findings indicate a high degree of *E. coli* contamination in poultry farm water sources. Additionally, Houssou et al. (2025) reported that 53% and 13% of poultry farm water sources in the Skikda region of Algeria were contaminated with total coliforms and fecal coliforms, respectively.

The present study also revealed that 95% of the surveyed farms lacked protocols for managing waterborne diseases, indicating a substantial gap in preventive strategies.

Furthermore, none of the farms conducted routine testing of water sources for microbial or physicochemical contamination, reflecting a complete absence of water quality monitoring. Such deficiencies may have profound implications for poultry health. In addition, 90% of the farms did not chlorinate their water sources. These findings underscore the urgent need for routine water-quality testing and for implementing effective waterborne disease management protocols on poultry farms. The use of disinfectants, such as chlorine, in both primary and secondary water sources is essential for reducing microbial contamination (Mohammed et al., 2020). The absence of chlorination, therefore, reflects inadequate efforts to control microbial hazards, thereby increasing the risk of disease transmission among poultry flocks (Raut et al., 2024). Previous studies have demonstrated that unsanitary conditions promote pathogen proliferation in and around water sources and within the farm environment, facilitating transmission through drinking water and posing risks to both poultry and human health (Ngwenya et al., 2023).

Improper waste management practices were commonly observed in the studied farms. Approximately 55% of the farms disposed of dead carcasses near farm premises, and almost the same proportion stored farm waste within 100 meters of water sources. Moreover, septic wells were located within 10–50 meters of poultry farms in 25% of cases. These conditions present similar contamination risks for both primary and secondary water sources. According to Jafari et al. (2006), surface water sources are particularly vulnerable to fecal contamination due to access by domestic and wild animals, improper disposal of animal waste and carcasses, and runoff of human sewage from nearby settlements.

Regarding the physicochemical characteristics of secondary water sources, turbidity and electrical conductivity exceeded acceptable limits in 10% of the samples. Turbidity reflects the presence of suspended particles that reduce water clarity, potentially including bacteria and viruses that pose health risks (Osei et al., 2019). Electrical conductivity, on the other hand, indicates the presence of dissolved salts and mineral ions. Although elevated conductivity levels do not appear to adversely affect poultry performance, as these ions generally do not negatively influence growth, health, or productivity, they may reflect broader water-quality issues (Coetzee et al., 2000).

Overall, monitoring the microbiological and physicochemical quality of poultry drinking water is essential, as the use of contaminated water can facilitate the spread of infections, reduce production efficiency, increase mortality rates, and pose serious public health risks through contact with poultry or consumption of poultry products (Do Amaral, 2004). In addition, maintaining strict hygiene standards within poultry farms, including regular cleaning and disinfection of water tanks, pipelines, and drinkers, is critical for minimizing microbial contamination (Ngwenya et al., 2023).

CONCLUSION

Based on the findings of this study, it is concluded that although most physicochemical parameters of poultry farm water sources in Kabul Province were within acceptable limits, the water sources were highly contaminated with total coliforms and fecal coliforms. The absence of water quality monitoring and waterborne disease management protocols, improper disposal of dead carcasses, storage of waste near farm premises, and inadequate chlorination of water sources are likely major contributors to this contamination. Therefore, it is strongly recommended that poultry farmers regularly monitor water quality, implement effective chlorination practices, maintain proper hygiene in water distribution systems, and ensure appropriate management of dead birds and farm waste. These measures are essential to improve poultry health and productivity and to reduce the risk of disease transmission to consumers and the wider community.

AUTHOR CONTRIBUTIONS

Conceptualization, Assadullah Samadi; methodology, Assadullah Samadi, Mohammad Haroon Rahmani; questionnaire design, Assadullah Samadi, Mohammad Haroon Rahmani; data curation and supervision, Assadullah Samadi, Mohammad Haroon Rahmani, Asmatullah Isaar; data analysis, Assadullah Samadi, Mohammad Haroon Rahmani; writing—original draft preparation, Mohammad Haroon Rahmani; Mohammad Haroon Rahmani; writing—review and editing, Assadullah Samadi, Mohammad Haroon Rahmani, Asmatullah Isaar. All authors have read and agreed to the published version of the manuscript.

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DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest

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