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Seasonal Variations Alter Drinking Water Quality at Different Points in The water Distribution Systems of Cattle Farms in Egypt

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Abstract

THE monitoring of seasonal variations in drinking water quality (DWQ) within the drinking water distribution system (DWDS) of Egyptian dairy and beef farms affected by emerging epidemics is the main focus of this work. Across 132 farms, the DWQ was examined at four locations along the DWDS: the water source (WS), water tank (WT), calf trough (CT), and adult trough (AT). Correlations between DWQ and DWDS sample points, DWQ and microbial composition, and water temperature (Tw) and ambient temperature (Ta) were found by statistical analysis. Seasonal variations were highlighted by the strong effect sizes (d=0.88–1) that showed significant differences between Tw and Ta. Significant differences with medium to strong effect sizes (d= 0.53–0.85) in physicochemical DWQs were noted between WSs and house troughs (HTs). Furthermore, significant differences in the small to large effect sizes (d = 0.47 – 0.87) of microbial DWQ between winter and summer were found. Subsequent investigations revealed significant differences, with variable effect sizes, in the microbial DWQs between the WS and WT points (d = 0.41 – 0.65), between the WT and CT points (d = 0.51 – 0.57), and between the WT and AT points (d = 0.56 – 0.65) in the DWDS (ranging from small to large). The investigation concluded that variations in microbial DWQ were caused by interactions between seasonal variations in Ta and Tw, which in turn affected the DWDS. Furthermore, the DWDS had a major effect on the physicochemical characteristics of the DWQ that were observed on the cattle farms.

Keywords: Beef and dairy, Bovine epidemics, Climate change, Farm hygiene, Sustainability, Welfare.

Introduction

One of the most important nutrients for maintaining life and maximizing the growth, lactation, and reproduction of cows is water, which is ranked second only to oxygen [1]. Compared to other mammals, cows have higher water requirements per unit of body mass [2]. Between seventy and ninety-

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seven percent of a bovine's water requirements are sourced from drinking water. The quality of drinking water (DWQ) holds immense importance because it significantly influences the health and productivity of cattle. The kind of water source (WS) and the degree of pollution it contains from both biotic and abiotic sources, such as dissolved nutrients or direct deposits such as feces or urine, affect DWQ [3]. The DWQ of cattle farms is evaluated mainly by considering important parameters. In addition to excessive mineral levels such as chloride, nitrates, and sulfates, physicochemical factors, including pH, hardness, and total dissolved solids (TDS), should be assessed. The total colony count (TCC) and total coliform count (TCFC) are two additional indicators of the microbial content that are known to be important for lowering the overall DWQ [4]. Water temperature (Tw) affects an animal's water consumption and general performance and is a major component of DWQ. Tw affects DWQ directly by altering its taste and acceptance by animals and indirectly by potentially impacting the microflora of the digestive tract [5]. Livestock animals generally prefer cooler water, especially under warmer environmental conditions. Egypt has two distinct seasons: a hot summer from May to October and a warm winter from November to April [6]. Variable regions have different ambient temperatures (Ta), with coastal areas experiencing winter temperatures of 14°C and summer temperatures of 30°C. Winter temperatures in inland desert regions range from 0°C at night to 18°C during the day, while summer temperatures in these regions are typically between 7°C and 43°C [5]. Physicochemical changes in cattle drinking water can occur along the drinking water distribution system (DWDS) from WS to the house trough (HT) in the animal house. These alterations may stem from various factors, such as increased microbial activity, resulting in a decrease in aesthetic DWQ. Furthermore, certain elements in the animal house, including the presence of dust, feed residues, or bedding or the contamination of water troughs with cud or feces, might cause these variations in DWQ [7]. These factors can collectively impact the physicochemical properties of water, potentially affecting its overall quality and suitability for cattle consumption. Microbiological investigations of water often focus on identifying microbial pathogens, which can indicate contamination or pollution levels. Frequently, indicators of this kind of contamination include an increased TCC or the presence of particular indicator microorganisms [8]. Coliform bacteria, which include significant species, such as *Escherichia coli*, *Klebsiella* spp., and *Enterobacter* spp., are frequently detected in contaminated water. Due to their potential to function as indications of fecal contamination and their prevalence in the guts of warm-blooded animals, these organisms are frequently used as indicators of water pollution [1][9]. Apart from coliform bacteria, noncoliform bacterial species such as Streptococcus, Proteus, and Pseudomonas have also been identified in polluted water sources. These organisms, while not necessarily used as primary indicators like coliforms, can still be present in contaminated water sources and indicate potential environmental or fecal pollution [10]. The connection between ecological variables and microbial DWQ suggests that many environmental factors influencing the survival and proliferation of bacteria in natural water habitats also have an impact on cattle HT [11]. DWDSs can create environments suitable for microorganisms due to factors such as increased microbial activity in HTs, particularly in warm weather when there are ample nutrients and slow-moving water. These conditions may lead to the formation of biofilms, which can evade treatment and disinfection processes. Moreover, potential sources of contamination in HTs include seepage from septic tanks, shoddy water pipe construction, and the possibility of dust, feed, dung, urine, and other forms of contamination. If HTs are not routinely treated or cleaned, they could behave as reservoirs for bacterial agents. Additionally, the extended retention of water in HTs can further contribute to the proliferation of microorganisms[2][3][12]. The principal aim of the research was to evaluate the DWQ in terms of hygiene in dairy and beef farms throughout Egypt's many regions, with a focus on places experiencing the emergence of new diseases. A methodical strategy was used to identify certain sampling locations for the purpose of gathering water samples to accomplish this goal. These samples were obtained from WS and HT to conduct physicochemical analyses. Furthermore, samples were collected for microbiological examination from several locations along the DWDS, such as the WS, water tanks (WT), calf troughs (CT), and adult troughs (AT). To determine how seasonal variations in ambient temperature (Ta) affect water temperature, sampling was performed in both the winter and the summer (Tw). This assessment aimed to understand how alterations in seasonal temperature might influence DWQ and potentially contribute to emerging epidemics on cattle farms.

Experimental procedures

Field survey

Study area and period

A comprehensive field study covering four regions in Egypt was carried out between October 2016 and September 2018: the West Delta (which includes the Alex Desert roads and Behira), the Middle Delta (which includes the Gharbia and Menoufia), the East Delta (which includes the Dakahlia, Kaluobia, Ismailia Desert roads and Sharkia), and Upper Egypt (which includes the Fayoum, Minya, and Beni-Suef). This study involved the collection of representative water samples from various points, including WS, WT, CT, and AT, which are located in animal houses. Within these researched districts, 132 farms were sampled, including 60 dairy cattle farms, 60 beef cattle farms, and 12 mixed dairy beef farms.

Study design

The study protocol aimed to monitor the hygienic DWQ in beef and dairy cattle farms situated across various regions in Egypt, particularly those affected by recent outbreaks. To accomplish this goal, a methodical strategy involving taking water samples from four different locations within the DWDS of each farm was used. This involved gathering samples for microbiological investigation from WS, WT, CT, and AT throughout the winter and summer. Additionally, samples from WS and HT were obtained specifically for physicochemical analysis.

These cow farms provided water samples, which were used for physicochemical analyses and indicator microbe counts. These farms were selected due to their history of animal health issues and the emergence of waterborne diseases in the research area.

Cattle farm descriptions

The bulk of the larger dairy and beef farms under investigation had loose/free stalls as their primary form of accommodation. Animals were housed separately within yards, each equipped with mangers and water troughs situated beneath sheds. These yards provided an area of approximately 7-10 square meters per animal. Notably, these yards lacked a proper drainage system, leading to the accumulation of manure, except for one enclosed farm that utilized cubicles or free stalls. Water sources, accessible for drinking, washing, and maintaining milking hygiene, were typically sourced from public utilities, surface water, or underground pumps. The observed hygienic practices on these farms were deemed moderate.

Conversely, in the case of smaller beef farms and those owned by individual householders, the housing structures were more traditional. These farms often feature cow sheds known as tiestalls, commonly found in rural areas of Egypt. These tiestalls were constructed using block bricks with wooden doors and windows on either side. Ceilings were primarily fashioned from wooden bars covered with straw and occasionally replaced with plastic sheets during winter. The flooring consisted of soiled soil, necessitating manual and irregular removal of excreta. Water is typically supplied via tap water, which is often chlorinated, although exceptions exist on certain farms.

Water Sampling

In all, 132 water samples—including commercial tap water, surface water, and ground water—were gathered from various sources across the governorates of Egypt. Equal numbers of dairy, beef, and mixed cow farms provided samples for collection in the winter season (December, January, and February) and summer season (June, July, and August). Each farm has four distinct locations where sampling was done: WS, WT, CT, and AT.

For physicochemical examination, clean and dry one-liter screw-capped plastic bottles were used to collect the water samples. Moreover, sterilized 1 L screw-capped glass bottles previously heated in a hot air oven at 170°C (60 minutes) were utilized for microbiological analysis. Before collecting the samples, the glass containers were thoroughly cleaned using the water to be analysed. Using the protocols described by Kamal et al., all of the samples were kept at 4°C and examined 48 hours collection [1].

Three different types of Dip-Slides (© Liofilchem®) were utilised for direct water sampling in addition to traditional methods of collecting water samples: CONTACT SLIDE CHROM 2 (TTC + Plate Count Agar + Neutralizing) Flex Dip-slide for the identification and counting of *E. Coli*, total bacterial count and coliform bacteria, CONTACT SLIDE 5 for the identification and counting of *faecal streptococci* and *Enterobacteriaceae*, and CONTACT SLIDE 4 for the identification and counting of *pseudomonas*, mould, and yeasts. The usage of these slides adhered to ISO guidelines [13].

Every sample had an appropriate label that specified its location, source, kind of watering system, and sampling date. Every sample was taken and sent to the lab within two hours of sampling in order to guarantee accuracy and integrity.

Laboratory examination of water samples

Chemical examination

The Veterinary Hygiene and Management Department at Cairo University's Faculty of Veterinary Medicine conducted chemical analysis of the water samples in accordance with the recommendations of Clesceri et al. [14].

A conventional thermometer having a 0 to 100°C temperature range was used to measure the temperature at the time of sampling. An electrometric pH metre (pHep® HI 98107- Italy) was used to measure the pH values of the water samples. A waterproof TDS/EC/NaCl percent/°C metre was used to measure the TDS concentration (HI 9835- Italy). We employed the "EDTA titrimetric determination" to assess the overall hardness. We assessed the levels of chloride (Cl^-) using the "argentometric technique." With the use of the "ultraviolet spectrophotometric screening method," nitrate-nitrogen (NO_3–N) was found. Utilizing the "ultraviolet spectrophotometric screening approach," nitrate (NO_3^-) was also calculated. Additionally, "the gravimetric procedures with drying of residues" were used to measure the sulphate levels (SO_4^{2-}) [15].

Microbiological examination of water samples

1. The pour plate method was used to calculate the total colony count (TCC) and total mycotic count (TMC). Furthermore, the multiple tube fermentation method was used to measure the total coliform count (TCFC), total *Enterobacteriaceae* count (TEC), *faecal Streptococci* count (FSC), and *Pseudomonas aeruginosa* count (PAC) in accordance with the guidelines provided by APHA and Clesceri et al. [14,15].
2. A microbial profile was created by isolating and characterising a variety of microorganisms. Additionally, using the API 20E system (BioMerieux, Marcy-l'Etoile, France), biochemical validation was performed on each of the bacterial isolates.
3. As previously mentioned, the manufacturer's handbook and technical criteria were followed for incubating and evaluating the dip-slides [13].

Statistical and data analysis

We used the statistical package for social sciences (SPSS) software (version 25.0) from SPSS, Inc., Chicago, IL, for data analysis. At first, every piece of information gathered was transformed into a variable. We utilised the Kolmogorov–Smirnov test to determine whether the data was normal. The results are presented using both descriptive and inferential statistics, and the Wilcoxon signed-rank test was utilised. In addition, Cohen's d and Eta squared values were used to compute effect sizes. According to the recommendations given in Campbell [16], A p-value of less than 0.05 was the cutoff point for statistical significance for each test.

Results

The following farms were included in the survey: 46 in the West Delta (19 in the Alex Desert Road and 17 in Behira), 12 in the Middle Delta (6 in Gharbia and 6 in Menoufia), 52 in the East Delta (6 in Dakahlia, 6 in Kaluobia, 33 in the Ismailia Desert Road, and 7 in Sharkia), and 22 in Upper Egypt (16 in Fayoum, 6 in Minya and Beni-Suef). This sample represented the range of herd sizes and operation types found in the Egyptian cattle population, despite not being chosen at random.

The study recorded Ta and Tw during sampling across different farms. Table 1 presents the frequency quartiles (Q1, Q2, Q3) for each recorded temperature. Laboratory analysis of water samples from these farms, specifically from WS and HT, revealed various physicochemical parameters (Table 2) and their corresponding quartiles. Additionally, the microbial contents of the WS, WT, CT, and AT water samples were analysed in both winter (W) and summer (S) and are displayed in Table 3, which provides frequency quartiles for several microbial parameters.

For every physicochemical parameter, the Spearman rank correlation analysis showed a statistically significant correlation ($p\text{-value} < 0.05$) between the HT and WS treatments (Figure 1). Moreover, Tw was significantly correlated with specific microbial parameters in both winter and summer (Figure 2).

Wilcoxon signed-rank tests were used to evaluate seasonal effects, differences between Ta and Tw in winter and summer, and differences within Ta and Tw separately in winter and summer (Table 4). For both Ta and Tw, there were significant differences ($p\text{-value} < 0.05$) between the winter and summer results. Furthermore, based on the results of the water physicochemical study, Wilcoxon signed-rank tests revealed significant differences ($p\text{-value} < 0.05$) between the HT and WS values (Table 5).

The impact of DWDSs on water quality was revealed by further analyses using Wilcoxon signed-rank tests, which showed significant differences ($p\text{-value} < 0.05$) in the water microbial analysis between the summer and winter results (Tables 6 and 7), between the WT and WS results (Table 8), between the CT and WT results (Table 9), and between the AT and WT results (Table 10).

Discussion

Water is vital to cattle because it helps them stay healthy and maximise their output. But both the amount and quality of water frequently encounter ongoing difficulties that are linked to seasonal fluctuations, weather patterns, a variety of water sources, including ponds, dugouts, and tap water, as well as contamination from different chemical and microbiological agents. The performance and overall health of cattle are greatly impacted by these water-related problems [2]. Monitoring the hygienic DWQ at dairy and beef cattle farms at various sampling points within the DWDS was the main goal of this study. The focus is on understanding the effects of DWDSs on DWQ and investigating potential seasonal variations observed during both the winter and summer seasons.

The findings displayed in Table 1 demonstrated that the wintertime temperature quartiles in Ta were much greater than those in Tw. Similarly, in the summer, there was a slightly greater disparity between the Ta and Tw quartiles, with the Ta quartiles exceeding the Tw quartiles. These findings are consistent with those reported by Reymond, Kaya, and Fidan [5,6]. Using Cohen's d effect size to further assess the difference between Ta and Tw, Table 4 shows that Ta was greater than Tw in 100% of the farms during winter and 94.7% of the farms during summer, with a strong effect size (d = 0.88 - 1). The reason for this discrepancy is that water troughs are frequently located beneath sheds, which means that water temperatures fluctuate more slowly than air temperatures. Cattle have long been known to use water as a cooling agent [17,18]. Furthermore, the findings show that Ta in the summer exceeded Tw in the winter for 99.2% of the farms studied throughout Egypt, and that Ta in the summer exceeded winter temperatures for every farm surveyed [6,19].

Analysis was performed at two sampling locations along the DWDS to keep an eye on the physicochemical quality of the drinking water (WS and HT). The distribution of each parameter and the differences between the WS and HT values are shown by quartile in Table 2. A statistical analysis showed that the physicochemical characteristics of WS and HT points were strongly positively correlated (rho 0.516 – 1) (Figure 1). This correlation suggested that there was a strong relationship between an increase in a certain physicochemical parameter in WS and the same parameter in HT. Using the d effect size, the difference in the physicochemical results between WS and HT was evaluated (Table 5). According to these values, the HT results for pH, TDS, EC, hardness, chloride, nitrate-N, nitrate, and sulfate are greater than the WS results for each farm by 96.2 percent, 54.5 percent, 54.5 percent, 37.1 percent, 47 percent, 84.8 percent, 84.1 percent, and 40.2 percent, respectively. This finding suggested a medium to large d effect size (d = 0.53 – 0.85). This discrepancy could be explained by possible internal sources of contamination, which could be impacted by variations in Ta that impact the physicochemical quality of the drinking water [5]. The elevated values of physicochemical characteristics observed in HTs may be caused by contaminants such as bedding, feed ingredients, animal faeces, or mineral precipitation. Notably, 3 percent of the farms had a higher pH in WS than in HT, and 6.4% and 6.8% of the farms had nitrate-N and nitrate readings, respectively, in WS that were greater than those in HT. These findings may be related to the inherent water quality or contamination problems of WS [7,20].

Microbiological studies were carried out to evaluate the microbiological quality of the drinking water across the four sample stations in the DWDS (WS, WT, CT, and AT). The quartiles displayed in Tables 2 and 3 emphasize differences between WS, WT, CT, and AT in both the winter season and summer season quartiles for each microbial count. As shown in Figure 2, there was a significant weak correlation (rho 0.167–0.244) between the summer Tw and the eight microbial counts. Furthermore, a moderate correlation between Tw in the summer and TMC in the WT was found (rho 0.271). These results indicate that variations in Tw have a significant effect on water microbial counts and are more pronounced in the summer than in the winter. Cohen's d values (Tables 6 and 7) were used to evaluate the difference in water microbiological results between the winter season and summer season, revealing greater microbial counts during the summer. At 66.5, 65.5, and 65.5 in 100 percent, 98.5 percent, and 98.5 percent, respectively, the highest mean ranks were noted for TMC in CT and AT, TCC in CT and AT, and TFC in AT. These results showed a significant d value (d = 0.87, 0.86, and 0.86, respectively), indicating a greater contamination risk in the summer season since animals tend to drink more frequently and microbes grow more quickly in the higher temperature ranges that are encountered during that time of year [21,22].

According to the d effect size values (Table 8), the majority of farms had higher microbial counts in the WTs than in the WSs when comparing the changes in water microbial analysis between the WSs and the WTs. The summer TMC had a medium effect size (d = 0.65) for 74.2 percent of the farms, with the highest significant positive mean rank (+mean rank 60.5). These findings suggest that the WTs may be contaminated from additional sources or that the DWDS has cumulative microbial loads from WS to WT. Growing biofilm formation or aged water networks are two likely reasons for the elevated contamination in WTs. Compared to WTs, WS occasionally showed greater microbial numbers. The most noticeable negative mean rank for TCC was observed in the winter (-mean rank 53.2) for 8.3 percent of the farms, indicating a medium effect size (d = 0.53). These notable differences in the numbers of microorganisms in the water between the WS and WTs could be caused by the presence of filter stations or disinfection systems within the distribution system [23,24].

Based on the d value effect size (Table 9), the microbial makeup of the WTs and CTs was compared, and for most farms, the CTs had higher microbial counts than did the WTs. Wintertime (+mean rank 71.8) for 71.96 percent of the farms had the most noteworthy positive mean rank (d = 0.52) for TCC, indicating a medium effect size. These results may point to potential open sources of microbiological contamination in CT, such as poorly hygienic bedding, faeces, or feeding procedures. On the other hand, on certain farms, the microbial counts were greater in the WT results than in the CT data. For 18.9 percent of the farms, the TMC winter mean rank was the most notable negative rank (-mean rank 60.6), suggesting a medium effect size (d = 0.54). The existence of filtration points, differences in disinfection techniques used between the WT and CT, or differences in routine trough disinfection could be the causes of these significant differences in microbiological DWQ. Alternatively, these disparities could be caused by ongoing sources of contamination in WTs [25–27].

Table 9 presents the results of utilising the d value effect size to evaluate the difference in the results of the microbiological analysis of the WT and AT points. The majority of farms had higher microbial counts in AT than in WT. Interestingly, for 78.03 percent of the farms, the summer season had the most notable positive mean rank (+mean rank 72.3) for TCC, suggesting a medium effect size (d = 0.65). These results may be explained by the presence of external sources of microbiological pollution in ATs as a result of inadequate hygiene and sanitation procedures as well as bedding, faeces, feeding, or biofilm formation. On the other hand, on certain farms, the WT points had greater microbial counts than did the AT points. In particular, a medium effect size (d = 0.59) was demonstrated by the most notable negative mean rank (-mean rank 55.9) for 15.2 percent of the farms in the PAC during the winter. These variations in microbial contamination between WTs and ATs could be brought about by continuous locations of contamination inside the WTs, regular trough disinfection, the use of filtering units or other disinfection techniques between the WT and AT, or any combination of these factors [28-32].

Conclusions

The study demonstrated a substantial correlation between ambient temperature and drinking water temperature, regardless of the season. While seasonal temperature changes did not notably impact the physicochemical drinking water quality, there was a significant influence observed from the drinking water distribution system, particularly from the water source to the animal house troughs. On the other hand, the drinking water distribution system, particularly from the water source to both the water tanks and house troughs, and seasonal temperature variations both had significant effects on the microbiological drinking water quality.

Subsequent studies ought to concentrate on creating strategies for mitigating the impacts of seasonal fluctuations in the quality of drinking water. To further ensure and maintain ideal drinking water quality requirements, it is essential to investigate and apply filtration and disinfection methods in drinking water distribution systems and possible contamination sites.

Conflict of interest

The authors have disclosed that they do not hold any conflicts of interest related to the publication of this article.

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TABLE 1. Frequencies of three temperature quartiles (Q1, Q2 (median), and Q3) for both ambient (Ta) and water (Tw) temperatures (°C) during the winter season and summer season on cattle farms.

Percentiles [a]	Winter temperature		Summer temperature	
	Ta	Tw	Ta	Tw
Q1	19	18	36	34
Q2	21	20	38	37
Q3	24	23	40	38

[a] The Q2 is the median, and the percentiles are equal to the frequency quartile (quartiles are an alternative to the arithmetic mean in nonnormally distributed data).

TABLE 2. Frequencies of three quartiles (Q1, Q2 (median), and Q3) of the physicochemical parameters of both water source (WS) and water in house trough (HT) and microbiological quality parameters (total colony count (TCC) and total coliform count (TCFC)) in WS, the water tank (WT), the calf trough (CT) and the adult trough (AT) in the winter season (W) and summer season (S) on cattle farms.

Physicochemical parameters	Percentiles [a]			Microbial parameters	Percentiles [a]		
	Q1	Q2	Q3		Q1	Q2	Q3
pH/WS	7.5	8	8	TCC/WS(W)	0	18.5	$3.2x10^{4}$
pH/HT	8.1	8.4	8.8	TCC/WS(S)	0	53	$7.1x10^{4}$
TDS/WS	305	665	1450	TCC/WT(W)	0	$3.7x10^{4}$	$33x10^{4}$
TDS/HT	305	680	1472.5	TCC/WT(S)	0	$5.7x10^{4}$	$53x10^{4}$
EC/WS	455.2	992.5	2164.2	TCC/CT(W)	$4.1x10^{4}$	$3.2x10^{6}$	$42.8x10^{6}$
EC/HT	455.2	1014.9	2197.8	TCC/CT(S)	$6.95x10^{4}$	$5.9x10^{6}$	$74x10^{6}$
Hardness/WS	280	470	696	TCC/AT(W)	$3.7x10^{4}$	$3.05x10^{6}$	$32x10^{6}$
Hardness/HT	285	472	698	TCC/AT(S)	$5.9x10^{4}$	$5.5x10^{6}$	$76x10^{6}$
Chloride/WS	150	240	447.5	TCFC/WS(W)	0	0	$3.4x10^{3}$
Chloride/HT	150	240	448	TCFC/WS(S)	0	0	$6.98\ x10^{3}$
Nitrate-N/WS	0	1	2	TCFC/WT(W)	0	$3.4x10^{3}$	$44x10^{3}$
Nitrate-N/HT	2	4	8	TCFC/WT(S)	0	$6.6x10^{3}$	$80.5x10^{3}$
Nitrate/WS	0	4.43	8.86	TCFC/CT(W)	$4.4x10^{3}$	$26x10^{4}$	$52.8x10^{4}$
Nitrate/HT	8.86	17.72	35.44	TCFC/CT(S)	$6.7x10^{3}$	$51x10^{4}$	$93.8x10^{4}$
Sulfate/WS	65	100	140	TCFC/AT(W)	$3.8x10^{3}$	$26.5x10^{4}$	$53x10^{4}$
Sulfate/HT	66	100	141.5	TCFC/AT(S)	$6.08x10^{3}$	$43x10^{4}$	$97.3x10^{4}$

TABLE 3. Frequencies of the microbiological water quality parameters (Q1, Q2 (median), and Q3) (total *Enterobacteriaceae* count (TEC), *fecal Streptococci* count (FSC) total mycotic count (TMC), and *Pseudomonas aeruginosa* count (PAC)) in the water source (WS), water tank (WT), calf trough (CT) and adult trough (AT), in the winter season (W) and summer season (S) on cattle farms.

Microbial parameters	Percentiles			Microbial parameters	Percentiles		
	Q1	Q2	Q3		Q1	Q2	Q3
TEC/WS(W)	0	0	$3.7x10^{2}$	PAC/WS(W)	0	0	26.75
TEC/WS(S)	0	0	$7.07x10^{2}$	PAC/WS(S)	0	0	57
TEC/WT(W)	0	$3.3x10^{2}$	$3.6x10^{3}$	PAC/WT(W)	0	18	$4.1x10^{2}$
TEC/WT(S)	0	$6.1x10^{2}$	$6.98x10^{3}$	PAC/WT(S)	0	45	$6.8x10^{2}$
TEC/CT(W)	$3.7x10^{2}$	$29.5x10^{3}$	$18.5x10^{4}$	PAC/CT(W)	17	$2.9x10^{3}$	$37x10^{3}$
TEC/CT(S)	$6.7x10^{2}$	$5.3x10^{4}$	$44.4x10^{4}$	PAC/CT(S)	45	$5.2x10^{3}$	$78x10^{3}$
TEC/AT(W)	$4.3x10^{2}$	$3.6x10^{4}$	$6.08x10^{4}$	PAC/AT(W)	29	$3.4x10^{3}$	$43.8x10^{3}$
TEC/AT(S)	$6.02x10^{2}$	$7.1x10^{4}$	$9.6x10^{4}$	PAC/AT(S)	52	$6.3x10^{3}$	$83.5x10^{3}$
FSC/WS(W)	0	0	33.75	TMC/WS(W)	0	18.5	$3.4x10^{3}$
FSC/WS(S)	0	0	61.5	TMC/WS(S)	0	38	$7x10^{3}$
FSC/WT(W)	0	18	$4.05x10^{2}$	TMC/WT(W)	27	$3.5x10^{3}$	$44x10^{3}$
FSC/WT(S)	0	45	$7.17x10^{2}$	TMC/WT(S)	42	$6.7x10^{3}$	$84.5x10^{3}$
FSC/CT(W)	16	$2.85x10^{3}$	$38.5x10^{3}$	TMC/CT(W)	$4.4x10^{3}$	$26x10^{4}$	$51.8x10^{4}$
FSC/CT(S)	44	$5.5x10^{3}$	$7.8x10^{4}$	TMC/CT(S)	$6.8x10^{3}$	$47.5x10^{4}$	$96x10^{4}$
FSC/AT(W)	26.25	$3.4x10^{3}$	$43x10^{3}$	TMC/AT(W)	$4.3x10^{3}$	$27.5x10^{4}$	$55.5x10^{4}$
FSC/AT(S)	49	$6.9x10^{3}$	$7.8x10^{4}$	TMC/AT(S)	$6.3x10^{3}$	$47.5x10^{4}$	$102.5\ x10^{4}$

TABLE 4. Signed-rank means with farm numbers (N), tie numbers, Z values, and effect sizes (d) output from the Wilcoxon test for paired winter season (W) and summer season (S) samples of ambient (Ta) and water (Tw) temperatures.

Temperature	+ Mean Rank (N)	Ties	Z	Cohen's d
Ta (W) - Tw (W)	66.5 (132)	0	11.489	1.00
Ta (S) - Tw (S)	63.0 (125)	7	10.117	0.88
Ta (S) - Ta (W)	66.0 (131)	1	9.941	0.87
Tw (S) - Tw (W)	66.5 (132)	0	9.979	0.87

The level at which the first variable is greater than the second variable is indicated by the (positive mean rank). The quantity of samples (N) for every variable. (Ties): indicates the quantity of samples yielding identical outcomes. Z: the difference between two related variables, for example, the temperature of the water and the ambient air, a Z value of 0 indicates that there is no difference. The impact of the first variable on the outcomes of the second related variable is indicated by Cohen's d value.

TABLE 5. Signed-rank means with farm numbers (N), tie numbers, Z values, and effect sizes (d) output from the Wilcoxon test for paired house trough (HT) and water source (WS) water sample physicochemical parameters.

Physicochemical parameters	+ Mean Rank (N)	- Mean Rank (N)	Ties	Z	Cohen's d
pH/HT - pH/WS	65.0 (127)	4.0 (1)	4	9.821	0.85
TDS/HT - TDS/WS	36.5 (72)	0	60	7.412	0.65
EC/HT - EC/WS	36.5 (72)	0	60	7.412	0.65
Hardness/HT - Hardness/WS	25.0 (49)	0	83	6.115	0.53
Chloride/HT - Chloride/WS	31.0 (62)	0	70	6.897	0.60
Nitrate-N/HT - Nitrate-N/WS	60.3 (112)	8.5 (4)	16	9.269	0.81
Nitrate/HT - Nitrate/WS	60.7 (111)	9.0 (5)	16	9.238	0.80
Sulfate/HT - Sulfate/WS	27.0 (53)	0	79	6.366	0.55

The number of samples for which the first variable is smaller than the second variable is indicated by the (negative mean rank).

TABLE 6. Signed-rank means with farm numbers (N), tie numbers, Z values, and effect sizes (d) output from the Wilcoxon test for the winter season (W) and summer season (S) paired samples of TCC, TCFC, and TEC water microbiological parameters.

Microbial parameters	+ Mean Rank (N)	Ties	Z	Cohen's d
TCC/WS(S) - TCC/WS(W)	40.0 (79)	53	7.723	0.67
TCC/WT(S) - TCC/WT(W)	48.0 (95)	37	8.464	0.74
TCC/CT(S) - TCC/CT(W)	65.5 (130)	2	9.894	0.86
TCC/AT(S) - TCC/AT(W)	65.5 (130)	2	9.894	0.86
TCFC/WS(S) - TCFC/WS(W)	32.0 (63)	69	6.903	0.60
TCFC/WT(S) - TCFC/WT(W)	41.5 (82)	50	7.868	0.68
TCFC/CT(S) - TCFC/CT(W)	61.5 (122)	10	9.586	0.83
TCFC/AT(S) - TCFC/AT(W)	65.5 (130)	2	9.894	0.86
TEC/WS(S) - TEC/WS(W)	29.0 (57)	75	6.569	0.57
TEC/WT(S) - TEC/WT(W)	41.0 (81)	51	7.82	0.68
TEC/CT(S) - TEC/CT(W)	60.0 (119)	13	9.468	0.82
TEC/AT(S) - TEC/AT(W)	63.0 (125)	7	9.703	0.84

TABLE 7. Signed-rank means with farm numbers (N), tie numbers, Z values, and effect sizes (d) output from the Wilcoxon test for the winter season (W) and summer season (S) paired samples of the FSC, PAC, and TMC water microbiological parameters.

Microbial parameters	+ Mean Rank (N)	Ties	Z	Cohen's d
FSC/WS(S) - FSC/WS(W)	20.0 (39)	93	5.447	0.47
FSC/WT(S) - FSC/WT(W)	38.5 (76)	56	7.576	0.66
FSC/CT(S) - FSC/CT(W)	57.5 (114)	18	9.267	0.81
FSC/AT(S) - FSC/AT(W)	59.0 (117)	15	9.388	0.82
PAC/WS(S) - PAC/WS(W)	20.0 (39)	93	5.447	0.47
PAC/WT(S) - PAC/WT(W)	38.5 (76)	56	7.576	0.66
PAC/CT(S) - PAC/CT(W)	58.5 (116)	16	9.348	0.81
PAC/AT(S) - PAC/AT(W)	62.0 (123)	9	9.625	0.84
TMC/WS(S) - TMC/WS(W)	38.5 (76)	56	7.576	0.66
TMC/WT(S) - TMC/WT(W)	58.0 (115)	17	9.308	0.81
TMC/CT(S) - TMC/CT(W)	66.5 (132)	0	9.969	0.87
TMC/AT(S) - TMC/AT(W)	66.5 (132)	0	9.969	0.87

TABLE 8. Signed-rank means with farm numbers (N), tie numbers, Z values, and effect sizes (d) output from the Wilcoxon test for water source (WS) and water tank (WT) paired samples of TCC, TCFC, TEC, FSC, PAC, and TMC water microbiological parameters.

Microbial parameters	+ Mean Rank (N)	- Mean Rank (N)	Ties	Z	Cohen's d
TCC/WT(W) - TCC/WS(W)	46.2 (82)	53.2 (11)	39	6.131	0.53
TCC/WT(S) - TCC/WS(S)	46.3 (82)	52.1 (11)	39	6.177	0.54
TCFC/WT(W) - TCFC/WS(W)	42.8 (71)	22.6 (9)	52	6.794	0.59
TCFC/WT(S) - TCFC/WS(S)	42.8 (71)	22.6 (9)	52	6.794	0.59
TEC/WT(W) - TEC/WS(W)	43.1 (62)	34.3 (19)	51	4.753	0.41
TEC/WT(S) - TEC/WS(S)	44.2 (62)	30.5 (19)	51	5.088	0.44
FSC/WT(W) - FSC/WS(W)	41.5 (59)	28.2 (17)	56	5.095	0.44
FSC/WT(S) - FSC/WS(S)	43.8 (59)	20.2 (17)	56	5.794	0.50
PAC/WT(W) - PAC/WS(W)	41.0 (60)	29.3 (16)	56	5.152	0.45
PAC/WT(S) - PAC/WS(S)	43.2 (60)	20.8 (16)	56	5.856	0.51
TMC/WT(W) - TMC/WS(W)	60.3 (98)	40.6 (16)	18	7.431	0.65
TMC/WT(S) - TMC/WS(S)	60.5 (98)	39.3 (16)	18	7.489	0.65

(W): winter, (S): summer

TABLE 9. Signed-rank means with farm numbers (N), tie numbers, Z values, and effect sizes (d) output from the Wilcoxon test for water tank (WT) and calf trough (CT) paired samples of water for TCC, TCFC, TEC, FSC, PAC, and TMC water microbiological parameters.

Microbial parameters	+ Mean Rank (N)	- Mean Rank (N)	Ties	Z	Cohen's d
TCC/CT(W) - TCC/WT(W)	71.8 (95)	48.3 (35)	2	5.962	0.52
TCC/CT(S) - TCC/WT(S)	72.4 (95)	46.7 (35)	2	6.094	0.53
TCFC/CT(W) - TCFC/WT(W)	63.3 (95)	49.9 (25)	12	6.242	0.54
TCFC/CT(S) - TCFC/WT(S)	64.5 (95)	45.4 (25)	12	6.536	0.57
TEC/CT(W) - TEC/WT(W)	62.6 (86)	39.2 (27)	19	6.197	0.54
TEC/CT(S) - TEC/WT(S)	63.0 (86)	37.9 (27)	19	6.296	0.55
FSC/CT(W) - FSC/WT(W)	62.4 (78)	34.1 (30)	24	5.888	0.51
FSC/CT(S) - FSC/WT(S)	62.9 (78)	32.6 (30)	24	6.026	0.52
PAC/CT(W) - PAC/WT(W)	61.5 (80)	34.6 (28)	24	6.054	0.53
PAC/CT(S) - PAC/WT(S)	62.0 (80)	33.1 (28)	24	6.179	0.54
TMC/CT(W) - TMC/WT(W)	65.4 (103)	60.6 (25)	4	6.212	0.54
TMC/CT(S) - TMC/WT(S)	66.8 (103)	55.1 (25)	4	6.542	0.57

(W): winter, (S): summer

TABLE 10. Signed-rank means with farm numbers (N), tie numbers, Z values, and effect sizes (d) output from the Wilcoxon test for water tank (WT) and adult trough (AT) paired samples of water for TCC, TCFC, TEC, FSC, PAC, and TMC water microbiological parameters.

Microbial parameters	+ Mean Rank (N)	- Mean Rank (N)	Ties	Z	Cohen's d
TCC/AT(W) - TCC/WT(W)	72.2 (103)	39.9 (27)	2	7.393	0.64
TCC/AT(S) - TCC/WT(S)	72.3 (103)	39.4 (27)	2	7.421	0.65
TCFC/AT(W) - TCFC/WT(W)	69.9 (103)	48.8 (27)	2	6.83	0.59
TCFC/AT(S) - TCFC/WT(S)	69.9 (103)	48.7 (27)	2	6.84	0.60
TEC/AT(W) - TEC/WT(W)	64.9 (103)	47.0 (20)	9	7.251	0.63
TEC/AT(S) - TEC/WT(S)	65.2 (103)	45.8 (20)	9	7.314	0.64
FSC/AT(W) - FSC/WT(W)	60.5 (96)	52.1 (21)	15	6.412	0.56
FSC/AT(S) - FSC/WT(S)	60.8 (96)	50.8 (21)	15	6.488	0.56
PAC/AT(W) - PAC/WT(W)	63.2 (103)	55.9 (20)	9	6.801	0.59
PAC/AT(S) - PAC/WT(S)	63.6 (103)	53.9 (20)	9	6.903	0.60
TMC/AT(W) - TMC/WT(W)	69.9 (104)	47.9 (26)	2	6.997	0.61
TMC/AT(S) - TMC/WT(S)	70.1 (104)	47.0 (26)	2	7.055	0.61

(W): winter, (S): summer

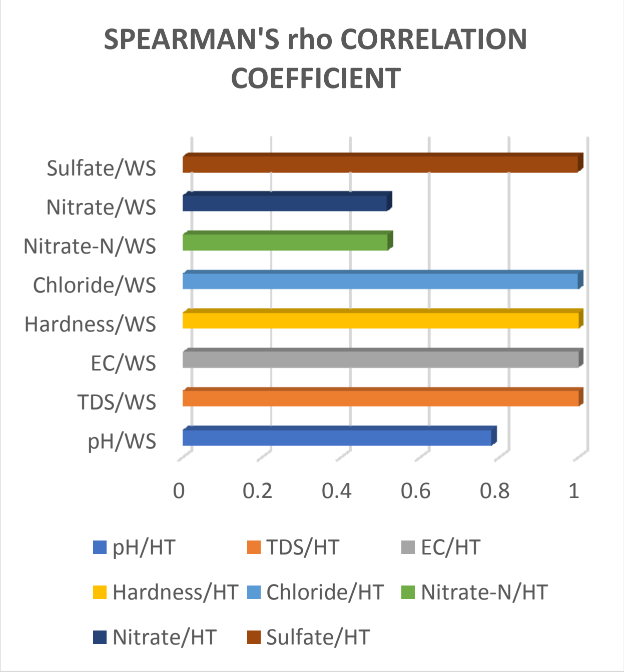

Fig. 1. Significant spearman correlation coefficient values (rho) between some water chemical parameters in both water source (WS) and house trough (HT)

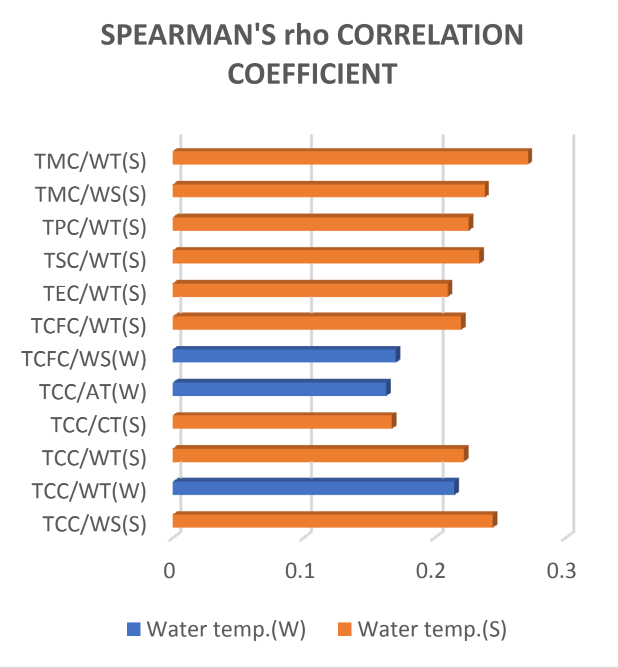

Fig. 2. Significant spearman correlation coefficient values (rho) between water temperature both in winter (W) and in summer (S) with some water microbial parameters

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تغير التغيرات الموسمية جودة مياه الشرب في نقاط مختلفة في أنظمة توزيع المياه لمزارع الماشية في مصر

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المستخلص

ركزت هذه الدراسة على رصد التغيرات الموسمية في جودة مياه الشرب (DWQ) داخل نظام توزيع مياه الشرب (DWDS) لمزارع الأبقار والأبقار المصرية المتضررة من الأوبئة الناشئة. تمت دراسة DWQ في أربع نقاط على طول DWDS - مصدر المياه (WS)، وخزان المياه (WT)، وحوض العجل (CT)، وحوض البالغين (AT) - عبر 132 مزرعة. وكشفت التحليلات الإحصائية عن وجود ارتباطات بين نقاط أخذ العينات DWQ وDWDS، وبين درجة حرارة الماء (Tw) ودرجة الحرارة المحيطة (Ta)، وبين DWQ والتركيب الميكروبي. أشارت النتائج إلى اختلافات كبيرة بين Tw وTa، مع أحجام تأثير قوية (d= 0.88-1)، مما يؤكد الاختلافات الموسمية. والجدير بالذكر أنه لوحظت اختلافات كبيرة في DWQs الفيزيائية والكيميائية بين WSs وأحواض المنزل (HTs)، بأحجام تأثير متوسطة إلى كبيرة (d = 0.53–0.85). بالإضافة إلى ذلك، تم تحديد اختلافات كبيرة في DWQ الميكروبية بين الشتاء والصيف، مع أحجام تأثير صغيرة إلى كبيرة (d = 0.47 – 0.87). كشف التحليل الإضافي عن وجود تباينات ملحوظة في DWQ الميكروبية بين نقاط مختلفة في DWDS: WS مقابل WT (d = 0.41 – 0.65)، WT مقابل CT (d = 0.51 – 0.57)، وWT مقابل AT (d = 0.56 – 0.65)، مع أحجام تأثير متفاوتة (تتراوح من الصغيرة إلى الكبيرة). وخلصت الدراسة إلى أن التقلبات الموسمية في Ta أثرت على Tw، والتي بدورها تفاعلت مع DWDS، مما أدى إلى تغييرات في DWQ الميكروبية. بالإضافة إلى ذلك، أثر DWDS بشكل كبير على الجوانب الفيزيائية والكيميائية لـ DWQ التي لوحظت في مزارع الماشية.

الكلمات الدالة: حيوانات اللحم والحلاب، الأوبئة البقرية، تغير المناخ، نظافة المزرعة، الاستدامة والرعاية.