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Seasonal variation in physical and bacteriological qualities of water used in dairy farm and surrounding households[#]

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Abstract

The present study was conducted to determine the physical and bacteriological qualities of samples collected from the dairy farm and surrounding households of Thiruvazhamkunnu, Palakkad district of Kerala. A total of 550 samples were collected, consisting of 400 water samples and 50 soil samples from the dairy farm, along with 100 water samples from nearby households. Of these, 275 samples each were taken during post monsoon and monsoon season. The water samples were analysed for pH, total dissolved solids, electrical conductivity, turbidity, hardness and coliform count. The mean pH of the water samples collected from the dairy farm increased from 6.30 ± 0.02 during post monsoon to 6.39 ± 0.02 during the monsoon season. In household water samples, the mean pH rose from 6.16 ± 0.07 to 6.47 ± 0.07 from post monsoon to monsoon season. In contrast,TDS, EC, turbidity and hardness decreased. However, statistical analysis using one way ANOVA revealed significant differences in pH and turbidity of samples collected from dairy farm and pH, TDS and EC from households during post monsoon and monsoon seasons. The coliform count of samples from the farm ranged from 72.68 ± 67.43 to 1040 ± 67.43 MPN index/100 mL, while the coliform count in household samples ranged from 293.81 ± 60.98 to 423.06 ± 60.98 MPN index/100 mL. The coliform count of the majority of the samples increased from post monsoon to monsoon season. A significant association was observed between the occurrence of coliforms in well water samples from households and factors such as distance from manure pits/ wastewater drainage and septic tanks using the Kruskal-Wallis test

Keywords: *Post monsoon, monsoon season, water, physical and bacteriological qualities*

Water is a fundamental resource essential for life, playing a pivotal role in sustaining the health and well-being of both humans and animals. It is indispensable for vital physiological processes, including nutrient transport, metabolic reactions and waste elimination. Despite its importance, over 2 billion people globally reside in water-stressed regions (WHO, 2023) and 785 million individuals lack access to safe and adequate drinking water (WHO, 2017).Water quality is highly compromised due to the natural and anthropogenic sources of contamination. It is

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commonly assessed using physical and microbiological parameters, which provide crucial insights into their safety and usability (Jagaba*et al*., 2021). Contaminants including harmful pathogens such as coliform bacteria serve as indicators of faecal contamination, posing serious health risks to humans and animals (Addisie, 2022). Alarmingly, 1.7 billion individuals worldwide are forced to use water contaminated with faecal matter, with polluted water contributing to an estimated 505,000 diarrheal deaths annually (WHO, 2023).

Seasonal variations further intensify water contamination, as changes in temperature, rainfall and runoff dynamics can significantly alter the physicochemical and microbiological qualities of water (Sharma*et al*., 2021). These changes heightened the health risks, particularly in rural and livestock-associated settings, where the challenges of maintaining water quality are often compounded. Inadequate farm management often exacerbates the issue, with farm runoff potentially introducing pathogens and pollutants into nearby streams, ponds and household water. This contamination affects both human and animal health, potentially compromising productivity and overall well-being. While, most research has focused on the quality of water consumed by humans, leaving a significant gap in understanding the water quality in livestock settings. Therefore, the present study evaluated the effect of seasonal variations in the physical and bacteriological quality of water at the Livestock Research Station, Thiruvazhamkunnu, Palakkad and its surrounding households.

Material and methods

Study area

The study was carried out at the Livestock Research Station Thiruvazhamkunnu (LRST) and nearby households, situated at coordinates 11° 2’ 4.2936’’ N latitude and 76° 22’ 13.3032’’ E longitude. The location of the livestock farm was at a distance of 7.5 km away from Manjeri state highway in Palakkad district and lies below the rear side of silent valley. The main water sources near the farm consisted of three wells, two ponds and a river. Of these, one well and one pond were used for drinking water, while the others were designated for irrigation. The surrounding households relied on wells and a piped water supply provided by Jalanidhi, Kerala Rural Drinking Water Supply Sanitation Agency, Government f Kerala.

Collection of samples

Samples were collected during two different seasons: post monsoon (December to February) and monsoon (June to August). A total of 550 samples were gathered, with 450 from LRST and 100 from surrounding households. During each season, 225 samples were collected from LRST and 50 from households. The LRST samples included 25 samples each from three wells, two ponds, a river, water troughs, shed washings and soil while the household samples comprised 50 well water samples per season.

The samples were collected in sterile 250 mL glass bottles. The bottles were lowered into the well by aseptically removing the cap and immersing them to a depth of one meter until full (Krishna *et al.,* 2020). River and pond water samples were collected upstream by submerging the bottles 30 cm below the surface and tilting the neck upwards to allow them to fill completely (Krishna *et al.,* 2020). The samples were immediately transported to the quality control lab of the Department of Veterinary Public Health, College of Veterinary and Animal Sciences Mannuthy with icepacks and were analysed within 24 h.

Assessment ofquality parameters

All the 450 water samples from the wells, ponds, river Water troughs and shed washings of dairy farm and households were analysed for various parameters *viz.,* pH (EUTECH pH meter), electrical conductivity (EC), total dissolved solids (TDS) (Multiparameter water meter, Thermo Fisher Scientific), turbidity (EUTECH turbidimeter) and hardness (Water testing kit, Nice chemicals, India).

Coliform detection was carried out on 550 samples, comprising 500 water samples and 50 soil samples obtained from the dairy farm and surrounding households, using the MPN method, as described by Cochran (2012). Samples were inoculated into lauryl tryptose broth and incubated at 35±0.5°C for 24 to 48 h and confirmed using brilliant green bile broth. The tubes with both gas formation and turbidity were considered coliform positive.

Statistical analysis

Statistical analysis was performed using SPSS version 24.0. Significant differences between the data of physical parameters and seasons *viz*., post monsoon and monsoon were analysed using one way ANOVA. Kruskal Wallis test was used to determine the significant association between the occurrence of coliforms and factors like distance from manure pit/ waste water drainage and septic tanks from wells in households.

Results and discussion

pH

The mean pH of water samples collected from the dairy farm during the post monsoon and monsoon seasons were 6.30 ± 0.02 and 6.39 ± 0.02, respectively

(Table 1). For household samples, the mean pH ranged from 6.16 ± 0.07 to 6.47 ± 0.07 across both seasons (Table 2). The result suggested that the samples had a pH below the acceptable limit of 6.5 to 8.5 as recommended by BIS (2012). The low pH of the samples could be due to the release of ions from the acidic soil present in the area. The rise in pH during the monsoon could be suggestive of the dilution of water sources due to increased rainfall. Significant differences were observed in the pH of water collected from both the dairy farm and households between the post monsoon and monsoon seasons (p <0.05).

Total dissolved solids

Total dissolved solids (TDS) value is the measure of amount of inorganic salts present in the water. As per BIS (2012), the TDS should be within 500 mg/L for acceptable limit however the permissible limit is within 2000 mg/L. In our study, the TDS of the water ranged from 49.00±1.88 to 45.47±1.88 mg/L in dairy farm water (Table 1) and 65.05±14.99 to 33.04±7.39 mg/L in households (Table 2) during post monsoon to monsoon season. The obtained TDS from all water sources were in the normal range. The findings of this study were contrary to the results of Sudarshan *et al*. (2019), who reported higher TDS(603 to 705 mg/L)in the post monsoon season compared to monsoon season (472 to 511 mg/L). No significant difference was found in the TDS values of water samples from the dairy farm between the post monsoon and monsoon seasons (p>0.05). However, a significant difference in TDS was observed between the post monsoon and monsoon seasons in household samples (p<0.01).

Electrical conductivity

Conductivity plays a crucial role in assessing water quality, as it indicates theability of water to conduct electricity. Dairy farm samples had a mean EC of 88.47 ± 3.69 µS/cm during the post monsoon, compared to 87.81 ± 3.69 µS/cm during the monsoon season (Table 1). Similarly, household water samples showed higher EC during the post monsoon season (151.12 ± 14.99 µS/cm) compared to the monsoon season (65.05 ± 14.99 µS/cm) (Table 2). All the values were within the acceptable limit of 10 to 1,000 µS/cm according to Chapman *et al*. (1996). A study conducted bySudarshan *et al*. (2019), reported higher EC during post monsoon (833-1201µS) season when compared to monsoon season (725-890 µS). Significant differences were noted in the EC values of water samples from households between the post monsoon and monsoon seasons (p<0.01).

Turbidity

Turbidity of water is affected by the presence of inorganic and organic substances. The mean turbidity observed during post monsoon season at the dairy farm (Table 1) and households (Table 2) was 6.36±0.71NTU and 1.58±0.60NTU, respectively. During the monsoon season, it decreased to 4.27±0.71NTU in dairy farmwater samples and 1.41±0.60 NTU in household samples, respectively. All the values, except those from the dairy farm during postmonsoon season, were below the maximum permissible limit of 5 NTU for turbidity and within the acceptable range (1-5 NTU) set by BIS

Table 1. Physical parameters of water collected from dairy farm

Sl. No.	Parameters	Seasons (Mean± SE)		P value
		Post monsoon	Monsoon	
1	pH	6.30±0.02	6.39±0.02	0.035*
2	TDS (mg/L)	49.00±1.88	45.47±1.88	0.162^{ns}
3	EC (µS/cm)	88.47±3.69	87.81±3.69	0.900^{ns}
4	Turbidity (NTU)	6.36±0.71	4.27±0.71	0.039*
5	Hardness (mg/L)	17.77±0.55	15.36±0.55	0.002^{ns}

*Significant at 0.05; ns nonsignificant

Table 2. Physical parameters of water collected from household samples

Sl. No.	Parameters	Seasons (Mean± SE)		P value
		Post monsoon	Monsoon	
1	pH	6.16±0.07	6.47±0.07	0.001*
2	TDS (mg/L)	74.69±7.39	33.04±7.39	0.001*
3	EC (µS/cm)	151.12±14.99	65.05±14.99	0.001*
4	Turbidity (NTU)	1.58±0.60	1.41±0.60	0.844^{ns}
5	Hardness (mg/L)	28.72±3.94	25.18±3.94	0.528^{ns}

*Significant at 0.01; ns nonsignificant

Table 3. Seasonal variation in mean coliform count of samples from dairy farm during post monsoon and monsoon

Sl. No.	Sources	Parameter	Season (Mean ± SE)		P value
			Post monsoon	Monsoon	
1	Well 1	CC	96.96[a] ±67.43	416.44[a]±67.43	0.001*
2	Well 2		72.68[a] ±67.43	189.44[d] ±67.43	0.221[ns]
3	Well 3		94.64[a] ±67.43	499.16[a] ±67.43	0.001*
4	Pond 1		439.68[b] ±67.43	509.56[a] ±67.43	0.464[ns]
5	Pond2		560.2[bc] ±67.43	787.6[b] ±67.43	0.018*
6	River		806.8[d] ±67.43	724[b] ±67.43	0.386[ns]
7	Water trough		722.12[cd] ±67.43	518.2[a] ±67.43	0.033*
8	Shed washings		1014.4[e] ±67.43	1040[c] ±67.43	0.788[ns]
9	Soil		655.84[cd] ±67.43	750.52[b] ±67.43	0.321[ns]

Table 4. Coliform count of water samples collected from households

Sl. No.	Sources	Parameter	Season (Mean ± SE)		P value
			Post monsoon	Monsoon	
1	Water samples	CC	293.81±60.98	423.06±60.98	0.137[ns]

Table 5. Association of factors with respect to the occurrence of coliforms in household samples

Sl. No.	Factors	Distance	Wells (per cent)	Coliform count		P value
				Mean	Std error	
1	Distance from well and manure pit/ wastewater drainage	<7.5 m	12	671.92[a]	115.091	<0.01*
		7.5-15 m	12	279.25[b]	116.641	
		>15 m	76	293.18[b]	45.353	
2	Distance from well and septic tank	<7.5 m	12	804.13[a]	152.388	<0.05*
		7.5-15 m	12	166.17[b]	49.591	
		>15 m	76	315.86[b]	45.430	

(2012). These findings were consistent with those of Anjali *et al*. (2024), who reported turbidity values of 4.84 ± 0.564 NTU and 3.84 ± 0.512 NTU from water samples collected in Thrissur and Kollam districts, respectively, both of which were within the acceptable range. The increased turbidity after the monsoon season might be due to the reduction in the volume of water due to evaporation. A significant difference in seasonal variation in turbidity was noted in water samples collected from the dairy farm between post monsoon and monsoon season ($p<0.05$).

Hardness

Hardness refers to the concentration of calcium and magnesium salts present in the water. According to BIS (2012),the acceptable limit of hardness is 200 mg/L, while the permissible limit is 600 mg/mL. Based on the classification by Sawyer and McCarty (1967), water with a total hardness of less than 75 mg/L is categorised as soft. All the samples in this study fell within this range. Dairy farm samples showed a slight decrease in total hardness from 17.77 ± 0.55 mg/L to 15.36 ± 0.55 mg/L between two seasons (Table 1), while in household samples the values ranged from 28.72 ± 3.94 mg/L to 25.18 ± 3.94 mg/L (Table 2). No significant differences were observed for hardness in both locations during post monsoon and monsoon seasons.

Coliform count

The water for consumption should be free of coliforms as recommended by BIS (2012). Among the dairy farm samples, higher mean coliform counts were recorded in shedwashings(1040±67.43 MPN index/100 mL)during the monsoon season and the lowest value (72.68±67.43) was noted in well 2 during the post monsoon season (Table 3). The mean coliform counts of soil samples in post monsoon and monsoon seasons were 655.84 ±67.43 and 750.52 ±67.43MPN index/100 mL, respectively (Table 3). All water and soil samples in this study exceeded the recommended coliform limits, consistent with the findings of Latheef *et al.* (2024),who reported a coliform count of 21-2400 MPN/100 mL in water samples collected from Ernakulam district.

Significant differences in mean coliform counts were observed in well 1, well 3, pond 2 and water troughs between post monsoon and monsoon seasons. Most of the sources including household water samples showed an increase in coliform counts from post monsoon to monsoon season. Dahnn *et al.* (2017) reported a similar pattern in rural villages of Maharashtra, where the coliform count of water decreased from monsoon (270-246 MPN/100 mL) to post monsoon (33 MPN/100 mL). This fluctuation in coliform count could be due to the initial flush phenomenon, where the first rains wash accumulated organisms from surfaces, soil and other environmental sources into water bodies, leading to a temporary increase in coliform levels.

The mean coliform count of 100 household water samples were 336.96±41.19 MPN/100 mL. A comparable observation was made by Aneesha *et al.* (2019) in water samples obtained from Anthikkad panchayat (116.21±43.82 to 658.22±112.4 MPN/100 mL) of Thrissur district, Kerala (Table 4). As shown in Table 5, a higher significant association was observed between the occurrence of coliforms in household wells and their distance from manure pits/ waste water drainage and septic tanks from wells. In this study, 12.00 per cent of the household wells were located at a distance less than 7.5 m from manure pit/ waste water drainage and the occurrence of coliforms was higher in samples collected from these households. Similarly, elevated coliform count was observed in 12 per cent of households situated less than 7.5m from septic tanks. A similar finding was reported by Sruthi *et al*. (2022), who observed a higher occurrence of *E. coli*in well water samplessituated within 7.5 m of septic tanks. Although the recommended minimum distance of wells from different contaminants was set to 15 meters (Park, 2017), the Kerala Building Rules have been amended to allow a reduced distance of 7.5 meters. Therefore, the elevated presence of coliforms in households could be due to the runoff from poorly managed manure pits of animal sheds or improper sewage disposal.

The onset of the monsoon season had led to a decrease in water quality, possibly due to increased runoff from the contaminants located near the water sources. This could result in high coliform counts that are capable of posing serious public health risks. Elevated levels of coliform bacteria could lead to serious intestinal diseases particularly in young children and immunocompromised individuals as it causes severe gastrointestinal diseases and diarrhoea, which may result in serious complications if left untreated. Therefore, the water should be regularly evaluated and proper disinfection methods should be followed to ensure its quality.

Conclusion

Seasonal variations in water samples were observed for all the parameters analysed from dairy farm and households in Thiruvazhamkunnu. The pH levels observedduring both seasons were below the acceptable limits for drinking water as per BIS standards (2012). Additionally, the coliform count in all samples exceeded the recommended limit, with a notable increase from the post monsoon to the monsoon season. The elevated coliform levelsin household water sources could be associated with inadequate distances between wells and potential contamination sources such as manure pit/ waste water drainage and septic tanks. The findings of this study emphasize the need to raise awareness among the people about the various contamination sources and the importance of proper construction and maintenance of manure pits, septic tanks, wastewater systems and wells. Implementing effective waste disposal strategies and adopting hygienic practices could significantly mitigate contamination risks. Moreover, regular disinfection along with proper covering and lining of water sources is essential for maintaining the water quality.

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Conflict of interest

The authors declare that they have no conflict of interest.

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