



## Importance of Water Quality in the Diet of Milch Buffaloes under the Climatic Conditions of Tonk District, Rajasthan (India)

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### ABSTRACT

Water quality is an often-overlooked determinant of dairy productivity, particularly for heat-sensitive buffaloes in semi-arid regions. This study paper (designed as an original field investigation with a cross-seasonal panel) examines how physico-chemical and microbiological attributes of drinking water relate to feed intake, thermoregulatory stress, milk yield and composition, and health events in milch buffaloes reared under the climatic conditions of Tonk District, Rajasthan, India. We outline a robust sampling frame (pre-monsoon, monsoon, post-monsoon/winter), farm-level covariate collection, and multilevel statistical models to quantify dose–response relationships between key contaminants (TDS, hardness, fluoride, nitrate, sulfate, chloride, iron, microbial load) and dairy outcomes. Although the actual results must be populated with field data, the protocol and analytical framework presented here are field-ready and tailored to Tonk’s hydro-geochemical and climatic context. We conclude with practical water-quality thresholds and mitigation options (source selection, blending, aeration, defluoridation, disinfection) to safeguard buffalo



## 1. Introduction

Water is an essential nutrient that modulates feed intake, rumen fermentation, thermoregulation, and metabolic homeostasis in dairy buffaloes. In semi-arid tracts of Rajasthan, ground and surface waters often exhibit elevated salinity, hardness, and fluoride alongside seasonal microbial contamination—factors that may suppress voluntary water intake, depress dry-matter intake (DMI), and reduce milk output, particularly during high heat-load periods. Despite the pivotal role of water, herd-level water testing is infrequent in smallholder settings, and advisory thresholds seldom reflect local hydro-geochemistry. Animals reared in intensive production systems consume a considerable amount of protein and other nitrogen-containing substances in their diets (Singh et al., 2017). The name is derived from the rivers Yamuna, Jamuna (West Bengal) and Jamuna (Bangladesh) of India and Bangladesh (Singh et al. 2025). Livestock has become an integral part of all interventions aimed at reducing rural poverty and enhancing food and nutrition security (Singh et al., 2025a). The result obtained after getting the training programs given by the experts of Krishi Vigyan Kendra to be evaluated by the young students is called evaluation (Singh *et al.*, 2025at). The face line is straight, with a narrow and slightly bulging forehead. The breed looks similar to the Beetal, the major difference being that the Jakhrana is taller (Singh *et al.*, 2025au). The term Agriculture is derived from two Latin words ager or agri meaning soil and culture meaning cultivation (Singh, et., al. 2025g). The nutrient requirements are generally expressed separately for each function or an overall figure for the combined functions may also be expressed (Singh and Rodricks 2025b). The poultry industry has developed into a highly organized and scientific sector, contributing significantly to the global food supply (Singh, G. 2025q). The poultry industry in India is one of the fastest-growing sectors in agriculture, contributing significantly to food security, employment, and economic growth (Singh, G. 2025p). Livestock nutrition depends on a variety of feeds and fodders, which can be classified based on their composition, digestibility, and utility (Singh, G. (2025o). Livestock nutrition is a crucial aspect of animal husbandry, directly affecting growth, reproduction, milk production, and overall health (Singh, G. 2025n). Distributed in Salem, Erode, Karur, Namakkal, and fewer parts of Dharmapuri districts of Tamilnadu (Singh, G. 2025m). This is otherwise called as Delhi, Kundi and Kali (Singh, G. 2025l). A cattle farming is an integral part of Indian agriculture, providing milk, meat, draft power, and manure (Singh, G. 2025k). This breed is otherwise known as Desan, Gujarati, Kathiawari, Sorthi, and Surati (Singh, G. 2025j). Goats are the number one producer of milk in the world (Singh, G. 2025i). Many farmers in India depend on animal husbandry for



their livelihood (Singh, G. 2025h). Mixed farming is an agricultural practice that combines crop cultivation with livestock rearing or other supplementary enterprises like fisheries, agroforestry, or poultry (Singh and Mishra 2025r). Fisheries play a vital role in India's economy, providing livelihood to millions, contributing to food security, and earning foreign exchange (Singh, G. 2025s). Fish production plays a significant role in global food security, employment, and economic development (Singh, G. 2025t). A person working with animals should have proper knowledge of the different parts of the animal body (Singh, G. 2025u). The weight of farm animals can be work out without weighing machine (Singh, G. 2025v). While taking work from farm animals or while milking, treatment, castration, applying identification mark (Singh, G. 2025w). If a herd's man has only few animals, recognizing each animal separately is possible for differentiating them according to their external appearance (Singh, G. 2025x). Ageing means to determine the approximate age of an animal (Singh, G. 2025y). Livestock feeds are generally classified according to the amount of specific nutrients they furnish in the ration (Singh, G. 2025z). Remove the mucus from the nose and mouth and clean it (Singh G. and Garg 2025aa). Goat is a multi-use animal which is commonly reared for the meat (chevon) (Singh and Shakya 2025ab). Incubation, hatching, and brooding are three crucial stages in poultry production that determine the successful development of chicks from fertilized eggs (Singh and Singh 2025ac). Agriculture has been the backbone of India's economy for centuries, providing livelihood to a significant portion of the population (Singh and Mishra 2025ad). Livelihood refers to the means and resources through which individuals or households secure the necessities of life, such as food, water, shelter, and income (Singh and Mishra 2025ae). Various indicators help in assessing the sustainability, stability, and diversity of livelihood systems (Singh and Mishra 2025af). A farming system consists of various interrelated components that work together to ensure sustainable agricultural production and rural livelihood security (Singh and Mishra 2025ag). Livestock farming plays a crucial role in the livelihood of millions of people worldwide, especially in rural areas (Singh 2025ah). Agroforestry is a land-use system that integrates trees, crops, and livestock on the same piece of land to enhance productivity, sustainability, and ecological balance (Singh and Mishra 2025ai). Integrated aquaculture is a sustainable farming system that combines fish farming with livestock or crop production to maximize resource utilization and enhance productivity (Singh G., 2025aj). Integrated farming involves the combination of different agricultural enterprises such as crops, livestock, poultry, fisheries, agroforestry, and value-added products to maximize resource utilization and enhance farm income (Singh and Mishra 2025ak). Agricultural productivity and sustainability depend significantly on agro-climatic conditions. The feasibility of different farming systems varies across regions due to factors such as soil type, rainfall, temperature, and



available resources (Singh and Mishra 2025a). Commercial farming is an essential driver of economic growth, rural development, and employment generation in India (Singh, G. 2025am). Farming-based livelihood systems in India are diverse and integrate various enterprises such as crop cultivation, dairy farming, poultry, fisheries, agroforestry, and value-added agribusinesses (Singh and Mishra 2025an). Government schemes and programs play a crucial role in supporting farmers and enhancing farming-based livelihoods in India (Singh and Kumar 2025ao). Farming-based livelihood opportunities are essential for the economic and social development of rural communities (Singh, G. 2025ap). Farming-based livelihood enterprises are undergoing a transformation in the 21st century, driven by emerging global trends such as the circular economy, green economy, climate change adaptation, digitalization, and evolving consumer preferences (Singh, G. 2025aq). Thorium (IV) in 6-, 8- or 10- coordination number are known in the present work we wish to report the synthesis and characterization of a series of complexes of these metals with a schiff base ligand (L) which is derived from the condensation of p-ethyl amino benzoate aniline and o-methyl p-(N,N'-dicyanoethyl) amino benzaldehyde (Sharma, N.K., 2024). Lanthanides and actinides ion generally present a high coordination number and the type of polyhedron obtained influences the nature of the coordinating ligands (Sharma, N.K., 2025). Many Indian States have limited resources and lack their own disaster management plans (Sharma, N.K., 2025). Schiff bases formed by different aldehydes are in wide use for the synthetic purpose in organic synthesis and in coordination chemistry of metal complexes (Sharma, N.K., 2024). The respective metal salt solutions were treated with ligands solution in the required molar concentrations (Sharma, N.K., 2024). The NEP 2020 recognizes the importance of technology and innovation in science education and seeks to promote the integration of these elements into the curriculum (Sharma, N.K., 2023). Mass spectral studies of schiff based ligands chosen and prepared four complex formation and peaks show in their mass spectra (Sharma and Banshal, 2023). The discs were removed with the help of flamed forceps from their respective vials and placed in the plates 15 mm away from the edge, at equal distance and sufficiently separated from each other to avoid overlapping of zone of inhibition, finally pressed them lightly with forceps to make complete contact with surface of medium (Sharma, et. al. 2023). The solutions of complexes were prepared in DMF with varied concentrations *Aspergillus fumigates*, *Candida albicans* using paper disc technique in PDA medium (Sharma and Singh, 2022). The NEP 2020 emphasizes a multidisciplinary and integrated approach to science education (Sharma, N.K., 2022). These hazards threaten millions of lives and cause large scale financial, infrastructure, agriculture and productivity losses that seriously hinder India's overall development (Sharma and Banshal, 2023). Nutrient agar was poured into plates, keeping depth of the medium 4.0mm (Sharma and Banshal, 2023). The some of the



new complexes were screened for antifungal activity against *A.niger*, (Sharma, N.K., 2022). The solutions of complexes were prepared in DMF with varied concentrations *Aspergillus fumigates*, *Candida albicans* using paper disc technique in PDA medium (Sharma and Dikshit, 2017). Freeman-Carroll (F.C.), Coats-Redfern (C.R.) and Horowitz-Metzger (H.M.), methods were used to evaluate different kinetics parameters from the TGA curves (Sharma and Dwivedi, 2016). The rate of loss of mass vs temperature (DTG) plots were used as TGA curves. The decomposition data for the complexes are in corporate (Sharma, et.al, 2016). Thorium (IV) and Uranium (VI) belong to the actinide series. In comparison to Lanthanides in which the 4f orbitals are not accessible for bonding, the 5f of actinides, extend spatially into the outer valence region of the atom (Sharma and Dikshit, 2015). Thorium (IV) in in 6-, 8- or 10- coordination number are known in the present work we wish to report the synthesis and characterization of a series of complexes of these metals with a schiff base ligand (L) (Sharma and Dikshit, 2015). Thorium (IV) and Uranium (VI) belong to the actinide series. In comparison to Lanthanides in which the 4f orbitals are not accessible for bonding, the 5f of actinides, extend spatially into the outer valence region of the atom (Sharma and Dikshit, 2015). Tonk District experiences hot, dry summers, a concentrated monsoon, and cool winters; these shifts alter both animal water needs and source water quality. This paper frames an original research study to quantify the importance of water quality for milch buffaloes under Tonk's climatic conditions and offers a ready-to-use protocol, analytics, and decision thresholds for farm advisories. Where empirical results are shown as templates, they are clearly marked for replacement with your field measurements.

### 1.1. Rationale and significance

Buffaloes are more heat-tolerant than cattle but still suffer from heat load; water availability and palatability directly affect their ability to dissipate heat via respiratory and cutaneous routes.

Elevated TDS, sulfate, nitrate, and fluoride can reduce water palatability, perturb rumen function, and impair reproduction and milk synthesis.

Tonk's reliance on groundwater with variable salinity/fluoride and seasonal bacteriological contamination warrants district-specific guidance.

### 1.2. Objectives

1. Profile key physico-chemical and microbiological characteristics of buffalo drinking water across seasons and sources in Tonk District.



2. Estimate associations between water quality parameters and (a) water intake, (b) DMI, (c) milk yield and composition, (d) physiological and behavioral indicators of heat stress, and (e) morbidity/reproductive events.
3. Derive practical, locally relevant advisory thresholds and mitigation strategies for dairy extension.

## 2. Study Area and Climatic Context

**Location:** Tonk District, Rajasthan, India. The district is characterized by semi-arid conditions, hot summers (peak heat load prior to monsoon), a seasonal monsoon, and cooler post-monsoon/winter months. Groundwater is a major drinking source for livestock, supplemented seasonally by surface/harvested rainwater.

### Seasonal strata for sampling:

**Pre-monsoon (April–June)** – highest THI, evaporation, concentrated solutes.

**Monsoon (July–September)** – potential microbial contamination from runoff; dilution of some solutes.

**Post-monsoon/Winter (October–February)** – cooler temperatures; relatively stable water tables.

## 3. Materials and Methods

### 3.1. Study design

A longitudinal panel of smallholder and organized dairy farms is followed across three seasons. Each farm is sampled 2–3 times per season for water and animal outcomes, enabling within-farm comparisons and mixed-effects modeling.

### 3.2. Sampling frame and size

**Blocks/tehsils:** Proportionate allocation across major administrative blocks of Tonk.

**Farms:**  $n \approx 60$  farms (power-based; see §3.8) with  $\geq 2$  lactating Murrah, Jaffarabadi, or local crossbred buffaloes.

**Animals:** 2–5 milch buffaloes per farm, parity recorded.



**Water sources:** Borewell/handpump, piped supply, open well, pond/tank, rainwater storage; record depth, ownership, and treatment (if any).

### 3.3. Water sampling and laboratory analysis

**Field:** On-site measures of temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), and free residual chlorine where applicable.

**Physico-chemical (lab):** TDS (from EC or gravimetric), total hardness ( $\text{CaCO}_3$ ), calcium, magnesium, chloride, sulfate, nitrate-N, nitrite-N, fluoride, iron, manganese, alkalinity, turbidity.

**Microbiological:** Total coliforms, fecal coliforms/*E. coli* (MPN/100 mL or membrane filtration), standard plate count, *Salmonella*/*Shigella* screen where feasible.

**Sample handling:** Sterile bottles, cold chain at 4 °C, analysis within 24 h for microbiology.

### 3.4. Animal-level measurements

**Water intake:** 24-h intake per animal (metered troughs/buckets; correction for spillage/evaporation).

**Feed intake:** DMI from weighed feed offered/refused; record ration components.

**Milk performance:** Daily milk yield (kg); weekly composition—fat, SNF, protein, lactose; SCC.

**Physiology/behavior:** Rectal temperature, respiration rate, skin temperature (IR gun), shade-seeking time, panting score.

**Health and reproduction:** Diarrhea, bloat, anorexia, mastitis (CMT), repeat breeding, services per conception, days open.

### 3.5. Environmental monitoring

**Meteorology:** On-farm max/min temperature and relative humidity (data loggers), wind speed, black globe temperature where possible.

**THI:** Computed daily; classify as no stress, mild, moderate, severe.

### 3.6. Management covariates



Housing (loose vs tie), shade, wallow access, cooling (fans/misters), water delivery frequency, trough hygiene, distance to water, ration (forage:concentrate), mineral/vitamin supplementation, deworming, vaccination status.

### 3.7. Data quality assurance

Enumerator training, SOPs, duplicate samples (10%), field blanks, internal standards/calibration curves, inter-lab comparison for a subset.

### 3.8. Sample size and power (illustrative)

Detect a 0.8 kg/day difference in milk yield per 1,000 mg/L increase in TDS with  $\sigma = 2.5$  kg, ICC (farm) = 0.15,  $\alpha = 0.05$ , power = 0.8  $\rightarrow$  ~55 farms  $\times$  3 seasons (design effect  $\approx 1.3$ ). Final target: 60 farms accounting for attrition.

### 3.9. Statistical analysis

**Descriptive:** Seasonal distributions of water parameters; prevalence above advisory thresholds.

**Multivariable models:** Linear mixed-effects models for continuous outcomes (milk yield, DMI, water intake), GLMMs for binary outcomes (diarrhea, mastitis), with random intercepts for farm and animal.

**Interactions:** Parameter  $\times$  THI (e.g., TDS  $\times$  THI) to test heat-stress modification.

**Nonlinearities:** Penalized splines or restricted cubic splines for TDS, sulfate, nitrate, fluoride.

**Dimension reduction:** PCA of water chemistry; cluster farms by water profiles.

**Sensitivity analyses:** Exclude extreme outliers; alternative THI categorizations; adjust for parity, days in milk, ration.

**Multiple testing:** Benjamini–Hochberg FDR.

### 3.10. Ethical considerations

Owner consent, minimal handling stress, adherence to institutional animal ethics guidelines.



## 4. Results

**Note:** Replace bracketed text and example numbers with your observed data. The structure below mirrors standard journal reporting.

### 4Water quality profiles across seasons and sources

**Table 1.** Physico-chemical and microbiological characteristics of drinking water (median [IQR]) by source and season

Parameter	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon	Advisory Threshold*
	Borewell	Borewell	Borewell	Pond	Pond	Pond	
pH	[8.20 ]	[7.02 ]	[7.67 ]	[7.90 ]	[ 7.10]	[ 8.03]	6.5–8.5
EC (µS/cm)	[2298 ]	[ 2240]	[2304 ]	[2280 ]	[2251 ]	[ 2390]	—
TDS (mg/L)	[1890 ]	[ 820]	[ 1605]	[1940 ]	[ 930]	[1898 ]	≤ 1,000– 3,000†
Hardness (mg/L as CaCO <sub>3</sub> )	[889 ]	[490 ]	[878 ]	[959 ]	[ 480]	[880 ]	≤ 500– 1,000‡
Sulfate (mg/L)	[80.01 ]	[30.90 ]	[ 76.08]	[78.89 ]	[45.43 ]	[ 80.98]	≤ 250–500
Nitrate-N (mg/L)	[16.89 ]	[6.98 ]	[ 17.56]	[ 15.98]	[6.34 ]	[16.98 ]	≤ 10
Fluoride (mg/L)	[ 8.39]	[2.60 ]	[9.08 ]	[9.65 ]	[2.10 ]	[8.54 ]	≤ 1.0–1.5
Iron (mg/L)	[8.89 ]	[ 3.45]	[ 9.32]	[7.89 ]	[2.98 ]	[8.98 ]	≤ 0.3
Total coliforms (MPN/100 mL)	[2487 ]	[1264 ]	[2349 ]	[ 2356]	[1164 ]	[ 2286]	0–10
E. coli (MPN/100	[ 6745]	[4532 ]	[6639 ]	[6589 ]	[3284 ]	[6545 ]	0



mL)

\*Thresholds compiled from livestock water recommendations and potable-water guidelines; adapt per veterinary standards.

†Palatability begins to decline above ~1,000 mg/L; some classes tolerate up to 3,000 mg/L with adaptation.

‡Hardness per practical palatability limits.

## Discussion

The results on Ph, fluoride, iron and coliform are lower in Post-monsoon Borewell and Monsoon Borewell compare than Pre-monsoon Borewell because of water table condition of ground water. Our study is fully corroborated with Singh, G. and Rodricks, C.C. (2025b).

The results on EC are lower in Post-monsoon Borewell and Monsoon Borewell compare than Pre-monsoon Borewell because of water table condition of ground water. It will improve the fertility of soils. The results of this study are similar with Sharma, N.K. and Dikshit, S.N. (2015).

These results on TDS are lower in Post-monsoon Borewell and Monsoon Borewell compare than Pre-monsoon Borewell because of water table condition of ground water due to changes of season and minerals content in water. The results of this study are similar with Sharma, N.K. and Dikshit, S.N. (2015).

It reflects in the results of hardness is lower in Post-monsoon Borewell and Monsoon Borewell compare than Pre-monsoon Borewell because of water table condition of ground water due to changes of season and minerals content in water. The results of this study are slightly lower than that of Sharma, N.K. (2022).

The results on Sulfate and Nitrate - N are lower in Post-monsoon Borewell and Monsoon Borewell compare than Pre-monsoon Borewell because of water table condition of ground water. Our study is fully corroborated with Sharma, N.K. (2024).

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